

Advanced
**Construction
& Carpentry
Skills**

*Volume 2 in the
McGraw-Hill Education
construction series*

Chapter	Australian Standard or National Building Code
1. Work health and safety	
2. Advanced roofing	AS1684 Residential timber-framed construction
3. Roof trusses	AS 4440-2004 Installation of nail-plated timber trusses
4. Wet areas	AS1684 Residential timber-framed construction AS 3740-2010 Waterproofing of domestic wet areas
5. Internal fixing	
6. Wall linings	AS/NZS 2589:2007 Gypsum linings – Application and finishing AS 3740-2010 Waterproofing of domestic wet areas
7. Joinery joints and products	
8. Window and door construction	AS 2047-1999 Windows in buildings – Selection and installation AS 1288-2006 Glass in buildings – Selection and installation
9. Curved work and mouldings	
10. Stair construction	AS1684 Residential timber-framed construction Building Code of Australia
11. Internal joinery	
12. Formwork for stairs and ramps	AS 6669-2007 Plywood-formwork AS 3610-1995 Formwork for concrete AS 3610 Supplement 2-1996 Formwork for concrete – Commentary AS 1428 Design for access and mobility Part 1: General requirements for access – New building work
13. Solid masonry	AS 4773-2010 Masonry in small buildings – Part I & II AS 3700 Masonry structures
14. Arch construction	AS 4773.2-2010 Masonry in small buildings
15. Approaches to sustainability in construction	

Advanced
**Construction
& Carpentry
Skills**

*Volume 2 in the
McGraw-Hill Education
construction series*

DANIEL BONNICI | PAT AIKEN | STUART ARDEN
JACK BARRINGTON | DIETER MYLIUS

**Mc
Graw
Hill**
Education



Copyright © 2014 McGraw-Hill Education (Australia) Pty Ltd

Additional owners of copyright are acknowledged in on-page credits.

Every effort has been made to trace and acknowledge copyrighted material. The authors and publishers tender their apologies should any infringement have occurred.

Reproduction and communication for educational purposes

The Australian *Copyright Act 1968* (the Act) allows a maximum of one chapter or 10% of the pages of this work, whichever is the greater, to be reproduced and/or communicated by any educational institution for its educational purposes provided that the institution (or the body that administers it) has sent a Statutory Educational notice to Copyright Agency Limited (CAL) and been granted a licence. For details of statutory educational and other copyright licences contact: Copyright Agency Limited, Level 15, 233 Castlereagh Street, Sydney NSW 2000. Telephone: (02) 9394 7600.

Website: www.copyright.com.au

Reproduction and communication for other purposes

Apart from any fair dealing for the purposes of study, research, criticism or review, as permitted under the Act, no part of this publication may be reproduced, distributed or transmitted in any form or by any means, or stored in a database or retrieval system, without the written permission of McGraw-Hill Education (Australia) Pty Ltd, including, but not limited to, any network or other electronic storage.

Enquiries should be made to the publisher via www.mcgraw-hill.com.au or marked for the attention of the permissions editor at the address below.

National Library of Australia Cataloguing-in-Publication Data

Author:	Bonnici, Daniel, author.
Title:	Advanced construction and carpentry skills. Volume 2 / Daniel Bonnici, Pat Aiken, Stuart Arden.
ISBN:	9781743079553 (paperback)
Series:	McGraw-Hill education construction series.
Notes:	Includes index.
Subjects:	House construction--Amateurs' manuals. House construction--Handbooks, manuals, etc. House construction--Safety measures. Carpentry Concrete construction--Formwork. Roofing. Wallboard. Joinery.
Other Authors/Contributors:	Aiken, Pat, author. Arden, Stuart, author.
Dewey Number:	690.8

Published in Australia by

McGraw-Hill Education (Australia) Pty Ltd
Level 2, 82 Waterloo Road, North Ryde NSW 2113

Publisher: Norma Angeloni-Tomas

Product developer: Alex Payne

Editorial coordinator: Valerie Wangnet

Senior production editor: Claire Linsdell

Permissions editor: Haidi Bernhardt

Copy editor: Nicole McKenzie

Proofreader: Julie Wicks

Indexer: diacriTech

Design coordinator: Dominic Giustarini

Cover design: Simon Rattray

Internal design: Lauren Statham, Alice Graphics

Typeset in Utopia Std 9/12pt by diacriTech

Printed in China by CTPS

Contents

<i>About the authors</i>	<i>vi</i>	<i>Competency mapping</i>	<i>x</i>
<i>Digital resources</i>	<i>viii</i>	<i>Preface</i>	<i>xiii</i>

PART 1 Work health and safety

Chapter 1 Work health and safety			02
Australian work, health and safety legislation, regulations and codes of practice	02	Safe work method statements and job safety analysis	05
Analysing workplace hazards	04	Work health and safety management plan	07
		<i>The green carpenter</i>	<i>07</i>

PART 2 Advanced roofing

Chapter 2 Advanced roofing			10
Hipped roof with oblique end	10	Scotch valley roof construction	18
Hipped roof of unequal pitch	14	<i>The importance of accurate material measurements</i>	<i>21</i>
Chapter 3 Roof trusses			22
Loads and forces	22	Roof shapes and truss layouts	25
Lightweight timber trusses	23	Job storage and lifting	27
Wall framing support	24	Erecting roof trusses	28
Camber	24	<i>Sustainability audits</i>	<i>31</i>
Fixing trusses to wall framing	24		

PART 3 Internal fixing and lining

Chapter 4 Wet areas			34
What is a wet area?	34	Installation of a bath	37
Set out of wet areas	34	Installation of sinks and vanities	39
Installation of a shower base	35	<i>What is sick building syndrome?</i>	<i>39</i>
Chapter 5 Internal fixing			40
Interior wall sheeting	40	Door hanging	45
Timber panelling	41	Trims	49
Doorsets	41	<i>Key principles for a healthy building</i>	<i>53</i>

Chapter 6 Internal linings		54
Plasterboard internal lining systems	54	Cornices
Plasterboard finish	56	Wet area lining systems and waterproofing
Plasterboard wall lining	60	Three-coat paint systems for internal plasterboard
Ceiling lining installation	62	<i>Organic insulation materials</i>

PART 4 Joinery

Chapter 7 Joinery joints and products		72
Framing joints	72	Joints used for widening timber
Carcase joints	85	<i>Life cycle thinking</i>
Chapter 8 Window and door construction		98
Window types	98	Vertical sliding sashes
Window manufacture	100	Glazing
Setting out of rods	102	Door construction
Marking out from the set-out rod	105	Door types
Assembling and gluing up the sash	108	<i>Windows and glazing</i>
Cleaning off the sash	109	
Chapter 9 Curved work and mouldings		119
Semicircular-headed door frame	119	Joining mouldings
Joints used in curved work	121	Enlarging and diminishing moulds
Bending timber	123	Raking mouldings
Mouldings	124	<i>Sustainable procurement of materials</i>
Chapter 10 Stair construction		129
General layout	129	Interior timber stairs
Stair dimensions	129	<i>Renewable building resources</i>
External open-riser stair	132	
Chapter 11 Internal joinery		137
Kitchen cupboards	137	Cabinet drawers
Carcase construction	139	Set-out rods
Hinges for particleboard	141	Worktops
Timber cupboard doors	143	<i>Formaldehyde</i>

PART 5 Advanced formwork and wet trades

Chapter 12 Formwork for stairs and ramps		150
Formwork materials	151	Ramps
Formwork standards	151	Formwork for a concrete wall
Formwork design	152	<i>Composite sheet building materials</i>
Formwork for concrete stairs	157	

Chapter 13 Solid masonry			165
Concrete masonry blocks	165	Autoclaved aerated concrete (AAC) block construction	171
Single leaf concrete masonry construction	167	<i>Mineral-based building resources</i>	<i>179</i>
Chapter 14 Arch construction			180
Terminology	180	Arch centres	193
Arch categories	181	<i>The Building Code of Australia</i>	<i>194</i>
Arch set out	181		

PART 6 Sustainable building

Chapter 15 Approaches to sustainability in construction			196
Sustainability in construction	196	Sustainability terminology	200
Legislation and sustainability	198	<i>Sustainability and suppliers</i>	<i>201</i>
Sustainability practices on the building site	199		
<i>Glossary</i>	<i>202</i>	<i>Worksheets</i>	<i>211</i>
<i>Index</i>	<i>205</i>		

About the authors

Daniel Bonnici

Daniel Bonnici contributed to Chapters 2, 4, 5 and 7 to 11. In 2014 Daniel was appointed Carpentry teacher at Bayside P-12 College (Paisley Campus, Newport) to run the Carpentry program in their newly constructed Technical Trades Centre. Prior to this Daniel was employed at Victoria University (TAFE). For the past ten years Daniel has been the VET in schools (VETis) coordinator for Carpentry, Bricklaying, Furnishing and Construction trade taster and school-based carpentry apprentices. Daniel taught in the areas of VETis and Apprenticeship Carpentry.

Daniel has worked in Australia and the United Kingdom as a carpenter in the domestic, industrial and commercial sectors. Daniel's qualifications include Certificate III in Carpentry-Industrial Broad Stream; Diploma of Vocational Education and Training; Certificate IV in Workplace Assessment (TAE); Graduate Certificate in Leadership in Education and Training; and Certificate IV in Building.

In 2006 Daniel founded and currently chairs the Certificate II Building Construction State Moderation Panel, which has representatives from all TAFEs in Victoria, and has contributed to the Victorian Certificate II in Building and Construction as a subject matter expert.

In 2007 Daniel was recognised for his work in the VET in Schools Carpentry area. In that year he was awarded the Australian Trade Teacher of the Year in General Construction (Institute for Trade Skills Excellence); the Victoria University Vice Chancellor Peak Award for Excellence in Teaching and Learning; and the Victoria University Vice Chancellor Citation for Excellence in Teaching and Learning for the Faculty of Technical and Trades Innovation.

Daniel is an avid supporter of Worldskills Australia, and has been a convener and judge for VETis Construction and Open Carpentry at regional and state competitions. He has also been a judge in the category of VETis Construction at the previous two national competitions.

Pat Aiken

Pat contributed to Chapters 1, 6 and 12 to 14. Pat started his career in construction as a Sydney Waterboard labourer at the end of Year 12. After completing a full-time bricklaying course at Randwick College of TAFE he became an apprentice bricklayer. Pat later worked as a contractor and then in refractory bricklaying, working in most Australian states as well as in Indonesia, New Zealand and Papua New Guinea.

Pat completed his Clerk of Works and obtained a builder's licence after starting a small building business, and later worked as a teacher of bricklaying. He became Head Teacher at Hornsby College of TAFE in 1994 and was appointed Program Manager Building Finishes in 1997 and Manager Building Finishes and Plumbing Programs in 2004. During this period he was involved in a benchmarking project in London in 2001 with Construction Training Australia. After an 18-month secondment to the NSW Office of Fair Trading, Pat retired from TAFE in 2007 and started working as a Licensed Builder and part-time TAFE Teacher.

Stuart Arden

Stuart wrote the sustainability features in each chapter. Stuart is an architect and academic and has practised architecture, interior design, heritage conservation and 'green' design in several countries. His most recent offshore assignment was in the UK where he led a team in the design and construction of a series of ecological villages, pioneering sustainable technologies for England's National Trust. Stuart has also integrated architectural practice with being Teacher in Construction at Sydney Technical College and a lecturer at universities. He was Head of the School of Architecture at the University of Tasmania, and Dean of the Faculty of Technology in Wellington, New Zealand, where he developed engineering and construction courses. Stuart is currently working on urban design and transportation options for the Sunshine Coast Council.

ORIGINAL AUTHORS

Jack Barrington

Jack was the lead author of *Practical Australian Carpentry: Framing and Construction* and *Practical Australian Carpentry: Joinery and Advanced Framing* which provided the basis for this new book. Jack is a former Senior Tutor and Head of Carpentry and Joinery at North Sydney Technical College.

Dieter Mylius

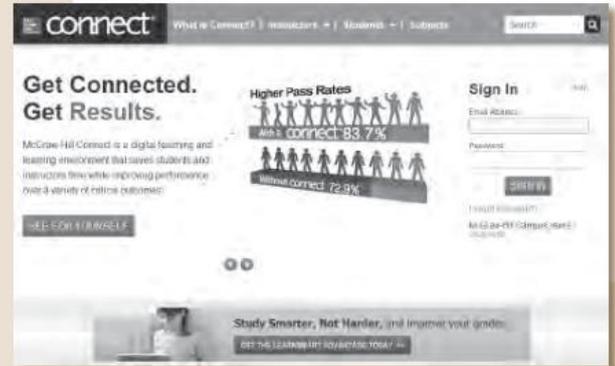
Dieter has been involved in the information and education side of the building industry for over 35 years. After graduating with a Bachelor of Science from the University of Sydney, he spent over 20 years with the Sydney Building Information Centre, heading the Information Services department, which, among other activities, developed a series of home renovation and owner building courses, as well as managing the building inspection services. During that time, he co-wrote the original two volumes of *Practical Australian Carpentry*, as well as several other books on building and home renovation. He acted as Senior Consultant on several publications with Readers Digest, and has also been involved with consumer organisations in matters related to building and home renovation. For the last 16 years he has been the Building and DIY Editor of *Better Homes and Gardens* magazine.

Q Students...

Want to get **better grades**? (*Who doesn't?*)

Ready to interact with **engaging online assignments** that help you apply what you've learned? (*You need to know how to use this stuff in the real world...*)

Need **new ways** to study before the big test? (*A little peace of mind is a good thing...*)



A With McGraw-Hill Connect

STUDENTS GET:

- **Interactive, engaging** content
- Opportunities to **apply** concepts learned in the course
- **Immediate feedback** on performance (*No more wishing you could call your lecturer at 1 am*)
- **Quick access** to quizzes, interactive practice materials and much more (*All the resources you need to be successful are right at your fingertips*)



Q Want to access Connect?

A **Connect** is available if your lecturer has elected to use **Connect** for your course. Ask your lecturer about access.

Q Want an eBook of this text?

A This title is available as an eBook and is conveniently accessible via your computer, laptop or tablet device. Interact with your eBook with the search, highlighting and inserting note functions. For more information visit www.mcgraw-hill.com.au/vet



Q Lecturers...

Would you like your **students** to show up for class better **prepared**? (*Let's face it, learning is much more fun if everyone is engaged and prepared...*)

Want ready-made **interactive assignments**, student progress reporting and auto-assignment grading? (*Spend less time marking...*)

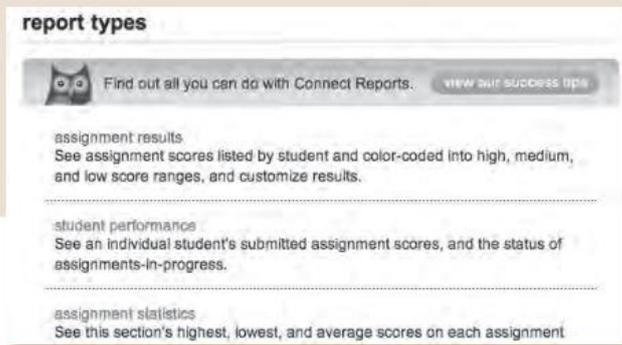
Want an **instant view of student or class performance** relative to learning objectives? (*No more wondering if students understand...*)

Need to **collect data and generate reports** required for administration or accreditation? (*Say goodbye to manually tracking student learning outcomes...*)

A With McGraw-Hill Connect

LECTURERS GET:

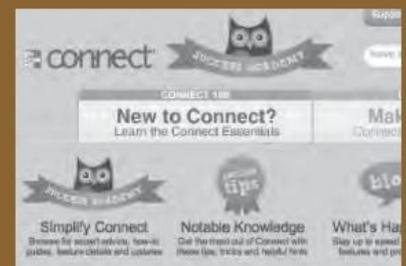
- Simple **assignment management**, therefore less administration time
- The ability to **identify** struggling students at the click of a button
- **Auto-graded** assignments, quizzes and tests to save time
- **Detailed visual reporting**, where student and section results can be viewed and analysed at a glance
- Sophisticated **online testing** capabilities
- A **filtering and reporting** function that allows easy assigning and reporting on materials that are correlated to accreditation standards and learning outcomes



Q Think learning should be a bit more interesting?

A Find out more about Connect

To see how you can access these exceptional digital resources, go to www.mcgraw-hill.com.au/digital/connect



Competency mapping

Chapter	CPC 08 units
1. Work health and safety	<ul style="list-style-type: none"> • CPCCOHS1001A Work safely in the construction industry • CPCCOHS2001A Apply OHS requirements, policies and procedures in the construction industry • CPCCBC4002A Manage occupational health and safety in the building and construction workplace
2. Advanced roofing	<ul style="list-style-type: none"> • CPCCCA3007C Construct a pitched roof • CPCCCA3009B Construct advanced roofs
3. Roof trusses	<ul style="list-style-type: none"> • CPCCCA3006B Erect roof trusses
4. Wet areas	<ul style="list-style-type: none"> • CPCCCA3012A Frame and fit wet area construction
5. Internal fixing	<ul style="list-style-type: none"> • CPCCCA3010A Install and replace windows and doors • CPCCCA3013A Install lining, panelling and moulding
6. Internal linings	<ul style="list-style-type: none"> • CPCCPB3002A Fix standard plasterboard ceiling sheets • CPCCPB3001A Fix standard plasterboard wall sheets • CPCCPB3009A Finish plasterboard joins manually • CPCCPB3012A Cut and fix paper-faced cornices • CPCCPB3010A Manually sand plaster work • CPCCPB3004A Fix wet area sheets • CPCCWP3002B Apply waterproofing process to internal wet areas
7. Joinery joints and products	<ul style="list-style-type: none"> • CPCCJN3004A manufacture joinery components • CPCCCM2005A Use construction tools and equipment
8. Window and door construction	<ul style="list-style-type: none"> • CPCCCM2005A Use construction tools and equipment • CPCCJN3003A Manufacture components for door and window frames • CPCCJN3004A Manufacture joinery components
9. Curved work and mouldings	<ul style="list-style-type: none"> • CPCCJN3003A Manufacture components for door and window frames
10. Stair construction	<ul style="list-style-type: none"> • CPCCCA3016A Construct timber external stairs • CPCCJS3002A Manufacture stair components for straight flighted stairs • CPCCJS3003A Assemble and install stairs • CPCCJS3011A Design and set out stairs
11. Internal joinery	<ul style="list-style-type: none"> • CPCCSH3001A Set out and assemble cabinets, showcases, wall units, counters and workstations • CPCCJN3004A Manufacture joinery components
12. Formwork for stairs and ramps	<ul style="list-style-type: none"> • CPCCOHS2001A Apply OHS requirements, policies and procedures in the construction industry • CPCCCA2003A Erect and dismantle formwork for footings and slabs on ground • CPCCCA3019A Erect and dismantle formwork to suspended slabs, columns, beams and walls
13. Solid masonry	<ul style="list-style-type: none"> • CPCCBL2001A Handle and prepare bricklaying and blocklaying materials • CPCCBL3013A Construct masonry structural systems • CPCCBL3005A Lay masonry walls and corners • CPCCBL3018A Install aerated autoclaved concrete products
14. Arch construction	<ul style="list-style-type: none"> • CPCCBL3010A Construct masonry arches
15. Approaches to sustainability in construction	<ul style="list-style-type: none"> • CPCCCM1012A Work effectively and sustainably in the construction industry

Certificate II Building and Construction 22216VIC**Certificate II in Joinery/Shopfitting/Stairbuilding (pre-apprenticeship) 22145VIC (Victorian modules)**

- **VU20955** Workplace safety and site induction

- **VU20979** Interior fixing
- **VU20978** Installation of window and door frames

- **VU20971** Carpentry hand tools

- **VU20971** Carpentry hand tools
- **VU20561** Construct basic doors and windows

- **VU20563** Construct a basic stair

- **VU20561** Construct basic shop fitting display unit

- **VU20982** Basic environmental sustainability in carpentry
- **VU20970** Basic environmental sustainability in bricklaying

Preface

This book has been developed to complement the training of students studying for Certificates II and III (Apprenticeship) in the trade areas of Carpentry, Joinery and Bricklaying. The text maps into the National Training Package CPC08, Victorian Building and Construction Qualification 22216VIC, as well as referencing Australian Standards and state and national building codes.

The text provides students with an understanding of the knowledge and skills underpinning the key concepts and principles in the construction industry. Students can then apply and adapt these skills to current workplace practices. In the workplace, techniques will vary as a result of the employer's own preference or building philosophy but the core skills will remain the same. Our text aims to describe these skills and support students as they practise and refine their own techniques in an ever changing workplace.

The publication uses the best parts of *Practical Australian Carpentry*, a highly respected resource that has been used for over 20 years. It has been updated and supplemented with new content relevant to the contemporary Australian construction industry.

Volume 2 covers the advanced skills and knowledge required by a carpenter, joiner and bricklayer including:

- Workplace health and safety
- Advanced roofing
- Roof trusses
- Wet area construction
- Internal fixing
- Wall linings
- Joinery joints
- Window and door construction
- Internal joinery
- Formwork for stairs and ramps
- Solid masonry
- Arches and centres
- Approaches to sustainable building.

Each chapter is aligned to specific units of competency, so trainers can plan their delivery. Student Research tasks and Worksheets are provided for each chapter that reinforce the content covered. With its clear step-by-step instructions and up-to-date content, this publication is a resource for both the trade and hobbyist alike.

The author team believes this publication will become a valued addition to any library and will remain as relevant today as the *Practical Australian Carpentry* series proved itself over the many years since its first publication.

Acknowledgments

The authors and McGraw-Hill Education would like to thank the following people for their input into the creation of this text.

For reviewing the manuscript:

- Geoff Leng
- Steven Baker
- Cameron Denison
- Kevin Radcliffe

For producing digital resources including testbanks, interactive questions and student quizzes:

- Glenn Costin

PART 1

Work health and safety

Chapter 1 Work health and safety

Tradie profile

Paul Gray – Owner, Graybuilt Pty Ltd, architectural carpentry and building

Paul started his career in building as an apprentice carpenter and joiner and completed a TAFE trade certificate in 1992. Paul has always been dedicated to a job he loves—building houses—and he has been able to develop that passion into a thriving building company, Graybuilt.

Paul found that he was increasingly in demand, not just for carpentry and joinery work but also to construct complete houses.

Needing a full builder's licence, Paul completed his Certificate IV in Building in 2007 through a combined Ultimo TAFE/HIA program that recognised existing supervision and management skills while providing gap training in new skills.

Paul undertakes all residential construction, from highly detailed architectural work through to minor alterations and additions. Increasingly he builds houses with sustainable features such as solar power, solar hydronic heating, solar hot water, greywater recycling systems, rain harvesting systems, water tanks and low-e glazing.

Paul has spent years establishing and developing his Graybuilt team to ensure high standards of workmanship. He insists on the highest levels of safety and has developed an excellent safety management system that ensures a safe and secure workplace for his employees and himself.

Paul is a recent recipient of the DARCH Horse Award presented by DARCH (the NSW Emerging Architects and Graduates Committee of the Australian Institute of Architects), an award that recognises and celebrates outstanding contributions by non-architects in the pursuit of a high-quality built environment, for his 'outstanding contribution to an architectural outcome in 2013'.

Having built houses for 20 years, Paul believes it is his communication and organisational skills, the detailing of building finishes, and his team of carpenters, apprentices and subcontractors producing the highest quality work that makes the job of building such a positive experience for all concerned. Paul's wife is also an important member of that team, providing the necessary financial and contract management that any small business needs to be successful.



Work health and safety

LEARNING OBJECTIVES

- 1.1 Working within the framework of Australian safety legislation
- 1.2 Understanding the responsibilities and roles related to site safety
- 1.3 Analysing workplace hazards and related documents
- 1.4 Applying a work health and safety management plan

The Work Health and Safety (WHS) chapter in Volume 1 of this series of construction texts reviews the heightened level of risk for young construction workers and the major causes of death and serious injury in the Australian construction industry. This chapter will provide information that will assist more experienced construction workers who have a higher level of responsibility in relation to WHS. It considers model safety legislation and codes of practice that have been implemented by most states and territories and what these mean for all construction workers.

Australian work, health and safety legislation, regulations and codes of practice

The model national legislation that addresses workplace health and safety is called the *Work Health and Safety Act 2011* (Cth) (WHS Act). The implementation of this legislation is supported by the *Work Health and Safety Regulations 2011* (Cth) (WHS Regulations) together with national standards and codes of practice. Under this model, all workers and employers have shared roles and responsibilities to ensure that construction worksites are safe workplaces. These shared responsibilities mean that individual workers must at times participate in the assessment of risks associated with tasks they undertake.

Most Australian states and territories have now adopted the model safety legislation of the federal government. An immediate benefit has been the mutual recognition of qualifications for mandatory general induction training and the adoption of common codes of practice. The 'harmonisation' of safety requirements across all Australian states and territories not only reduces red tape but also makes the management and implementation of workplace safety more consistent and consequently more effective than it has been in previous years.

Since January 2013 the WHS legislation of South Australia, New South Wales, Queensland, Tasmania, the Australian Capital Territory and the Northern Territory is aligned to the model legislation of the Commonwealth of Australia. However, national WHS codes and guidance materials have no legal status in Victoria. Western Australia adopted the regulations relating to the National Standard for Construction Work and will adopt most of the model legislation. For WHS legislation in these states, contact the relevant authority.

There is broad mutual recognition of construction induction White Cards across all state and territory authorities but interstate workers should check with local authorities to confirm acceptance of the card they hold. A construction induction card will not be accepted if it does not have all details required by the local authorities or is out of date.

Work Health and Safety Act 2011 (Cth)

Fig. 1.1 Work Health and Safety Act 2011 (Cth)



Source: Courtesy Commonwealth of Australia

The following information from the *Guide to the Work Health and Safety Act* (provided courtesy of Safe Work Australia) details the main purpose and aim of the *Work Health and Safety Act 2011* (Cth):

The WHS Act provides a framework to protect the health, safety and welfare of all workers at work and of other people who might be affected by the work.

The WHS Act aims to:

- protect the health and safety of workers and other people by eliminating or minimising risks arising from work or workplaces
- ensure fair and effective representation, consultation and cooperation to address and resolve health and safety issues in the workplace
- encourage unions and employer organisations to take a constructive role in improving WHS practices
- assist businesses and workers to achieve a healthier and safer working environment
- promote information, education and training on work health and safety
- provide effective compliance and enforcement measures, and
- deliver continuous improvement and progressively higher standards of work health and safety.

In furthering these aims there must be regard for the principle that workers and other persons should be given the highest level of protection against harm to their health, safety and welfare from hazards and risks arising from work as is reasonably practicable.

For these purposes 'health' includes psychological health as well as physical health.

A full copy of the Act can be downloaded from www.comlaw.gov.au/Details/C2011A00137/Download.

The *Guide to the Work Health and Safety Act* can be downloaded from www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/717/Guide-to-the-WHS-Act.pdf.

Work Health and Safety Regulations 2011 (Cth)

The Work Health and Safety Regulations 2011 (Cth) (WHS Regulations) complement and support the general duties under the WHS Act and supports it by setting out mandatory obligations on specific matters. You can access the comprehensive 600-page WHS Regulations document at the Safe Work Australia website (www.safeworkaustralia.gov.au).

The regulations impose 'duties' (see note on 'duty of care') on people who have a role in undertaking construction work (see Chapter 6), including:

- the person who commissions the construction work must consult with the designer of the structure on matters relating to health and safety during construction work and provide a health and safety report by the structure designer to the principal contractor

Fig. 1.2 Work health and safety regulations



Source: Courtesy of Safe Work Australia

- the designer of the structure must provide a written health and safety report to the person who commissioned the project
- the principal contractor is responsible for the overall management and control of site health and safety, including collecting work method statements for high risk construction work, providing and maintaining a WHS management plan and informing all workers of the content of the WHS management plan
- workers must comply with the WHS management plan and have available their general induction training card.

The term *duty of care* refers to a requirement to exercise due diligence in performing a WHS duty and to act proactively to ensure health and safety at work. It is applied to all people, regardless of the level of responsibility they have in undertaking construction work.

The meaning of construction work

The WHS Regulations (Part 6.1 Preliminary, 289, p. 277) define construction work as follows:

- (1) ..., **construction work** means any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning or dismantling of a structure.
- (2) ..., **construction work** includes the following:
 - (a) any installation or testing carried out in connection with an activity referred to in subregulation(1);
 - (b) the removal from the workplace of any product or waste resulting from demolition;
 - (c) the prefabrication or testing of elements, at a place specifically established for the construction work, for use in construction work;

- (d) the assembly of prefabricated elements to form a structure, or the disassembly of prefabricated elements forming part of a structure;
- (e) the installation, testing or maintenance of an essential service in relation to a structure;
- (f) any work connected with an excavation;
- (g) any work connected with any preparatory work or site preparation (including landscaping as part of site preparation) carried out in connection with an activity referred to in subregulation (1);
- (h) an activity referred to in subregulation (1), that is carried out on, under or near water, including work on buoys and obstructions to navigation.

For any construction worker who has responsibility for the actions of other workers in relation to safety, see the comprehensive details in Chapters 2–11 of the Regulations.

Codes of practice

Codes of practice provide guidelines for meeting the requirements of the WHS Act and the WHS Regulations and may be used in a court of law as evidence to prove compliance with the WHS legislation (Fig. 1.3). Construction sites that are not operating safely will often be referred to a copy of a code of practice by WHS inspectors to demonstrate why their work procedures have failed to comply with WHS legislation.

Compliance with codes of practice is not mandatory. In some cases, it may be better to use another method or system of work that results in improved outcomes when compared to the outcomes of a model code of practice. However, all responsibility is on the person using an alternative to a code

of practice to prove that it is at least equally safe to use and provides an equivalent or higher standard of WHS than suggested by the code of practice.

A comprehensive register of model codes of practice is available for download at www.safeworkaustralia.gov.au/sites/swa/model-whs-laws/model-cop/a-z-cop/pages/a-z.

Relevant state and territory authorities also have a range of codes of practice related to the construction industry.

Analysing workplace hazards

The process of analysing workplace hazards would normally commence with a site safety audit or safety inspection. Any worker on site can be called up to assist a safety officer to undertake a safety audit. On larger construction sites, a site safety audit should be undertaken by at least two people to ensure that all hazards are identified. Depending on the level of risk, these may be undertaken every day.

Figure 1.4 shows the front page of a sample site safety checklist to which other items may be added. A very simple handwritten list of risks may also be used in this process provided it is properly signed and dated. Normally the audit report will include recommendations or comments from the person undertaking the safety audit and a date when previous safety issues have been resolved. After completion, the checklist is filed for future reference as evidence that a risk analysis had been carried out.

Fig. 1.3 Codes of practice for high risk construction work



Source: Adapted from Safe Work Australia, 2014, *A-Z Model Code of Practice*, Commonwealth of Australia. Courtesy of Safe Work Australia

Fig. 1.4 Sample front page of a site safety checklist

SITE SAFETY CHECKLIST

Site address			
Contact name			
Contact number			
Date			
Fax number			
Email address			
Prepared by			
SUMMARY OF INSPECTION AND SITE DESCRIPTION			
Comments, Additional Safety Issues and Site Specific Hazards			
List of issues or hazards that require attention or corrective action			
REQUIREMENT	YES/NO	COMMENT/ACTION REQUIRED	DATE COMPLETE
Safety management Documented WHS management system Workers inducted to site and record kept			
Site safety signs and notices Construction site safety signs displayed			
Site security/public protection Safeguard for public and after hours (e.g. locked plant and switchboards, barricaded trenches, etc.)			
Site amenities Toilets and handwashing facilities Meals area and drinking water			
First aid and emergencies First aid kit and contact for first aid assistance Emergency procedure and contact numbers Register of injuries			
Risk assessments and WMS/JSAs Risks assessed for all activities including work at heights, trenching, working near powerlines, etc.			

Risk categories

Once the risks have been identified, each must then be analysed and a 'risk category' determined. A typical risk assessment matrix used in the construction industry is shown in Figure 1.5. The likelihood of occurrence is first identified in the far left-hand column. The consequence is then estimated and from this the category of risk is classified as follows:

- E—Extreme risk—death or permanent disability
- H—High risk—long-term or serious injury
- M—Moderate risk—lost time
- L—Low risk—first aid treatment.

Where the work undertaken is considered to be a 'high risk construction activity', a safe work method statement must be

developed identifying an appropriate way to either remove the risk altogether, if feasible, or control the risk to a point where the consequence is either moderate or low.

Safe work method statements and job safety analysis

A safe work method statement (SWMS) is a simple document that outlines the logical steps required to successfully and safely complete a task. When completed, it should be readily accessible and understandable to workers who use it. According to current legislation, a SWMS must be used to remove or minimise risk when people undertake high risk construction work. On construction sites valued at more than \$250 000, it is the responsibility of the principal contractor to

Fig. 1.5 Risk assessment matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

ensure that all trade contractors provide a SWMS before they undertake high risk work. (See Volume 1 for an example of a SWMS.) Alternatively, a job safety analysis (JSA) may also be utilised. A JSA is a form of risk assessment detailing step by step how the task is to be carried out safely. It is broken down into three components—basic steps, hazards and procedure.

Work Health and Safety Regulations 2011 (Cth) state the following requirements for a SWMSC (Courtesy of Safe Work Australia):

Regulation 299 Safe work method statement required for high risk construction work

- (2) A safe work method statement must:
- identify the work that is high risk construction work; and
 - specify hazards relating to the high risk construction work and risks to health and safety associated with those hazards; and
 - describe the measures to be implemented to control the risks; and
 - describe how the control measures are to be implemented, monitored and reviewed.
- (3) A safe work method statement must:
- be prepared taking into account all relevant matters, including:
 - circumstances at the workplace that may affect the way in which the high risk construction work is carried out; and
 - if the high risk construction work is carried out in connection with a construction project — the WHS management plan that has been prepared for the workplace; and
 - be set out and expressed in a way that is readily accessible and understandable to persons who use it.

Safe Work Victoria, the Victorian workplace safety authority, recommends following these five steps when creating a JSA (Courtesy of Safe Work Victoria):

- Document the activity:** Assemble those involved in the activity and then, using the JSA worksheet, write down the tasks that make up the activity, step by step.
- Identify the hazards:** Next to each task, identify what part of the task may cause injury to those doing the work or to anyone else nearby.
- Document the control measures:** For each identified hazard, list the measures that need to be put in place to eliminate or minimise any likely risk of injury to those involved.
- Identify who is responsible:** Document the name of the person responsible for implementing the control measure.
- Monitor and review:** Make sure the activity is supervised to ensure the documented process is being followed. The JSA should be reviewed whenever a documented activity changes, when there is a change of personnel or after an appropriate length of time.

Remember

- The JSA provides a written record of the process to be used to undertake a task. As it is a record that can be used in court, it should be signed off by the parties who have responsibility for the tasks.
- The JSA is only a written record. Management processes must be in place to ensure workers have the skills to complete the job and that there is a required level of supervision to ensure the tasks are completed as documented.
- The JSA should be developed in consultation with all employees who may undertake the task, not just the principal contractor or supervisor.

JSA's and SWMS's are identical in concept but there is no prescriptive or mandated layout. Either document can be designed to achieve the outcomes required under national WHS legislation.

Work health and safety management plan

The principal contractor must prepare a WHS management plan before construction work commences. Where the value of the construction work is \$250 000 or more, a WHS management plan is required by law. The principal contractor has a duty to make the WHS management plan accessible for all workers and to review the plan regularly and advise all workers of any changes to the plan.

The size and complexity of WHS management plans for construction sites varies with the size of the job and the number of workers on site at any time and the number of high risk construction activities taking place. So certain jobs will have a highly complex, comprehensive and lengthy document comprising several lever-arch files or volumes; larger projects will also include a separate demolition management plan and traffic control plan. For a small trade contractor or a smaller project, a less complex plan is needed.

The WHS Regulations describe the minimum requirements for a WHS management plan. It must include the following in relation to a construction project:

- the names, positions and responsibilities of all persons at the workplace whose positions or roles involve specific health and safety responsibilities
- how persons conducting a business or undertaking at the work place will undertake consultation, cooperation and the coordination of activities under their duty to comply with the Act and Regulations
- the arrangements for managing any work health and safety incidents that occur
- any site-specific health and safety rules, and arrangements for ensuring that everyone at the workplace is informed of these rules
- the arrangements for the collection, assessment, monitoring and review of SWMS.

In practice, a WHS site safety management plan can become a much larger overall safety management system by providing additional guidance and information required under WHS legislation, such as:

- evacuation plan
- contact details for the principal contractor and other key safety personnel such as the first aid officers and safety officers
- site map of first aid stations and emergency telephones
- register of all general construction induction card holders working on site
- register of workers who have undertaken site-specific safety training or induction
- register of major plant maintenance schedules
- schedule of all high risk construction work including dates, location and who is undertaking the work
- demolition plan
- traffic control plan
- recycling and waste disposal plan
- asbestos removal plan
- register of incidents/accidents
- safety committee details
- worker facilities and amenities available on site
- location and contact details of closest hospital and medical centres
- register of hazardous substances and materials safety data sheets (MSDS)
- register of required signage.

Student research

Review the codes of practice available at Safe Work Australia (www.safeworkaustralia.gov.au) and determine which of these are specific to the construction industry.

The green carpenter

Your role as a carpenter is to focus on the things you can do to reduce the impact of building on the environment. This includes:

- disposing of your waste responsibly
- sorting waste into designated waste disposal bins on site
- cleaning up liquid or powder spills immediately
- notifying the site supervisor or builder of inadequate environmental practices you observe
- examining materials pricing information and assessing the use of suppliers of sustainable materials
- offering ideas or feedback to the site supervisor on what you have learned about sustainable practices, including more suitable materials for the job and using minimal amounts.

PART 2

Advanced roofing

Chapter 2 Advanced roofing

Chapter 3 Roof trusses

Tradie profile

Chris Nance – Carpenter

Complex roofing is probably the best test of a carpenter's skill. On a normal roof it can be as simple as cutting a few rafters and working out a couple of bevels—a piece of cake! But throw in a building with a skewed end, a top plate with a bend in it and an intersection with another roof of a different pitch, as well as a dormer window and even a hip end and you start to realise why they're called 'bastard valleys'—and it's got nothing to do with marital status! But with all that to deal with, and probably a few other things for interest, when the finished roof is perfect, there's no greater satisfaction.

I'm reminded of a roof I built some time back, on top of some mud brick walls. The client had great fun making and building those walls and was undoubtedly very proud of them. The problem though, from my perspective, was that each wall was a different length, there were no square corners and the plates were well out of level, facing various directions.

To build a pyramid roof made life interesting. After a bit of head scratching, the use of a calculator that was smoking from overuse and a bewildered apprentice, we ended up building a beautiful roof, and everyone was very pleased.



Advanced roofing

LEARNING OBJECTIVES

- 2.1 Hipped roof with oblique end (skew end)
- 2.2 Hipped roof of unequal pitch
- 2.3 Scotch valley roof construction

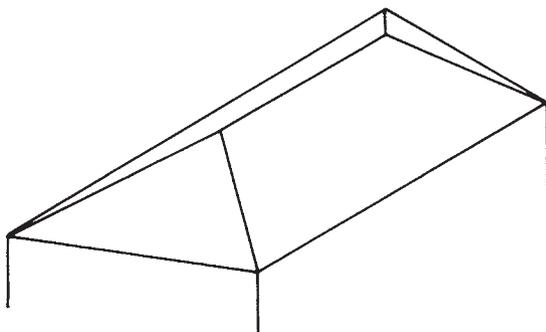
This chapter is an extension of the roofing chapters in Volume 1. You should review those chapters first before proceeding with this chapter. The types of roofs covered in this chapter are of a more complex nature; however, all the underpinning knowledge and techniques are transferable. These roofs will test your skills and knowledge and reinforce your previous learning.

It is important that time is taken when drawing and calculating the roof members as a simple mistake can make the construction of these roofs quite difficult.

Hipped roof with oblique end

Figure 2.1 illustrates a hipped roof, equally pitched, with oblique end. As the remainder of the roof has been dealt with previously, only the oblique end will be described in this chapter.

Fig. 2.1 Hipped roof with oblique end



Setting out of wall plates

Refer to Figure 2.2 and note the following points:

1. The amount that the oblique end is splayed will be called the *offset*, and if the roof is rectangular at its other end, it will be the difference in length between the two sides.

2. The distance across the oblique end is the hypotenuse of the right-angled triangle ABH ; if not already indicated on the plans, it can be measured directly off the job once the wall plates are in position, or it can be calculated from the following formula:

$$\text{end} = \sqrt{\text{span}^2 + \text{offset}^2}$$

3. As the roof is equally pitched, the hips AC and BC will bisect the corners and meet at C . The centring rafters are then CF and CE .
4. Rafters on plan are always at right angles to the wall plate that supports them. Therefore, CG will become the crown end rafter and on centre line will be the same length as the centring rafters.
5. It can be shown that the angle between the hips, $\angle ACB$, is a right angle; if a semicircle is drawn on the end with centre D and the radius equal to half the end, it will join points A , C and B .
6. Any triangle drawn within a semicircle with the hypotenuse corresponding to the diameter of the circle and with the third point on the circumference will be a right-angled triangle. Therefore, the distance CD is also equal to half the end, and BJ and HJ will each be equal to half the offset. From this information the position of the centre lines for the centring rafters and the crown end rafter can be determined from the following formula:

$$AF \text{ and } AG = \frac{1}{2} \text{ end} + \frac{1}{2} \text{ offset}$$

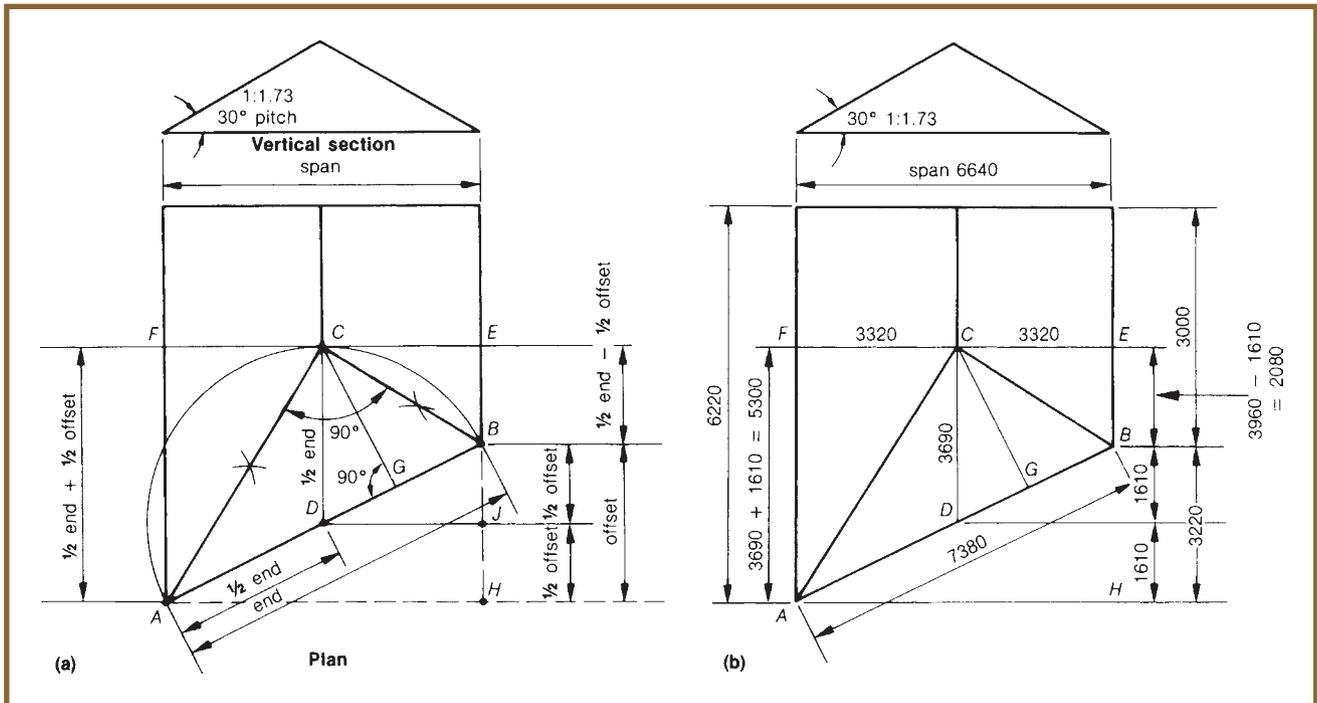
$$BE \text{ and } BG = \frac{1}{2} \text{ end} - \frac{1}{2} \text{ offset}$$

If sufficient information is given, these distances can be calculated and, in practice, can be applied to the roof when setting out the position of rafters on the wall plates.

Example

The following brief specification will be used as an example in further calculations (Fig. 2.2(b)).

Fig.2.2 (a) Set-out of an oblique end; (b) an example



rafters = 100 mm × 50 mm
 hips and ridge = 175 mm × 32 mm
 rafters spacing = 600 mm

span = 6640 mm
 1/2 span = 3320 mm
 pitch = 30°
 long side = 6220 mm
 short side = 3000 mm
 ∴ offset = 3220 mm
 1/2 offset = 1610 mm

$$\begin{aligned} \text{end} &= \sqrt{6640^2 + 3220^2} \\ &= \sqrt{6.64^2 + 3.22^2} \\ &= 7.38 \text{ m} \\ &= 7380 \text{ mm} \end{aligned}$$

∴ 1/2 end = 3690 mm

$$\begin{aligned} \therefore AF \text{ and } AG &= 3690 + 1610 \\ &= 5300 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{and } BE \text{ and } BG &= 3690 - 1610 \\ &= 2080 \end{aligned}$$

From these figures, mark the position of the centre lines of the centring and crown end rafters and indicate them in a distinctive way. From these marks, using the 'in and over' method, set out the creeper rafters at their maximum spacing towards corners A and B.

Roof bevels

To obtain the necessary bevels to cut the oblique end roof, set out a single-line drawing to a suitable scale, including the plan and the vertical section as shown in Figure 2.3; the

accompanying table of roof bevels (Table 2.1) must also be drawn up.

Table 2.1 Roof bevels

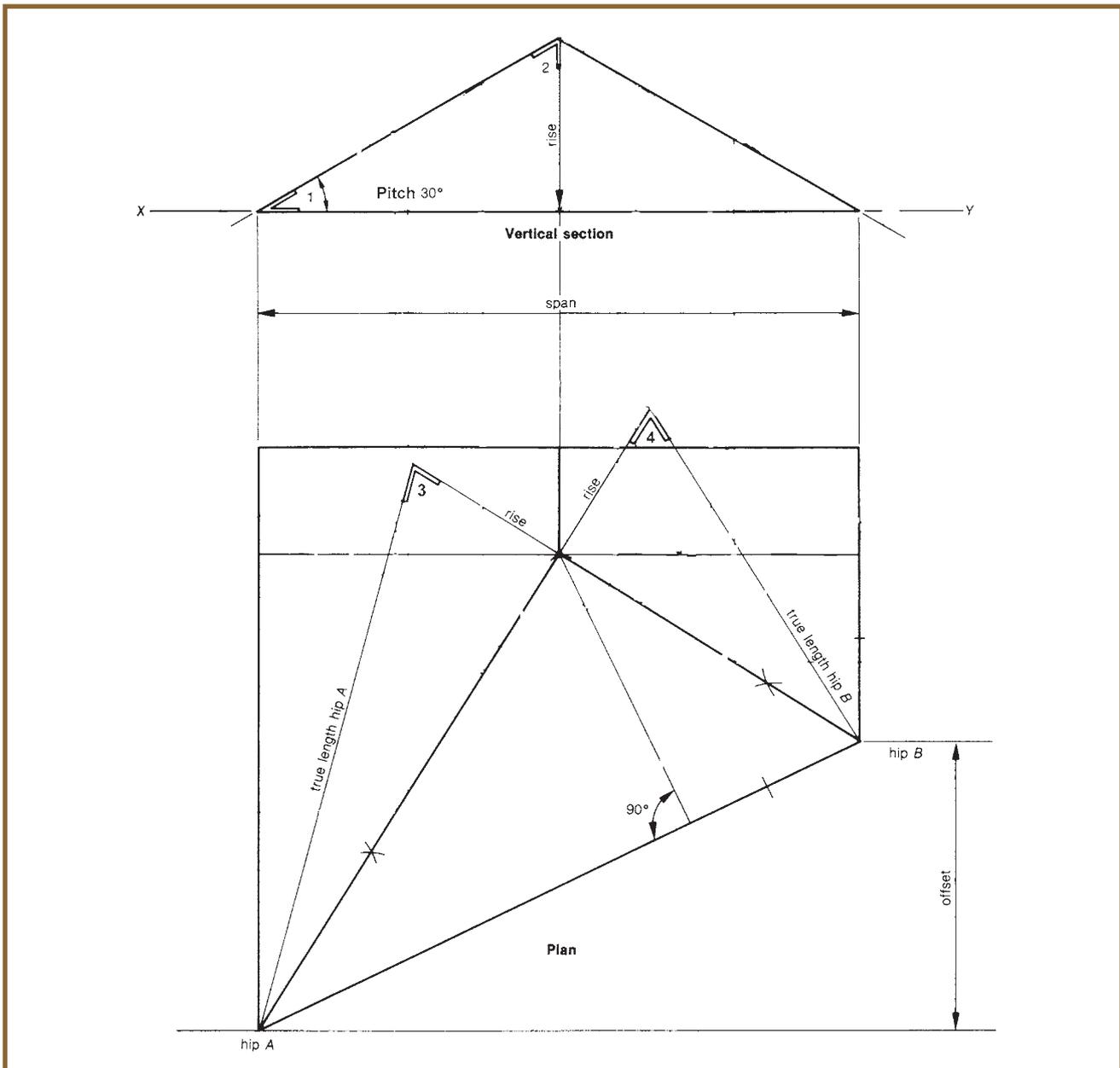
No.	Bevel
1	Level bevel common rafter, creeper rafter and crown end rafter
2	Plumb bevel common rafter, creeper rafter and crown end rafter
<i>Bevels hip A</i>	
3	Plumb bevel hip rafter
<i>Bevels hip B</i>	
4	Plumb bevel hip rafter

Set out the majority of roofs to a scale of 1:10 on a sheet of plywood or hardboard.

The roof is equally pitched; therefore the level bevel and plumb bevel must be the same for all common rafters. These are the only bevels that are common throughout the whole roof and can be taken directly from the vertical section. The crown end rafter will now also require an edge bevel. Beyond this point, a separate set of bevels must be developed for each hip (hip A and hip B) and the creeper rafters for hip A and hip B.

Rafter lengths

Details relevant to the length of rafters have been indicated on a separate scale drawing, Figure 2.4, for the sake of clarity. With practice, sufficient information can be taken from a single drawing.

Fig. 2.3 Roof bevels

The true length of the common rafter is measured directly from the vertical section at the appropriate scale and converted to the full-size dimension.

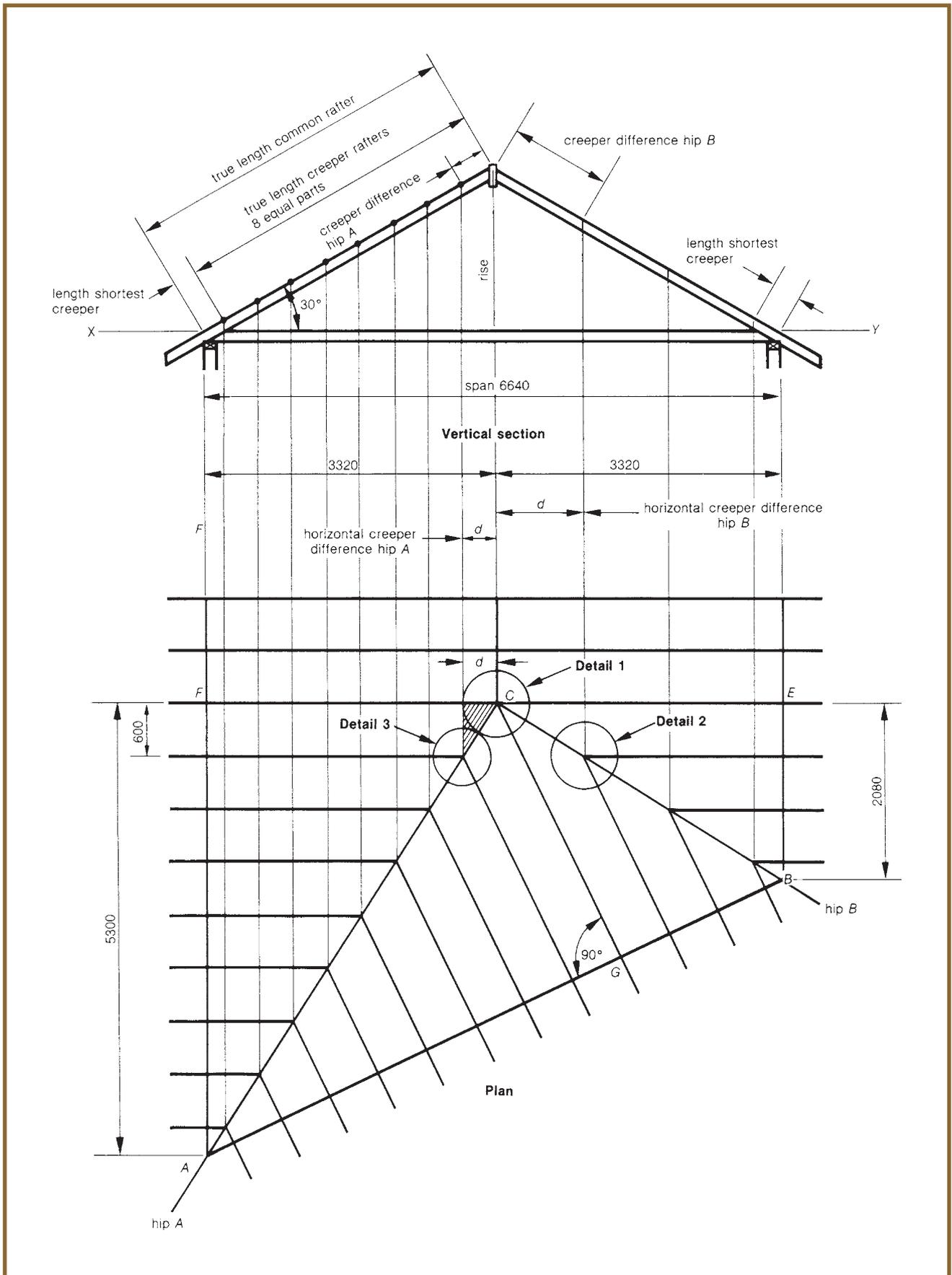
Creepers are indicated on the plan set-out at their maximum spacing; their true length on the centre line is then found by projecting the plan length up to the vertical section onto the common rafter.

In practice, only sufficient of the creeper rafter need be projected up to the vertical section to obtain enough information to set out a pattern rafter. This can be done in a number of ways:

- From the birdsmouth, mark off the length of the shortest creeper and divide the remainder of the rafter into as many parts as there are creeper spacings—in this example, eight in the case of hip A and three for hip B.
- Obtain the creeper difference by measuring the length along the common rafter between any two adjacent creeper rafters.
- Obtain the horizontal difference in the length of creeper rafters. This can be found by measuring from the scale drawing, or more accurately, by calculations as described later.

The true length of the hip rafters can be measured from the development of bevels and may be useful in obtaining an order length. However, in practice, it is more satisfactory to measure the length of hips directly from the job and set them out as described previously, using bevels developed from hip A or hip B.

Fig. 2.4 Rafter length



Calculations

Much of the information necessary for the setting out of a pattern rafter can be obtained from the following calculations.

Length of common rafter

Refer to Table 15.1 in Volume 1, which gives the length of common rafter per metre of run.

The following is a calculation using the example in Figures 2.3 and 2.4:

Pitch angle (°)	Pitch ratio	Common rafter mm/m run
30	1 : 1.73	1155

$$\begin{aligned} \therefore \text{length of common rafter} &= \text{length mm/m run} \times \text{run in metres} \\ &= 1155 \times 3.32 \\ &= 3835 \text{ mm} \end{aligned}$$

Horizontal creeper difference

The horizontal difference in the length of creepers can be calculated from a simple ratio.

For hip A, take the triangle AFC in Figure 2.4. The sides FC and AF are in the ratio 3320:5300. Take also the similar shaded triangle at corner C, where the horizontal difference in the length of creepers is indicated as *d*. Then we have:

$$\begin{aligned} d : 600 &= 3320 : 5300 \\ \therefore d/600 &= 3320/5300 \\ d &= 3320 \times 600/5300 \\ &= 376 \text{ mm} \end{aligned}$$

Therefore, horizontal creeper difference is 376 mm.

True creeper difference

For hip A, the true distance between the length of creeper rafters is:

$$\begin{aligned} \text{common rafter mm/m run} \times \text{run in metres} \\ &= 1155 \times 0.376 \\ &= 434 \text{ mm} \end{aligned}$$

For hip B, take the triangle BEC. Then we have:

$$\begin{aligned} d : 600 &= 3320 : 2080 \\ d &= 600 \times 3320/2080 \\ &= 958 \text{ mm} \end{aligned}$$

Therefore, horizontal creeper difference is 958 mm.

For hip B:

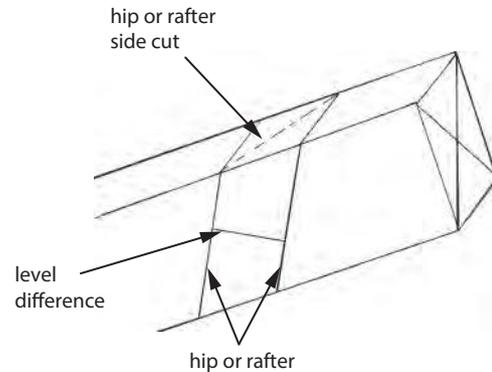
$$\begin{aligned} \text{true creeper difference} &= 1155 \times 0.958 \\ &= 1106 \text{ mm} \end{aligned}$$

Ridge bevel, rafter shortening, level difference distances and side cuts

Figure 2.7 shows the detail of the encircled parts of Figure 2.4. The thickness has been added to the members and the crown end assembly has been arranged with a single edge cut on the hips.

The common rafters must be shortened by half the thickness of the ridge and the crown end rafter/jack rafter by the level shortening measurement indicated. Detail 1 indicates the angle the end of the ridge needs to be cut to accommodate the jack rafter. Figure 2.7 shows how the level difference distances are calculated; these measurements are required so the side cuts for the hips and creeper rafters can be worked out. Figure 2.5 shows how the level difference measurements are applied and the hip and creeper side cuts are obtained.

Fig. 2.5 Developing hip and rafter side cuts



When applying the level difference, hold the rule at 90° to the plumb cut.

Obtaining under purlin bevels

The figure below indicates how the under purlin side and down cuts can be obtained. Using the known rafter plumb and side cuts and applying them to a block of timber as shown in Figure 2.6, angles 3 and 4 can be developed.

Hipped roof of unequal pitch

The construction of a hipped roof where the surfaces are of unequal pitch introduces a number of problems. The length of common rafters will vary with the pitch and can place some limitations on the type of roof covering that can be used. For example, courses of roof tiles will not meet up at the

Fig. 2.6 Developing underpurlin side and down cuts

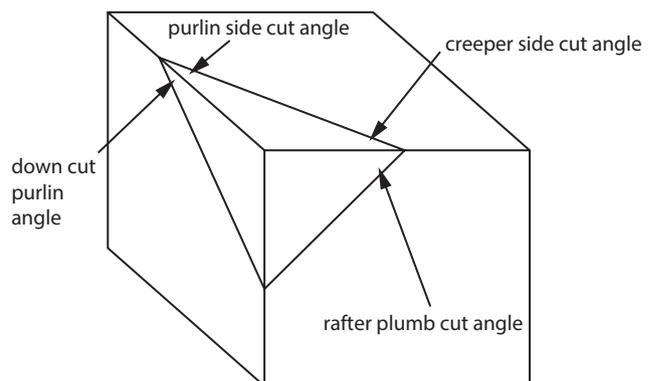
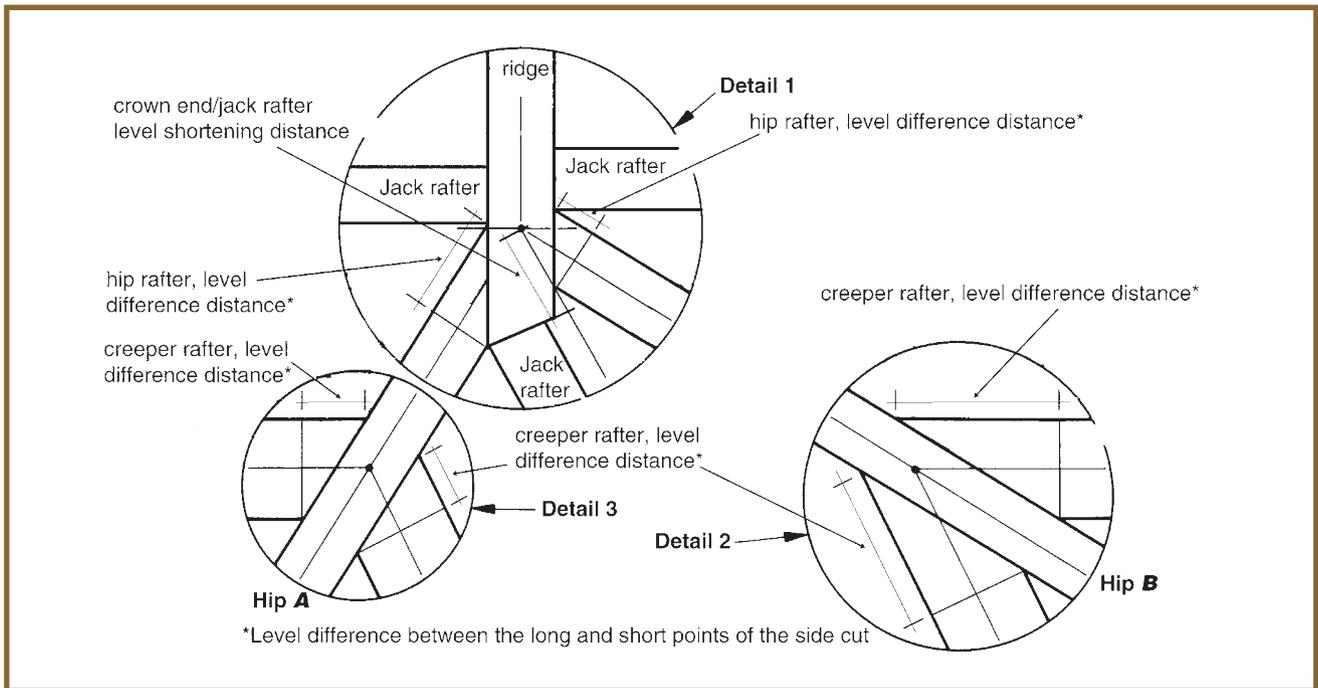


Fig. 2.7 Rafter shortening distances



unequally pitched hip unless the lap can be varied sufficiently to accommodate the change.

If the unequally pitched roof were to have no overhang, many of the problems would be eliminated. However, if an overhang is added, and if a level fascia line is to be maintained as is most probable, then either the eaves width must be varied, or if the eaves width is to remain equal, the height of the wall plates must be varied. The second solution seems to be the one most likely to be adopted, and the following description of the unequally pitched roof will be based on this assumption.

Figure 2.8 is a set-out for a roof, rectangular in plan and unequally pitched; the surfaces are pitched at 1:1.73 (30°) and 1:1.19 (40°). To avoid confusion on the drawing, only information relating to the unequal pitch is shown. Parts are not necessarily drawn to scale. To distinguish between the roof members of surfaces of different pitch, all surfaces pitched at 30° are distinguished by an (A) and all surfaces pitched at 40° are distinguished by a (B).

Table 2.2 Roof bevels

No.	Bevel
<i>Surface A</i>	
1	Level bevel common rafter, 1:1.73 (30°)
2	Plumb bevel common rafter
3	Plumb bevel hip A to B
<i>Surface B</i>	
4	Level bevel common rafter, 1:1.19 (40°)
5	Plumb bevel common rafter

One side and the end are equally pitched at 40° and the junction of these surfaces will be the same as described in Volume 1.

Graphic set-out

The length of rafters and the necessary bevels, together with other details, can be obtained from a graphic set-out drawn to a scale of at least 1:10; for some of the information, full-size details will give a more accurate result. A sheet of plywood makes an excellent drawing board and should accommodate the dimensions of most roofs.

To draw the set-out, refer to Figure 2.8 and work through the following steps:

- Note that the XY line has been moved down to the eaves line, which is to remain level throughout the roof. It is important that the new position of the XY line and the reason for the change be understood. Along the XY line, mark off the distance from A to C, which is equal to the span plus twice the eaves width. From A, set off the roof pitch 1:1.73 (30°) and from C set off the pitch 1:1.19 (40°); these meet at point B. The vertical height from the XY line to B is then the total rise of the roof. From A and C, measure the eaves width in along the XY line and square up to the rafter; establish points E and D. Note the difference in height between E and D. From the set-out so far, the following information is obtainable:
 - AB = total length common rafter (A)
 - AE = eaves overhang (A)
 - BC = total length common rafter (B)
 - DC = eaves overhang (B)

2. From the vertical section, project down and draw, in single lines, sufficient of the plan to indicate the line of the hips. As the surfaces indicated by (B) are equally pitched, the hip will bisect the corner at 45°. However, the remaining hip forming the junction between surfaces A and B must be drawn in by joining the corner of the roof at the eaves line to the gathering point. For convenience, it will be referred to as the *unequally pitched hip*. Note that when this hip is drawn in, the point where it meets the plate moves away from the corner of the walls. This distance can be scaled from the drawing, or perhaps more accurately determined by measuring from full-size details as shown later. From the gathering point, set off at right angles a distance equal to the total rise; join back to the corner to obtain the plumb bevel hip (no. 3 in Table 2.2) and its total length from which an order length can be obtained.
3. Commence from the crown end and centring rafters, and mark on the plan the centre line of the creeper rafters at their specified spacing. Note that they will not meet opposite each other along the unequally pitched hip. The true lengths of creepers to surface A are found by projecting the plan length up to the vertical section and measuring their lengths along the common rafter. The lengths of creepers to surface B are obtained by introducing an auxiliary vertical

section, shown to the left of the plan. Project their plan length onto this section and measure along the common rafter. Remember, the length as scaled from the drawing is the length on the centre line.

4. For greatest accuracy, some of the details can best be found from full-size sections.

In Figure 2.9, the relevant parts of the roof have been separated to avoid confusion. With experience, however, much of the drawing can be superimposed over other set-outs and the information obtained with a minimum of line work.

Referring to Figure 2.9, establish an XY line and, from points A and C, measure in the eaves width, square up to the common rafter and locate points E and D. Mark in the width of the common rafters, take out approximately one-third the width for a birds mouth. Note the amounts left above the birds mouth: x and x_1 .

The wall plates can be drawn in and their difference in height measured directly from the set-out. Depending on how great the difference is, the height of the plates can be adjusted either by laying a second plate over an existing plate and packing it up to the required height, or by adding the difference in height to the length of the studs to raise the plate to the higher level.

Fig. 2.8 Set-out for unequally pitched roof—not to scale

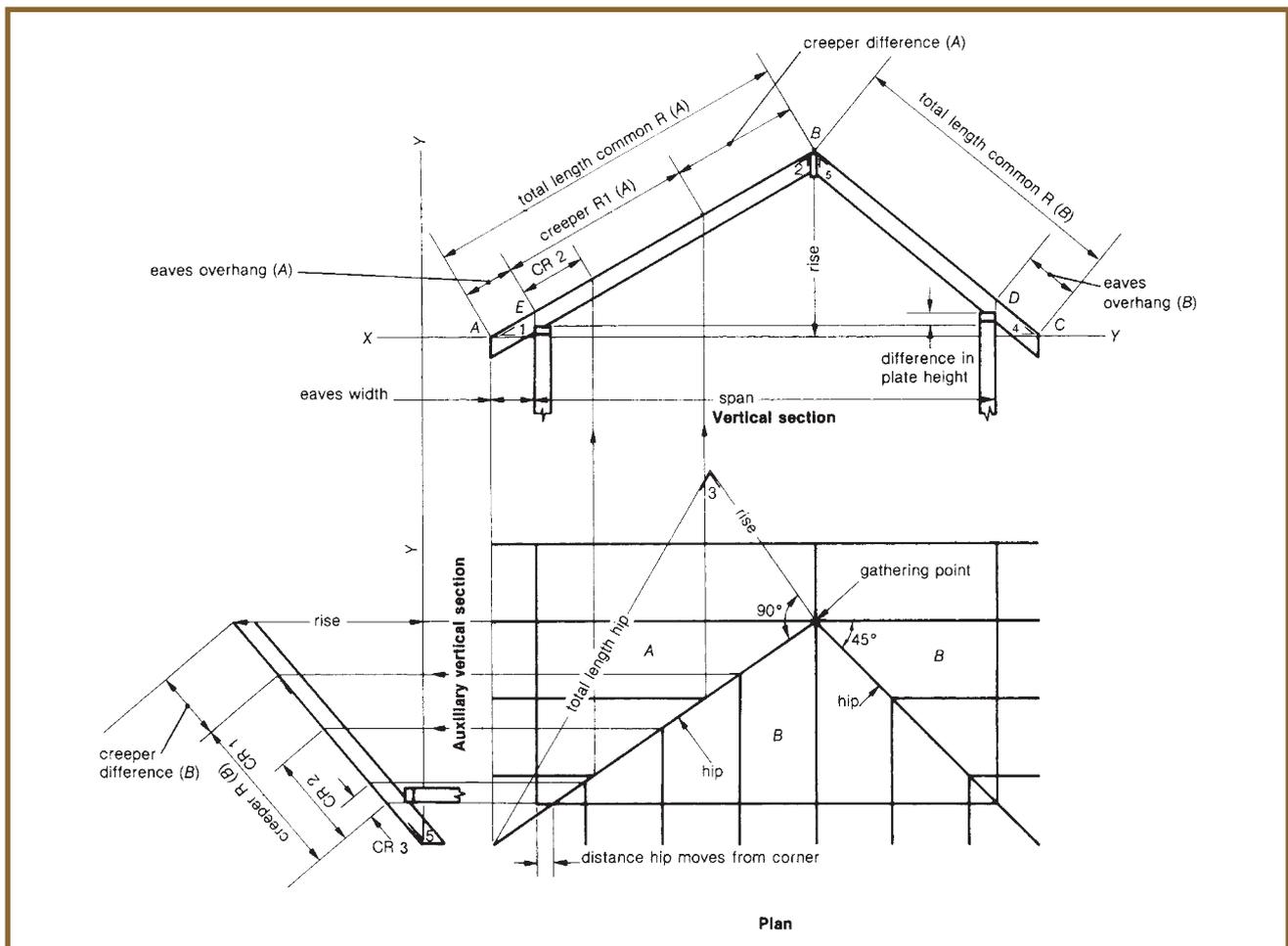
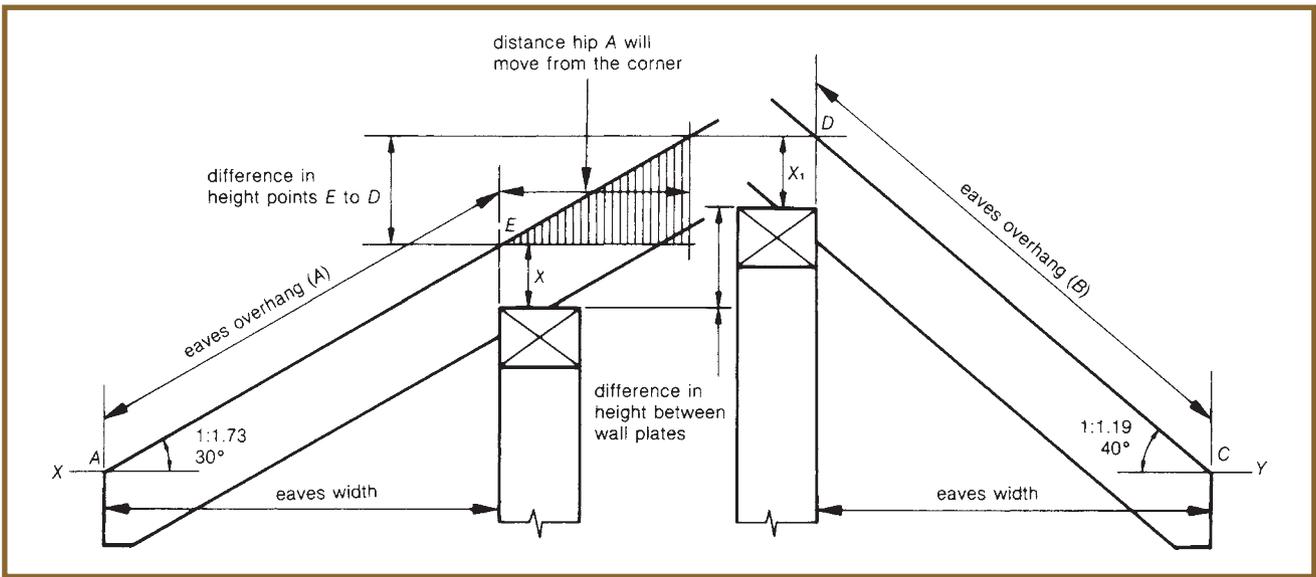


Fig. 2.9 Section through unequally pitched roof



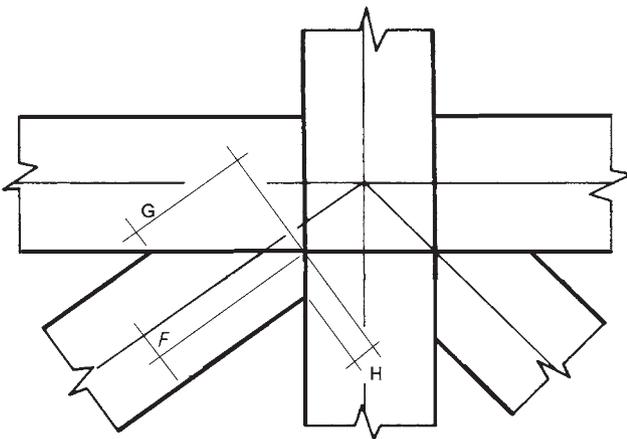
5. The distance the unequally pitched hip moves from the corner is readily obtained from the full-size set-out. Measured to the *top* of the rafters, the difference in height from the corner to the point where the hip meets the plate is equal to the difference in height between points *E* and *D*. Measure the horizontal component of this distance when the pitch is 30°; this is the amount the centre line of the hip will move from the corner.

need to be developed by drawing a pair of creeper rafters onto the crown end drawing for this roof (Fig. 2.10). For an example, refer to Figure 2.7, detail 2 and 3.

Erecting the unequally pitched roof

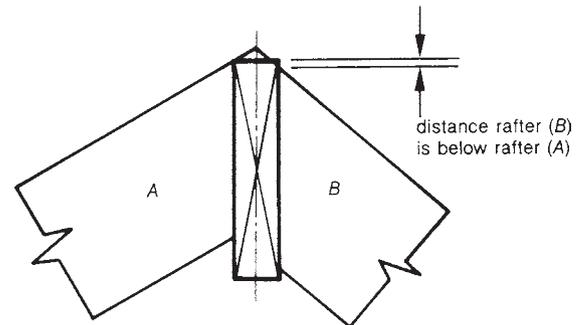
Follow the procedures described in Volume 1, except that at the ridge, rafters to surface *B* will fix slightly below the level of rafters to surface *A* (Fig. 2.11).

Fig. 2.10 Crown end assembly



6. The edge bevels to the hip will also be unequal and the point will move away from the centre line. Details can be taken from a full-size set-out of the gathering point. Note how far the point is off the centre line *F* and set off the side cuts *G* and *H*. The level difference measurements for *G* and *H* will be needed to develop the hip side cuts. Refer to Figure 2.5 for details. The side cuts for the creeper rafters adjoining the unequally pitched hip will have to be developed. Firstly, the level difference for the cuts will

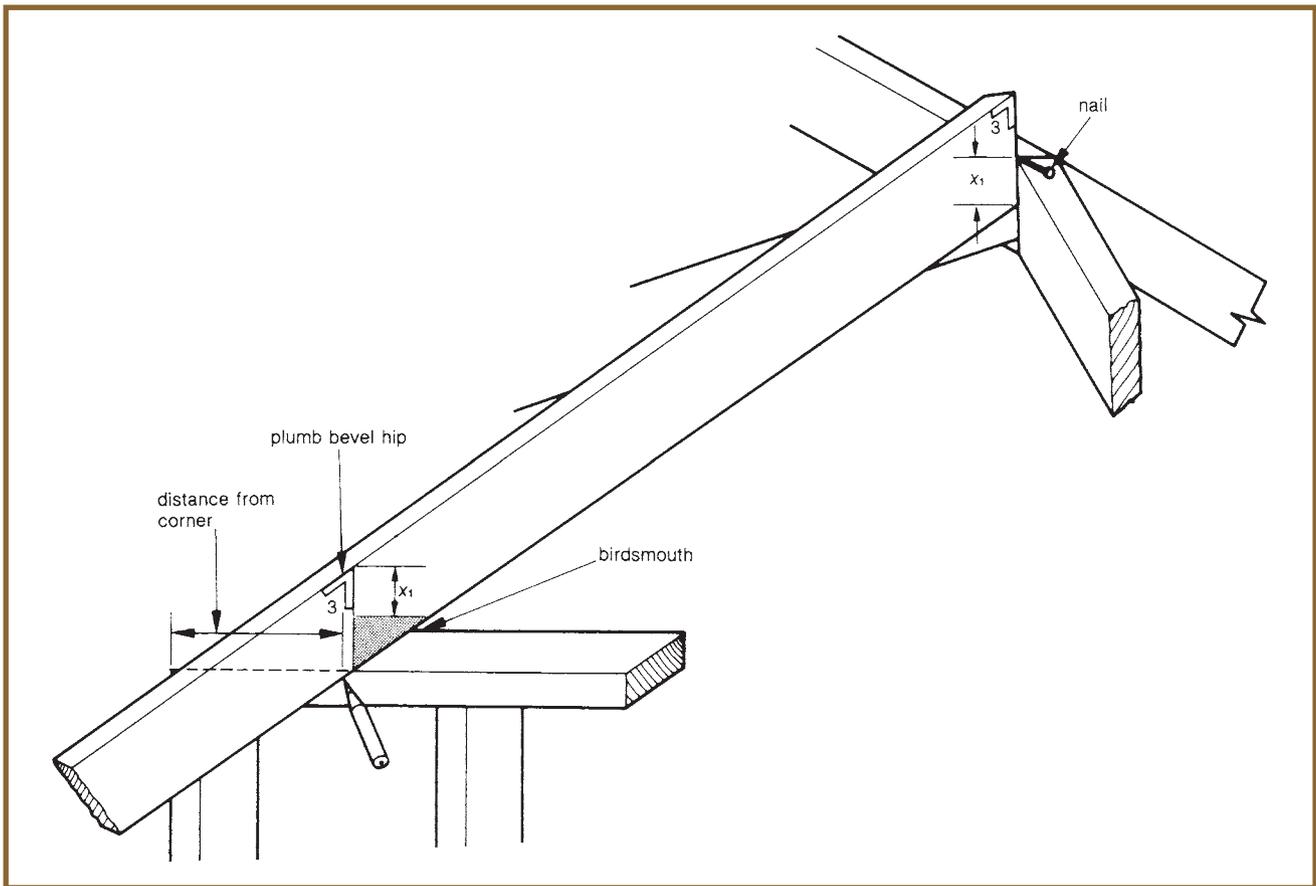
Fig. 2.11 Ridge detail



Measuring and fixing the unequally pitched hip can no doubt be best carried out in a practical manner.

Figure 2.12 shows a method of marking a hip; it is very adaptable to this situation. The procedure is as follows:

1. Mark and cut the plumb and edge bevels to the top of the hip. Measure up from the bottom edge, along the plumb line, the distance X_1 and drive a nail through the point of the hip.
2. Stand the hip in position, supported by the nail at the top, and with its centre line over the point marked from the corner.

Fig. 2.12 Practical hip set-out

3. Mark the single edge bevel underneath and a plumb line on the face. Mark down the distance X_1 to the level cut on the birdsmouth.
4. When the birdsmouth is cut and the nail removed, the whole hip will move down into position.
5. Fix the creeper rafters and complete the purlins and strutting. Cut the tail of the rafters off to a straight line at the required eaves width, and fix the level fascia.

Scotch valley roof construction

The scotch valley roof is commonly used in the construction of additions to an existing dwelling. The beauty of this type of roof is that it can be constructed without disturbing the existing structure. Only the eaves of the existing roof need to be removed to allow the construction of the scotch valley.

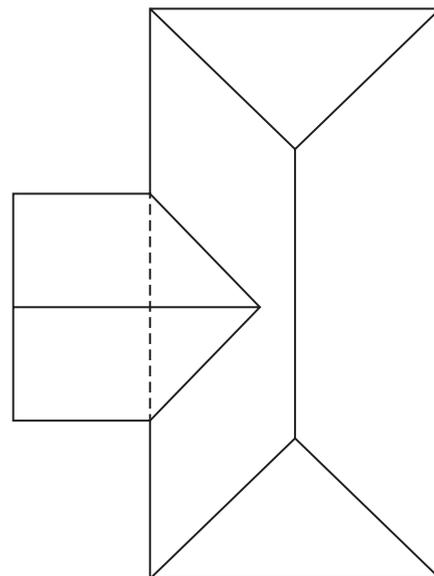
Essentially the new roof is built over the existing roof, and once completed and clad, there is no difference in appearance between a scotch valley roof and a conventional hip and valley roof with a broken hip (described in Volume 1).

Figure 2.13 is a diagram of an existing house with a hip roof where an addition is to be built. Notice the dotted line where the existing wall plate is. The plate will remain as it is required to support the existing rafters.

Generally the new roof will be the same pitch as the existing roof, therefore the existing roof with larger span will become

the major span roof and the new addition with the smaller span will become the minor span roof.

To calculate the rafter length and roof bevels, follow the processes described in Volume 1.

Fig. 2.13 Existing house with planned addition

1. Once the minor span rafter has been calculated, the position of the new minor span ridge can be determined. Place the minor span rafter next to the two rafters that will sit either side of the centre of the new ridge and mark the end of the minor span rafter (Fig. 2.14). This mark locates where a trimmer that will support the new minor span ridge will be situated.

Assuming the minor span roof has a gable end, calculate the ridge length using the following calculation: extension length + ridge overhang at gable + distance between the existing wall plate and the ridge trimmer for the new minor span

ridge = ridge length. Mark out the rafter positions on the ridge and the top plates, using the same method as described earlier. Remember, it is good practice to mark the plates first and then lay the ridge next to the plate and transfer the marks. Install the trimmer to support the new ridge. Then cut a second minor span rafter and the new ridge can be installed. See Fig. 2.15.

You will notice the rafter tails of the major span roof have been removed.

Fig. 2.14 Marking the end of the new minor span rafter

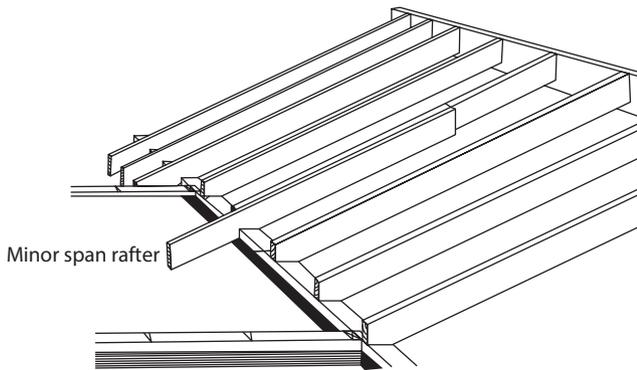
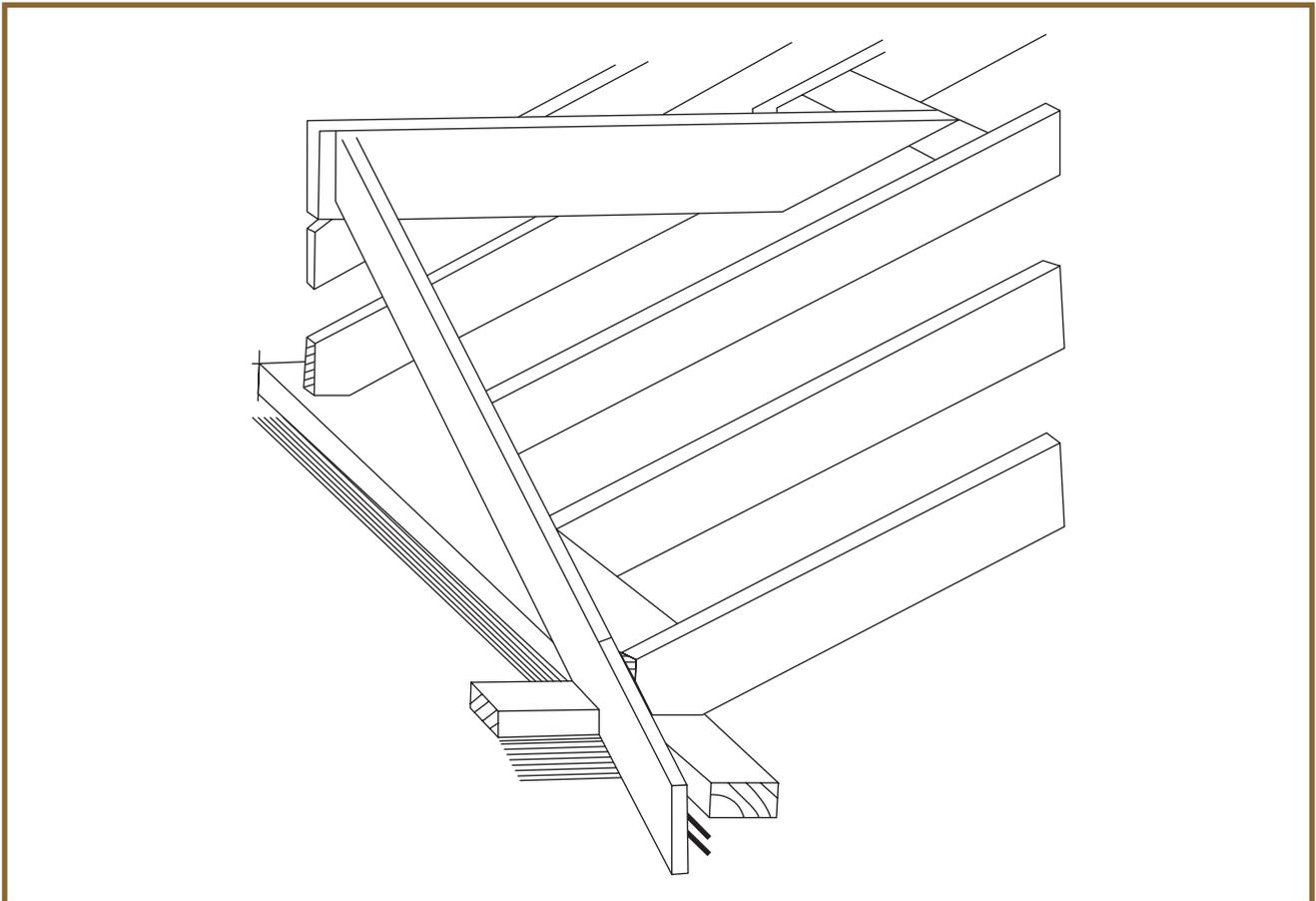


Fig. 2.15 Installing the new ridge



2. Now the position of the sleeper can be found using a gauge block, the same thickness as the sleeper, to locate its position, where the gauge block intersects with the leading edge of the ridge and the common rafter, mark this point and square the line across (Fig. 2.16).
Now the position of the sleeper has been found, run a string line between these two points (Fig. 2.17).
3. The string line will allow a bevel to be set for the top face angle of the sleeper. The edge cut you will see will be square. Ensure when finding the bevel angle that the bevel is laying in the same plane as the sleeper will eventually be.
4. The bottom cut of the sleeper can now be found. The face bevel can be found the same way as the top by using a

sliding the bevel. The edge bevel is found by using an offcut of the sleeper material laying it next to the string line and scribing the angle off the common rafter using a

Fig. 2.16 Finding sleeper position with gauge block

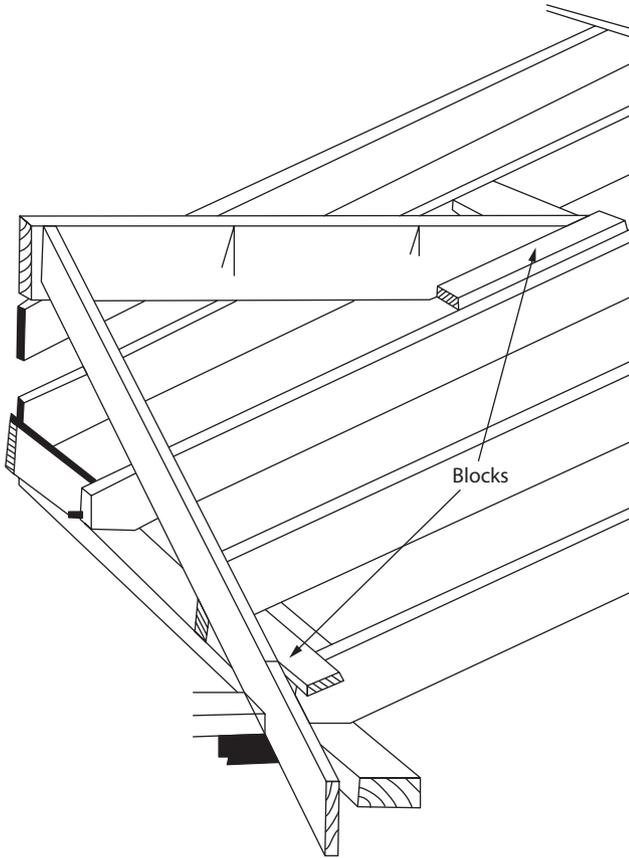
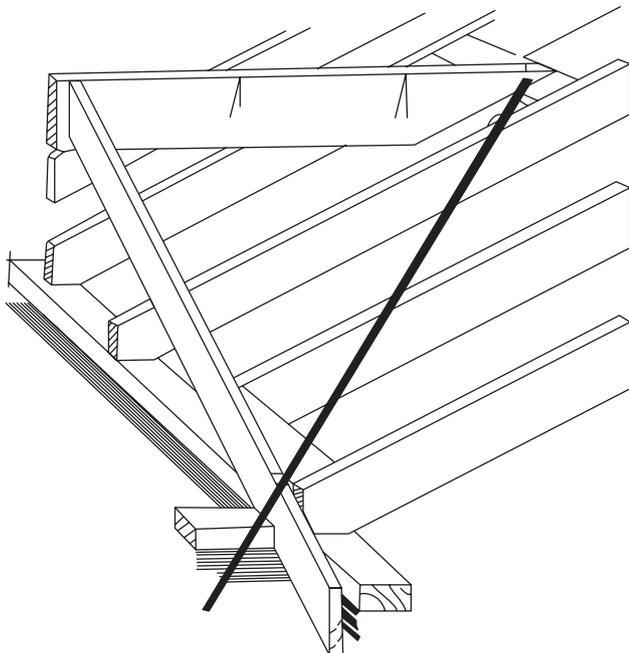


Fig. 2.17 String line along sleeper position



block of timber or a 4 fold rule. Now measure the length of the sleeper and install (Fig. 2.18).

5. Mark the position of the creeper rafters on the sleeper, by measuring square of the common rafter; once done, the length of the creepers can be found by measuring from the top of the ridge to the outside edge of the sleeper.
6. The plumb cut and foot cut for the creeper rafters are the same as the common rafter. The edge cut on the foot of the creeper is the same as the creeper side cut used on the creeper rafters connecting to the hip.
7. Install the remaining creeper and common rafters and the roof is built (Fig. 2.19).

Fig. 2.18 Sleeper installed

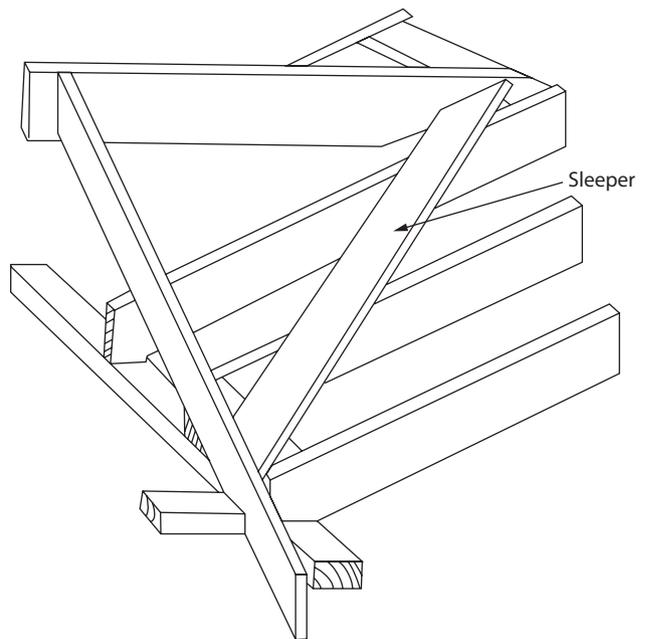
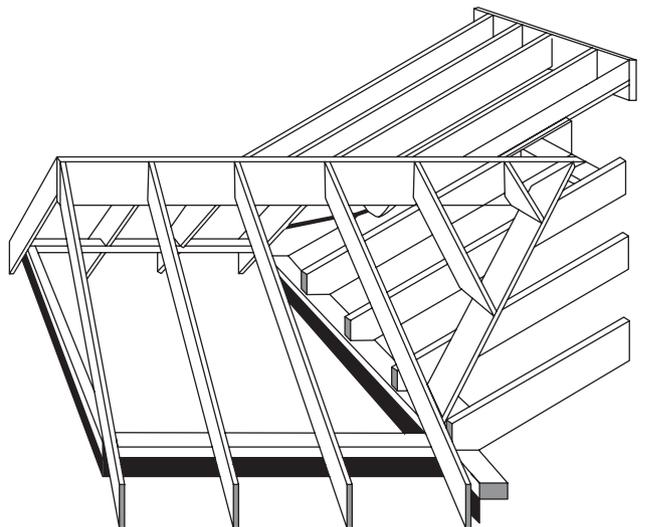


Fig. 2.19 Finished roof



Student research

1. Research at least three other roof types that are not covered in this chapter. For what reasons are these roof types usually constructed?
2. How are the roof bevels for these roofs calculated?

The importance of accurate material measurements

It is commonsense not to waste high-cost materials, as with all materials used in a building. The precise measurement of quantities of materials needed for a job is a major contributor to avoiding unnecessary waste. The most common mistakes when ordering materials are:

- ordering too much
- not ordering enough
- ordering incorrect lengths or sheet sizes.

Note the following information:

- Timber lengths and sheet sizes for composite boards are available in standard sizes.
- Timber lengths start at 1200 mm and increase in 300 mm increments, usually to a maximum of 6000 mm.
- Sheet sizes start at 600 mm width up to 1200 mm and lengths from 1200 mm up to 3600 mm, depending on the manufacturer.

In order to minimise waste, you should use standard sizes (hopefully the building designers are doing the same) as non-standard sizes result in larger amounts of waste and subsequent cost.

Roof trusses

LEARNING OBJECTIVES

- 3.1 Loads and forces
- 3.2 Truss types
- 3.3 Truss insulation

Roof trusses have long been used as the roofing system for industrial and commercial buildings. Trusses permit large areas to be spanned without the need for intermediate supports in the form of internal walls or columns. This chapter covers all aspects of roof trusses including roof shapes, types of trusses and layouts, and erecting and fixing them to wall framing.

Loads and forces

Roof trusses are subjected to a combination of loads (as are other roofs):

- **Dead load.** This is the permanent load due to the mass of materials—roof tiles, ceiling lining, timber, steel, etc.—carried by the truss and includes the weight of the truss itself.
- **Live load.** This is due to the weight of workers and materials that will be applied for short periods during erection and maintenance of the truss.
- **Wind load.** This is due to the wind presence; it can have a strong uplifting effect on roof surfaces.

The members of the truss must be designed to restrain one or more of the following forces:

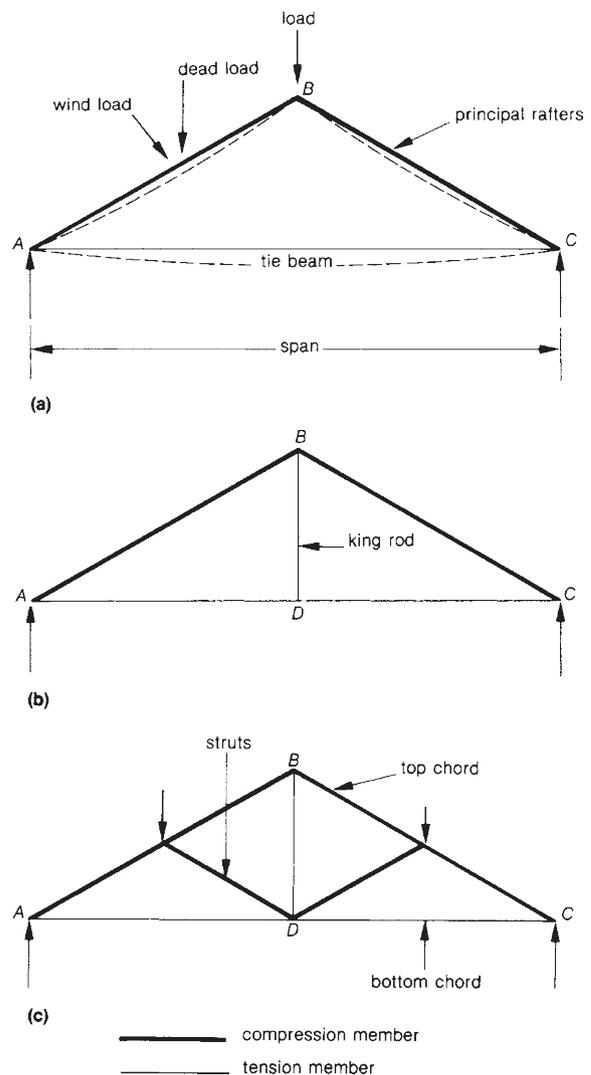
- **compression**—a pushing or crushing force
- **tension**—a pulling or stretching force
- **bending force** or **bending moment**—causes members to deflect or sag under load.

Truss members may be subjected to a combination of these forces, including bending and compression, or bending and tension.

To understand the principle of the truss and how it is able to support loads over wide spans, refer to Figure 3.1.

- Commence with the basic triangular frame *ABC*, which, if the joints and members are sufficiently strong, cannot be distorted. The top sloping members are *principal rafters* and are in compression, transmitting the roof loads down to the supports. The bottom member is the *tie beam* and is in tension preventing *A* and *C* from spreading under the applied load (Fig. 3.1(a)).

Fig. 3.1 Basic principles of the truss: (a) basic triangular form showing different load types; (b) the king rod is a vertical post supplying support; (c) the struts and top and bottom chord



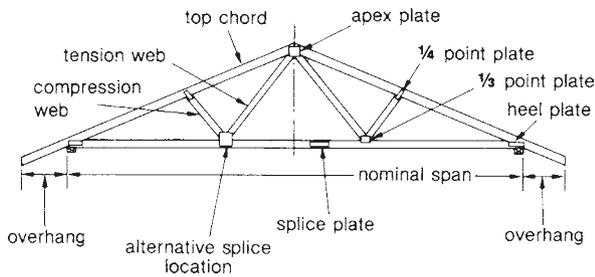
- As the span increases, the members will begin to deflect in their length due to bending so they must be supported. This is generally achieved by inserting a king rod (Fig. 3.1b) and additional struts (Fig. 3.1c). These struts will have different types of forces acting upon them (either tension or compression) depending on their location. The space between the top and bottom chords (or the top and bottom beams) determines the depth of the truss (Fig. 3.1c).

Lightweight timber trusses

In recent years, the most notable change in the application of roof trusses has been the development of the lightweight timber truss. Its use has now largely superseded conventional roof framing in residential and some commercial buildings.

A typical lightweight truss is illustrated in Figure 3.2. The joints are secured with patented metal nail plates which, when correctly applied, produce joints that are immensely strong in comparatively small timber sections. The nail plates are fixed to both sides of the joint and require considerable pressure to drive them into the timber.

Fig. 3.2 Lightweight timber trusses

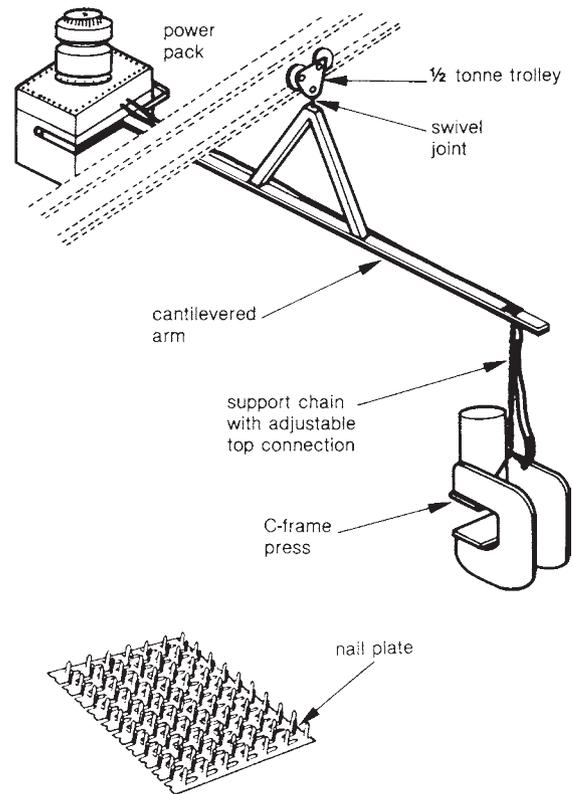


Pressure may be applied by the use of a hydraulic C-frame press (Fig. 3.3), or in more automated production plants by passing the truss through metal rollers that embed the nail plates just the right amount for maximum strength.

Factory-made trusses are manufactured through a network of licensed and franchised fabricators and are available in most areas.

Fig. 3.3 Hydraulic press and nail plate

Fig. 3.3 Hydraulic press and nail plate

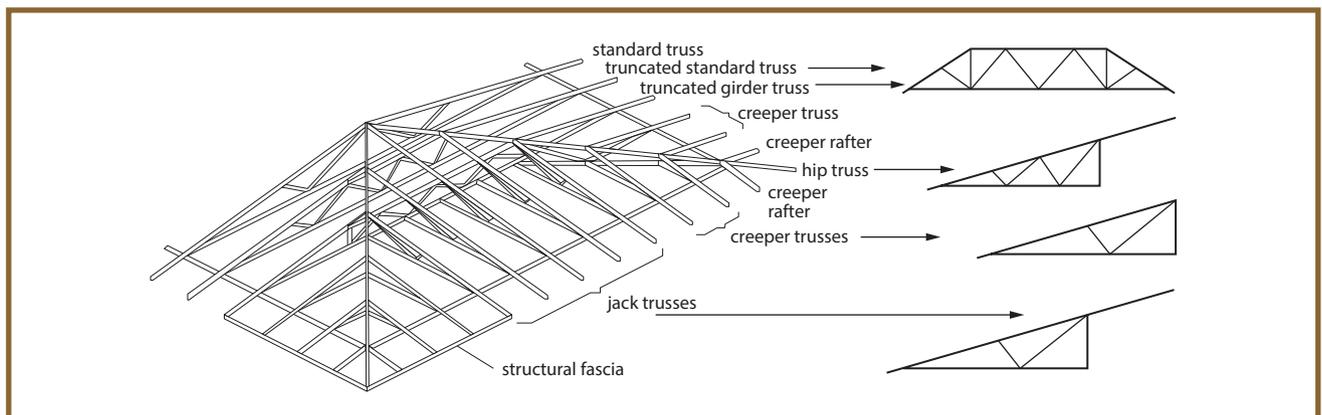


The general construction of a trussed roof is shown in Figure 3.4.

The use of prefabricated lightweight trusses provides a number of advantages:

- The advanced truss design permits the various stress grades of timber to be used to their best advantage and is more economical in the utilisation of timber resources.
- Trusses are supported only on external load-bearing walls or columns, permitting maximum clear internal areas without permanent obstructions. Internal divisions can be made simply by the use of lightweight partitions; in domestic buildings, these can be readily relocated as the needs of the household change.

Fig. 3.4 Prefabricated truss roof

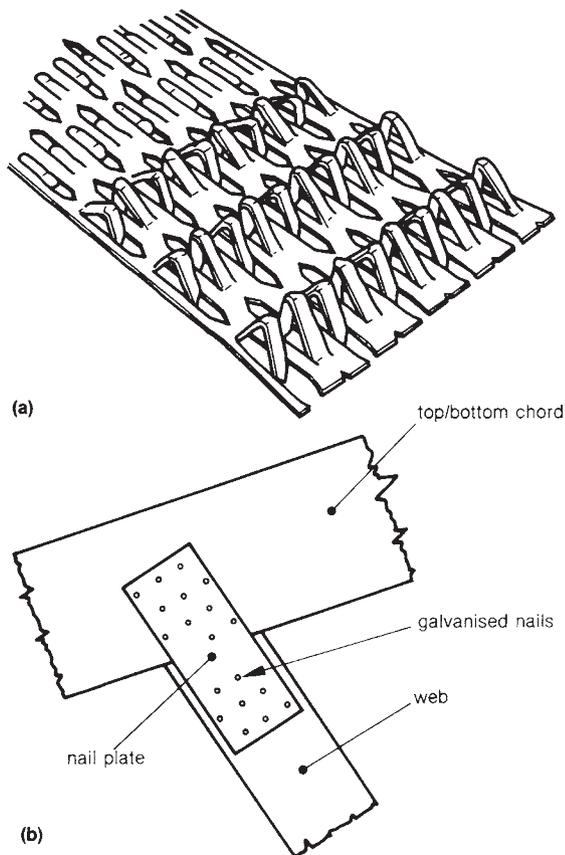


- Trusses are produced under controlled conditions in the 'ready-cut' type workshop and can be speedily erected with a minimum of on-site labour.
- Trusses can be manufactured in a variety of shapes and sizes to meet almost any architectural design.

Manufacturers offer a comprehensive design and advisory service and provide detailed instructions, which should be followed carefully, with each roof supplied. This information is delivered with the trusses and includes a layout for the trusses, the location of bracing and the nailing information for all the fixings points.

Spans up to 25 m are practical, in a range of standard pitches from 7.5° to 27.5°. The spacing of trusses is dependent on the type of roof covering: generally 600 mm and occasionally 900 mm for terracotta or concrete-tiled roofs, and 900, 1200 or 1800 mm for sheet-metal roofing. However, for most domestic situations, the 600 mm spacing is the most convenient and economical and generally will be found on terracotta or concrete-tiled roofs, while the 900 mm spacing is used for sheet roof materials.

Fig. 3.5 (a) and (b) Nail plates



Metal plate connectors are manufactured in a variety of sizes from light-gauge galvanised steel with teeth spaced and formed within the parent metal. Nail plates are normally pressed into the side of the timber, into opposite faces of the timber pieces to form a spliced or gusseted type of joint.

Wall framing support

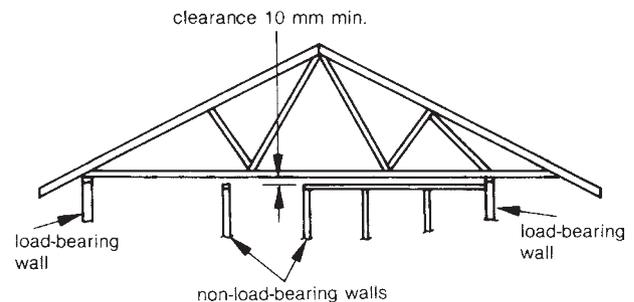
Roof trusses are supported on the external walls only, and the effective roof length for the selection of studs, lintels and

verandah beams is equal to the full roof span. Supporting walls must be designed as load-bearing walls, and if framed in timber, they must be in accordance with AS 1684 Residential timber-framed construction. It is preferable that trusses be located directly over the wall studs in which case top plates can be selected as for direct loading.

Generally, in today's construction, all wall frames are made the same height and adding an extra top plate to the external wall frames will give the required clearance between the internal wall frames (the minimum clearance is 10 mm) and external frames. This also creates a thicker top plate that allows for the truss to sit without the need for the studs to be directly underneath the truss. Generally if the truss is within 100 mm of a stud it is acceptable. There are exceptions to this and the girder truss is one, along with some truncated girder trusses where it is required to have extra support under the truss.

This extra support can be either double or triple studs directly under the truss and, in some cases, a metal post to help distribute the load into the rest of the frame, foundations and footings.

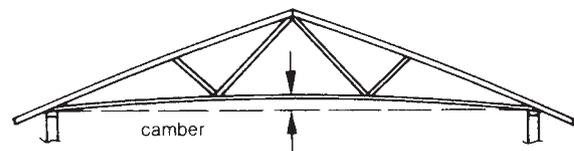
Fig. 3.6 Top plate clearance



Camber

The bottom chord of the truss has a camber built in to allow for deflection when the truss is loaded (Fig. 3.7). The amount of camber depends on a number of factors and is specified by the designer; it may vary from 6 mm to 20 mm, with a minimum camber of 3 mm.

Fig. 3.7 Camber in the bottom chord



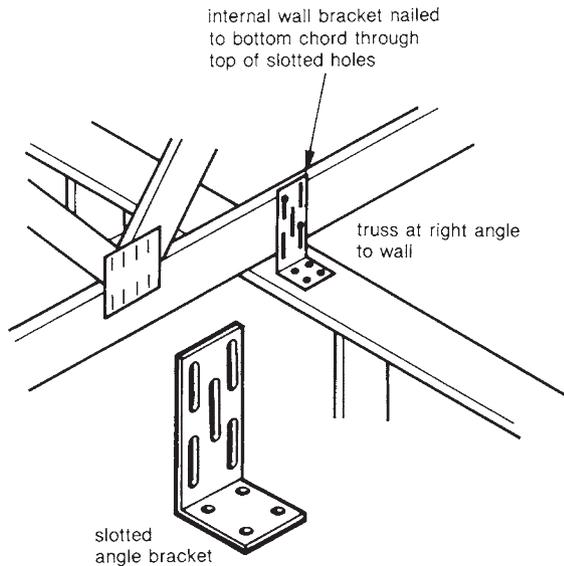
Fixing trusses to wall framing

To allow for the truss to settle down under load, the top plate of the non-load-bearing walls is fixed to the truss by the use of slotted angle brackets at 1800 mm centres.

The nails shown in the slot in Figure 3.8 must *not* be nailed home so as to allow for movement of the trusses. Refer to information supplied by the manufacture of the truss as to how to nail the 'L' bracket.

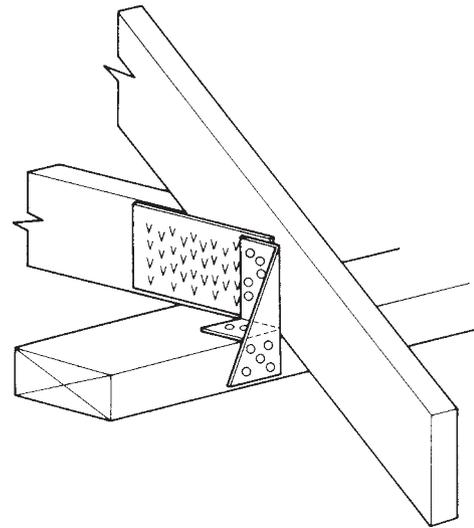
The brackets are fixed to the truss through the top of the slot with galvanised nails (Fig. 3.8). Where walls are parallel with the trusses, trimmers are fixed between the trusses and the angle brackets are attached to the trimmer.

Fig. 3.8 Truss to top plate connection—slotted angle bracket



Considerable stress may be placed on the joint between the roof truss and the top plate, particularly in high-wind areas. Skew nailing is unsatisfactory as it offers little resistance to wind uplift and probably will split the bottom chord. The use of galvanised steel framing anchors is recommended at each end of the truss. Figure 3.9 shows the 'Trip-L-Grip,' an economical connecting unit that simplifies jointing in framing.

Fig. 3.9 'Trip-L-Grip'



Roof shapes and truss layouts

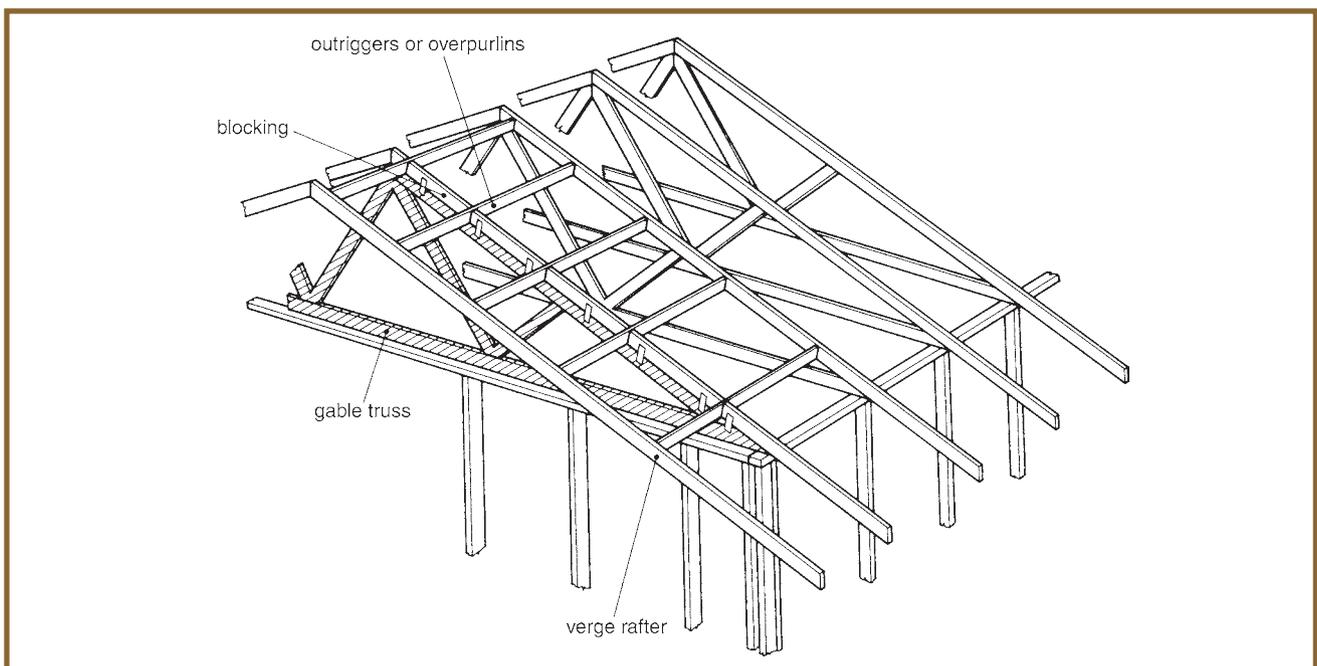
Refer also to the section on roof shapes and styles in Chapters 15 and 16 of Volume 1.

Gable roof

The most economical trussed roof is the gable roof. It consists of a number of identical standard trusses. The overhanging gable end may require some variation.

The exact positioning of the gable truss will depend upon the type of external finish. Figure 3.10 shows a *raking truss* (also known as set-down or cut-down truss) being used to accommodate outriggers. The other way to form an eave or overhang on a gable end is to use verge sprockets.

Fig. 3.10 Gable roof truss



Hipped roof

A system of truncated standard trusses and a truncated girder are used to form the hipped end of a hipped roof (Fig. 3.11). Positioning of the girder truss is important and the correct distance from the corner to the face of the truss must be set out first. The point where the girder truss sits is commonly referred to as the *station* or *station point*. This measurement is on the plan supplied by the truss manufacturer: it is a critical measurement to get right. The hipped end can be completed with a hip truss with a series of jack trusses—short trusses with an extended top chord fixed to the truncated girder.

Dutch gable roof

The Dutch gable roof (also called the *gambrel roof*) is a popular shape for the trussed roof (Fig. 3.12). It permits the maximum number of standard trusses to be used and still retains the main features of the hipped roof. A Dutch hip girder truss, to

which a waling plate is fixed, must first be set out at the correct distance from each corner.

The hipped end can be completed with either conventional framing or a hip truss with a number of jack trusses fixed to the Dutch hip girder truss.

Intersecting roofs

Roofs that intersect at 90°, either L- or T-shaped, will form a valley at the junction of the roof surfaces to the internal corner.

Refer to Figure 3.13 and note how the girder truss, placed parallel to the truss of the secondary roof, will support the ends of the trusses of the primary roof with brackets without the need for load-bearing internal walls. The girder truss carries a considerable load and may need to be a double truss requiring additional supporting structure, which should be completed before the trusses are erected. Saddle trusses, placed over the trusses of the primary roof, complete the ridge and valley at the roof intersection.

Fig. 3.11 Hipped roof truss

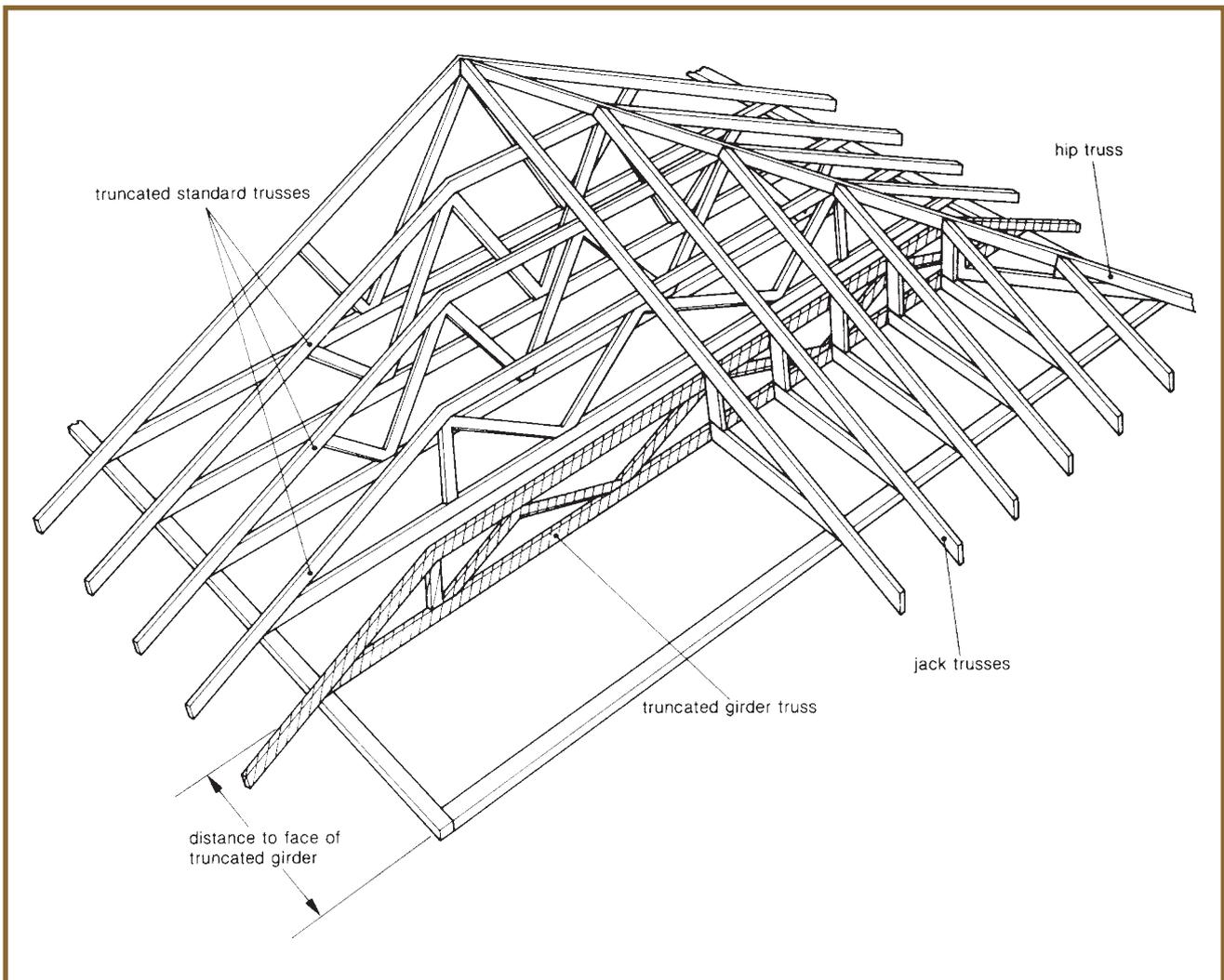
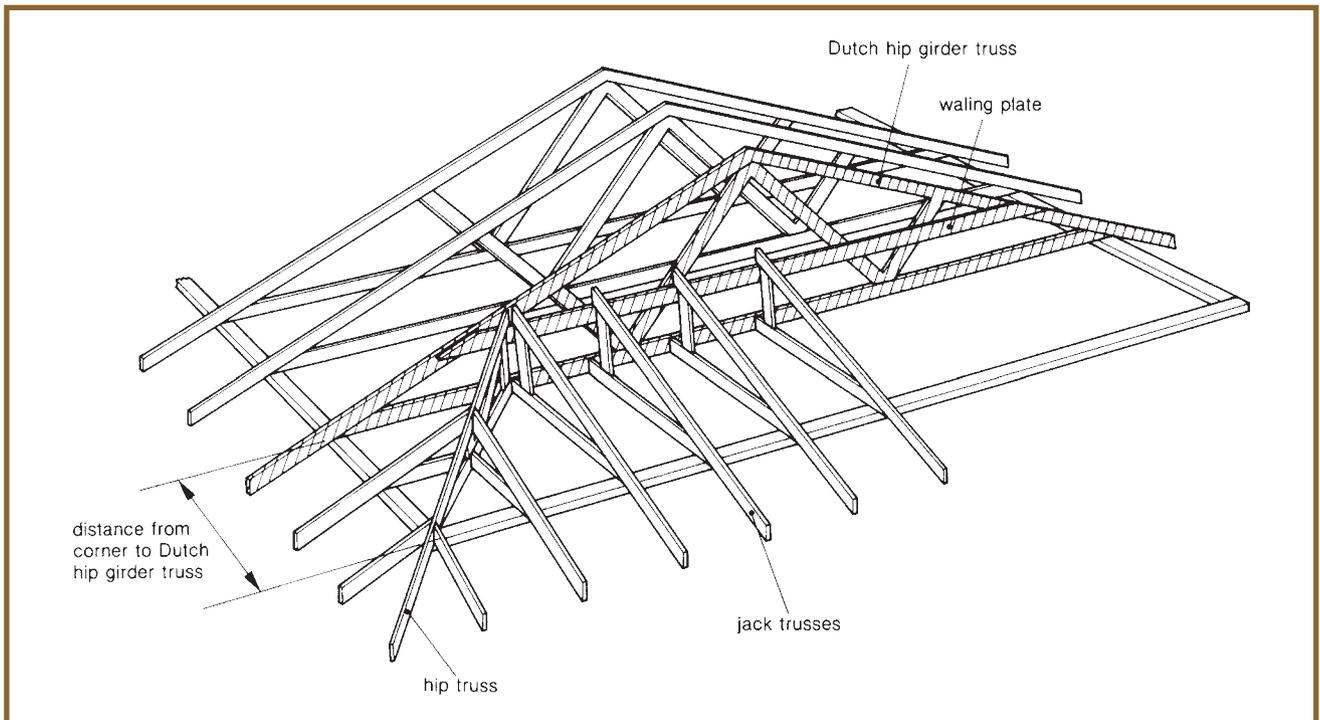
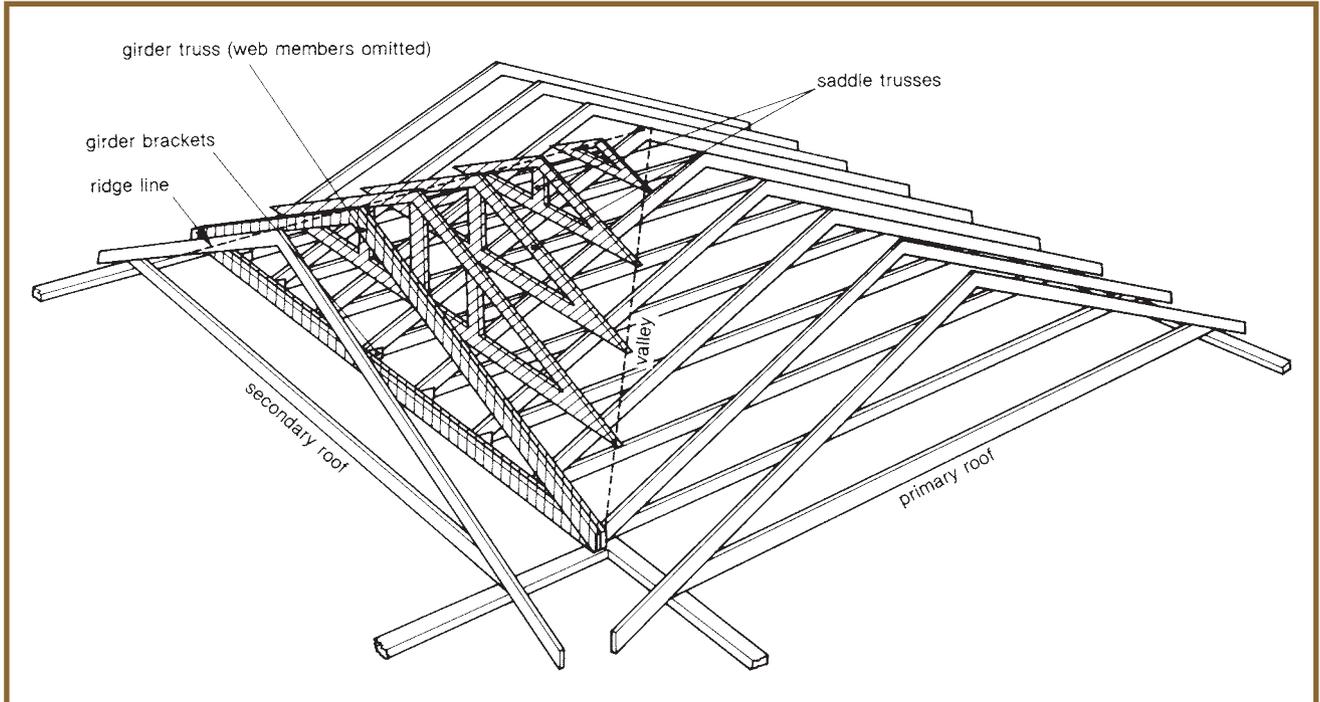


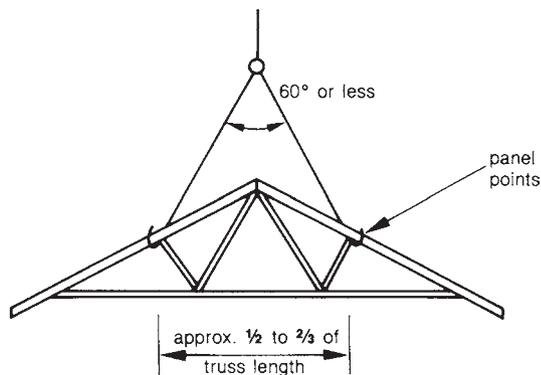
Fig. 3.12 Dutch hip or gambrel roof truss**Fig. 3.13** Intersecting roof

Job storage and lifting

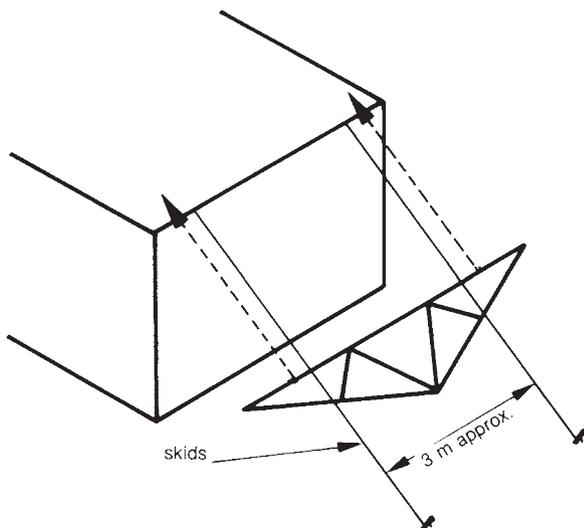
When trusses are delivered to the job site in an undamaged condition, they must be handled with care until such time as they are finally fixed in position. It is important that any excessive lateral distortion be avoided otherwise the joints and the timber will be damaged. Trusses should be stored flat on billets of timber clear of the ground. The best option is to

have the main truss pack lifted and placed on top of the wall frames when it is delivered, which saves you having to lift them up yourself.

When lifting trusses, attachments must be made at the panel points otherwise damage can occur to the truss (Fig. 3.14). Generally they are delivered on a truck supplied by the truss manufacturer.

Fig. 3.14 Lifting trusses

Never lift from the apex joint only. When lifting trusses of larger spans, spreader bars attached to the panel points are necessary.

Fig. 3.15 Skids for lifting trusses

In most domestic-type buildings, trusses can be placed on the top plates by pulling them up skids spaced about 3 m apart. It is important to ensure that they do not sag between supports.

Erecting roof trusses

Ensure you are using safe work practices when erecting roof trusses. Your local WorkSafe office will have information to help you with this.

Each state or territory will have information from their respective WorkCover authority on fall protection and the installation of trusses. These should be consulted before work begins.

AS 4440 Installation of nail-plated timber trusses suggests that the supplier and the builder must discuss all options during the manufacturing process to ensure that the trusses

are manufactured correctly and the right information is delivered for the job.

It is also important that a crane is used to deliver trusses for a double-story house and that carpenters are on site to help with the delivery. The trusses should be placed in the best position for installation and not damaged in the delivery as this would cause delays for the builder.

A useful publication in this regard is *Prevention of falls in housing construction* (Code of Practice No. 29, 2004) and the fact sheet *Fall protection for roof work* (2011), both available from the WorkSafe Victoria website at www.worksafe.vic.gov.au or any WorkSafe Victoria office.

Before proceeding it is important to ensure that all the top plates are straight and braced so that you will have no movement of the wall frames when the trusses are erected or when the trusses are delivered and placed onto the top plate.

Temporary bracing should be strong enough to stop the trusses being pushed over in strong winds while they are being erected, as outlined in AS 4440 Section 3 and Appendix C.

The procedure for erecting a roof truss is as follows:

1. Accurately locate the position of any gable end or girder truss (the station point). Set out the position of intermediate trusses, not exceeding the maximum spacing.
2. Stand the first truss, which must then be plumbed. Straighten the top and bottom chords within allowable tolerances and place erection props at the panel points. Figure 3.16 illustrates suitable erection props to a gable end.
3. Set up a string line along the apex of the trusses (Fig. 3.17). Stand each successive truss and space accurately using a gauging rod. Align each apex with the string line and fix with erection ties at top chord panel points.
4. Brace all trusses adequately so that they do not move or fall over while being erected. All temporary bracing should *not* be removed until permanent bracing is installed.

Permanent bracing

Permanent bracing should include all of the following:

- sideways (lateral) restraints to the truss top chords—these can include roof battens or purlins
- diagonal bracing to truss top chords using either timber or steel (the most common form of bracing is steel brace)
- bottom chord bracing—this is to stop the sideways movement of the bottom cord. It can be achieved through a few different methods:
 - (a) battens fixed directly to the bottom chords and the plaster attached to the battens
 - (b) bottom chord restraint (another term would be *strong back*)—this can be retained as permanent bracing. It is used where the plaster is fixed directly to the bottom cord of the truss.
- web ties, if required—this will be in the information supplied by the manufacturer.

Fig. 3.16 Erection prop: (a) elevation view; (b) plan view

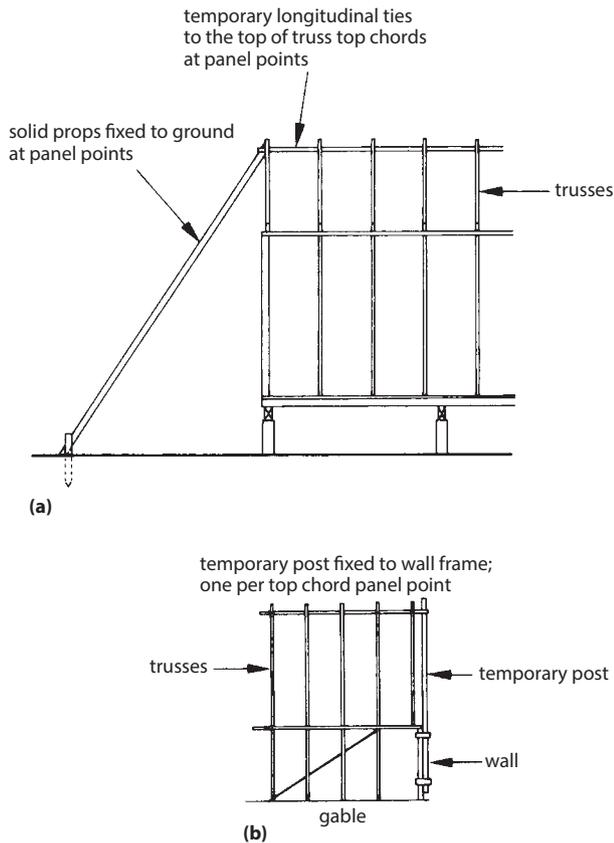
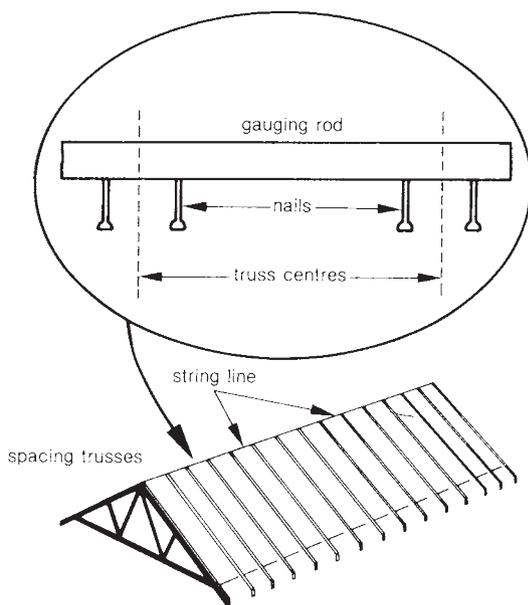


Fig. 3.17 String line and detail of gauging rod



More information on permanent bracing can be found in the AS 4440 Section 4 Roof bracing.

Requirements for each individual roof may vary; details should be supplied by the truss manufacturer. Diagonal bracing may consist of timber fixed to the underside of the truss top chord. It should run continuously from near the apex

of the roof to the wall top plate at an angle of 30°. This form of bracing is only done with the gable ends.

A fast and effective system of permanent bracing can be provided using a patented metal brace (commonly referred to as a *speed brace*). This is diagonally fixed over the top chords in two directions and is securely anchored at its ends to both a point near the apex of the roof and to the wall top plate (Fig. 3.18). For further information on fixings, refer to the information supplied by the truss manufacturer.

During this time it is important to place all the fittings, triple grips, L brackets, cyclone ties (if required) and truss boots (if they have not been completed) so everything is ready for the frame inspection. The location of these and the fixing requirements for these fittings can be found in the information supplied by the truss manufacturer and will need to be followed for the truss roof to work correctly.

Erection tolerances

When erecting the trusses they should be as straight and plumb as possible. If a truss is out of plumb too much, it will reduce the effectiveness of that particular truss and cause stress on the other truss, which in turn could cause the whole frame to collapse.

Straightness of the top and bottom chords

The formula to ensure any bow in the top or bottom chord is not too great is: $\text{Chord length} \div 200$
or 50 mm.
Use whichever is the *least* measurement.

For example, if we have a top chord length of 3495 mm and a bottom chord length of 6120 mm, then:

Working out: $3495 \div 200 = 17.475$

Thus, the maximum amount the top chord can have for a bow is 17.475 mm as this is the *least* amount.

Working out: $6120 \div 200 = 30.6$

Likewise, the maximum amount the bottom chord can have for a bow is 30.6 mm as it is the *least* amount.

Thus, the formula to make sure the trusses are level enough is: $\text{Height} \div 50$
or 50 mm.
Use whichever is the *least* measurement.

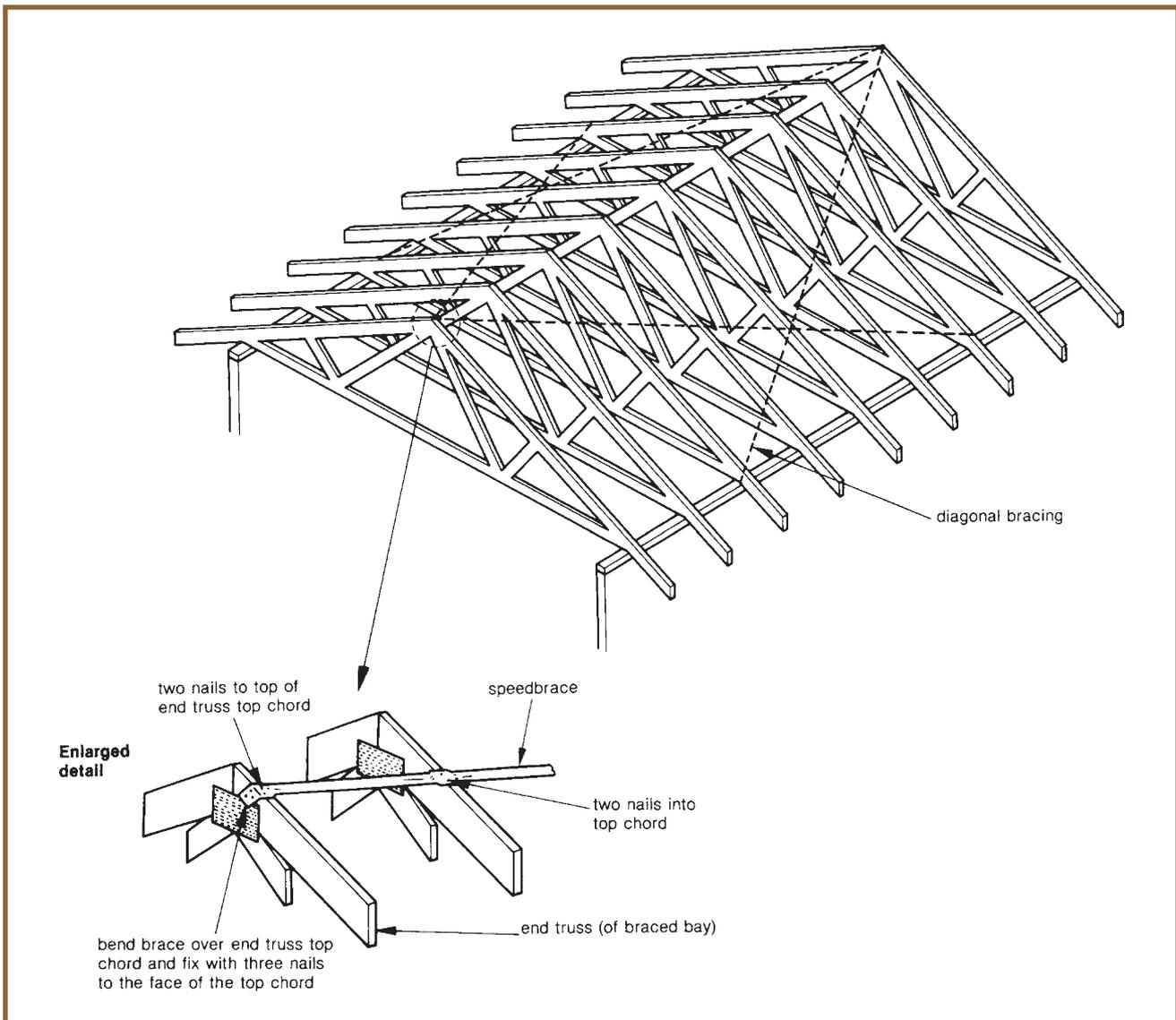
For example, we have 1500 mm where the level is placed to plumb the truss.

Working out: $1500 \div 50 = 30$

Therefore 30 mm is the most the truss can be out of level at that point because it is the *least* amount of measurement.

Steel trusses

Steel-framed houses have grown in popularity in recent years. They have been around for a very long time but it is only in the last 20 years that they have had a reasonable market share. There are many different types of steel frame manufacturers and most will have a different way of building their frame.

Fig. 3.18 Diagonal metal bracing

While the truss system used in a steel-framed house is similar to traditional trusses, it is also very different in its application and it is advisable to follow the manufacturer's instructions.

The National Association of Steel-Framed Housing Inc. (NASH) has very useful resources on steel frame assembly.

Student research

Visit the website of the National Association of Steel-Framed Housing (www.nash.asn.au) and read some of the available publications such as the Fact Sheet and the NASH Handbook.

Sustainability audits

A sustainability audit is an assessment of a situation or a site in respect to risks to human life or damages that may result from building activity on the environment. The assessment is usually done by a certified person, but you may be asked to provide information.

The three most common types of audit are:

- *Job Safety Analysis*: This audit seeks to identify potential hazards and risks to health for the tasks to be undertaken. The risks are rated as low, medium and high. The resulting worksheet will provide a description of the measures that need to be taken to eliminate or minimise risks.
- *Environmental Site Analysis or Risk Assessment*: This audit identifies risks to the environment from site development, including the demolition of older buildings. Like the Job Safety Analysis, after risks are identified, measures to control damage to the environment must be stated. For example: 'Asbestos identified in a building to be demolished is hazardous to human health, and the measures to control asbestos particles need to be described and adhered to.'
- *Site Sustainability Audit*: This audit assesses high-level assessment work practices on a building site to ascertain if changes in work practices or behaviour are needed to make the building process become more sustainable or responsive to environmental concerns.

See Chapter 15 for voluntary accreditation programs that can be used to make sustainability audits.

PART 3

Internal fixing and lining

Chapter 4 Wet areas

Chapter 5 Internal fixing

Chapter 6 Internal linings

Tradie profile

Bart Harrowell – Owner, Harrowell Painting and Decorating

After finishing Year 12, Bart undertook a Certificate III in Information Technology. He then looked for a career that would provide flexibility and opportunity and enrolled in a TAFE pre-employment course in painting and decorating. On completion he obtained an apprenticeship with the New South Wales Master Painters Group Training Company.



Bart completed a Certificate III in Painting and Decorating and was awarded Outstanding Third Year Apprentice by the NSW Master Painters Group and an Excellence in Training award by TAFE NSW. After completing his apprenticeship, Bart began working as a trade contractor running a small painting and decorating business, Harrowell Painting and Decorating. In 2007 Bart was awarded NSW Master Painters Young Contractor of the Year.

As an enthusiastic young contractor, Bart built on his existing skills and knowledge and added additional services to his business such as high-pressure water cleaning, small commercial fit-outs and plastering. This has helped ensure the highest standards of painting and decorating together with providing flexibility and versatility to his customers.

Bart now lives and works in Victoria and is currently painting and decorating for a Melbourne five-star hotel. His range of work has extended further to include restorations and the application of specialised decorative effects. And on top of this busy career, Bart is now pursuing his lifelong interest in the performing arts by undertaking a Bachelor of Arts degree specialising in musical theatre!

Wet areas

LEARNING OBJECTIVES

- 4.1 Setting out wet areas
- 4.2 Installing a shower base
- 4.3 Installing a bath
- 4.4 Installing sinks and vanities

This chapter concentrates on the role of a carpenter in constructing a bathroom using the example bathroom detailed in the Volume 1 Appendix as a case study. It details the skills and knowledge required to complete the necessary tasks.

What is a wet area?

The Building Code of Australia (BCA) defines a wet area as:

An area within a building supplied with water from a water supply system. This includes: bathrooms, showers, laundries and sanitary compartments. It excludes kitchens, bar areas, kitchenettes or domestic food and beverage preparation area.

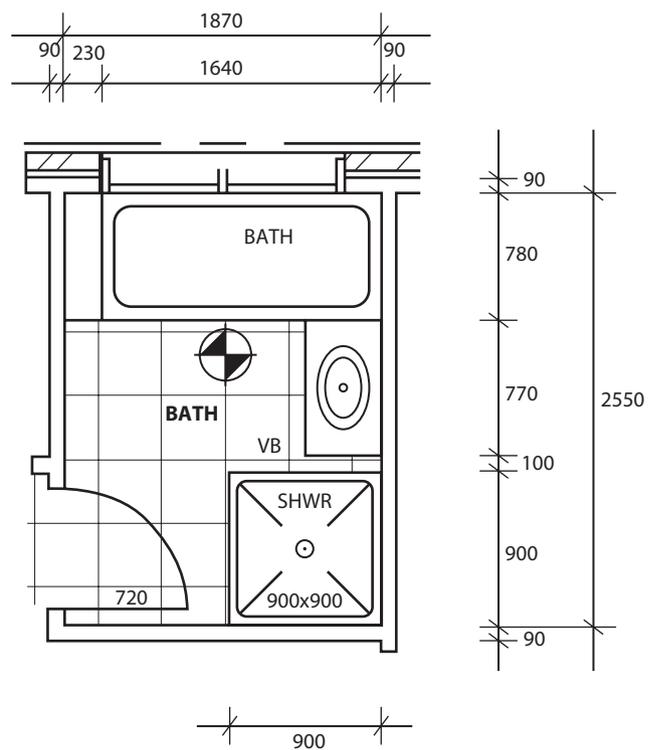
The typical construction of a wet area usually involves a number of different trades.

- A carpenter builds the frame and installs the shower, bath and vanity.
- A plumber installs and connects the water pipe and wastes.
- An electrician installs the electrical items such as lights, exhaust fans, etc.
- A plasterer installs the wall sheeting.
- A waterproofer coats the required surfaces with a water-resistant membrane.
- A tiler installs the tile underlay on the floor and lays the floor and wall tiles.
- A glazier installs the shower screen.

As there are so many stages that occur in the construction of a bathroom, it is important that each tradesperson completes their task to the required standard before the next tradesperson steps in to avoid any problems. Wet areas can cause a lot of headaches for the owners if they are not constructed properly as water can cause huge amounts of damage if it gets into unwanted areas.

Figure 4.1 shows an exploded view of a bathroom with all the measurements indicated. The house in which this bathroom exists is of brick veneer construction with a timber subfloor incorporating concrete stumps and a particleboard platform floor. The wall frames are of timber construction.

Fig. 4.1 Exploded view of a typical bathroom



Set out of wet areas

Setting out a wet area is the first critical task to perform as it determines where the bath, shower and other features will be located. In the construction of the subfloor, it is good practice to locate where the bath will be going and strengthen that area with extra floor joists to take the load from the bath when it is full of water and a person is in it. This is a must when installing large spa baths as there is a potential for the floor to fail if it is overloaded. In some cases extra stumps and bearers may need to be incorporated in the design to take the potential load from

the spa; an engineer or architect should be consulted in those instances.

Once the floor is complete, mark out where the bath and shower will sit. Then determine where (a) the wastes for these items will go so the plumber can locate the waste pipes in the right position and (b) where the taps will go and at what height so the plumber can rough in the water pipe once the walls are built. The location of the noggings for fixing the tap set will also need to be determined.

When the wall frame is being constructed, it is important to identify the walls the shower base is going to be installed next to so the bottom of the walls can be prepared to take the shower base.

Installation of a shower base

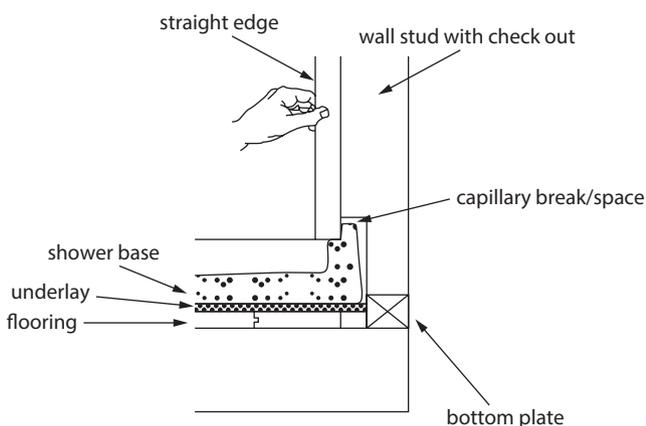
It is important that the bathroom wall is constructed to allow the shower base to recess into the wall. Figure 4.2 shows how the bottom plate has been ripped and stud checked so the shower base fits into the wall cavity. The use of a straight edge shows how the wall covering will act as an over-flashing and run into the recess in the shower base. This will allow for any water to run into the shower base and find its way to the drain. The size of the check-out in the wall frame will vary depending on what base is used.

The height of the check-out for a platform floor is calculated by adding:

- the height of the shower base
- the thickness of the underlay
- the thickness of glue or mortar that the shower base is bedded on
- the gap or space between the top of the base and the top of the checkout (min. 5 mm).

When installing a sink, vanity basin, bath or shower base there must be a 'capillary break' to prevent water from encroaching into the timber framing to avoid mould, rot and frame failure. The space (or break) should be maintained at no less than 5 mm (it can be more depending on site requirements).

Fig. 4.2 Including a capillary break is important to prevent mould, rot and frame failure

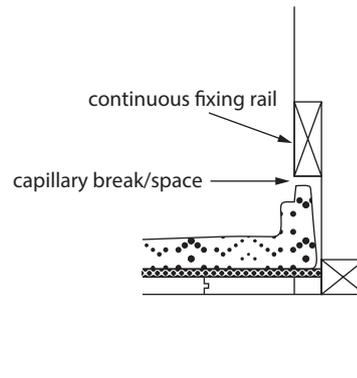


If the floor is a fitted floor, as shown in Figure 4.2, then the thickness of the floor also needs to be added to the height of the check-out.

Once the walls are complete, it is time to lay the tile underlay and install the shower.

1. Locate where the waste pipe is going to go so a hole can be cut through the flooring and underlay.
2. Install noggings from the top of the shower rebate to take the wall linings, or the check-out can be made bigger and a continuous fixing rail installed (Fig. 4.3). The latter method has the benefit of being less time consuming and it is easier to fix securely than installing individual noggings.

Fig. 4.3 A continuous fixing rail



AS1684 Residential timber framed construction states that 'a horizontal line of notches up to 25 mm may be provided for the installation of baths'.

3. Install the shower according to the manufacturer's instructions, using either mortar or silicon. If using mortar, a softer mix is required so the shower base can be bedded firmly.

If the base is not bedded properly into the mortar there is a good possibility that the polymarble base will crack, so ensure the mortar is fresh and moist.

4. If using mortar, a temporary formwork needs to be used to stop the mortar from spreading (Fig. 4.4). Then spread the mortar as level as possible and roughly trowel it off.

Fig. 4.4 A temporary formwork prevents mortar spreading

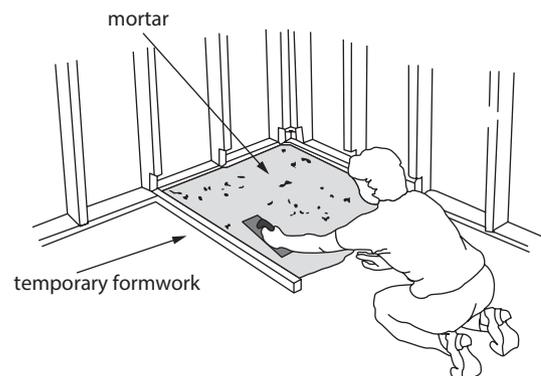
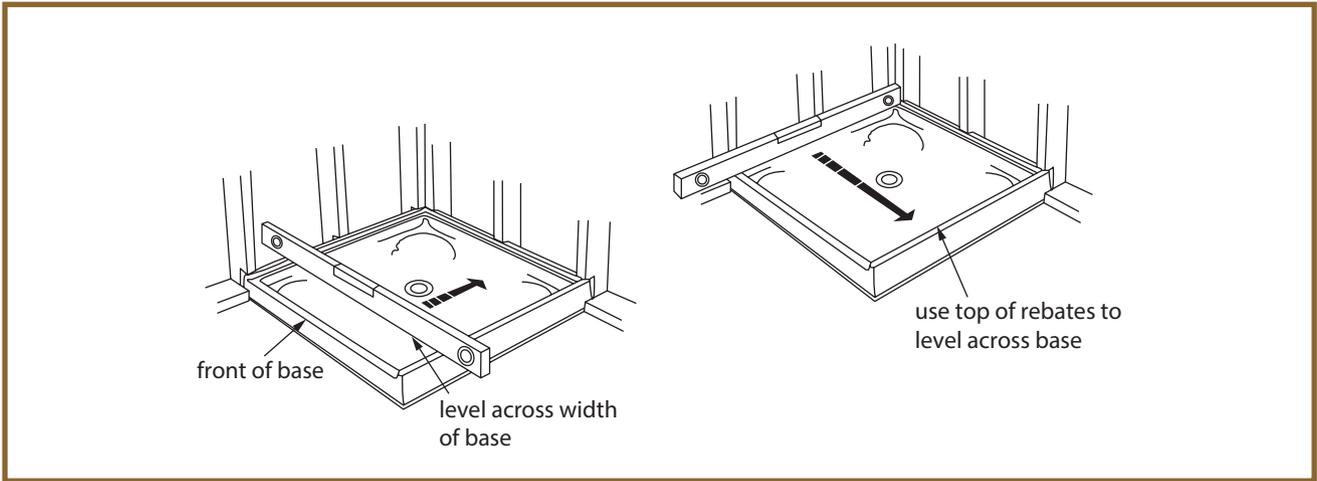


Fig. 4.5 Levelling the shower base



- Place the shower base onto the mortar; you will need to wiggle it so it beds down. Then check it for level (Fig. 4.5). Wiggling or twisting the base can help level it.

If the shower base has a twist in it, ensure the sides of the base where shower screens are to be installed are perfectly level. Otherwise the screens, which are delivered in a square configuration, may not be able to be installed properly.

- Once the shower base is secure, install metal flashing to run over the studs and into the shower base (Fig. 4.6). Then install a metal angle in the wall corner of the shower (Fig. 4.7).

Fig. 4.7 Wall flashing detail for corner of shower cubical

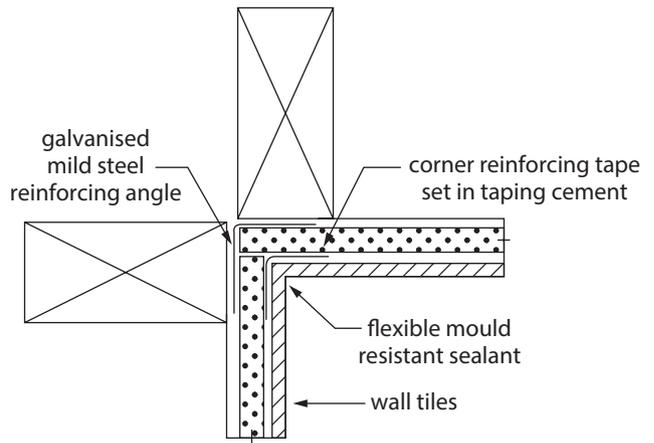
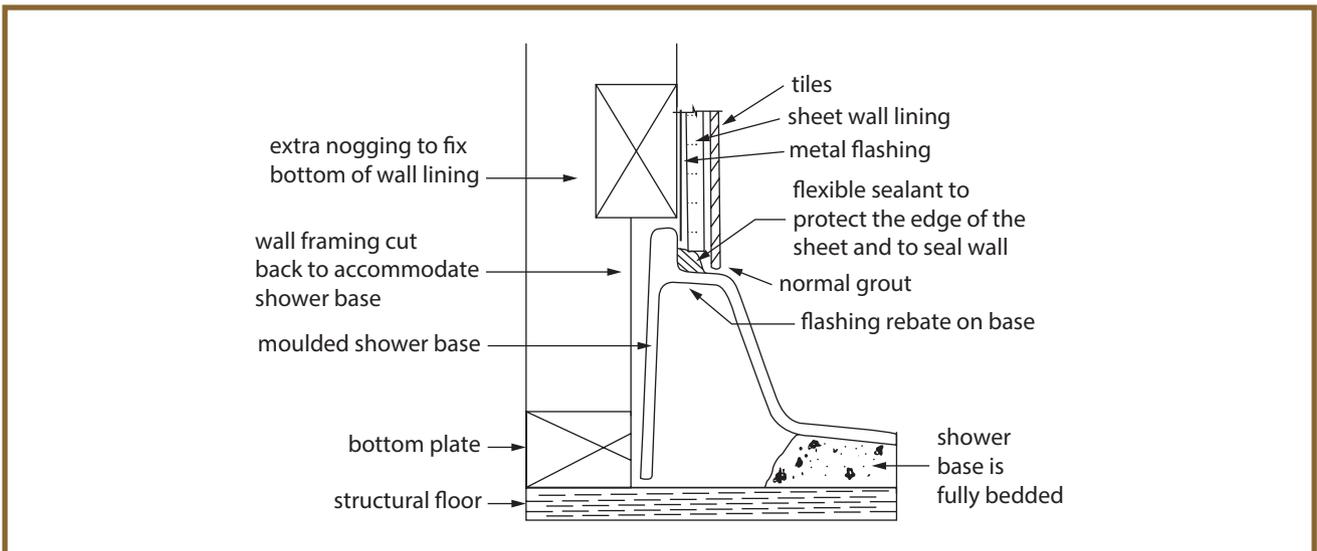


Fig. 4.6 Flashing detail for shower base



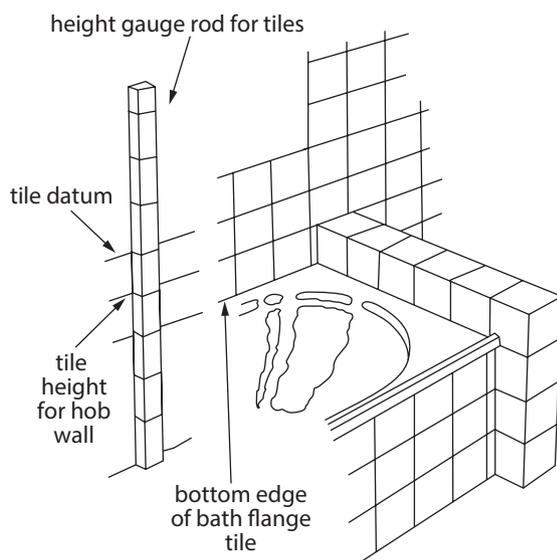
7. The plumber (if it hasn't already been done) runs all the water pipes and connects the waste pipe up to the sewer. You may be asked to install some noggings to hold the tap sets and shower head, and so on. (It is also the carpenter's responsibility to install noggings for towel rails, soap holders and so on, and anything else that will hang off the wall.)
8. Once flashed and noggied out, the plasterer installs the water-resistant wall lining. Then the wet area needs to be waterproofed. (AS 3740 Waterproofing of wet areas within residential buildings details waterproofing requirements.)
9. The tiler installs the tiles to finish off the bathroom and all the accessories can be installed.

Installation of a bath

The installation of a bath is similar to that of a shower base; however, certain installation methods result in the finished bath having a certain look. The method detailed below is one of the more common methods used in the industry.

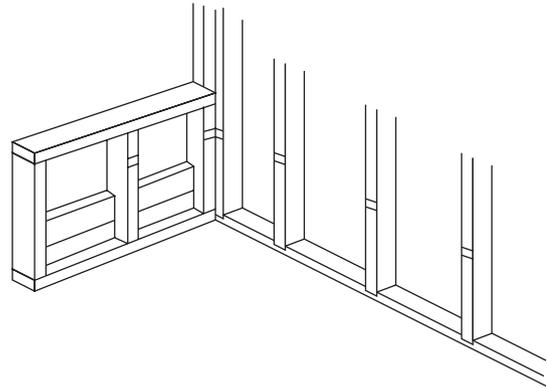
1. Referring back to Figure 4.1, we can see that the bath tub abuts two walls and has a hob (dwarf wall) at one end. Locate this position in the bathroom and set out where the bath is going to sit. Mark where the waste pipe will be and cut a hole to allow for the connection.
2. The walls will be built at this stage so all the remaining work is carried out on the walls in place. Firstly determine what the finished height of the bath will be—this is paramount. This height could be determined by the type of tiles being used, the owner wanting a full tile sitting on the top lip of the bath, or it just could be a specific height wanted for comfort.
3. If the height is determined by the tiles, then use a gauge rod with the height of the tiles marked and the gap between each tile shown so an accurate measurement can be made. Figure 4.8 shows how the gauge rod works and how the bath height and the height of the hob can be determined.

Fig. 4.8 Using a gauge rod to determine height of bath



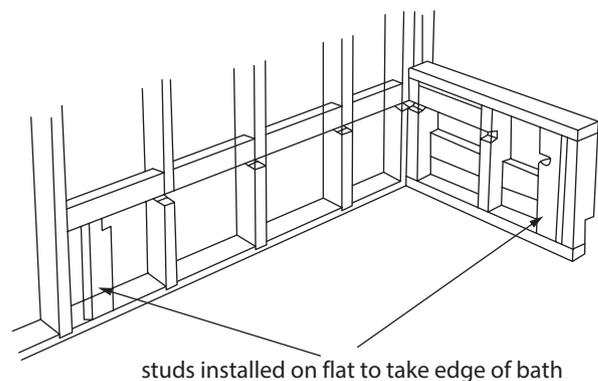
4. Once the height is determined the wall needs to be prepared to take the bath. The check-out needs to be marked on each stud where the long side and end will be located, as can be seen in Figure 4.9. Note the small wall at the end—this is the hob. For this case the hob is one tile higher than the bath, hence the check-outs have to be cut into the hob as well.

Fig. 4.9 Marking check-outs on studs



5. Once the check-out is completed, an extra stud can be installed at each end to pick up the edges of the bath and noggings can be installed at the top of the check-out to accommodate the wall lining and flashings (Fig. 4.10). Alternatively, the check-out can be made bigger and a continuous fixing rail can be installed. This method is less time consuming and it is easier to fix securely than installing individual noggings.

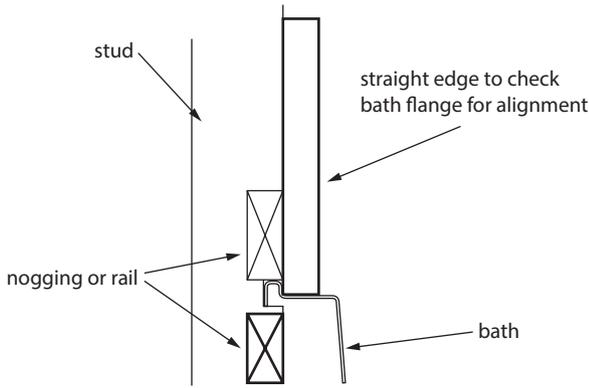
Fig. 4.10 Additional studs installed to accommodate wall lining and flashing



AS1684 states: 'a horizontal line of notches up to 25 mm may be provided for the installation of baths.'

6. The plumber runs all the water pipes and will indicate if any noggings are needed for tap sets, etc.
7. Try the bath to ensure the check-out is adequate and bath is well supported and level (Fig. 4.11).

Fig. 4.11 Checking the level of the bath



It is good practice to install noggings or a rail on the bottom of the check-out for the bath flange. These will give continuous support to the bath and may prevent the bath flange from splitting the stud where it is sitting.

8. With the bath in place, mark out on the floor where the infill walls will go using a spirit level (Fig. 4.12a). This mark will indicate where the finished wall is going to be or, in this case, where the tiles will be (Fig. 4.12b). From this line, calculate how far back the plate has to be positioned.
9. Once the back set has been calculated, install the plate onto the floor and build the infill walls. For this case the material is going to be used so the face of the timber is facing into the room; this will eliminate the need to rip down the studs and the top plate. Figure 4.13 shows a detail of how the infill wall is built and the completed bath installation.

When installing a bathtub refer to the manufacturer's instructions as the bottom of the bath may need to be bedded into mortar.

10. Install the flashing. The process is the same as detailed in the installation of the shower base (Figs 4.6 and 4.7).

Fig. 4.12 Marking the line of the finished wall: (a) using a spirit level; and (b) a cross-section

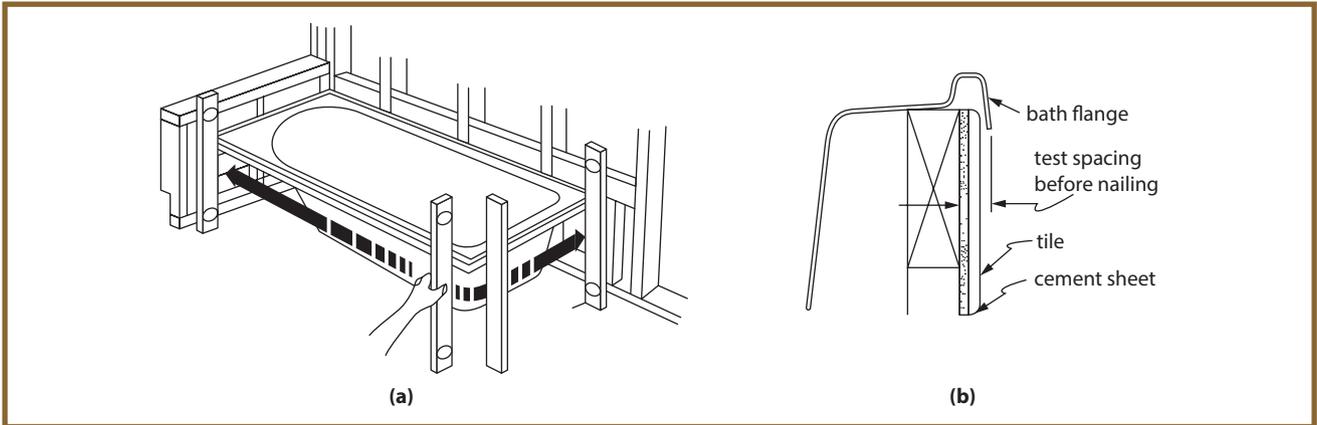
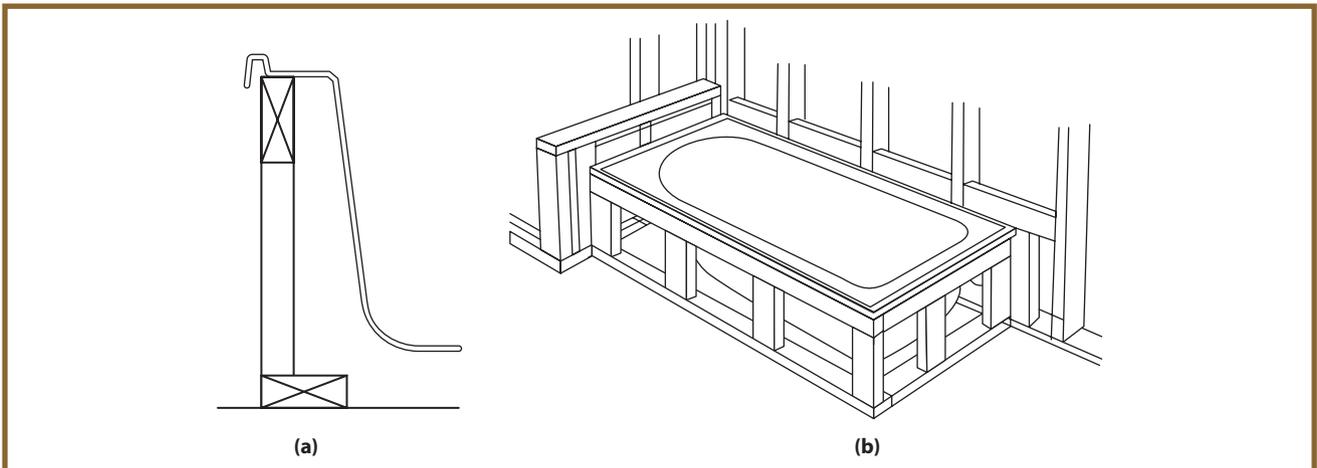


Fig. 4.13 The infill wall: (a) cross-section; and (b) completed bath installation



Installation of sinks and vanities

It is common today for a bathroom vanity to come in a unit where the sink is installed in a cupboard and all the tapware is installed in the sink and not in the wall, such as the vanity shown in Figure 4.14. The carpenter may need to install some noggings in the wall frame so the vanity can be fixed to it.

Ensure you find out what type of vanity is being specified and what work you may need to perform so the vanity can be installed.

Student research

Investigate at least four different types of wall linings that can be used in wet areas.

Fig. 4.14 A typical bathroom vanity



Source: Courtesy of Reece

What is sick building syndrome?

The last few decades have seen interest grow in the relation between health and buildings. These concerns have given rise to 'sick building syndrome' (SBS). This refers to a cluster of symptoms such as headaches, nausea, sore throat, eye and nose irritation, and lack of concentration that can affect a building's occupants, subsiding only after the person has left the building.

The causes of SBS are uncertain; however, good ventilation, natural daylighting and interior surfaces made from natural materials such as timber, wool, natural fibres and earth materials, and the elimination of volatile gases from composite materials (chipboards, etc.) used in interiors seem to eliminate the syndrome.

A healthy interior environment needs not only to be free of toxic gases and substances but to actively promote good air movement and thermal, visual and acoustic comfort. This is achieved through the building fabric or envelope modifying the exterior climate to make the enclosed interior spaces more comfortable for the human body.

Many people argue that modern buildings are less healthy than the older ones that used natural materials and incorporated natural ventilation. However, today we are exposed to greater stresses and contaminations that often lead to health problems, such as external air and water pollution, living or working in buildings established on contaminated ground, and exposure to traffic noise and chemically treated foods.

Internal fixing

LEARNING OBJECTIVES

- 5.1 Wall linings
- 5.2 Wall straightening and plumbing
- 5.3 Construction and installation of door jambs and frames
- 5.4 Door hanging
- 5.5 Architraves and skirtings

Fixing is the term applied to the interior finishing of a building and includes such things as fitting door frames and hanging doors, applying finishing moulds around door and window frames, fixing built-in cupboards and fitting hardware furniture to doors and windows. (Note: If a fitted floor is used in a timber-framed building it must first be laid before any fixing out work can be commenced.) This chapter deals with the traditional methods of fixing out a house.

Interior wall sheeting

Plasterboard

Plasterboard consists of a core of gypsum plaster with a sheet of heavy paper bonded to each side. This combination, with the paper reinforcement on the extreme outside faces of the board, produces a very strong and rigid board that can still be easily cut by scoring the paper face on one side with a sharp utility knife and snapping the sheet along the line.

Plasterboard is available in the following sheet sizes:

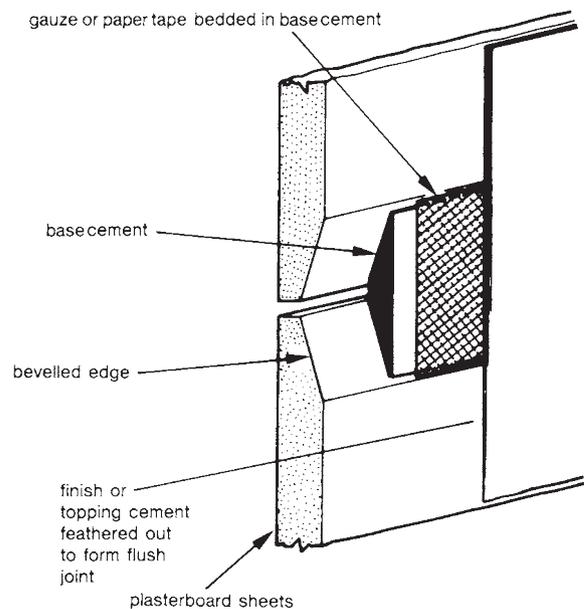
- thicknesses:
 - 10 mm and 13 mm—normal domestic use
 - 13 mm and 16 mm—fire rated construction
- sheet widths: 900 mm, 1200 mm and 1350 mm
- sheet lengths: 1800 to 6000 mm in 300 mm increments.

The usual thickness for wall sheets in domestic work is 10 mm; the long edges of sheets are bevelled where flush joints are to be made. Figure 5.1 shows the jointing procedure.

The sheets are fixed to studs with either lattice head nails or plasterboard screws and plasterboard adhesive. A 10 mm clearance is allowed at the top and bottom of the wall. The manufacturer's recommendations regarding the size and frequency of adhesive and the number of nails/screw per sheet should be closely followed.

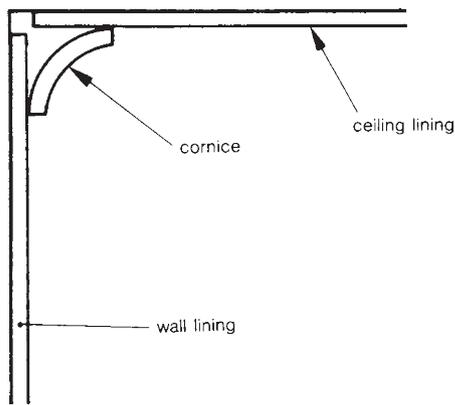
Ceiling sheets are fixed directly to the ceiling joists and are 10 mm thick where joists are at 450 mm centres, and 13 mm thick where the joists are at 600 mm. Some people,

Fig. 5.1 Plasterboard jointing



however, may prefer to use 13 mm plasterboard for all ceiling installations. Fixing is usually by adhesive and screws or nails and the sheets are temporarily held in until the adhesive dries. Cornice moulds are fixed to the joint between the wall and ceiling with cornice cement (Fig. 5.2).

The cornice can be either a paper-faced product or a plaster moulding that is reinforced with a fibre-type product. These come in a range of profiles (e.g. cove and scotia) and sizes (e.g. 55, 75 and 90 mm), with lengths up to 5.4 metres.

Fig. 5.2 Cornice detail

Plumbing and straightening wall frames

Before any interior sheeting can be put up, all studs, noggings and corner blocking must be secured. Use a straight edge to check that corners are straight and plumb and that wall studs and noggings are in alignment. If the studs are not in line:

- If there is a stud that is sticking out further than the rest, firstly see if that stud has a bow along its length. If that is the case, using an electric plane, plane the high part of the bow taking longer cuts with every pass until the stud has been straightened and is now in line with the other studs.
- If the stud is sitting lower than the rest then the bow must be in the other direction. This time use long strips of packing (usually 3 mm plywood or hardboard that has been ripped down to around 40 mm wide and is about 1.8 m long). The thickest amount of packing should be in the middle, with the packing getting thinner the closer to the plates you get. Use multiple layers of packing to achieve the thickness you require.

With either scenario the aim is that studs are in line, so when the wall lining goes on, there are no lumps or bumps in the wall which will show up once the wall is painted.

Plywood

Plywood for interior use will have one side with a face veneer of some attractive timber species. Plywood is commonly available in lengths of 2400 mm or 2440 mm, with a width of 1200 mm to 1220 mm. Occasionally, longer sheets are available.

Plywood can be supported on battens or studs and spacings should suit the width of the sheet being used. Noggings should be inserted at 600 mm centres for vertical support. Ply sheets can be nailed or screwed.

Refer to the manufacturer's specifications for fixing details. The fixings can be hidden where nail holes are punched or screws are recessed and filled with a coloured stopping compound matching the veneer colour. Sometimes the fixings are part of the desired look, usually screws, so spacings and lines of screws are very important to get right.

Plywood may also be fixed using wallboard adhesive, according to the manufacturer's instructions.

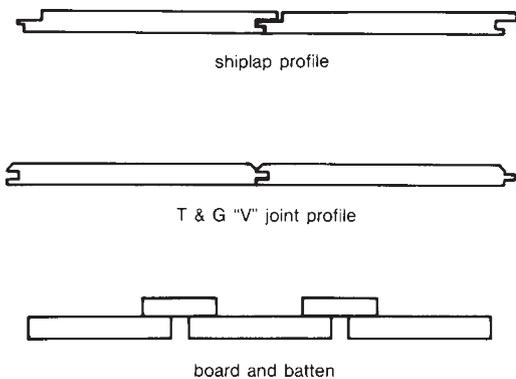
Timber panelling

Jointed timber panelling is also referred to as *shiplap* and *tongue and grooved panelling*. For internal linings they are normally at least 12 mm thick.

The lining boards selected should be seasoned. Wide boards should be avoided where there are extremes of temperature or humidity, as the timber may tend to cup or otherwise distort, affecting the appearance of the surface. Where wide fluctuations in atmospheric conditions are likely to occur, it may be best to use shiplap rather than tongue and grooved boards because of the easier movement between timber panels.

Tongue and grooved boards may be 'V' jointed or flush-edge jointed as in floor boards. Most popular is the 'V' joint, often with a separate 'V' machined out of the back of the board to give the choice of widths for different effects.

Shiplap boards were originally designed so that one panel overlapped the next, thus hiding a direct joint. Modern milling methods make available shiplap with a tongue and groove jointing system, which allows for secret nailing so that no nails are visible in the finished panelled surface.

Fig. 5.3 Profiles of lining boards

Timber panelling is either fixed to the noggings or to battens nailed to the studs when the panels are vertical. Occasionally, they may be installed diagonally or horizontally where the studs themselves must then be used. The nails are normally 40 mm × 1.6 mm bullet head nails, for the smallest possible head size.

Doorsets

Doorsets consist of two components:

- the jamb/frame lining, which is accurately fixed into the structural opening and which will support the door
- the door, which is, of course, the movable leaf fitted to the jamb lining.

Standard dimensions of the door opening

Standard opening sizes in a frame for doors are:

- Height — 2100, 2400 and 2700 mm
 Width — 700, 800, 900 and 1000 mm for single doors
 — 1200, 1500, 1800 for double doors.

Standard size doors are made to fit into these opening sizes together with their jambs/frames with room for adjustment for squareness and packing.

The actual standard door sizes are:

Height — 2040, 2340 and 2640 mm

Width — 620, 720, 820 and 920 mm for single doors
— 1120, 1420 and 1720 mm for double doors.

Robe doors are also available in odd sizes such as 2340 mm × 840 mm.

The thickness of doors should not be less than 35 mm for internal doors and 40 mm for external openings. Doors manufactured to these standard sizes are readily available and should be adopted for greatest economy. However, doors can be made to any required size.

Door types

Flush doors

Flush doors are widely used in domestic construction. They have a flat, smooth face and are easy to keep clean. Since they are mass produced, they are the most economical.

Hollow core doors

Hollow core or honeycomb doors are one of the most common types in use. The stiles and rails are timber with a minimum width of 32 mm, held together at the corners by staples. The core of the door is composed of a cellular infill of expanded cardboard the same thickness as the stiles. Bonded to each side by an adhesive is a sheet of plywood or hardboard with a minimum thickness of 3 mm. A lock block at least 400 mm long can be located on one or both sides depending on the manufacturer; its position is indicated on the outside edge of the stile.

For external use, doors made up with waterproof adhesives are available. This fact should be indicated on the edge of the door.

Solid core doors

In solid core doors the core is made of a blockboard infill consisting of individual strips of timber no more than 50 mm wide and all of the same species. Veneers are then bonded to each face: first a cross veneer on each side and finally a face veneer of selected timber, the grain running in the same direction as the core. Edge strips matching the face veneer are applied to the edges.

Medium density fibreboard core doors

In medium density fibreboard core doors the stiles are of timber no less than 42 mm wide. The top and bottom rails are doubled with a minimum width of 84 mm. The infill consists of solid fibreboard. Veneers are bonded to the faces, or the faces can be of a hardboard or plywood no less than 3 mm thick. The face of this type of door is often carved to give a panelled effect and can be most impressive as an entrance door.

Jamb linings

Solid jamb linings/door frames come pre-made or in sets that need to be made up. They should have a nominal thickness of

Fig. 5.4 Hollow core door

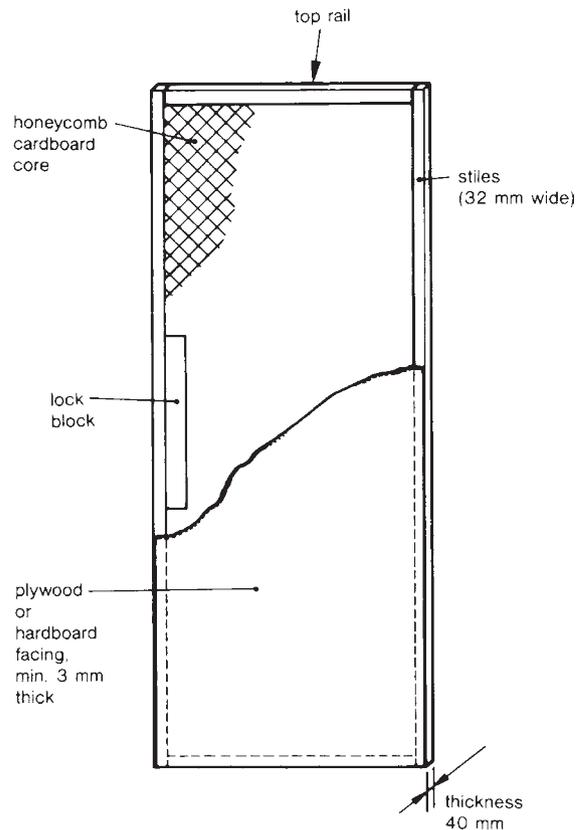
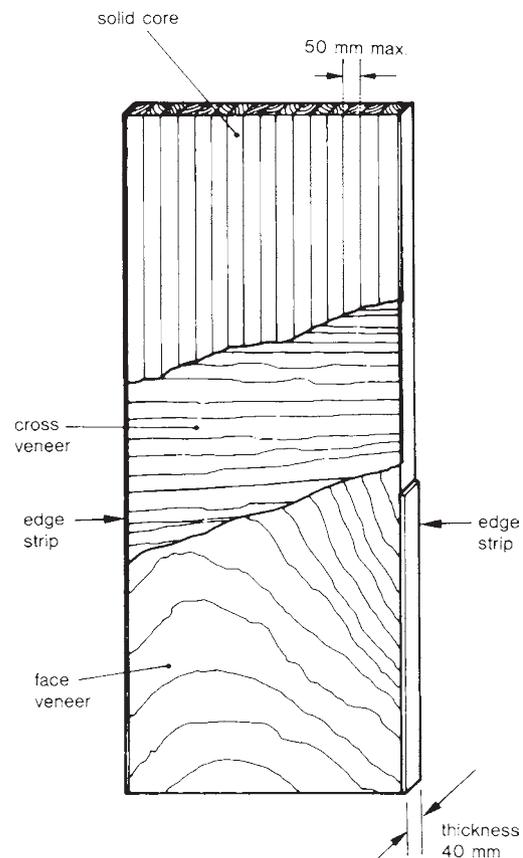
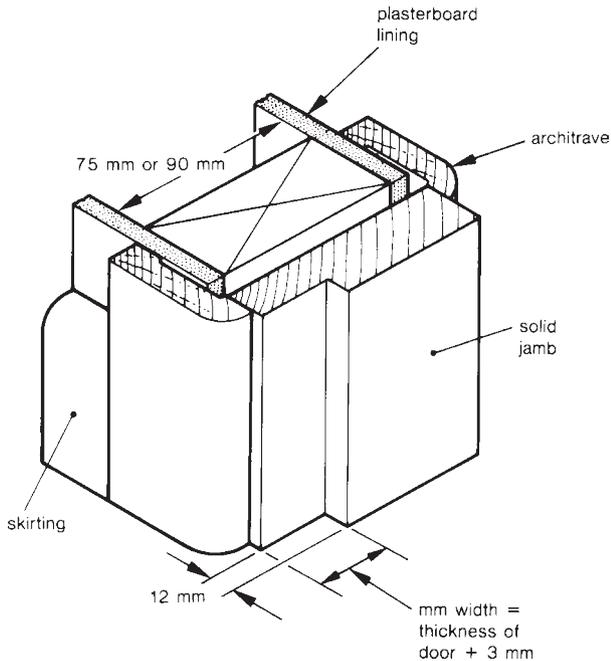


Fig. 5.5 Solid core door



at least 38 mm and are rebated 12 mm deep to receive the door, as shown in Figure 5.6. The width of the rebate must be at least equal to the thickness of the door plus 3 mm for clearance. These frames can also come with a timber sill.

Fig. 5.6 Solid jamb lining



Rectangular door jambs at least 25 mm thick with a separate planted door stop can also be used. In the example shown in Figure 5.7, the jamb lining is fixed and the door is hung before the planted stop is fixed to the line of the door. For security reasons, loose stops are not recommended for external door openings.

Jamb linings are made up into sets: the vertical side members are the *jamb*s and the top is the *head*. A set of rebated jamb linings is shown made up in Figure 5.8. Note the *brace* and the *spreader* to maintain the correct width at the bottom. Accuracy is essential in setting out jamb linings if the door is to fit with a minimum of effort.

Many doors have very narrow stiles and rails and it is good practice to remove no more than is absolutely necessary during fitting. Allowance should be made at the bottom to allow for floor coverings. For carpets allow at least 20 mm and sometimes even more. The clearance at each side and top should be no more than 3 mm. In our example 2 mm is allowed.

The length of the stile is set out to the height of the door plus the top and bottom clearances, say 2040 plus 2 plus 20 equals 2062 mm at least. If it is certain that no carpet is contemplated then the bottom clearance can be reduced to 10 mm.

For width, set out the distance between the rebates equal to the width of door plus a clearance of, say, 4 mm. The stile is

Fig. 5.7 Assembled or 'made up' jamb linings

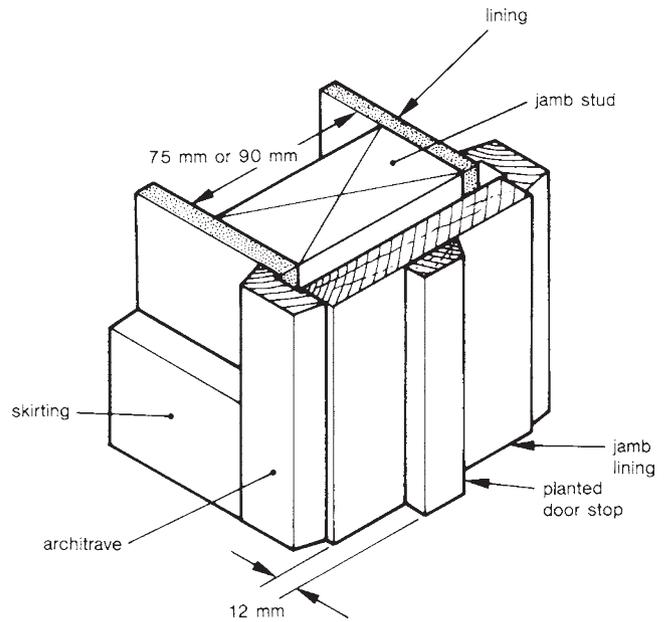
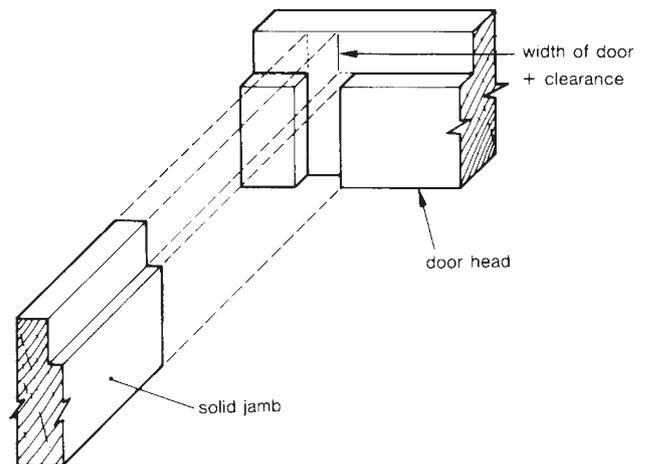


Fig. 5.8 Housing of jamb linings



housed into the head; see Figures 5.9 and 5.10 which show the setting out of the head.

Mark the distance between the rebates on the face. Take a short piece of jamb material and line the rebate up on this mark, and then mark each side for the width of the housing. Gauge to the depth of the rebate and remove the waste. Cut the spreader to the distance between rebates, assemble the jambs, hold square and attach the brace.

Sets of rectangular jambs with loose stops are made up in much the same manner except that the stiles are made longer to house into the head at least 5 mm. The loose stops can be cut to length, temporarily pinned to the jamb and finally fixed after the door has been hung.

Fig. 5.9 Set out of head

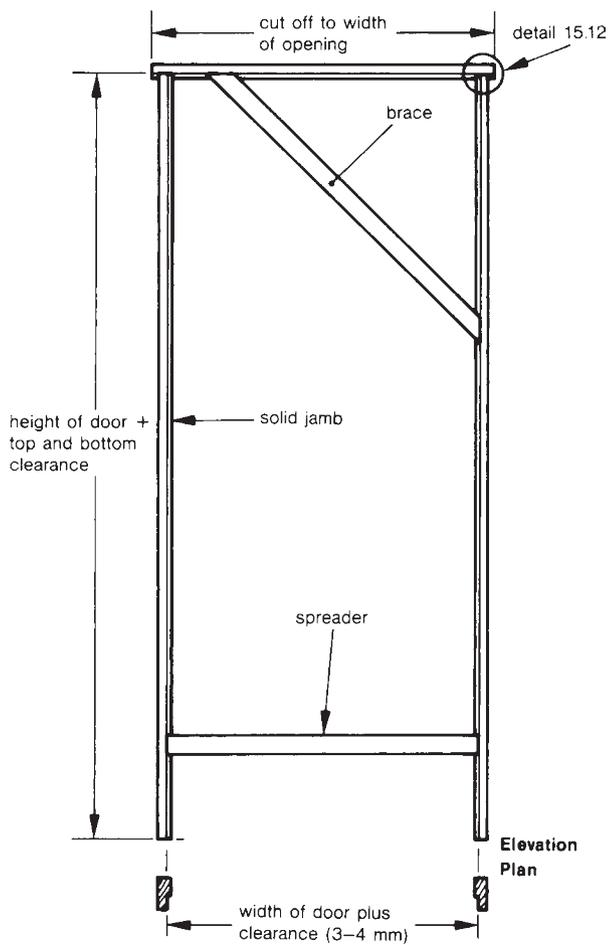
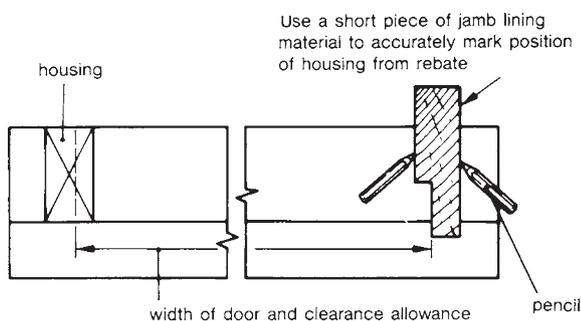


Fig. 5.10 Marking out jamb and head



Fixing jamb linings

To fix the jamb linings, follow these steps:

Step 1

Check the floor across the opening for level. Theoretically it should be level, but due to some of the uncertainties when working with timber there could be some minor discrepancies. Say the floor at B is found to be 5 mm lower than at A, then 5 mm must be cut off the stile at A so that the head will remain level.

Fig. 5.11 Fixing jamb linings

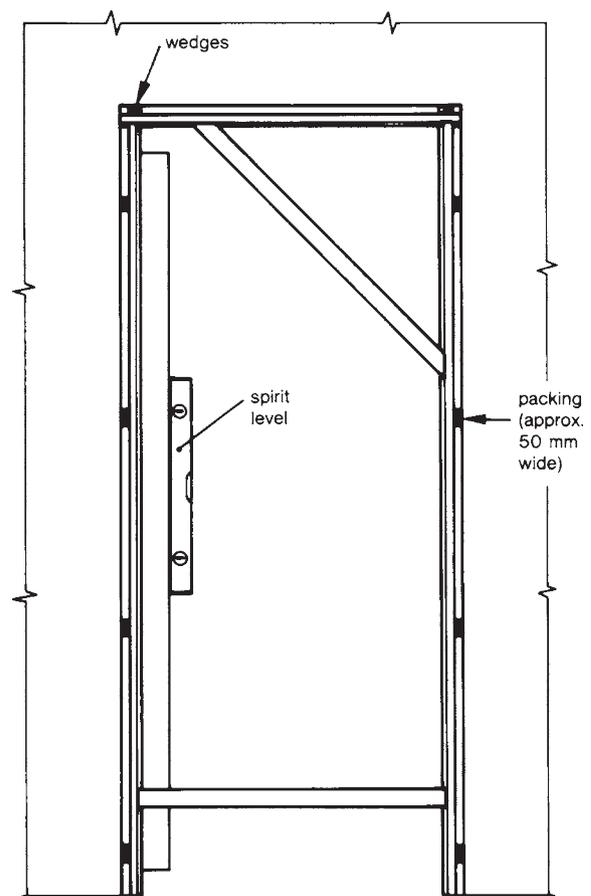
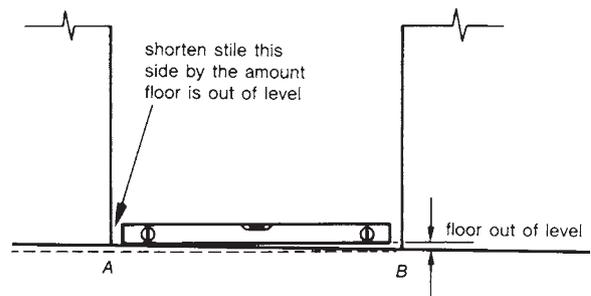


Fig. 5.12 Checking floor for level at door opening



Step 2

The jamb head is cut 1 mm shorter than the stud opening; this alleviates packing/wedging the top of the jamb and also allows for equal clearance on both sides of the jambs.

Step 3

Stand the linings in the opening and lightly drive a wedge directly over the stile between the jamb and the head trimmer to hold the jambs in place.

Step 4

Using a straight edge and level, check the jamb on one side for plumb in both directions and adjust as necessary. At a

point about 150 mm from the bottom, pack the space between the jamb and door stud and secure the jamb to the stud. Suitable packing can consist of strips of plywood, hardboard or bituminous felt for making minor adjustments. Ensure that the nails are below the packing so the packing does not fall and minor adjustments can be made to the packing if needed. Nails for the fixing of jamb linings are long and of a slender gauge, about 65 mm or 75 mm × 2.8 mm. Use two nails at each fixing point, one through the face and one through the rebate. Continue packing and fixing the jamb lining at the top and at intermediate points, taking care to keep it straight and plumb.

Step 5

Test and adjust the second side for straightness and plumb. Pack and secure in place, maintaining the correct width between the rebates. Take care that the two stiles are accurately plumbed laterally and are in 'wind' (i.e. the jambs are parallel in the vertical plain, when sited through opening). Remove spreaders and braces ready for fitting and hanging the door.

Door hanging

The process of fitting—hinging and applying the lock furniture to doors—is covered by the trade term *hanging doors*. When a door is hung, the sides assume a particular identity and are referred to as the *hinge side*, or *hanging side*, and the *closing side*. Doors are sometimes referred to as *right* or *left hand*.

Fig. 5.13 Door swing for right-hand door

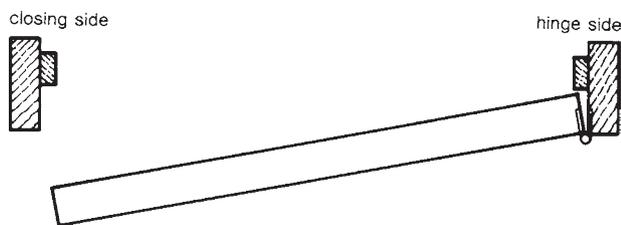


Fig. 5.14 Door swing for left-hand door

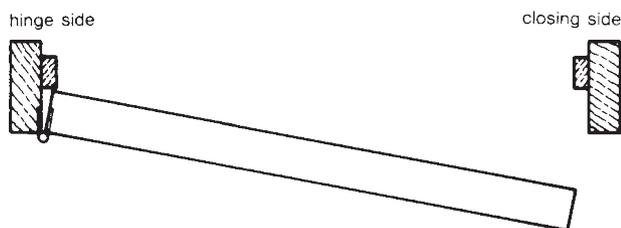
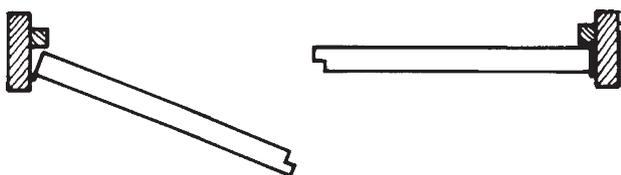


Fig. 5.15 Double door opening

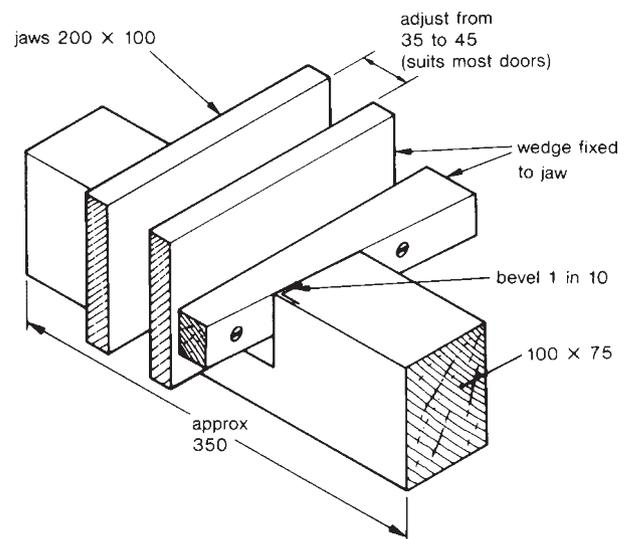


If you view the door from the hinge side, then the side of the hinges is the *hand* of the door. Where pairs of double rebate doors are specified, the leaf which will open first is indicated as left or right hand. When fitting doors with a separate lock block on one side, then this side must become the closing stile and the hinges will be fitted to the opposite stile.

A *door block* is used on site to hold the door upright when planing or working on the edges. It is worthwhile to make up a door block that will clamp the door and hold it rigid without damaging the face. Figure 5.16 shows a door block using the flat wedging principle that will give satisfactory service for a long time.

Doors in domestic construction are usually hung with steel butt hinges; however, brass butts may sometimes be specified.

Fig. 5.16 Door block



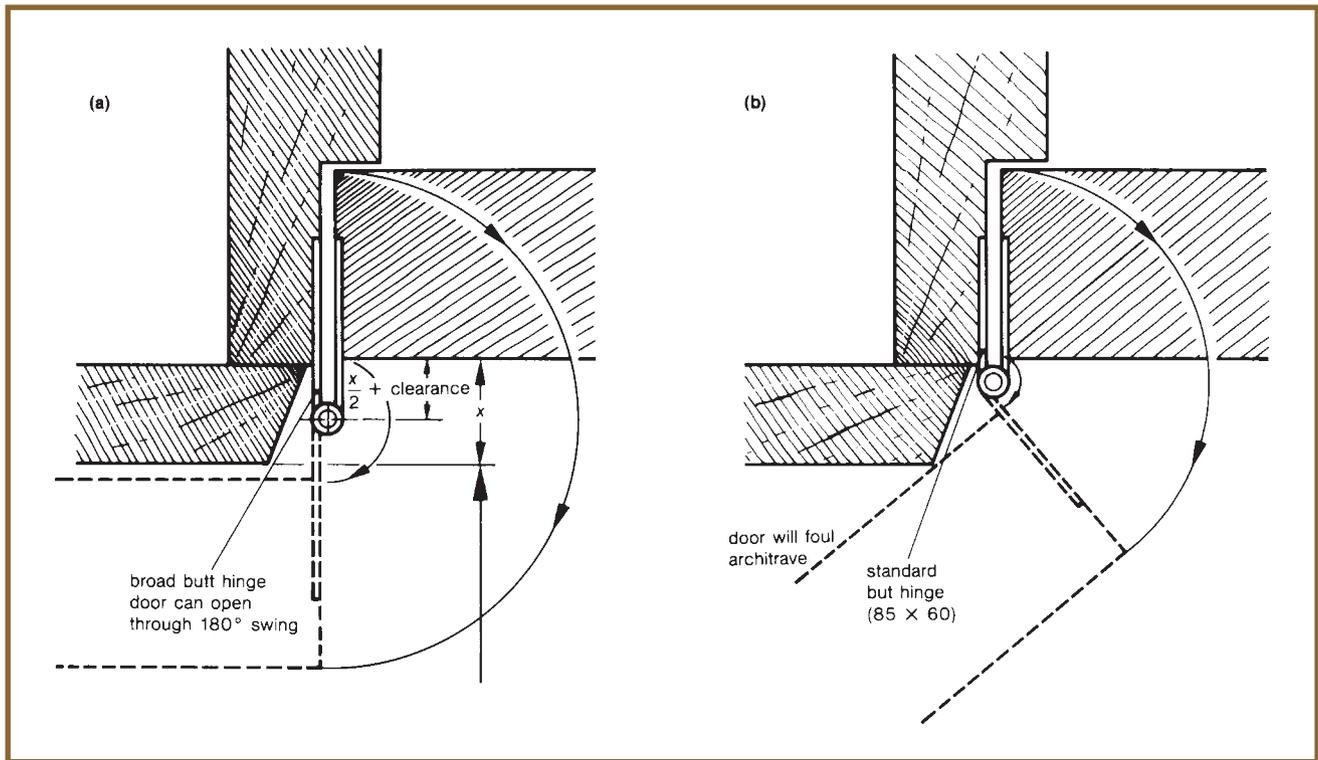
Generally speaking only two hinges are required for the installation of most doors. It is good practice for external doors to have three hinges. Usually external doors are heavier and three hinges provide more security. Very heavy and tall doors may have four hinges with two hinges being installed close together at the top of the door to support the door weight and stop the door from sagging.

The standard hinge is satisfactory for any domestic doors, but where the door is required to open through 180°, this type of hinge will often foul the architrave and lead to the edge splitting and pulling away from the hinges. The broad butt hinge will overcome this.

Note the distance x from the hinge face of the door to the face of the architrave in Figure 5.17(a). The position of the hinge must now be adjusted so that the distance from the centre of the pin to the face of the door is half of x plus an allowance for clearance, say at least 2 mm, giving a clearance over the architrave of twice that amount.

Slide-in door sets

Sliding doors which disappear into a cavity formed within the thickness of the wall are commonly used as an alternative

Fig. 5.17 (a) Broad butt hinge; and (b) standard butt hinge

to hinged doors and permit the maximum use of floor and wall area.

A precision factory-made cavity unit can be obtained and fitted into walls as little as 70 mm thick. Split jambs are on one side of the unit, and concealed behind the jambs are steel angles which keep the sides of the cavity quite rigid. Built-in noggings on each side of the unit provide fixing for any specified wall sheeting, which is applied according to normal practice. The manufacturer's installation details are supplied with each unit and should be followed carefully.

Determining opening dimensions for doors

The dimension of the opening required to install various applications of sliding door pockets is provided. As an example, for a single door 2040 mm × 820 mm that will project 50 mm beyond the split jambs, the wall opening size is as follows:

height (h) = door height + 110 mm measured from top of floor to underneath head

width (w) = 2 × door width + 15 mm

Therefore, opening size, $h = 2150$ and $w = 1655$ mm.

Only one jamb lining is required in the door opening and the door running track is fixed to a pelmet across the head of the opening. A removable pelmet permits the door to be installed or removed from the cavity within a few minutes and conceals the running gear. The bottom of the door is fitted with a low friction rubbing strip and nylon guides which are adjustable and fixed to the split jambs (Fig. 5.19).

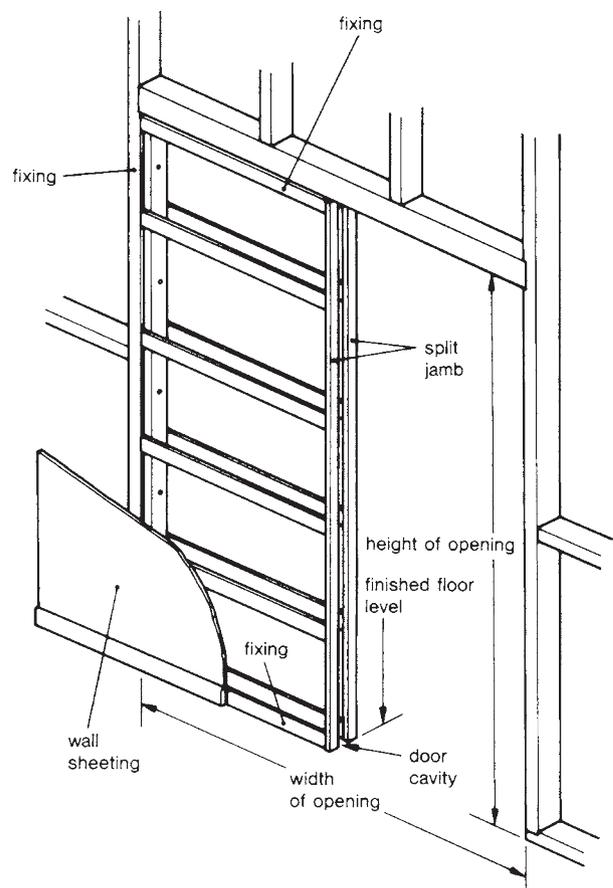
Fig. 5.18 Slide-in door sets

Fig. 5.19 Split jambs

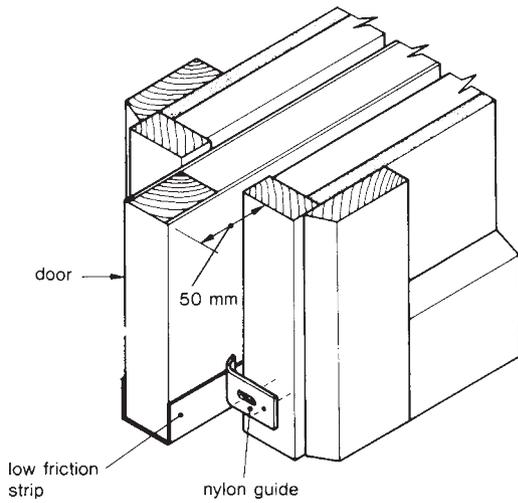
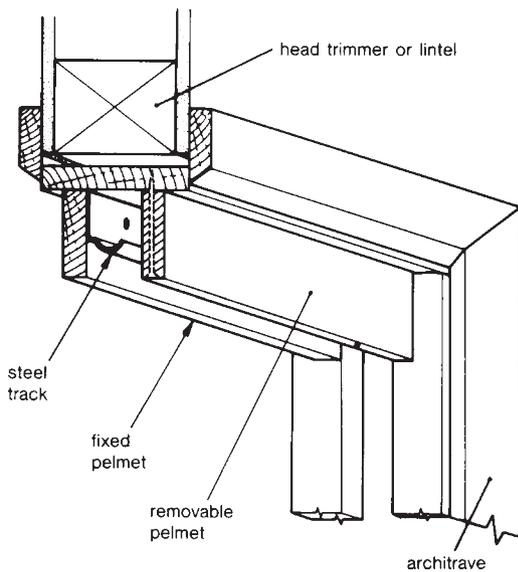


Fig. 5.20 Head and door track



Fitting and hinging of doors

Follow these steps when fitting and hinging doors:

Step 1

Stand the door in the opening and note any adjustments that should be made to maintain a 2 mm clearance at both sides and top. The object is to reduce individual fitting to a minimum by making up and fitting the jambs accurately. For the average door the closing stile is bevelled off 2 mm so that the back edge will clear the jamb as it rotates around the hinge pivot point. Very narrow or thick doors may have to be bevelled even more.

Step 2

With the door standing in the opening and with a spacer at the top to maintain a clearance, lightly wedge underneath to hold the door in position. Mark the position of the hinges—down 150 mm to 180 mm for the top hinge and up 200 to 250 mm from the bottom, are the usual positions.

Step 3

Doors are usually hung by *half and half hinging*, that is, the flaps of the hinges are let into the door and into the jamb, maintaining the required clearance in between. When hanging a door to a rebated jamb there are three dimensions to be gauged to locate the door on the jamb (Fig. 5.21).

- Distance *A* is from the face of the rebate to the back edge of the hinge.
- *B* is the distance from the closing face of the door to the hinge where the difference between the two is the clearance against the rebate.
- *C* is the depth of the check-out for the thickness of the hinge and is gauged on the face of the door and the edge of the jamb. There is no need to let the back edge of the hinge in any more than just below flush.

Fig. 5.21 Half and half hinging

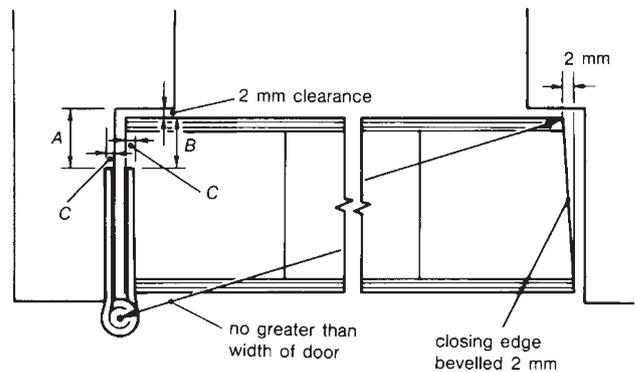
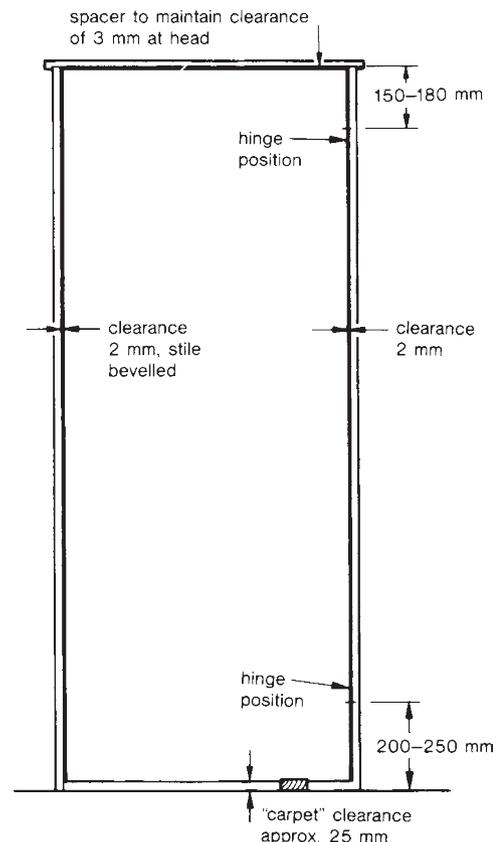


Fig. 5.22 Marking the length of the hinge



Step 4

Hold the door in the door block and, using the hinge as a template, mark the length of the hinge. Gauge for distances *B* and *C*. Check out for the hinge and fix the flap of the hinges with two screws.

Step 5

Again using a hinge, mark the length of the hinges on the jamb. Gauge *A* from the face of the rebate and *C* on the edge of the jamb. Check out for the hinge.

The checking out of the hinge can either be performed with a chisel or a router. If installing many doors in the one job, a jig can be constructed to use with the router to speed up the checking in process.

Fig. 5.23 Marking and check-out for hinge on door

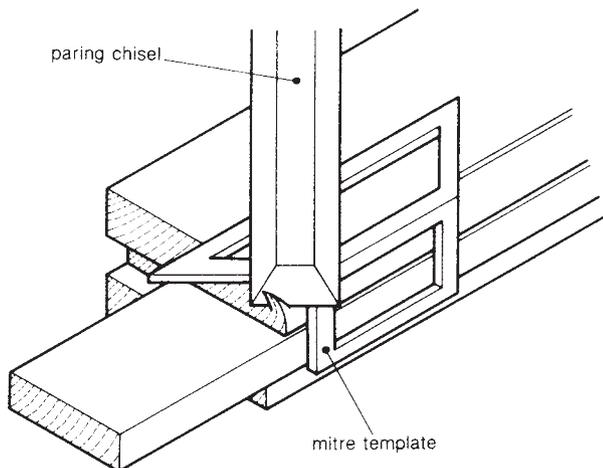
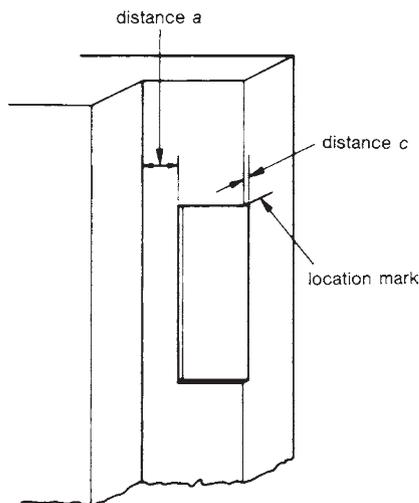


Fig. 5.24 Hinge check-out on jamb

**Step 6**

Stand the door beside the opening, locate the hinges in the check-out in the jamb and secure with two screws. Always drill a pilot hole for screws so that they can enter squarely and accurately without damaging the door or jamb.

Step 7

Check the operation of the door and make any minor adjustments to maintain a minimum clearance of about 2 mm. The thickness of the blade of a combination square is a handy gauge to check for clearance. Insert the remaining screws and make any minor adjustments to the gauge setting for further use.

In some areas, with the spread of the sub-contract system, door hanging and hinging has become a specialist task; some carpenters do nothing else. By equipping themselves with special tools (often made up by themselves), such as hinge router templates and portable mortise machines for fitting locks, it is remarkable how the work can be sped up. Once the basic requirements are understood, the procedures can also be varied. For example, some carpenters hinge the door to the jamb before it is fixed into the opening and adjust the jambs to suit the door.

1. Cut the jambs to length, set out and trench the head.
2. Prepare the door, bevel off the closing stile.
3. Preferably using a router with a router template, check out for flap of hinges on jamb and door hanging stile. Using loose pin hinges, fix mating flaps to door and stile.
4. Make up jamb linings, check the floor for level and adjust. Stand in the opening and fix the hinge stile, accurately plumbing up in both directions.
5. Using loose pins, hang the door; the closing stile can now be fixed, adjusting clearances to suit the door.

Obviously, whatever procedure is adopted, accuracy in working is essential if it is to produce the expected results and adequate rewards to the carpenter.

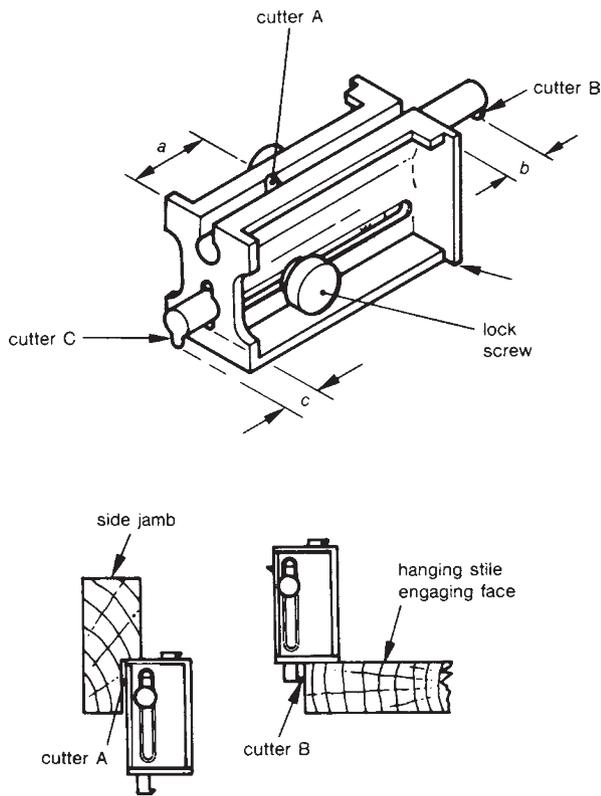
Butt gauge

The butt gauge is a gauge specially designed for use when fitting butt hinges. Gauging for *A*, *B* and *C* can be done with the one gauge, without any need for change. The gauge is adjusted so that when distance *B* is set, distance *A* will automatically be approximately 2 mm greater, that is, the allowance for clearance.

Fitting to the jamb with loose stop

When doors are being hinged to a jamb with loose stop, gauging for the width of the hinge check-out is made from the hinge face of the door and the outside edge of the jamb, so that the face of the door will be a little below the level of the jamb. The loose stop is later fixed, allowing a clearance to the door.

Fig. 5.25 Butt gauge



Trims

Architraves

Architraves are mouldings used to frame the outline of doors and windows and to cover the joint between the frame and the structural members. Architraves are commonly 50 mm to 75 mm in width and 15 mm to 25 mm in thickness. They can be a variety of moulded profiles; some of the most used profiles are shown in Figure 5.26.

Note how some architraves may have a wide milling groove taken out of the back face. This makes them much easier to fit, as the groove will bridge any irregularities in the level of the wall sheeting while the edges will fit down tightly on the wall and frame.

Fig. 5.26 Architrave profiles

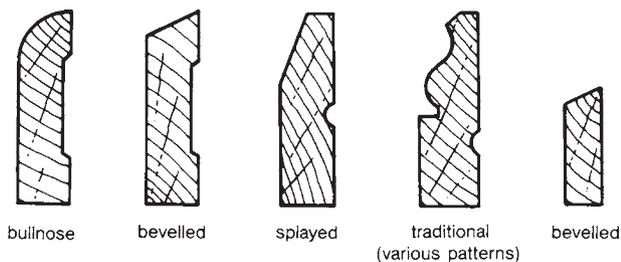
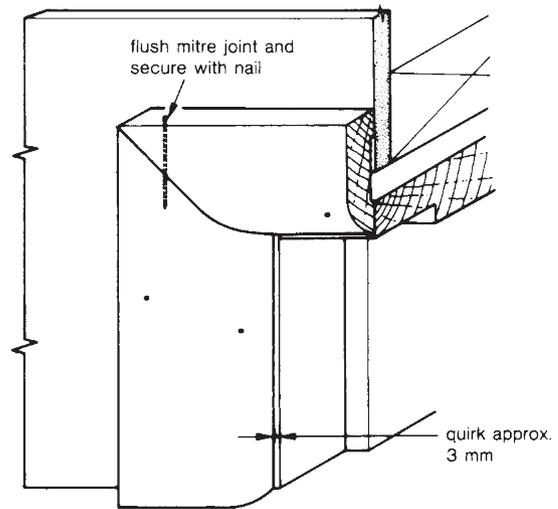


Fig. 5.27 Architrave mitre joint



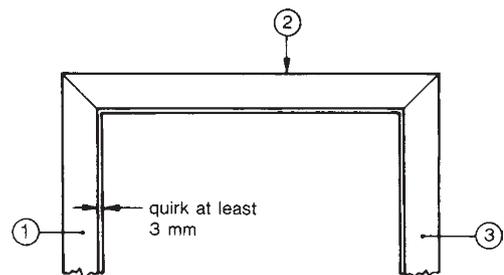
The corners of architraves are mitred.

When fitting architraves to an opening, cut the side pieces and fix in position, allowing a *quirk*, approximately 3 mm, at the edge of the jamb. Cut and fit the head piece and fix the bottom edge to the jamb head. Flush the mitred joint and secure with a nail through the top edge only.

In the two top corners of the jamb mark the 3-mm quirk on the head and the stile. This intersection will give you the length of each piece of architrave to the short point of the mitre.

1. Starting from the left side, cut the mitre on the architrave and then cut to length and fix.
2. Cut the left-hand mitre on the head piece of architrave and fit. When this mitre fits well, cut the second mitre and fix.
3. Hold the right side architrave on the jamb and mark off the length of the architrave. Cut the mitre and offer it up to see if the mitre joint fits well. There is scope for some adjustment on this cut, but only a small amount.
4. Once fitting well, fix and remove the arriss (the sharp edge) off the back of the architrave with some sandpaper.

Fig. 5.28 Procedure for fixing architraves



Skirting

Skirting is located at the base of the internal walls and covers the joint between the wall and the floor, protecting the wall from damage.

Moulded profiles for skirtings are similar to those for architraves except that skirtings can range in size from under 75 mm to 100 mm wide; in the restoration of old buildings skirtings 150 mm to 200 mm wide, and occasionally more, may be used.

When fitting skirtings, scribed joints are used for internal corners, and external corners are mitred.

Fig. 5.29 Skirting and skirting blocking

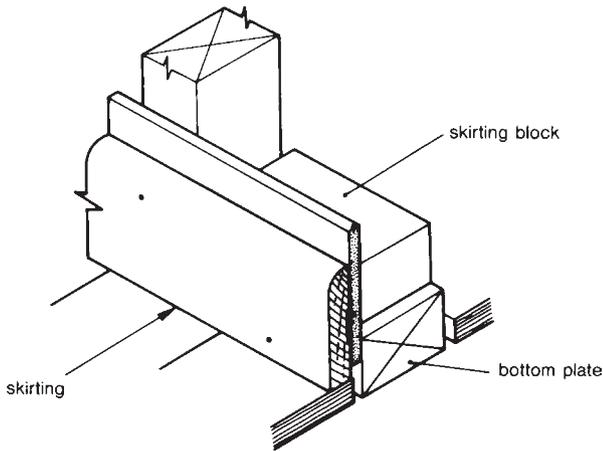
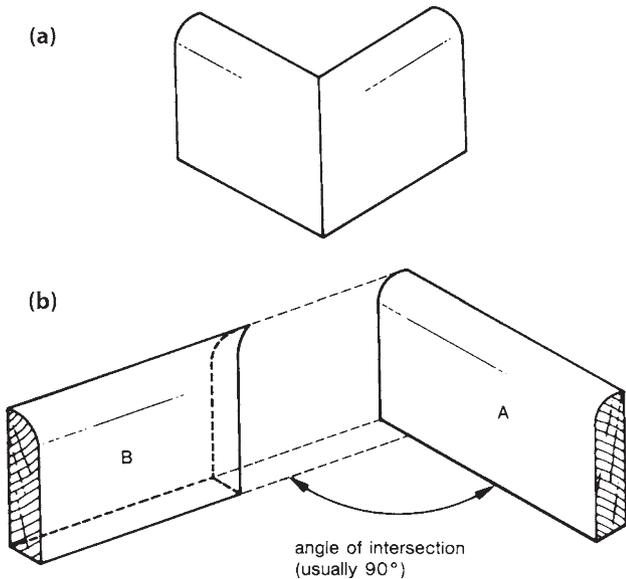


Fig. 5.30 (a) Mitred joint; and (b) scribed joint

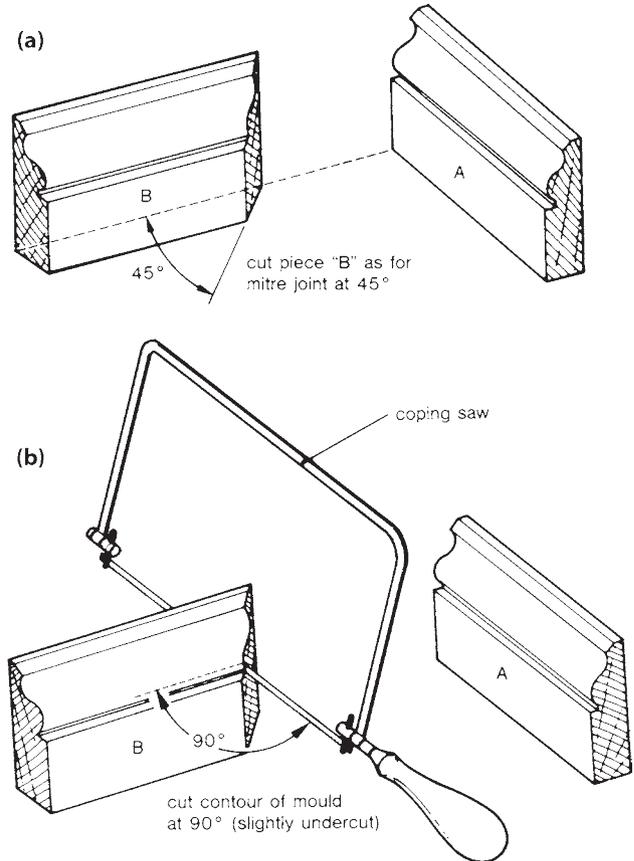


Scribed joint

To make the scribed joint, the first piece *A* is cut off square and fixed in position. The second piece *B* is mitred at half the angle of intersection, usually 90°, as in this example, making the mitre angle 45°. The contour of the mould is then cut with a coping saw at the angle of intersection, in this case 90°.

The advantage of the scribed joint for internal corners is that piece *B* can be cut slightly long (say 2 mm depending on length) and sprung into place, cramping the joint together. Thus the joint will not be forced apart when nailed to the frame. Joints can at times open up due mainly to shrinkage of the structural framing and should be so arranged that a person will not be looking straight into the open joint from the most probable viewing positions.

Fig. 5.31 Making a scribed joint



Generally, the skirting opposite the door is fixed first and then work continues back towards the door, finally butting against the back of the architrave. A *pinch rod* can be used to measure the length of skirting quickly. This consists of two light laths of timber which are extended to measure the required lengths. Pinch them together and mark across them to ensure that there is no movement as they are laid along the skirting and the length is marked from the rod.

Fixing trim to window openings

Timber window frames are finished at the back of the sill with a window nosing and apron mould. Window nosings are milled from stock 50 mm or 75 mm x 38 mm and, when cut to length, are fitted around the window stud, and the mould returned on the ends. The nosing is drilled and fixed to the back of the sill by nails which are so positioned that they will only penetrate the window flashing close to its top edge.

The apron mould covers the joint below the nosing and can be of various sections—bullnose, bevelled, scotia, for example.

Great care must be exercised when nailing the apron mould that no nails are allowed to penetrate the sill flashing.

Fig. 5.32 Order of fixing skirting to a room

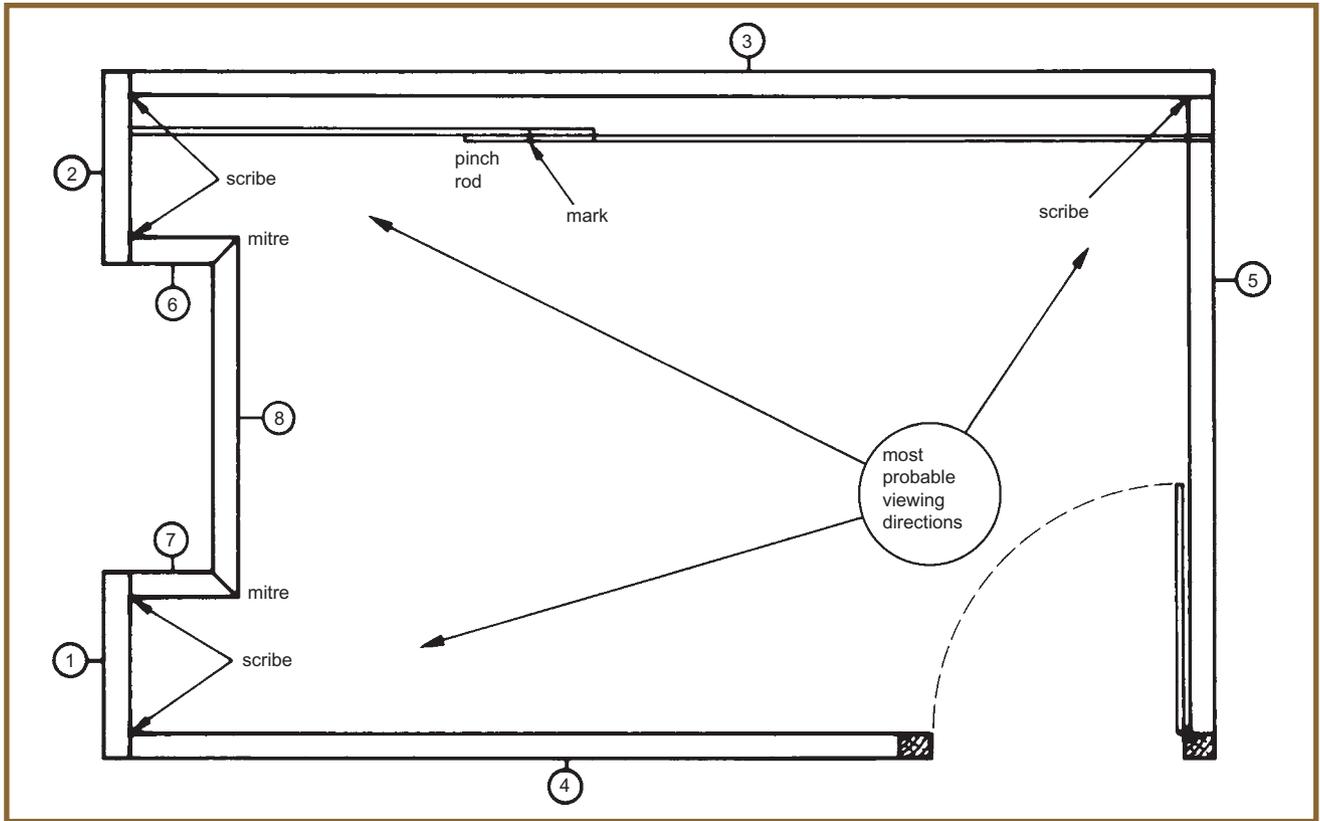
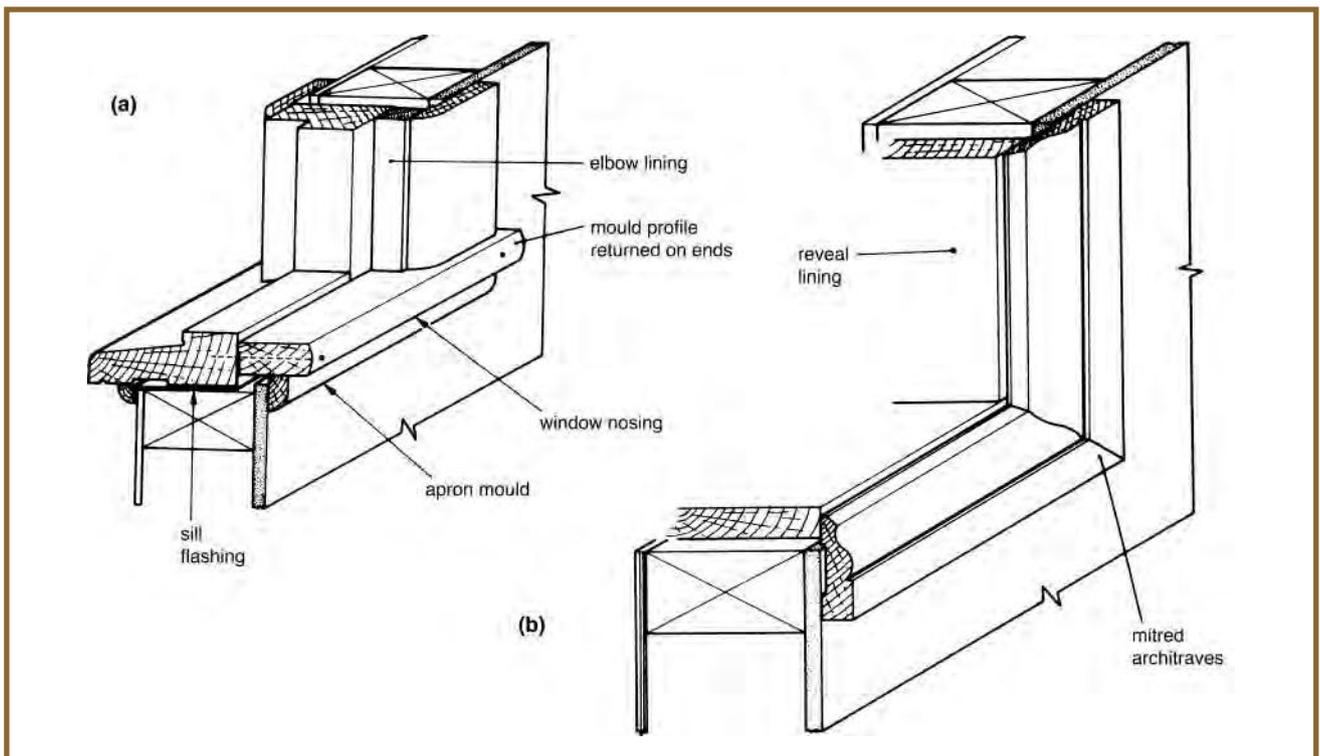


Fig. 5.33 Fixing of internal trim to window openings: (a) timber and (b) aluminium



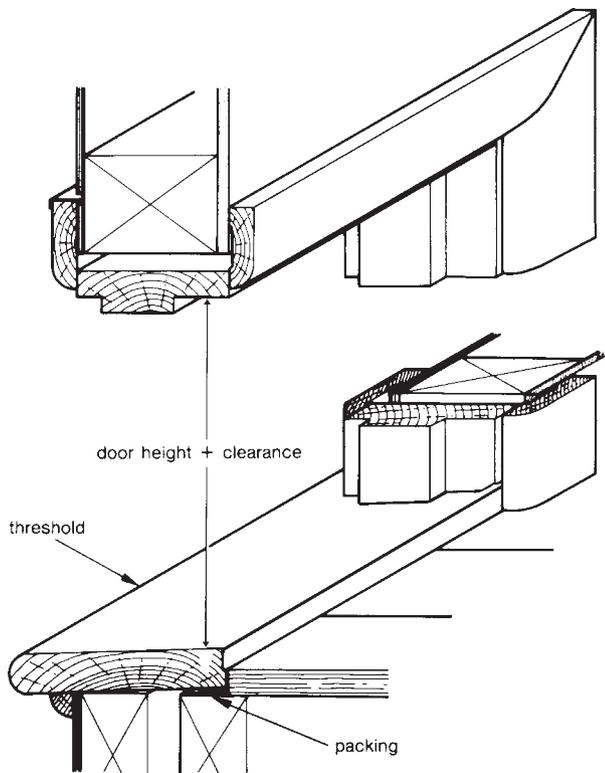
The sides and head of the window opening are finished with an architrave in a manner similar to door openings, but depending on the thickness of the wall and the window frame used, an elbow lining may be necessary to cover the reveal from the frame to the face of the interior lining.

Exterior door openings

Timber-framed buildings use a timber threshold to external doorways. This is milled from stock usually 175 mm × 38 mm of equivalent durable timber.

The threshold is made weather resistant by fixing it with a slope to the outside of say 5 mm, which allows a strip of hardboard to be used as packing to the inner edge.

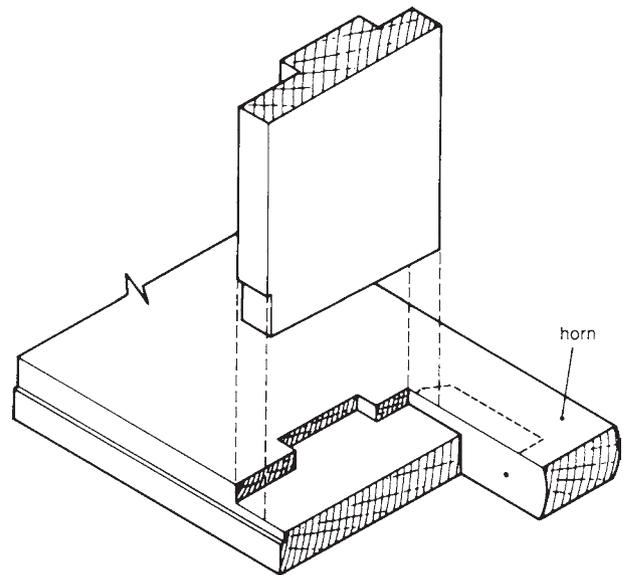
Fig. 5.34 External door openings



The jambs are housed to the ends of the threshold which is also cut around the face of the exterior sheeting to form a horn. The front edge of the threshold can be fixed by nail through the horn, but be sure to drill a hole with ample clearance to prevent splitting this close to the end: only the end of the jamb and housing should be painted before assembly.

Thresholds can be manufactured with rebates to stop wind and rain from entering the house. There is also a wide range of weather strips available to make doors more draft and rain resistant.

Fig. 5.35 External jamb lining housed into threshold



Student research

1. Research what materials other than those mentioned can be used to line the walls of a home.
2. Research how many different types of hinges there are and their applications.

Key principles for a healthy building

Exterior environment

Select a site that allows for idealised orientation of the building to sun and breeze exposure.

Avoid the following:

- contaminated ground
- low-lying ground
- natural drainage pathways
- localised air pollution pathways
- unhealthy noise sources.

For building, consider using the following:

- natural materials
- low or no formaldehyde-emitting materials
- materials with a high fluff factor such as wall-to-wall carpets in high-use areas
- organic paints.

Avoid the following:

- materials that contain heavy metals, biocides, lead or asbestos
- PVC (polyvinyl chloride) materials and products
- timber preservative.

Interior environment

Consider the following:

- adequate daylight with a good number of openable windows
- good levels of insulation for thermal comfort
- natural ventilation or good airtight construction (depends on climatic zone)
- the ventilation of excess moisture and internal air pollutants from kitchens and bathrooms—maintain adequate levels of humidity (above 40% for eyes, nose and throat but below 65% so mould and fungi do not grow)
- simple-to-operate heating and cooling systems
- minimising exposure to electromagnetic field, such as not locating the meter box near bedrooms and minimising room-based equipment (computers, TV, microwave ovens, etc.).

Internal linings

LEARNING OBJECTIVES

- 6.1 Wall lining installation
- 6.2 Ceiling lining installation
- 6.3 Wet area wall lining systems
- 6.4 The three-coat paint system

Historically, many homes used traditional fibrous plaster lining for walls and ceilings, while the internal walls of cavity brick homes were finished with a thin plaster set finish over cement render. However, since 1947, Australian homes have moved to using paper-backed gypsum plaster sheeting or **plasterboard** for their internal wall and ceiling lining systems in full masonry or timber or steel-framed constructions. This chapter covers plasterboard lining systems for walls, ceilings and wet areas, as well as the three-coat paint system.

Plasterboard internal lining systems

Plasterboard lining systems for timber and steel framing are similar. Generally nails or wood screws are used in conjunction with adhesive to fix plasterboard on timber framing, and screws combined with adhesive are used for fixing plasterboard to steel framing. In both cases, there are reasonably low tolerances—from 3–5 mm, depending on the level of finish. However, commencement of plasterboard installation is considered to be an acknowledgement that the frame meets the tolerances required as a substrate for a plasterboard lining system.

In full masonry construction, the plasterboard may be direct fixed to the masonry substrate using a fast-setting adhesive only.

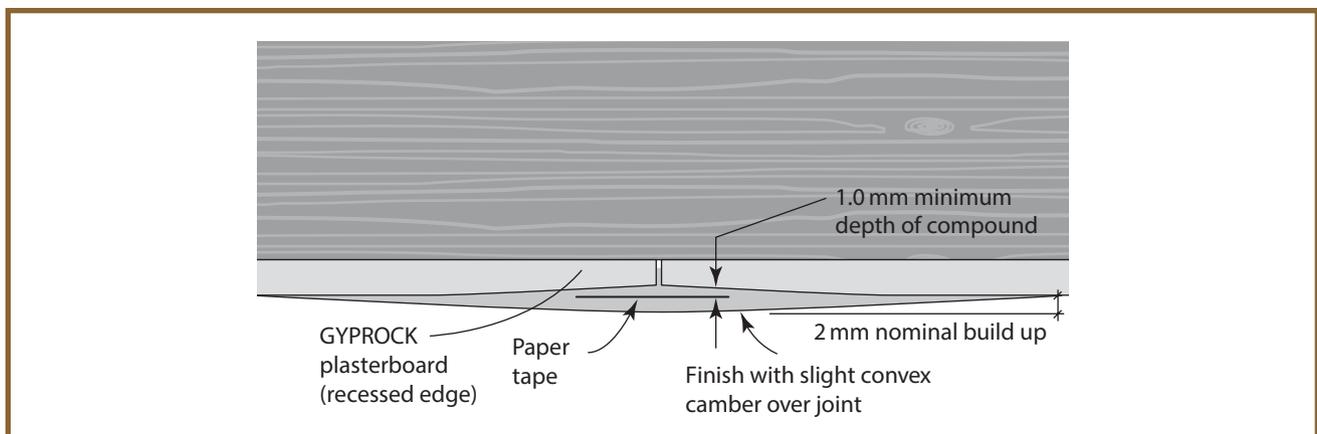
Plasterboard should only be installed after plumbers and electricians have completed their initial **rough-in** and services are in place. Service penetrations through the plasterboard should be cut neatly to suit and electrical wiring should be drawn through the plasterboard at locations indicated by the electrician.

In addition to standard plasterboard, manufacturers offer a range of plasterboard linings, jointing and fixing materials and accessories designed for specific purposes. These are covered in the following sections.

Types of plasterboard

Plasterboard is available with either a square edge or a recessed edge (Fig. 6.1). The majority of residential plasterboard lining systems use recessed edge plasterboard sheets that facilitate the finishing of joints between sheets.

Fig. 6.1 Recessed edge plasterboard



Source: Courtesy of Gyprock

Plasterboard can be used for:

- areas of high humidity and wet area linings
- fire and acoustic purposes
- impact resistant linings, curved walls and ceilings.

There is also a wide range of jointing materials and accessories and specialised tools and equipment used to install plasterboard to walls and ceilings.

Jointing and finishing systems

Jointing is another equally critical part of the process for installing plasterboard. There is a range of jointing compounds available for specific purposes. Setting compounds are mixed on site and have a defined initial set time of 20, 45, 60 or 90 minutes due to a chemical reaction rather than a drying action. They are used to embed tape into recessed and butt joints and to apply the base or foundation jointing, and generally require around 30 minutes to 2 hours setting and hardening time between coats (Fig. 6.2).

Fig. 6.2 Setting compounds—base coats



Source: Courtesy of Gyprock

Topping coats are generally a drying compound that requires around 24 hours of drying time before they can be recoated or sanded to the final smooth finish ready to receive a decorative finish. Drying compounds are generally pre-mixed and have a comparatively long shelf life once the material has first been opened. They also include products that can be used for all coats in a three-coat system.

Personal Protective Equipment

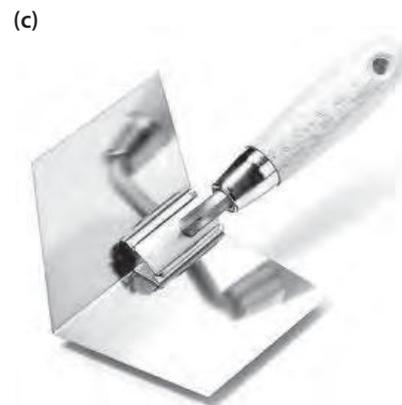
As there is a certain amount of cutting, sanding and manual handling involved, it is important that basic Personal Protective Equipment (PPE) is available as required. These include:

- safety glasses or other eye protection
- dust masks and respirators—Class P1 or P2
- hearing protection—ear muffs or plugs
- gloves and safety boots
- protective work clothing.

Hand tools

Relevant hand tools for plasterboard work are shown in Figure 6.3.

Fig. 6.3 Plasterboard tools: (a) clockwise from top left—mud pan, small broad knife, large taping knife, hand sander, jab saw, sanding block; (b) plasterers' hawk; and (c) internal square angle jointer



Source: Images used with permission from www.plasteringsupplies.com.au.

Specialised equipment

Specialised equipment used to fix plasterboard includes the sheet lifting equipment shown in Figure 6.4.

Fasteners

Fixings for plasterboard include ring shanked nails, clouts and screws, which are available in various lengths, as shown in Figure 6.5.

Screws and nails for timber and steel framing must have an increasing length as the board thickness and mass/weight increases; screws for softwood framing should be a minimum of 30 mm.

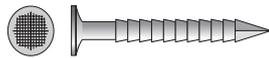
Fig. 6.4 Sheet lifting equipment

Source: iStock.com

Fig. 6.5 Nails, clouts and screws for specific types of substrates

- **Ring Shank Nails**

Hardwood 25 x 2.8 mmØ.
Softwood 30 x 2.8 mmØ.



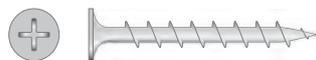
- **Clouts**

(Hot-dip galvanised).
30, 40 and 50 mm x 2.8 mm.



- **Plasterboard Screws**

N°6 Type 'W'
for timber framing.



N°6 Type 'S' Needle Point
for lightweight steel studs
and furring channel up to
0.8mm thickness



N°6 Type 'S' Drill Point
for steel framing 0.8 mm
to 1.2mm thickness.

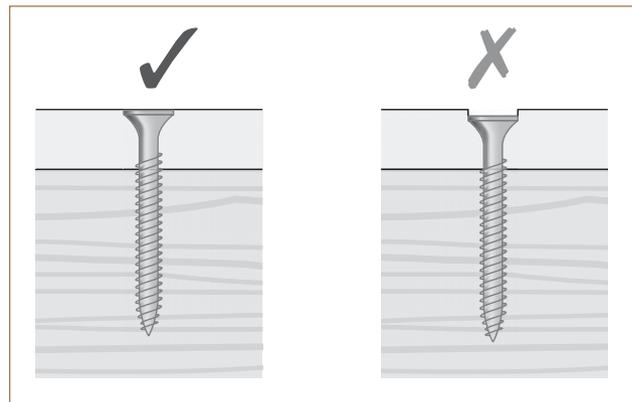


Source: CSR Gyprock, 2011. *Residential Installation Guide including Wet Area Systems*.

Fasteners should be driven home with the head left slightly below the surface of the plasterboard, but not driven through the paper surface layer resulting in damage to the board (Fig. 6.6).

Accessories

Other relevant plasterboard accessories are shown in Figures 6.7 and 6.8.

Fig. 6.6 Depth of fasteners

Source: Courtesy of Gyprock

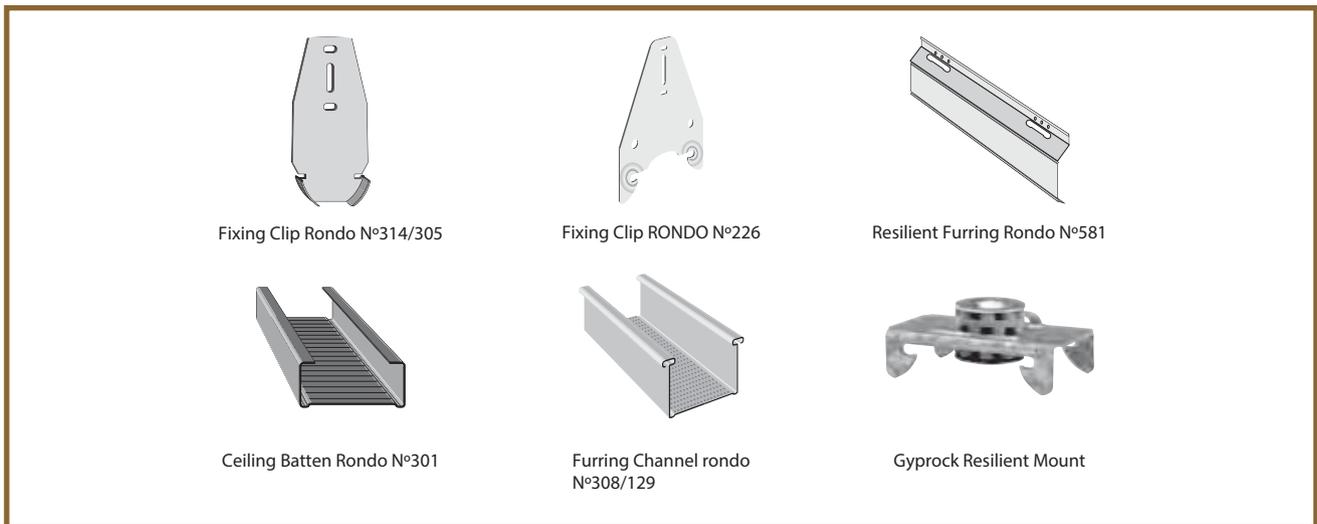
Plasterboard finish

Plasterboard provides a consistent high level of finish for the application of paint. However, to achieve a long-lasting, high-quality final decorative finish, the following critical points must be considered before the plasterboard is installed:

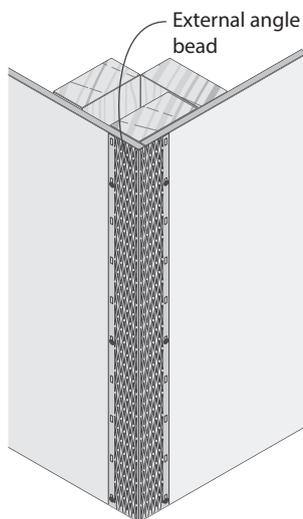
- The timber or steel framing or masonry—the **substrate**—to which the plasterboard is fixed must achieve required tolerances in accordance with the Building Code of Australia (BCA).
- Direct fixing of plasterboard to ceiling joists or the bottom chord of roof trusses will result in an unacceptable deviation of the plasterboard surface if the framing does not meet tolerances required by AS 1684 Residential timber-framed construction. Lighting with a **low angle of incidence** that is projected along a wall or ceiling surface will highlight the slightest imperfection in either the plasterboard surface or the decorative finish.
- The joint finish of the plasterboard and final decorative finishes to the plasterboard are handcrafted and despite the best efforts of skilled trades there will always be imperfections.
- High-gloss or semi-gloss painted finishes will accentuate minor imperfections, while a flat or matt paint finish will reduce the appearance of minor imperfections.
- Lighter coloured finishes also tend to hide imperfections while darker finishes tend to expose them.
- The roof or ceiling space must be adequately ventilated to remove condensation and prevent potential sagging of the ceiling lining. High moisture levels and high adjacent temperatures from heating appliances may also have a detrimental effect on plasterboard.

Six levels of finish

The current AS/NZS 2589:2007 Gypsum linings—application and finishing identifies a Level 4 finish as the default finish and rationalises the six levels of finish from earlier standards to Level 3, Level 4 and Level 5 finishes only. The industry, however, still uses the following six different levels of finish to specify or describe finishing criteria to include situations

Fig. 6.7 Accessories for suspended ceiling systems

Source: Courtesy of Gyprock

Fig. 6.8 External angle corner bead

Source: Courtesy of Gyprock

where plasterboard is used for other than residential building work or where a high level of finish is not required:

- Level 0: For temporary construction where sheeting is fixed but not jointed such as pedestrian walkways when major refurbishment of a shopping centre is undertaken.
- Level 1: Where the linings will not be seen in building services areas with tape embedded in jointing compound only and joints may show visible tool marks and edges.
- Level 2: Where surface appearance is not a primary concern such as a warehouse; tape is embedded in jointing compound and one separate jointing coat is applied over all joints and fastener heads, with minor tool marks and edges remaining.
- Level 3: For areas that will have an applied texture coat or wall paper finish; joints have embedded tape, one separate

joint coating over all joints and fastener heads and joints are finished smooth.

- Level 4: Accepted level of finish for domestic construction; tape embedded in joints with two separate jointing compound coats over all joints and fastener heads with all jointing compound finished smooth and free of tooling marks and ridges.
- Level 5: Used where a gloss or semi-gloss paint finish is required and where lighting with a low angle of incidence is likely to expose the slightest imperfection in the plasterboard finish. Tape is embedded in joints and there is a minimum of two coats of jointing compound over all joints, fasteners and accessories such as external corner beading. All jointing compound is finished smooth and free of tooling marks and ridges. A further finish is then applied. This may be a proprietary finishing compound but is generally a final skim coat of jointing compound not exceeding 1 mm. This provides a consistent, smooth finish, filling any imperfections in the paper surface of the plasterboard.

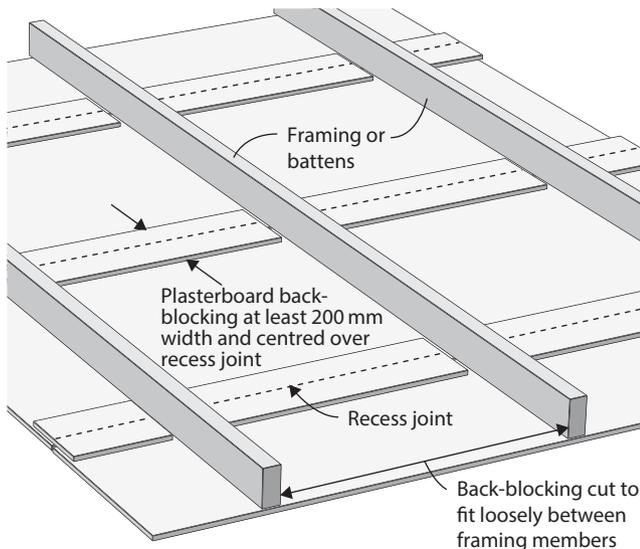
A Level 5 finish cannot be achieved without the coordination and cooperation of the trades responsible for the framing, internal plasterboard lining and painting.

Backblocking of joints

Backblocking is a critically important part of the installation process that will often be omitted without the diligence expected of a qualified tradesperson. Backblocking allows joints on walls and ceilings to be reinforced and for butt joints particularly to be correctly reinforced and jointed so that a consistent finish can be produced across the surface of the plasterboard. Lighting with a low angle of incidence is more likely to expose imperfections in jointing if backblocking has not been properly undertaken.

Level 4 and Level 5 finishes cannot be achieved without the required backblocking being placed, as specified by AS/NZS 2589:2007 Gypsum linings—application and finishing and as recommended by manufacturers.

Fig. 6.9 Example of backblocking to ceilings



Source: Courtesy of Gyprock

Jointing procedure—Level 4 finish

It is important to leave each consecutive coat as smooth as possible to reduce sanding and to provide a quality finish. Setting or drying compounds may be used and the joint is sanded between coats. A setting compound should not be placed over a drying compound.

Recessed joints

Three coats are applied with sanding between coats. With each coat the jointed surface area is increased slightly by 25 mm, raised slightly and feathered out to nothing at the edges. Refer to Figure 6.10 (a) to (d) for the following procedure.

Step 1. Tape coat (a)

- Using a 150 broadknife, fill recess with jointing compound.
- Place tape in the middle of the joint.
- Apply a thin coat of compound over the tape.
- Cover fastener heads and spot-fill any indentations or damage.
- Sand when compound has set or is dry.

Step 2. Second coat (b)

- Apply second coat with a 170mm trowel or broadknife.
- Leave surface slightly rounded and raised and feathered flush with board at the edge of the joint.
- Cover fastener heads and any indentations or damage with a raised and wider coat.
- Sand when compound has set or is dry.

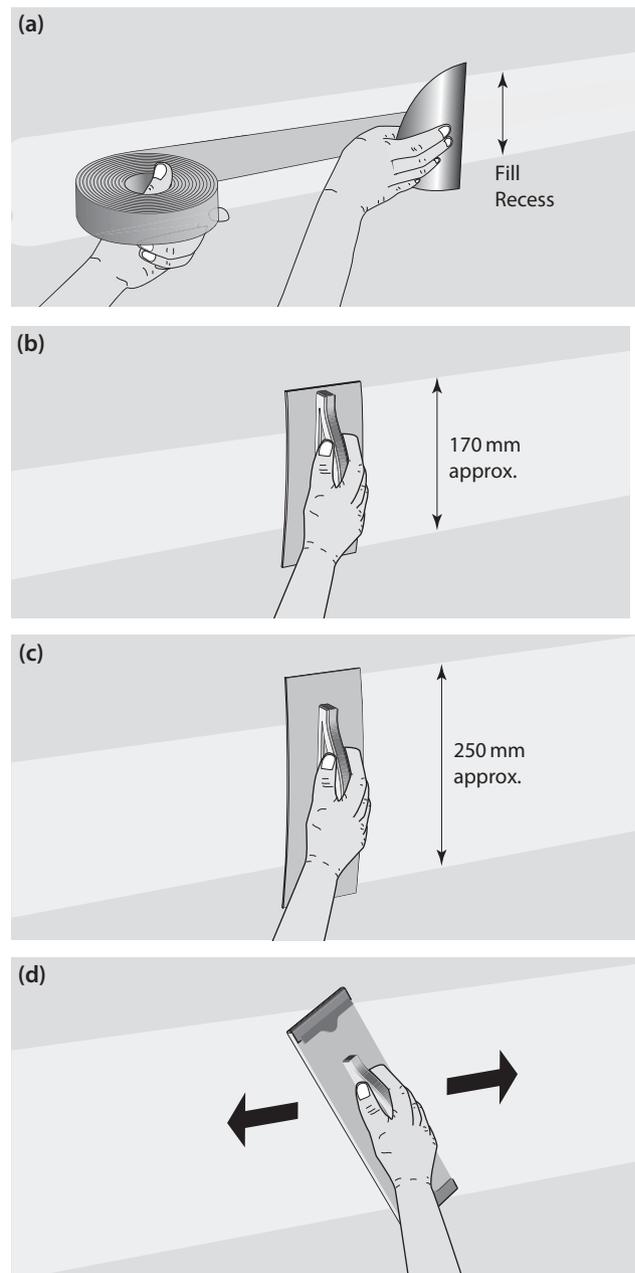
Step 3. Finish coat (c)

- Apply a thin topping coat with a 250 mm trowel or broad-knife.
- Leave the centre surface raised 2 mm with feathered edges.
- Cover fastener heads and other marks with a raised and wider coat.

Step 4. Sanding (d)

- Sand to a smooth finish when dry with 150 grit sandpaper or 220 sanding mesh.

Fig. 6.10 Form recessed joints: (a) tape coat; (b) second coat; (c) finish coat; and (d) sanding

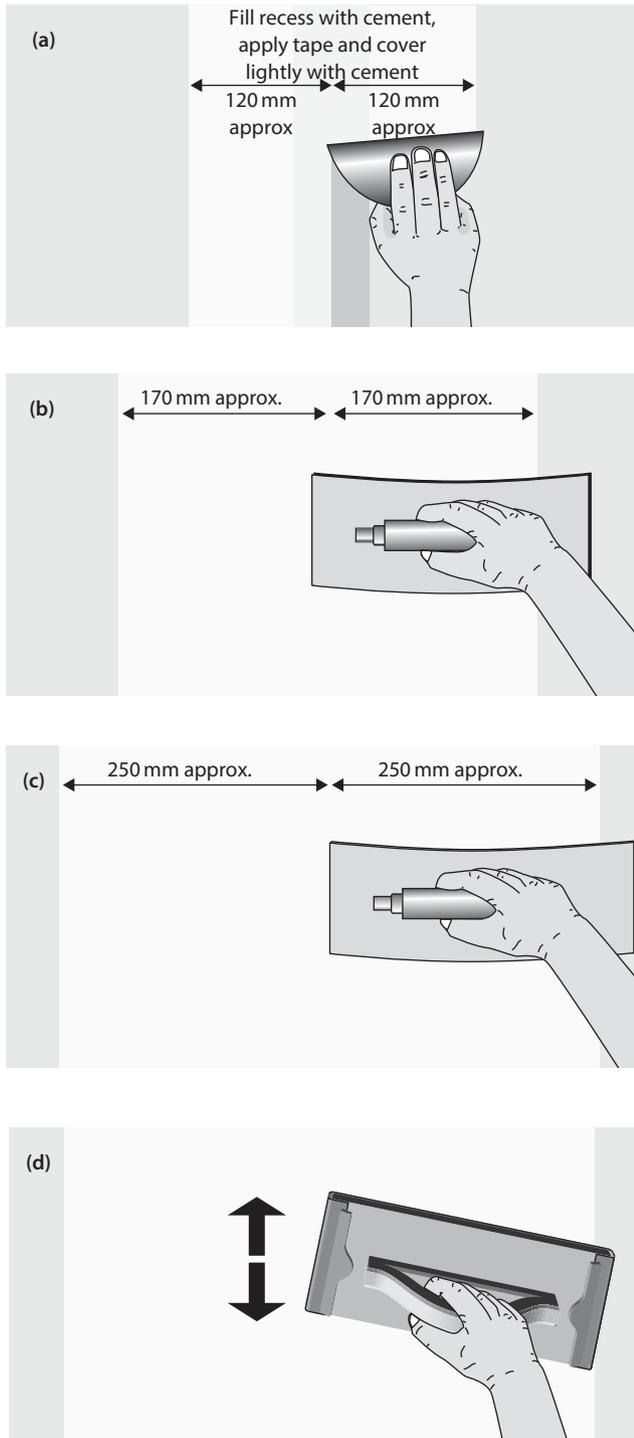


Source: Courtesy of Gyprock

Butt joints

As there is no recess between boards, the butt joint over framing is twice the width of a recessed joint and is also raised higher. Refer to Figure 6.11 (a) to (d) for the following procedure.

Fig. 6.11 (a) to (d) Jointing procedure for butt joints over framing



Source: Courtesy of Gyprock

Step 1. Tape coat (a)

- Apply a thin coat of compound over the butt joint.
- Place tape in the middle of the joint.
- Apply a thin coat of compound over the tape about 240 mm wide.

Step 2. Second coat (b)

- Apply second coat about 170 mm wide on each side of the joint.
- Leave surface slightly convex and feathered flush with board at edges.

Step 3. Finish coat (c)

- Apply thin topping coat 250 mm each side of the joint.
- Leave the centre surface raised about 3 mm and feathered at edges.

Step 4. Sanding (d)

- Sand to smooth finish when dry with 150 grit sandpaper or 220 sanding mesh.

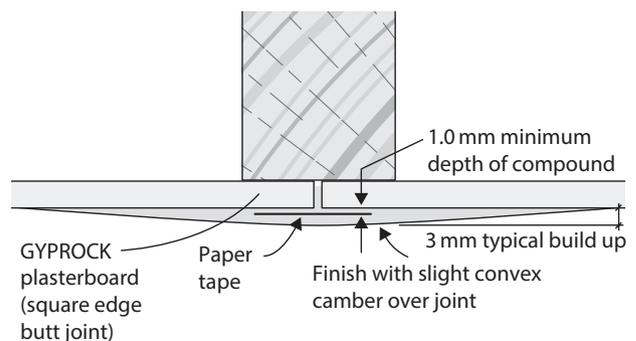
Internal and external corner jointing

The same concepts and principles apply as for recessed and butt joints but specialist trowels and accessories are also used.

Internal corners are formed with a two-coat system by using an internal corner trowel or a trowel to first place at least 1 mm of jointing compound on each return. The jointing tape is folded and placed evenly into the corner over the jointing compound and a thin layer of compound is applied over the tape. Ensure that the compound is left smooth and feathered to the edges. The final topping coat is applied 100 mm to each side of the corner and sanded when dry.

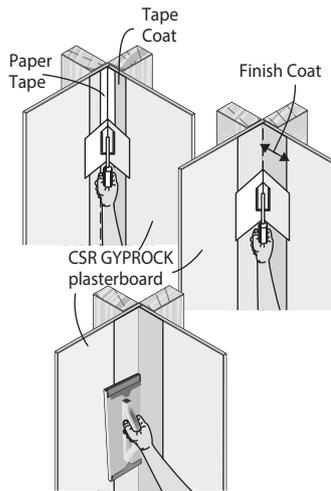
External corners are formed using a mesh corner angle fixed over the plasterboard and fixed through the flanges to the external corner stud at 300 centres. A three-coat jointing system is applied in a similar way as for a recessed joint with a final finish of 250 mm for each side of the corner.

Fig. 6.12 Section view through finished butt joint over a stud



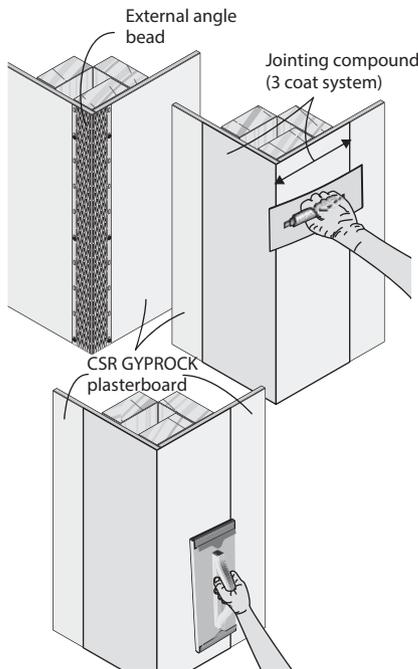
Source: Courtesy of Gyprock

Fig. 6.13 Jointing procedure for an internal corner: (a) tape coat, (b) finish coat; and (c) sanding



Source: Courtesy of Gyprock

Fig. 6.14 Jointing procedure—external corner



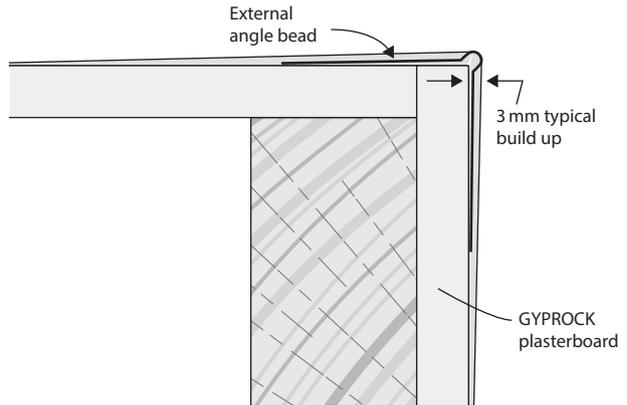
Source: Courtesy of Gyprock

Plasterboard wall lining

Plasterboard may be fixed to timber or steel framing using a combination of adhesive and fasteners, or with fasteners only, and can also be directly fixed to masonry walling using adhesive only. Wall linings are best fixed horizontally because:

- jointing is reduced by up to 25 per cent
- it provides a stronger wall when fixed at 90 degrees to wall studs

Fig. 6.15 Cross-section of the jointing detail for an external corner



Source: Courtesy of Gyprock

- unacceptable light reflections are reduced
- it is a more convenient height for joint finishing.

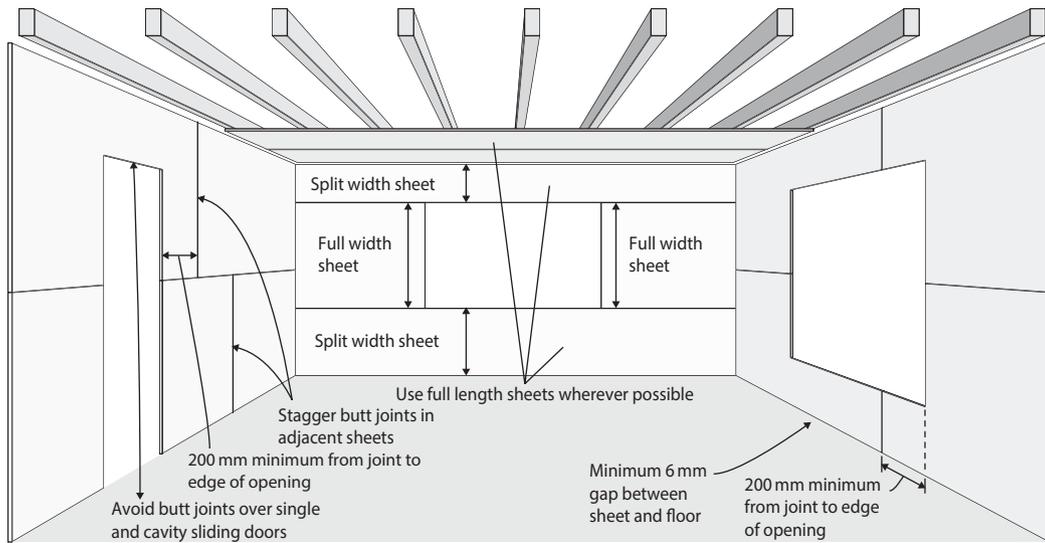
An example sheet layout for lining a wall using plasterboard is shown in Figure 6.16.

Fixing plasterboard to timber or steel wall framing using a combination of adhesive and fasteners

Important points to note when fixing plasterboard to timber or steel wall framing using a combination of adhesive and fasteners are as follows:

1. Check framing for deviations from plumb and alignment. Once the plasterboard is fixed this is considered to be acceptance that the framing meets the required standards for timber and steel framing as a substrate for plasterboard.
2. Frame should be clean and free of dust and grease or any materials that will prevent proper adhesion between the plasterboard and the framing.
3. Amounts of approved adhesive approximately 25 mm in diameter × 15 mm high are placed onto the wall studs at 200–300 centres maximum and not less than 200 mm from the location of any fasteners.
4. Plasterboard sheets may be fixed from the top down or from the bottom up. If a small gap or no gap is required between the ceiling and the top edge of the wall lining then it may be preferred to fix the top sheet first and then cut the bottom sheet to fit if required.
5. Place temporary packers on the floor along the bottom plate of the wall framing to form a 10 mm gap between the floor and the bottom of the lower board to allow free movement of the lining with any future movement of the frame.
6. The plasterboard sheet is then placed in position against the framework and fasteners are fixed along the recessed edge of the plasterboard at each stud between 10–15 mm from the edge of the board. This is repeated for the other edge of the board while pressing the sheet firmly against the framing.

Fig. 6.16 Example sheet layout for plasterboard wall linings



Source: Courtesy of Gyprock

7. The ends of the plasterboard are fixed at 300 mm centres vertically to the internal corner studs and at 300 mm centres around all openings.
8. Individual sheets must be held in place for at least 24 hours to allow the adhesive to set by fixing temporary blocks of plasterboard along the horizontal centre of each sheet at every second stud.
9. Butt joints should be avoided but where they must be used they should be placed within 50 mm of the center-line between studs and backblocked.
10. Butt joints may be placed over studs but as they cannot be backblocked in this situation, the jointing should be

250 mm to either side of the butt joint and built up to a maximum thickness of 3 mm.

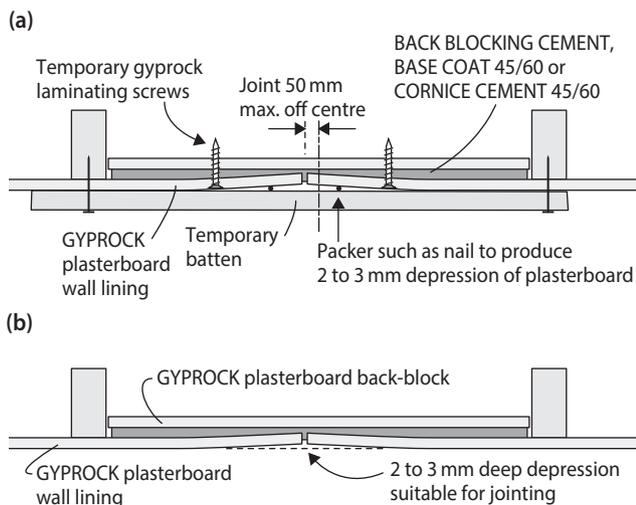
11. Butt joints should be lapped at least 450 mm by the second row of sheeting. With internal walls the butt joint on the opposite side of the wall should also be offset.

Fastener fixing only to timber or metal wall framing

Important points to note when fastener fixing only to timber or metal wall framing are as follows:

- Sheets must be held firmly against the frame while being fixed with screws or nails. Fix fasteners from the centre of the sheet, to the ends and edges, or start at one edge and work across the sheet to the other edge to ensure sheet is hard against frame.
- Screws are fixed at 400 mm maximum centres and nails are placed at 240 mm maximum centres.
- All fasteners are to be placed 10 to 16 mm from sheet edges.
- Butt joints are to be formed as for combined adhesive and fastener fixing.
- For butt joints on wall studs, nail at 150 mm maximum centres or screw fix at 200 mm maximum centres.
- Fix internal and external corners at 300 mm maximum centres with fasteners opposite each other.

Fig. 6.17 Backblocking butt joint in plasterboard wall lining: (a) forming the joint; and (b) ready for setting



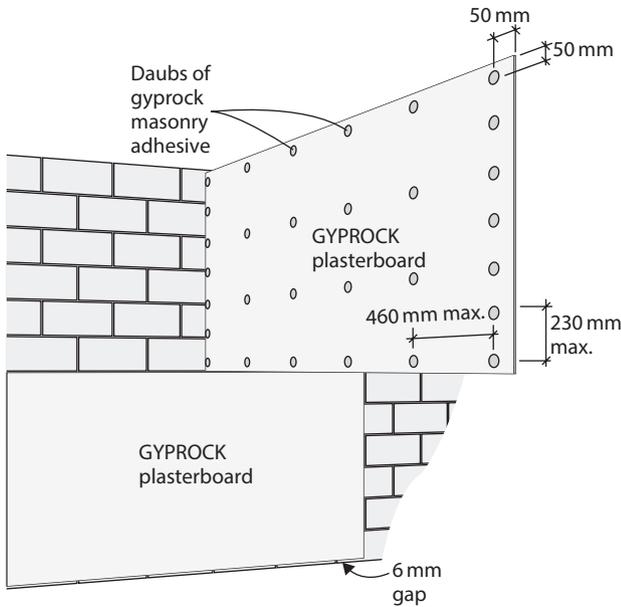
Source: Courtesy of Gyprock

Direct fixing of plasterboard to masonry walls using adhesive

Plasterboard may be used as an alternative to a cement render and hard-set plaster finish over masonry by direct fixing with an approved adhesive, provided the wall is plumb and straight (Fig. 6.18). Any deviations from acceptable tolerances will require levelling with a suitable levelling material or cement render, and the masonry wall must be dry otherwise

the adhesive may fail or the plasterboard may be damaged. Sheeting may be fixed vertically or horizontally.

Fig. 6.18 Adhesive fixing to masonry



Source: Courtesy of Gyprock

- Ensure that the masonry is dry and free of dust or any material that will prevent adhesion to the substrate.
- Amounts of approved adhesive approximately 25 mm in diameter × 15 mm high are placed onto the wall or the back of the plasterboard, 50 mm from all edges at not less than 230 mm centres and at 460 mm centres maximum for the remaining area to be covered. Additional adhesive must be applied at butt joints, external angles and around power points, plumbing fixtures, doors, windows and skirtings.
- Align plasterboard vertically and horizontally using a straightedge to tamp the sheets into alignment. Hold sheets in position to allow adhesive to set using temporary masonry nails through sheet edges and if necessary, use temporary blocks or props.
- The sheeting should remain undisturbed for 48 hours.

For wet area masonry walling, the plasterboard must be fixed with fasteners only to battens or furring channels.

Ceiling lining installation

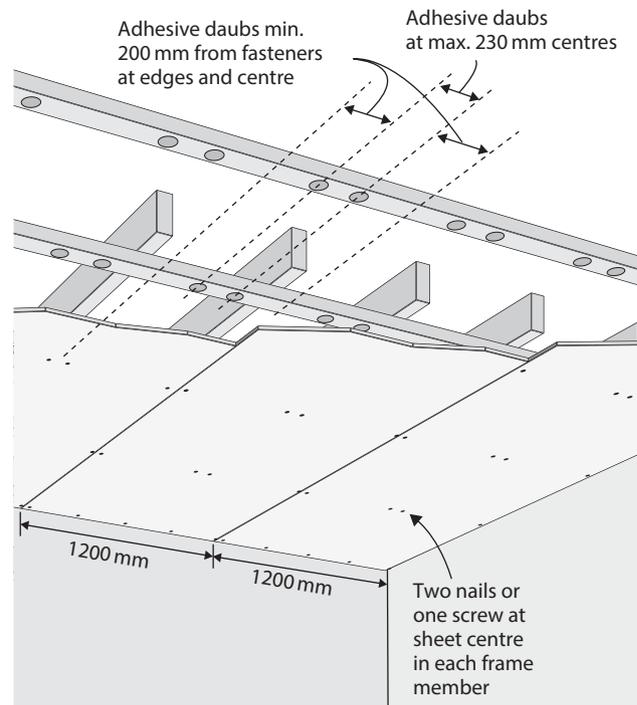
Plasterboard may be direct fixed at 90 degrees to the ceiling joists or bottom chord of roof trusses, but only where the framing meets minimum tolerances. Timber trusses seldom meet these minimum tolerances, leaving no alternative but to use (a) ceiling battens that are packed to maintain a flat ceiling; (b) a metal furring system fixed directly to the bot-

tom chord or ceiling joists; or (c) a full suspended ceiling system.

A combination of adhesive and fasteners may be used, or fasteners only. A fastener-only system must be used for linings to garage ceilings and in wet areas. If the combined adhesive and fastener method is used, there is an option to place a single middle row of fasteners along the length of the plasterboard sheet, or to divide the sheet into three equal spaces along its length and fix fasteners around the edges and along two lines of fasteners at one-third spacings (Fig. 6.19).

This chapter will mainly detail direct fixing to timber or steel ceiling framing, which has similar requirements to fixing plasterboard to timber or steel **wall framing**.

Fig. 6.19 Combined fastener adhesive system for ceilings



Source: Courtesy of Gyprock

The ceiling framing must be checked for defects in alignment and the substrate must be clean and free of grease or other materials that will reduce the adhesion of the ceiling lining to the ceiling framing. It will be considered as acceptance that the ceiling framing has met the requirement as a substrate for plasterboard when the plasterboard is fixed.

Fixing to timber or steel ceiling framing using a combination of adhesive and fasteners

Important points to note when fixing to timber or steel ceiling framing using a combination of adhesive and fasteners:

1. Amounts of approved adhesive approximately 25 mm in diameter × 15 mm high are placed onto the ceiling framing at 230 centres maximum and not less than 200 mm

from the location of any fasteners. Place plasterboard and fasten one recessed edge at each ceiling joist or truss between 10–15 mm from the edge of the board.

2. The plasterboard sheet is then pushed firmly against the ceiling framework and fasteners are fixed along the other recessed edge of the plasterboard at each ceiling joist or truss and 50 mm from the edge of the board. Where there are more than three rows of sheeting, all recessed joints must be backblocked if a Level 4 or Level 5 finish is required.
3. The ends of the plasterboard sheet are fixed at 300 mm centres for a cornice finish and at 200 mm centres maximum for a square set finish.
4. Using the **conventional fixing method**, fasteners are then fixed along the centerline of the sheeting at each ceiling joist or truss. If nails are used, two nails are fixed through the sheeting 50–75 mm apart on either side of the centerline of the sheet. Using the **1/3 method**, an additional row of fasteners are fixed through the plasterboard by placing fasteners along each edge and along the sheet at one-third interval lines instead of only along the centerline or halfway interval. Adhesive is placed centrally between the four rows of fasteners
5. Individual sheets must be held in place for at least 24 hours to allow adhesive to set by fixing temporary blocks of plasterboard along the horizontal centre of each sheet at every second ceiling joist or truss.

Butt joints should be avoided. However, if they must be used, they should be placed within 50 mm of the centreline between ceiling joists or trusses and backblocked using a length of plasterboard at least 1300 mm long and 400 mm wide (Fig. 6.20) or by using a purpose-made 300-mm steel batten with a 2.5 mm bend along its length (Fig. 6.21). Where butt joints must be made on the ceiling framing, nail fix at 150 mm or screw fix at 200 mm maximum centres. Butt joints must be lapped by adjacent sheets by at least 600 mm.

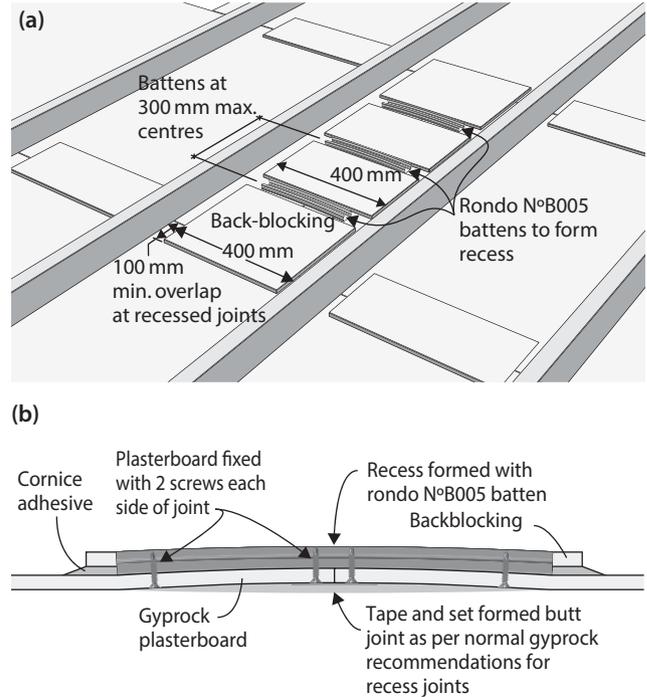
In slow-drying conditions, the ceiling sheets may need to be held in place for up to 48 hours using temporary blocks fixed through to the ceiling framing.

Fastener fixing only to timber or metal ceiling framing

Important points to note when fixing fasteners only to timber or metal ceiling framing:

- Hold sheets firmly against the frame while fixing screws or nails.
- Fix fasteners from the centre of the sheet to the ends and edges, or start at one edge and work across the sheet to the other edge to ensure sheet is firmly against the framing.
- Fix screws at 400 mm maximum centres on walls and 300 mm maximum centres on ceilings. Nails are placed at 240 mm maximum centres on walls and 200 mm maximum centres on ceilings. Fasteners are placed 10 to 15 mm from sheet edges.

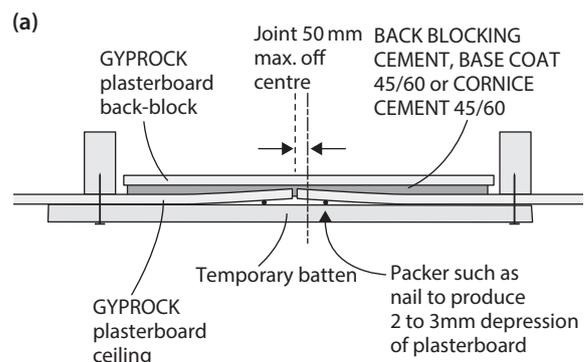
Fig. 6.20 Backblocking of butt joints in ceilings using Rondo battens: (a) top view; and (b) side view



Source: Courtesy of Gyprock

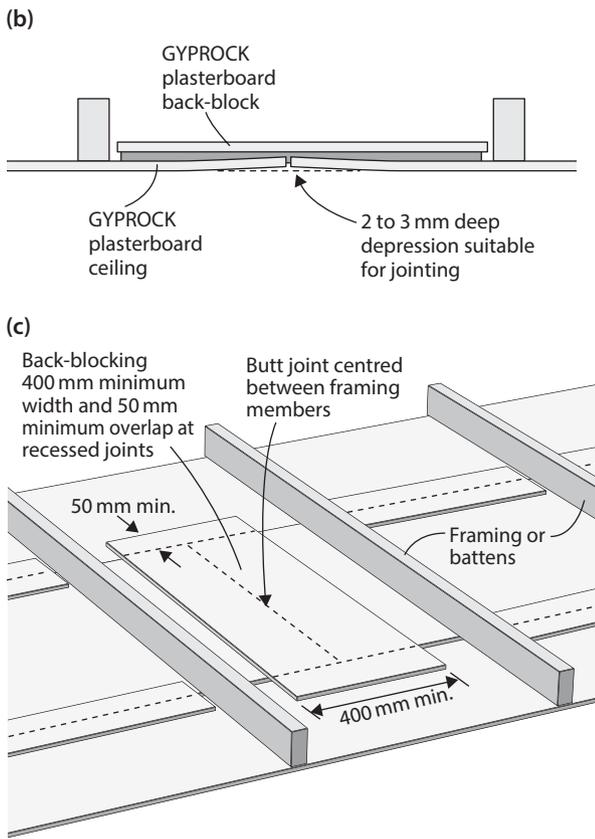
- Where butt joints are to be formed between framing, they should be placed within 50 mm of the centerline between ceiling joists or trusses and backblocked.
- Where butt joints on framing members are permitted, nail at 150 mm maximum centres or screw fix at 200 mm maximum centres and backblock the joint.
- Fix internal and external corners at 300 mm maximum centres with fasteners opposite each other.
- For a cornice finish, fix ends of ceiling sheets at 300 mm maximum centres.
- For a square set finish, fix ends of ceiling sheets at 200 mm maximum centres.

Fig. 6.21 (a) Forming the joint and; (b) the joint ready for setting; and (c) backblocking of butt joints in ceilings using plasterboard blocks



(Continued)

Fig. 6.21 (Continued)



Source: Courtesy of Gyprock

Cornices

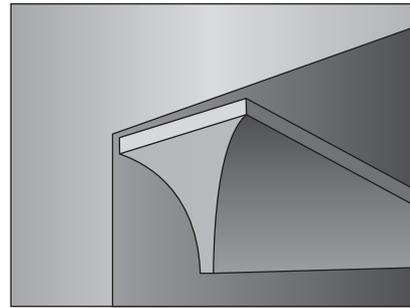
There is a range of different cornices available but the most common used is a cove cornice, which is available in 55 mm, 75 mm and 90 mm (Fig. 6.22). These sizes indicate the actual distance covered by the cornice from the ceiling and wall junction. Internal and external angles should be **mitred** and where a cornice finishes with a stopped end, it is finished neatly by filling the end of the cornice and shaping it to suit the situation (Fig. 6.23).

Fig. 6.22 Cove cornice: sizes available



Source: Courtesy of Gyprock

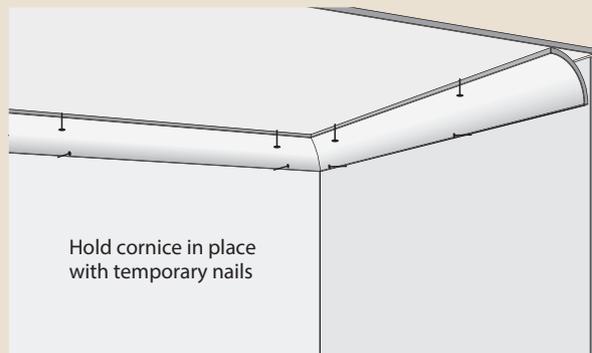
Fig. 6.23 Cove cornice stopped end finish



Cove cornice installation

- Mark the distance covered on the wall by the cornice by measuring down from the junction of the wall and ceiling and marking the wall with a pencil at 55 mm, 75 mm or 90 mm, depending on the size of the cornice.
- Mark and cut the cornice to the actual length required. Use a mitre box with the cornice oriented as it is to be fixed. Prepare the ends of butt joints so that they butt properly together.
- Using a trowel, swipe or **butter** cornice cement along each back edge of the cornice and butter each mitre and butt joint at the same time. Mix cornice cement after cornice has been cut and mitred and is ready for placement.
- Place the cornice on the marked lines and use temporary nails to prevent the cornice from moving by tapping them into the wall lining at both the top edge and bottom edge of the cornice (Fig. 6.24).

Fig. 6.24 Use of temporary nails to hold cornice



Source: CSR Gyprock, 2011. *Residential Installation Guide including Wet Area Systems.*

- Clean off surplus cement and then remove any remaining cement with a damp brush or sponge.
- Allow to set before removing the temporary nails.
- Apply a second coat of cement to the mitres and butt joints, and fill nail holes and any imperfections, and then clean up with a damp brush or sponge.

Wet area lining systems and waterproofing

Wet areas such as bathrooms or laundries may be finished with an internal lining of wet area plasterboard or 6 mm wallboard manufactured from dense fibre-cement board. Wet area lining systems must be installed in compliance with AS 3740:2010 Waterproofing of domestic wet areas.

Wet area lining systems must be fastener-fixed only as the high level of humidity in a wet area will cause the wallboard adhesive to fail. Where ceramic tiles are fixed to the wall lining system, fasteners must be at 150 mm spacings vertically on every stud and around any openings.

Where a wet area wall lining system is used in full masonry construction the linings must be fixed to a batten system (timber or steel at 600 centres maximum). For more details, refer to AS 3740:2010 Waterproofing of domestic wet areas, the manufacturer's instructions, and CSR's *Gyprock residential installation guide including wet area systems*.

Three-coat paint systems for internal plasterboard

Preparation

Where there are defects in the lining surface these should be removed using an appropriate filling compound and grade of sanding paper or sanding blocks. The entire surface must also be thoroughly brushed down and dusted to ensure proper adhesion of the sealing coat to the plasterboard surface. Failure to complete this basic preparation procedure can result in failure of the surface coating.

First coat—sealer

It is highly recommended that a proprietary sealing coat be applied as the first coat and that this be applied by roller or brush—not sprayed.

A brushed or rolled coating of sealer will ensure good connection and adhesion to the substrate but do not overwork or over-roll the paint when sealing any jointed sections as the paint is likely to lift off. This is a consequence of the paint drying more quickly over jointing material resulting in the top layer of jointing material lifting as it is over-worked and becomes moist.

A good quality sealer in combination with a comparatively long 'nap' of more than 10 mm will provide a slight 'orange peel' texture finish. The roller will hide minor defects in the wall lining and provide a consistent finish over jointed and non-jointed surfaces.

If the plasterboard has yellowed due to a delay in applying a decorative coating, check if the sealer will cover the colour of the linings. A pigmented solvent-borne sealer may be required.

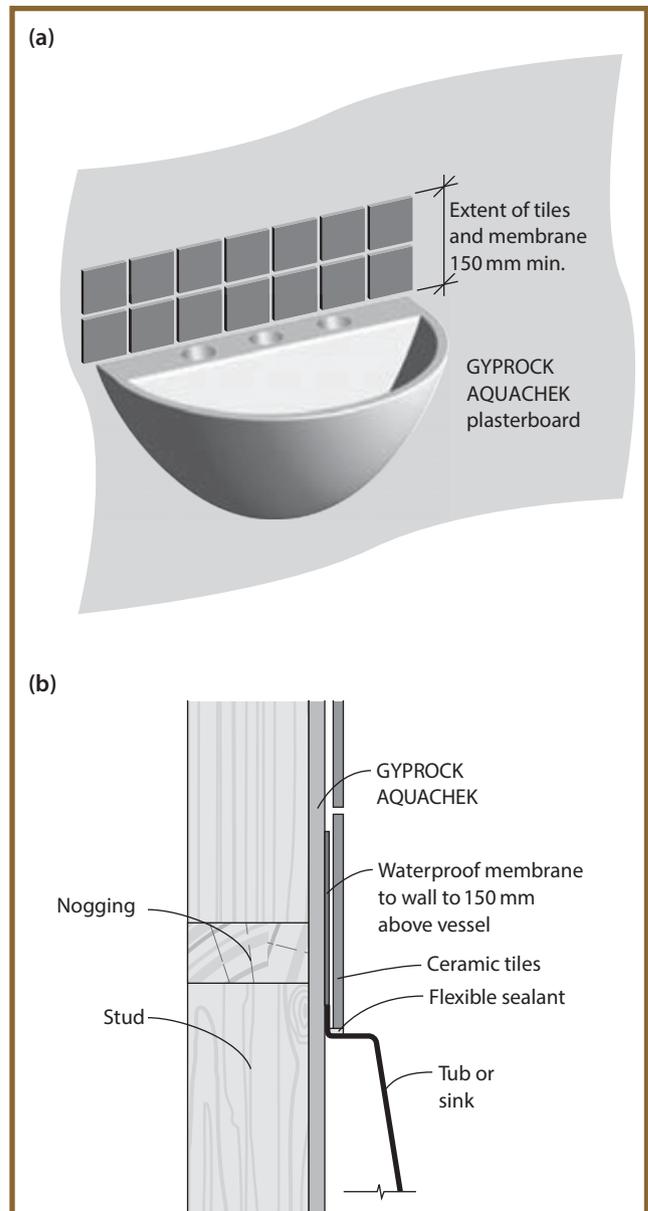
Special attention should be given to any wet area linings to ensure the paint system will protect the linings from the expected regular exposure to high humidity over a long period of time.

Second and third coats—finishing

Apply the two finishing coats strictly in accordance with manufacturer's instructions. Lightly sand between coats, if required. Preference should be to use a roller as this will provide a consistent finish while continuing to facilitate the removal of minor defects with the plasterboard.

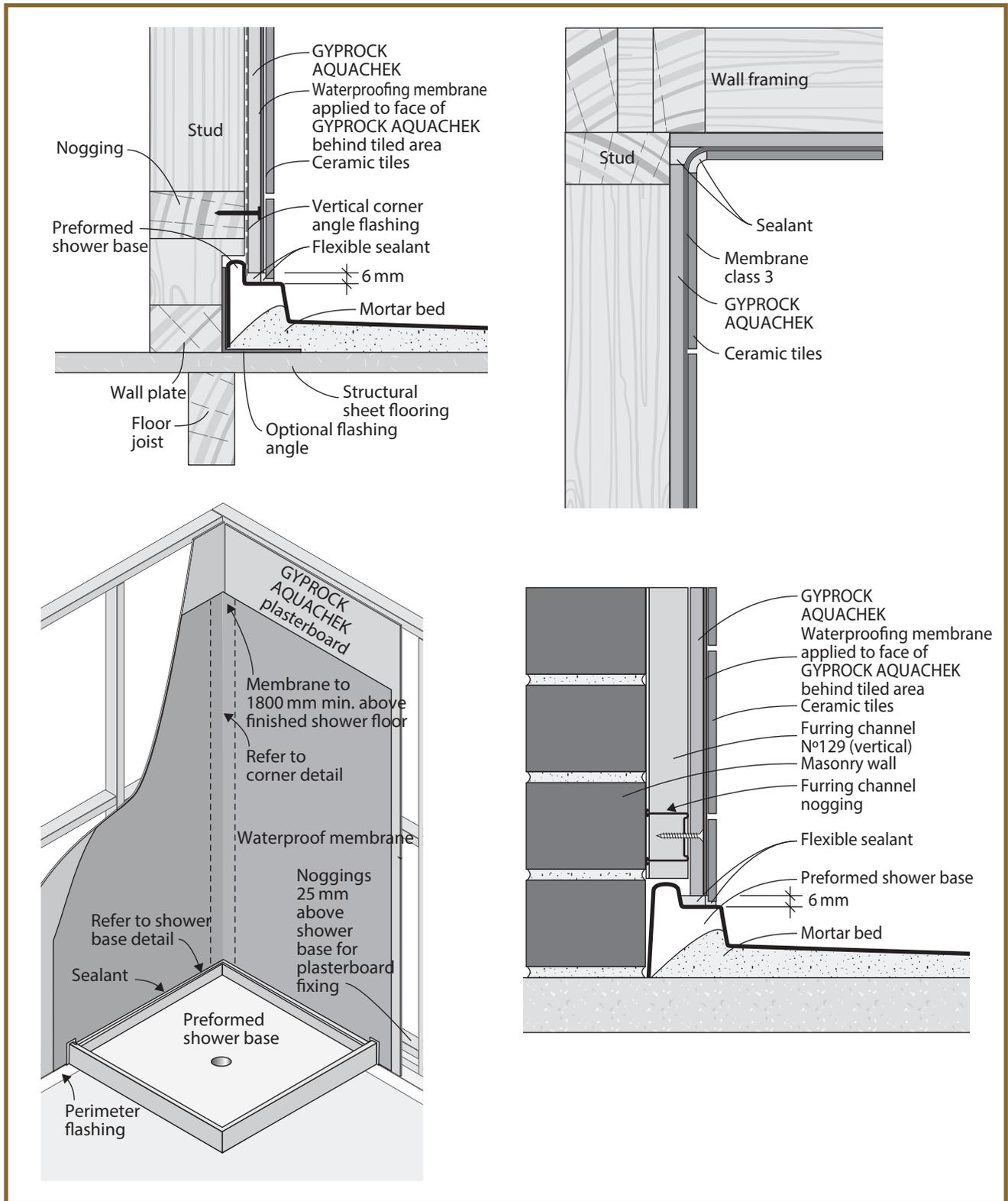
Where possible, complete the painting before the electrician or plumber has completed the final fix and allow the paint to dry hard before any fixtures are placed in position against any painted surfaces. For more information, refer to AS/NZS 2311:2009 Guide to the painting of buildings.

Fig. 6.25 Hand basin or laundry tub installation: (a) extent of tiles; and (b) section detail



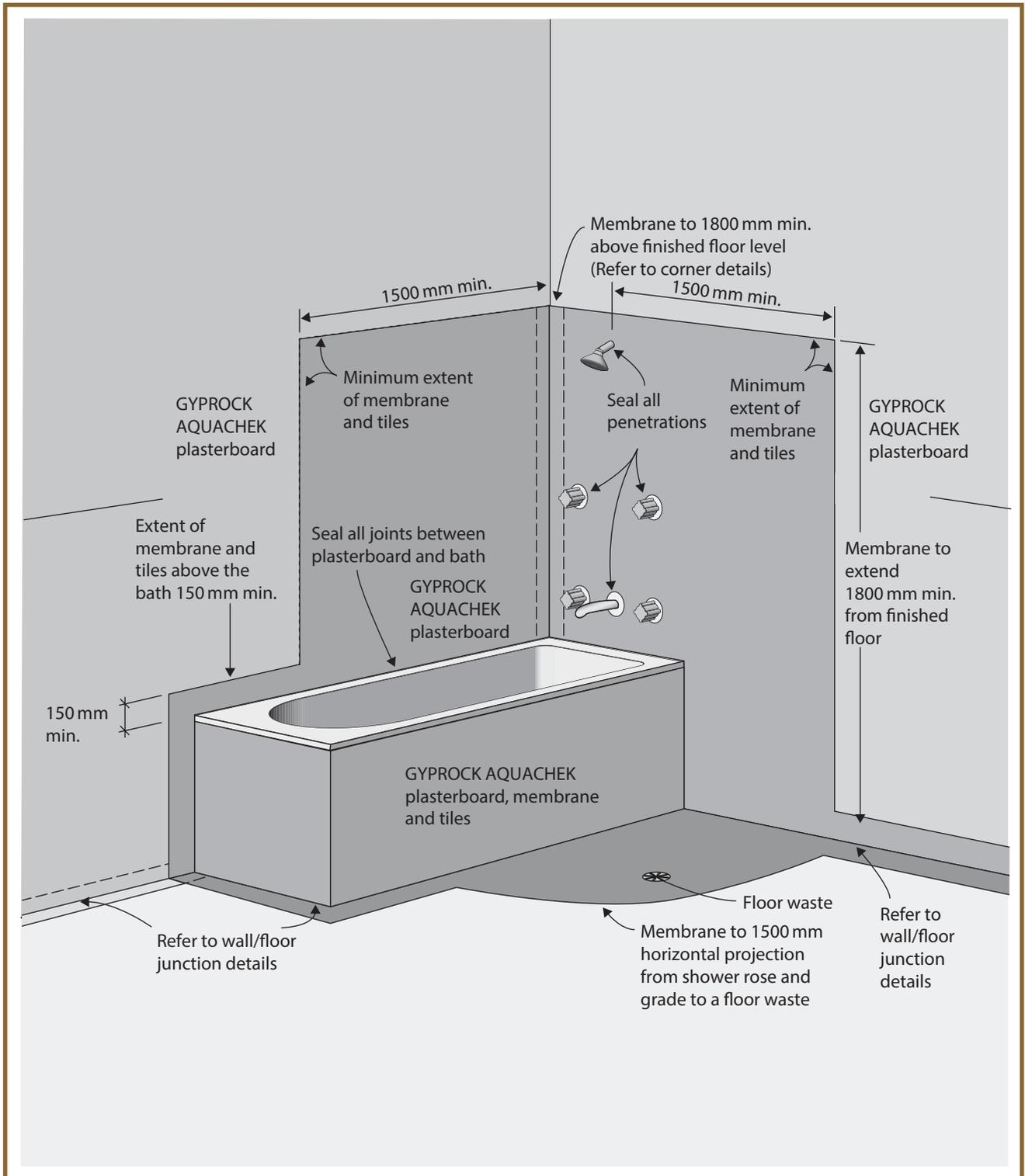
Source: Courtesy of Gyprock

Fig. 6.26 Wet area lining system for a shower recess



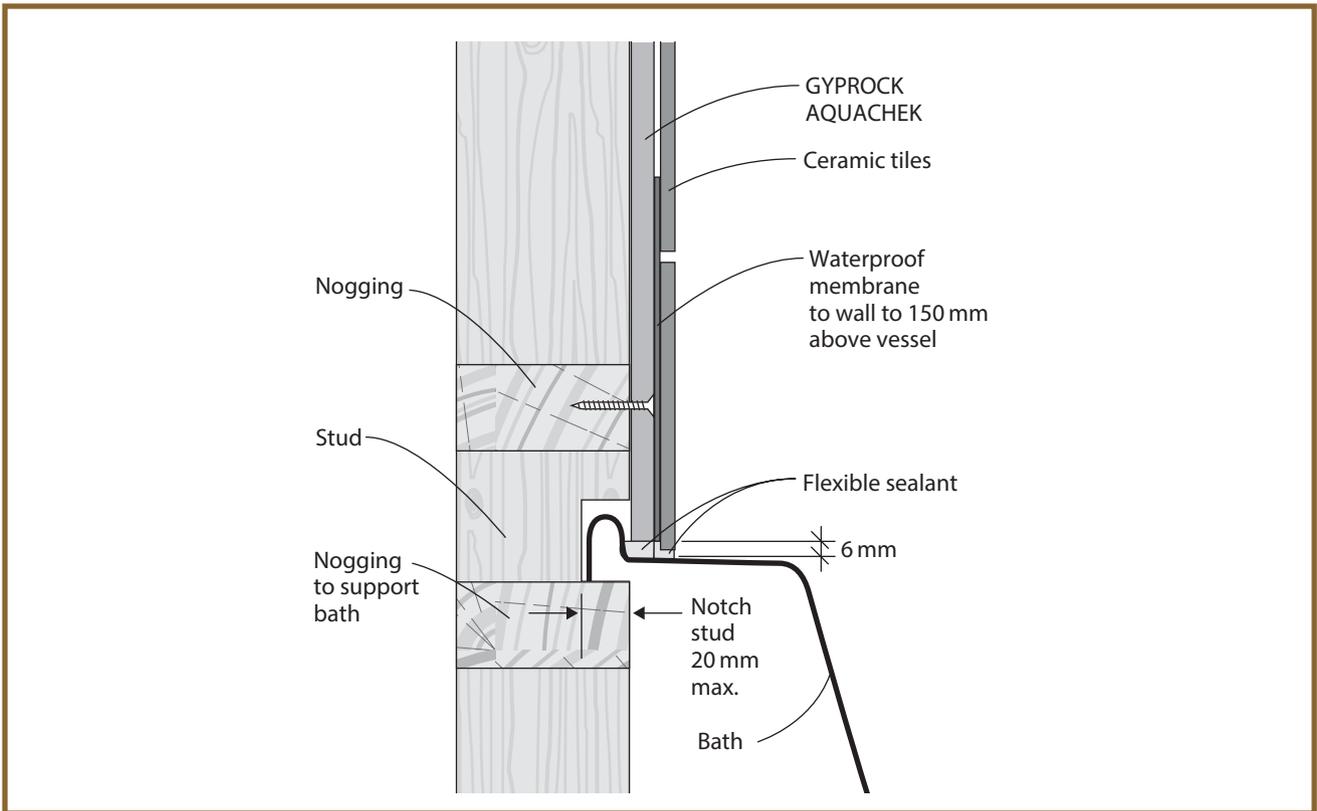
Source: Courtesy of Gyprock

Fig. 6.27 Unenclosed shower over a bath



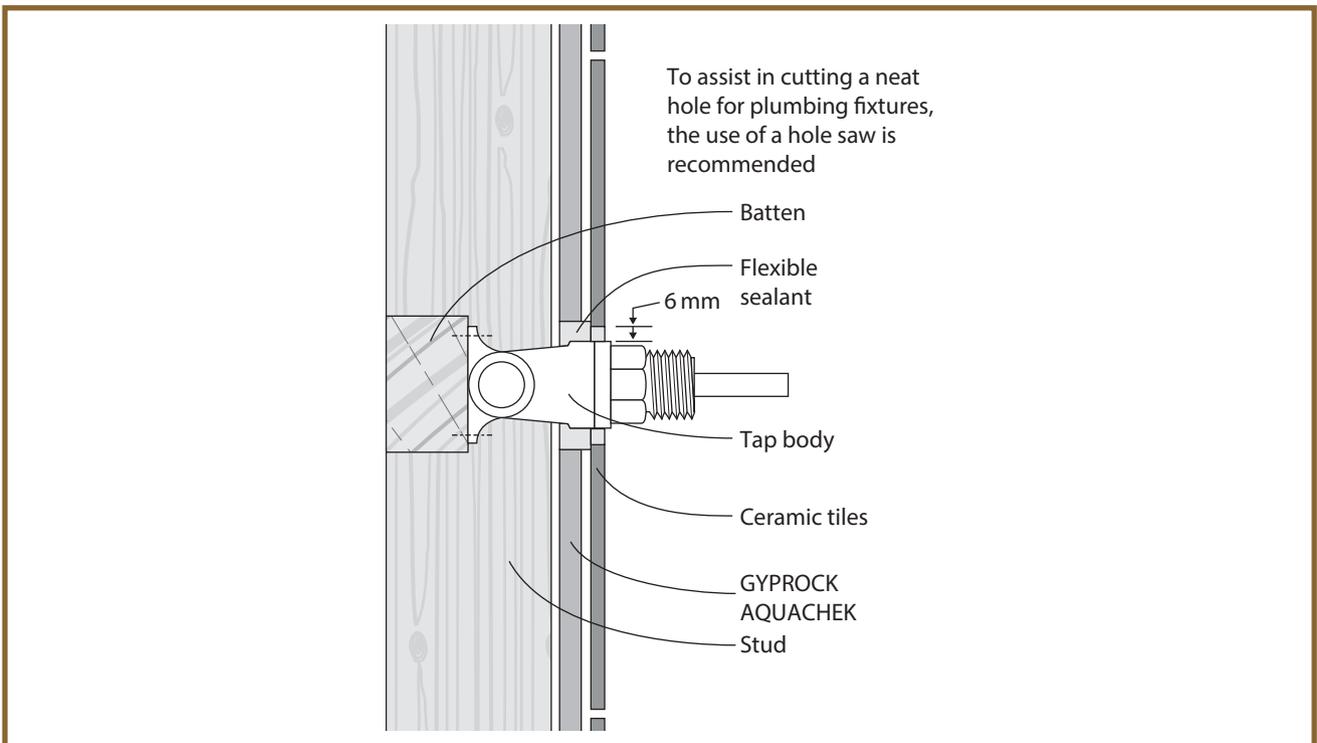
Source: Courtesy of Gyprock

Fig. 6.28 Tap installation-elevation

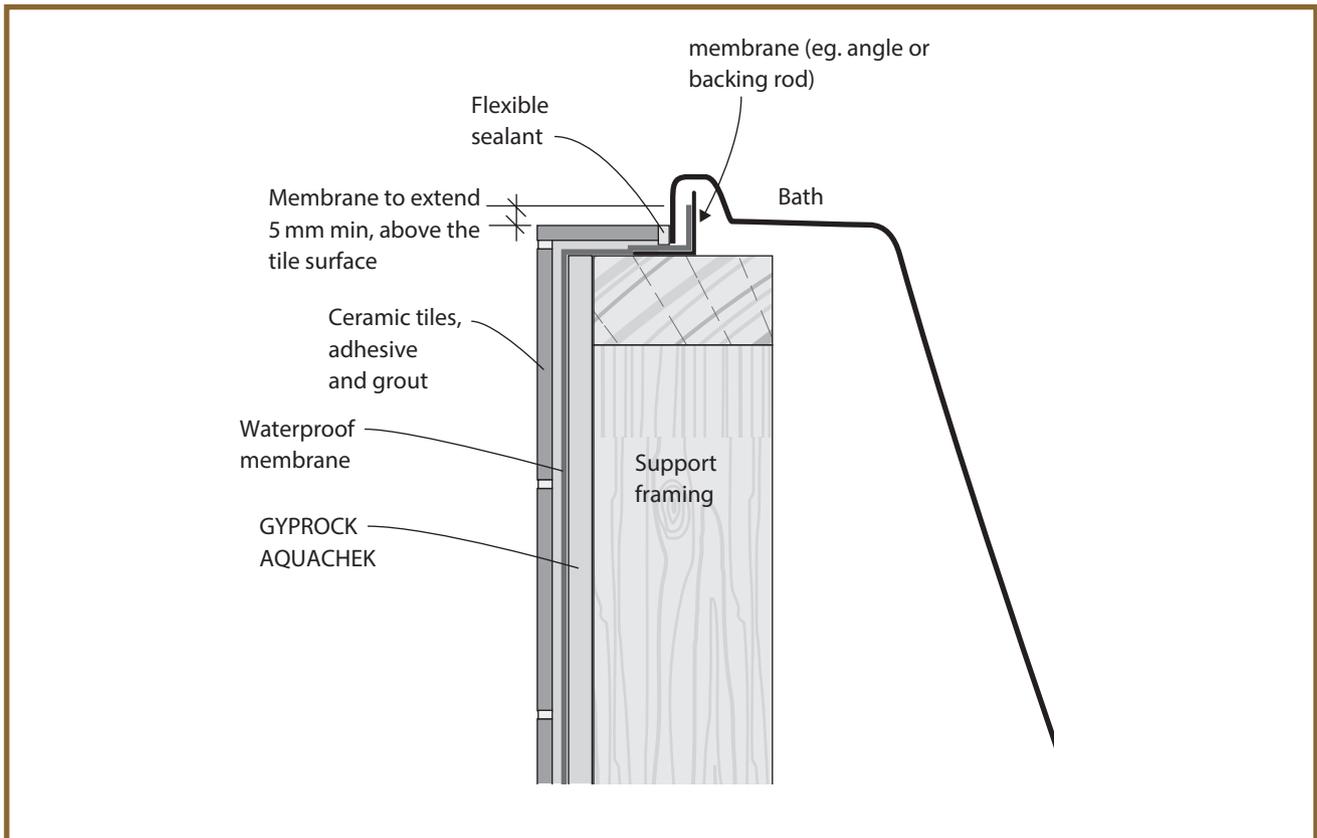


Source: Courtesy of Gyprock

Fig. 6.29 Bath installation



Source: Courtesy of Gyprock

Fig. 6.30 Exposed bath edge

Source: Courtesy of Gyprock

Student research

1. Search the internet for information about the use of curved plasterboard finishes. Compare the differences in the installation procedure between straight walls and ceilings and curved walls and ceilings.
2. Search the internet to identify the key issues related to installing plasterboard ceilings to garages and outdoor covered areas.

Organic insulation materials

Reducing fossil fuel use is the greatest challenge for sustainability. Insulation has the greatest potential role in buildings for reducing greenhouse gas emissions. Energy conserved through insulation use over time far exceeds the energy used in its manufacture. Many insulating materials are available for selection that comply with Australian Standards, ranging from the familiar mineral wool and polystyrene to low-energy alternatives produced from renewable and recycled materials:

- wool insulation—made from sheep wool in bats and rolls, with a polyester binder and treated for insect and fire resistance; used in roof and wall (breathable) construction
- cellulose insulation—bats made from recycled waste paper and newspaper and treated for fire resistance and insect/fungi attack; can be used in roof, wall and upper floor construction; and is available in loose form for pouring or spraying
- wood wool insulation—made from wood thinnings and sawdust combined with a binder of polyester and treated for fire resistance; breathable material, used in roof and wall construction
- wood fibre insulation—made from wood chips from saw mills, soaked then pressed and dried without any binder
- hemp insulation—hemp mixed with recycled cotton or wood fibres with a polyester binder and treated for fire resistance; breathable material, used in roof, walls and floor construction
- flax insulation—made in bats of flax with a polyester binder and treated for fire resistance; breathable material, used in roof, walls and floor construction.

PART 4

Joinery

Chapter 7 Joinery joints and products

Chapter 8 Window and door construction

Chapter 9 Curved work and mouldings

Chapter 10 Stair construction

Chapter 11 Internal joinery

Tradie profile

Matthew Neale – Carpenter (subcontractor)

What is the biggest job you have done?

My biggest job was at the Chadstone campus of GippsTAFE, a multi-level construction that was completed over two years. I was involved in most aspects of the carpentry, including framing, cladding and fitting out.

And the most difficult job?

The refurbishment of the old Collingwood Town Hall, from late 2012 to early 2014, at a cost of approximately \$13.8 million. The Town Hall was constructed in the 1880s and the building is heritage-listed so extreme care is required for any work undertaken. There are a lot of highly detailed skirting boards, architraves and columns as well as ceiling work, and these must be retained in their original condition. Sections of flooring had to be pulled up to allow for a new fire service, cables and plumbing to be installed. Anything removed from the building has to be labelled and put back exactly as it was. Any damaged materials cannot just be re-ordered from the timber yard; special orders have to be made for the reproduction of materials that match the original.

What do you enjoy about your job?

Because carpentry is such a diverse trade, no day is ever the same. There are always different scenarios on every job you undertake. I really enjoy it when a client comes back and says how impressed they are with the end product. One job I did recently was for an architect on his own job and part of the work was a special ply ceiling. This project was shown on the Melbourne Open House Day and it had 400-plus visitors. There were a lot of good comments on the ceiling work we had done. The architect, one of the best known in Australia, was really impressed, and to impress someone like that gives you a lot of satisfaction.

What advice do you have for future carpenters?

While going through your apprenticeship you should try to stay focused and not just go through the motions. Try and learn as much as you can while you have the opportunity so that when you complete your time you will be ready to go out there and do it yourself.



Joinery joints and products

LEARNING OBJECTIVES

- 7.1 Framing joints
- 7.2 Carcase joints
- 7.3 Joints for widening timber

This chapter covers the more advanced joints used and construction techniques in the production of furniture, timber doors, timber windows, and so on. The techniques shown are geared towards traditional hand tool methods; however, the substitution of power tools or static machines in many cases would be the norm in today's industry. Whether carried out using hand tools or power tools, attention to detail, clean working and a thorough knowledge and proficient use of the tools being used is necessary to produce high-quality work.

Framing joints

Framing joints are those joints that usually join members at right angles, such as those found in doors, windows and other framed units. However, before proceeding with details of the various joints, note the names given to the framing members in Figure 7.1. The *stiles* are the vertical side members. The *rails* are the horizontal members connecting the stiles and are named according to their location—top, middle or intermediate, or bottom.

Mortise-and-tenon joint

The mortise-and-tenon joint is probably the strongest and most universally used joint in framing, and is adaptable to many situations.

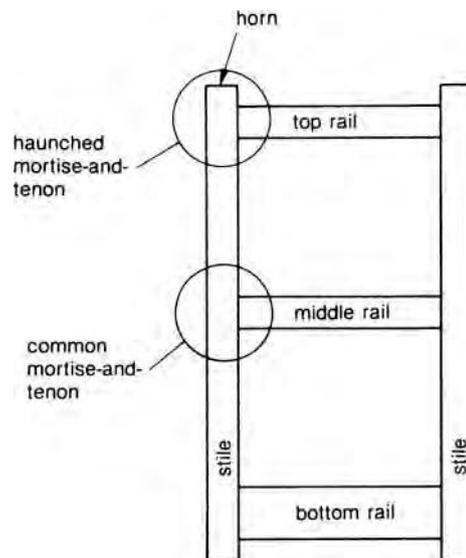
Common mortise-and-tenon joint

The common mortise-and-tenon joint (Fig. 7.2) is one in which the tenon is the full width of the rail and goes fully through the stile. A typical application would be the joint between a middle rail and stile.

The thickness of the tenon is made one-third the thickness of the stile or piece to be mortised, or is made to the nearest chisel size. This ensures equal strength between the tenon and the sides of the mortise. 'Through' tenons are held securely in the mortise by wedges which should penetrate the stile about two-thirds of the stile's width. To be effective, wedges should only be slightly tapered and not made to a sharp point.

Figure 7.3 shows the effects of both a correctly shaped wedge and one with too much taper. A tapered wedge allowance (WA)

Fig. 7.1 Framing members



is cut back on each end of the mortise. A suitable WA is one-twelfth the width of the stile.

It is not being suggested that one should start splitting millimetres or delve into the mortise to measure the wedge, but with experience and keeping these few rules in mind, the joiner will be able to estimate and proportion wedges that will serve their purpose effectively.

Haunched mortise-and-tenon joint

The haunched mortise-and-tenon joint is used where the joint is made at the ends of the stile, i.e. between the top or bottom rail and the stile (Fig. 7.1).

During manufacture, waste of 10 mm to 20 mm called *horn* is left on the ends of the stiles and is not removed until the item is finally being fitted. The horn serves a number of purposes: it strengthens the end of the stile while it is being worked (mortising and wedging); it can often be used to secure the framing during cramping-up and cleaning-off

Fig. 7.2 Common mortise-and-tenon joint

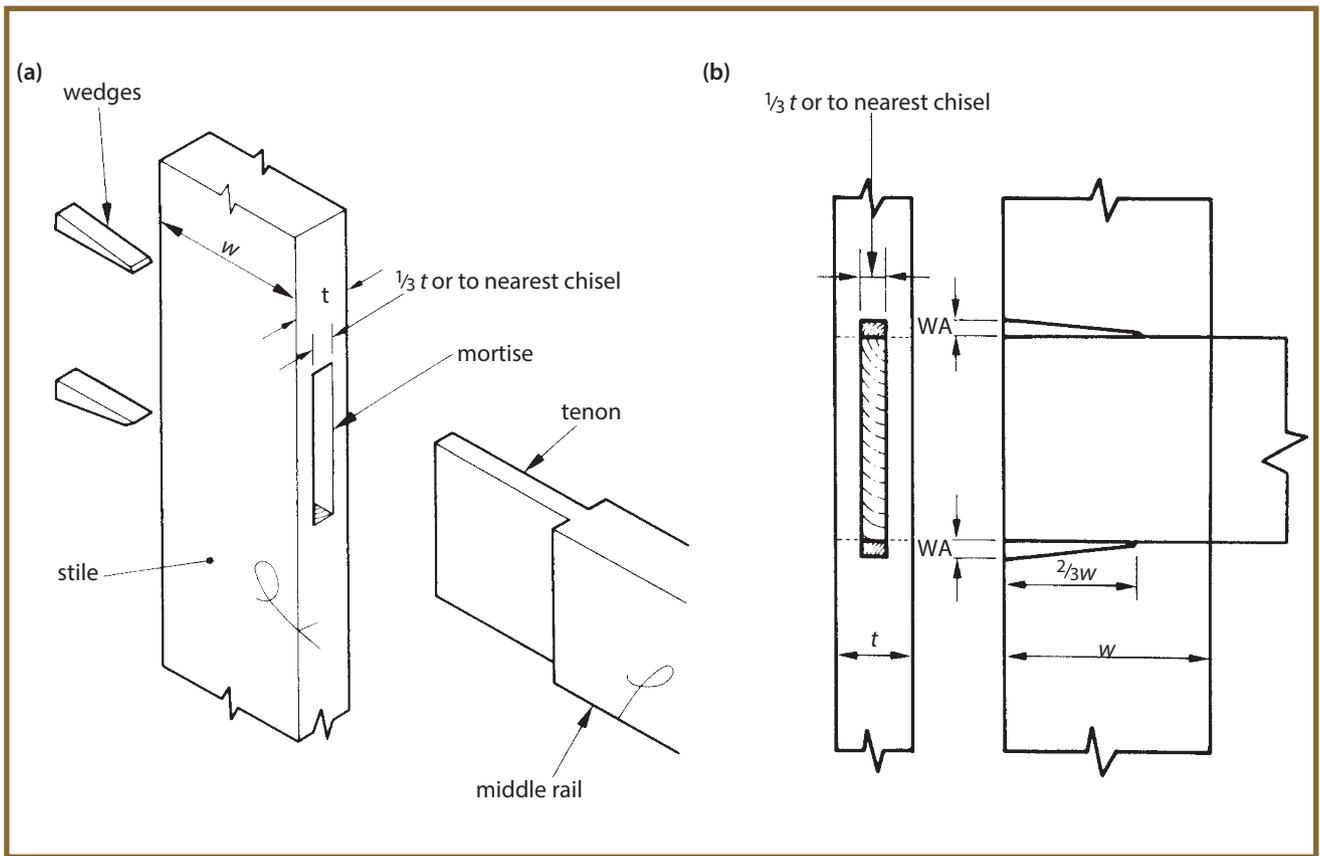
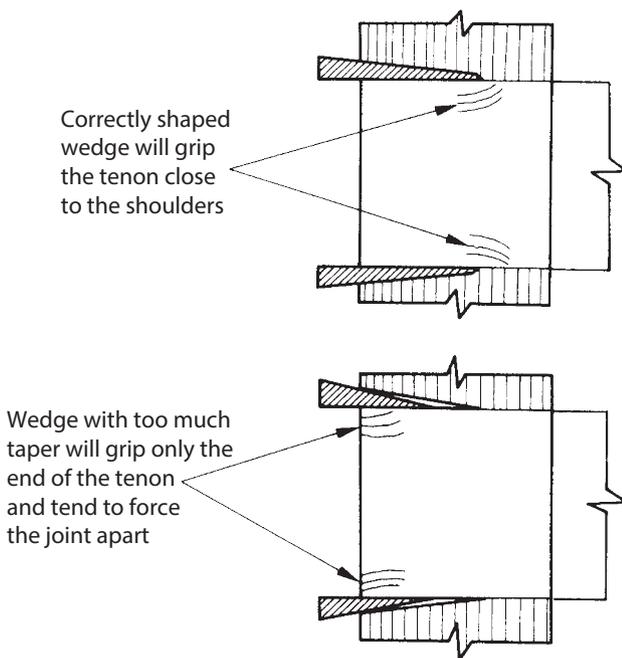


Fig. 7.3 Wedge shape



operations; and it will protect the ends during stacking and transporting. When the joint is finished, it can eventually be accurately flushed off.

If the tenon were made the full width of the rail, there would be nothing left to hold it in once the horn was removed. Therefore it is reduced in width and sufficient material is left on the end of the stile for the wedge to hold. A short portion of tenon, the actual *haunch*, is left near the shoulders to prevent the rail from twisting. The length of haunch is made the same as the thickness of the tenon, to a maximum of 12 mm. A rule for the width of the tenon is that it should be made two-thirds the width of the rail minus one WA (Fig. 7.4).

Other parts of the joint are proportioned as for the common mortise-and-tenon joint.

Faults

Some possible faults in mortise-and-tenon joints are shown in Figure 7.5.

Modifications to mortise-and-tenon joint

In joinery work, it is seldom that the mortise-and-tenon joint is as simple as so far explained. Where the joint is used for framing up doors or windows, the edges of the members may

Fig. 7.4 Haunched mortise-and-tenon joint

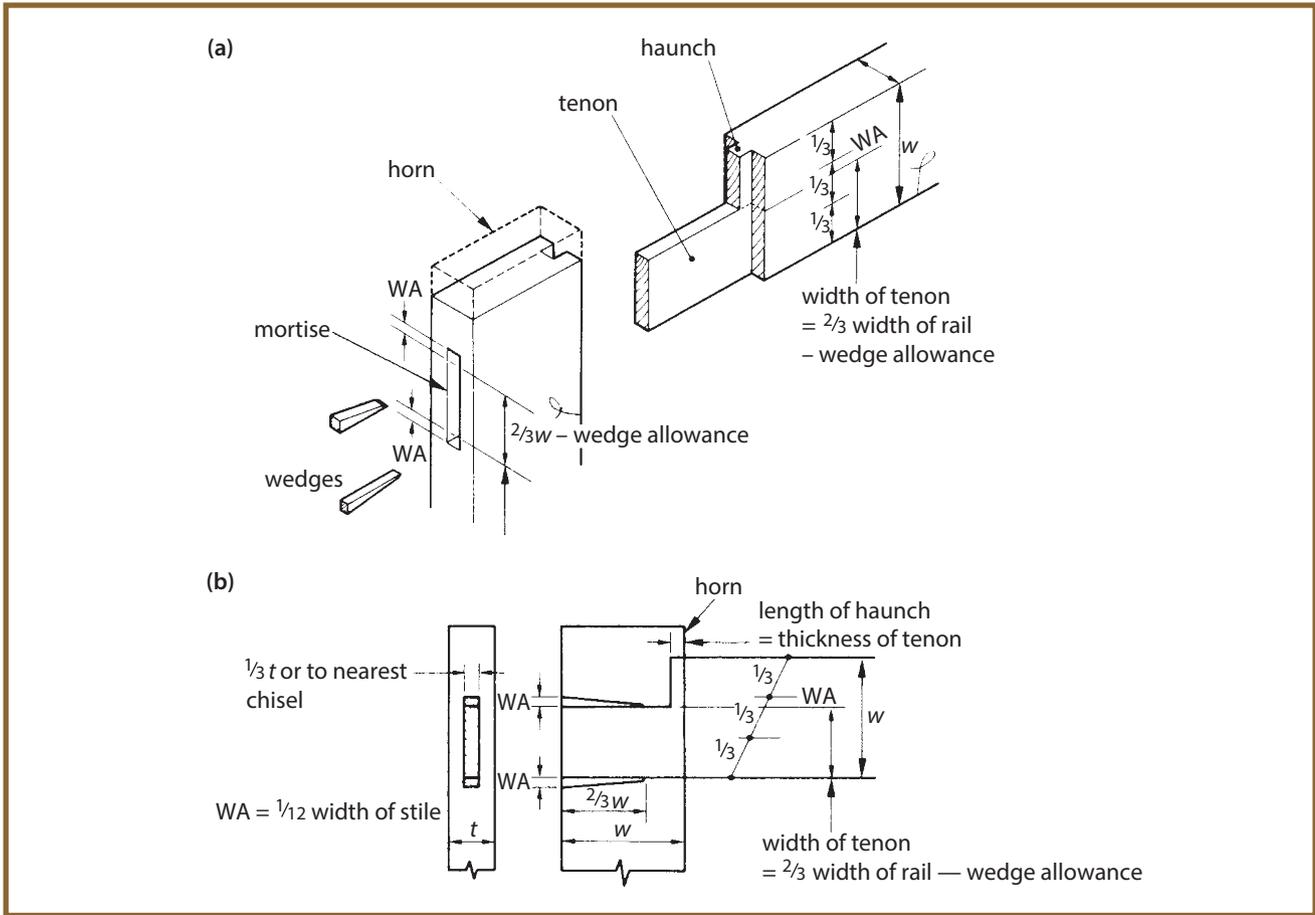
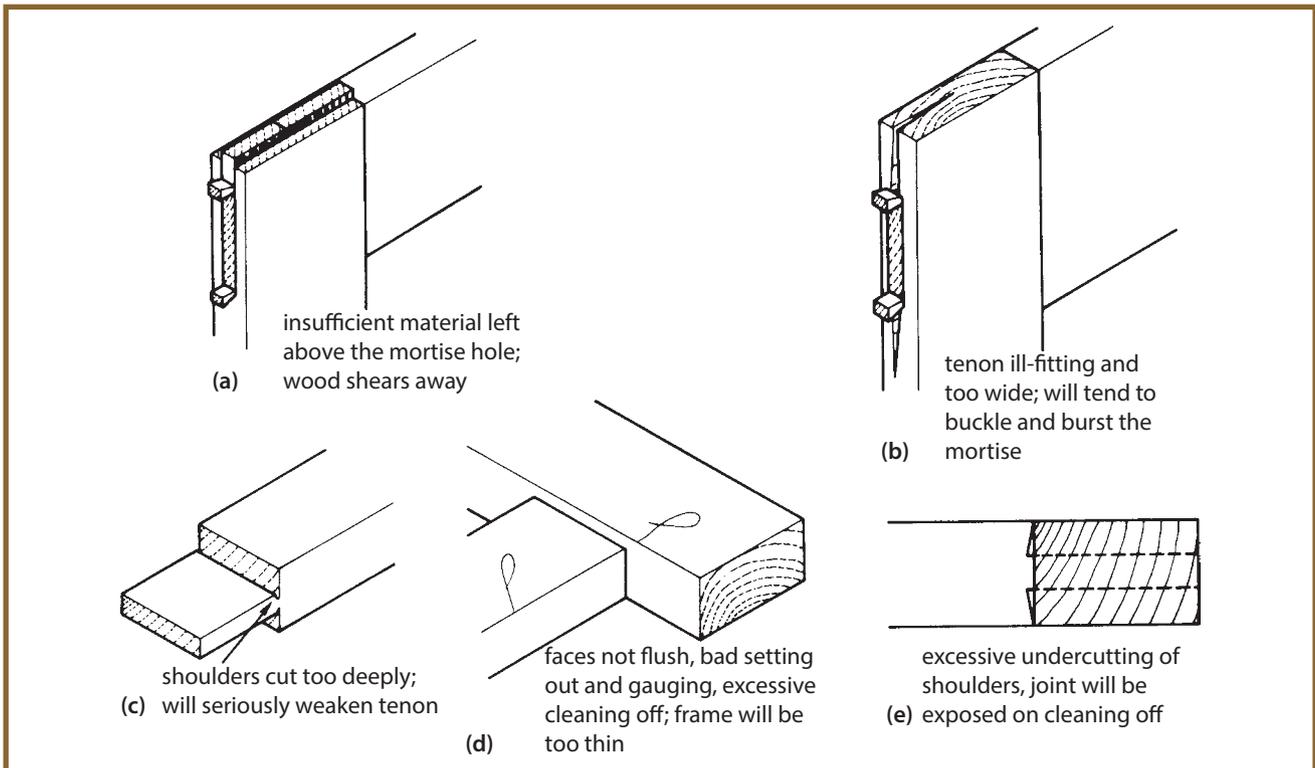


Fig. 7.5 Faults in mortise-and-tenon joints



be plough grooved or rebated to receive panels, and the joint must be modified accordingly.

Figure 7.6 shows a haunched mortise-and-tenon joint between a rail and stile where a plough groove has been run on the inside edges. To proportion the width of the tenon, the word 'effective' must be added to the rule: the tenon is made two-thirds the effective width of the rail minus one WA.

The effective width of a rail can be defined as the width of the middle one-third, this being the one-third on which the mortise and tenon are located. In this joint, the width of the plough groove is made the same as the thickness of the tenon; the haunch will fill the groove.

Double mortise-and-tenon joint

The double mortise-and-tenon joint is used where the rail is considerably wider than the stile, for example, the middle or bottom rail to a framed and panelled door. The stile would be badly weakened if a mortise were cut out long enough to receive a tenon the full width of the rail.

To correct this, a double mortise-and-tenon joint is used. The stile is not weakened and the wedging power is doubled. The width of a tenon should not exceed five times its thickness. The setting out is shown in Figure 7.7.

Fig. 7.6 Joint between top rail and stile

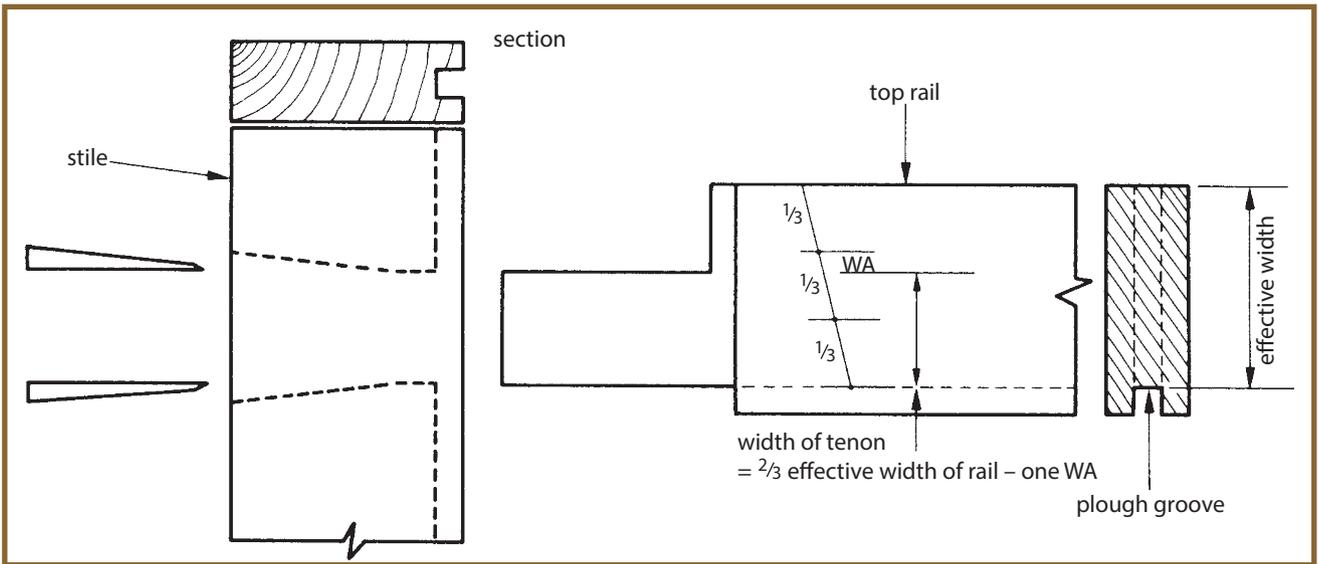
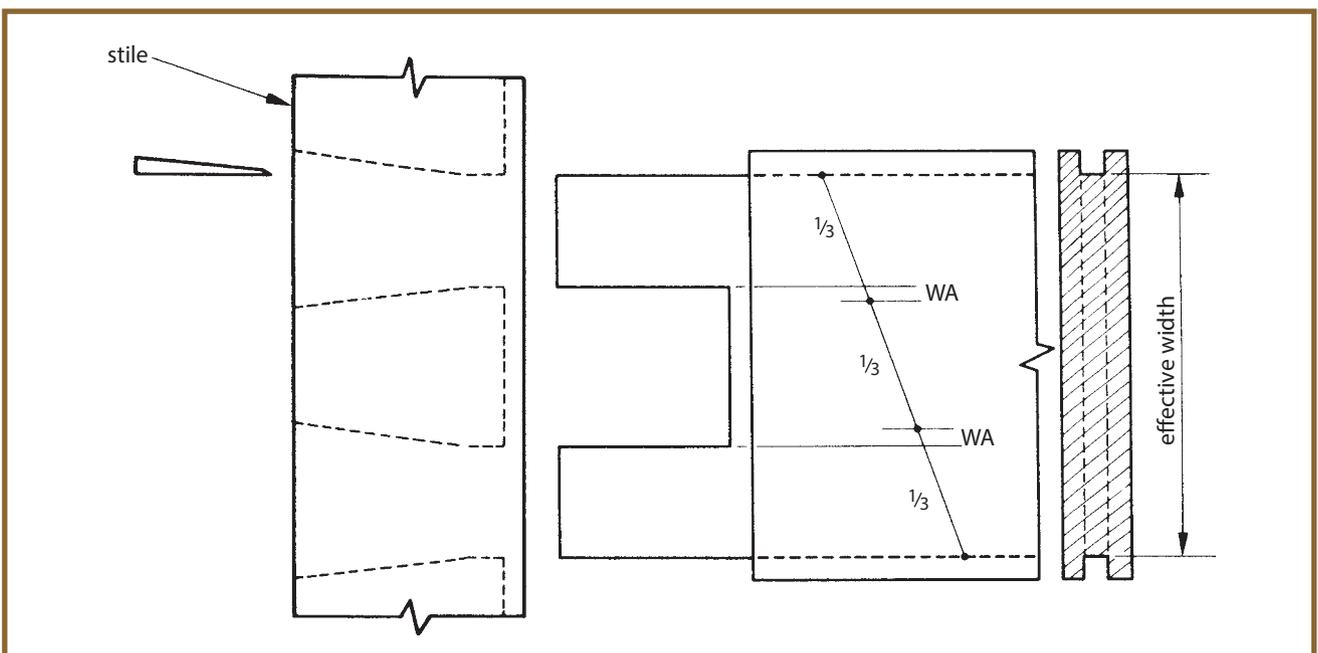


Fig. 7.7 Double mortise-and-tenon joint at the middle rail



Note that the effective width is divided into three parts and each tenon is minus one WA, taken from the middle of the rail.

Figure 7.8 shows the setting out for a wide bottom rail to a stile; besides a double mortise-and-tenon, an allowance has been made for a haunch. The effective width is divided into eleven equal parts and proportioned as shown. One WA is taken from the bottom of each tenon.

Long and short shoulder mortise-and-tenon joint

The inside edges of stiles and rails may be rebated to receive panels or glass; the shoulders on the rails are different in length. The difference in length is equal to the depth of the rebate.

When a neat appearance across the edge is more important than maximum strength, as for instance on showcase doors, the splayed haunch can be used. Note that the effective width is again divided into three equal parts when setting out the haunched tenon (Fig. 7.9).

Barefaced mortise-and-tenon joint

The barefaced mortise-and-tenon joint is used where the stile is thicker than the rail; this is the case in some doors where the sheeting is continuous over the face of the rail. In this type of mortise-and-tenon there is only one shoulder on the rail (Fig. 7.10).

The *double* barefaced mortise-and-tenon joint is suitable for a wide rail.

Twin mortise-and-tenon joint

When the rail is very thick, and a tenon one-third the thickness would mean the joint is weakened by an unusually large mortise, the twin mortise-and-tenon joint is used (Fig. 7.12).

Fig. 7.9 (a) Long and short shoulder mortise-and-tenon; and (b) splayed haunch

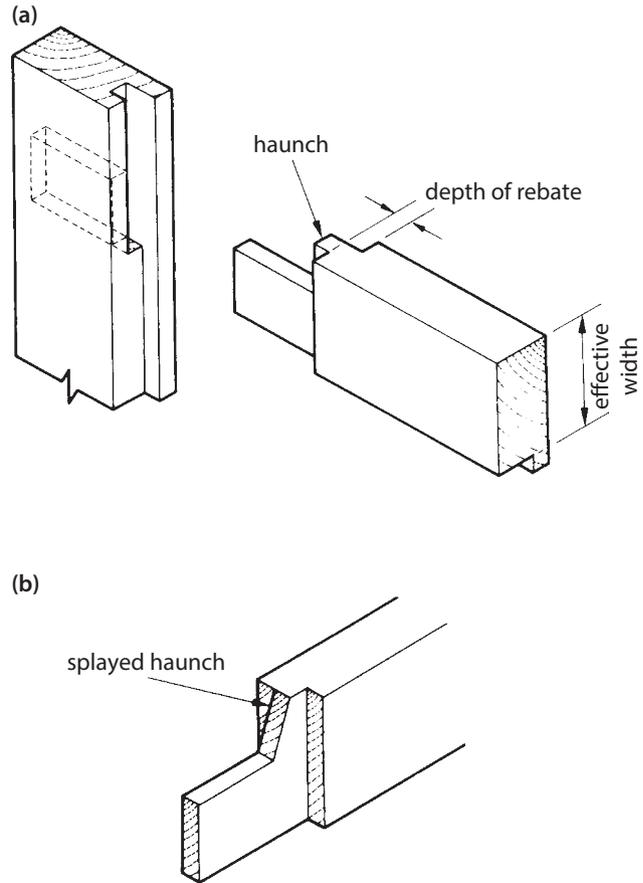


Fig. 7.8 Joint between bottom rail and stile

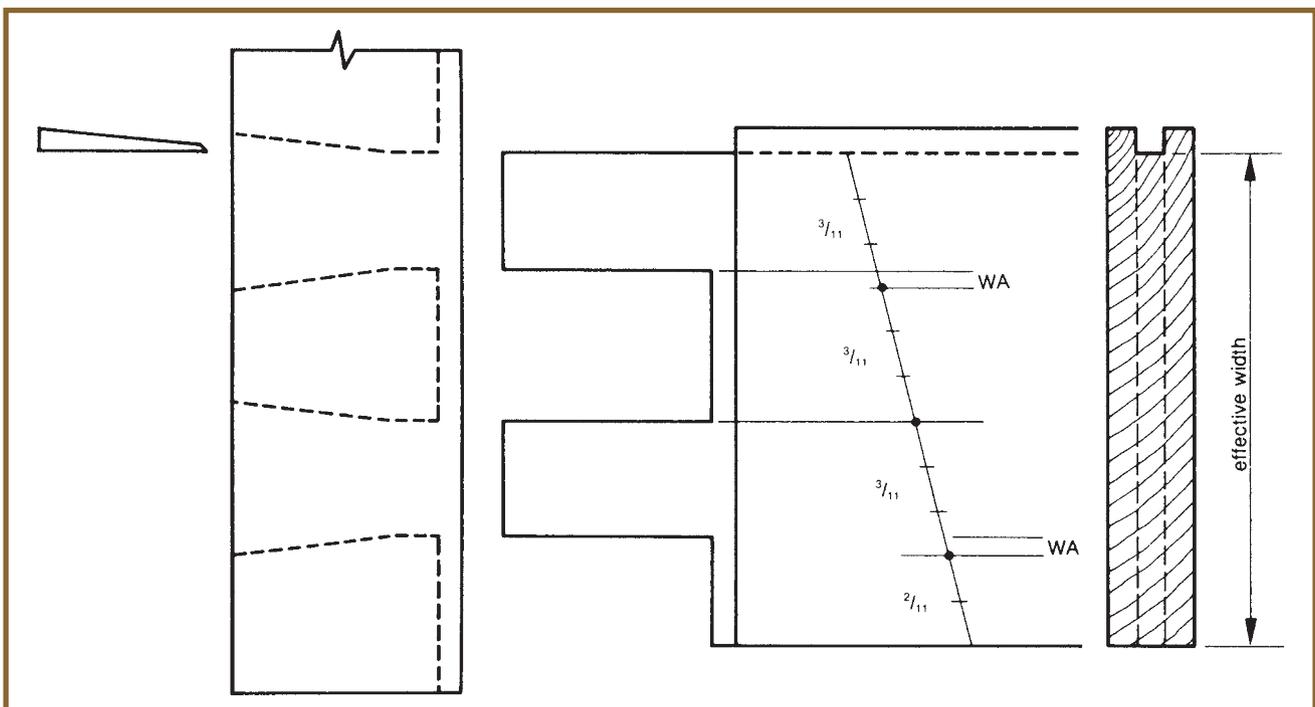


Fig. 7.10 Barefaced mortise-and-tenon joint

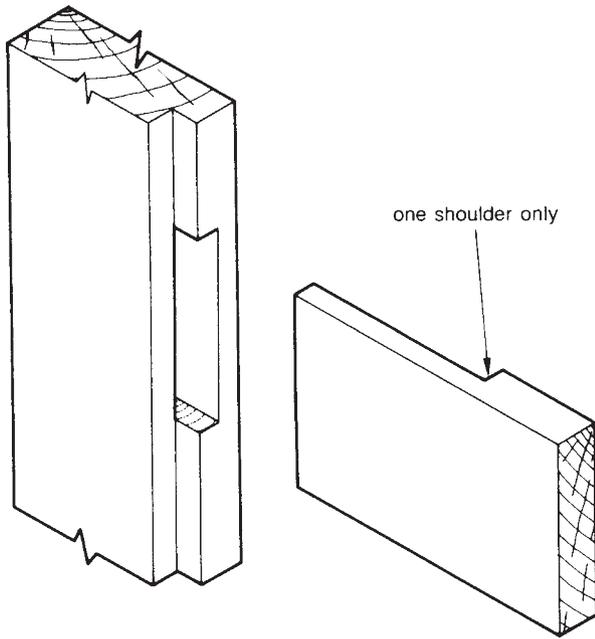


Fig. 7.12 Twin mortise-and-tenon joint

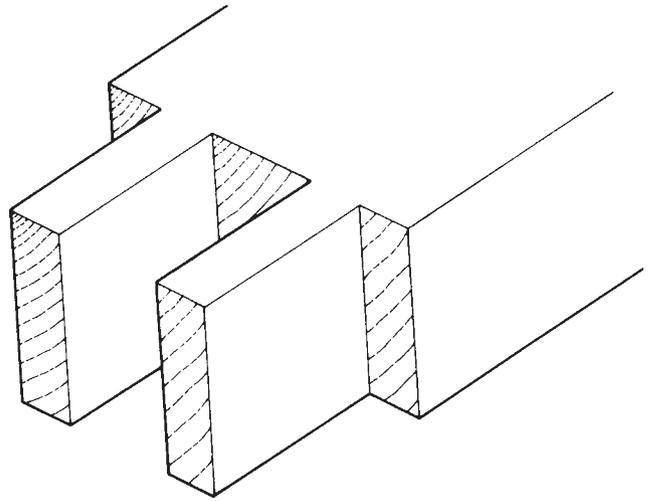


Fig. 7.11 Double barefaced mortise-and-tenon joint

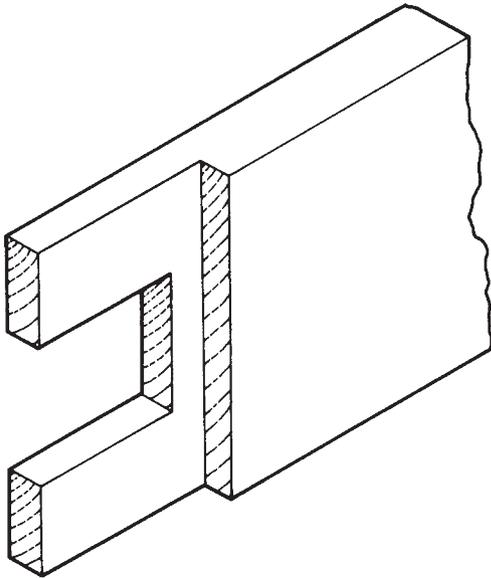
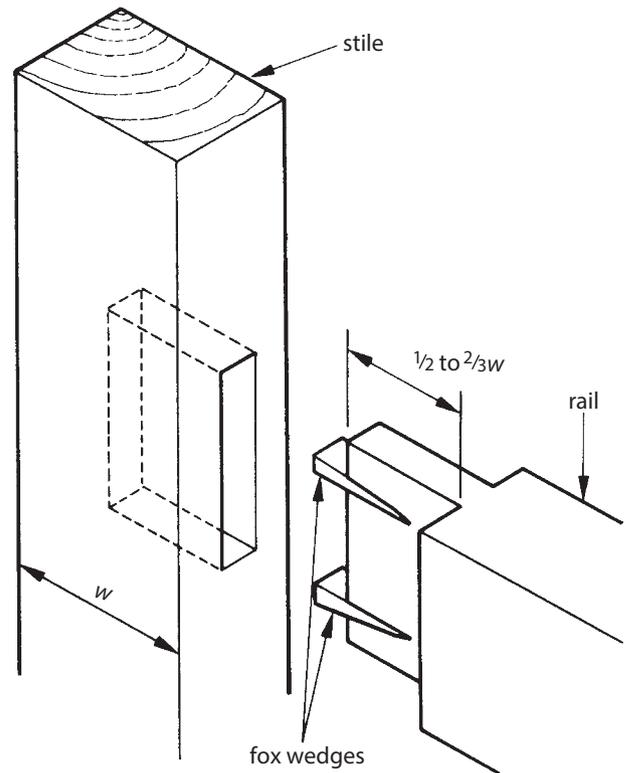


Fig. 7.13 Stump mortise-and-tenon joint



The rail is prevented from twisting and there is twice the gluing area.

Stump mortise-and-tenon joint

The tenon need not always pass fully through the stile. In cases where the end grain and wedges showing on the edges would be objectionable, for example, on cabinet doors, the stump (or stub) mortise-and-tenon joint could be used (Fig. 7.13).

The depth of the mortise is made one-half to two-thirds the width of the stile. The tenon cannot be wedged from the outside so it can be fitted neatly to the mortise and held with an adhesive, or alternatively it can be wedged using fox wedges.

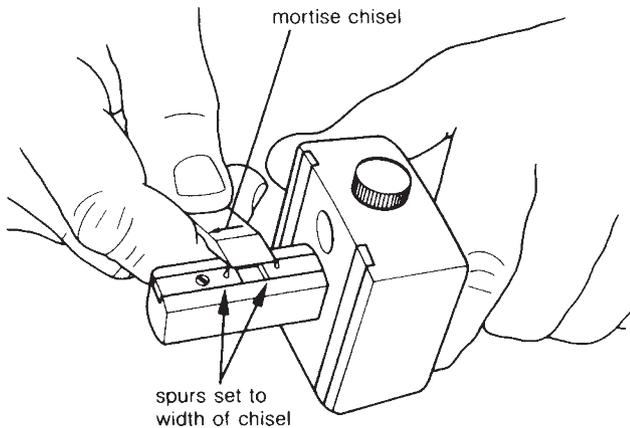
Fox wedging consists of inserting two small wedges into saw cuts in the tenon, which, on striking the bottom of the mortise, wedge the tenon as it is cramped into the mortise.

Making the mortise-and-tenon joint

The setting out of joinery items and the marking off of components in preparation for machining a mortise-and-tenon joint will now be dealt with more fully. Some pointers as to the use of hand tools in the marking out and cutting of mortise-and-tenon joints are included.

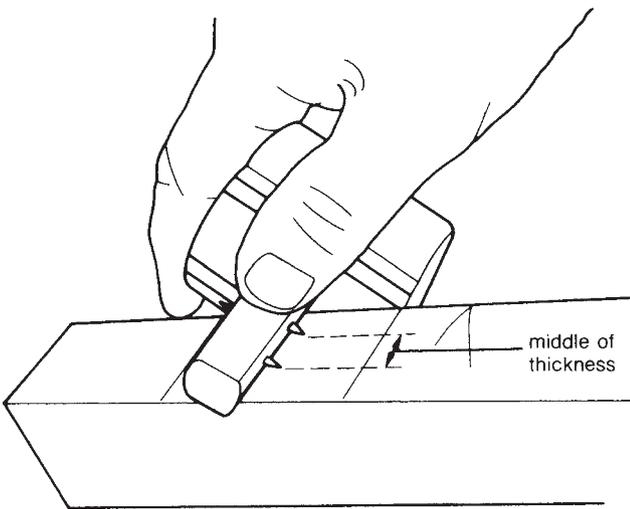
- Gauging.** Set the distance between the spurs of the mortise gauge to the width of the actual chisel used for mortising (Fig. 7.14).

Fig. 7.14 Setting the mortise gauge



Gauge the mortise and the tenon, one immediately after the other, using the same gauge and keeping the stock firmly against the face side (Fig. 7.15).

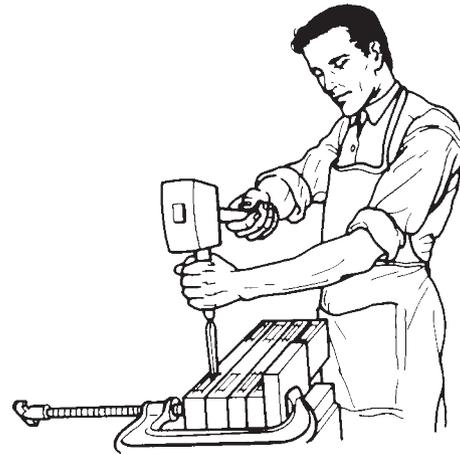
Fig. 7.15 Gauging the mortise-and-tenon joint



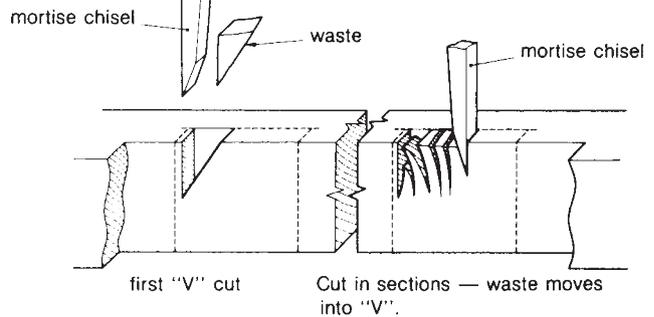
- Chopping the mortise.** To chop the mortise, hold the stile in the mortise block, face edge down. Stand as near as possible to, and in line with, the mortise to get a good view to ensure that the chisel is held straight (Fig. 7.16a). Commence near one end of the mortise and chop a 'V' with the chisel. Turn the chisel around and continue cutting in sections allowing the waste to move into space made by the 'V' (Fig. 7.16b).

Fig. 7.16 Chopping the mortise: (a) hold the chisel straight; and (b) the waste from each cut moving into the previously cut space

(a)



(b)



Cut half-way through and finish by squaring the ends down accurately. A number of cuts to chop up the waste more finely will make it easier to remove. The mortise should finish up exactly the same width as the chisel, and it should never be necessary to turn the chisel and pare away at the sides. Turn the timber over and repeat the process from the face edge. Chop up the waste more finely and then remove it with a core driver which is a tapered piece of hardwood slightly smaller than the mortise hole. Finish by cutting back the WAs tapered to about two-thirds the width of the stile.

- Ripping the tenon.** Small tenons can be cut with the tenon saw; however, an experienced tradesperson would do the job much more quickly and easily with a hand saw. Hold the timber in the vice, leaning away at about 45°. Keep on the waste side and, following the two lines visible, rip one-half of the tenon diagonally. Turn the timber around and follow the line along the third side, finishing with the saw square to the shoulder.

Fig. 7.17 Ripping the tenon

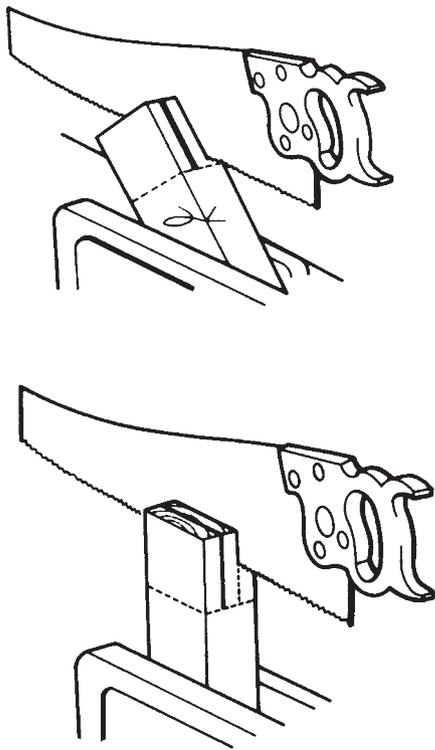
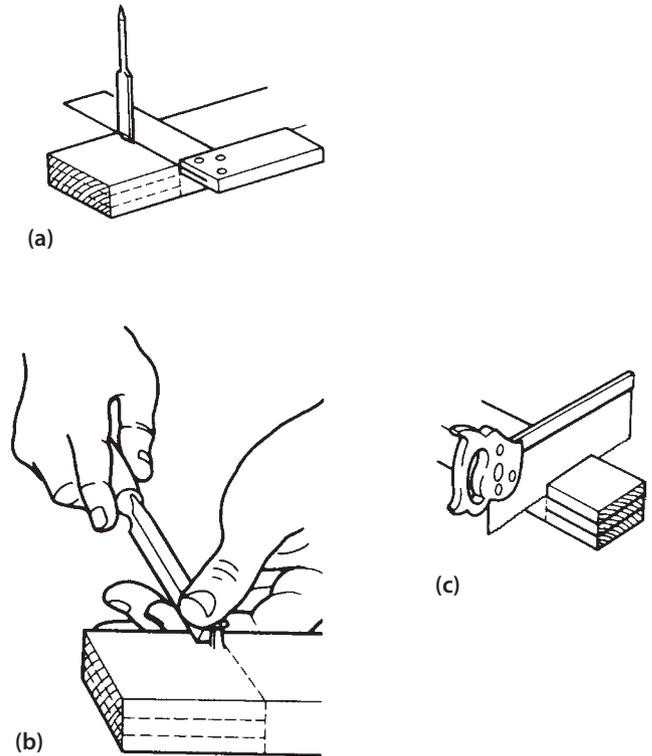


Fig. 7.19 Cutting the shoulder line: (a) knife cut to shoulder line; (b) form recess and (c) complete cutting shoulder line

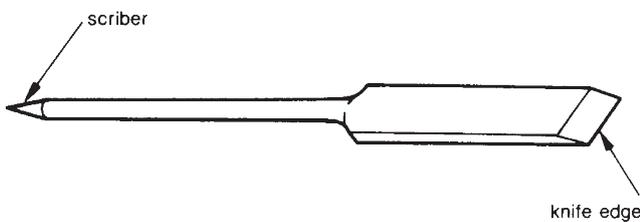


The tenon should fit straight off the saw with only very minor smoothing of the cheeks. Always rip first and then cut the shoulder line.

4. **Cutting the shoulder line.** The initial setting out is usually done with a sharp pencil. However, a much cleaner and accurate shoulder may result if the shoulder line is cut using a marking knife.

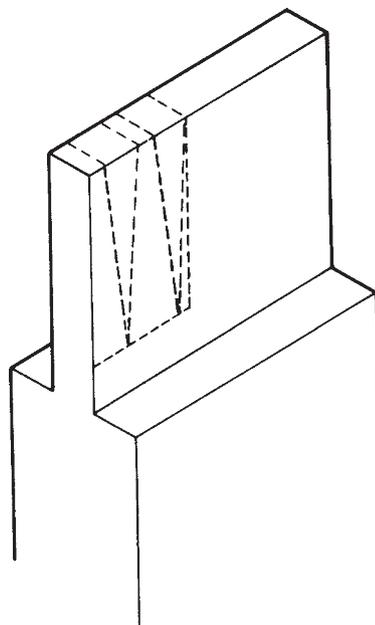
5. **Cutting the wedges from the waste.** Remember that wedges will be required when a haunch is being cut. Wedges can be cut from the waste which will have the exact thickness required.

Fig. 7.18 Marking knife



Place the blade of the knife on the line, slide the try square up to it and cut the line. If a small recess is chiselled on the waste side of the line, it can then be continued with the tenon saw (Fig. 7.19), only slightly undercutting the shoulder.

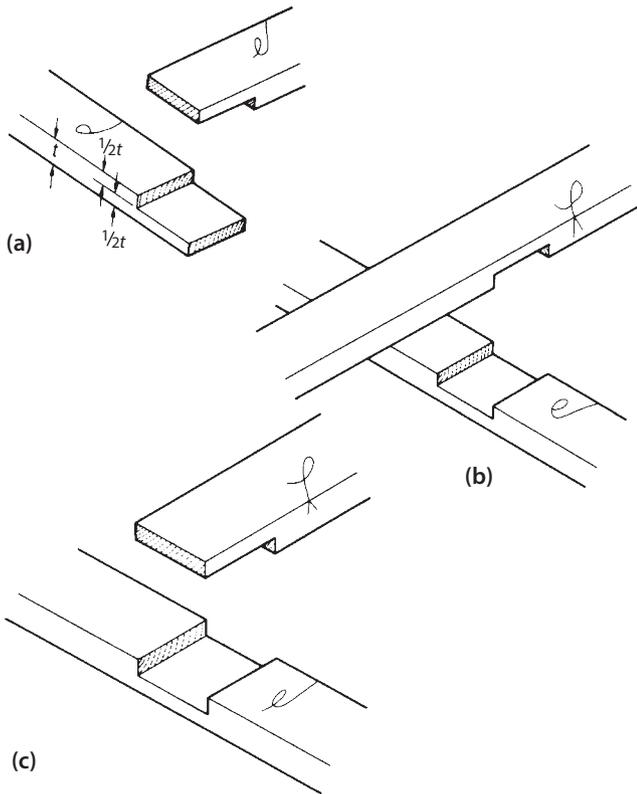
Fig. 7.20 Cutting wedges from waste



Half-lapped joint

The half-lapped joint is also called the *halved joint*. The half-lapped joint in timber frame construction is described in Volume 1 Chapter 5; this joint also finds applications in joinery and cabinet work.

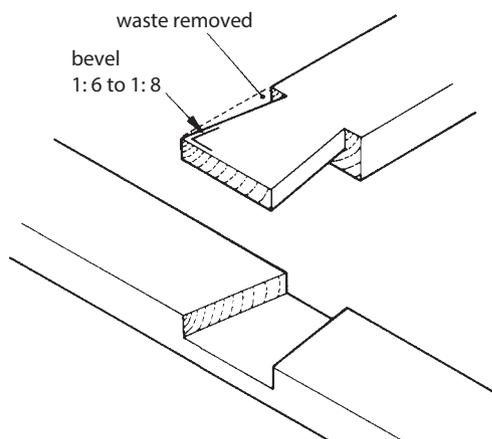
Fig. 7.21 (a) Corner halved joint; (b) cross halved joint; (c) tee halved joint



Set the gauge to one-half the thickness of the timber and gauge both parts from the face side. Cut the halvings, following the same procedure as for the cheeks of the tenon, that is, rip first, cross cut second.

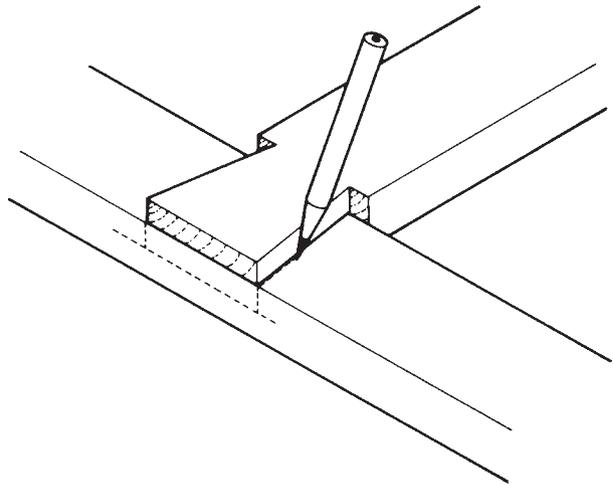
A modification of the half-lapped joint is the dovetailed tee halved joint (Fig. 7.22). From the dovetail, lay it in position

Fig. 7.22 Dovetailed tee halved joint



on the second piece and with a sharp pencil mark the bevel (Fig. 7.23). The sides of the tapered trench are then cut on the waste side, leaving the pencil line clearly visible. The dovetail should be a close fit, acting as a wedge drawing the shoulder together.

Fig. 7.23 Marking the dovetail



Cutting a trench

The four steps in cutting a trench are illustrated in Figure 7.24. This is applicable to housed joints as well as to the dovetailed tee halved joint and the bridle joint.

Dowelled joint

The dowelled joint consists of mating holes, drilled into the two parts, into which round pegs called *dowels* are inserted, joining the parts together. When correctly proportioned and assembled with a suitable adhesive, the joint is adequately strong for most purposes; there is a saving in timber as the rails are cut off at the shoulder line.

Dowels are made from hardwood or softwoods, in the standard diameters of 6, 8, 10 and 12 mm. Dowels have a fluted circumference which ensures a firm grip on the dowel hole. The fluting also allows the surplus glue and air to escape from the bottom of the hole as the dowel is driven home. Dowel rod is available in long lengths from 1 m to 2 m, or dowels may be ready-cut to length and pointed.

The most common diameter size in dowel is 10 mm. The dowel should not be an overtight fit in the hole; if the dowel is too tight it will probably split the timber.

The setting out of dowels on the ends of the rails is shown in Figure 7.27. The ideal proportions are shown.

A little compromise may be necessary at times to fit the dowels onto a narrow rail. Remember, however, that a stronger joint may result if a small size of dowel is used rather than a dowel which is too large for the job, seriously weakening the timber around the dowel.

Fig. 7.24 Four steps in cutting a trench

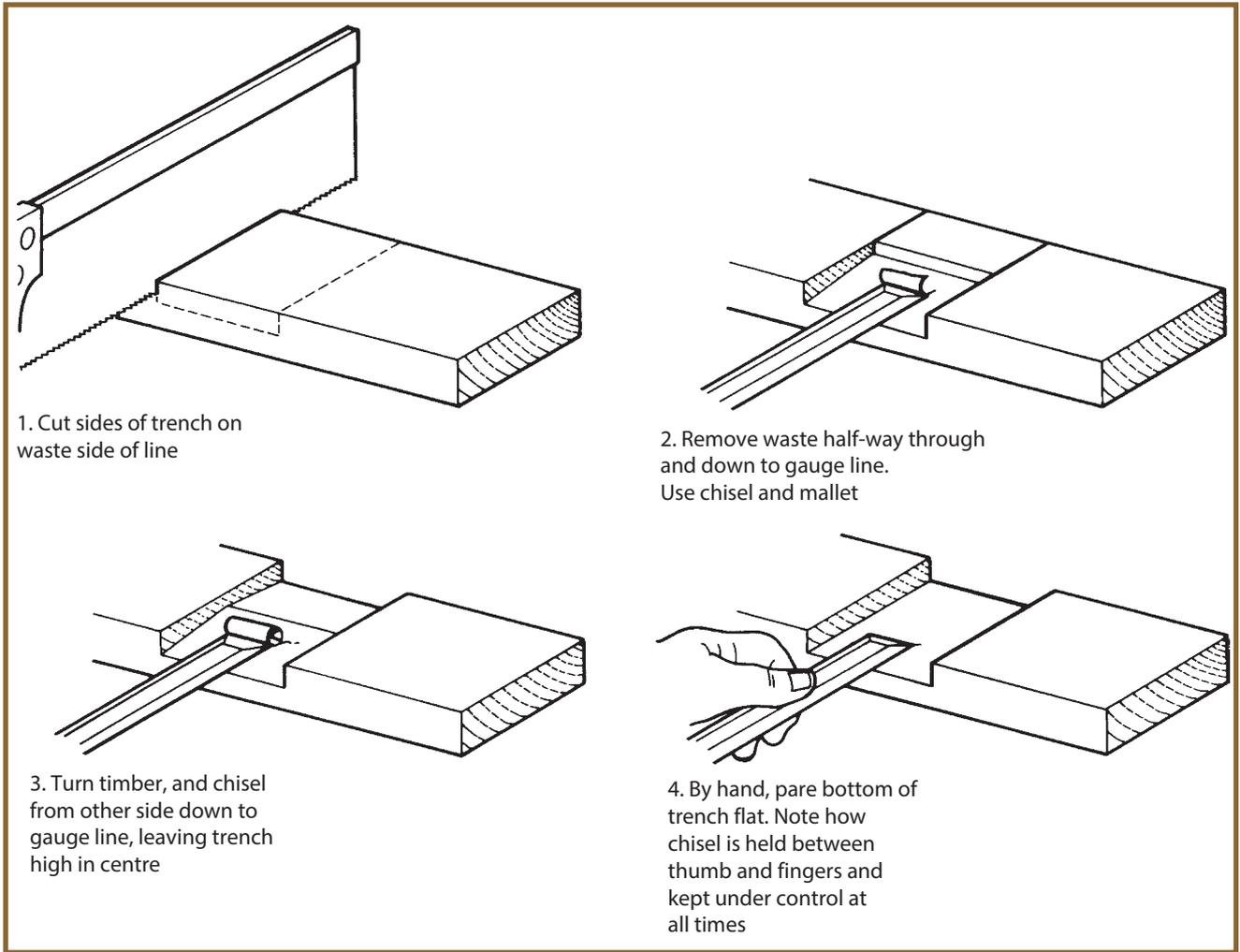


Fig. 7.25 Dowelled framing joint

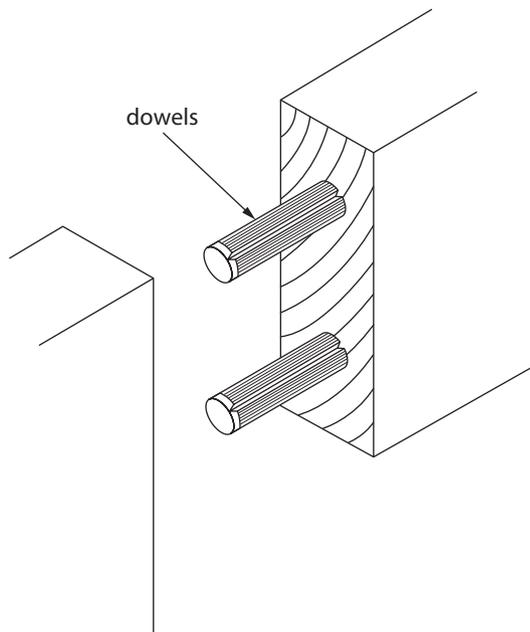


Fig. 7.26 Dowel profiles

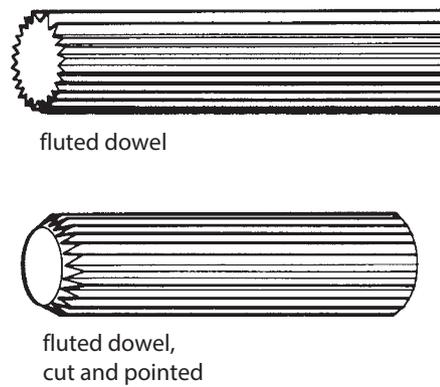


Fig. 7.27 Setting out dowels

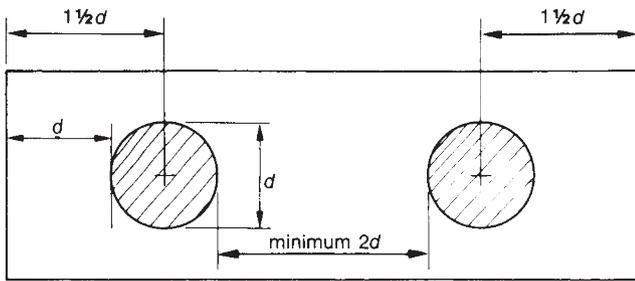


Table 7.1 Dowel selection chart

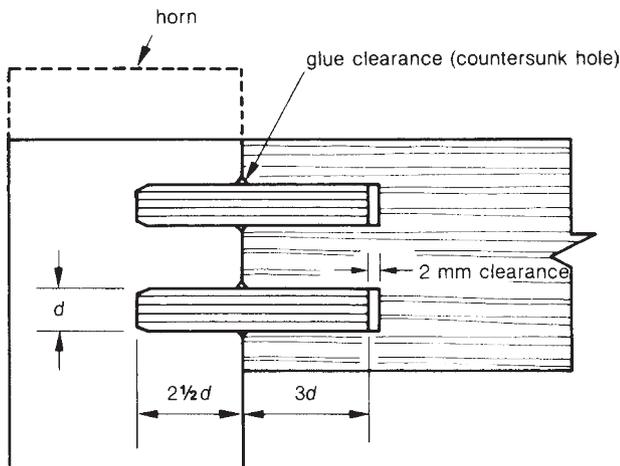
Diameter of dowel (mm)	Thickness of timber (mm)
6	10–14
8	15–18
10	19–26
12	27–32

Table 7.1 is a guide to the diameter of dowels to use relative to the thickness of the timber to be dowelled. Because 10 mm is the most common diameter of dowel, it is used over a slightly wider range of timber thicknesses than are the other sizes. If the two parts forming the dowelled joint are of unequal thickness, the dowels must be chosen to suit the thinner of the two.

The dowels used must be long enough to penetrate each part of the joint sufficiently so that maximum strength is attained. Penetration can vary from two to a maximum of three times the diameter.

The dowel holes must be drilled deep enough to allow at least 2 mm clearance beyond the end of the dowel. The use of a large countersink bit to form a small glue clearance around the hole will also help when cramping the shoulder of the joint tightly together.

Fig. 7.28 Dowel penetration

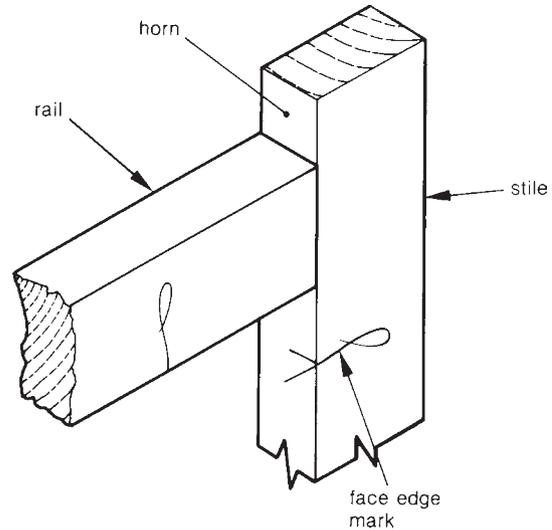


On wide rails, more than two dowels can be used provided there is sufficient material left between the dowels, say a minimum of twice the diameter.

Making the dowelled joint

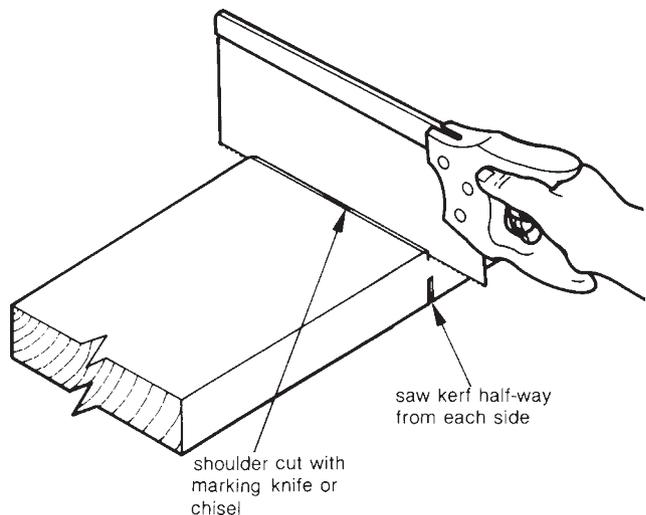
The procedure for making the dowelled joint, as found on the corner of a piece of dowelled framing, is outlined below. Note the direction of the face and face edge marks in Figure 7.29.

Fig. 7.29 Corner of a dowelled frame



1. **Cutting shoulder lines to rails.** To cut the shoulder lines to the rails using the tenon saw, first square completely around the shoulder line, cutting with the marking knife, and chisel a small groove beside the cut line in a similar manner as for the mortise-and-tenon joint.

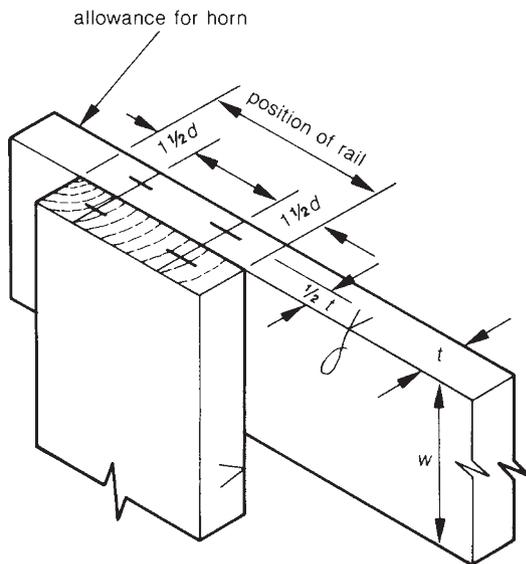
Fig. 7.30 Cutting the shoulder



Continue to cut the shoulder with the tenon saw, only very slightly undercutting. Cut until half-way through, turn the rail over and repeat the process, meeting up with the first cut.

2. **Marking out.** The dowel holes in the stile and rail must mate together. First, mark the position of the rail on the face edge of the stile and mark the dowel centres.

Fig. 7.31 Setting out dowel centres



Transfer the dowel centres onto the end of the rail and square them across.

Set the marking gauge to half the thickness of the material and, keeping the stock to the face side, gauge the centres for the holes. Depending on the equipment available to bore the holes, it may only be necessary to gauge the position of one hole which can then be used as a guide to setting up a dowel jig or machine to the required setting.

3. **Boring the dowel holes.** The *dowelling jig*, shown in Figure 7.32, used in conjunction with a dowel bit in the electric drill, is a fast and accurate way to reproduce holes. The jig is supplied with a number of bushes to suit the size of dowel drills—6, 8, 10 and 12 mm. The bush provides the guide for the drill and can be adjusted to drill holes a fixed

Fig. 7.32 Dowel jig

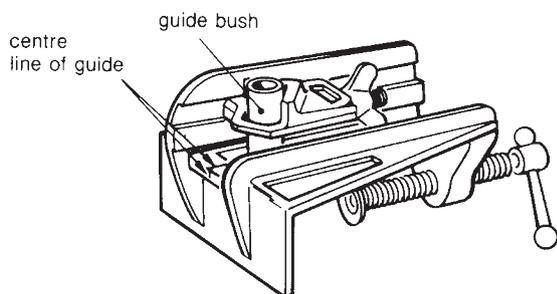
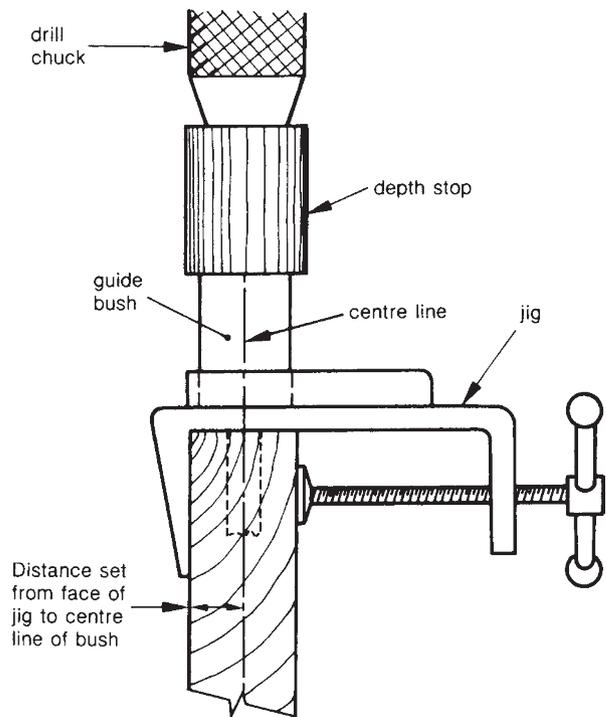
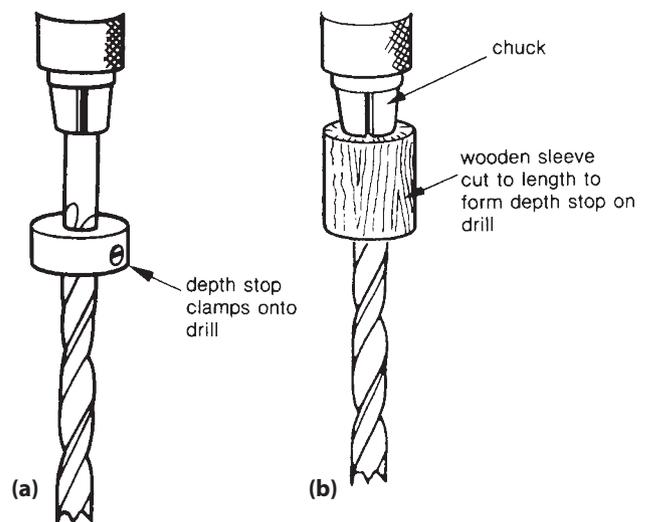


Fig. 7.33 Setting up the dowel jig



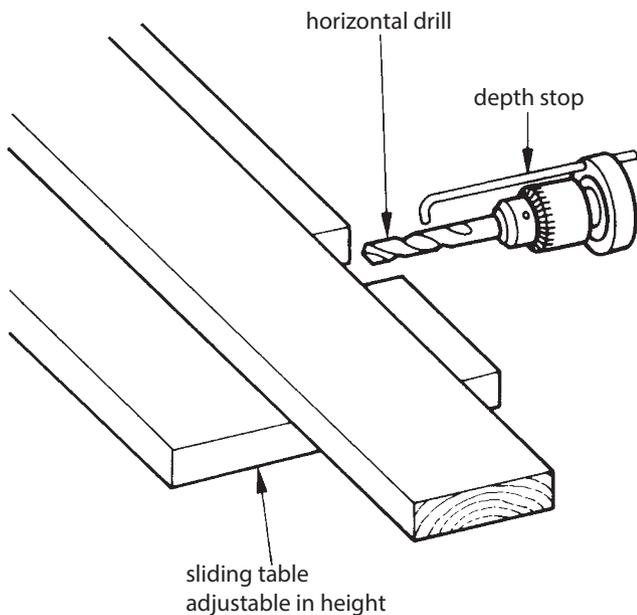
distance from the face side. A mark on the front of the jig enables it to be lined up accurately with the line of the hole. To use the dowelling jig, select and fit the required guide bush to the jig and adjust the centre of the bush to the gauge line for the centre of the dowel holes. Clamp the jig to the timber, aligning the mark on the jig with the line of the hole, and drill the hole to the required depth. A depth stop is necessary on the drill and there are a number of types available that clamp onto the drill. A most effective stop can also be made up as follows: drill a hole lengthwise through a piece of wood and cut off to length; round the corners and fit over the drill (Fig. 7.34).

Fig. 7.34 Depth stops



The *dowel borer* is basically a horizontal drill mounted over a table which is adjustable in height (Fig. 7.35). To set up a dowel borer, fit a drill of the required size and adjust the height of the table so that the distance from the table to the centre of the drill is equal to the distance from the face of the material to the centre of the dowel hole. Set the depth stop to drill the holes to the required depth.

Fig. 7.35 Dowel borer



To use the dowel borer, lay the timber on the table face side down, grip firmly and slide the table forward, feeding the timber onto the drill until the depth stop is reached. In a modern workshop, horizontal dowel-boring machines may be much more refined than described here; however, the basic principles remain the same.

4. *Assembling.* After the dowels have been cut to length and pointed, the joint is ready to assemble. Glue the dowel by dipping the ends into the adhesive. Adhesive can also be applied to the dowel holes by taking a short length of smaller diameter dowel or stick, dipping the end into the adhesive and wiping it around the hole.

Drive the dowels into the stile first. Apply a little adhesive to the holes and shoulder line of the rail, then tap the joint together. Pull together firmly with a sash clamp to ensure a tight fit. The well-made dowel joint should be square, with close-fitting shoulders on both sides and with the face side flush, and of course the timber must not be split. If splitting occurs this usually indicates the dowel is too long or the hole is too tight.

Biscuit joints

Biscuit joints are an alternative to dowel joints. Figure 7.36 shows two examples of corner joints using biscuit joints for butt and mitre joints. The advantage with this method is the machine for cutting the joint is portable and highly accurate. This method has many applications including widening

boards (Fig. 7.37) and corner joints. This method of joining can also be used without glue, if a means of locating components in large pieces is required.

Setting out of biscuit joints follows a similar procedure to dowel joints.

Fig. 7.36 Two examples of corner joints using biscuits for (a) butt joints and (b) mitre joints

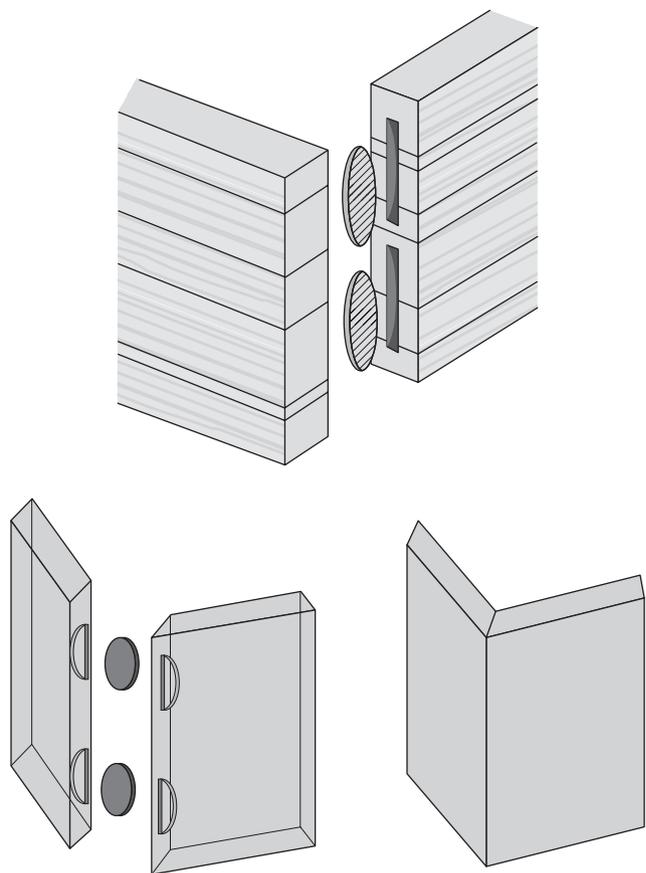


Fig. 7.37 Widening boards using biscuits

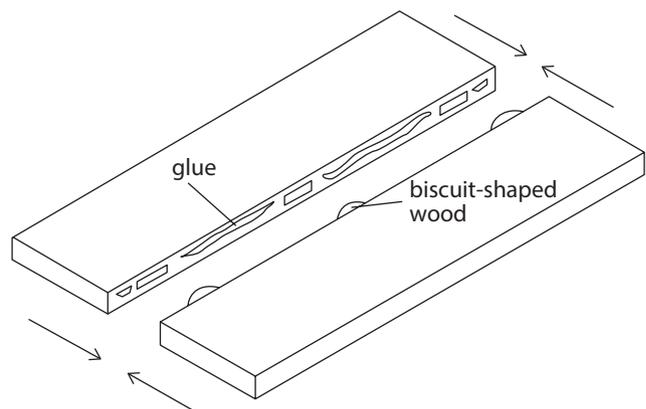
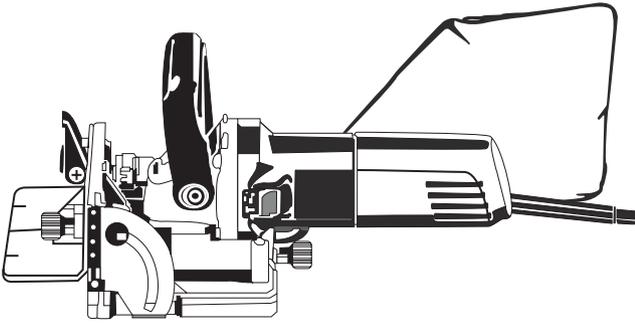


Fig. 7.38 Powertool used to cut biscuit slots

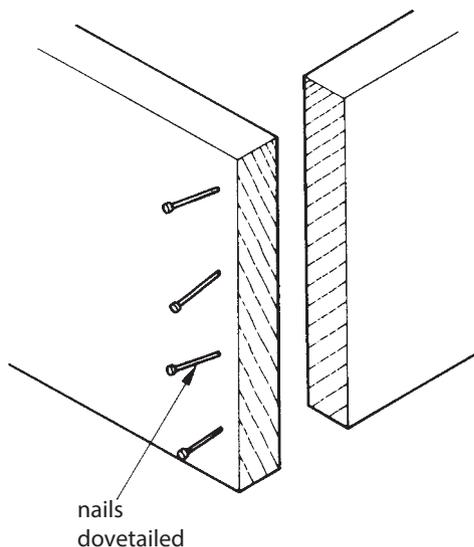
Carcase joints

Carcase joints are sometimes referred to as *angle box joints*. Joints in this group are distinguished by the fact that the angle formed is between the face sides. They are used in joining up the carcass to cabinets, corners of drawers, shelving, and so on.

Again, for satisfactory results, joints must be accurately set out and cut to detail. Fixing is often by nails and screws in conjunction with an adhesive, or if concealed fixing is required, dowels or 'feathers' can be used. If the joint is cramped, some adhesives on their own may be adequate.

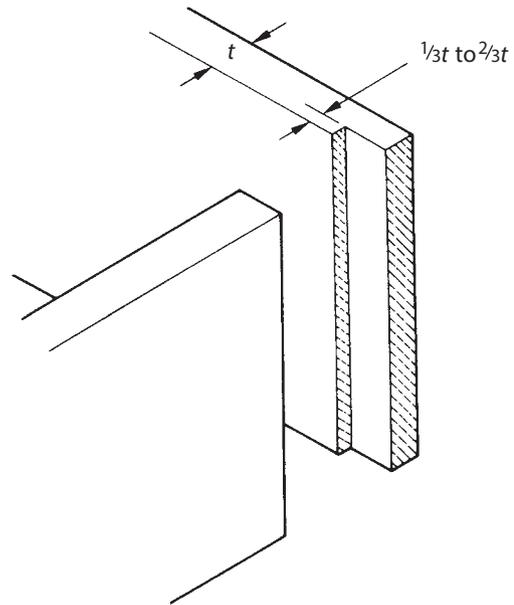
Butt joint

The butt joint is the simplest carcass joint and it can be nailed or screwed (Fig. 7.39). The ends must be cut square across both the face and edge. To nail the joint, start the nails in the top piece, 'dovetailing' them at an angle to secure a better grip, apply adhesive, bring the joint together and complete the nailing. Finish by punching the nails slightly beneath the surface prior to the glue setting. Otherwise if the nails are punched after the glue sets, the glue joint could fracture. The butt joint can be strengthened by the addition of glue blocks to the inside corner.

Fig. 7.39 Butt joint

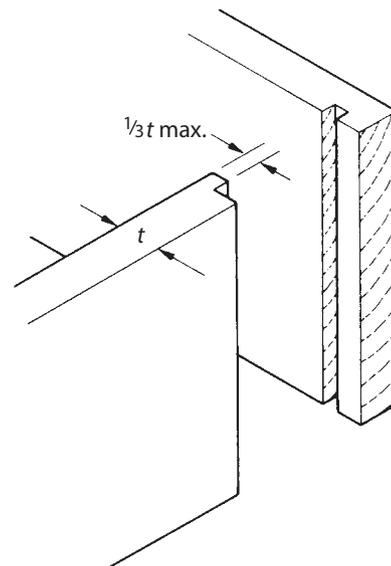
Rebated joint

The rebated joint is commonly used and is adaptable to a variety of materials and applications including drawers (Fig. 7.40). The depth of the rebate can vary from one-third to two-thirds the thickness of the material, and therefore shows little end grain. Fixing is by adhesive and nailing or screwing; the nailing can be made from either side of the joint.

Fig. 7.40 Rebated joint

Tongued and trenched joint

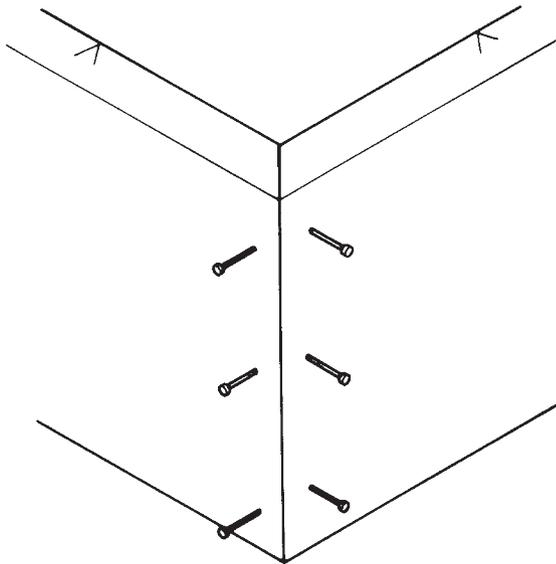
The tongued and trenched joint makes a strong neat joint that can be fixed adequately using an adhesive only (Fig. 7.41). The short grain beside the trench is a weak point which makes it unsuitable for use with manufactured boards. The tongue should be no more than one-third the thickness of the timber.

Fig. 7.41 Tongued and trenched joint

Mitred joint

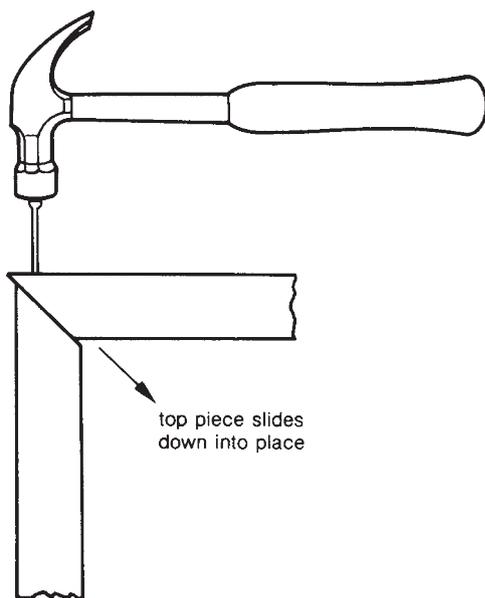
The mitred joint shows no end grain (Fig. 7.42). The parts of the joint must be cut at 45° where the joint is to be at right angles and must be dressed accurately. It can be fixed by an adhesive, nailing or screwing, or a combination.

Fig. 7.42 Mitred joint



In this case, the nails should be started in the top piece (Fig. 7.43). Apply a little adhesive and bring the joint together.

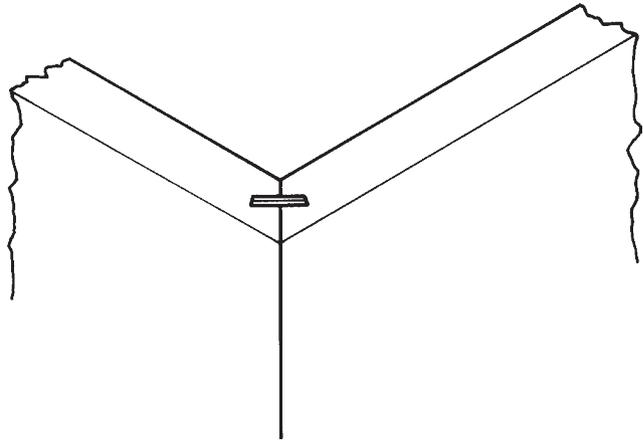
Fig. 7.43 Nailing the mitred joint



Keep the top piece a little uphill, because when the joint is nailed, it will slide down into place pulling the parts together and expelling any surplus adhesive. Nailing can be carried out from both sides; the nails are then punched below the surface. The recess is filled with a suitable stopping compound.

Concealed fixing can be achieved by use of a 'feather' or loose tongue (Fig. 7.44).

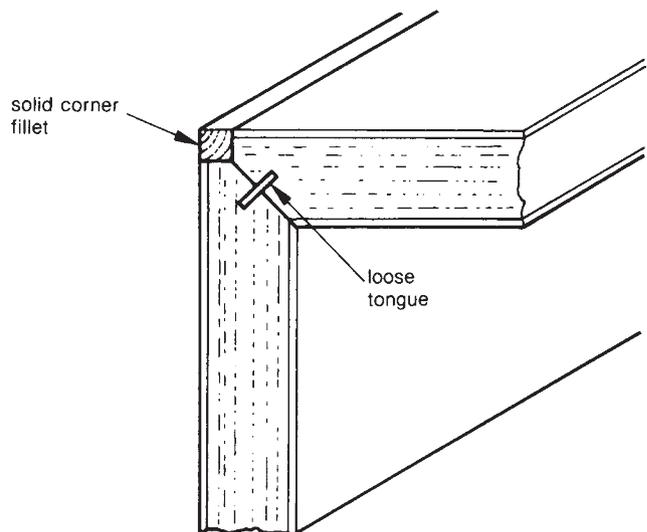
Fig. 7.44 Loose tongue in the mitred joint



Make a saw cut, or use the router to run a small groove, across the joint. Into this can be fitted a tongue of thin plywood or veneer.

Due to the thin feathered edge of the mitre, this joint is sometimes unsuitable for use in veneered or manufactured boards as the face veneer can chip away easily. Figure 7.45 shows a modification of the joint more suitable to this material.

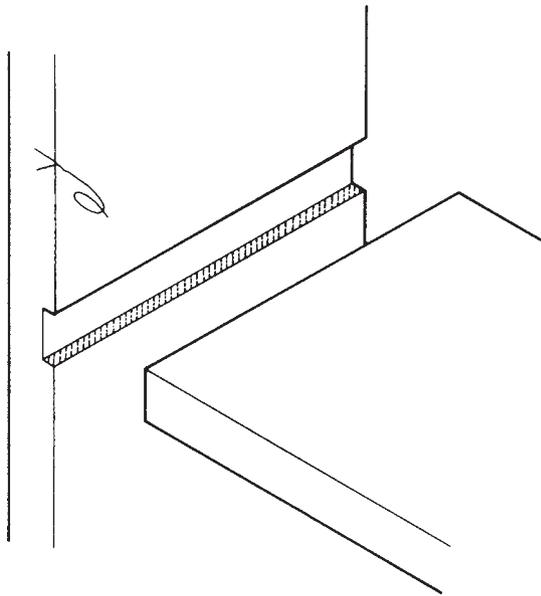
Fig. 7.45 Modification of the mitred joint for veneered boards



Housed joints

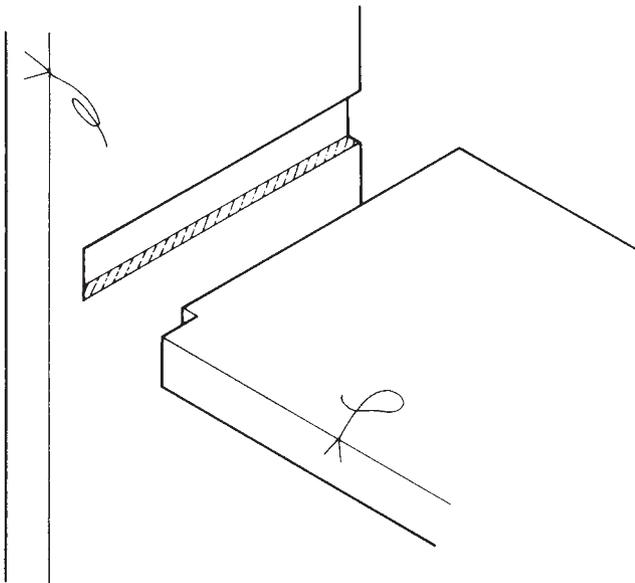
Housed joints are used in solid timber furniture construction, supporting shelving, and so on. A *through housing* will show the joint on the exposed edge (Fig. 7.46).

Fig. 7.46 Through housed joint



If this is undesirable, a neater joint is the *stopped housed joint* (Fig. 7.47).

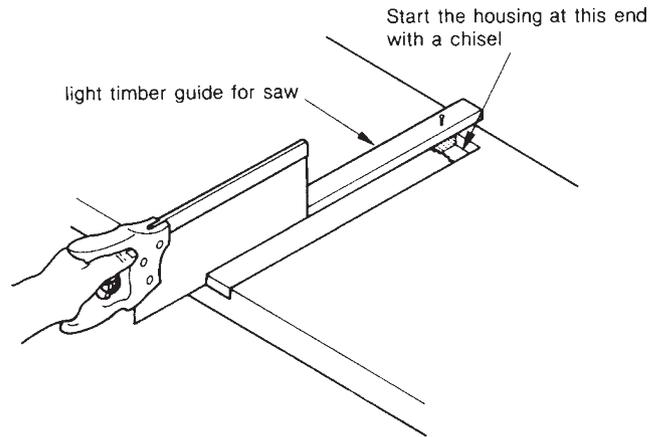
Fig. 7.47 Stopped housed joint



In this joint, the housing is stopped short of the edge and the shelf is cut to butt against the side.

To cut the stopped housing using hand tools in solid timber, first mark the position of the housing. Use the thickness of the board to be fitted as a template for marking the exact width, and cut the sides with the marking knife or pencil.

Fig. 7.48 Cutting the stopped housed joint



At the stopped end, use the chisel to start the housing sufficiently to allow the tenon saw to cut down the sides. A light timber strip, pinned or clamped along the line, is a useful saw guide over a long cut. After sawing both sides, chisel away the waste and smooth the bottom of the housing to a uniform depth, preferably using the hand router plane.

Housed joints can be made readily with the use of an electric router with an appropriate cutter the thickness of the board to cut the housing

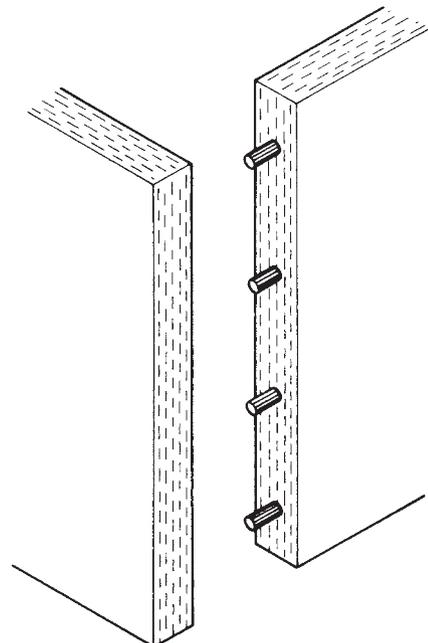
Shelf supports

Another popular method for supporting shelves in carcasses is to use adjustable shelf supports.

Dowelled joint

The dowelled joint can also be used as a carcase joint and is particularly adaptable for use with particleboard where the range of other suitable joints is limited (Fig. 7.49).

Fig. 7.49 Dowelled carcase joint



Details on the setting out and construction of the dowelled joint have already been described. Precut 8 mm dowels are convenient for use with 16 mm or 18 mm particleboard. Apply a suitable adhesive to the joint and cramp together until set.

Dovetail joints

The dovetail joint is the strongest of the carcase joints. The presence of handmade dovetail joints in manufactured articles has long been regarded as a sign of quality.

Each joint must be individually marked and accurately fitted. Face sides and face edges must be clearly marked and followed so that the joints will come together in the finished article the correct way around. The face sides can be either *all inside* or *all outside*. Face edges must *all* point in the same direction. In the examples shown, the face side has been marked on the inside. The most common use for dovetails in joinery and furniture is in joining the fronts and sides of drawers.

All parts must have face and edge marks to avoid confusion. Dovetail joints are set out from the end of the timber and parts must be cut to their finished length and the ends dressed square as a first step to making the joints.

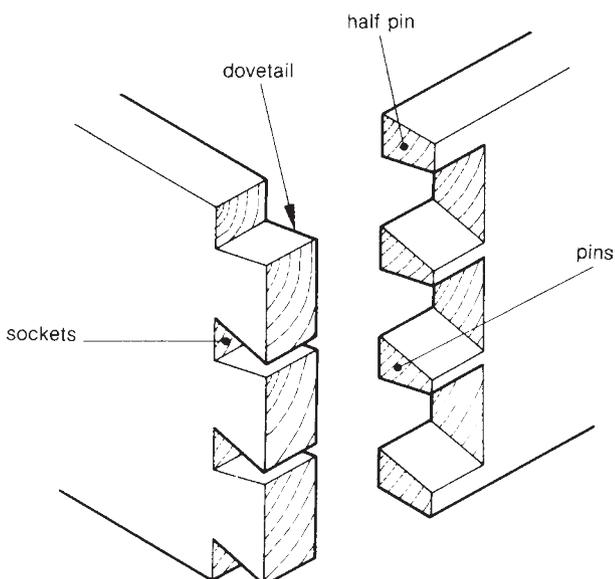
This section covers handmade dovetail joints; however, proprietary dovetail jigs are readily available for use with an electric router fitted with a dedicated 'dovetail' router bit to suit a wide variety of applications.

Types of dovetail joints are now described.

Common dovetail joint

The common dovetail joint is one in which the pins and sockets go fully through the timber, and when assembled, show end grain on both the outside faces. The angle or ratio of the pins illustrated in the following examples can be between 1 in 4 to 1 in 7.

Fig. 7.50 Common dovetail joint



To make the common dovetail joint, proceed as follows:

1. **Squaring.** After the ends have been dressed square, measure back from the end the thickness of the material and square around both pieces to be joined. Use a sharp pencil and a try square.
2. **Setting out the pins.** Set out the pins on the end of the timber. The details of setting out are shown in Figure 7.51. Take three-quarters the thickness ($\frac{3}{4}t$), which is the maximum width of the pins, and round to the nearest millimetre; set a sliding bevel to 1 in 4 (Fig. 7.52). Mark a half pin (so named because it has a slope on one side only) on each edge of the timber. If there are to be two intermediate pins, there will be three spaces. Adopting the 'in and over' method, divide the width into the required number of equal spaces. Mark out one pin to each space (Fig. 7.51). Then mark the bevel of the pins across the end of the timber. The maximum distance between pins is three times the width of the pin ($3 \times \frac{3}{4}t$). To ensure a close-fitting shoulderline, use the marking knife to cut along the line of the waste between the pins.
3. **Ripping the pins.** Using a fine dovetail saw, rip the pins, keeping on the waste side of the line (Fig. 7.54).
4. **Removing the waste.** There are two recognised methods of removing the waste from between the pins. The first uses the coping saw to cut away the waste (Fig. 7.55). Keep just on the waste side of the line and use a paring chisel to true up the shoulder line. Very slightly undercut, working from both sides of the timber. The second method is to chisel down the shoulder line and remove the waste in the form of a 'V' for half the thickness (Fig. 7.56). Turn the timber over and remove the other half of the waste in a similar manner; cutting in this way, and leaving the front end of the waste intact, provides support for the end when the timber is turned over. There is always a strong chance that the timber will break out between the pins so use a very sharp bevelled-edge chisel and proceed cautiously in the manner described.
5. **Marking the sockets.** Use the pins as a template to mark out the sockets on the other piece (Fig. 7.57). Use a sharp pencil and square the line across the edge (Fig. 7.58).
6. **Ripping the sockets.** To rip the sockets, keep on the waste side of the line. The pencil line should remain visible and completely intact (Fig. 7.59).
7. **Removing the waste.** Using a suitable narrow paring chisel, remove the waste, again working from both sides for the intermediate pins and saw away the waste to the half pins. If necessary, use a medium to fine grade abrasive paper to sand the inside faces. The joint is ready to assemble.
8. **Assembling.** If the joint has been cut out accurately, it should fit off the saw with only minor adjustments to the fit. The tapered pins should fit neatly, tending to pull the shoulder lines together without the need for any other form of cramping. Apply a small amount of adhesive to the mating surfaces, enter the pins into the sockets and tap the joint together. A diagonal brace may be required to hold the article square while the adhesive sets, after which the outside faces can be flushed off with the smoothing plane and sanded.

Fig. 7.51 Setting out pins for a dovetail joint

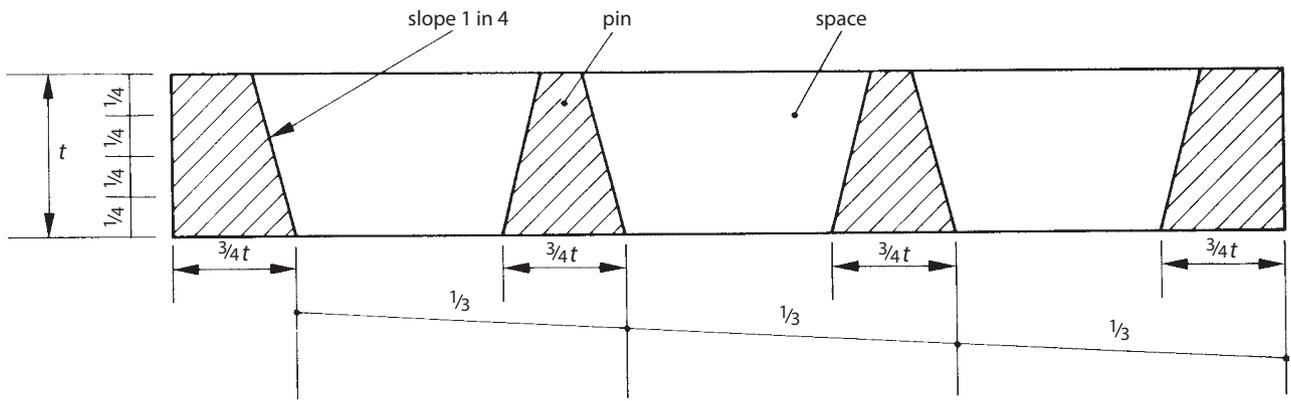


Fig. 7.52 Setting the bevel

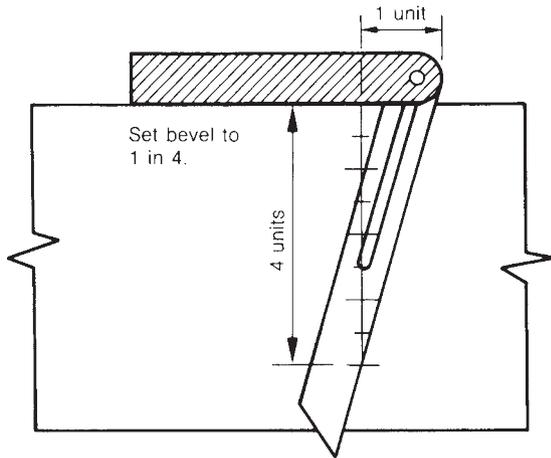


Fig. 7.54 Ripping the pins

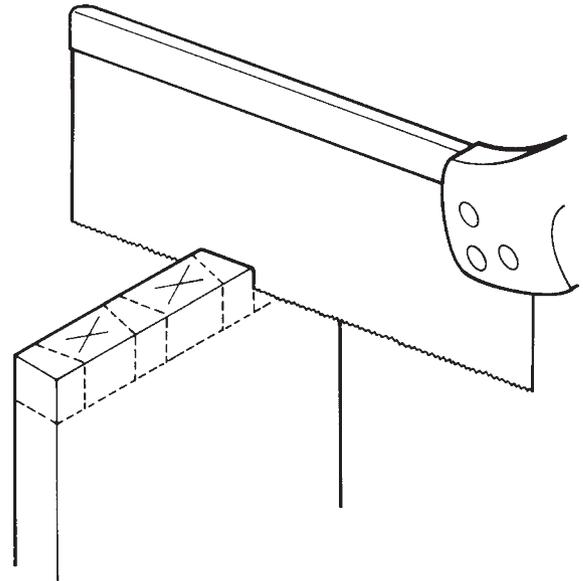


Fig. 7.53 Completed set-out of dovetail pins

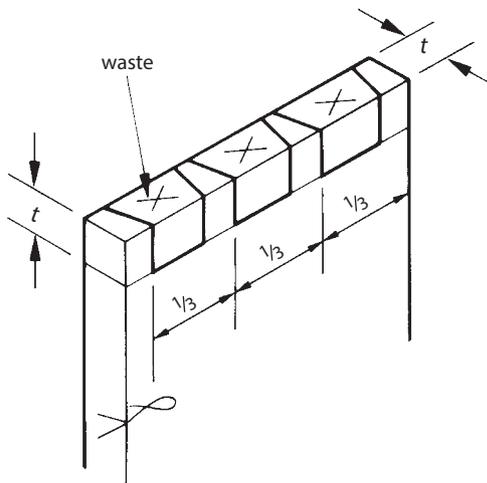


Fig. 7.55 Cutting the waste with a coping saw

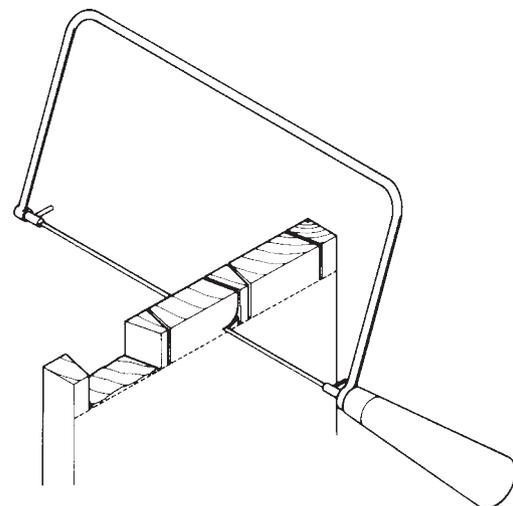


Fig. 7.56 Chiselling out the waste

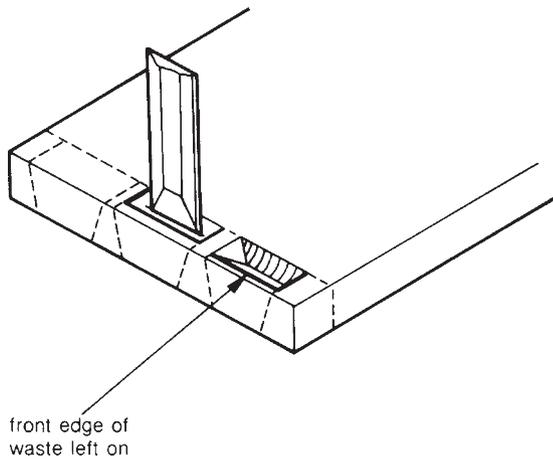


Fig. 7.57 Marking the sockets

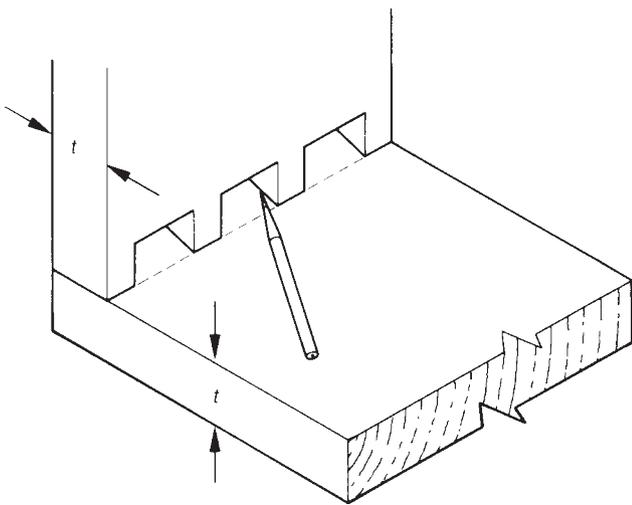


Fig. 7.58 Squaring the sockets

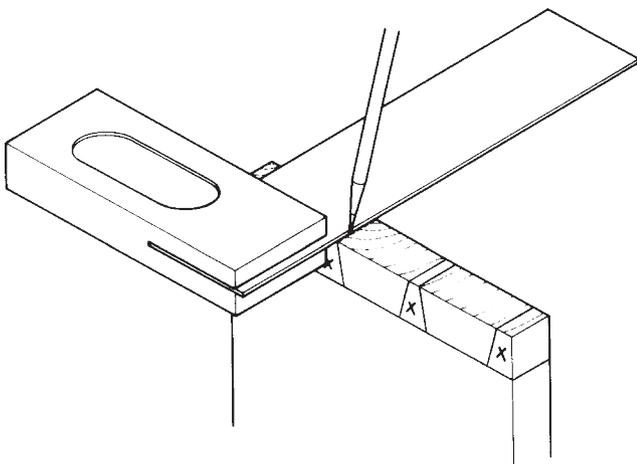
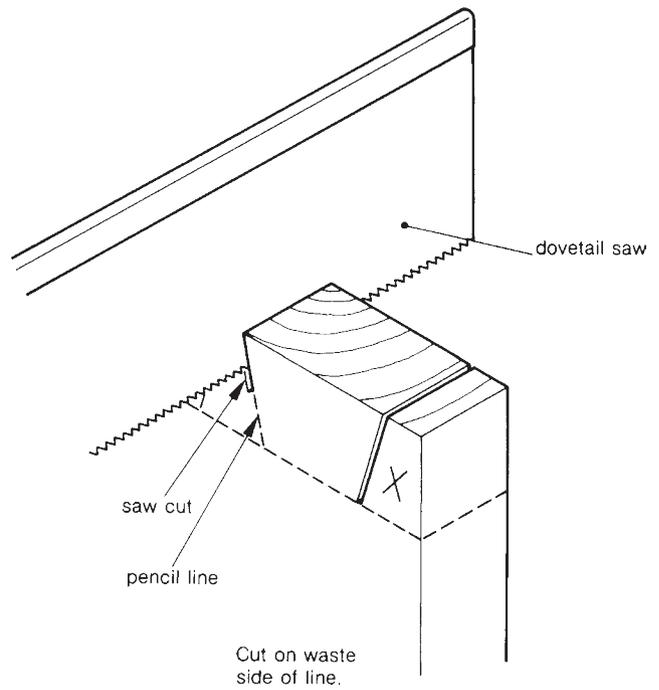


Fig. 7.59 Ripping the sockets



Lapped dovetail joint

The lapped dovetail joint is so named because of the lap formed on one piece, so that when the joint is assembled, end grain will be seen on one side only (Fig. 7.60). The most common application of the lapped dovetail is the joint between the front and side of a drawer. The thicker piece containing the lap is the *front*, and the other piece is the *side*. They will be referred to as such in the description of the procedure.

The setting out of the pins on the drawer front is shown in Figure 7.61. Divide the thickness into three equal parts and

Fig. 7.60 Lapped dovetail joint

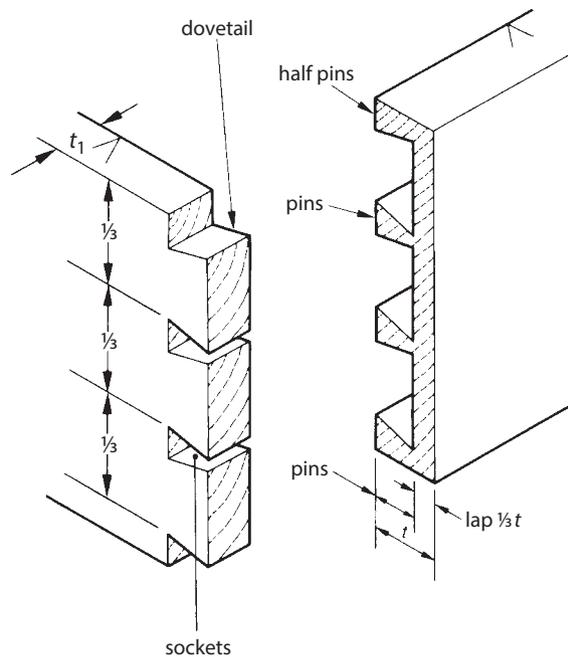
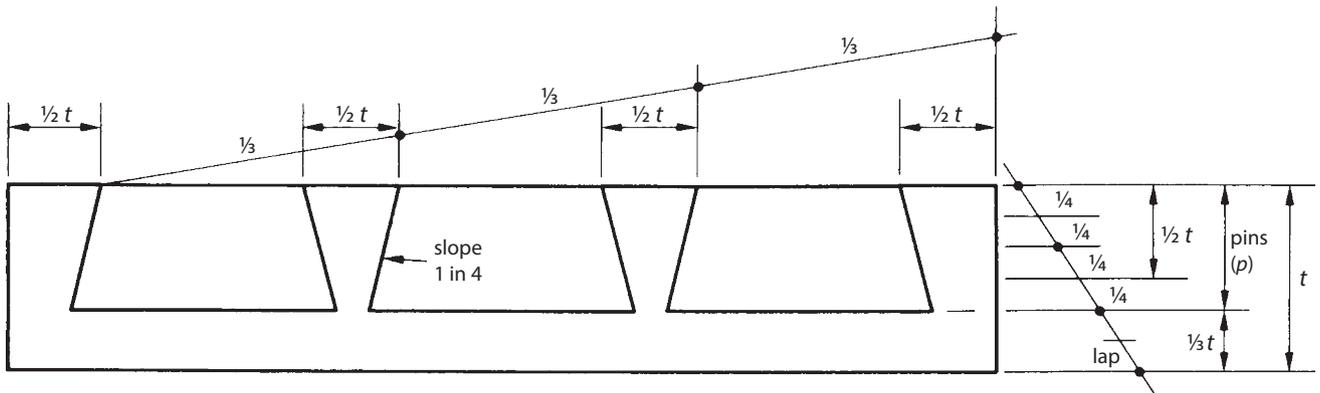


Fig. 7.61 Setting out of pins for a lapped dovetail joint

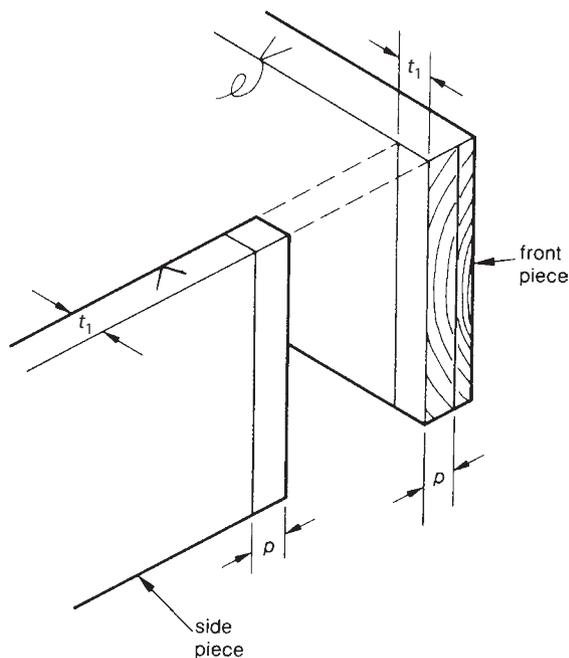


make one-third the lap. Dovetail pins are then set out on the remaining two-thirds, their width referred to as p . It can be seen from the set out that if the maximum width of pins is $\frac{3}{4} p$, this is the same thing as $\frac{1}{2} t$ (t being the thickness of the front), rounded off to the nearest millimetre.

To make the lapped dovetail joint, proceed as follows:

1. After squaring the ends, gauge the distance p on the end of the front piece and also from the end of the side piece across both faces and edges. Gauge the distance t_1 (the thickness of the side from the end of the front) (Fig. 7.62).

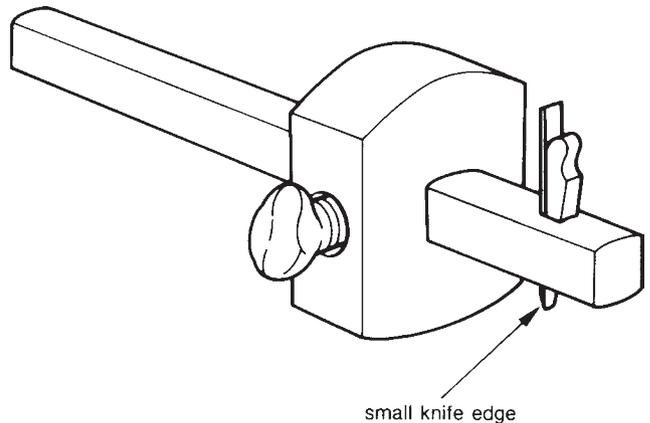
Fig. 7.62 Gauging for a lapped dovetail joint



A marking gauge is adequate if a cutting gauge is not available.

Gauging these distances can be made with a cutting gauge, which is similar to a marking gauge except that a small knife replaces the spur (Fig. 7.63). Its purpose is to gauge

Fig. 7.63 Cutting gauge



across end grain or to cut parallel strips of thin timber. First set the gauge to p and gauge the front and around the end of the side—gauge lightly across the outside face where the mark may be difficult to remove. Reset the gauge to t_1 and gauge across the front.

2. Set out the dovetail pins on the end of the front, adopting the 'in and over' method, and mark the slope on the pins with a sliding bevel set to 1 in 4 (Fig. 7.61).
3. Rip the dovetail pins half-way diagonally (Fig. 7.64).
4. Remove the waste from between the pins using a sharp bevelled-edge chisel: cut off the waste, slightly undercutting and pare it away (Fig. 7.65).
5. Use the dovetail pins as a template to mark the sockets on the side (Fig. 7.66). Stand the front piece on the side and with a sharp pencil mark the pins.
6. Remove the waste from the sockets in a manner similar to the common dovetail.

Fig. 7.64 Ripping the dovetail pins half-way

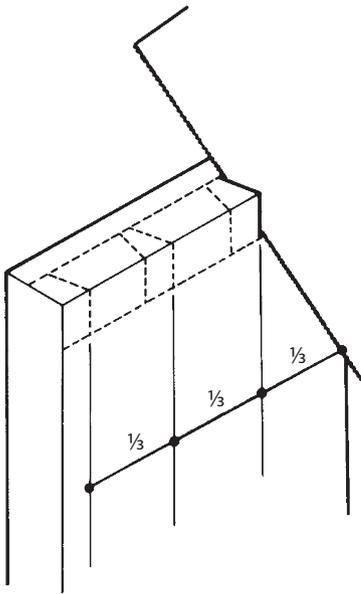


Fig. 7.65 Removing the waste

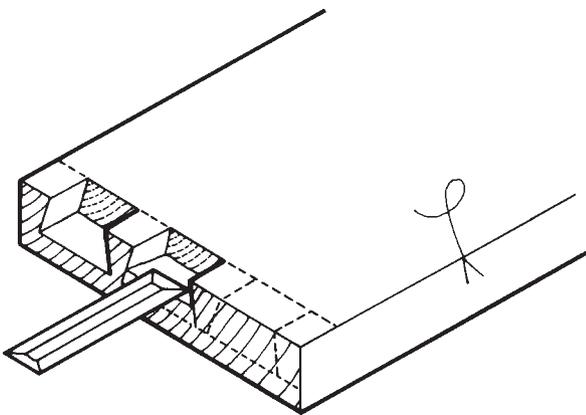
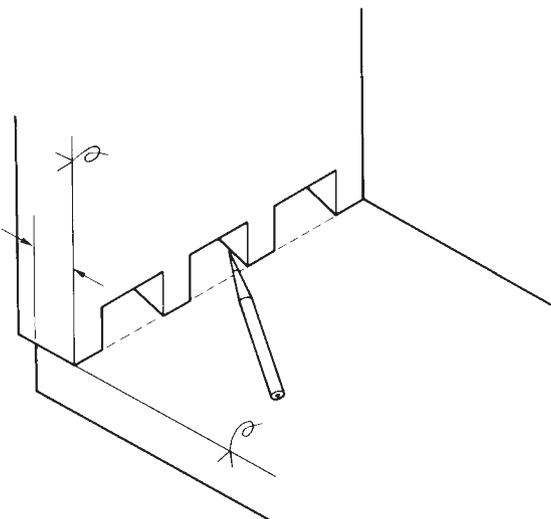


Fig. 7.66 Marking the sockets



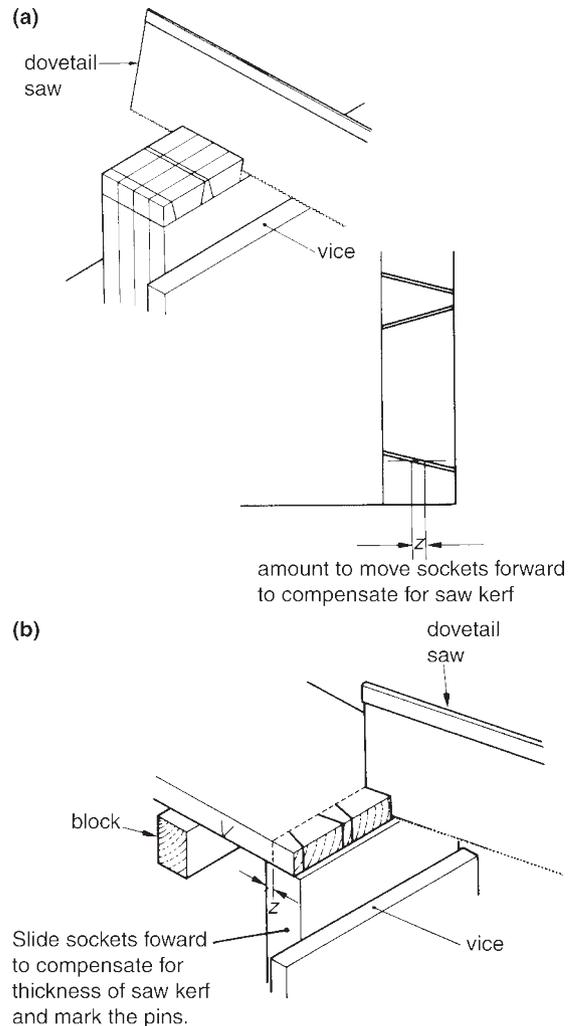
7. Check the joint for fit; if necessary, sand the inside faces. Apply adhesive lightly and tap the joint together. As with the common dovetail, the tapered pins should be a close fit, tending to draw the joint together.
8. After the adhesive has set, clean off and sand the outside face.

Alternative method for making the dovetail joint

The alternative method for making the dovetail joint involves marking the pins from the sockets. Proceed as follows:

1. Set out the sockets on the side, proportioning in the same manner as for the pins.
2. Use a fine dovetail saw and rip the sockets but do not remove the waste. A number of pieces, say, three or four can be cramped together and the sockets ripped from the one set out.
3. Lay the side on the end of the front, moving it forward sufficiently to compensate for the thickness of the saw kerf. This distance is illustrated in Figure 7.67. Measure square across the sloping saw kerf and note the distance z . If using a fine dovetail saw, this distance may be approximately 2 mm but must be checked with the actual saw being used on the job.

Fig. 7.67 Setting out from the sockets



Hold the side in position firmly, place the point of the saw into the saw kerf and mark onto the end of the front for each pin.

4. Remove the side and square down the face of the front of the line of the saw cut marked on the end; rip the pins on this line.
5. Remove the waste from the sockets and between the pins. Fit and assemble the joint as previously described. Note any correction considered necessary to the distance z for future use.

Joins used for widening timber

With the widespread use of plywoods, medium-density fibreboard (MDF) and other manufactured boards in large sheet sizes, the need to edge joint solid timber to make up wide boards has greatly diminished. However, for items such as tabletops, countertops, and so on, there is often a preference for the individual warmth of solid timber.

Fig. 7.68 Butt joint for widening

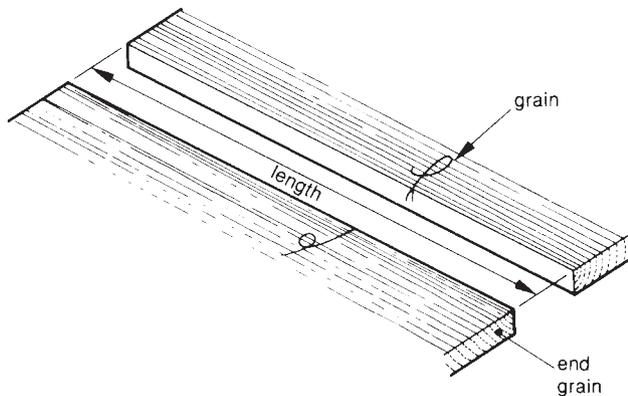
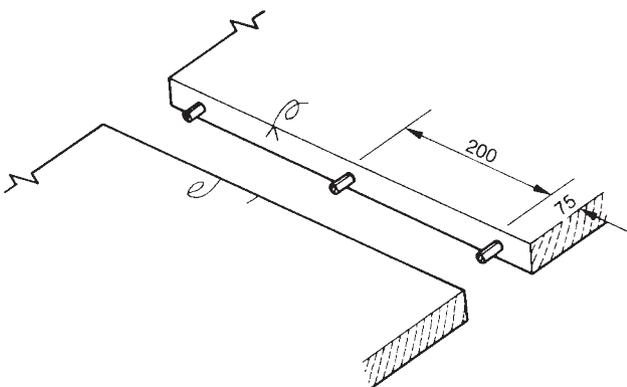


Fig. 7.69 Dowelled joint for widening



Butt joint

The butt joint is suitable for use where the joint is subject to only minor stresses and has stable moisture content. The jointed edges must be planed or machined straight and square, and be close fitting before gluing and cramping together with a suitable adhesive (Fig. 7.68).

The butt joint can be strengthened by the addition of dowels or biscuits, positioned so that they align the face of the boards (Fig. 7.69). This is probably the most commonly used joint for this purpose. The dowels/biscuits are set out at approximately 75 mm from the ends and 200 mm apart. See the section 'Dowelled joint' (p. 80) for the proportioning of dowels.

Loose-tongue or 'feather' joint

The butt joint, after preparation, can also be strengthened by the addition of a loose tongue (Fig. 7.70). The tongue can be of plywood, cut with the greater number of veneer layers laying across the line of joint. Alternatively, a tongue can be cut from solid timber, with the grain running diagonally across, and a thickness no more than one-third the thickness of the boards. Cut the width of the tongue about 1 mm less than the combined depth of the plough grooves. The groove that is to receive the tongue is gauged from the face side which should be flush when the joint is assembled.

Matching boards for edge jointing

Boards should be matched for grain and colour to the best advantage for both ease of working and final appearance. First check and mark the direction of the grain in each board, taking a trial shaving if necessary. If the boards are cut from one long length of timber, take care that their direction is not reversed. Joint the boards with the grain running in the same direction. Besides the difference in colour caused by the light falling on the grain in opposite directions, cleaning off is also made more difficult if the grain in one board is running in the opposite direction to the one adjacent to it.

Lay out the boards, and when it is thought that they are in the best combination, mark the face sides pointing to the edges to be jointed; if there is more than one joint, indicate by marks or numbers the pairs to be joined (Fig. 7.71).

Jointing the boards by hand

Hold the two boards to be jointed back-to-back and secure them in a vice. Straightening a long length of timber is a job for the trying plane. The technique is shown in Figure 7.72.

Shoot the edges of the two boards together. One theory is that if the boards are together and are planed slightly off-square, and the edges are then brought together, the face will lay on a straight line as the bevel on one board will complement the bevel on the other. Experience shows, however, that it is better to keep the edges square by testing with the try square from the face side.

After the boards have been planed straight and square, they can be tested for accuracy as shown in Figure 7.73.

Hold one board in the vice and stand the second board on top. First, see that the faces are in a straight line by sighting down or using a short straight edge. Then check that the boards are a close fit along their length. To test, grip one end of the top board and move it from side to side. If there is a high spot, the

Fig. 7.70 Loose-tongue joint

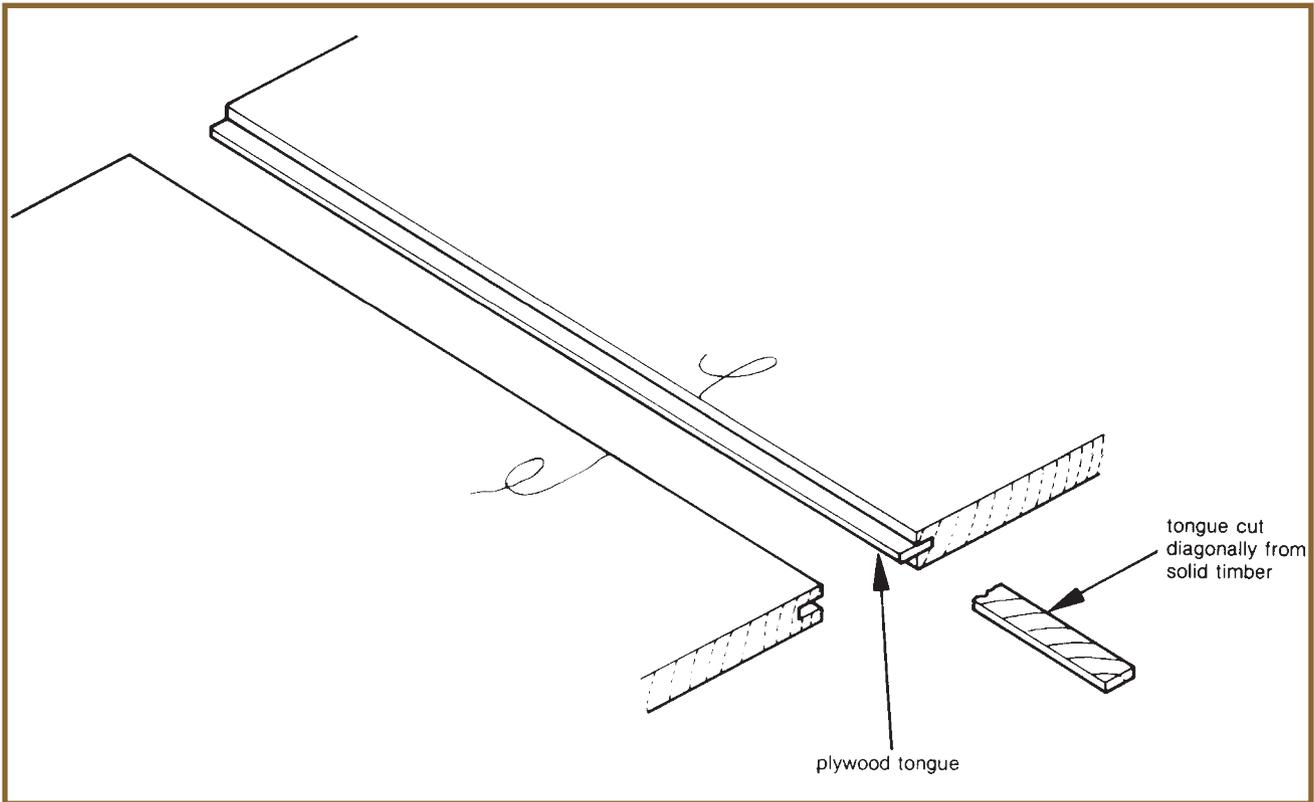


Fig. 7.71 Matching boards

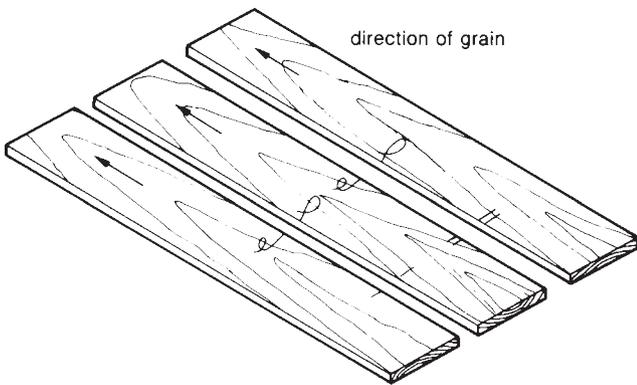


Fig. 7.73 Testing for accuracy

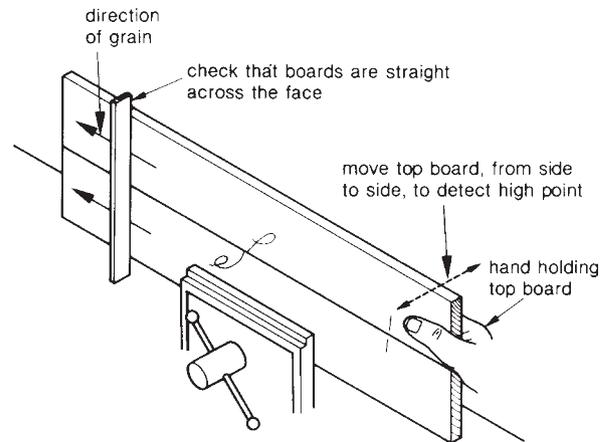
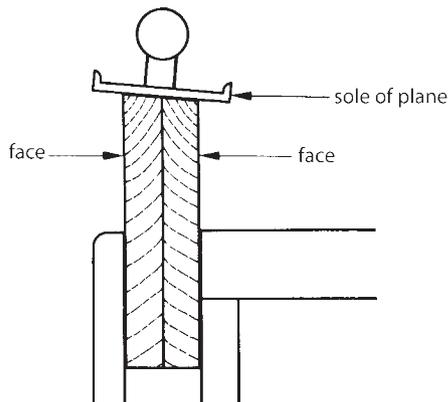


Fig. 7.72 Planing the edges

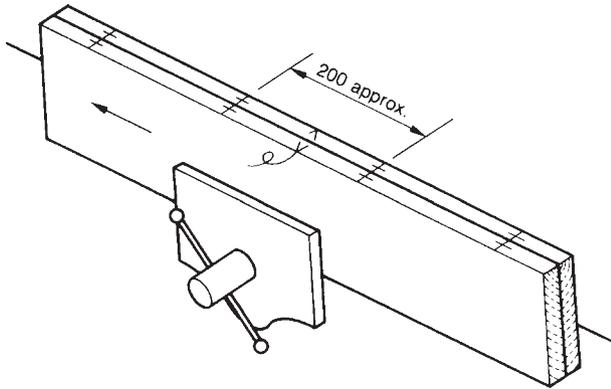


top board will pivot on this point which can be easily detected and removed with a fine shaving. If the board pivots on an end point, it is probably too hollow in the centre and the high point at the end is removed. Continue testing until the boards are a close fit along their length and no high spots can be detected.

Another theory is that when boards are planed, they should be finished slightly hollow along their length towards the centre of the board so that a narrow strip of daylight can just be seen when held to the light. This is so that when the boards are jointed together and are adjusting to their environment over a period of time, the ends will tend to shrink to a greater degree than will the centre of the boards. The hollow planing will compensate for this uneven timber movement.

If the boards are to be dowel or biscuit jointed, again hold them back-to-back in the vice, mark the position of the dowels or biscuits (Fig. 7.74), and square them across both boards; then gauge the holes from the face side on both pieces.

Fig. 7.74 Marking for the dowels or biscuits



See the procedure for the boring of dowel holes under the heading 'Making the dowelled joint' (p. 82) earlier in this chapter.

Gluing up jointed boards

Lay out sash cramps and have available blocks of scrap timber that can be used under the shoe of the cramps to prevent the edges of boards being damaged.

Hold the two edges to be jointed together, apply adhesive to the dowelled joints or the tongue and groove joints as the case may be, and enter the dowels or the tongue. Align the remainder of the joint, bring it together and tap it lightly. Lay the boards in the sash cramps and, holding them hard down on the bar of the cramps, clamp them together lightly. Lay another cramp across the top and, keeping the bar hard down on the boards, tighten the cramps, as shown in Figure 7.75. This will hold the boards flat and prevent them buckling as the cramps are tightened uniformly to bring the joint together and expel any surplus adhesive. Do not overtighten the cramps to the point where the boards are distorted.

Finally, wipe away any surplus adhesive with a dry cloth (Fig. 7.76).

Fig. 7.75 Cramping the boards

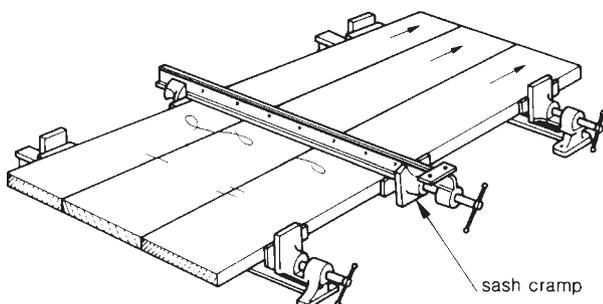
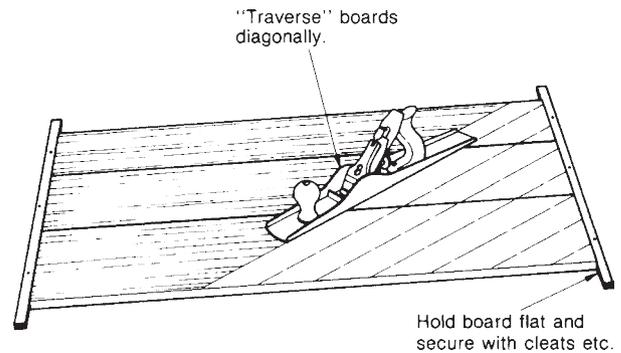


Fig. 7.76 Cleaning off wide boards



Use a trying plane with a sharp blade which is set to take a fine shaving, and commence by planing diagonally across the boards, a practice termed *traversing*. Work in strips the width of the plane iron, overlapping each step slightly. Continue planing in a similar manner across the opposite diagonal until any small irregularities are removed. Complete the cleaning off by planing in strips in the direction of the grain until any surface blemishes are removed.

Sanding the surface of wide boards is carried out in the same sequence as for planing, whether by hand or by electric sander. Start with a fine grade of paper, say 120 grit, so as not to make any deep scratches that will be difficult to remove later, and sand diagonally across the boards in strips. Next, sand in the direction of the grain with a medium grade of paper, say 100 grit, until any scratches are removed and then finish with a fine paper, 120 or 150 grit.

If you have access to a static machine called a 'thicknesser', the planing of the jointed boards by hand can be skipped, provided the machine is wide enough to accept the piece. If it is not, the accepted method is to produce the piece in narrower sections, allowing it to fit the thicknesser and later to be glued together and finished as above.

Fixing wide boards of solid timber

Wide boards made of solid timber will shrink and expand with changes in moisture content. When they are fixed in place, provision must be made for them to move freely to accommodate these changes.

A good example of what can happen is to be seen in many old tables which have a split right down the middle. Close examination would probably show that the top was simply nailed to the frame around its outer edges and was therefore restrained from shrinking. If this were the case, the stresses set up during one or more long dry summers would have been so great that the boards simply split down the centre. The damage would probably not have occurred if the top had been attached to the frame by means of 'buttons' that hold the top down but allow it to shrink or expand with atmospheric changes (Fig. 7.77).

Fig. 7.77 Buttons for a table top: (a) close up and (b) full view

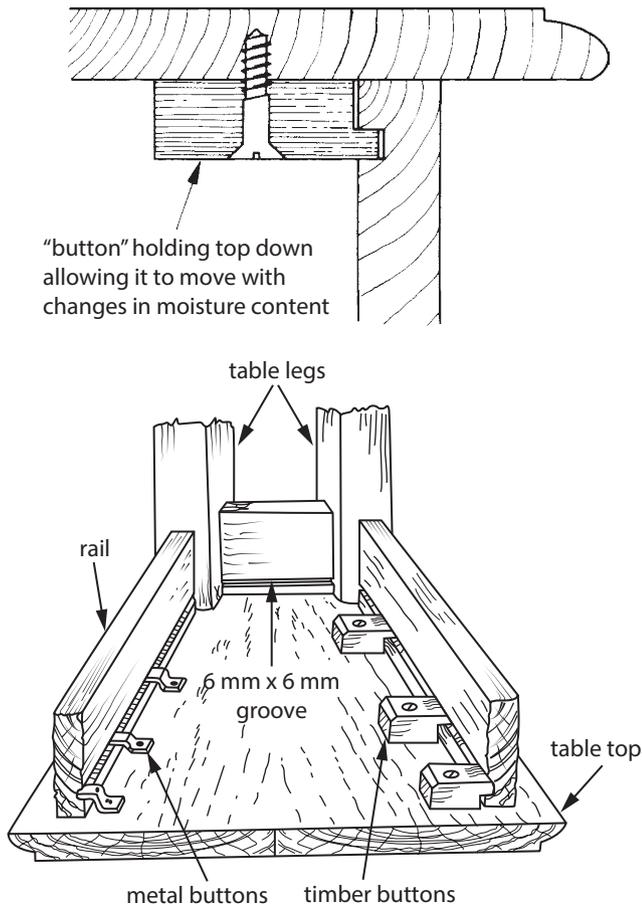
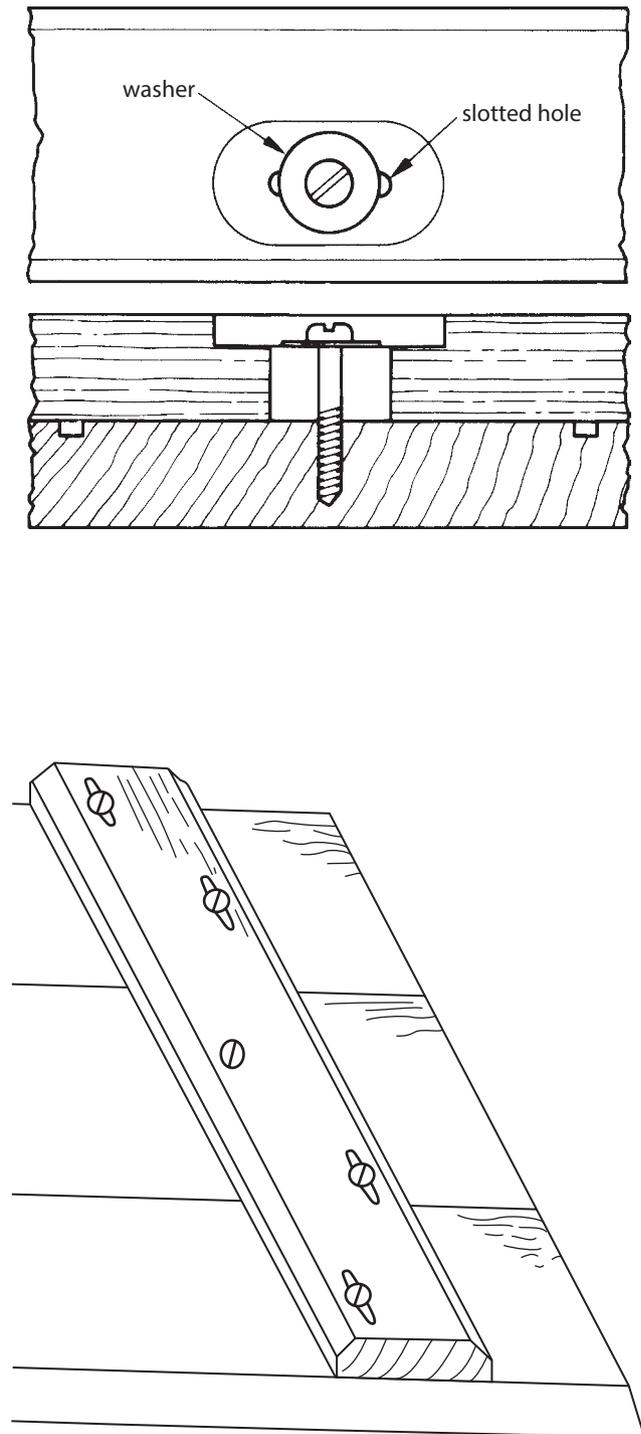


Fig. 7.78 Slotted hole in cleat method



Another example is where the wide board is held flat by cleats screwed across the back, but the screw holes are slotted to allow the board to move as its moisture content changes (Fig. 7.78).

Another procedure that minimises the shrinkage in wide boards is to run a number of plough grooves in the back surface. This means that the shrinkage across the surface will be localised into a number of smaller widths and will be less overall.

Student research

Search the internet for ‘heavy framing joints’ and look at the other types of joints that can be used to join timber together in large timber-framed buildings.

Life cycle thinking

Life cycle thinking is an approach taken when selecting materials and components whereby the good and poor aspects of each step in a product's entire life cycle is assessed.

Common considerations of life cycle aspects are:

- the initial purchase price, availability, installation issues, training of others to use it
- the maintenance regime, repair costs, product usage, exposure to weather
- the operating costs (if applicable), consumables (water, energy, materials)
- the disposal costs, recyclability.

The two most common approaches are whole-of-life costing and life cycle analysis. **Whole-of-life costing** is the more useful in a selection process. It is a tabulation of all the actual and estimated costs of a material or product over its entire life. **Life cycle analysis** is more **complex** and is of limited use in everyday decision making. It includes environmental impacts at all the stages in the life of a product (see International Standard ISO 14040 Environmental management—Life cycle assessment—Principles and framework), but does not take into account social benefits or economic considerations.

The key consideration is to determine what stage in the life cycle of a material or product has the greatest impact or cost. For example, considerations to make when selecting a timber wall cladding material that is exposed to high wind conditions carrying dust and sand, which will erode the cellular structure of the wood, will be that protection of the material would rely on the maintenance of the surface coating, whereas selecting a masonry material in this situation results in lower maintenance costs.

Window and door construction

LEARNING OBJECTIVES

- 8.1 Types of windows and doors
- 8.2 Window construction
- 8.3 Door construction

This chapter details the construction of timber windows and doors, which requires a high level of skill from the tradesperson. These items can be beautiful and become adornments to the dwelling as well as serving a practical purpose. Many of the techniques discussed in the joinery joints chapter are used in the construction of these items.

Window types

Windows are an essential component in residential buildings, their purpose being to admit light and ventilation. Building regulations specify the minimum requirements. Windows are composed of two parts:

1. the window *frame*, which is permanently fixed into the structure of the building
2. the *sashes*, which are the movable parts of the window (in some cases fixed), and are fitted to the frame.

Windows are named according to the way in which the sashes operate within the frame.

Fixed sashes

Fixed sashes are permanently fixed in the frame and admit light only (Fig. 8.1a). All the sashes to a room cannot be fixed; some must be operable to meet building regulation requirements.

Casement sashes

Casement sashes are either hinged on the side or have a friction stay (Fig. 8.1b). The friction stay allows the sash to pivot near the side and open to its full extent, or lock by friction to any intermediate position (Fig. 8.2).

The advantages of casement sashes are that they will provide maximum ventilation and can be cleaned readily from the inside. On the other hand, ventilation is not so easy to control, insect screens are more difficult to fit, and the sash projecting beyond the face of the wall can sometimes be a dangerous obstruction.

Fig. 8.1 (a) Fixed sashes; and (b) casement sashes

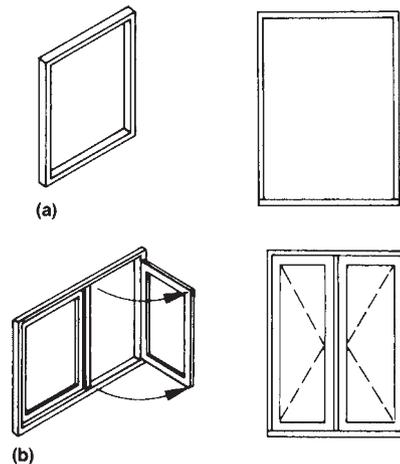
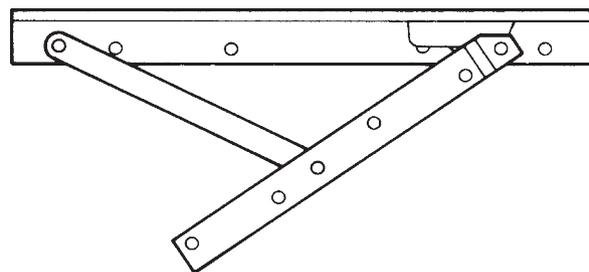


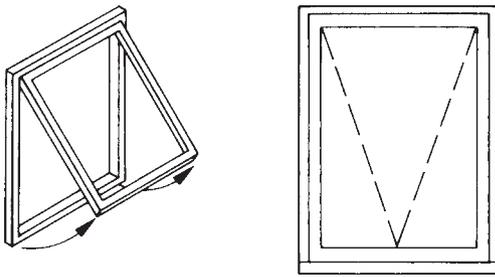
Fig. 8.2 Friction stay



Awning-type sashes

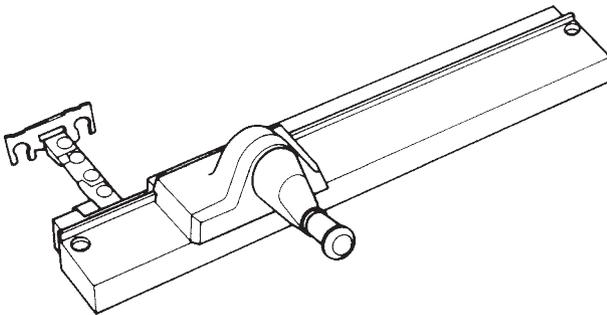
Awning sashes pivot from near the top and can be a single sash or a number of sashes arranged above each other (Fig. 8.3). They are sometimes wrongly named 'hopper windows'.

Sashes can be fixed on friction stays; this allows them to open and be held in any position. The manufacturer's

Fig. 8.3 Awning sash

instructions should be consulted when selecting a stay so that one long enough to suit the overall height and weight of the sash is chosen.

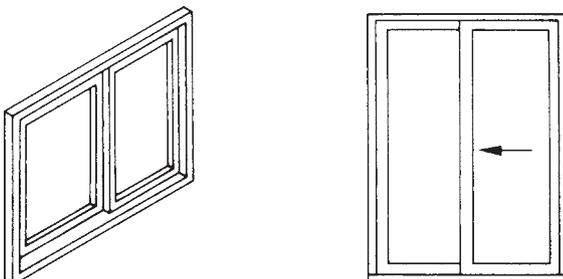
Single awning sashes are a popular type of window. They are often fixed with a non-friction type hinge and an extending chain winder on the sill opens the sash and holds it in position.

Fig. 8.4 Sash winders

Ventilation can be controlled, avoiding direct draughts, and insect screens can be conveniently fitted inside.

Horizontal sliding sashes

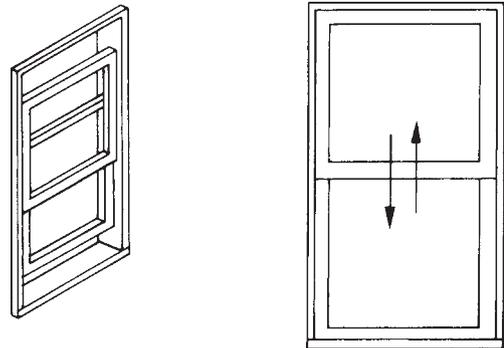
Sliding windows are widely used and an extensive range of stock sizes is available in aluminium windows. The sash slides on metal or plastic rollers along tracks fixed to the sill. The sashes should have a wheel base as wide as possible, and preferably the height of the sash should be no more than two times its width. The sash pull should be set close to the base where it will not tend to tilt the sash sideways in operation. On a single track, no more than half the window can be opened and ventilation is not readily controlled. However, as the sash is contained wholly within the frame, insect screens can be conveniently fitted to the outside, and the windows can be quite economical.

Fig. 8.5 Horizontal sliding sash

Vertical sliding sashes

Vertical sliding sashes are also sometimes referred to as *box-frame sashes*, or commonly as *double-hung sashes*.

Double-hung windows have long been a very popular type of window; they were originally developed from the box-frame window with sashes hung on cords and counterbalanced by cast-iron weights (Fig. 8.6). Today the timber or aluminium sashes are hung on spiral spring balances.

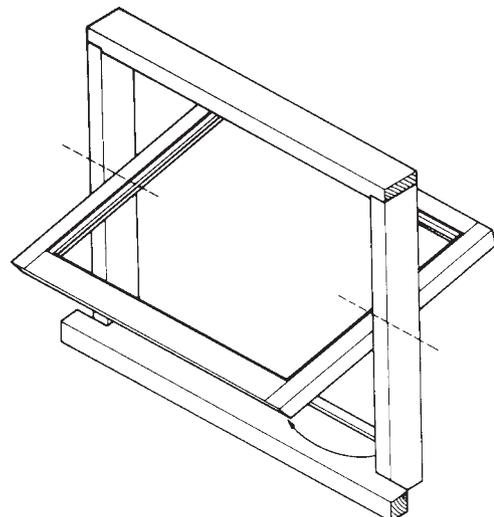
Fig. 8.6 Double-hung window

Double-hung sashes have a number of advantages. Ventilation is readily controlled and can be at the top, bottom or both. The sashes are contained within the frame and insect screens can be fitted to the outside. However, only half the window area can be opened at any one time, and poorly fitted sashes can present some problems such as jamming or rattling.

Some double-hung sashes are available that are 'sash-less', that is, the window glass is held in a counterbalanced suspension system, without being fitted into a timber or metal frame.

Other window types

Other sashes still seen occasionally, but practically 'extinct' in new construction, are the *hopper-type sash* and the *pivot-hung sash* window (Fig. 8.7).

Fig. 8.7 Pivot-hung sash window

Window manufacture

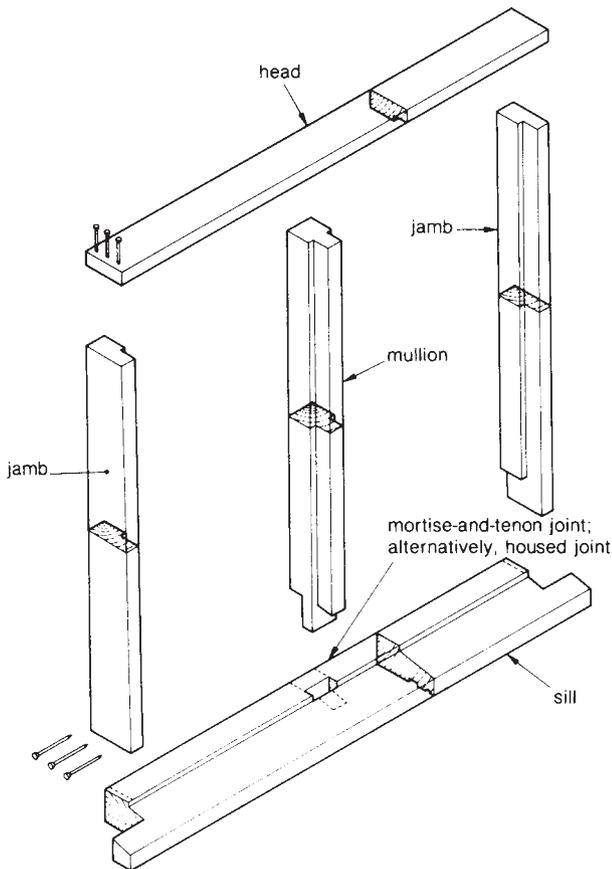
Window frames built into the external walls of a building are subject to some of the harshest weather conditions. They must be made from durable materials and constructed in such a way as to resist the penetration of dampness around the sashes. Timber species used include clear Oregon, western red cedar, Tasmanian oak, meranti (Pacific maple) or pressure-treated pine. For sills, which are the most exposed, tallowwood, redgum and merbau are often used, and no doubt in some areas other local timbers serve equally well. Window frames vary in construction according to the type of sashes to be fitted.

Solid-rebated window frame

A solid rebate is used with casement and awning sashes. Fixed sashes can be fitted; however, it is more usual to set a glass panel directly into the rebate of the frame and secure it with timber fillets or beads.

The basic construction of the solid frame is shown in Figure 8.8. The timber sections are an example of standard metric profiles for milled products available from timber merchants. Manufacturers of mass-produced frames will mill sections to their own details which also meet the demands of durability and weatherproofing.

Fig. 8.8 Elements of a solid window frame

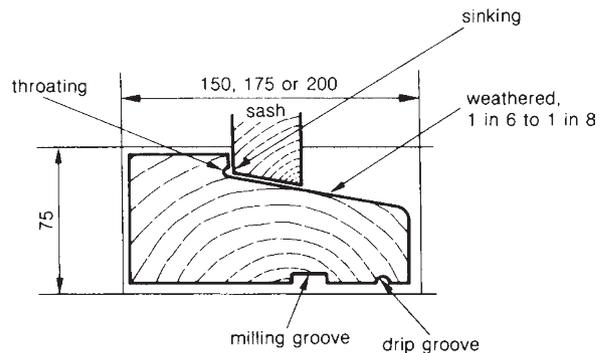


Parts of the solid frame include the *head* and the *stiles*, which are of the same section as single-rebated material. A vertical dividing member between sections is called a *mullion*

and may be double-rebated. The bottom member of the frame is the *sill*; this is of special interest as it must resist most of the weather.

Figure 8.9 shows the detail of the sill section, which is described as *sunk*, *throated* and *weathered*. These are all features to assist the sill to fulfil its function. *Sinking* is the drop in level behind the sash. *Weathering* is the slope on the sill which varies from 1 in 6 to 1 in 8. *Throating* is the small groove formed at the corner of the sinking; it may not be included in the standard section, but it will increase the weatherproofing of the sill by breaking the capillary action of water tending to seep under the sash, especially when assisted by a stiff breeze.

Fig. 8.9 Detail of a window sill



On the bottom of the sill is a *drip groove* for the purpose of preventing droplets of water forming on the edge of the sill and running underneath. The *milling groove* helps to prevent distortion of the sill by breaking up the wide underside into narrower widths and reducing the overall amount of shrinkage.

The stiles and mullion are housed into the head of the frame (Fig. 8.8). Note the mortise and tenon joint between the mullion and sill. The mortise is made 25 mm wide and lines up on one side with the sinking in the sill. The shoulders on the mullion are bevelled where necessary to butt down tightly onto the sill. The tenon is wedged from underneath the sill. Wedges are driven uniformly to avoid forcing the frame out of square. Alternatively, a housed joint may be used.

Frames are assembled after painting the joints with a timber primer or other equivalent product. They are nailed together with galvanised flat-head nails, checked for square by making the diagonals equal, and a temporary brace is fixed to the inside face.

Finishing window frames

The outside is finished with an architrave when used in a timber wall or with storm mouldings in brick-veneer construction, as shown in Figure 8.10.

Sashes

Sashes are made from comparatively slender sections; the names of the members are shown in Figure 8.11.

The procedure for joining the stiles and the top and bottom rails is consistent with the procedure for other framed joinery items. Members dividing the glazing into smaller

Fig. 8.10 External trim to a solid window frame: (a) timber frame construction, (b) brick veneer; and (c) cavity brick construction

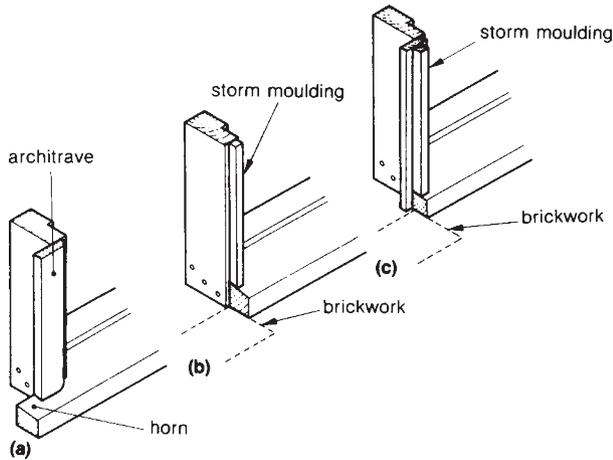
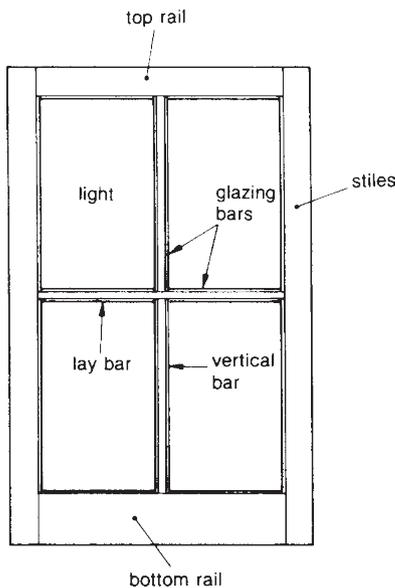


Fig. 8.11 Parts of a sash



areas are called *glazing bars* and are either vertical or horizontal; horizontal bars are referred to as *lay bars*.

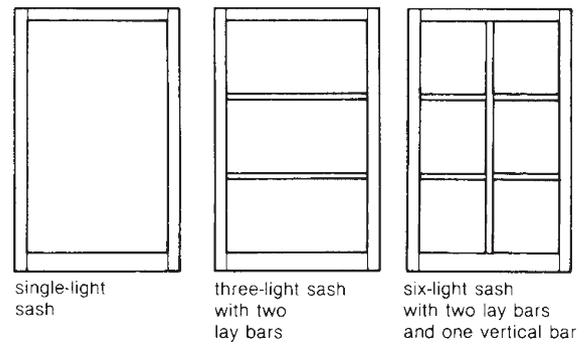
Each separate pane of glass is a *light*, and a sash can be described by the number of lights and the arrangement of the glazing bars. Examples are given in Figure 8.12.

Sash stock is shaped in a particular manner and the thickness is divided into three approximately equal parts.

The rebate is necessary to hold the glass panels which are secured in place with putty or glazing beads; it is on the external face of the sash.

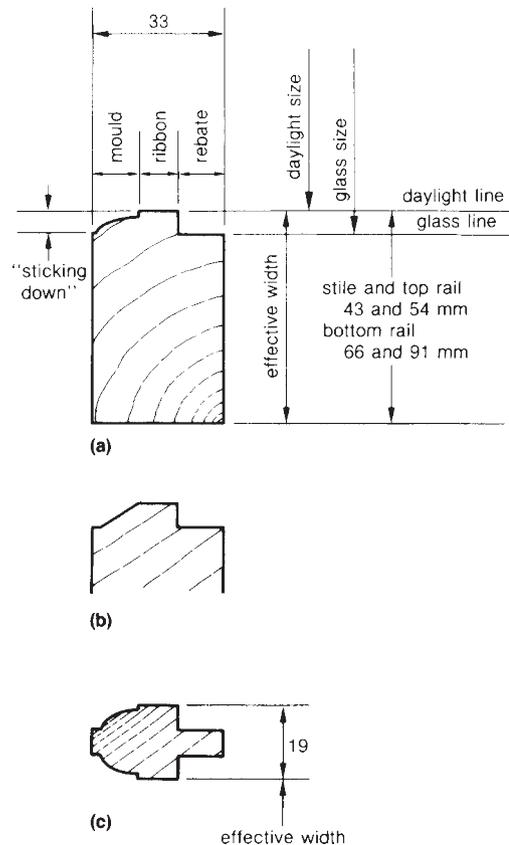
The actual amount of daylight seen through the sash is measured to the *daylight line*, and the glass size is measured to the *glass line*, allowing a clearance for expansion and contraction. The difference between these two dimensions is the depth of the rebate. The centre third is the ribbon, on which

Fig. 8.12 Arrangement of lights and glazing (lay) bars



are located the mortise-and-tenon joints; it is approximately 10 mm wide. The mould on the interior third softens the harsh bulky edge of the frame and can be an *ovolo* mould, or commonly, a *splayed* mould (Fig. 8.13).

Fig. 8.13 Sections of sash stock: (a) ovolo moulding, (b) splayed moulding; and (c) sash bar

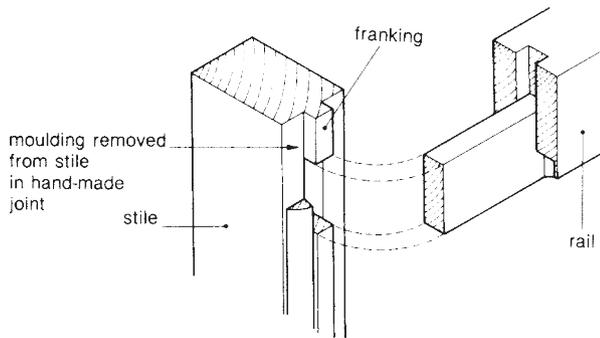


The mould 'sticks down' on the face the same distance as the rebate, making a straight shoulder line on the rails. Note that the effective width is the full-face width of the members, giving the maximum amount of material on which to proportion the mortise-and-tenon joints. Dimensions of members, including sash bars, are given as examples of stock material.

Sash joint

Stiles and rails are joined with mortise-and-tenon joints, modified to the situation and referred to as *sash joints* (Fig. 8.14).

Fig. 8.14 Sash joint

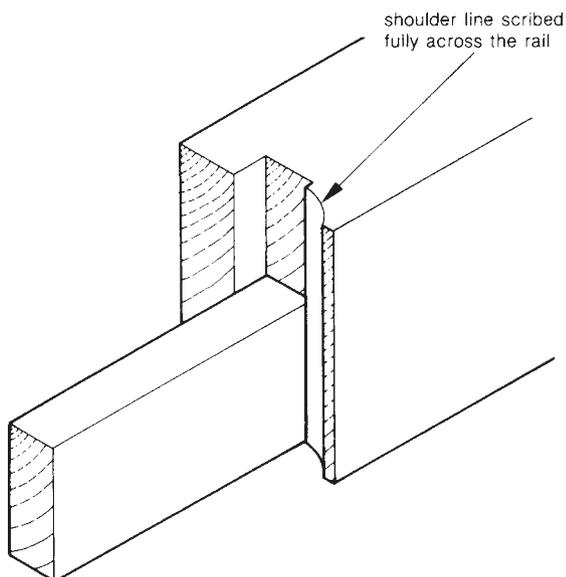


The width of tenon is again two-thirds the effective width of the rail minus one wedge allowance; the thickness is 10 mm. Due to the slenderness of the stile, it is not haunched but a projection is left on the stile which engages into a corresponding recess in the rail. This type of joint is called a *franked joint* and the actual *franking* is the projection on the stile.

The shoulder on the rail is scribed over the mould on the stile. In a machine-made joint, the scribing is across the full width of the rail (Fig. 8.15). However, if this part of the job is done by hand, it is simpler to remove some of the mould from the stile and scribe only sufficient of the shoulder to make the joint between the moulds.

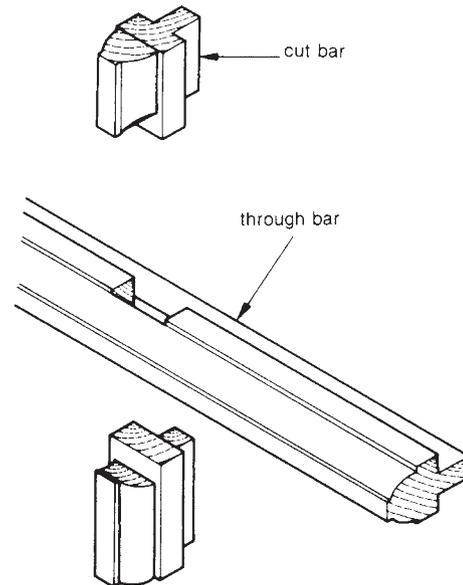
Where sash bars meet at right angles, there will be a *through bar* and a *cut bar*. The through bar is made in the direction where it will tend to strengthen the sash most effectively. The bars can be stub-tenoned into the stiles and rails. The joint between the bars is shown in Figure 8.16.

Fig. 8.15 Machine-made sash joint



The procedure for setting out, using set-out rods, and for making a casement frame and sash, including the glazing bars, will now be described. It is well realised that the bars are not always included in new sashes; so if single-light sashes are being made up, ignore any reference to glazing bars.

Fig. 8.16 Through and cut glazing bars



Setting out of rods

The manufacture of joinery items requires that information be extracted from building plans, correctly interpreted and passed on to the various personnel engaged in the production process. The only adequate way that this information can be prepared and clearly passed on to others is by the preparation of full-size workshop drawings; these drawings are termed *rods*.

An experienced joiner can no doubt make up a piece of simple joinery without the aid of detailed rods, but when he or she becomes part of a production team where the job will pass through different hands for each stage—setting out, preparation of the material, marking off, machining and assembly—before it is completed, a detailed drawing to which all can refer is essential.

The setting out of rods is carried out by a responsible person who must be able to read drawings, be conversant with production methods and have a sound knowledge of building construction so that adequate allowances for manufacture and building in can be provided.

For simple joinery items, such as a rectangular door or window frame, a vertical and a horizontal section will provide all the necessary information; these can usually be set out full-size on a board, 150 mm to 200 mm wide.

When more complicated shapes such as curves are involved, elevations become necessary and these are set out on a sheet of plywood or hardboard. In rare instances, the only space large enough for a set-out is the floor of the workshop, made available by pushing back the benches.

Table 8.1 Cutting list for sash

Member	Width	Thick	Material	No.	Length	Remarks
Stiles	54	33	Oregon	2		stock ovolo-moulded
Top rail	54	33	Oregon	1		stock ovolo-moulded
Bottom rail	91	33	Oregon	1		stock ovolo-moulded
Lay bars	19	33	Oregon	2		stock ovolo-moulded
Vertical bar	19	33	Oregon	1		stock ovolo-moulded

Table 8.2 Cutting list for frame

Member	Width	Thick	Material	No.	Length	Remarks
Sill	142	66	Tallowood	1		stock casement sill
Stiles	91	41	Oregon	2		stock rebated
Head	91	41	Oregon	1		stock rebated
Storm mould	19	19	Oregon	21		standard quad

The main points when setting out a rod are as follows:

1. Dimensions must be accurate—any discrepancies at this stage will carry on through the job and assume greater proportions the further the job progresses.
2. To assist in the reading of the rod, the sections should always be drawn with the face of the item facing the person setting out, with the bottom member, such as the sill or bottom rail, to his or her right-hand side.
3. Sections are drawn to full size and should show clearly the actual size of the various members and their relationship to each other. Dimensions are not shown except for an overall height and width.
4. The rod should be clearly and easily interpreted. Remove any surplus setting-out lines that could be misleading. Light hatching can be shown on end sections, but remember that the purpose is to make the area easier to identify and not to obliterate the essential information.

The method of fixing should be clearly indicated—mortises are crossed diagonally and wedge allowances are not shown. The centres of dowel holes are indicated with a cross and circled, with the diameter of the dowel indicated.

5. A cutting list should accompany the rod. This can be regarded as an order for the material required to complete the job. The length of members can be measured directly off the full-size rod and should include any allowances for cutting waste or horns required during manufacture or building in.

Order each item as the number of pieces of the actual length required; do not add them up into long lengths as this could result in many wasted short lengths.

The section sizes of members, if these are finished sizes, are indicated and included in the remarks column. They also draw attention to any other machining necessary, such as rebates or plough grooves indicated on the rod. If making up items from stock material, some of these details can be omitted and the different sections identified by a number or other description.

Copies of the cutting list will probably be required to pass to another part of the workshop for ordering the material, or to go to the office for the job to be costed.

An example of a set-out rod for a solid-frame six-light casement sash is shown in Figure 8.17.

If the frame is to suit a brick veneer or brick cavity wall, the height is measured from underneath the sill to the top of the storm moulding and is a multiple of brick courses. Deduct 10 mm from the height to allow for packing or bedding under the sill. Width is measured over the backs of the storm mouldings and is made to suit the opening in brickwork.

When bars are set out, it is important that the daylight size to each light is exactly equal. Even with only a small variation, it is possible that every square of glass would have to be cut to a different size—an expensive mistake. The bars are set out by the 'in and over' method.

To set out the rod, straighten one edge and secure the rod to the bench with the straight edge overhanging 10 mm to 15 mm. All gauging is done in pencil from the straight edge, the quickest way being with the rule and forefinger (Fig. 8.18).

Alternatively, a wooden runner attached to the rule and gripped between the thumb and forefinger is an aid to accurate gauging. Square across the rod from the straight edge.

Steps in setting out the rod are illustrated in Figure 8.20 and are described as follows:

1. Mark off the overall height and gauge a line to represent the interior face of the frame. Use short lengths of the stock material, cut from scrap, as templates to mark in the outline of each section.
2. After the sill is marked, continue with the head, first positioning the storm moulding and then locating the head relative to it. Using short lengths of sash stock, mark in the sash top and bottom rails, and space the bars in between (Fig. 8.17).
3. Proportion the mortise-and-tenon joints, mark in and cross the mortises.

Fig. 8.17 Set-out rod for casement window sash

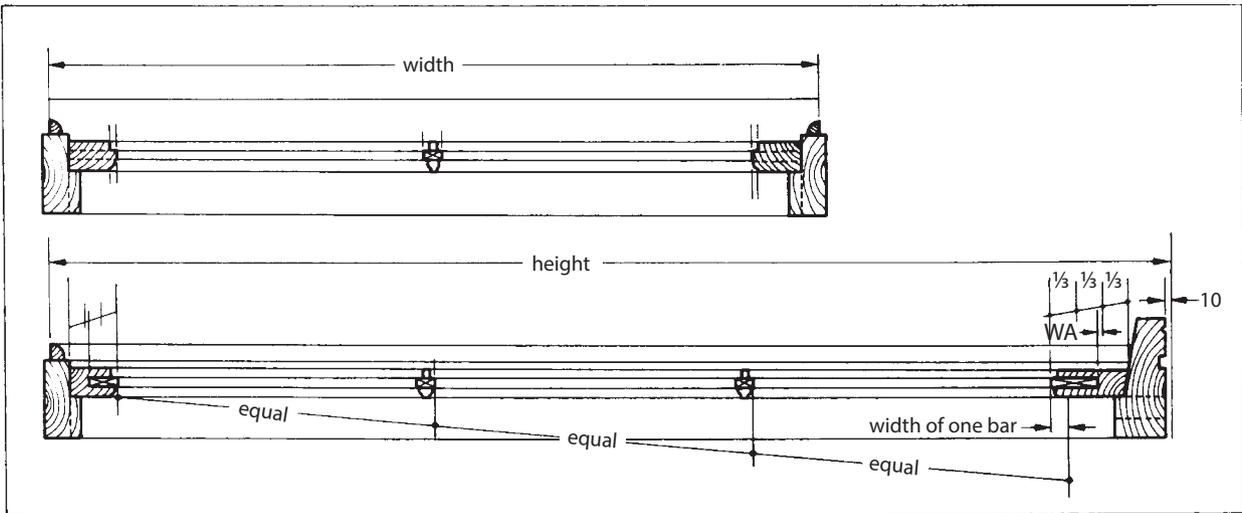


Fig. 8.18 Finger gauging

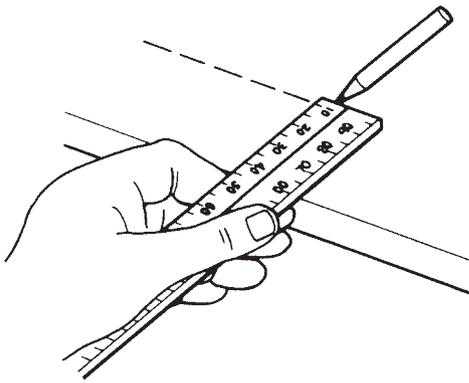


Fig. 8.19 Using a wooden runner

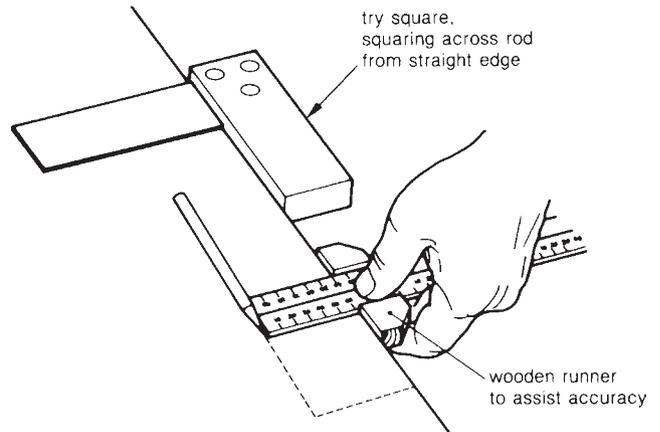
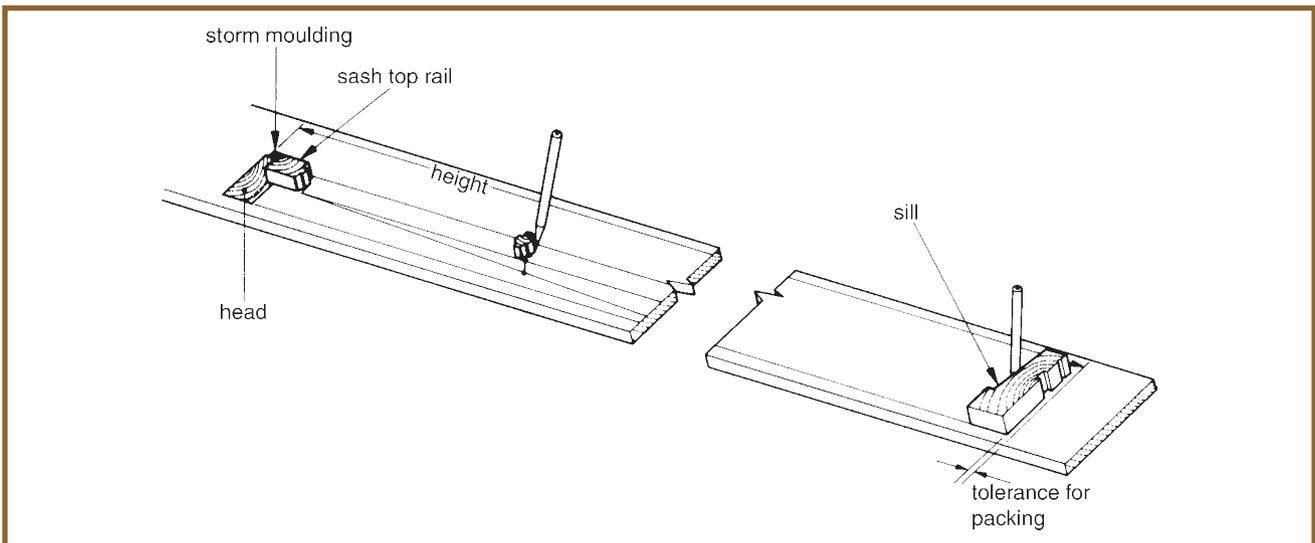


Fig. 8.20 Setting out steps for the rod



4. Follow a similar procedure with the horizontal section, first setting off the width and locating the storm mouldings, followed by the other members.
5. Finally prepare the cutting list.

Marking out from the set-out rod

Marking out members of both the frame and the sash is done by laying them face down on the rod and projecting the relevant points directly onto the timber.

Marking out the stiles

Marking out the sash stiles is shown in Figure 8.21.

The procedure is as follows:

1. Lay the stile on the vertical section; the point of the try square can assist in transferring the position of the mortises onto the ribbon of the stile. To square around a section where the sharp corner has been removed by a mould etc., use a *box square*. This is made up from wood, or folded from metal, and the ends must be square (Fig. 8.22).
2. Always mark out stiles in pairs; hold them together with the face edges together and the face sides opposite (Fig. 8.23). With sash stock, the moulded side is taken as the face side.
3. Square the mortises across both stiles and transfer the position around to the back of the stiles where there are to be through members. The try square can be adapted to square across the stiles by attaching an extension to the face: make a saw cut in a light lath of timber and slide it over the blade of the square.

Fig. 8.22 Box square for mouldings

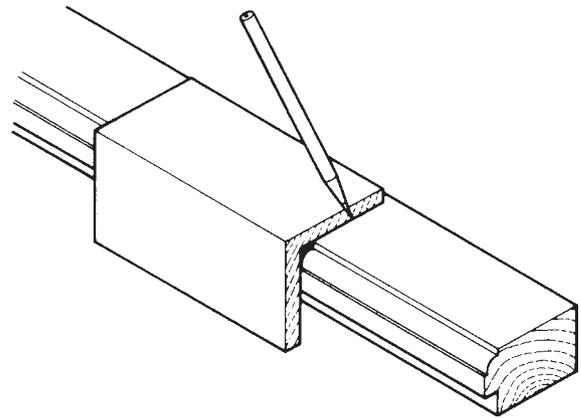


Fig. 8.21 Marking out the stiles

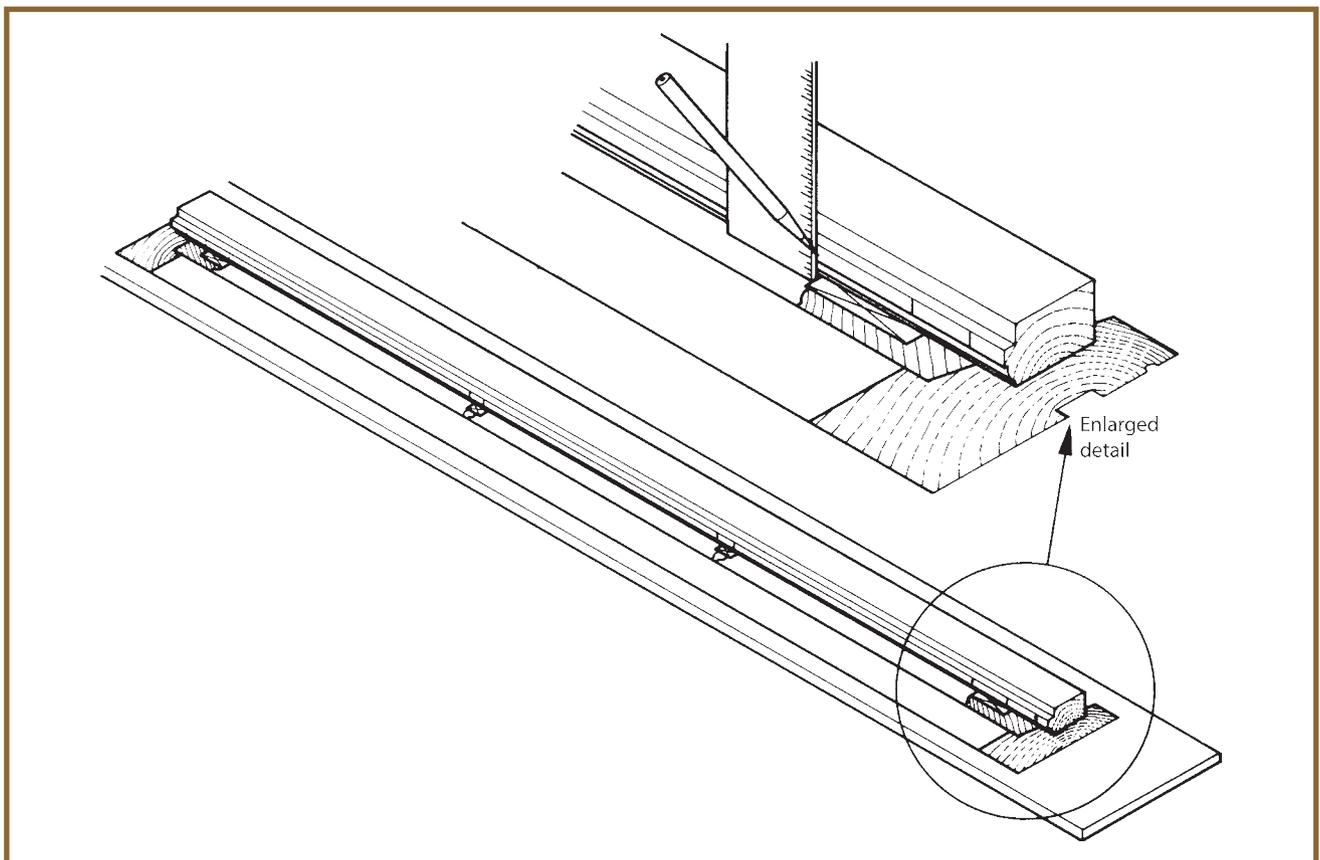
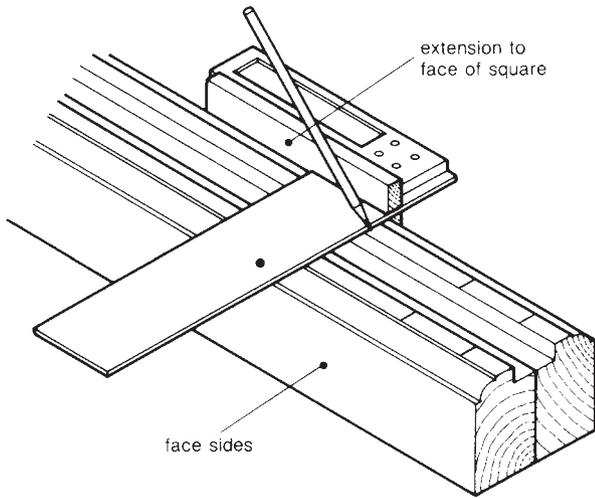


Fig. 8.23 Marking out the stiles in pairs



If a number of stiles are to be marked out to the same pattern, proceed as shown in Figure 8.24.

Arrange the stiles in pairs, half of the face sides pointing in one direction, the other half pointing in the other direction, with the pattern stiles to the outside. Square the ends and hold them together with a light sash clamp. Use a short straight edge to mark the mortises across.

Marking out the rails

The procedure for marking out the rails is as follows:

1. Lay a rail on the horizontal section and transfer from the rod both the glass line and the daylight line. Square the glass line across the faces; this becomes the shoulder line.

Cut back, to the daylight line, the recess for the franking. If there is to be a vertical glazing bar, mark also the position of the mortise.

2. Hold the rails together and mark from the pattern rail to ensure they are all of the same length.
3. Gauge the mortise-and-tenon joints as described previously, lining up one side of the mortise with the rebate.

Depending on the type of machining equipment available in the workshop, it may only be necessary to set out one rail in detail to enable the machines to be set up.

Fig. 8.25 Marking out the rails

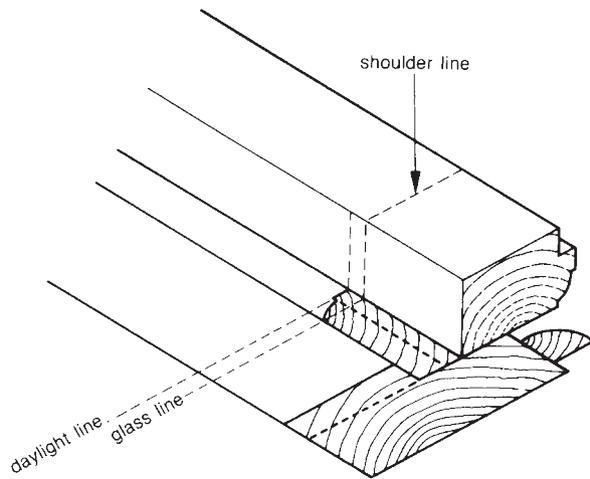
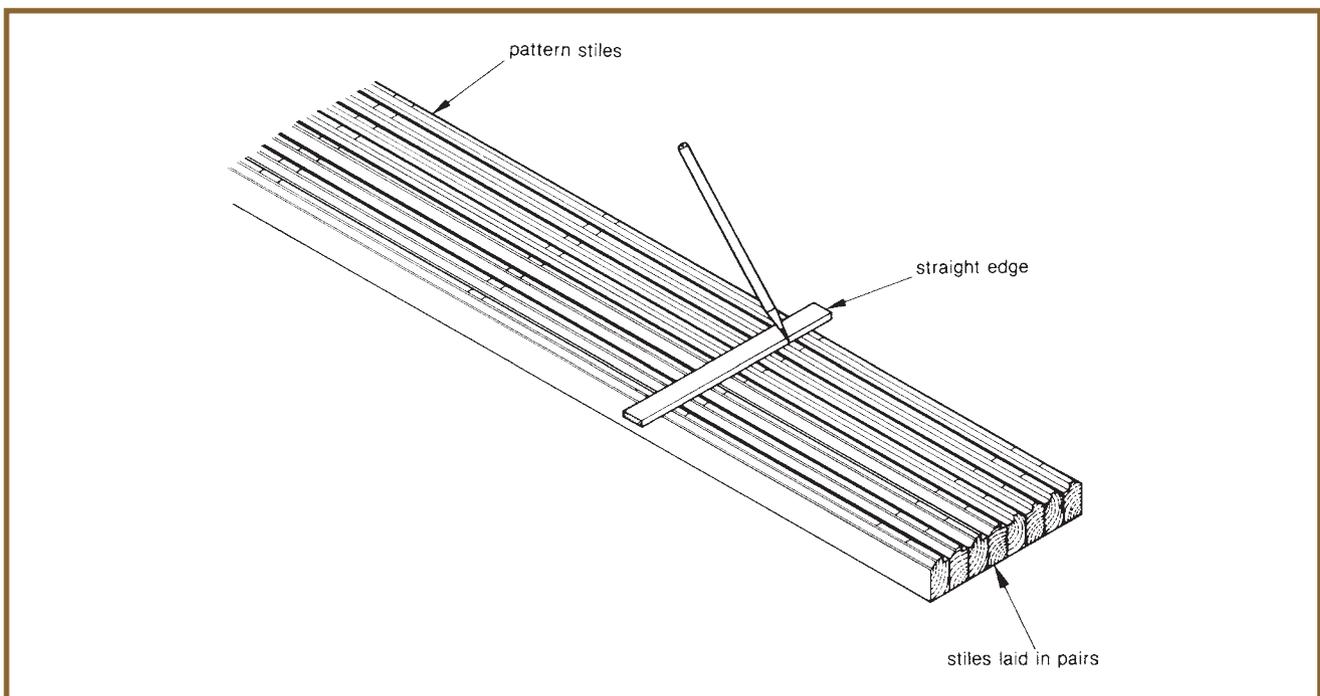


Fig. 8.24 Marking out multiple stiles



Making the sash joints

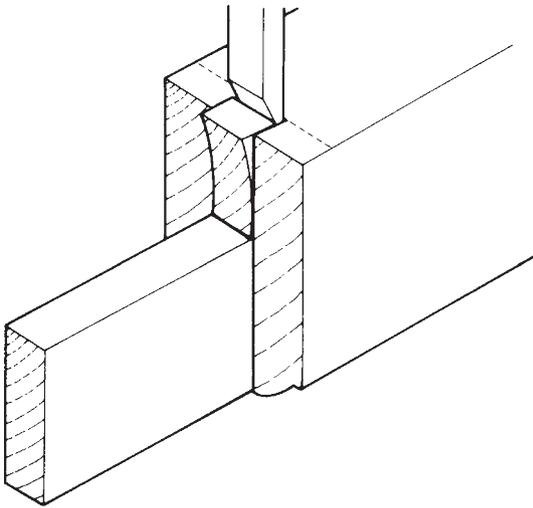
Proceed by carrying out the following steps. (Some of these steps are more fully described in Chapter 7, under the heading 'Making the mortise-and-tenon joint', p. 77.)

1. Chop the mortises.
2. Rip the tenons.
3. Cut the shoulder lines.
4. Cut the tenon to width, including cutting wedges from the waste.

From this stage on, the joint is modified, as illustrated in the following figures. If the joint is to be finished by hand, follow these steps:

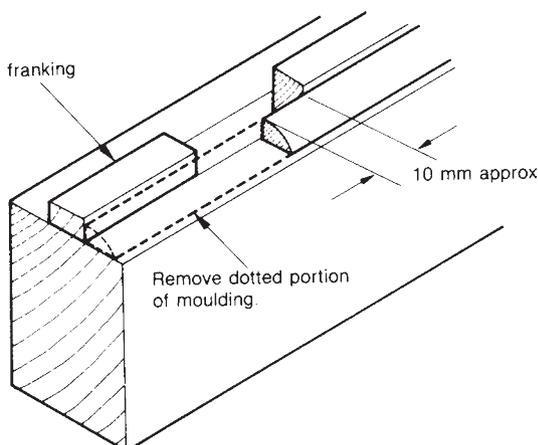
5. Cut the recess for franking (Fig. 8.26).

Fig. 8.26 Recess for franking



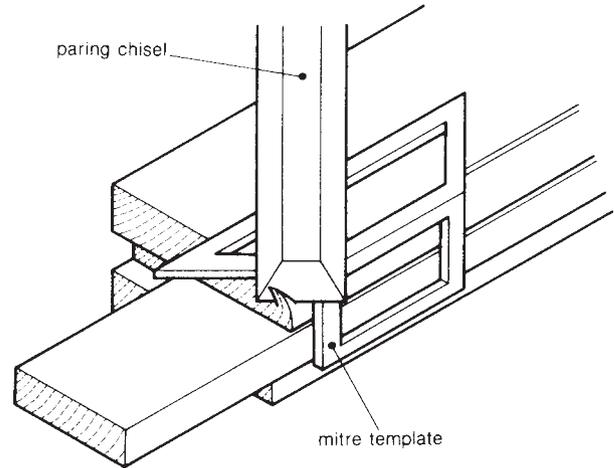
6. Remove a portion of the mould from the stile, being careful not to damage the franking (Fig. 8.27). Leave sufficient of the mould on the rail to scribe over later.

Fig. 8.27 Portion of moulding removed from stile



7. To scribe the mould on the rail, first mitre the corner. Use a brass mitre template, or use a wooden one which can be made up.

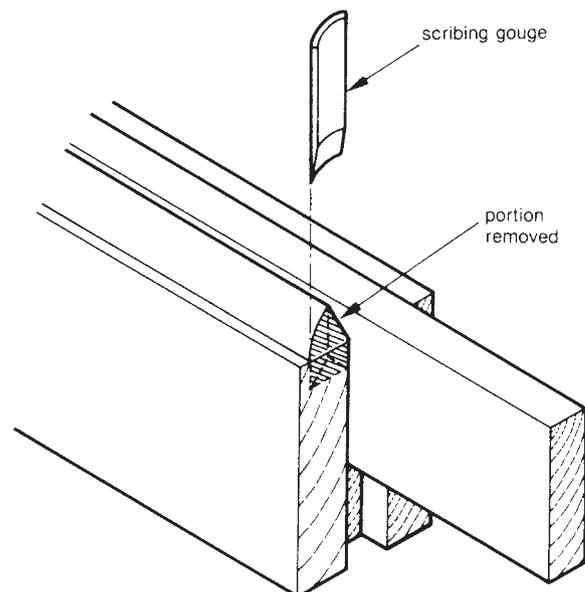
Fig. 8.28 Scribing the moulding



Hold the template across the corner, and using a sharp chisel guided by the face of the template, pare the mould at 45°.

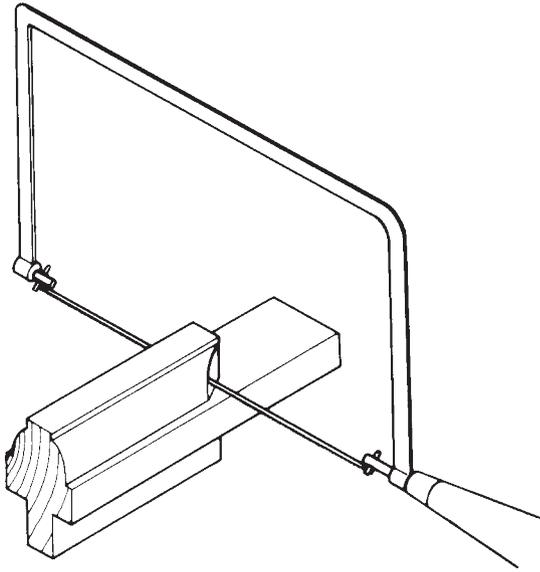
8. Use a scribing gouge to scribe the shoulder line to the contour of the mitre, and remove the shaded portion shown in Figure 8.29. The joint is now ready for fitting.

Fig. 8.29 Scribing the shoulder line



Other moulded shapes can be undercut using a chisel or suitable gouge. The mould on glazing bars is scribed over the other moulds as shown in Figure 8.30. First mitre the mould and undercut to the mitred contour using a coping saw.

Fig. 8.30 Scribing the mould on glazing bars over other moulds



Assembling and gluing up the sash

Before proceeding to glue up the sash, assemble the necessary equipment and materials. Lay sash cramps out on the gluing-up bench and site across the bars of the cramps to ensure that they are out of 'wind'. Another requirement is a squaring rod,

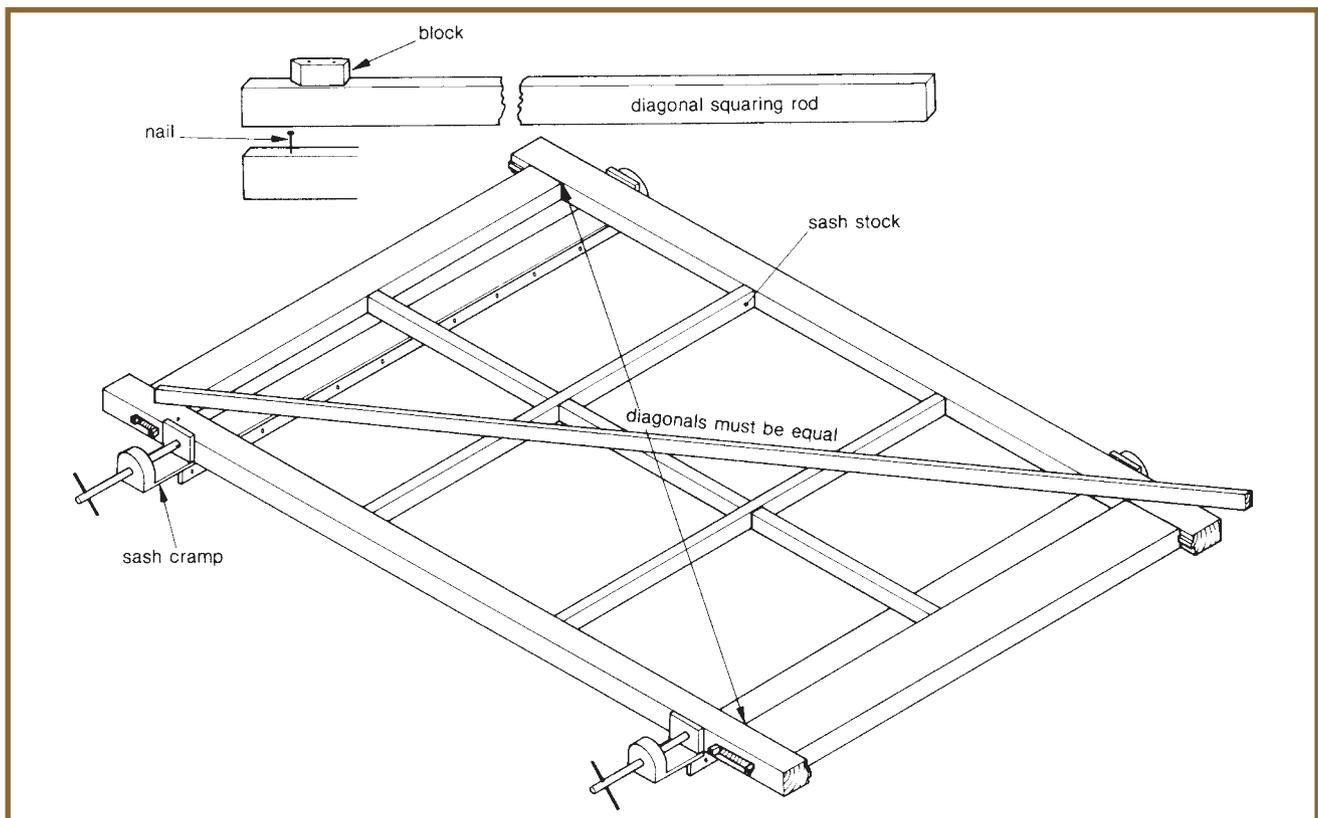
consisting of a light lath of timber which is at least long enough to measure the diagonals of the frame. At one end of the squaring rod, drive a nail in, or attach a block, to positively locate the end when measuring.

Prepare the adhesive and have ready a suitable application brush. For most joinery, a PVA adhesive is satisfactory unless a more water-resistant adhesive is specified. Wedges and hand tools must also be to hand.

To assemble the sash, proceed as follows:

1. Apply adhesive to the tenons, particularly around the shoulder line and the franking to the stiles. Enter the joints and tap the frame lightly together. The procedure may vary depending on the arrangement of members. In the example shown in Figure 8.31, the assembling would commence with the sash bars, followed by the top and bottom rails and finally the stiles.
2. Lay the sash in the cramps, keeping it hard down on the bars. Ensure that the cramps are applied square across the sash, and cramp the joints together. The cramp should be positioned so as not to foul the wedges or bow the stiles; positioning across the horns is often the most satisfactory.
3. To square the sash, use the squaring rod to measure the diagonals. These must be made equal. If one diagonal is longer than the other, slacken off the cramps and position them at a slight angle across the sash to pull the long diagonal shorter.

Fig. 8.31 Gluing-up procedure



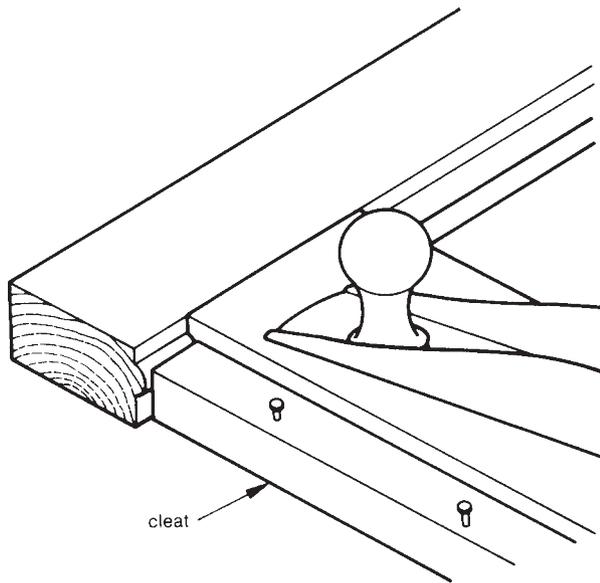
4. Before wedging it is essential that the sash is square and perfectly flat or, to use the trade term, out of 'wind'. Apply adhesive to the wedges and enter them into the wedge allowance. Commence driving the end wedge first, followed by the other wedges; drive them uniformly so as not to force the sash out of square.
5. Wipe away any surplus adhesive with a cloth that is just damp, remove the sash from the cramps, and stack flat for the adhesive to set ready for the cleaning off.

Cleaning off the sash

Cleaning off the sash by hand requires a smoothing plane, the blade of which is sharp and set to remove a fine shaving. The sash must be laid flat on the benchtop and held securely. Corner blocks, or often a cleat fitting between the horns and attached to the bench, will provide adequate restraint.

Hold the plane as shown in Figure 8.32, with the toe pointing to the outside edge of stiles or rails. Work around the framing, flushing off the joints by removing any rough spots or other blemishes, and setting-out marks. Take only a fine shaving and follow the direction of the grain. Test the surface for flatness, particularly across the joints, using a straight edge or tilting the sole of the plane.

Fig. 8.32 Cleaning off joints



Finish the surface with an abrasive paper held over a sanding block. First sand across the rails, followed by the stiles and work up to the shoulder line; remove any scratches. If the sanding is carried out with an electric sander, follow a similar procedure.

Vertical sliding sashes

Box frames

Box frames are used with vertical sliding sashes that are counterbalanced with cast-iron or lead weights. The jambs of the frame are made up from comparatively light sections and

are formed into a boxed section which gives them rigidity and provides a space in which the weights can operate.

The frame members which form the box are the *pulley stile*, the *outside lining*, the *inside lining* and, in brick construction, the *back lining*. A *pendulum strip* hangs in the box and separates the weights. Two *sash channels* are formed on the face of the box by the outside lining, the parting bead which separates the sliding sashes and the stop bead. The sashes slide vertically in the sash channels. In addition to the stile and the top and bottom rails, there are the *meeting rails* which come together when the sashes are closed. Note the difference in the profile of the top and bottom meeting rails and the manner in which they are splayed to come together and seal the junction (Fig. 8.33). The sashes are hung on *sash cords* which are fixed into a plough groove at the back of the sash stile; they pass up and over axle pulleys near the top of the frame and are attached to the weights inside the boxed section. Some very old windows may even have a chain instead of cords.

For many years, well-made box-frame windows provided one of the most popular and reliable types of window available. However, in recent years, for various reasons—possibly mainly economic—the box frame has almost been superseded by other types of window in new constructions.

Repairing box-frame windows

The main interest in box-frame windows, for today's practising carpenter, is their maintenance, installing new sash cords in particular. The following discussion will be limited to the procedure for re-cording a box-frame window. The steps are as follows:

1. *Removing the sashes.* To remove the sashes from the frame, use a suitable chisel to prise away the stop beads and remove them from the frame. Remove the bottom sash. If there is a cord that is not broken, lift the sash to near the top of the frame and cut the cord. The weight will fall the short distance to the bottom of the box. Prise out the parting bead—it should not be nailed but it can be stuck in with paint, and care is necessary to avoid it being broken. Remove the top sash.
2. *Removing the weights.* When the sashes are removed, find the axle pulleys near the top of the frame. Apply a spot of oil to ensure that they are rotating freely. On the inside sash channel, near the bottom, is the *pocket piece*. This provides access to the weights. Remove the pocket piece. Move the pendulum strip aside and remove the weights through the pocket. Do not mix the weights as the top and bottom sashes may have slightly different weights—the bottom sash usually being the heavier.
3. *Marking the length of the cords.* To mark the length of the cords, note the plough groove in the back edge of the sash stile in which the sash cord has been fixed. Mark the end of the cord on the stile and remove the old sash cord. Measure the distance from the end of the cord to the bottom of the sash and mark the same distance up from the sill on the pulley side. On the drawing in Fig. 8.35, this distance is indicated as *c*. Do this for both sashes—the marks might not necessarily come in line.

Fig. 8.33 Structure of a box frame

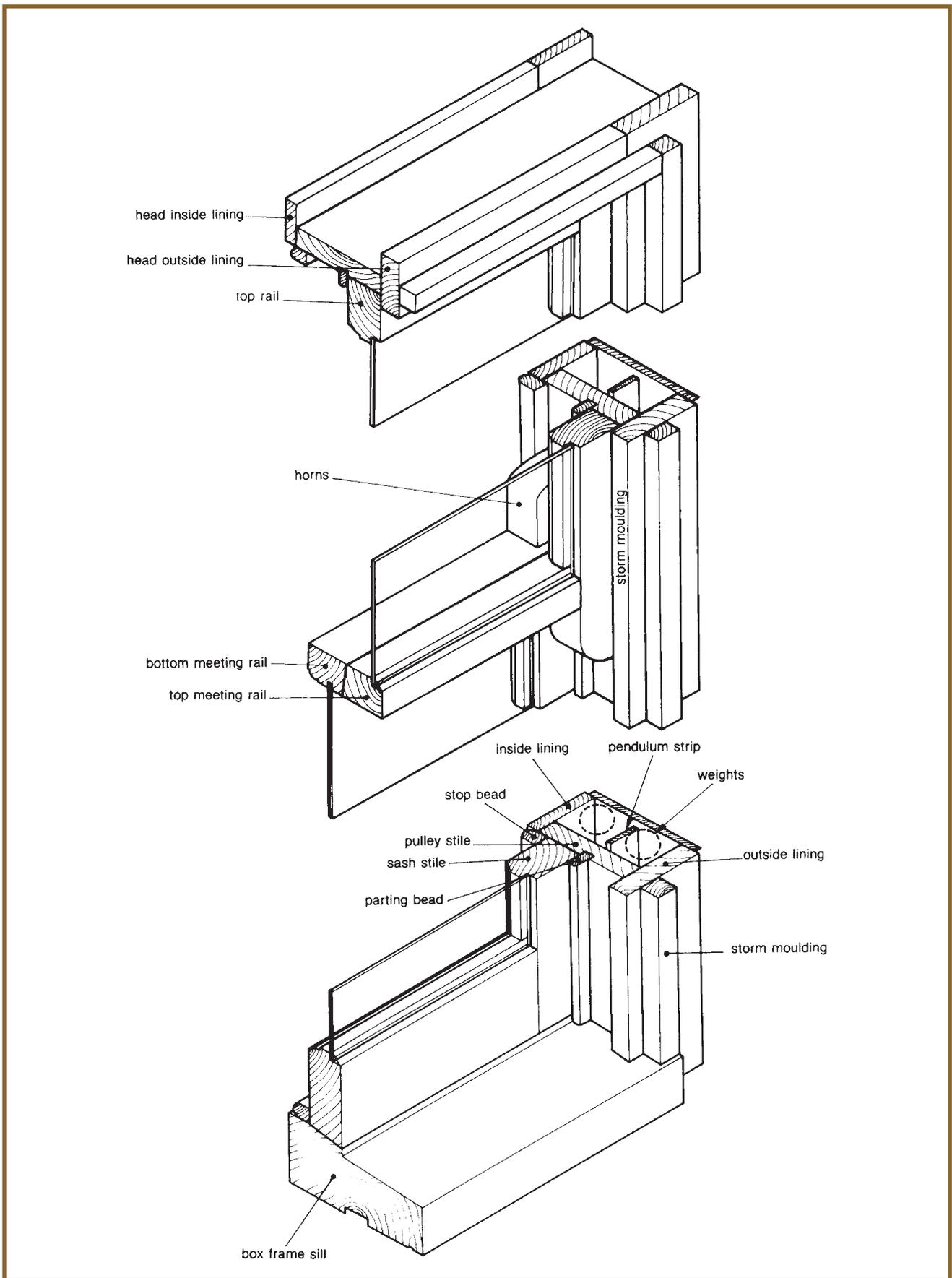


Fig. 8.34 Axle pulleys and pocket piece

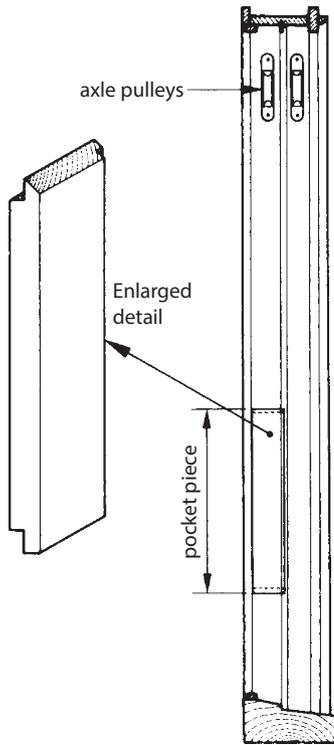
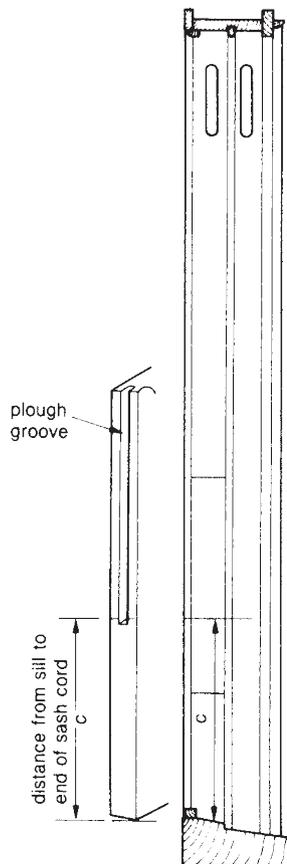


Fig. 8.35 Marking the length of the sash cords

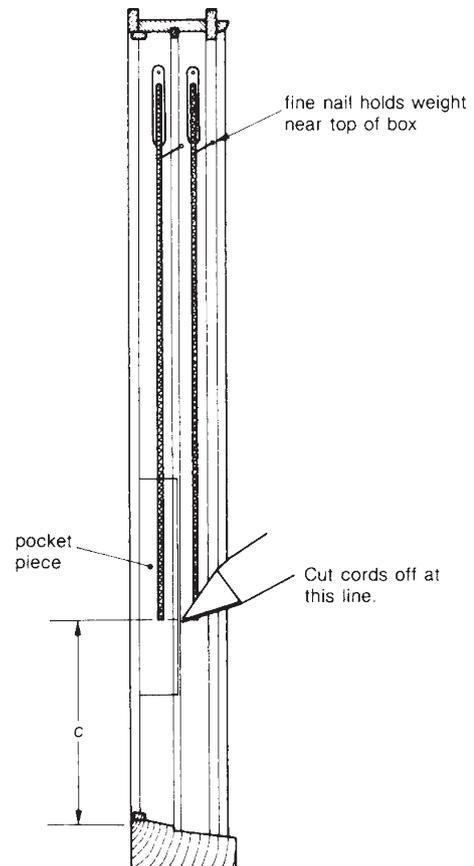


4. *Threading new cord.* (Fig. 8.36.) To thread new sash cords, a 'mouse' is necessary (Fig. 8.37). This consists of a length of string with a small weight on the end which can be passed over the axle pulleys.

Use a No. 8 sash cord for most applications. Attach the mouse to the end of the cord with a few half hitches. Pass the weighted end over the axle pulley and out through the pocket, followed by the end of the sash cord. Attach the appropriate weight to the ends of the cord and secure by a figure-8 knot on the end of the cord (Fig. 8.38).

Place the weight back into the box and pull it to the top of its travel. Drop it back about 30 mm from the top and secure it in this position by driving a fine nail through the cord just below the axle pulley (Fig. 8.36). Cut the cord off at the mark on the pulley stile. Repeat this step for each weight and replace the pocket piece.

Fig. 8.36 Threading new sash cord



5. *Attaching the cords to the sashes.* (Fig. 8.39.) Replace the top sash first. Fit the new sash cords into the plough groove with the end on the mark made previously and secure with no more than three 20 mm clout nails. The top nail must be below the level of the axle pulley when the sash is fully up. Remove the nail holding the weight and locate the sash in its channel. Replace the parting beads, first sanding off any surplus paint that will affect the smooth operation of the sash. Attach the bottom sash to the new cords in a similar manner and locate it in its channel.

Fig. 8.37 A 'mouse'

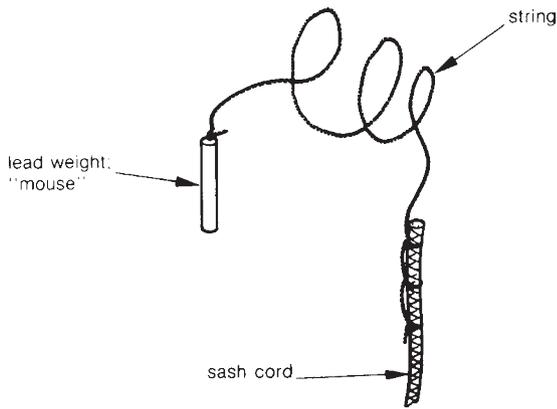


Fig. 8.38 Attaching the weight

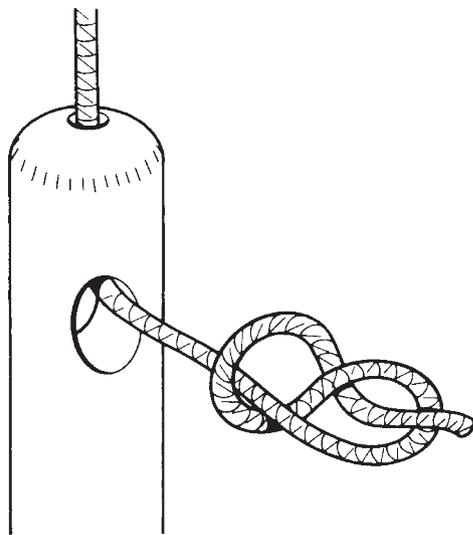
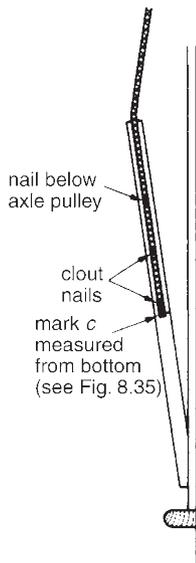


Fig. 8.39 Attaching the cord to the sash



Denail the stop beads—usually less damage to the bead will result if the heads of the nails are pulled right through with a pair of pincers. Replace the stop beads and renail, allowing the sash a clearance of no more than 2 mm in the channel so that it can operate freely without rattling.

Check the pair of sashes for satisfactory operation.

Spiral spring balances

Spiral spring balances have almost entirely superseded cast-iron weights as a means of counterbalancing vertical sliding sashes in new domestic constructions. The balance in Fig. 8.40 consists of a plastic casing in which are housed the tension springs and a twisted extension rod to which the sash is attached. The balance is accommodated in a groove, formed in the back edge of the sash stile (Fig. 8.41).

For trouble-free operation, it is important that the grooves be of the correct size (check with the manufacturer), and it is recommended that they be made after the sashes have been fitted to the frame.

Window frames incorporating spiral spring balances can be adapted to any type of construction. The example in Figure 8.42 shows a frame fitted into timber-framed construction. Note the two sash channels and how the outside lining also functions as an architrave.

Fig. 8.40 Spiral spring balance

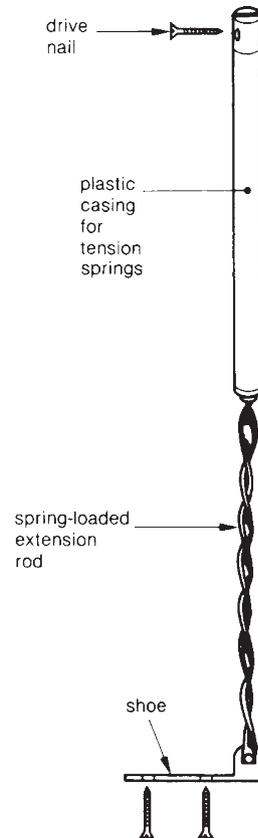
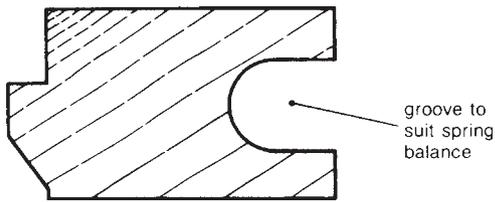


Fig. 8.41 Sash-stile groove for spring balance



Set-out for spiral balances

Details of a set-out rod for a double frame and sashes with spiral spring balances to suit the situation in Figure 8.42 are shown in Figure 8.43.

A standard box-frame sill is used, and when grooving the pulley stiles for the parting bead, make the outside width of the sash channel equal to the thickness of the sashes plus 2 mm clearance.

To set out the sashes, mark in the sash channels; bisect the distance between the daylight lines to locate the centre line of the meeting rails which can now be marked in. If the setting out is correct, there should be equal daylight opening to both the top and bottom sashes. Mark the length of the horns and a common mortise-and-tenon joint on the meeting rails. Note, in the horizontal or width section, how the spring balances allow the use of a narrow mullion, therefore permitting a maximum daylight opening to the frame.

Fig. 8.42 Spiral spring balance in a double-hung window

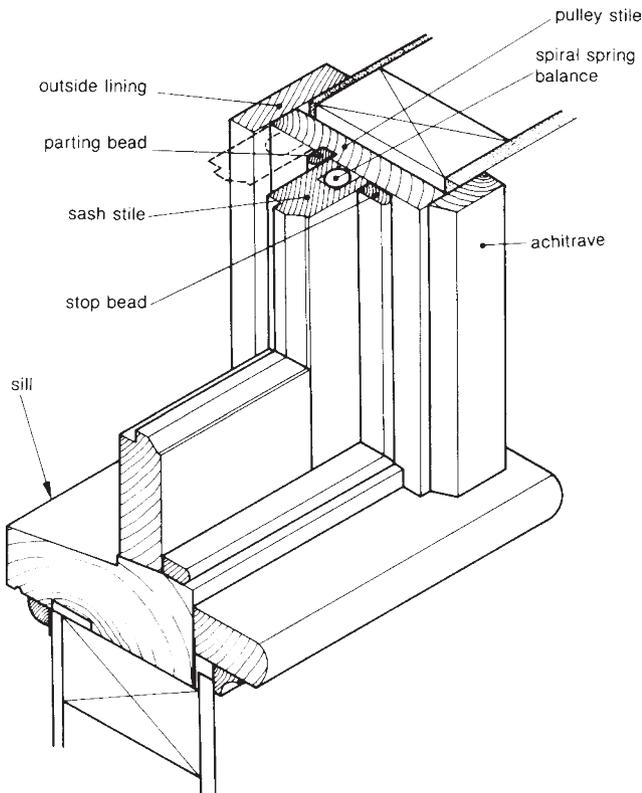
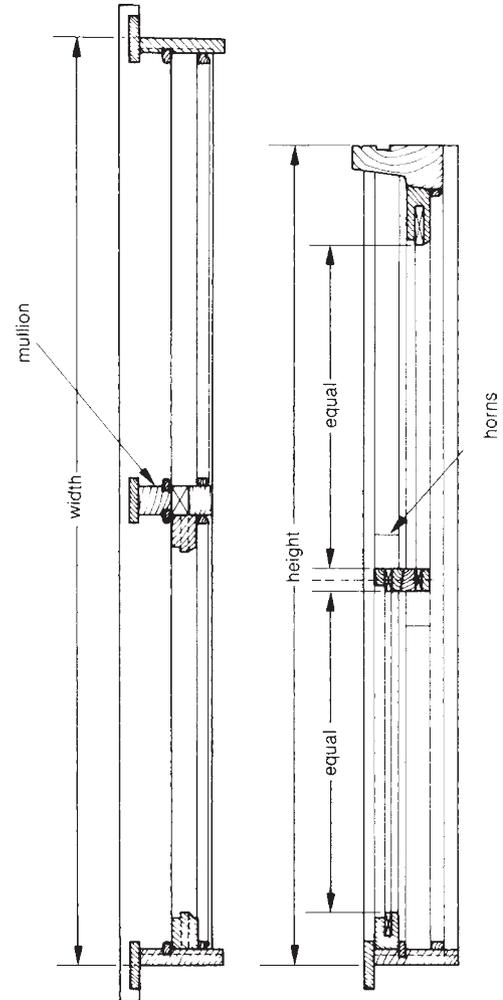


Fig. 8.43 Set-out rod for a double-hung window with spiral spring balances



Glazing

Sashes are usually glazed with a flat transparent glass; in bathrooms and WCs, obscure glass in a variety of patterns may be specified.

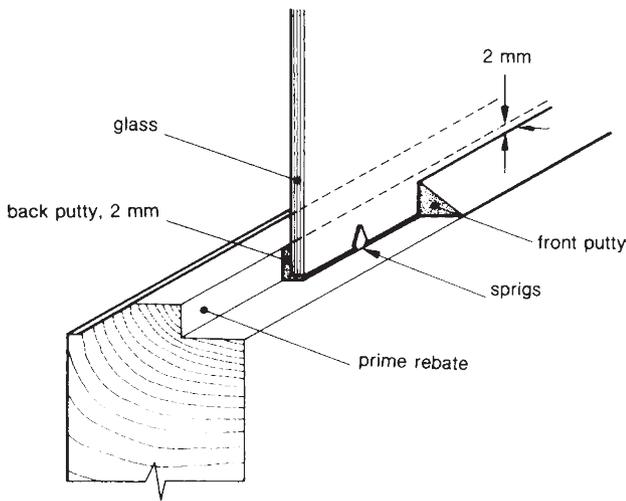
Most flat transparent glass used today is termed *float glass*. It is manufactured by a process where the raw materials are melted in a furnace and the molten glass moves from the furnace in a continuous ribbon over a bath of molten tin. Here, all irregularities are melted out and both surfaces become flat and parallel with a fire-polished finish.

Float glass is manufactured in thicknesses of 3, 4, 5, 6, 8, 10, 12, 15, 19 and 25 mm. Most domestic glazing uses thicknesses of 3, 4, 5 and 6 mm.

There must always be a proper relationship between size, thickness and use of glass. Where doubt exists, it is better to use a thicker glass. For internal applications, consideration should be given to the degree of use, exposure to traffic and the possibility of accidents; some situations may indicate that a toughened form of glass should be used. In situations such as picture windows, window walls and full-height windows adjacent to doors, authorities may require the use of toughened or laminated safety glass in accordance with AS1288: 2006 Glass in buildings – selection and installation.

The glass is bedded and fixed in the sash rebate with linseed-oil putty and metal sprigs (Fig. 8.44). The rebate should be primed with a suitable priming paint (or similar) before glazing. This will seal the timber and prevent the oil from the putty soaking into the timber, causing it to dry out and crack prematurely.

Fig. 8.44 Glazing with putty



The procedure for glazing sashes using putty is now described.

After the rebate has been primed and the paint is dry, apply a bead of putty to the rebate and press the glass into place, allowing a bed of about 2 mm. Fix the glass with sprigs 300 mm apart, and apply the front putty splayed off to a point 2 mm below the daylight line of the sash (Fig. 8.44).

When it is specified that sashes keep their natural clear finish, the glass may be bedded in clear glazing mastic and then secured on the face with a timber-glazing bead.

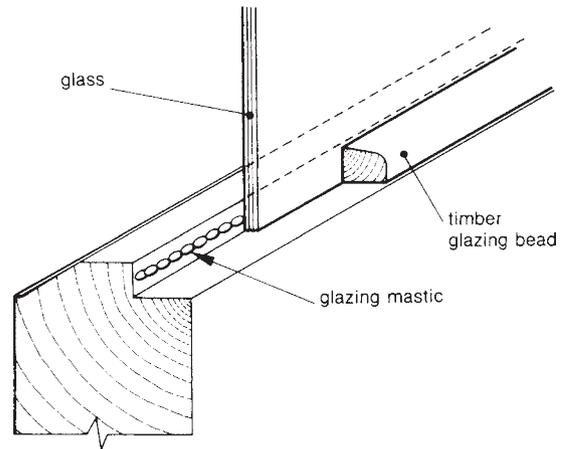
Door construction

Doors are made in a number of types, each designed to provide satisfactory service in different situations. Two broad divisions can be made:

- 1. doors suitable for exterior use
- 2. doors intended only for interior use.

A door designed for exterior use must have a flat face so that water can run off freely. It must be made in such a way that variations in moisture content of the timber can occur without the door becoming distorted.

Fig. 8.45 Timber-glazing bead



Doors for interior use can incorporate elaborate panels and moulds to achieve their purpose without fear of moisture and decay penetrating the joints and ruining the door.

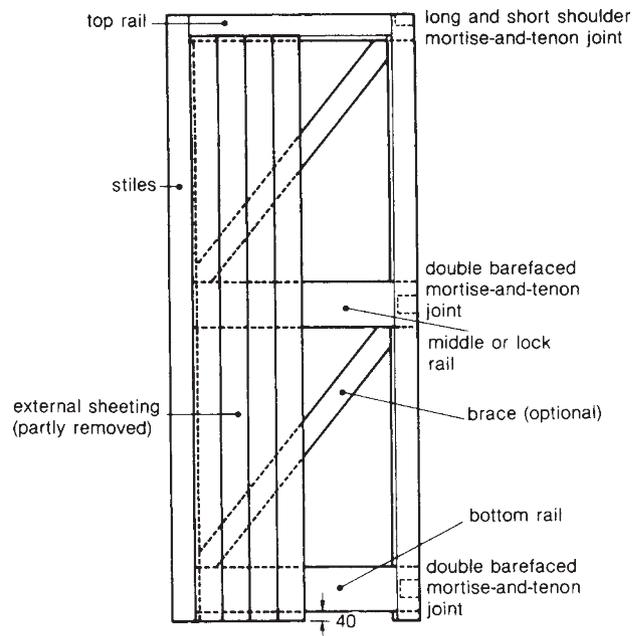
Door types

Factory-made flush-panel doors are now the most commonly used door in new construction. They are suitable for interior use, and also exterior use when bonded with water-resistant adhesives. Other types of fabricated doors, sometimes referred to as *joinery doors*, include these which are now described.

Framed ledge door

The framed ledge door is a very strong type of door, suitable for exterior use where it could be subjected to hardwearing. The stiles and ledges are mortised and tenoned together to form a rigid frame which can be further strengthened by the addition of a brace. The face is then sheeted with vertical tongue and grooved boards.

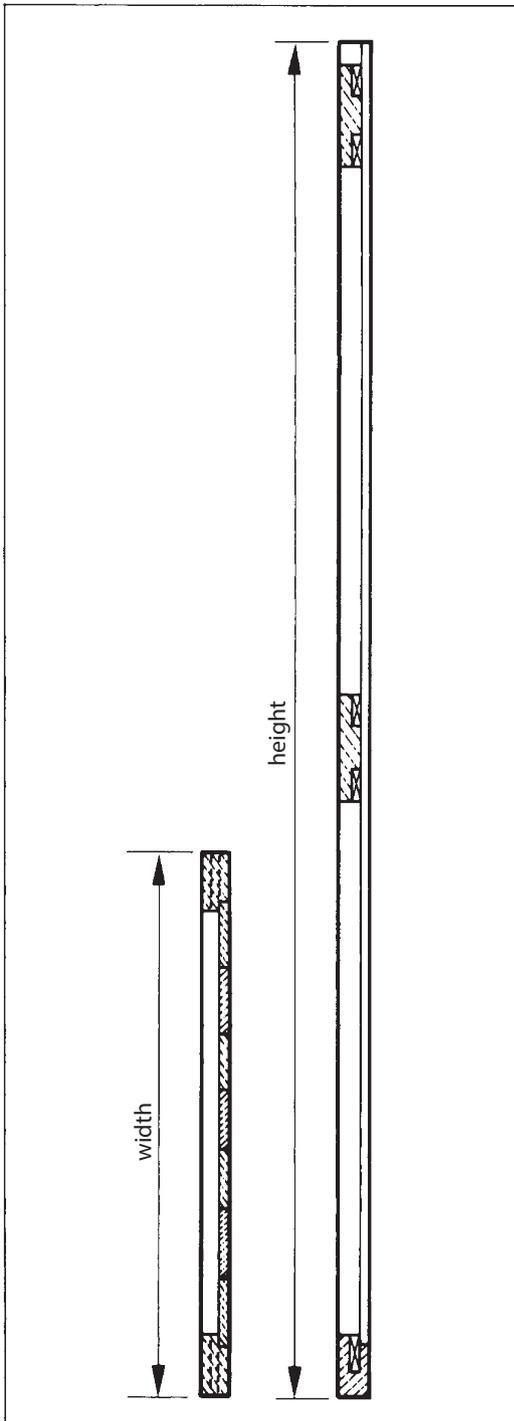
Fig. 8.46 Framed ledge door (sheeting partly removed)



The top rail has the same thickness as the stiles, but the thickness of the ledges is less the thickness of the sheathing. The ledges are joined to the stiles with barefaced mortise-and-tenon joints, as explained earlier. If the ledge is wide, a double barefaced mortise-and-tenon joint is used. The external sheathing is fitted to rebates in the top rail and the stiles and over the ledges to the bottom of the door.

A set-out rod for a framed ledge door, shown in Figure 8.47, illustrates the construction. Details of proportioning the mortise-and-tenon joints are explained earlier in this chapter.

Fig. 8.47 Set-out rod for a framed ledge door

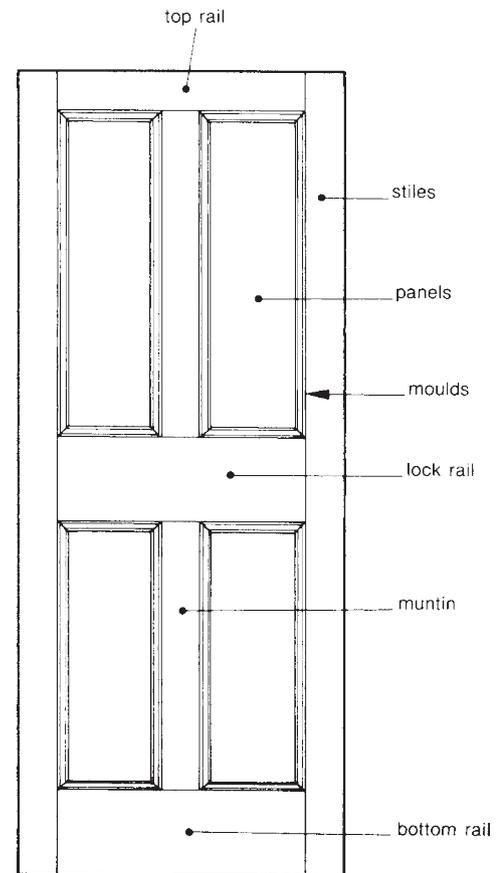


Framed and panelled doors

The use of panelled doors is now usually limited to interior situations; however, they may be used as external entrance doors only where adequate protection is provided from the prevailing weather.

The design of panel doors can vary considerably; a basic four-panel door is shown in Figure 8.48.

Fig. 8.48 Four-panel door



Note that the stiles and the top rail are of the same width and that the bottom rail is about twice that width. The middle rail, also called the *lock rail*, is about the same width as the bottom rail. Vertical members dividing panels into smaller areas are *muntins*.

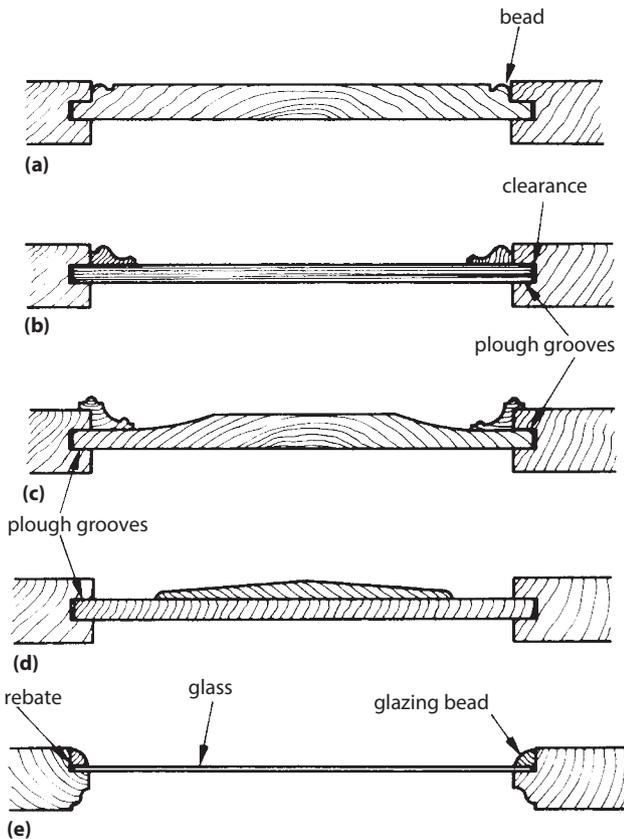
The following sections will describe some of the traditional features of panelled doors and how they have been adapted to the mass-produced doors of today.

Panels

Framed and panelled doors are largely identified by the arrangement and type of panels used in the design. The panels can be solid timber, plywood, glass or various hardboards. Sections through panels are shown in Figure 8.49.

1. *Flush panels* are for external use and are made from solid timber. A bead joint, where the panel meets the framing, will help to hide any shrinkage that occurs in the width of the panel during seasonal changes. Note that the face of the

Fig. 8.49 Sections through panels: (a) flush panel; (b) flat-sunk panel; (c) raised panel; (d) laminated raised panel and (e) panel fixed into rebates



panel is slightly below the level of framing by approximately 1 mm. This allows the face of the panel to be cleaned off before being assembled into the framing; the framing can then be cleaned off without touching the face of the panel.

- Flat-sunk panels** have a flat face which is sunk below the level of the framing. They may be of plywood, but if they are of solid timber they must be free to move with changes in moisture content. Any mouldings applied around the panel should be fixed to the framing; if fixed to the panel, they will shrink away as the panel moves.
- Raised panels** have the centre of the panel raised and the outside perimeter moulded and may be referred to as the *field*. The contour can be varied and the face of the panel is again kept just below the level of framing. A simple way of forming a raised panel is to fix a raised centre section to a flat-sunk panel.

Timber panels are usually held in the framing by being fitted to a plough groove which runs around the inside edge. A clearance is allowed in the bottom of the groove.

Using a rebate is another way of fixing panels. Rebates are used particularly for installing glass panels which, of course, cannot be fitted until the framing is completed. The glass is retained with glazing beads or putty.

Mouldings

Mouldings are placed around panels to soften the harsh change in level between the panel and framing, and to improve the

appearance of the door. Mouldings can be of two types: they may be 'run in the solid' where the moulding is run directly into the solid timber (Fig. 8.50), or they may be 'planted' where the moulded section is machined as a separate piece in long lengths, and then mitred and fixed around the panels (Fig. 8.51).

Fig. 8.50 'Run in the solid' mouldings

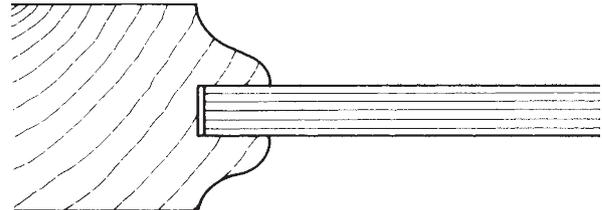
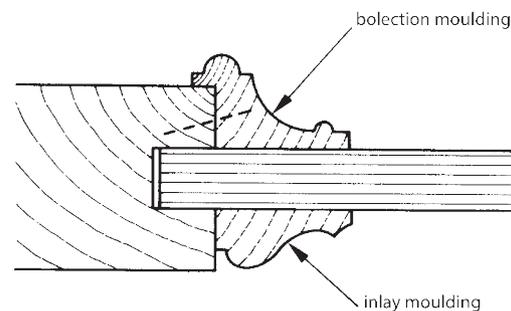


Fig. 8.51 'Planted' mouldings



Planted mouldings are again divided into two types:

- inlay mouldings**, where the profiles can vary but the thickness is such that the top of the moulding will finish just below the level of the framing
- bolection mouldings**, where the moulding will rebate over, and finish above, the level of the framing.

Bolection mouldings give a door the appearance of being thicker and more solid than perhaps it really is. In conjunction with raised panels, it makes a most impressive entrance door.

Simulated panelled doors

Figures 8.52 and 8.53 show examples of modern doors where the design is routed out of the solid panel. The panel material is usually MDF. The routing may be further enhanced by the addition of planted mouldings.

Fig. 8.52 Simulated panelled door

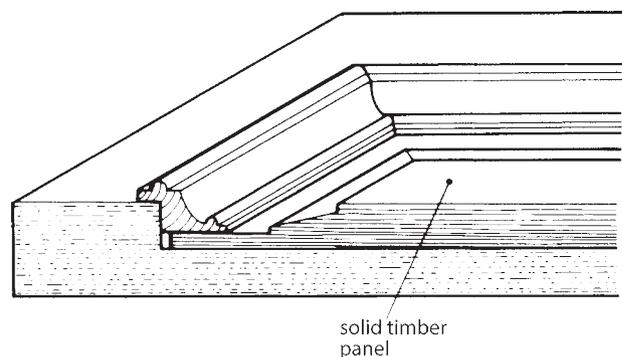
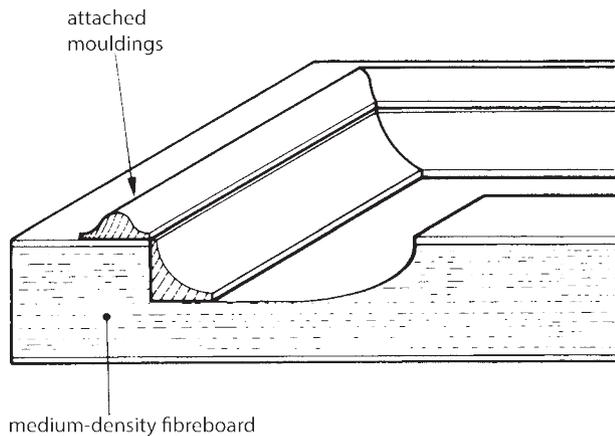


Fig. 8.53 Simulated panelled door, routed and with a planted moulding



Student research

Investigate the other types of windows that are available for modern buildings. Investigate the range of materials that windows can be made from as an alternative to timber.

Windows and glazing

The energy gained or lost through typical window openings in a house is approximately 10 per cent. Heat energy is gained or lost through:

- radiation through the glazing (about two-third)
- conduction through glazing bars (if any)
- air leakage around the opening sash and frame (about one-third)
- conduction through the window frame itself.

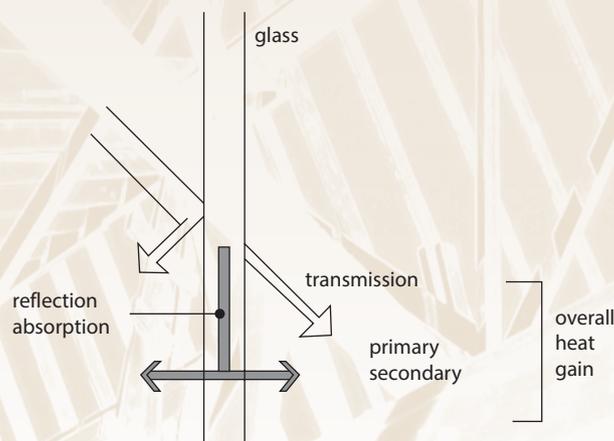
The actual amount is dependent on the frame material and its sealing in the wall structure. In general, timber frames perform better than metal frames, although some composite material frames (metal with softwood core and PVC and softwood core) outperform timber.

The type of opening sash also determines the amount of air leakage (heat in or heat out). Traditional double-hung windows perform the worst and casement/awning windows the best. Gaps between the frame and wall should be sealed with low-expanding foam and single-sided, pre-formed and high-performance adhesive tape to provide an airtight bond and vapour control seal.

Heat is absorbed through the glazing in two ways:

- solar gain directly transmitted through the glass
- energy absorbed by the glass itself and subsequently transferred inwards by convection and radiation.

Fig. 8.54 Heat is absorbed through glazing in two ways: direct transmission and energy absorbed and transferred inwards



(Continued)

(Continued)

The type of glass specified for windows is an important decision for lowering heat gain. Glass is available in a range of thicknesses and types. The most common are:

- *low-emissivity glass (low-e)*—glass that has a coating on the outer surface of metal oxide
- *double glazing or insulated glass unit*—two panes of glass in a frame where the gap between the panes is filled with a gas; improves the window performance by reducing the conduction of heat
- *solar control glass*—glass with a high-iron content, which reduces its light transmittance and therefore its solar gain
- *tinted glass*—glass with a ceramic non-metallic film or coating applied to the outer surface which converts solar gain to infrared radiation; similar to low-e glass
- *laminated glass*—this consists of two sheets of glass on either side of a centre layer which bonds the glass; this glass eliminates approximately 99 per cent of harmful UV rays.

Curved work and mouldings

LEARNING OBJECTIVES

- 9.1 Semicircular-headed door frames and curved windows
- 9.2 Bending timber
- 9.3 Mouldings and joining mouldings
- 9.4 Enlarging and diminishing mouldings
- 9.5 Raking mouldings

Curved work can be produced in a number of ways, and when selecting a suitable method of construction, consideration must be given to the nature and proportions of the job and the quality of finish required.

Semicircular-headed door frame

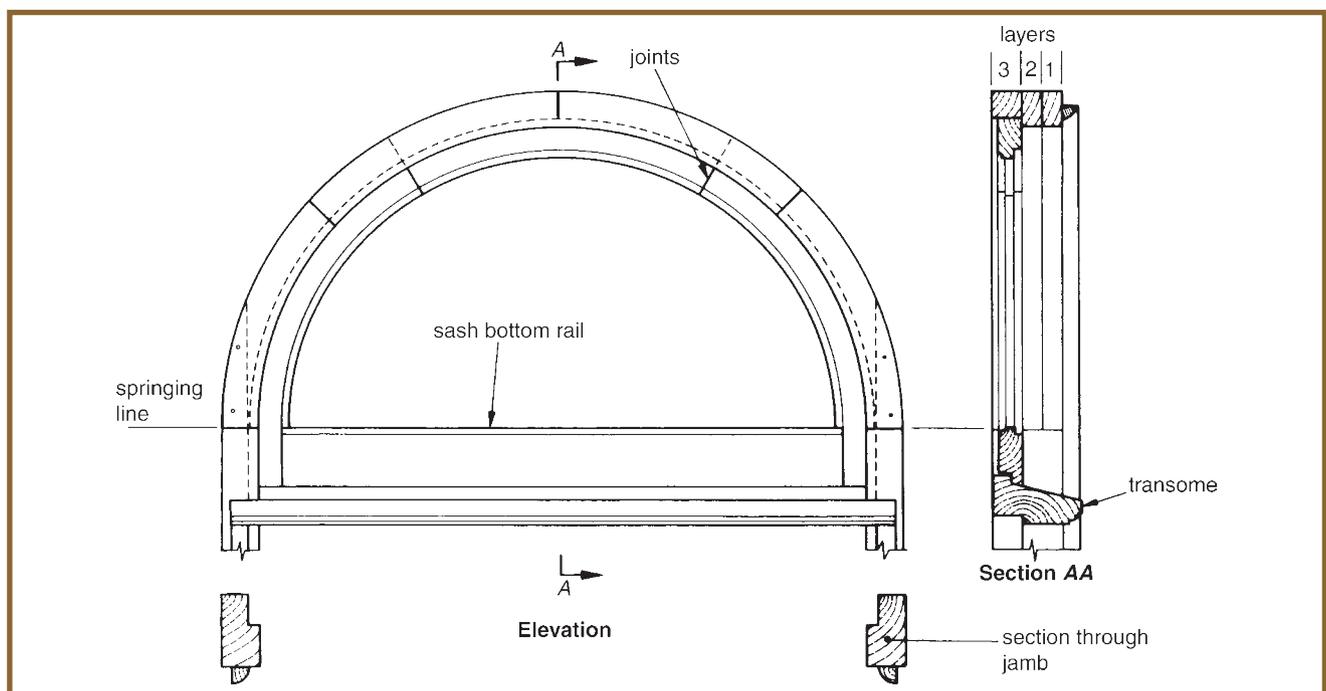
A typical example of curved joinery work is the semicircular-headed door frame with fanlight, as shown in Figure 9.1. A *fanlight* is a sash placed over a door opening; it either can be fixed or it can be an opening type to provide ventilation to a passageway. The *transome* is the horizontal member that serves the dual purposes of a head for the doorway and a sill for the fanlight.

Note that the daylight line of the sash bottom rail is on the springing line; the shoulder line on the bottom rail is then a straight line with a sash joint. The daylight opening of the sash will conform to the true geometrical shape of the curved head, in this example a semicircle. The head is built up with segments laminated together and the joint between the head and straight jambs is made on the springing line.

Constructing the curved section

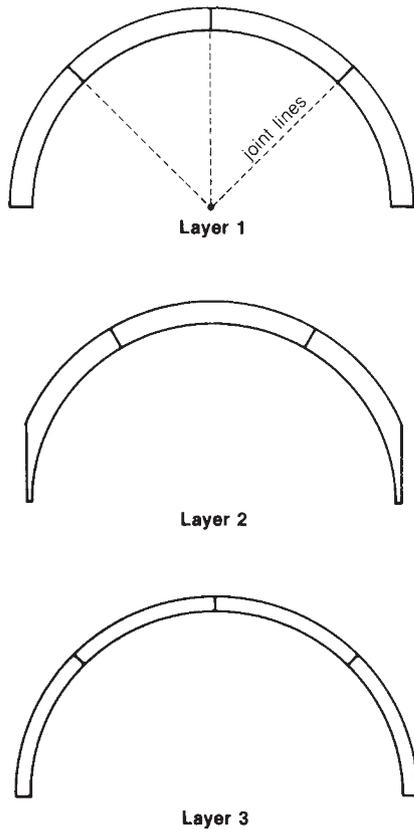
The first essential step for making up any curved section is to set out a rod, which will include full-size elevations providing sufficient detail to set out templates of the required curved segments and the position of the joints.

Fig. 9.1 Semicircular-headed door frame



The head is built up in three layers (indicated as 1, 2 and 3 in the vertical section AA of Figure 9.1). The joints between segments must be 'staggered'; a layout of the three layers is shown in Figure 9.2.

Fig. 9.2 Layout of a laminated head



The number of segments in each layer will vary with the radius of the curve. If segments are made too long, they must be cut from wide boards leading to excessive waste and short grain. A stronger job may result if each layer is divided up into a greater number of parts.

The segments are marked onto planks from the templates and are cut by the bandsaw on the waste side, leaving the line on. The inside edge is cleaned up square to the face and then laid on the rod to check the accuracy of the curve and to mark the joints. When the three layers have been prepared and fitted, they are glued and nailed together.

Fig. 9.3 Cutting segments from planks

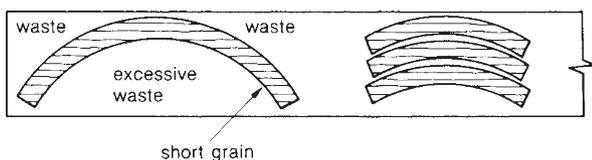
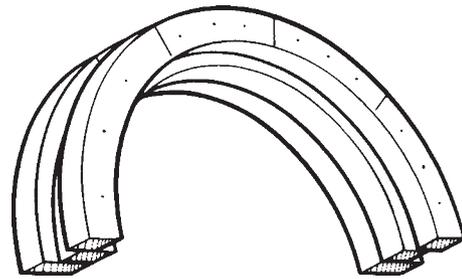


Fig. 9.4 Built-up curved head



The joint between the transome and the jamb is shown in Figure 9.5. The joint can be housed and nailed. The alternative would be a mortise-and-tenon joint. Below the transome, the jambs are similar to a standard rectangular door frame. A spreader and brace are fitted to keep them square and parallel.

The joint between the jamb and the curved head is shown in Figure 9.6.

A tongue is formed on the jamb to engage in the slot formed between the layers of the head. The joint can be prepared for draw pins, and when adhesive is applied and the joint assembled, the pins will pull the shoulder tightly together.

Sash

From the rod, templates of the segments to build up the curved head are prepared, which can then be cut from planks. The inside edge is cleaned up and checked for accuracy by laying the segments on the rod. When satisfactory, the joints are marked and fitted to each other. The edge is rebated and moulded using either the router or spindle moulder.

Fig. 9.5 Joint between the transome and the jamb

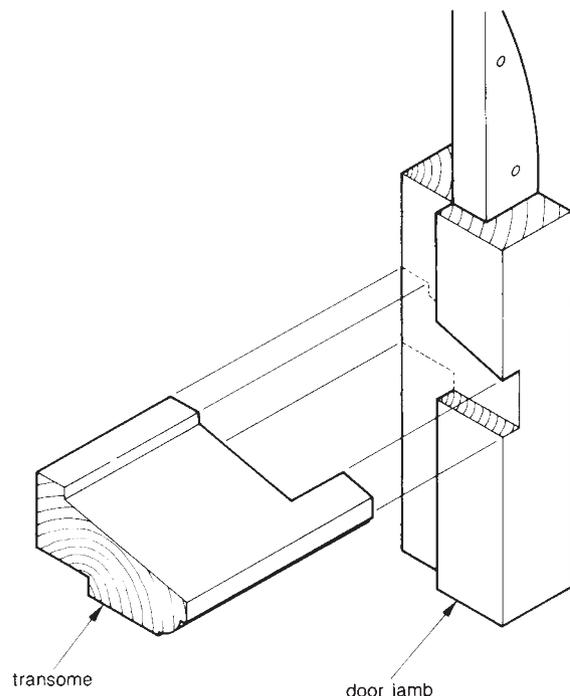
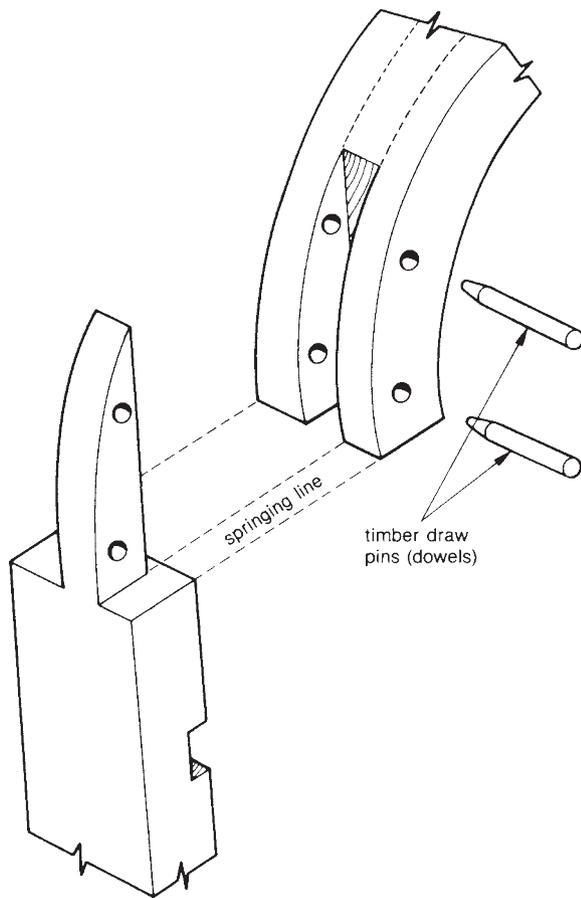


Fig. 9.6 Joint between the jamb and the curved head

Consideration is given to the shape of the sash, how it is to be assembled and whether this would be best done before or after some of the joints have been permanently fixed.

Joints used in curved work

Joints that can be used to join the segments of the sash and which are also applicable to other curved work of a similar nature include the slip-tongue joint, the dowelled joint, the light plywood tongue and the handrail bolt.

Slip-tongue joint

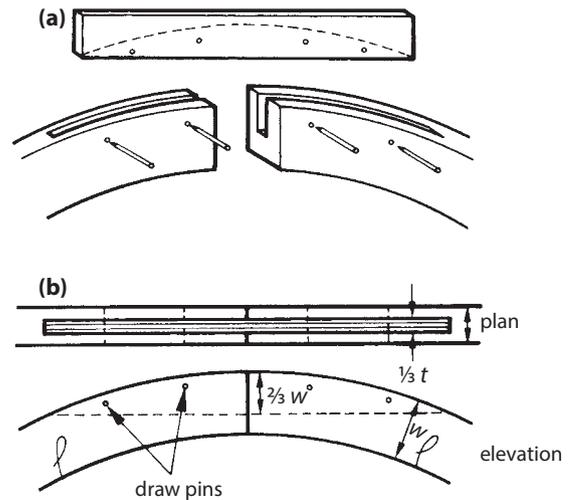
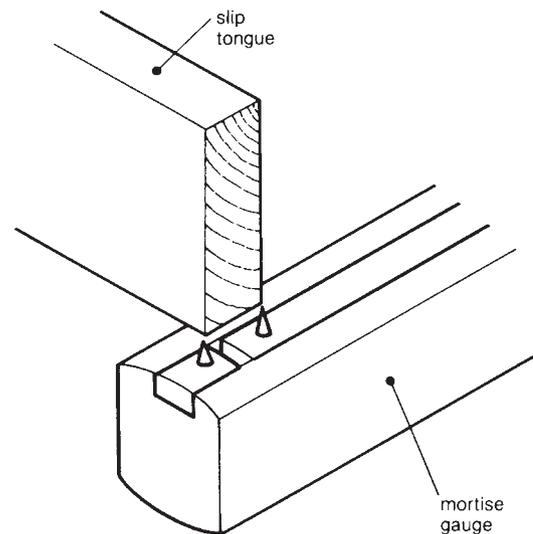
The slip-tongue joint is probably the strongest joint for the purpose (Fig. 9.7a). The tongue is made approximately one-third the thickness of the material and two-thirds the width of the material (Fig. 9.7b).

The tongue is prepared and the spurs are set on the mortise gauge to the correct thickness; the slot is then gauged on the segments (Fig. 9.8).

The joint is pulled tightly together by the use of draw pins. The tongue is fixed to one-half of the joint. When boring for the pins in the other half, the holes are moved in the tongue slightly closer to the shoulder.

Dowelled joint

The joint is proportioned in a similar manner as a dowelled joint between straight pieces of timber, except that if there is

Fig. 9.7 (a) Slip-tongue joint between segments of sash; and (b) plan and elevation**Fig. 9.8** Setting the gauge for the slip tongue

short grain towards the end of the curved segment, the dowels may be made longer than usual to penetrate into more stable timber (Fig. 9.9).

A convenient way of marking the centres for dowels in curved or other irregularly shaped work is to use *dowel centres* or 'specs' (Fig. 9.10). The centres come in sets to suit the usual dowel sizes—6, 8 and 10 mm. The dowel holes are bored in one-half of the joint and the dowel centres inserted. The two parts are laid face down on a flat surface and brought together, keeping them in alignment. They are pressed firmly together to transfer the centres of the dowels to the second piece. Cramping lugs should be left on the outside of the segments. A light bar cramp or G-cramp applied across the lugs will pull the joint tightly together. The lugs are positioned so that the pressure will be applied along a line close to the centre of the joint (Fig. 9.9).

Fig. 9.9 Dowelled joint for curved work

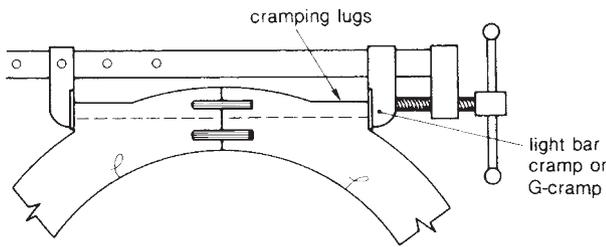
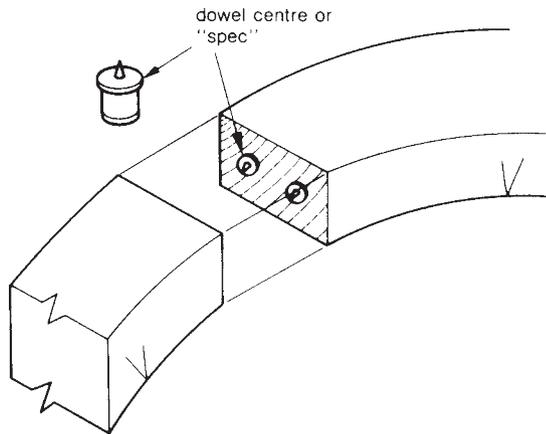


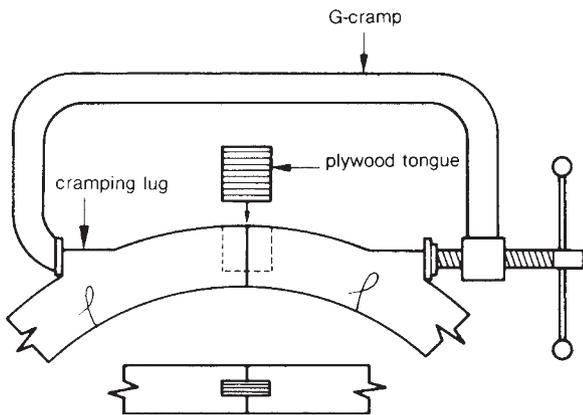
Fig. 9.10 Use of dowel centres



Light plywood tongue

The joint is fitted and a slot is cut to take a plywood tongue (Fig. 9.11). Adhesive is applied to the joint, which is cramped together using the lugs provided. The tongue is then inserted and the adhesive allowed to dry.

Fig. 9.11 Use of a plywood tongue

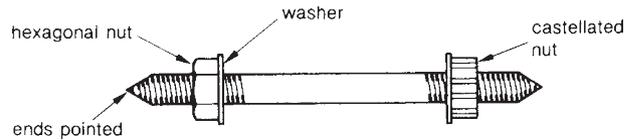


The tongue can be inserted from either the concave or the convex side of the joint, depending on which edge of the joint is to show.

Handrail bolt

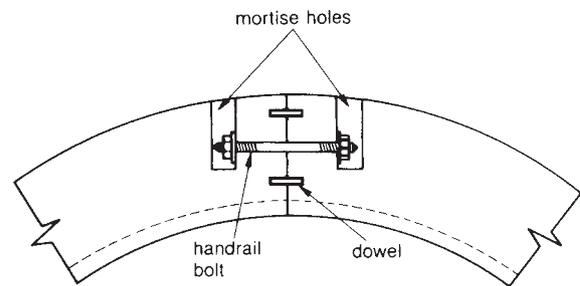
For joining up heavier sections, the handrail bolt is often adopted and is most effective in keeping the joint in alignment and pulling it tightly together. An example of one type of handrail bolt is shown in Figure 9.12.

Fig. 9.12 Handrail bolt



The handrail bolt consists of a steel bolt, threaded and pointed at each end. On one end is a hexagonal nut and washer; on the other end is a slotted or castellated nut and washer that can be tightened with a suitable punch. A cutaway view of a joint, secured with a handrail bolt, is shown in Figure 9.13.

Fig. 9.13 Section of a joint with handrail bolt



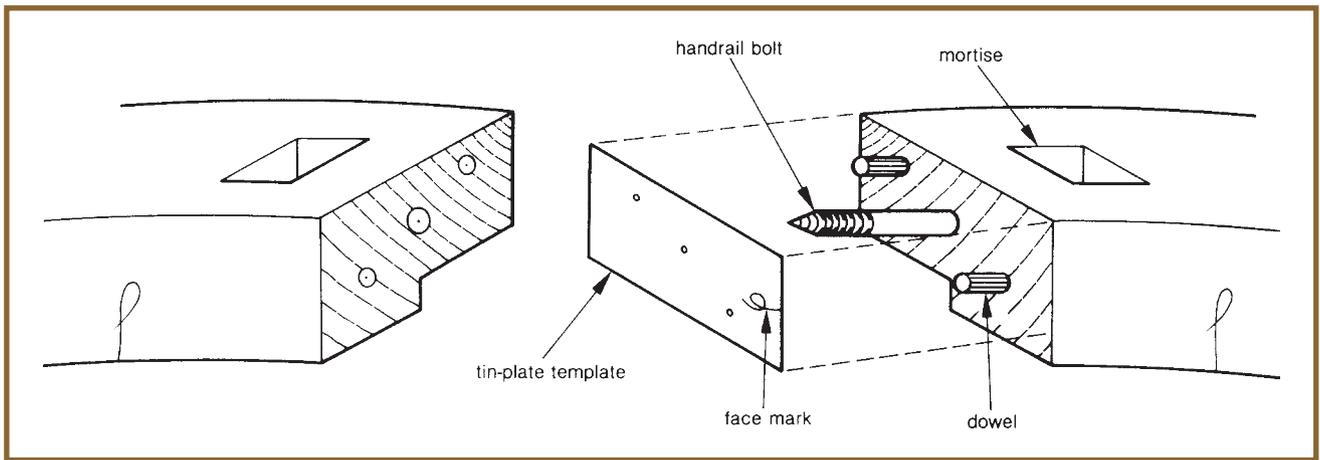
The dowels are included to align the members and prevent them from turning.

As an example, Figure 9.14 shows the set-out for a joint in a curve-headed door frame secured with a handrail bolt. The centres for the holes can be accurately marked onto both parts by using a tinplate or ply template.

To bore the holes for a handrail bolt, first punch or drill holes in the template for the centres of the bolt and dowels. Apply the template to the timber and prick through the holes with a pointed Bradawl or scriber. Include a face mark on the template so that in use it is always kept to the face side of the joint. For the dowels, bore holes which will be a neat fit; holes for the handrail bolts should be at least 1 mm larger than the bolt. Mortise holes are made to permit the nuts and washers to be fitted.

To fit the bolt, first drop the hexagonal nut and washer into the mortise to receive it, and then screw in the bolt. Put the castellated nut and washer into the opposite mortise; push up the bolt and turn the nut by means of a suitable punch, and engage the nut on the bolt. Continue turning the nut with the punch and hammer until the joint is pulled together tightly.

Fig. 9.14 Set-out of a joint in a curve-headed door frame



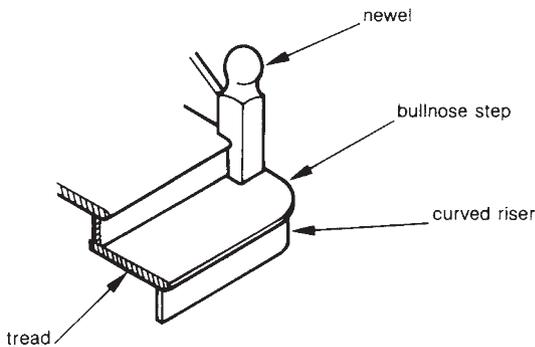
Bending timber

In some examples of curved work, timber must be bent to a required curve and, although the timber may not be bent easily, this can be done in a number of ways. The first essential when bending timber, which can make the difference between success or disappointment, is to select a suitable piece of material. Most timbers can be bent, but the sample must be straight-grained and of uniform texture. Avoid species that are brittle or show any defects.

Bullnose step

The bullnose step is a typical example of where timber is bent. It occurs when the first riser to a flight of interior stairs is curved on plan to a quarter-round and returns against the face of the newel.

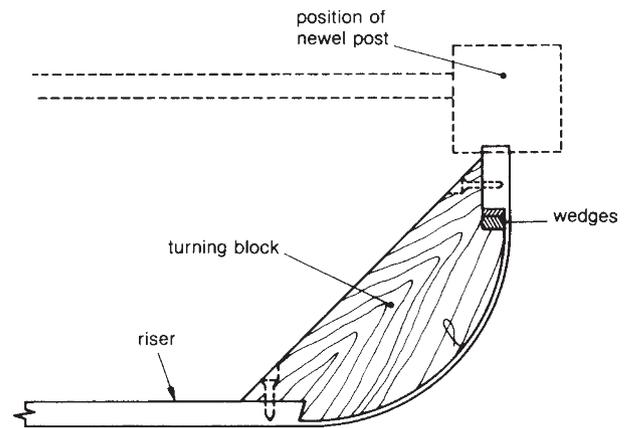
Fig. 9.15 Bullnose step



The set-out of the curved riser with the tread removed is shown in Figure 9.16.

Note how in this method of bending timber, the curved portion is reduced to the thickness of a veneer and bent around a turning block. The thickness of veneer that will bend satisfactorily will depend on the species of timber and the radius of the curve. This could be about 3 mm, but it is essential that the thickness be uniform over the whole area; any thin or weak

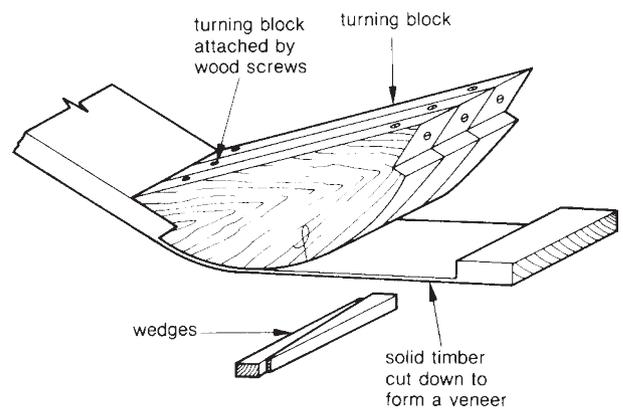
Fig. 9.16 Set-out of a curved riser



spots will almost certainly mean the timber will break at this point.

The turning block is built up in laminations. A template is prepared from the drawing to mark the shape onto the block, which is then cut accurately and square to the face.

Fig. 9.17 Bending a curved riser



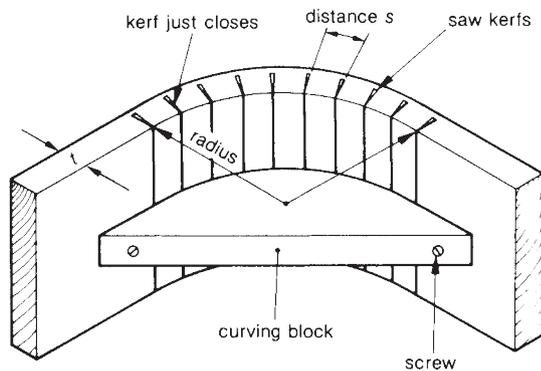
To assemble the joint, first apply adhesive to the veneer and the block and then attach one end of the block with wood screws. Roll the veneer around the block and lightly secure the other end with screws. Insert and tighten the wedges; this will pull the veneer closely around the block. Finally, tighten the screws and wipe away surplus adhesive. The veneer may be bent more readily if it is first dampened with boiling water.

Saw kerfing

Another common method for bending timber is by saw kerfing. This consists of making a number of saw cuts in the timber to weaken it sufficiently so that it can be bent around the required curve.

The spacing between saw kerfs is such that the cut will just close when the timber is bent to the curve.

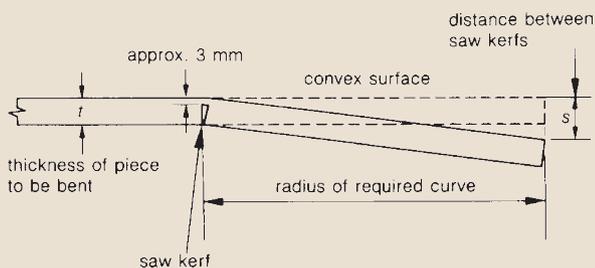
Fig. 9.18 Saw kerfing



To determine the spacing, proceed as follows (refer to Fig. 9.19):

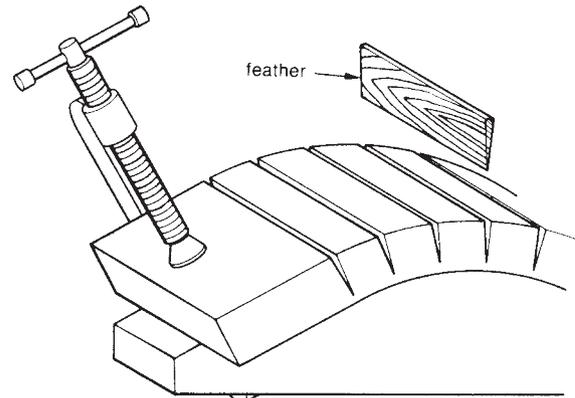
1. Take a lath of timber, the exact thickness of the piece of timber to be bent, and measure from the end the required inside radius of the curve. Make a sample saw kerf at this point with the actual saw that will be used for the job, stopping about 3 mm from the opposite side. Bend the lath until the saw cut closes. The distance the end moves from a straight line is the distance s between the saw kerfs.
2. Set the dividers and space out the distance s between the kerfs; make the cuts using the same saw and to the same depth as the sample.
3. A uniform curve will result if the timber is bent around a curved block. Work some adhesive into the saw kerfs and secure the block at one end with a screw. Bend the timber around the block and secure the other end. Allow the adhesive to set. In some situations, the block can be left in place.

Fig. 9.19 Determining the spacing of saw kerfs



The saw kerf method can also be used to bend timber when the concave side is to be the face of the board. To do this, make a series of saw kerfs in the piece and clamp it around a block or drum of the required radius. When it is bent, the saw cuts will open up.

Fig. 9.20 Open kerfs with wedges



Prepare wedge-shaped pieces called *feathers* (Fig. 9.20) and fit them to the saw cuts. Apply adhesive and lightly tap them in with a hammer to fix.

Using laminated thin veneers

Using laminated thin veneers, curved members of complex shapes can be built up, and interesting examples can be seen in some modern furniture designs. The work usually involves the manufacture of *curved formers* or *cauls*, between which the multilayers of veneer are bent to the required shape and pressed together. In joinery work, curved items can often be laminated together by comparatively simple methods.

Laminations can be made from thin strips of solid timber. The thickness will vary with the radius of the curve and the species of timber. However, laminations should not be too thick, say 3 mm to 4 mm maximum; otherwise they will tend to straighten out rather than retain the curved shape when released from the cramps. Strips of thin plywood, 3 mm to 4 mm thick, are also used in laminations and have the advantage that they will bend around fairly tight curves, especially if cut across the grain of the face of the ply.

An example of a curved section built up with laminated strips and cramped between wooden former blocks is shown in Figure 9.21.

The most suitable adhesive to apply to the laminations is a non-staining adhesive. This type is often found to be the most satisfactory as it can be easily spread with a brush or roller; it allows ample assembly time and, under pressure, the surplus will readily squeeze out from between the laminations.

Mouldings

Mouldings are used as a form of ornamentation and to soften the appearance of harsh outlines. Examples are also found where moulded sections are used to cover ugly joints or to conceal the effects of movement in timber.

Fig. 9.21 Curve of laminated timber

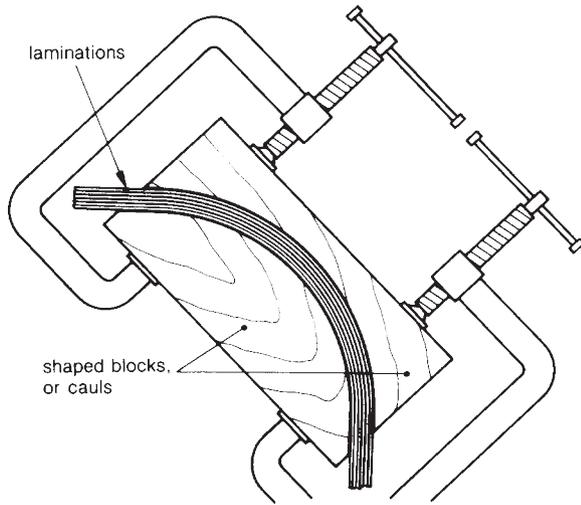
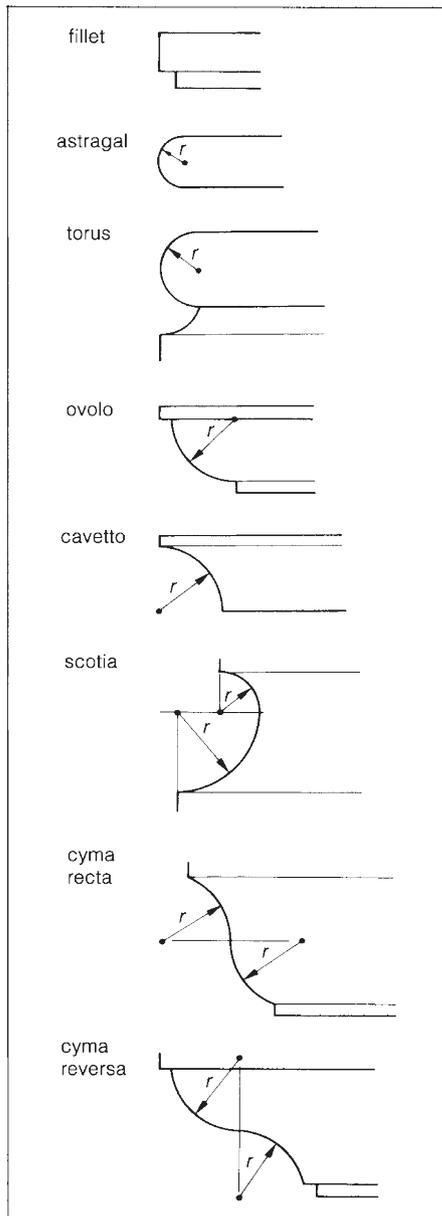


Fig. 9.22 Traditional mouldings

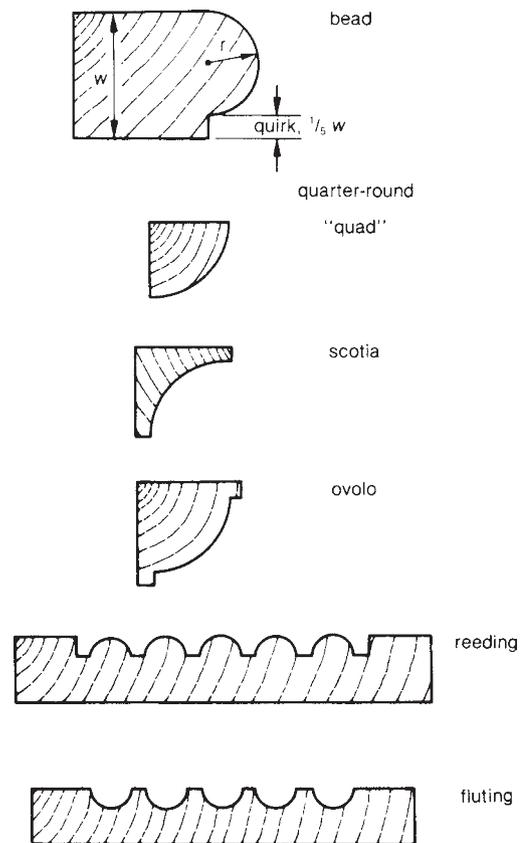


The mouldings in use at the present time are, in general, based upon those used by the Ancient Greeks and Romans. The Greek mouldings were based on parts of an ellipse, whereas the Roman mouldings always made use of the arcs of a circle.

There are eight fundamental shapes—*fillet*, *astragal*, *torus*, *ovolo*, *cavetto*, *scotia*, *cyma recta* and *cyma reversa*—all shown in Figure 9.22. Other mouldings were made up by combining the standard moulds, the fillet being used mainly as a connecting member.

Today, a number of stock mouldings are in common use. Figure 9.23 illustrates some that are frequently encountered.

Fig. 9.23 Common modern mouldings



Joining mouldings

Mitre joints

The most commonly used joint for joining mouldings is the *mitre joint* (Fig. 9.24). If the mouldings are of equal width, each piece is cut to an angle half the angle of intersection; for example, if the mouldings intersect at an angle of 90°, the mitre angle is 45°.

Scribed joint

The *scribed joint* is sometimes preferred, particularly where the mouldings intersect in an internal corner (Fig. 9.25). One piece is first mitred and then cut to the contour of the mould; it can then butt tightly against the other part.

Fig. 9.24 Mitre joint

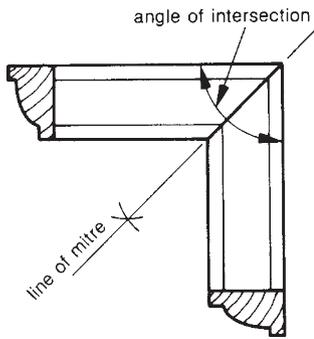
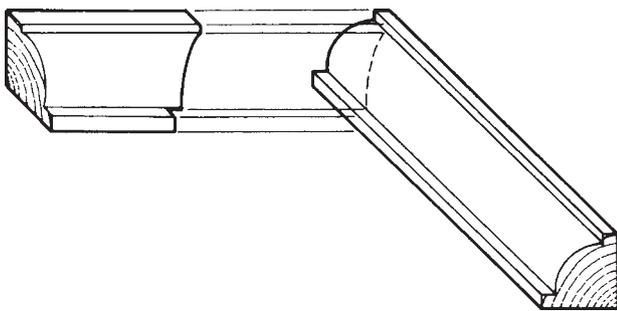


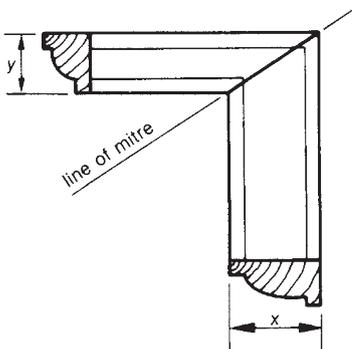
Fig. 9.25 Scribed joint



Cutting of mitred and scribed joints is explained in more detail in Chapter 5 in Volume 1.

Where mouldings are of unequal width, the line of mitre is found by joining the points at which the outside and inside edges intersect (Fig. 9.26).

Fig. 9.26 Joining mouldings of unequal width

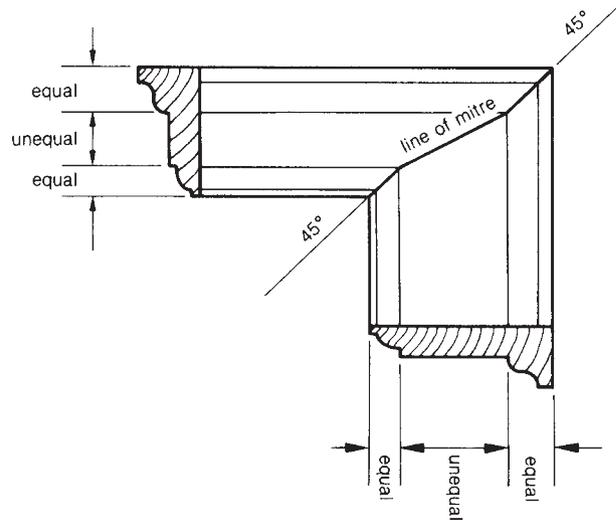


These moulding profiles of different widths must be developed so that the moulds will match up on the line of the mitre.

Dog-leg mitre

In the restoration of old buildings, examples may be found where mouldings of unequal width were made up as shown in Figure 9.27. The difference is in the width of the flat connecting member only. In this case, the line of the mitre is not straight; it is termed a *dog-leg mitre*.

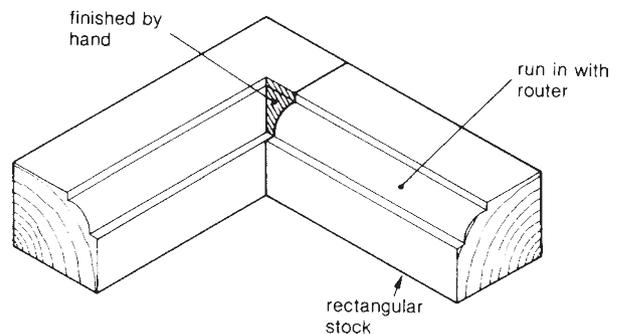
Fig. 9.27 Dog-leg mitre



Mason's mitre

The *mason's mitre* can be found in some of the oldest examples of joinery work (Fig. 9.28). Its use greatly simplifies the joint between the two parts. The stock used is rectangular, the shoulder line is straight and the parts butt together. The mould is then run, usually with the router, and the return mitre is finished by hand.

Fig. 9.28 Mason's mitre



Enlarging and diminishing moulds

Enlarging width

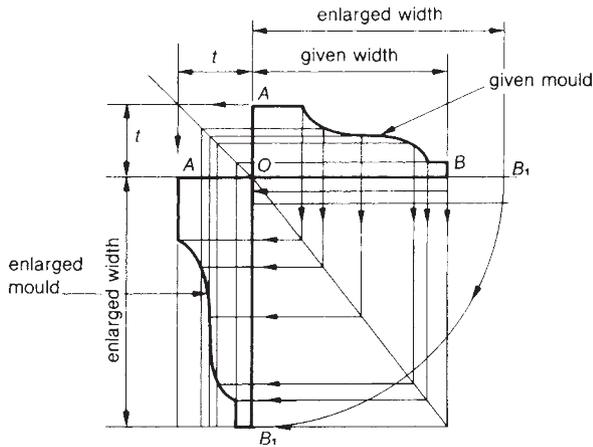
A problem is sometimes encountered where it is necessary to enlarge a given mould in width only. The procedure is as follows (Fig. 9.29):

1. Beside the given mould AOB , construct a rectangle, the sides of which are equal to the given width OB and the enlarged width OB_1 ; draw in a diagonal line.
2. Take the main points on the given mould and sufficient points on the curve to reproduce it with the required degree of accuracy. Project these points onto the diagonal line and then at right angles to enlarge the width.
3. So that the thickness will be the same for corresponding points on the mould, project the same points in thickness

onto a 45° line from point *O* and then at right angles to meet the same points already projected for enlarging the width.

4. Join the intersecting points with a uniform curve where relevant, to obtain the enlarged mould AOB_1 .

Fig. 9.29 Enlarging a mould in width only



Enlarging both the width and thickness

The problem may also arise where it is necessary to increase a given mould in width, with a proportionate increase in thickness.

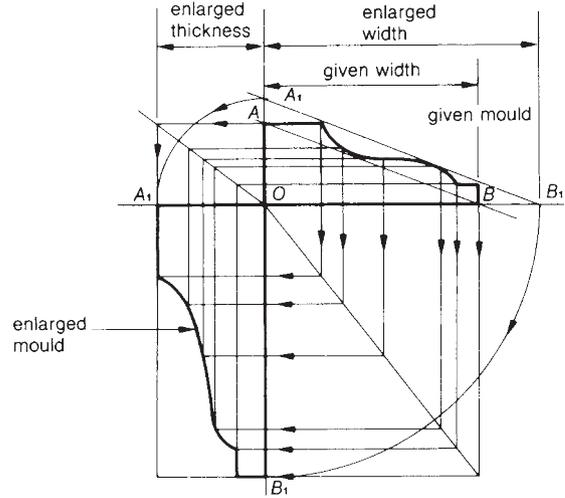
The procedure is as follows (Fig. 9.30):

1. Take the given mould AOB and draw a line joining points A and B . Mark, along the OB line, the new width OB_1 . Draw a second line parallel to AB through point B_1 ; OA_1 then becomes the proportionate increased thickness.
2. Beside the given mould, again construct a rectangle with sides equal to the given width OB and enlarged width OB_1 . Take points on the mould and project them to increase the width as described in the previous procedure.
3. Beside the given thickness, construct a rectangle with sides equal to the original thickness OA and the enlarged thickness OA_1 . Draw a diagonal and project the points taken on the mould onto the diagonal line, and then at right angles to meet the same points already projected to enlarge the width.
4. Join the intersecting points to define the enlarged mould A_1OB_1 .

Diminishing moulds

For diminishing a mould, follow a similar procedure to that for enlarging a mould.

Fig. 9.30 Enlarging a mould in proportion



Raking mouldings

The problem with raking (sloping) mouldings occurs where they must intersect with a level return mould. A typical example is a cornice to a room with a sloping ceiling, where the moulding will meet at right angles on plan. This situation is illustrated in Figure 9.31. If the raking mould A is given, then the level return B and C must be developed; as can be seen, the profiles of the three sections are very different.

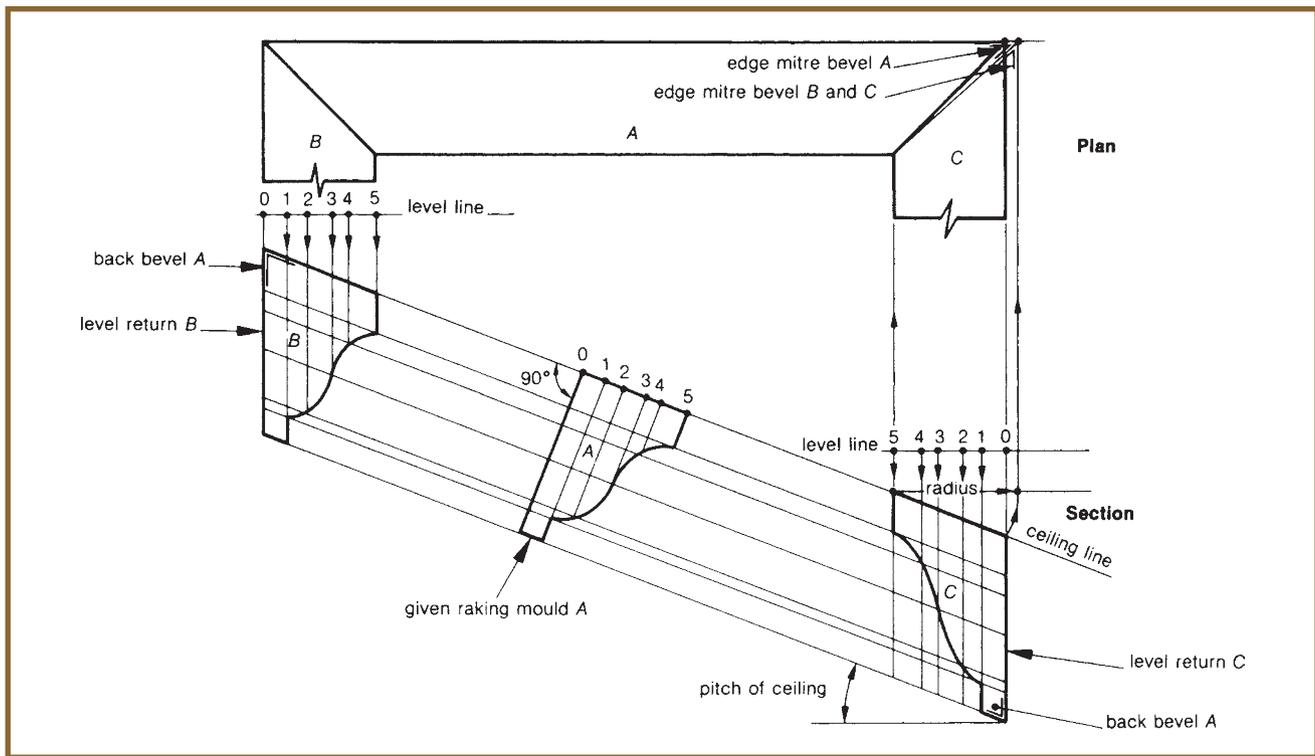
To develop the level return B and C , proceed as follows:

1. Draw a line at the pitch of the ceiling, and at 90° to this line, mark in the normal profile A of the given raking mould.
2. Take the main points on the mould and enough points on the curve to reproduce it with sufficient accuracy, and project these points parallel to the pitch of the ceiling.
3. Project the same points onto the top edge of the mould, and from the back corner number them 0, 1, 2, 3, 4, 5.
4. From the back face (vertical wall) of the level moulds B and C , set off, along a level line, the points 0, 1, 2, 3, 4, 5 and project them vertically down to meet the same points projected along the pitch of the ceiling.
5. Join the points with a uniform curve where applicable to obtain the profile for B and C .

It is important that the distances 0, 1, 2, 3, 4, 5 be set off along a level line, that is, at right angles to the back of B and C , and *not* along the pitch of the ceiling.

The true edge mitre bevel for A , B and C must be developed. Follow the development as shown on the plan. The back bevel for the raking mould is found directly from the elevation and the back bevel for the level return is 90°.

Where other examples of raking moulds are found, follow the same procedure to develop level returns where required.

Fig. 9.31 Development of a raking mould**Student research**

Investigate the range of shapes that windows and doors frames can be made into and how they are made.

Sustainable procurement of materials

Any product or material can be thought of as having a life cycle—from the initial manufacture, its use, to disposal at some time in the future. Thinking about sustainability can be applied throughout the decision process of procuring or obtaining materials for a project. In order to do this, each stage needs to comply with the axiom 'reduce, re-use, recycle'.

The procurement stages are as follows:

1. Identify the construction need for the product or material.
2. Understand any potential environmental and social risks.
3. Examine alternative or recycled products or materials if available.
4. Invite potential suppliers to provide a response.
5. Evaluate the alternative solutions.
6. Revise the specification if necessary.
7. Purchase the product or material.
8. Identify areas for improvement after use.
9. Determine how the goods may be disposed of in the future.

Stair construction

LEARNING OBJECTIVES

- 10.1 Stair construction
- 10.2 External stairs
- 10.3 Internal stairs

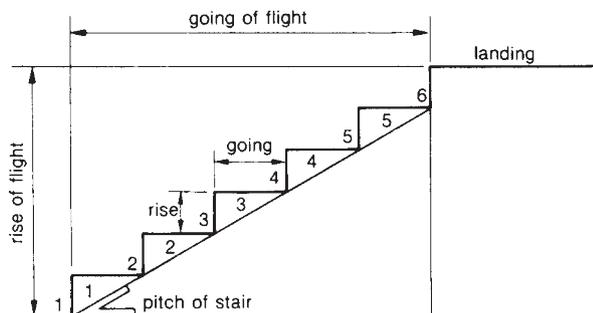
Stairs are a means by which ascent or descent is made from one level to another. Other means of achieving the same purpose are ramps, used to overcome minor changes in level or for the convenience of elderly or disabled people, and mechanical systems such as lifts, inclinators, escalators and moving walkways.

Staircase building is a specialised branch of the joiner's trade and a complete understanding of the geometry and methods involved will go beyond the methods discussed in this chapter. However, by following the examples given, there is ample information for the construction of a safe and attractive staircase in most situations.

General layout

A stairway is composed of a number of individual steps. The horizontal distance covered by each step is termed the *going* and the vertical height of each step is the *rise*. When a number of steps are combined together they form a flight of stairs; the total horizontal distance covered is the *going of flight* and the total vertical rise is the *rise of flight*.

Fig. 10.1 General layout of stairs



There will always be one less going than the total number of risers. The angle formed by the rise and going is the pitch of the stair.

Stair dimensions

Stairs are proportioned so that they can be negotiated safely by the average person and the dimensions must fall within certain limits. The figures quoted in the following examples are taken from the Building Code of Australia (BCA) within the National Construction Code.

Rise

The maximum rise for a stair other than a spiral stair is 190 mm and the minimum is 115 mm. The most important thing to ensure is that all risers in a flight are equal.

Going

The maximum going for a stair other than a spiral stair is 355 mm and the minimum is 240 mm. The formula to calculate slope relationship is twice the rise + going = maximum of 700 mm to a minimum of 550 mm, or $2R + G = 700$ mm to 550 mm.

The BCA also states the maximum gap between underside of a tread to top of next tread cannot exceed 125 mm. Similarly, the gap between balusters and other components (e.g. stainless steel wire) is not to exceed 125 mm.

Example

Calculate a suitable rise and going for a stair if the rise of flight is 1350 mm and there is no restriction on the going of the flight. The procedure is as follows:

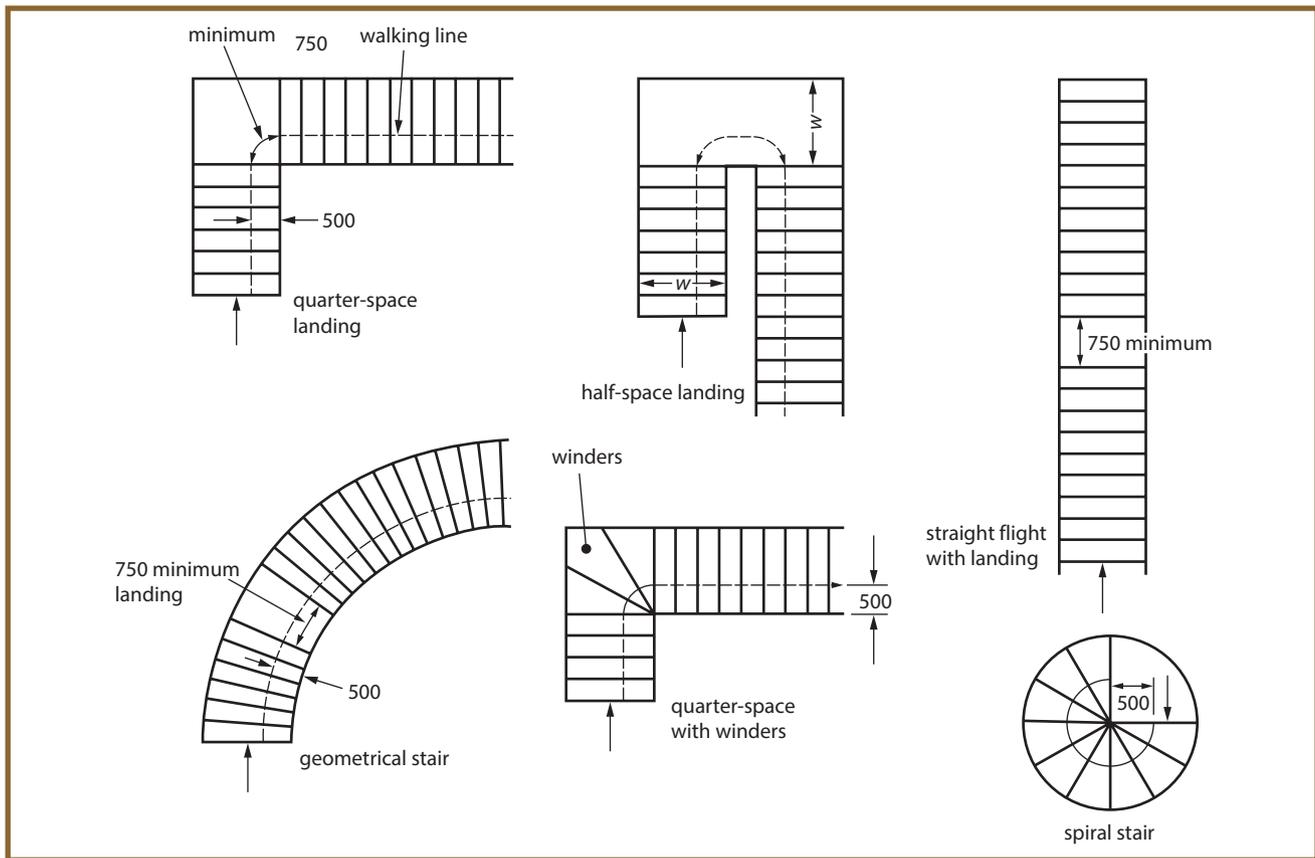
1. Determine the approximate *number of risers*, given that the average riser is 170 mm:

$$\text{Approx. no. of risers} = 1350/170$$

$$= 7.94$$
 Therefore 8 risers are required.
2. Calculate the actual *rise*:

$$\text{rise} = 1350/8$$

$$= 168.75 \text{ mm}$$
 Therefore the rise is 169 mm for practical purposes.

Fig. 10.2 Arrangements of landings**3.** Calculate the *going*:

$$2R + G = 625 \text{ (midpoint of slope relationship)}$$

$$G = 625 - 2R$$

$$= 625 - (2 \times 169)$$

$$= 625 - 338$$

$$= 287 \text{ mm}$$

Therefore the going is 287 mm.

4. Calculate the *going of flight*:

$$\text{Going of flight} = 287 \times 7$$

$$= 2009 \text{ mm}$$

Note that the going of 287 mm falls close to the midway point of the maximum and minimum going dimension; it could be longer or shorter by 22 mm and still fall within the limits of the formula.

The minimum number of risers in a flight is 2 and the maximum number in a single flight is 18. Beyond this, an intermediate landing not less than 750 mm long should be provided. Where a change in direction is required, the length is measured 500 mm from the inside edge of the landing.

The minimum clearance above a flight of stairs is 2000 mm, measured vertically from the nosing line (Fig. 10.3).

The BCA does not prescribe minimum stair width. A handrail must be provided along the open side of stairways and should be fixed at a height of not less than 865 mm, measured above the nosings (Fig. 10.4).

Terminology

The following terms are generally used for the components of a stair:

- **tread** the board forming the horizontal face of the step
- **riser** the board forming the vertical face of the step; where there is no board enclosing the riser, it is termed an *open riser*
- **stair string** the inclined board supporting the ends of the treads and risers; strings can be further subdivided into *closed strings*, *cut strings* and *wall strings* (see below)
- **closed string** a string that is parallel and housed on one side to support the ends of treads and risers
- **cut string** a string cut on the upper edge with a square abutment to which the treads and risers are fixed
- **wall string** a string located against a wall
- **newel** the post at the end of a flight which supports the handrail and string; it is sometimes turned or carved as a decorative feature of the staircase
- **nosings** the shaped front edge of the stair tread
- **handrail** the rail fixed parallel above the string to serve as a guard rail and to give assistance in ascending and descending the stairs
- **baluster** upright members between the string and handrail
- **balustrade** the combined framework between the handrail and string

Fig. 10.3 Minimum overhead clearance

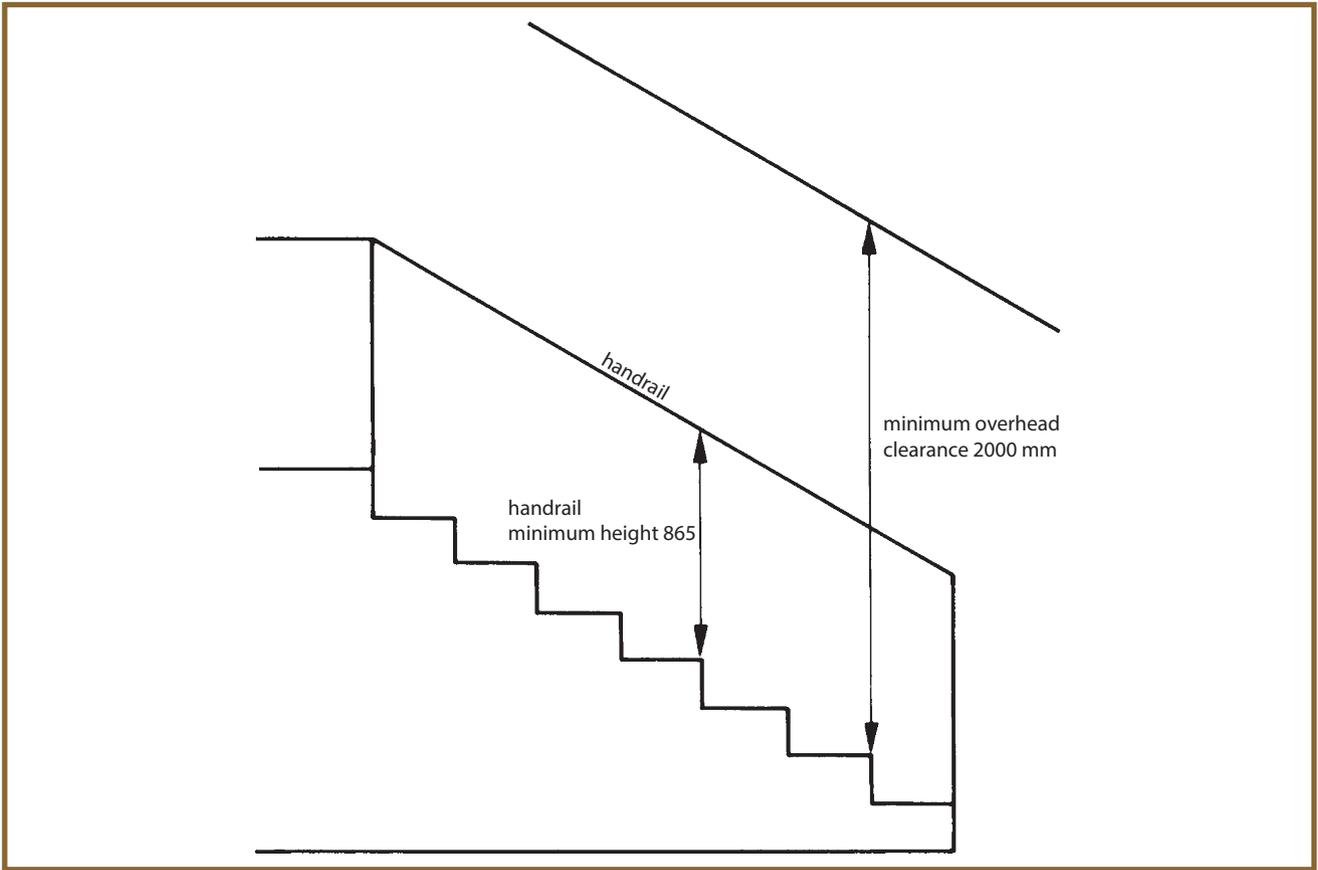
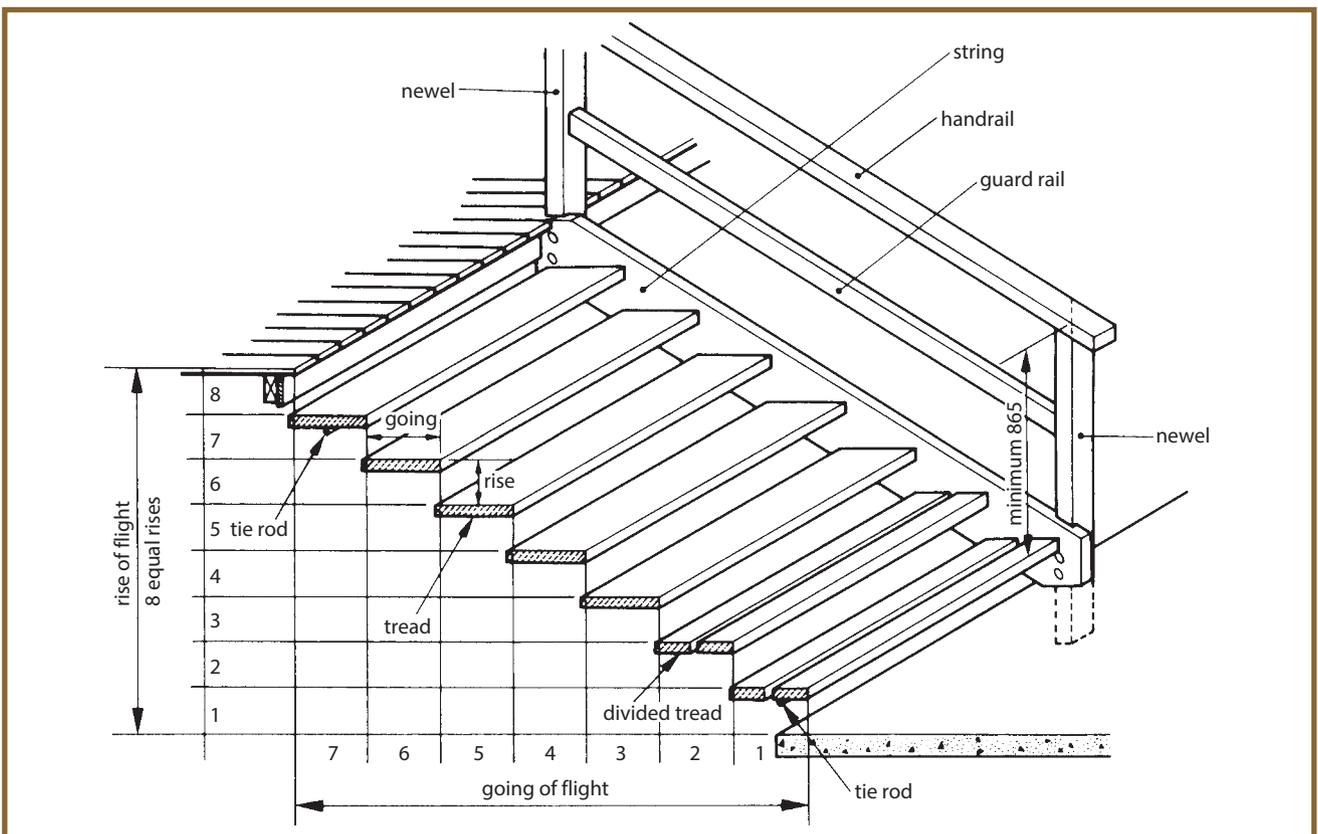


Fig. 10.4 External open-riser stair



External open-riser stair

An external open-riser stair, often found providing access to a verandah or landing, is shown in Figure 10.4. The stair is constructed from a durable hardwood. A divided tread, with a 13 mm space between, can also be used. Rainwater can run off divided treads more readily and they will not distort as much as wide boards.

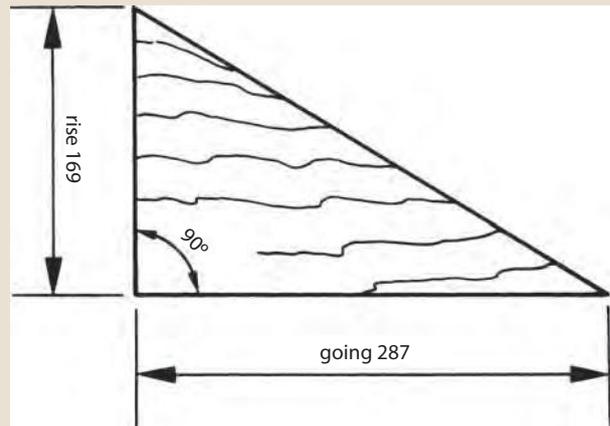
Treated pine is a good alternative to hardwood for an external stair; however, ensure the fixings used in the construction of the stair are suitable for use in treated pine.

In Figure 10.4, the rise of flight is 1350 mm and the stair has been set out to the rise and going calculated in the previous example. Note that the going commences from the edge of the overhanging verandah boards.

To set out the string, refer to Figure 10.5 and follow this procedure:

1. From the top edge of the string, gauge a distance equal to the margin, that is, the distance from the front edge of the tread to the edge of the string. This is usually about 38 mm.
2. Prepare a pitch board from a piece of plywood: plane two edges square to each other; on one edge mark the rise and on the other edge mark the going. Then cut and plane the triangular template to the marks (Fig. 10.6).

Fig. 10.6 Triangular pitch board



Lay the pitch board to the string with the hypotenuse (the long side) of the triangle to the margin line, and mark off the required number of risers (8 in this example).

The steel square is an alternative way of setting out the string: set the rise and going on the arms of the square from the gauge line and set the fence to the edge of the string.

Slide the square along the string, marking off the required number of risers.

3. At the eighth rise, add the horizontal distance for the edge of the verandah flooring to the joist (or any other point to which the string will be attached).

Fig. 10.5 Set-out of string

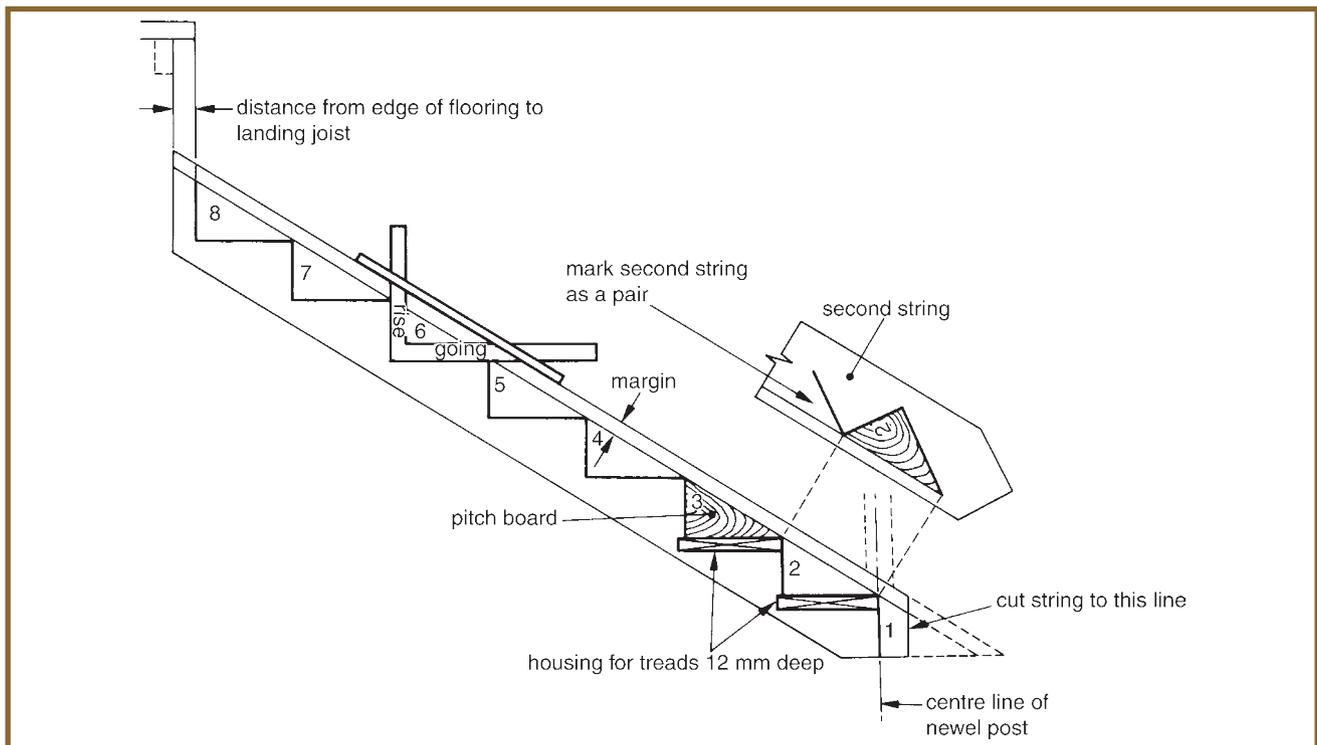
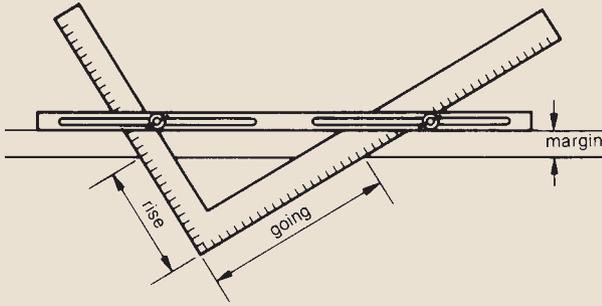


Fig. 10.7 Setting out using a steel square

4. The centre line of the newel will line up with the face of rise 1. From this point, add sufficient to bolt the string to the newel and mark the line to which the string will be cut.
5. The treads are housed 12 mm into the strings. Mark out the housings, measuring the width and thickness of the tread from the rise and going already indicated. It may be preferred to continue the housings through to the back edge of the string.
6. Strings must be set out in pairs. Lay the second string alongside, gauge the margin and square across the position of the treads. Turn the pitch board over and mark in the rise and going and repeat as for first string (Fig. 10.5).

Cutting out and fixing

Cut the housings to the strings and cut the treads to length. Paint the ends of the treads and housings, or alternatively, use some other preservative treatment. Assemble the stair and secure with galvanised nails. Steel tie rods with a nut and washer at each end, placed under the treads about 1200 mm apart, will clamp the strings tightly together and increase the life of the stair.

Bolt the newel to the side of the string, cut it to height, and fix the handrail and guard rail in position. Shape the top of the handrail by rounding off the corners and smoothing to remove any splinters or other defects. If the end of the newel is sunk into the ground to increase its rigidity, treat it with a preservative.

Interior timber stairs

A simple example of a traditional timber staircase, with closed strings and risers, is shown in Figure 10.8. With modifications, this type of stair forms the basis of most interior timber staircases.

A vertical section through the stairs is shown in Figure 10.9. Note the placing of the members relative to the rise and going. A margin of about 38 mm is allowed on the string, and the face of the treads and risers are placed on the set-out lines.

The centre line of the newels is aligned with the face of the riser and the strings are tenoned into the newel. The edge of the

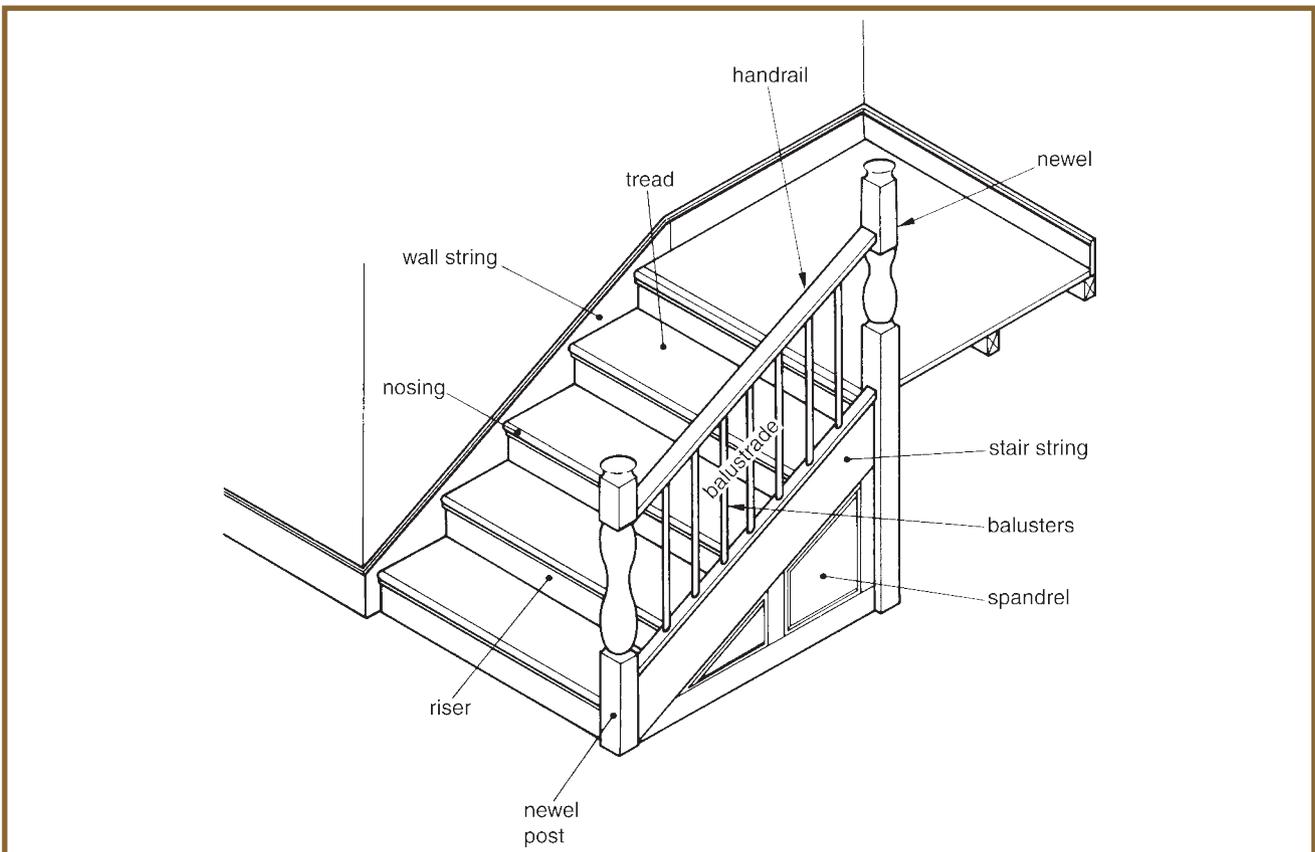
Fig. 10.8 Traditional timber staircase

Fig. 10.9 Vertical section through a timber staircase

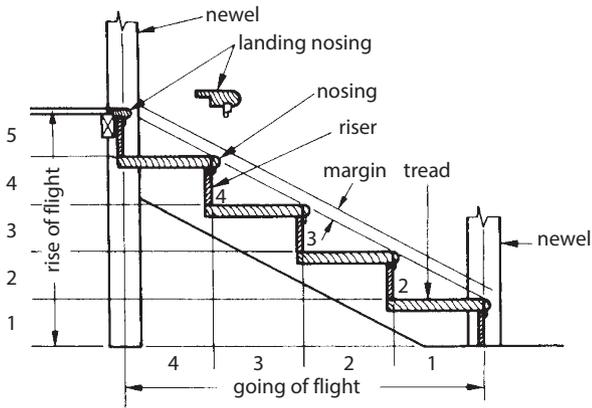
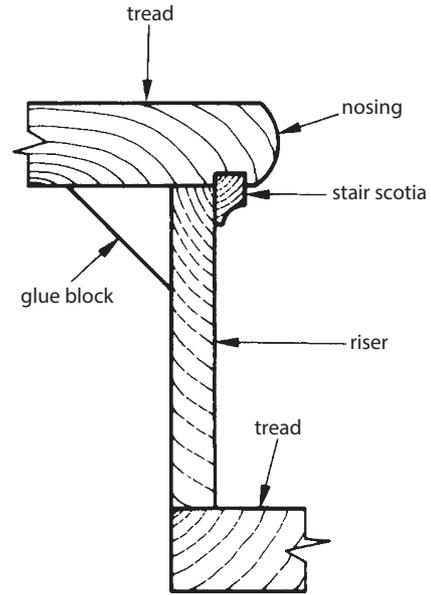


Fig. 10.10 Section through the nosing and riser



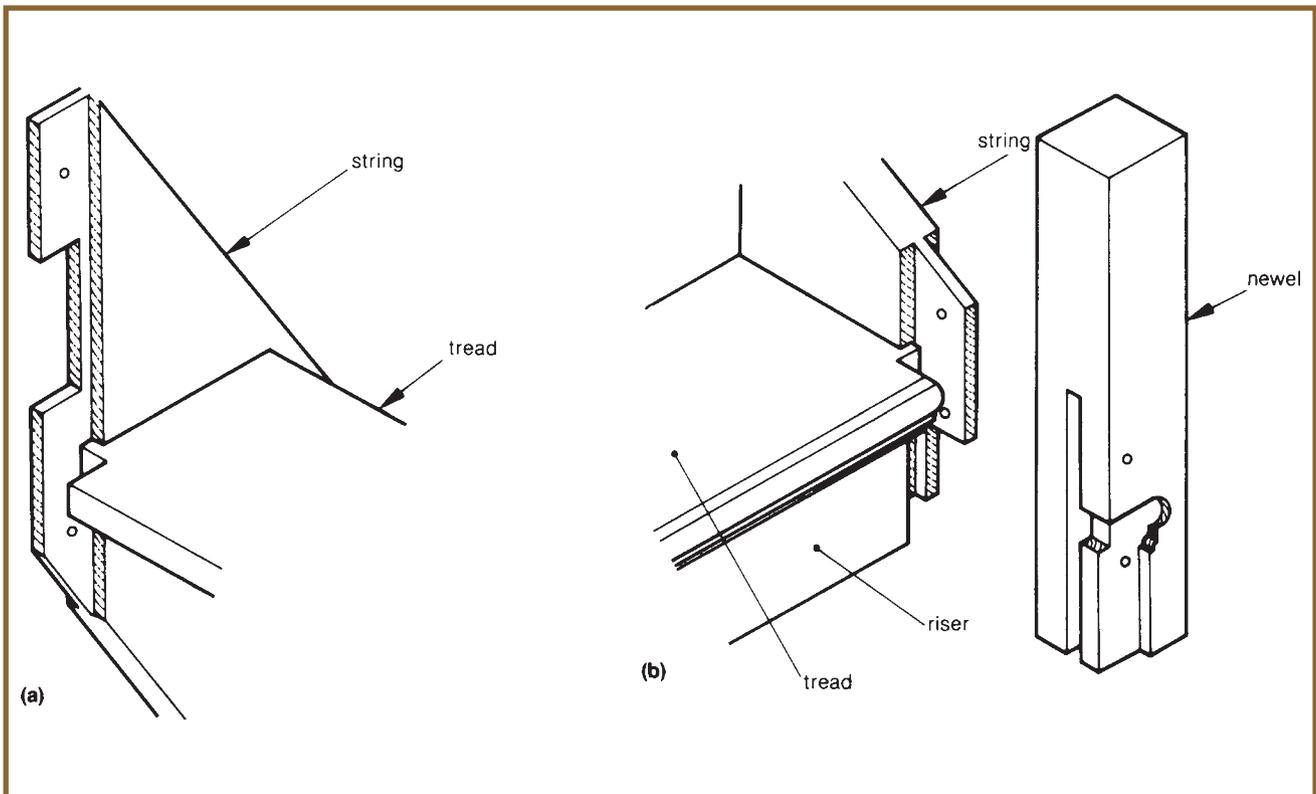
treads is finished with a nosing which has a scotia moulding underneath. Details of the section through the nosing and risers are shown in Figure 10.10.

It is important that the same nosing be applied to all the treads including the top landing; a moulding is applied to the landing nosing—the same moulding as that on the tread nosing.

Examples of mortise-and-tenon joints between the strings and newels are shown in Figure 10.11. Note how the tread and the riser are housed in and cut around the newel.

The mortise-and-tenon joints would be difficult to cramp, but they can be pulled together with a draw pin. To bore for a draw pin, termed *draw boring*, first use a clean cutter bit of

Fig. 10.11 Mortise-and-tenon joints between the string and the newel post: (a) at the top and (b) at the bottom



the required size and bore through the two sides of the mortise in the newel. Assemble the joint and, with the point of the bit, mark the centre of the hole onto the tenon. Take the joint apart and, before boring the tenon, move the centre of the hole closer towards the shoulder line. The amount that the joint can be drawn will vary with the diameter of the pin and the nature of the timber: for a 12 mm pointed pin, the maximum distance the second hole could be safely moved towards the shoulder would be about 2 mm. The point of the draw pin is tapered to enter the holes without damage, and when the joint is assembled and the pin driven through, it will tend to pull the two holes into alignment, drawing the string into the newel.

The treads and risers are housed about 13 mm into the strings and secured by a wedge driven from the back. Wedge room is allowed for when the strings are being housed.

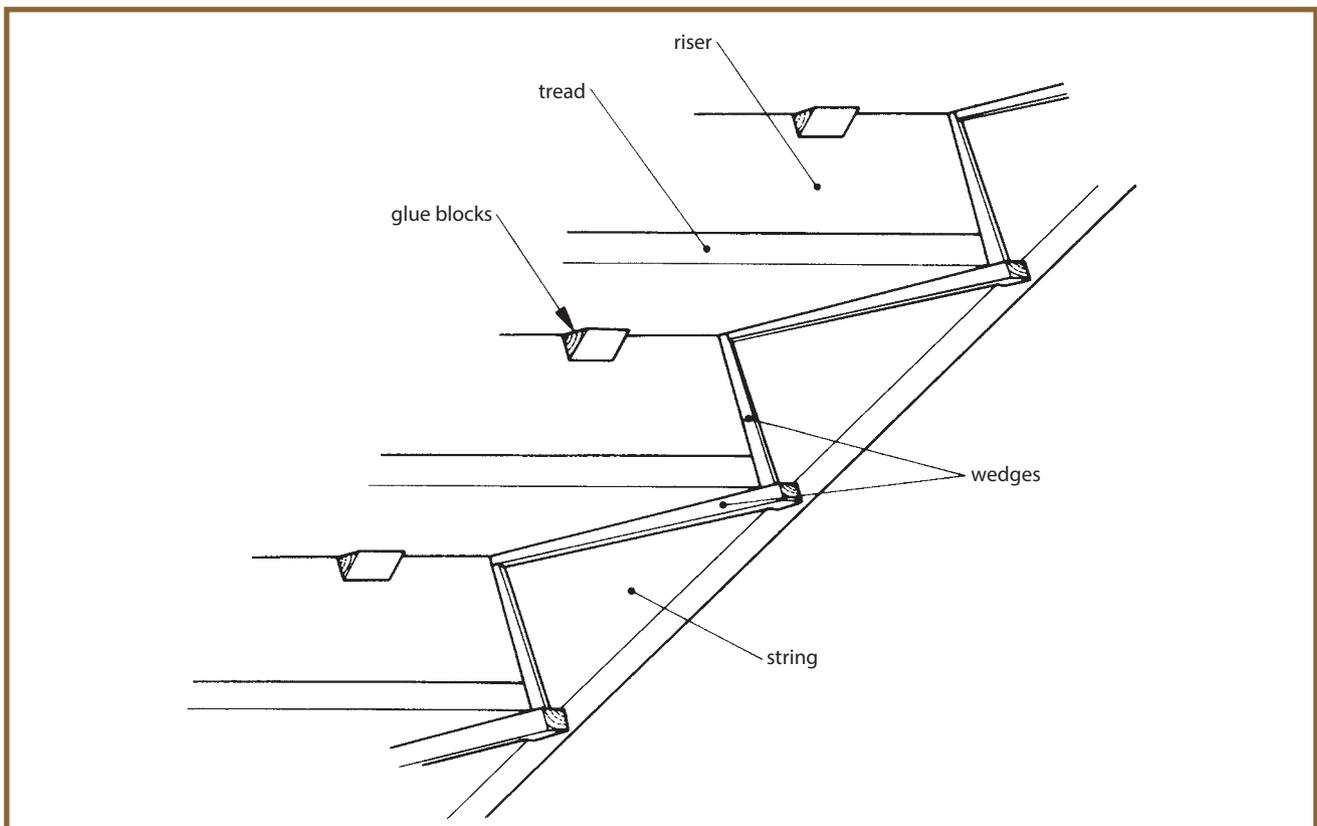
Figure 10.12 is a view of the underside of the stairs, showing the wedges which are glued and pinned in place after the stair has been assembled and clamped together. Glue blocks strengthen the joint between the tread and riser.

Setting out the string

To set out the string, refer to Figure 10.13 and carry out the following procedure:

1. From the edge of the string, gauge the width of the margin.
2. Prepare a pitch board to the rise and going of the stair. If the margin is also included, it can be applied from the edge of the string. Alternatively, set up the steel square to the required rise and going (Fig. 10.7). Step off the required number of risers (5 in this example).
3. From plywood, prepare tread and riser templates which include the thickness of the tread or risers plus an allowance for the wedge. Allow a taper of 6 mm to 8 mm in the width of the tread and keep the same taper on the riser template. Set out a separate small template of the profile of the nosing or include this on the riser template.
4. The housings for the treads are marked out by keeping the tread template to the face of the treads; the housings for the risers are marked by keeping the riser template to the face of the risers.
5. From the first and last risers, measure back half the width of the newel to determine the shoulder line. Mark in the tenons and cut the string to length.
6. Gauge the tenon and reset the mortise gauge to gauge the mortises in the centre of the newel.

Fig. 10.12 Underside of stairs



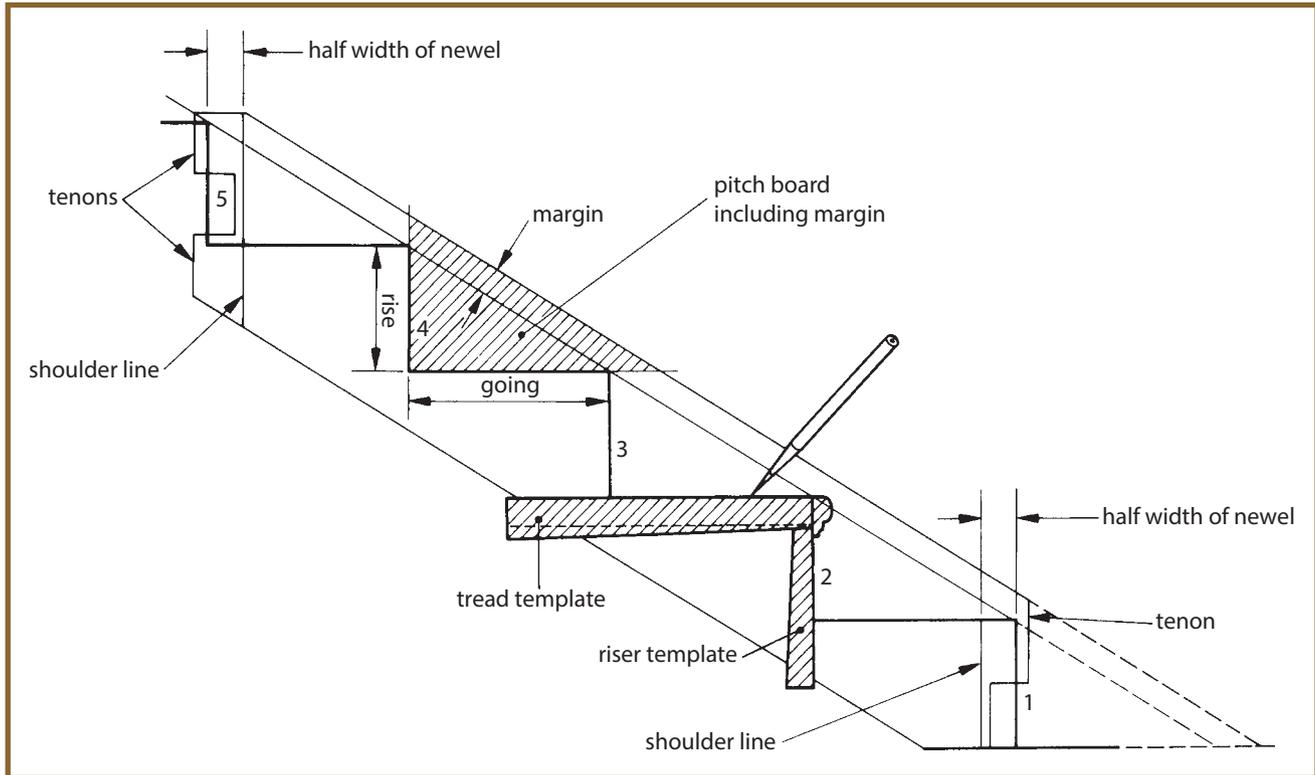
Handrails

Handrails are moulded to provide a comfortable hand grip and are continuous between newels. The ends are mortised and tenoned into the newel and the joint can be pulled tightly together and secured with a draw pin.

Student research

Identify as many different stair types as you can and describe how or where they are most commonly used.

Fig. 10.13 Set-out of the string



Renewable building resources

Timber is the most commonly used renewable building material available. Other renewable materials include:

- engineered-timber products—remanufactured timber, laminated timber beams
- plant fibres—jute, coir, sisal, seagrass, hemp, bamboo, flax, reed, cotton, straw, cork, cellulose fibre
- animal fibres—wools, hair
- organic resins.

These materials are becoming more common in both contemporary and alternative construction. Straw, for example, is an alternative construction product often used in the dryer southern regions of Australia; it has high thermal resistance, is non-toxic, low cost, long life and usually locally available. The industrial manufacturing system has also taken up using straw to produce lightweight but structural sheet products. Through innovation, more of these materials will be used for future construction products.

Internal joinery

LEARNING OBJECTIVES

- 11.1 Kitchen cupboards
- 11.2 Carcase construction
- 11.3 Doors and draws
- 11.4 Benchtops

The manufacture and installation of interior fitments is a staple of the cabinetmaker. Construction is generally of the solid type, with the carcasses being a plain-coated product such as melamine, and the customisation of the fitment applied to the exterior. There are many products available to customise the function of the fitments, such as pre-made draws for corner units, special runners, baskets, locks, handles and hinges (see the manufacturer for a catalogue or check their website).

This chapter covers certain elements of internal joinery: the installation of kitchen cupboards, carcasses, doors, drawers and benchtops.

Kitchen cupboards

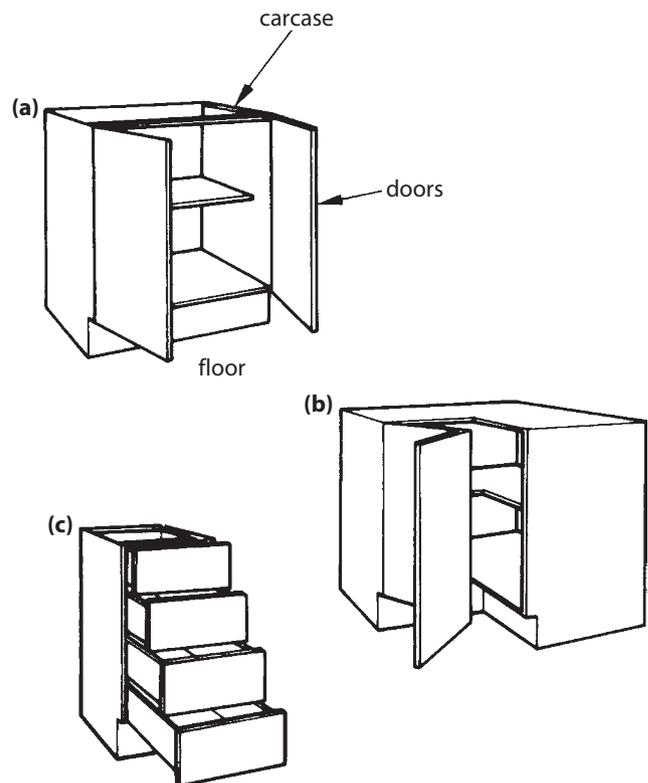
Kitchen cupboards are usually designed as an arrangement of modular units. The floor cupboards are supplied without the tops. The tops are selected separately and are fitted as a continuous item, together with a kitchen sink and drainer and any cooktops or counter savers included in the design. Figure 11.1 shows typical floor units that usually form the basis of a kitchen layout.

The plain shelf unit shown in Figure 11.1(a) is made up in various lengths and with 1, 2 or 3 doors; the shelf may be adjustable in height. The corner units continue around the corners and may feature a divided door which permits ready access to deep corners. An addition to the corner unit is the rotating circular shelf, sometimes called the 'lazy Susan' (Fig. 11.2); this allows even greater access to items stored in the cupboard. Kit form corner drawers are also available which provide greater access to the space in a corner unit.

Drawer units can vary in size from units containing drawers fitted for cutlery and other small items to deep 'pot' drawers suitable for the storage of bulky kitchen utensils (Fig. 11.1c).

Other units available from most manufacturers are a pantry unit, suitable for the storage of non-perishable foodstuffs, a broom cupboard and a wall oven unit, used where the wall oven is to be installed. Filler units, to make up any odd spaces after the modular units are set out, can also be supplied.

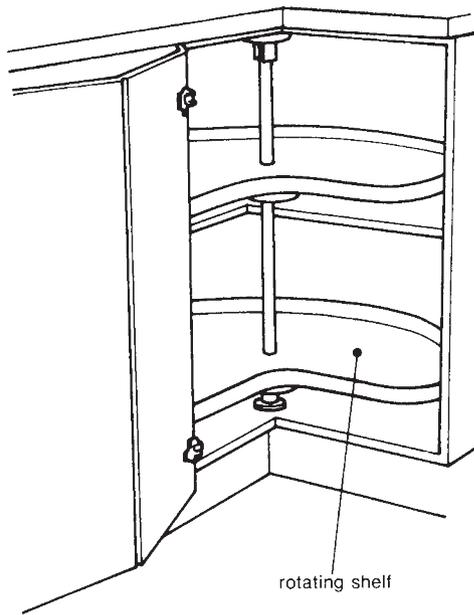
Fig. 11.1 Standard floor units: (a) floor unit (1, 2 or 3 doors); (b) corner floor unit; and (c) drawer unit



In the construction of the kitchen, space for other items such as a dishwasher, microwave and sometimes a washing machine needs to be taken into account when constructing the kitchen cupboards.

Wall units, also in modular sizes, often complete the usual kitchen layout.

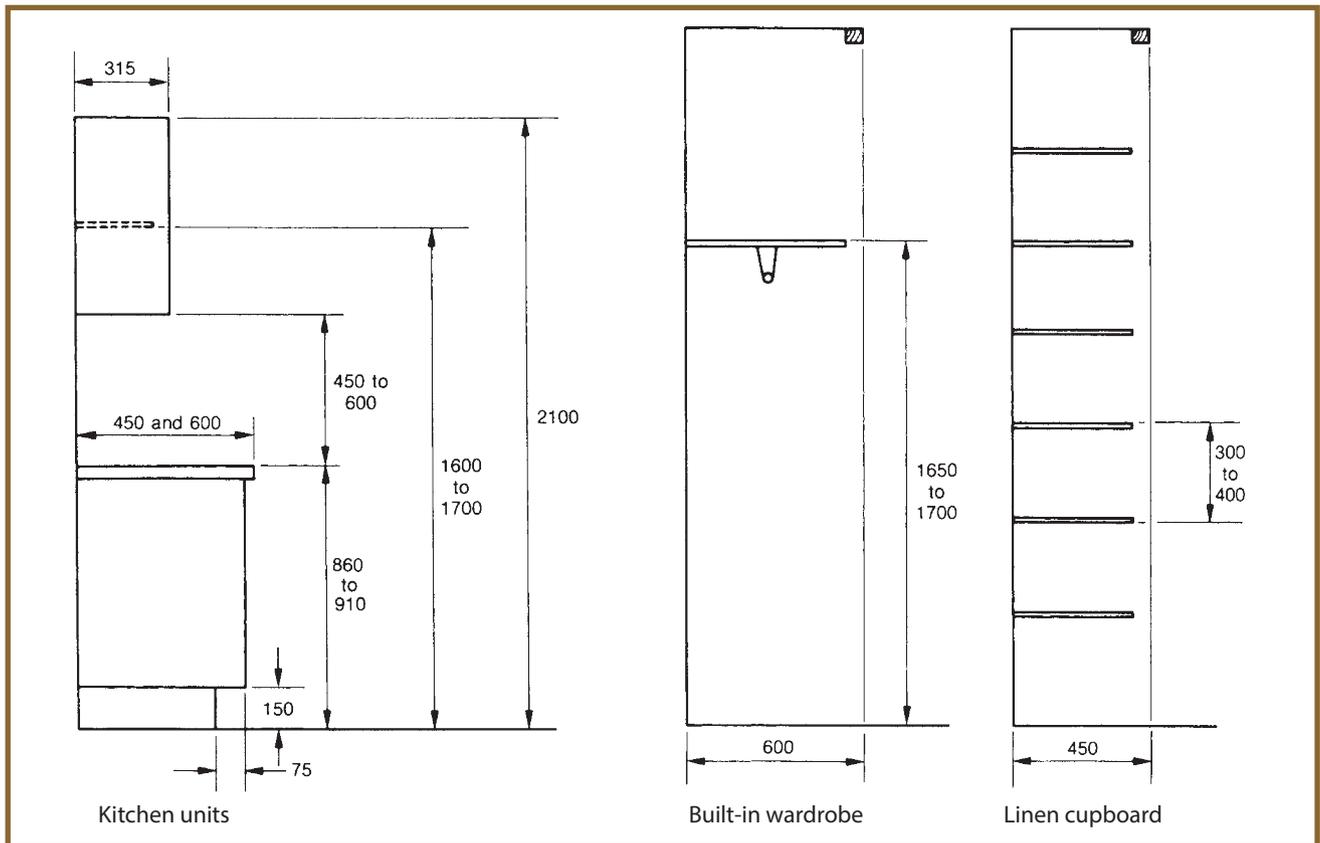
Fig. 11.2 Rotating circular shelf



Dimensions of built-in units

It is important that the dimensions of built-in units be sized so that the units are comfortable to use without the necessity for undue stooping or reaching. Figure 11.3 illustrates the approximate range of dimensions suitable for most units.

Fig. 11.3 Range of preferred dimensions



Kitchen cupboards are subject to the most critical attention, in particular the height of floor units. This is usually made to be about 900 mm by most manufacturers, but small variations can be made by adjusting the height of the kickboard. It is generally agreed that in the past, kitchen floor cupboards were often made too low. A rough rule occasionally quoted is that the person who uses the cupboards most should be able to stand naturally at the cupboards and place the palm of his or her hand flat on the bottom of the kitchen sink.

Wall units should be placed so that all parts of the worktop can be viewed by a person without obstruction and yet not be at such a height that the shelves are out of reach.

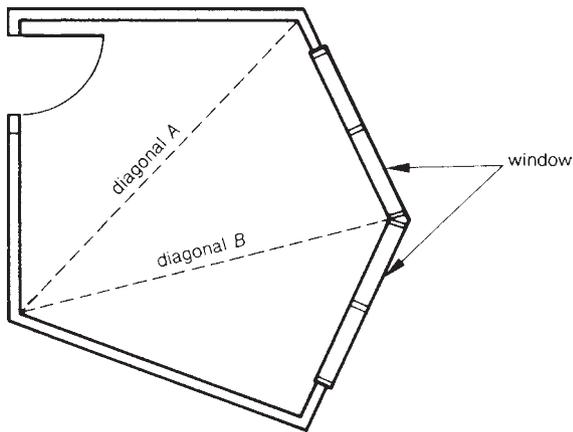
Wardrobe units need to be at least 600 mm deep over the doors if clothes are to be hung without crushing. However, if linen cupboards are deeper than about 450 mm, items pushed to the back of the cupboard are not so readily accessible.

Measuring up

To measure up a room for the installation of interior fittings, accurate dimensions are essential and care must be exercised to avoid some common pitfalls. If a room is rectangular, it is a comparatively simple matter to measure the length of the walls, the position of doors, and the position and height of windows. It cannot always be assumed that a room is perfectly rectangular and it is advisable to check the length and width at both ends to ensure that the walls are parallel.

Irregular areas present further difficulties—take the example in Figure 11.4.

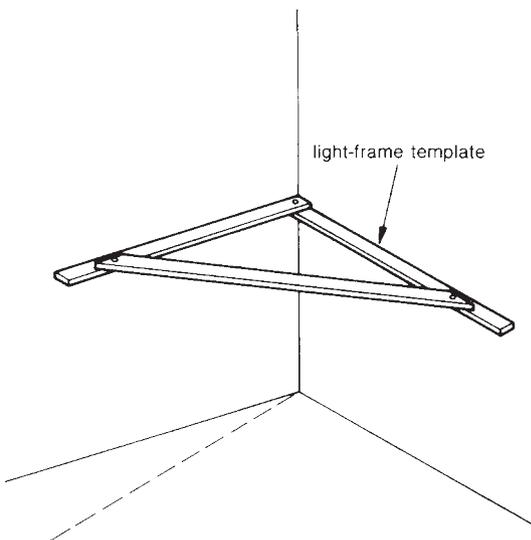
Fig. 11.4 Irregular room shape



Here, besides measuring the length along the walls, also measure the diagonals *A* and *B* so that the area can be accurately drawn to scale and units designed to fit.

Irregular angles can also be recorded by making up light-frame templates (Fig. 11.5). These are made from light laths of timber, pinned together on site and taken back to the workshop for reference. They can also be made from off-cuts of MDF or a similar product that have the angles scribed onto them and then fitted to the corner to create a template.

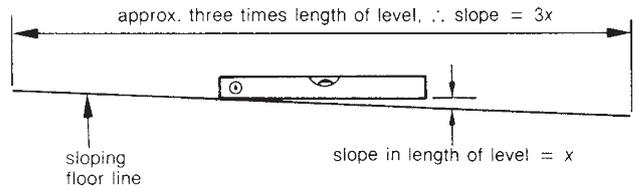
Fig. 11.5 Measuring irregular angles



The floor should also be checked for level using a spirit level and a long straight edge. If the floor appears straight, an estimate of the amount of slope can be made as shown in Figure 11.6. Where the amount out of level is small, the cupboards can be levelled by inserting wedges or packing under the low end; alternatively, adjustable feet are available that screw into a bracket fixed under the bottom shelf, by which means the cupboard can be levelled.

Where it becomes necessary to scribe the cupboard base to the floor to provide a level support for the cupboard, lay the

Fig. 11.6 Checking the floor for level



base in position and pack the low corners until it is level. Then open the dividers to the distance indicated as *x* and mark the base parallel to the floor. Trim to this line and set the base level on the floor. This is shown in Figure 11.7.

Walls must be checked for plumb (Fig. 11.8).

Fig. 11.7 Scribing a cupboard base to a sloping floor

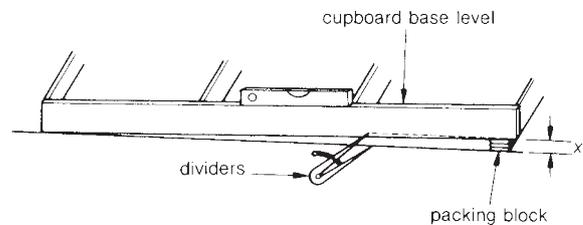
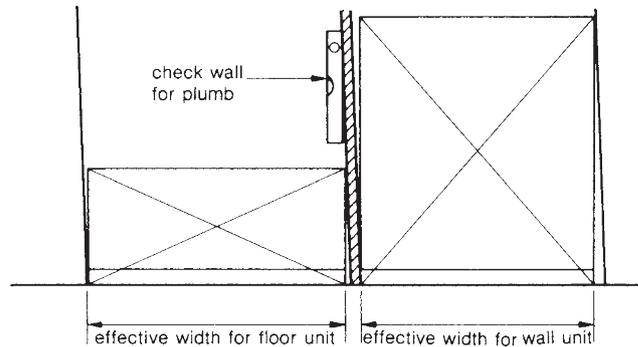


Fig. 11.8 Checking walls for plumb



Note how the maximum effective width of the units, as a function of the height of the units, will be reduced according to the amount the walls are out of plumb. Any gap at the sides is filled by a matching strip scribed to the wall.

Carcase construction

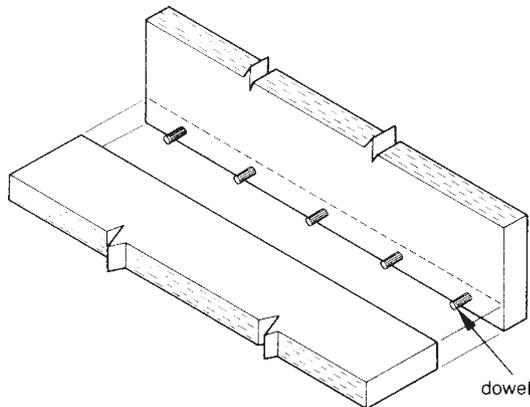
Most interior fitments and many items of furniture consist basically of a carcase to which is fitted doors or drawers. The carcase is almost invariably fabricated from a manufactured board. The doors and drawer fronts, however, can be fabricated from a range of materials including timber, laminate, vinyl wrap and two-pack polyurethane paint.

Carcase joints in manufactured boards are in the main fairly simple and are designed to be produced quickly with power tools (it is impractical to work most manufactured boards with hand tools).

Carcase doweled joint

The carcase doweled joint is very suitable for the jointing of some manufactured sheet products (Fig. 11.9). A number of dowelling jigs are available for accurately drilling the dowel holes. Dowels are readily available, cut to length and pointed, in diameters of 6, 8 and 10 mm. Select a dowel with a diameter no more than half the thickness of the material. The joint, of course, must be glued and cramped together.

Fig. 11.9 Carcase doweled joint



Housed and rebated joints

The housed joint (Fig. 11.10) and the rebated joint (Fig. 11.11), as used in carcasses, require the use of an electric router.

Butt joint with slip tongue

A strip of plywood, 4 mm or 5 mm in thickness, can usually make a suitable tongue (Fig. 11.12). Run the grooves with a router cutter, then glue and cramp the joint together.

Flat-dowel joint

Biscuits are suitable for use with any of the manufactured boards and are a popular method for jointing employed in many workshops. The 'biscuits' are made from compressed timber; the dampness of the adhesive causes them to swell which guarantees that there will be great strength in the joint.

To make a biscuit joint, mark the centres for the tongues; a biscuit machine will mill the slots at exactly the right position.

Glue the slot and push the tongue in; press the parts together. A perfect joint should result. Examples of flat-dowel joints are shown in Figure 11.13.

Knockdown fittings (KD fittings)

A variety of knockdown fittings are available for use in manufactured sheet products. They have the advantage that the joint can be assembled dry as the fittings incorporate some means of clamping the joint together. Some short dowels are also usually included in the joints to maintain the parts in alignment. A further big advantage of the KD fittings is that the joint can be readily taken apart at a later stage. These types of fittings are very popular with flat pack fitment manufacturers, where the items are manufactured and then flat packed to be later assembled by the purchaser.

Fig. 11.10 Housed carcase joint

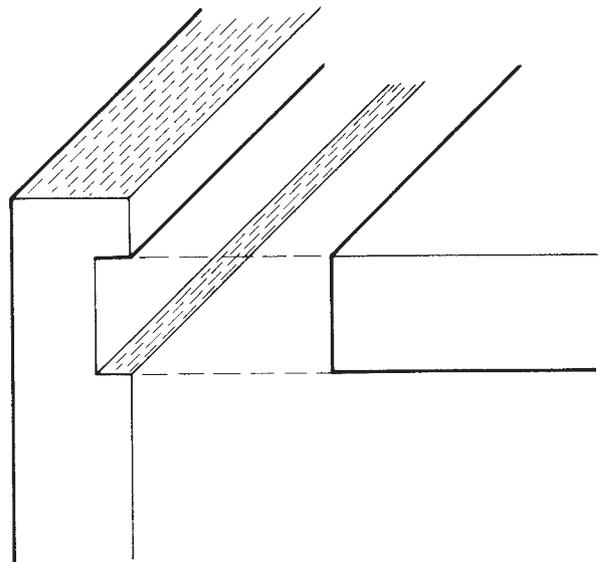


Fig. 11.11 Rebated carcase joint

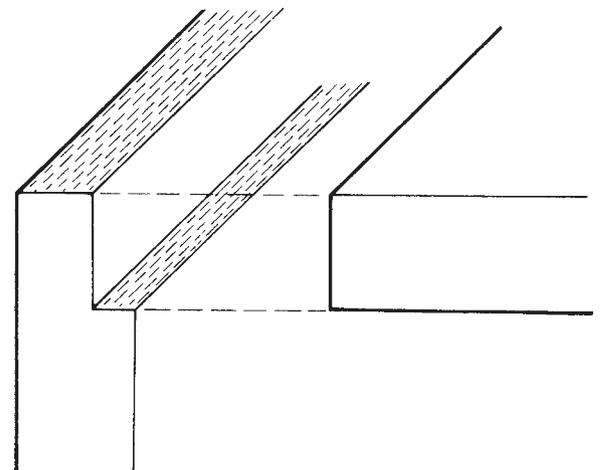


Fig. 11.12 Butt joint with slip tongue

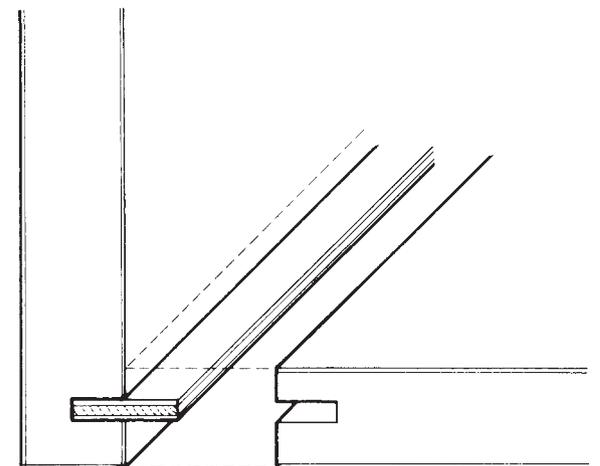
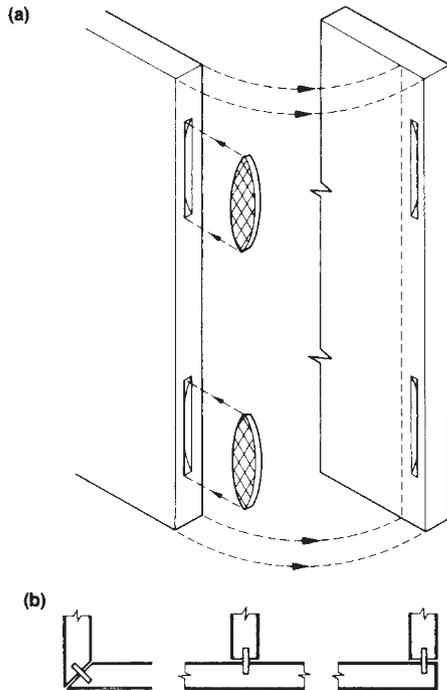


Fig. 11.13 (a) Butt joint with flat dowels; and (b) flat-dowel joints



Examples of KD fittings are the bolt with cross dowel (Fig. 11.14) and the metal dowel with cam (Fig. 1.15).

A one-piece connector screw, a 'Direkta', for use in particleboard is shown in Figure 11.16. The thread is specially designed to cut its way into the particleboard and secure a very firm grip. Stepped drills can be obtained to bore the receiving holes the correct size in the one operation. The screws have either a 'Posidrive' slot or a hexagonal slot for use with an Allen key. Plastic dowel caps can cover the heads where necessary.

Fig. 11.14 Bolt with cross dowel

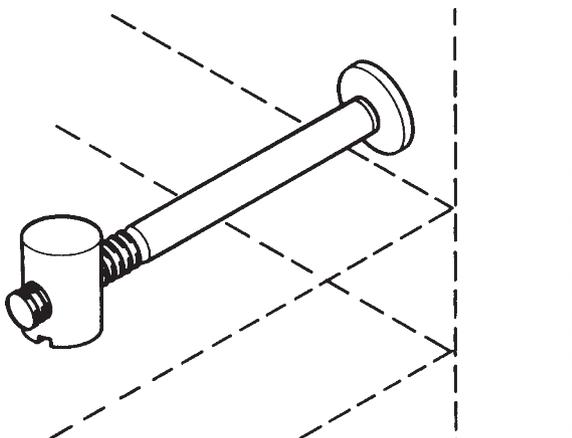


Fig. 11.15 Metal dowel with cam

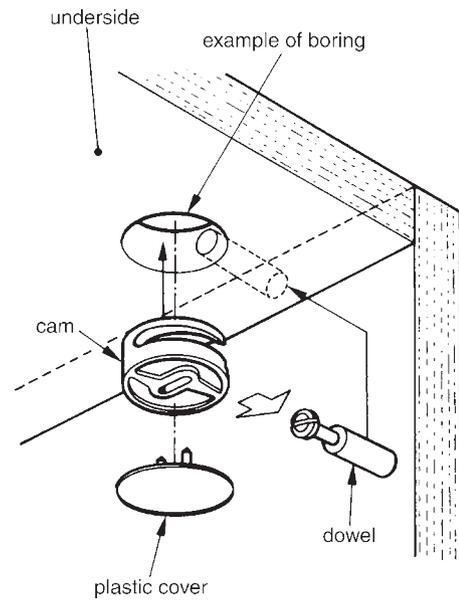
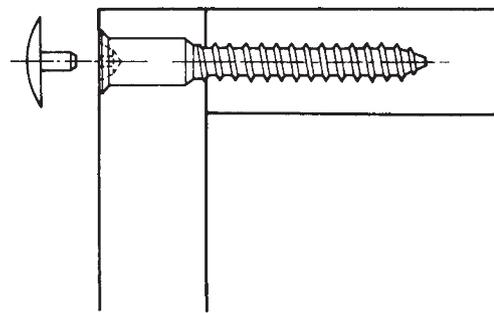


Fig. 11.16 'Direkta' screw



Hinges for particleboard

Doors, very commonly, are made of the manufactured boards; a large array of special hinges and fittings are available, all designed for use with manufactured sheet products.

Concealed hinge

Overlaid doors which completely cover the carcass, used in conjunction with a concealed hinge, are suited to mass production and are widely adopted.

The door, if cut to size accurately, can be applied to the carcass without the need for any hand fitting. The hinges provide for rapid adjustment. Note the distance x which is the clearance necessary for the door to open, and must be allowed for when setting out and determining the overall size of the door.

Concealed hinges require the use of a special tungsten-tipped cutter, set up in a fixed drilling machine, to mill for the circular cup on the back of the door. The mounting plate is attached to the carcass. Except for the final adjustment, the whole procedure can be a machine operation. Examples of concealed hinges are shown in Figure 11.18 (opening to approximately 90°) and Figure 11.19 (opening to approximately 180°).

Fig. 11.17 (a) and (b) Overlaid door and concealed hinge

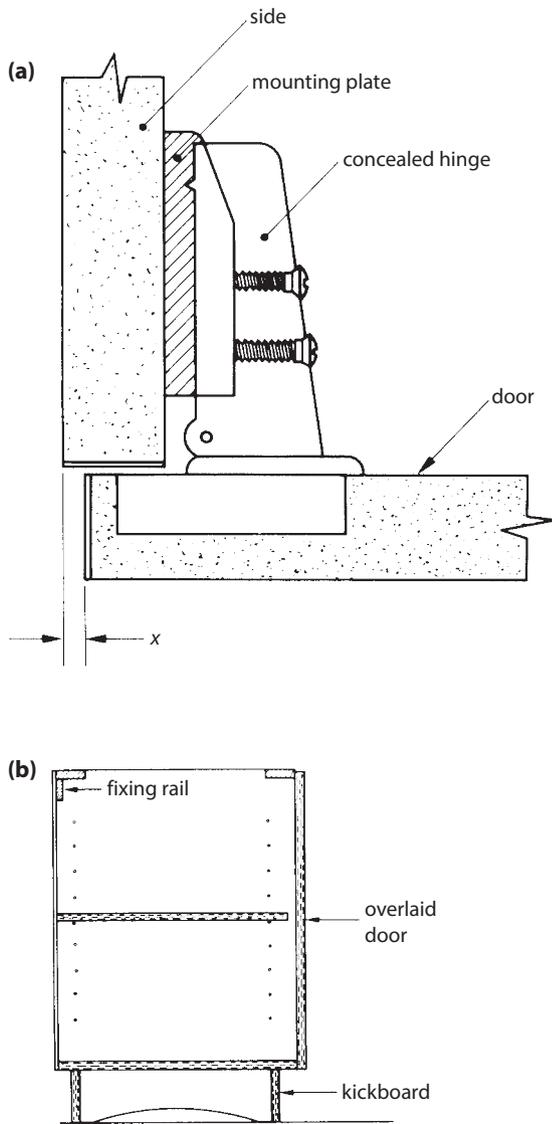


Fig. 11.18 90° concealed hinge

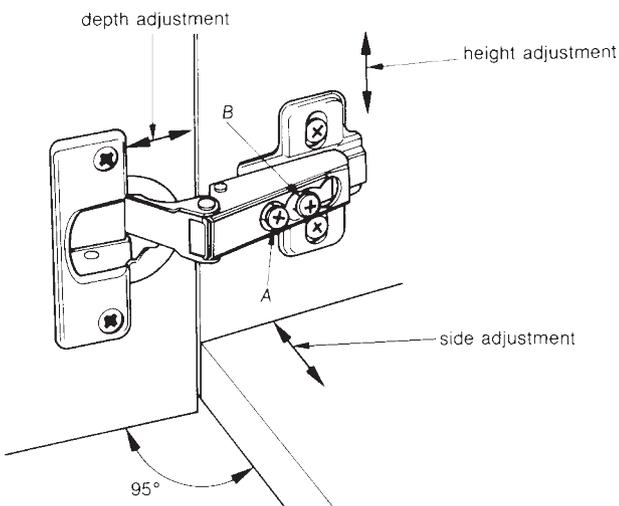
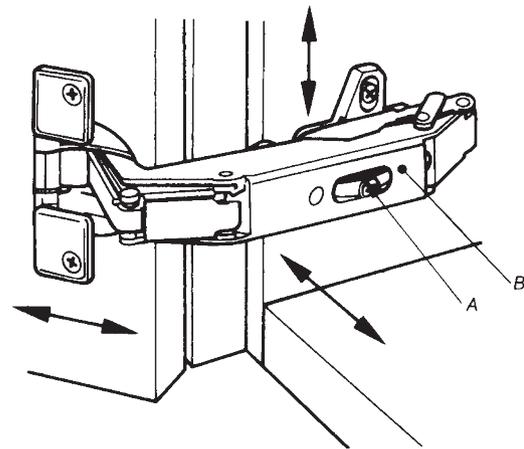


Fig. 11.19 180° concealed hinge



To adjust the hinges, proceed as follows:

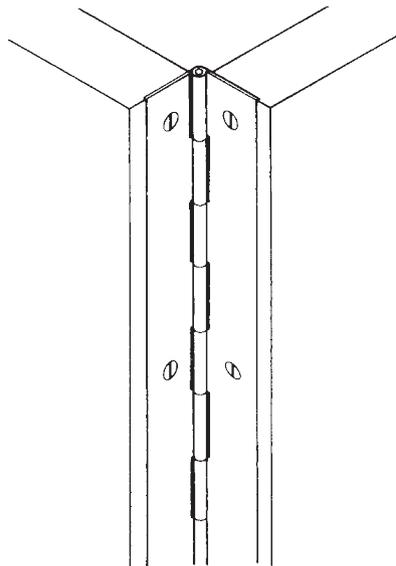
1. *Side adjustment:* Loosen the hinge arm fastening screw *B*. Then loosen or tighten the adjusting screw *A* until the door is balanced. Afterwards, tighten the fastening screw *B*.
2. *Depth adjustment:* Loosen the hinge, regulate the distance between door and carcass with the fastening screw *B*, and then finally tighten with screw *B*.
3. *Height adjustment:* Adjust the height of doors accurately with height-adjustable mounting plates.

Piano hinge

The continuous piano hinge is used where a rigid hinged joint is essential (Fig. 11.20).

A typical example is the hinged joint between the two leaves of a divided door to a corner cupboard. Special piano-hinge screws that have a smaller head than usual are used.

Fig. 11.20 Piano hinge



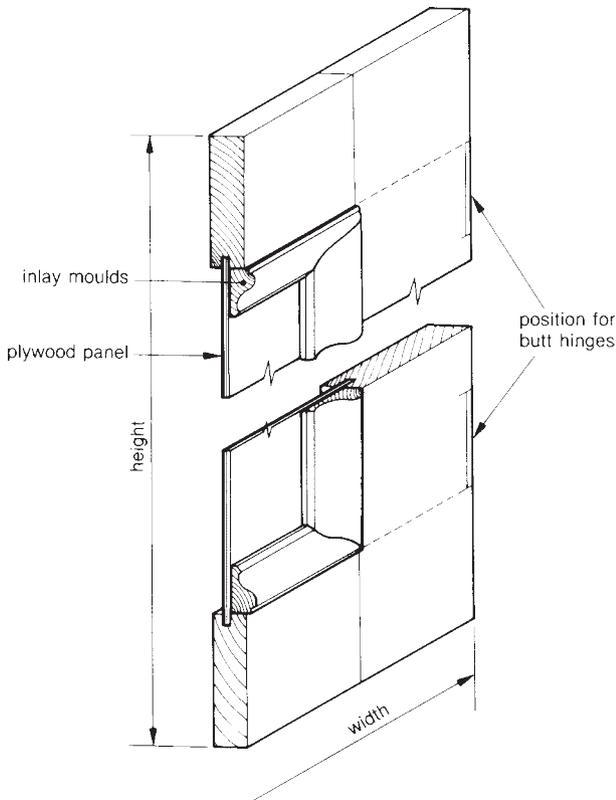
Timber cupboard doors

Doors can, of course, be made up in solid timber, and stock sizes are available to meet most situations. They are set out and fitted as either *overlaid* or *fitted* doors.

Timber plywood-panelled door

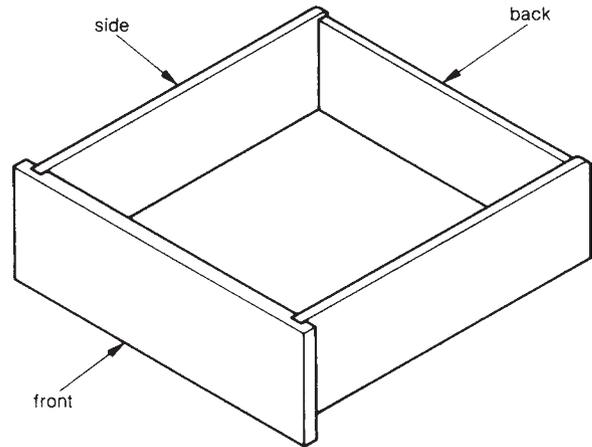
The construction of a simple timber plywood-panelled door that can be made up with hand tools is shown in Figure 11.21, and the procedure is described below.

Fig. 11.21 Simple panelled door



Commence with a dowelled frame and run a plough groove about 5 mm wide and 6 mm deep around the inside edges to hold the plywood panel. The addition of inlay moulds, whether a simple splayed section or a more traditional mould (as illustrated), will soften the abrupt change in level between the frame and panel, and transform the appearance of the door to blend with any decor.

Fig. 11.22 Typical overlaid drawer



Cabinet drawers

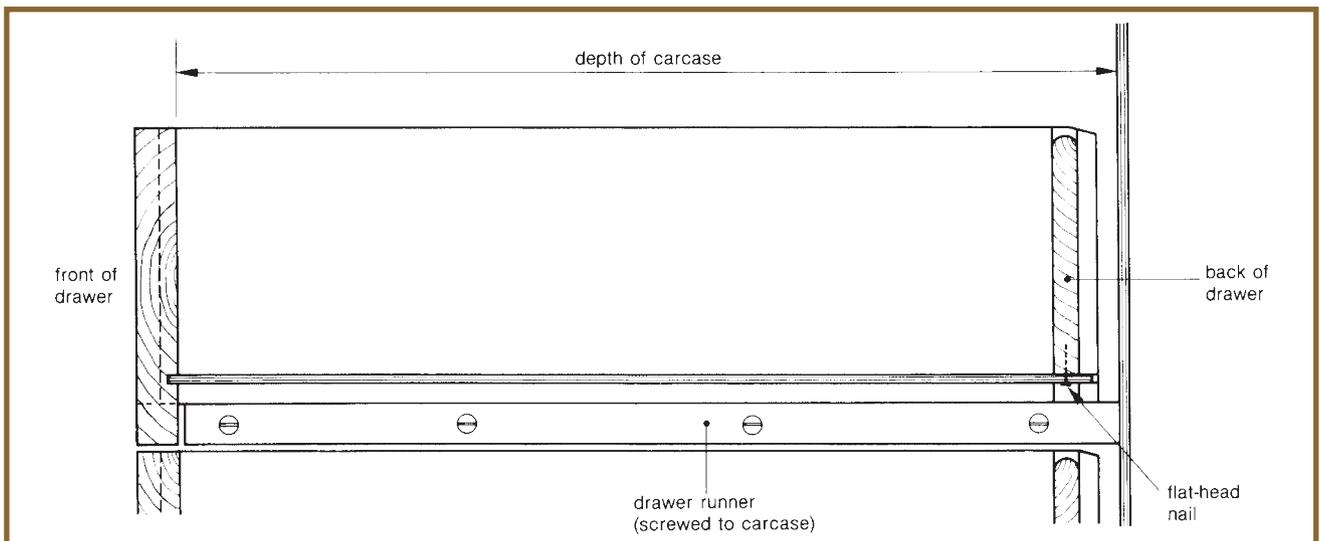
Drawers, like doors, can be *overlaid*, with the fronts concealing the carcass, or *fitted*, finishing flush with the face of the carcass.

Overlaid drawer

The basic construction of the drawer remains essentially the same. A typical overlaid drawer has the front extended to cover the carcass. The sides and the front have a plough groove about 12 mm up from the bottom into which the drawer bottom, usually made of plywood or hardboard, is fitted.

In Figure 11.23, note how the back is made narrower than the sides, and how the bottom edge lines up with the plough groove so that the bottom can slide into the groove. The bottom

Fig. 11.23 Vertical section through an overlaid drawer

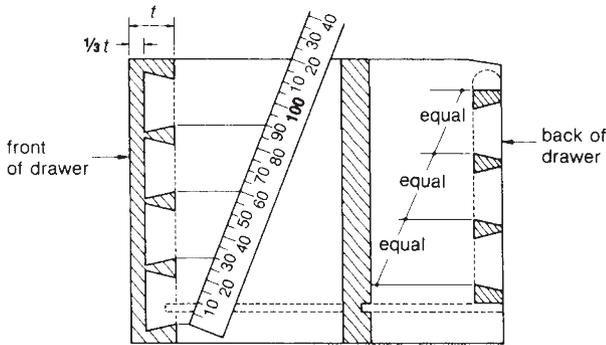


can then be fixed to the bottom of the back by flat-head nails or screws. Drawers slide on metal runners screwed to the side of the carcass.

Dovetailed drawers

If the kitchen or fitment is of a traditional design and an all-timber construction, then for those with a passion for a fully dovetailed drawer, the set-out of pins for the lapped and common dovetail, as applied to the drawer, is shown in Figure 11.24.

Fig. 11.24 Set-out of dovetail pins



Revise the information on the dovetail joints discussed in an earlier chapter, and note how the pins are equally spaced by the 'in and over' method. To set out the pins in the example in Figure 11.24, make four equal divisions on the rule and lay it obliquely (on an angle) across the width of the timber. Mark the intermediate points and transfer them parallel to the edge to locate the side of the intermediate pins.

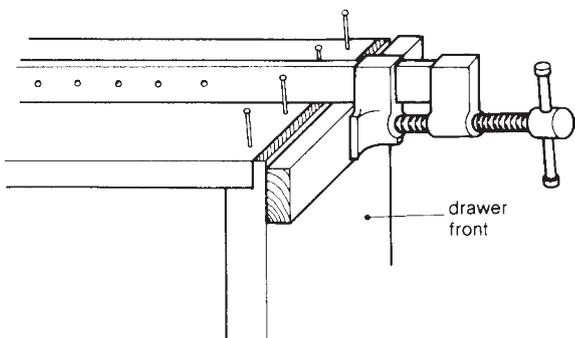
Rebated drawer fronts

For lightly loaded drawers, as found in most domestic cupboards, the sides can be joined to the front by a simple rebated joint (Fig. 11.25).

To assemble the joint, use a PVA adhesive and a light bar clamp to pull it together as illustrated in Figure 11.25. Slope the nails in slightly. An adequately strong joint will result. Take care not to nail through the plough groove.

Other joints also used are the trenched and housed joint and the machine dovetail joint, which gives extra strength in the direction of the pull on the drawer.

Fig. 11.25 Rebated joint



The backs of drawers finish a little below the top of the sides. The sides can be set out in pairs and housed about 3 mm deep to receive the back. Alternatively, a butt joint glued and screwed or nailed is often used. After assembly, check that the drawer is square by making sure the diagonals are equal, and accurately square the bottom so that when it is fitted to the groove, the drawer will remain square.

Mechanical drawer runners

Mechanical drawer runners, operating on ball-bearings or nylon rollers, are the norm for use in cupboard drawers. They will then run freely with little effort.

Examples are shown in Figures 11.26 and 11.27. Note that sufficient clearance must be provided to allow for the runner to be fitted and this distance must be known and allowed for when setting out. In common with hinges and other assembly devices, fixing instructions are available from manufacturers or distributors.

Fig. 11.26 Mechanical drawer runner with nylon rollers

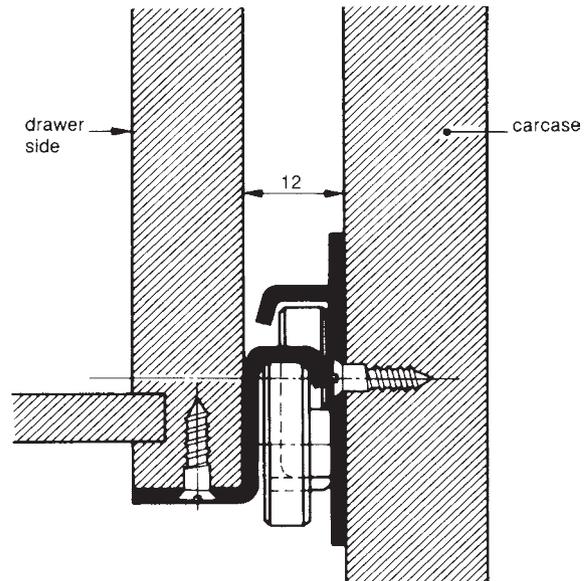
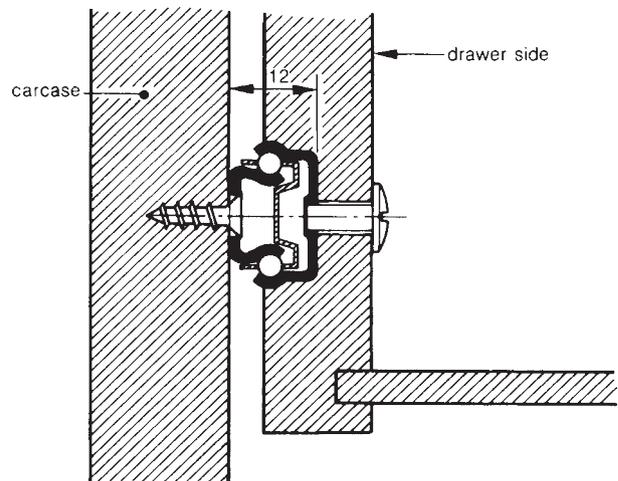


Fig. 11.27 Mechanical drawer runner with ball-bearings

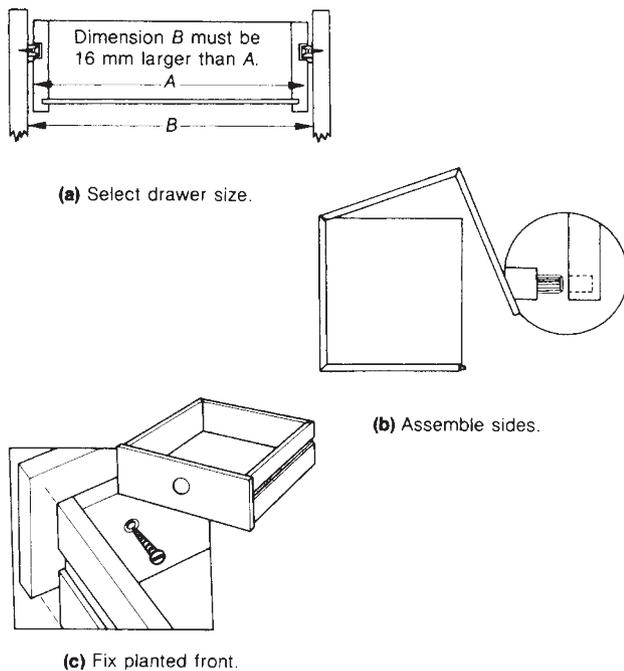


Mass-produced drawers

Mass-produced drawers are available in a number of stock sizes and materials, and are a commonly adopted alternative to custom-made units. They may be plastic, metal or sheet material.

Drawers are also available in kit form. Here, the four sides of the drawer are made from particleboard, wrapped in vinyl, and are grooved to accommodate the bottom of the drawer and the nylon runners. The drawers are supplied as a kit in a continuous length. The corner mitre joints are precut.

Fig. 11.28 Assembly of precut drawers



To assemble the drawer, apply a little adhesive to the joints, wrap the sides around the bottom and finally tap the last doweled joint together. A planted drawer front of selected material is screwed to the front, and nylon runners are screwed to the sides of the carcass.

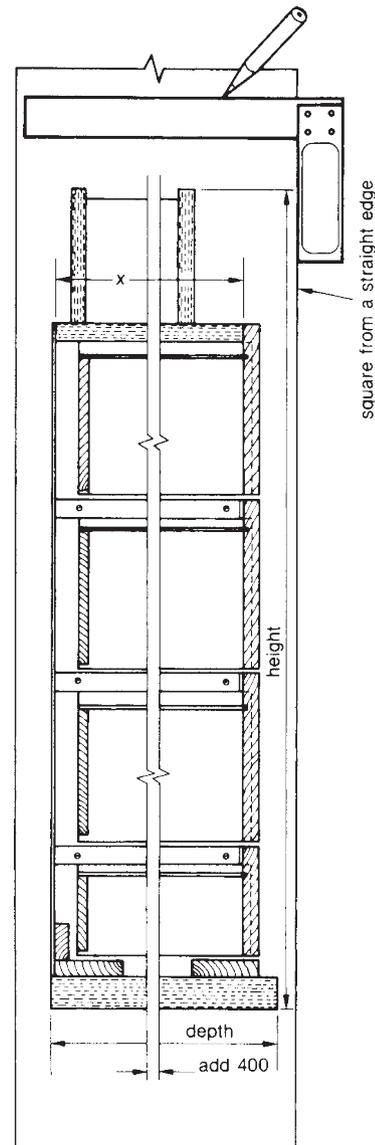
Set-out rods

Rods for interior fittings and cabinets are set out following the same principles as described in a previous chapter. In most instances, full-size vertical and horizontal sections will be adequate to provide sufficient details for construction, from which accurate cutting lists can be prepared. It is not always necessary to show the full depth on the rod.

Figure 11.29 illustrates an example of a vertical set-out for a four-drawer unit. Where the depth is broken, it is good practice to take out a fixed amount. For example, in this example, 400 mm has been taken out, so any dimension in depth will be 400 mm plus the distance in depth measured from the rod. Following this procedure, the depth of the cupboard bottom will be $400 + x$ mm. A strip of plywood or hardboard, 200 mm

to 300 mm in width, with a straight edge will be sufficient to contain most of the set-outs. Only in the case of some curved or corner units will it be necessary to set out full-sized plans or elevations on large sheets of material.

Fig. 11.29 Vertical set-out rod for a four-drawer floor unit



All necessary installation details relevant to hinges, drawer runners and other fittings must be available and provided for as setting out proceeds.

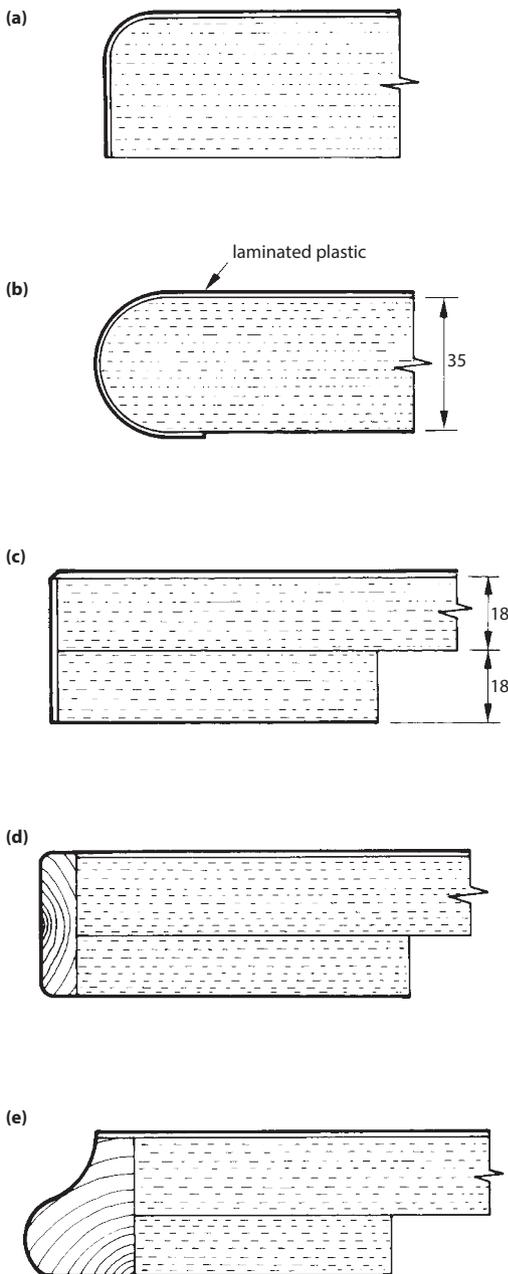
Worktops

Benchtops or worktops to kitchen cupboards are fitted on site after the various units making up the layout have been connected together and fixed in position. Benchtops can be made from particleboard faced with a hard-wearing laminated plastic surface. Where there is a possibility of dampness penetrating the particleboard, such as around kitchen sinks,

a water-resistant grade of board is recommended. Whatever the case, tops should be fitted closely around any wet areas and raw edges should be sealed with silicone mastic. Other materials commonly available include laminated timber surfaces finished with a clear product to seal the timber; natural and man-made stone products; and stainless steel.

Examples of edge finishes to cupboard tops are shown in Figure 11.30. Benchtops are normally 35 mm thick particleboard faced with laminated plastic, which may be moulded to a round edge using postformable materials, either through 90° or 180°. Benchtops are made up in various lengths and

Fig. 11.30 Benchtop edge profiles: (a) round edge 90°; (b) round edge 180°; (c) square edge; (d) timber edge; and (e) moulded timber edge



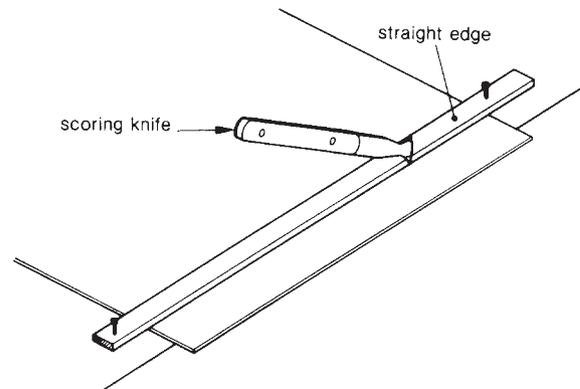
widths of 450 mm and 600 mm. Other examples include 18 mm particleboard with edges built up by laminating together two thicknesses.

Fixing plastic laminates

Laminated plastic surfaces can be applied on site after the tops have been fitted. The edge strip is applied first and is trimmed off square and flush with the surface of the core material. The surface sheet is applied *after* the edge strip. The procedure is as follows:

1. Cut sheets about 3 mm oversize around all edges. To cut the material, a fine-toothed saw will do, but far more effective is a scribing knife tipped with tungsten carbide. Lay the sheet face up on a flat surface and secure a straight edge along the line of the cut.

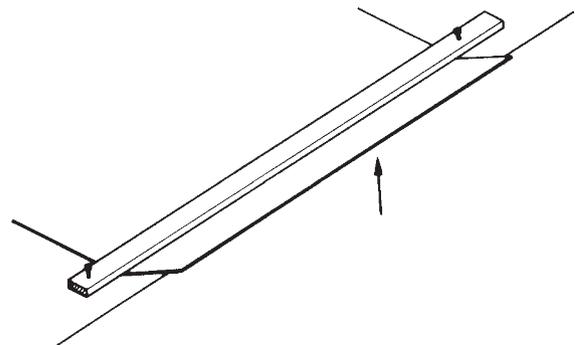
Fig. 11.31 Scoring laminated plastic sheet



Warning: Ensure that the straight edge is adequately secured by a clamp or nail and will not move during the cutting process.

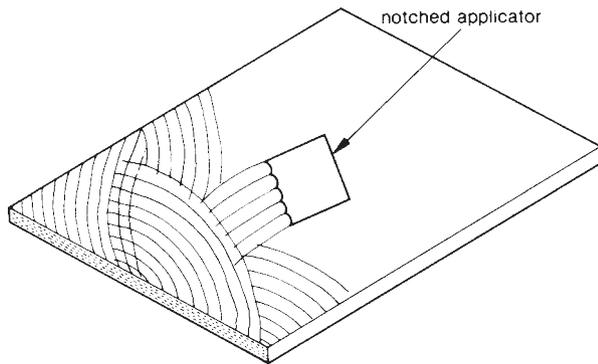
Score the sheet deeply along the straight edge (Fig. 11.31) and snap the sheet upwards to make a clean break (Fig. 11.32).

Fig. 11.32 Snap sheet up to break



- Use a contact adhesive to bond the laminated plastic to the surface of the particleboard. Use the notched applicator supplied with the adhesive to spread an even film of adhesive to both the plastic sheet and the particleboard surface (Fig. 11.33).

Fig. 11.33 Applying the adhesive



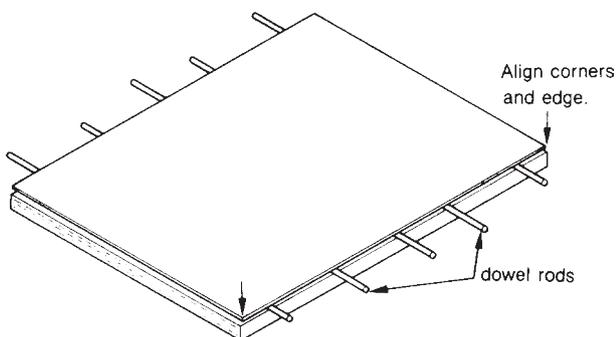
Porous surfaces such as the edge of particleboard may require two coats.

Allow the applied adhesive to become tack-free. This will probably be about 20 minutes, but the time may vary with the ambient temperature. It is important that the adhesive is dry before attempting to fix the sheet. Test for dryness by touching with the knuckles; when the adhesive will not transfer to the knuckles, it is ready for fixing.

- Position the laminated plastic sheet over the surface. Because the contact adhesive bonds immediately on contact, it is important to line up one edge and one corner of the sheet very carefully.

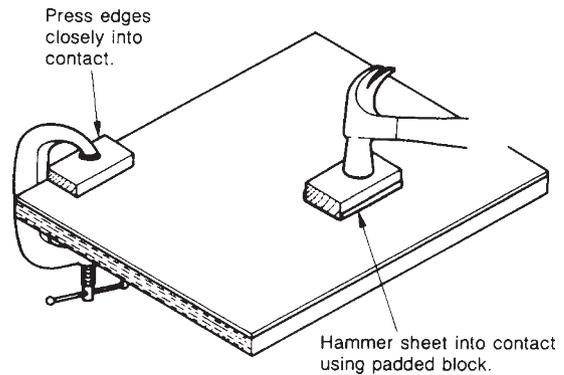
For large areas, accurate alignments can be achieved by using lengths of dowel rod to separate the adhesive-coated surfaces.

Fig. 11.34 Aligning the sheet using dowel rods



When the sheet is correctly aligned, remove the dowel rod from the centre and press the plastic sheet against the core material. Remove the dowels one at a time until all have been removed.

Fig. 11.35 Fixing the laminated plastic sheet



Fix the sheet by applying pressure using a cork or a padded wooden block, and tap firmly with a hammer to ensure tight, even bonding. It is good practice to work along the edges with a G-cramp and block of wood, to press the sheet closely into contact with the core. Alternatively a large padded roller can be used to press the laminate down.

- Laminated plastic sheet can be trimmed off with a smoothing plane and the corners finished with a single-cut file (Fig. 11.36). However, it is preferable to use the veneer trimmer.

Fig. 11.36 Trimming the laminated plastic sheet

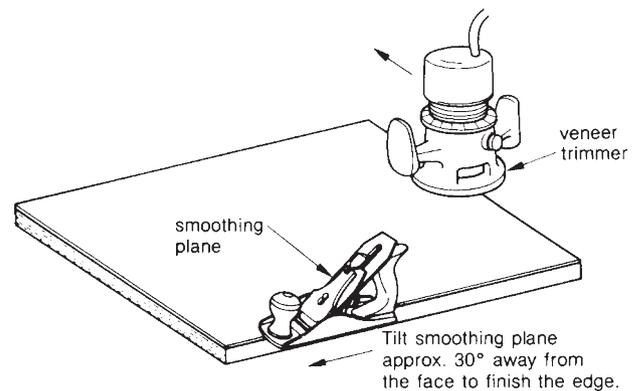
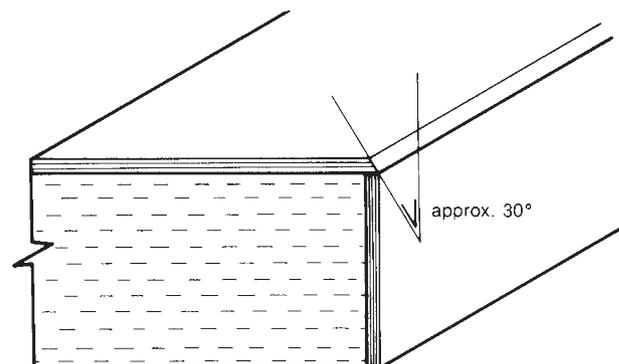


Figure 11.37 illustrates the procedure for finishing the plastic laminated edge.

Fig. 11.37 Finishing the laminated plastic edge



The edge strip is trimmed flush with the surface of the core material (as previously mentioned) and the edges of the top are finished and trimmed off at about 30° to the vertical.

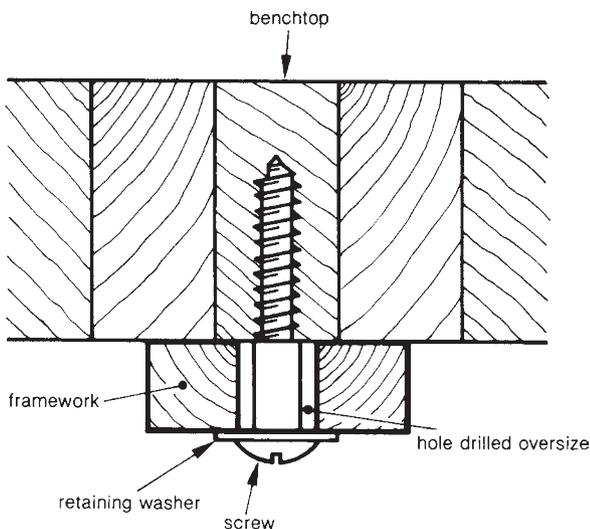
Laminated timber benchtops

The benchtop is normally prepared by the manufacturer who will provide for splashbacks, front aprons, rounding of corners, cut-outs for hotplates and sinks, and drainage grooves if required.

The finished benchtop is then delivered, often with a polyurethane finish already applied, and installed by the carpenter. As the top is solid timber, allowance must be made for expansion and contraction across the grain. This movement may be 2 mm to 3 mm across a 600 mm wide benchtop.

Never glue the top to the carcass. Gluing will not allow for movement. The recommended method of fixing is to screw from underneath. Holes two sizes larger than the screw diameter are drilled through the frame or cleats, so that when the screw is driven there is room for movement between the screw and the fixing on the carcass.

Fig. 11.38 Screw fixing to underside of benchtop

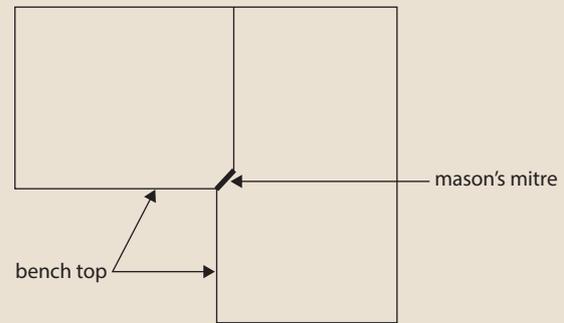


A washer is installed with the screw to provide a good hold, even though there is an oversized hole.

If a benchtop has to be mitred to a corner, the recommended procedure is as follows:

1. Carefully measure and mark the mitre on the benchtop using a *mason's mitre* (Fig. 11.39).

Fig. 11.39 Benchtop with mason's mitre



2. Cut the top slightly oversize to allow for accurate trimming to the marked line.
3. Set up a straight edge on one of the benchtops so that a router with a straight cutter can be guided along it to produce an accurate finely trimmed surface. Move the router towards the sharp point of the mitre.
4. The adjoining section of benchtop is turned face down; trim the mitre from the underside of the benchtop, once again towards the point. This allows accurate mating of the two surfaces should the router be slightly out of true.
5. Glue the joint. The recommended adhesives are either full-strength epoxy resin or similar product. Special metal connectors are available to strengthen the joint which clamps it together.

Student research

Investigate the different hardware and accessories available for the use in construction of a contemporary kitchen.

Formaldehyde

Formaldehyde is one of the volatile organic compounds (VOC) group. These compounds become a colourless, pungent and flammable gas at normal room temperatures. Formaldehyde exists naturally in the atmosphere, a by-product of combustion of fossil fuels.

Formaldehyde is used in a wide range of products and materials. In construction it is used as a binder in insulation products, an adhesive in composite timber sheet products and in furniture. There is considerable concern about the health effects of formaldehyde, ranging from skin irritation and nausea to cancer. Indoor air quality and a safe formaldehyde level is not specified in any regulation; however, well ventilated spaces are considered important. Older houses, particularly those built before the Second World War, contain more natural materials and the formaldehyde level has been found to be lower than in modern houses.

It is important to be aware of products that contain formaldehyde and select an alternative that does not off-gas.

PART 5

Advanced formwork and wet trades

Chapter 12 Formwork for stairs and ramps

Chapter 13 Solid masonry

Chapter 14 Arch construction

Benny Sorrenti – Carpenter and Licensed Builder

Benny is a first-generation Australian of Italian descent who operates a successful family building business that specialises in providing formwork and concrete for large, high-quality swimming pools, as well as doing a range of general building work.

Recent projects that Benny has worked on include public swimming pools in Alice Springs and Brisbane and the reconstruction of the public pools at the Parramatta Swimming Centre in New South Wales. These Olympic-standard pools have a tolerance of plus or minus 5 mm over their 100 metre length!

Benny's father, Giovanni, came to Australia in 1966 and started the business that Benny now runs. In Italy, Giovanni worked as a highway patrol officer; in Australia, he became a formwork carpenter, learning on the job, and in a short period of time had a formwork business. Benny was born soon after the family arrived in Australia and grew up with the family business.

From the age of 14, Benny worked for his father as an apprentice and by the time he was 26 he was running all aspects of the family building company. He is now the company's qualified supervisor.

Benny struggled as an apprentice in the TAFE system, preferring to be working on the job. However, when the time came to become the qualified supervisor, he battled with work commitments to complete his Certificate IV in Building and Construction, and then applied for a full building supervisor licence.

Benny has employed and trained a number of apprentices, ensuring that they completed their trade certificate. His son, John, is following in his father's footsteps by planning to complete a Certificate IV in Building and Construction to meet the qualification requirement for a builder's licence in New South Wales. Having already completed his Certificate III in Construction Carpentry, John will first complete the additional units of learning he needs to achieve a Certificate III in Carpentry and then undertake the Certificate IV in Building and Construction through the TAFE system.



Giovanni, Benny and John Sorrenti

Formwork for stairs and ramps

LEARNING OBJECTIVES

- 12.1 Stairs and ramps
- 12.2 Suspended slabs and beams
- 12.3 Columns and walls
- 12.4 Safety requirements

In Chapter 12 Basic Concrete and Formwork in Volume 1, concreting and simple formwork for reinforced footings and concrete slab-on-ground construction were discussed. This chapter will review the use of more complex formwork systems. Increasingly, commercial systems of building and construction are used in residential building work. There are three dominant factors behind this ongoing change:

- work health and safety
- project timeframes—major cost advantages related to faster completion times
- skilled labour shortages and labour costs.

These modern systems are generally modular (Fig. 12.1).

Despite the loss of jobs that construction technology has delivered, it has also opened pathways for a greater range of

Fig. 12.1 Modular formwork systems: (a) table form/flying form; (b) flying form with scaffolding and handrail; (c) column system; and (d) horizontal panel/wall system



(a)



(b)



(c)



(d)

skilled jobs such as operators of boom pumps and cranes, scaffolding, rigging, formwork, concreting and steel fixing. These occupations are now recognised by formal Australian qualifications under the Australian Quality Framework (AQF) and provide a pathway to Certificate IV and Diploma qualifications in the modern construction industry.

Formwork materials

Materials used to construct formwork must be of good quality, free of defects that will seriously affect their strength and be sufficiently durable for the job.

Timber

Oregon (Douglas fir) is suitable for forms as it will retain its shape and with normal care can be reused many times. Specially designed, laminated veneer lumber (LVL) is also available as supporting timber for suspended formwork and for the edge boards for slab-on-ground construction. Whatever type of timber is used, its relative strength must be taken into account when designing the formwork.

Formply

Formply is widely used for formwork and is available in standard size sheets 2400 mm × 1200 mm and 1800 mm × 1200 mm and in 12 mm and 17 mm thicknesses, with stress grades F14 and F17 finished with a smooth plastic or a resin surface finish.

Plywood used as concrete formwork must comply with AS 6669: 2007 Plywood—Formwork, (which includes structural requirements of AS/NZS 2269: 2008 Plywood—Structural) and must be branded with a stress grade to AS 6669: 2007, the class of off-form finish and bond type.

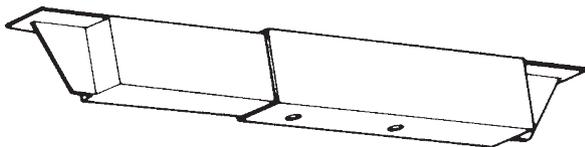
Fasteners

Hot-dipped galvanised stainless steel or alloy nails and screws are recommended to prevent concrete staining for Class 2 and 3 finishes.

Steel and aluminum

Adjustable props, expanding beam centres (Fig. 12.2), supporting framework and circular or square columns are manufactured in steel and aluminium.

Fig. 12.2 Beam centre



Polyvinyl chloride, polystyrene and fibre cement

Polyvinyl chloride (PVC) and fibre cement (FC) fabrications are commonly used for circular columns, whereas polystyrene and PVC are used to form voids in waffle slabs. All three are used for concrete wall systems.

Formwork standards

Relevant legislation, standard and code of practice

The installation of formwork is addressed by AS 3610: 1995 Formwork for concrete and AS 3610 Supplement 2: 1996 Formwork for concrete—Commentary (under revision).

Under the federal *Work Health and Safety Act 2011* and Safety Regulations 2011, formwork installation will often meet the criteria for classification as a high-risk activity requiring a discrete safe work method statement. This being:

- work requiring temporary support of structural components
- the risk of falling more than 2 metres.

The information that follows is from *Formwork and Falsework: Code of Practice* (Safe Work Australia, 2013) and AS 3610: 1995 Formwork for concrete.

Freshly poured concrete that is still fluid imposes forces on the supporting structure that can lead to **progressive collapse** if all elements, particularly the shoring system, are not properly installed. Failed formwork is a significant contributor to the annual statistics of death and injury of building and construction workers. The mass of concrete is 2400 kg per cubic metre; this doesn't include the mass of the formwork.

The following critical points must be considered when installing formwork and pouring concrete for suspended slabs:

- Formwork should only be erected by a competent/qualified person (e.g. someone holding a Certificate III in Falsework and Formwork).
- A licensed scaffolder is required for work over 4 metres.
- Safe access must be provided for workers installing formwork.
- Formwork frames must be erected progressively and safely.
- A safe **false deck** (scaffolding) must be provided for the erection of a formwork deck exceeding 2 m in height.
- Edge protection must be provided for formwork decks.
- The laying of formply must be planned so that a safe work platform is provided at all times.
- Cantilevers or 'traps' must be secured to prevent falls.
- Workers must be protected from falls through open penetrations such as stairwells.
- Barriers must be installed to prevent following trades from entering an active formwork zone.
- Placing loads onto active formwork decks must be planned and supervised to mitigate overloading and catastrophic collapse.
- Formwork must be inspected by an experienced structural designer/engineer before the concrete is poured.
- When concrete is poured, only one designated observer may be under the formwork.
- Pouring of concrete must stop when emergency repairs are required.
- Heavy equipment should not be placed on formwork unless the formwork has been designed for that purpose.

- Concrete should not be stripped until a competent person provides written confirmation that the formwork can be removed (e.g. structural engineer).
- **Drop stripping** should not be undertaken.
- **Backpropping** must be supervised by a competent person and be designed to allow for any loads that may be placed on recently poured concrete.

Each state and territory has their own code of practice for the erection and dismantling of formwork.

Formwork finish

There are five levels of surface finish for concrete to consider when designing formwork:

- Class 1—for monuments and other special finishes; not required for general building work
- Class 2—a high level of finish when viewed in close detail, e.g. facades and foyers
- Class 3—a high level of finish when viewed overall, e.g. internal and external facades
- Class 4—good alignment but concealed from general view with applied finishes
- Class 5—alignment and finish are not critical—totally concealed, e.g. footings.

Formwork design

The proper sizes and spacing of components are subject to a number of variable factors:

- The volume of concrete to be contained in the form
- The rate at which the concrete will be poured—rapid pouring means a greater head of liquid concrete, and requires stronger formwork
- The temperature at the time of pouring the concrete—higher temperatures mean the concrete will begin to stiffen more rapidly and reduce the liquid head
- The use of vibrators and heavy equipment requires stronger formwork—there are concrete additives that reduce the amount of vibration required
- The strength and grade of the plywood, timber and other materials used—plywood formwork is generally stronger than solid timber and can lead to a reduction in the number of supporting members.

A factor of safety must always be used in designing formwork. If in doubt, it is better to over-design rather than risk movement in the formwork once pouring has commenced because at this stage it is almost impossible to correct any inadequacies.

Formwork for a concrete beam

The typical arrangement of formwork for a light concrete beam is shown in Figure 12.3. In this example, a beam 430 mm deep × 230 mm wide is to be cased in situ over an opening in the brickwork. The beam sides and soffit form are made up into units from random boards which have been cleated together. The soffit is first erected and supported on T-toms. Folding wedges on sole plates are used to adjust the height (Fig. 12.4).

Fig. 12.3 Formwork for lightweight concrete beams

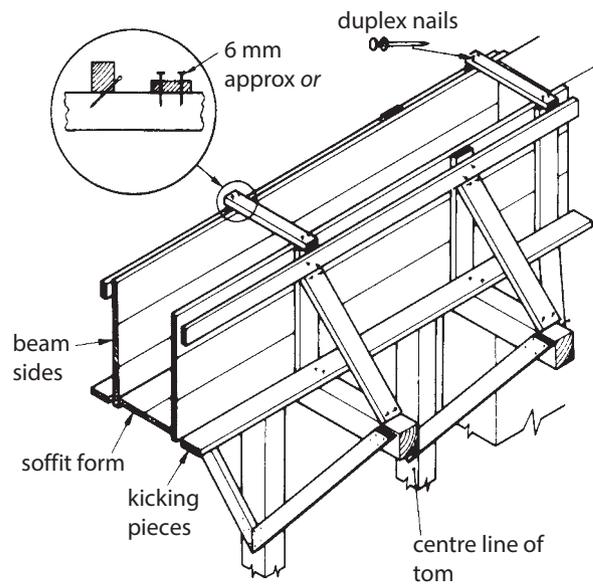
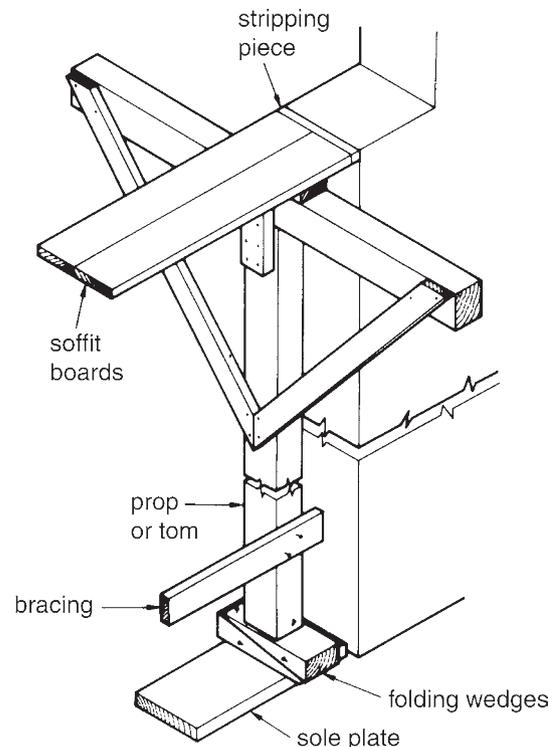


Fig. 12.4 Soffit formwork



Note that the stripping piece (perhaps not essential in this case) is used to prevent any damage to the end of the form during stripping. The beam side can now be erected and must be straight and plumb, then securely braced back to the head bearer. Spacers on the top will hold the beam sides at the correct distance apart.

Joints must be taped to prevent the cement paste running down over face brickwork. The reinforcing steel may be placed before the remaining beam side is installed.

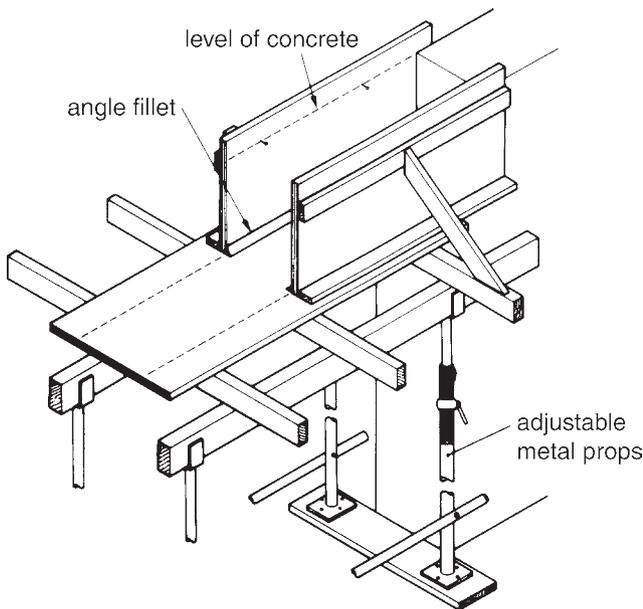
Removal of forms

The removal of forms can be the reverse procedure. The beam sides can be removed first, with the props and soffit left in place, until the concrete gains sufficient strength to be self-supporting.

The vertical surfaces can be stripped in as little as two days and up to approximately seven days, but horizontal surfaces to beams and slabs require longer—from seven to 28 days, depending on the span and the air temperature prior to stripping.

In Figure 12.5 short joists and bearers are supported on tubular steel props that can be adjusted quickly and accurately to height. Formply is used for the soffit and beam side that have been arranged to avoid unnecessary cutting of the sheets. Beam sides must be plumbed and braced securely. Steel reinforcement to the beam is usually made up in the form of a cage and then lifted into the form. Another often more convenient procedure can be to place the reinforcement cage in place before the second beam side is fixed. This allows easy access for positioning the steel accurately, a most important factor in reinforced concrete.

Fig. 12.5 Typical formwork for a concrete beam



Props must be braced close to the bottom to avoid possible movement.

An alternative system is to use a proprietary right angle bracket that can be nailed directly to the plywood or timber framework. These are available from PERI Australia as an AW stopend for use with light beams up to 600 mm without the need for additional ties.

Fig. 12.6 The PERI AW stopend system for beams up to 600 mm



Source: PERI Australia Pty Limited, www.periaus.com.au

Traditional formwork for a concrete column

Formwork for a concrete column may be made up in the form of a column box; the four sides of which are cut to size, cleated as necessary and assembled to form the box (Fig. 12.7). When the formwork is filled with liquid concrete, it will tend to force the box apart, particularly at the bottom where the pressure is greatest: it will attempt to lift the box and escape from under the formwork. To prevent the column box failing as a result of these pressures, the sides must be securely tied together with some form of column yoke and the bottom fixed to the floor or footing.

Fig. 12.7 Column formwork

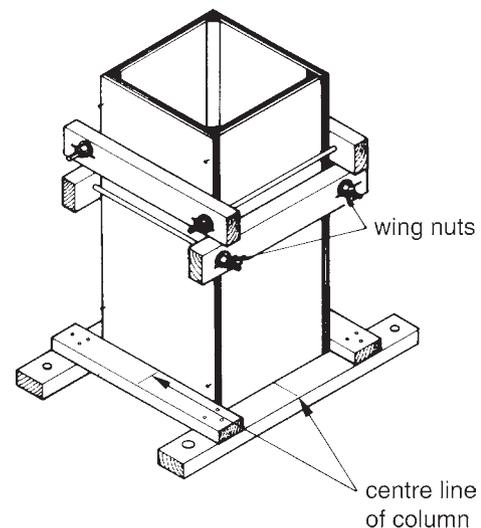
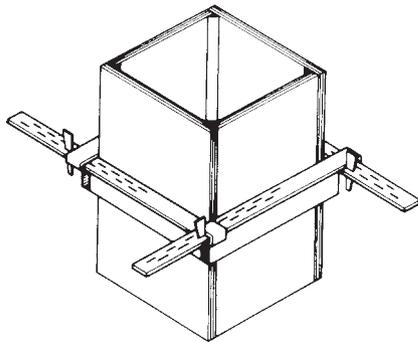


Figure 12.7 illustrates an example of a column yoke. Strong cleats are fixed to the side forms at different levels and the box is clamped together in two directions with the tie rods. Rods can be made up to suit standard Whitworth threads. Continuous threaded rods are also available, with a fast thread and wingnuts to suit, which facilitate a speedy application.

Figure 12.8 shows a widely adopted type of yoke consisting of interlocking slotted bars that can be adjusted to size and tightened with a wedge. They are manufactured in three sizes, permitting adjustment from 250 mm to 1230 mm for square or rectangular columns.

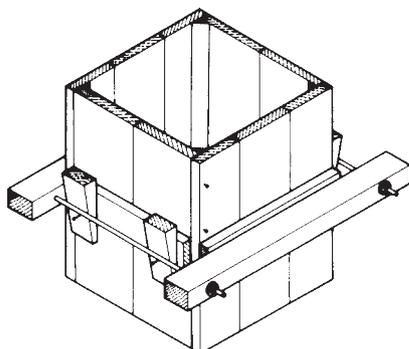
Fig. 12.8 Patent column formwork



The yoke shown in Figure 12.8, although considered ‘old fashioned’ in some areas, is nevertheless quite effective and can be readily made up in places where materials may be plentiful. The column base is placed over the splice bars and fixed to the floor to accurately locate the column in position. The dimensions for locating the column are often given to the centreline, in which case the centrelines are marked on the base and the relevant measurements are made to these points (Fig. 12.7).

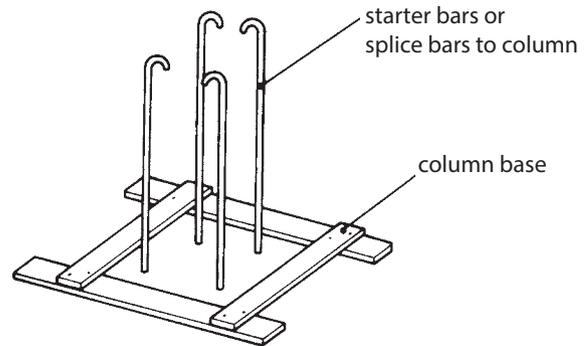
Concrete columns are reinforced with steel rods made up in the form of a cage and attached by wire ties to splice bars left projecting from the floor or footing (Fig. 12.10). Before the column box can be erected, the reinforcement cage is made up, stood in position and tied to the splice bars. Stand the column sides around the reinforcement cage, lightly nail them together and then clamp the column yokes in position. If using the yokes illustrated in Figure 12.9, open the yokes up

Fig. 12.9 Column formwork—traditional method



and lay the required number over the splice bars and, when the column sides are in place, lift the yokes up to their position, top yoke first. The column formwork must then be plumbed and braced as necessary.

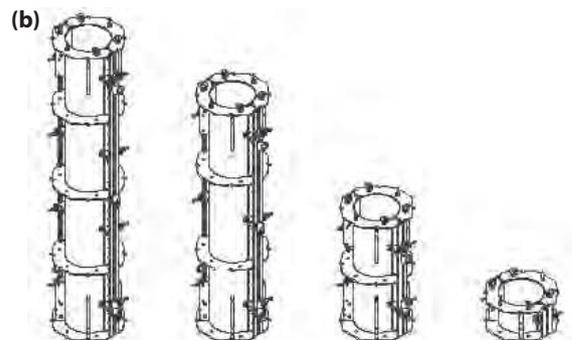
Fig. 12.10 Starter bars



Formwork for circular columns

Circular columns may be formed with steel, aluminum, PVC or FC, all of which are capable of providing a Class 2 finish.

Fig. 12.11 (a) PVC form by Plastube; and (b) a PERI SRS steel circular column



Source: (a) Courtesy of plastube; (b) PERI Australia Pty Limited, www.periaus.com.au

Formwork for concrete slabs

There are two types of concrete slabs to consider: slabs cast on the ground and suspended slabs.

Formwork for slab-on-ground construction

In Chapter 12 of Volume 1 there is information on basic formwork for slab-on-ground construction. Other formwork systems for residential slab-on-ground construction to consider include Cupolox®, a structural dome concrete slab system made from recycled non-toxic polypropylene. Each dome easily interconnects to create a self-supporting structure that acts as permanent formwork.

Fig. 12.12 Cupolox dome system



Source: www.aus-styrene.com.au

Fig. 12.13 Waffle slab using polystyrene forms



Formwork for suspended reinforced concrete

Supporting formwork for concrete floor areas involves the use of a system of unit frames that can be very speedily erected and adjusted. A typical frame consists of vertical legs with diagonal bracing, framed into a rigid unit (Fig. 12.14).

Lugs incorporating a latch pin provide positive fixing for diagonal bracing, which is available in suitable lengths for the frames to be spaced between 1220 mm and 3050 mm apart (Fig. 12.15). Basic frames can be connected together vertically to build up to the required height.

Fig. 12.14 Basic formwork frame

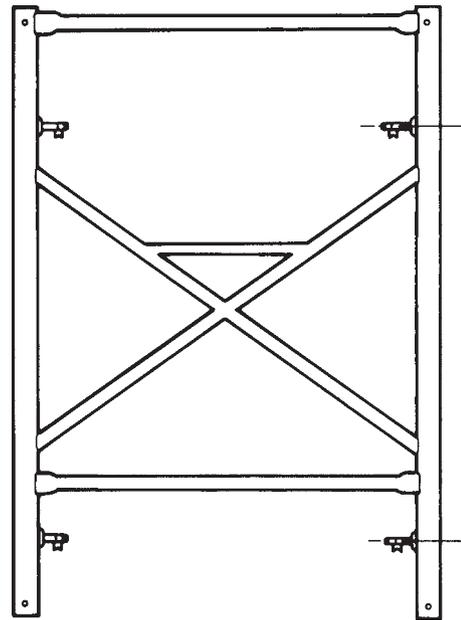
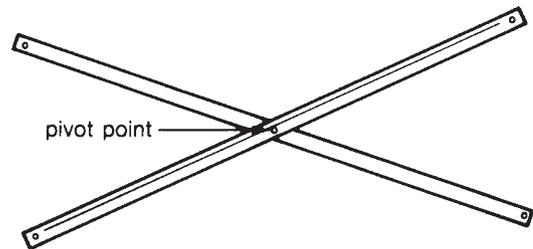
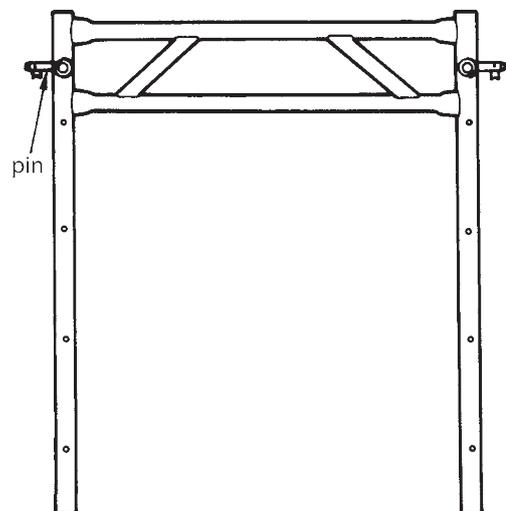


Fig. 12.15 Diagonal bracing



In order to provide for intermediate adjustments in height, telescopic frames are fitted to the top of the basic frame (Fig. 12.16). With suitable bracing, these frames provide for adjustments of 305 mm intervals. Adjustable screw jacks

Fig. 12.16 Telescopic frame



are fitted to the tops of the frames and support bearers, permitting speedy adjustment to the level of the formwork.

On firm surfaces such as a concrete floor, frames are supported on the base plates 200 mm × 200 mm, but on sloping ground it is necessary to level the frames by the use of screw jacks fitted into the legs (Fig. 12.17). Set up the first screw jack on a solid sole plate at the highest part of the ground and adjust it to its lowest position, then level the frames by adjusting the other screw jacks. Frames can be coupled together with diagonal bracing to cover any area and to support bearers and joists. Set out to support plywood or timber decking panels.

The bracing of props is important as there is a strong tendency for a floor slab to sway sideways due to the pressure of wet concrete and also the movement set up by personnel and the equipment used to transport and place concrete. Newly erected masonry walls cannot be relied upon to provide lateral stability. Lateral bracing must be provided no more than 300 mm from the top and bottom of props, and diagonal bracing must be provided in both directions, fixed as close as possible to the top or bottom of props.

Fig. 12.17 Adjustable screw jacks: (a) foot of basic frame; and (b) top of frame

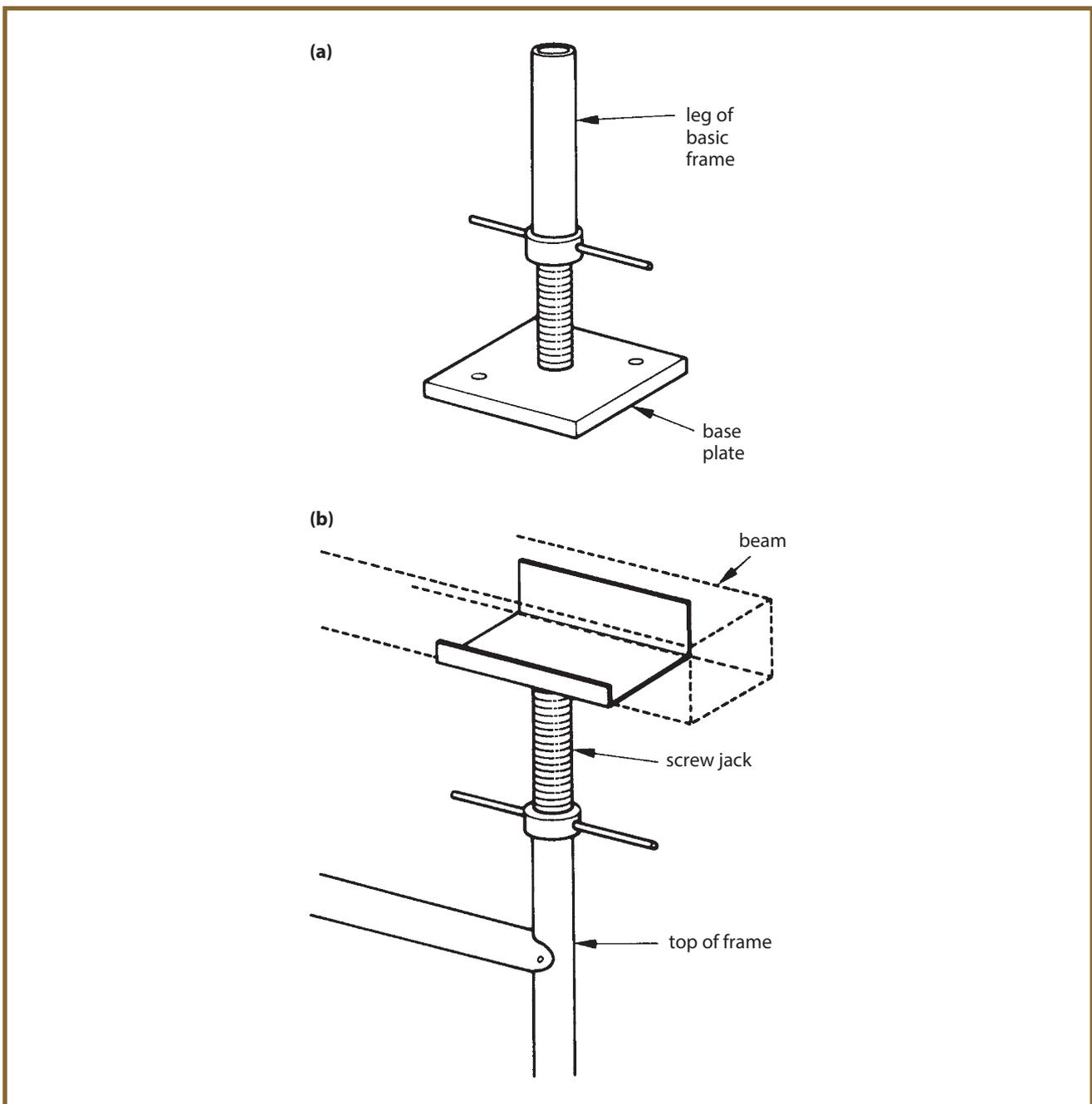
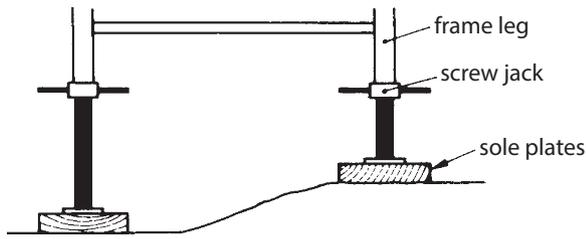


Fig. 12.18 Levelling base frames

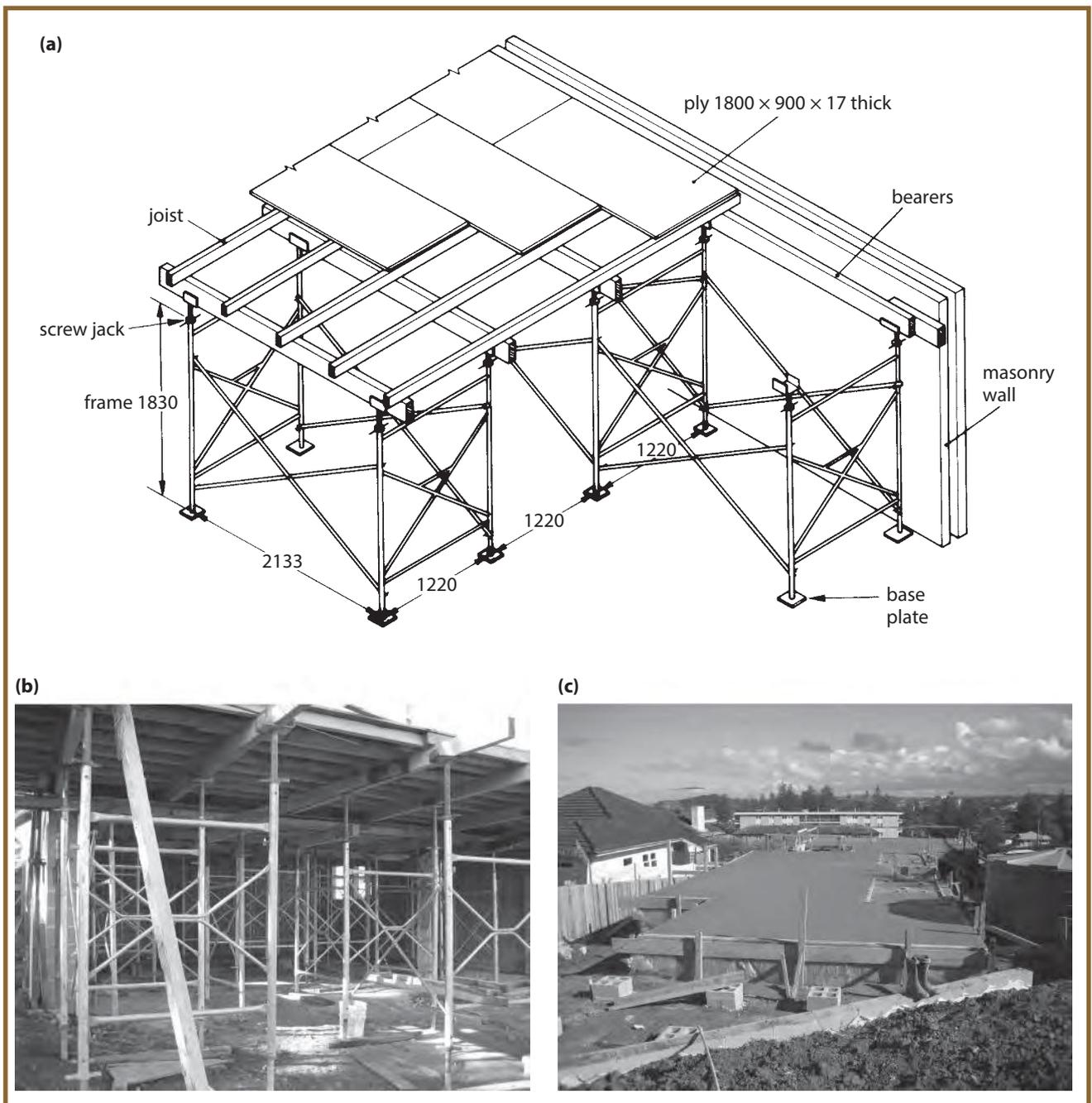


Formwork for concrete stairs

Many staircases are cast from concrete; the basic principles and proportions between treads and risers remain unchanged. However, formwork must be constructed that will conform to the stair design and retain the concrete.

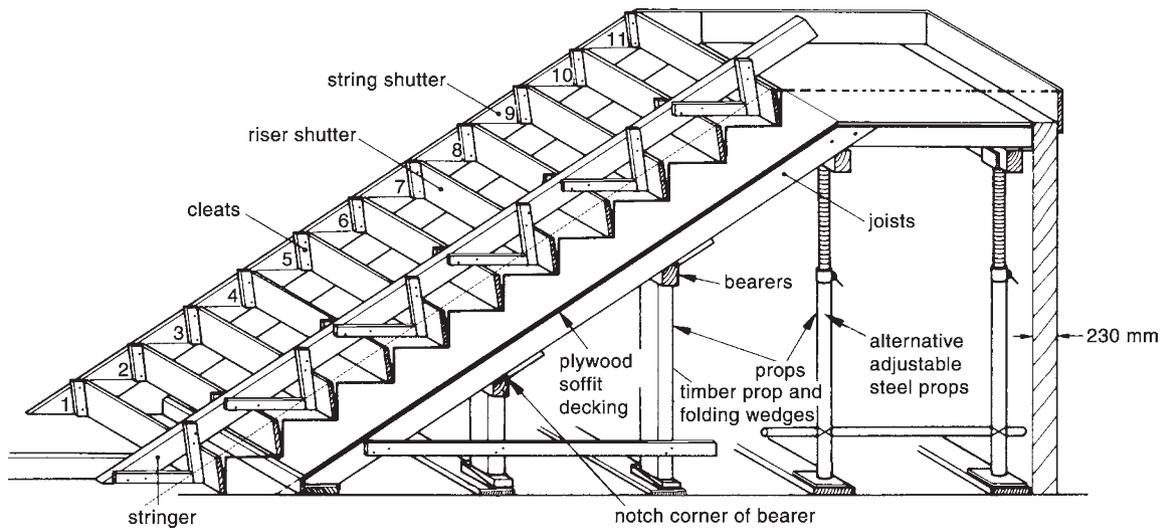
The soffit decking is supported by joists and bearers in combination with props of adjustable tubular steel or of timber on folding wedges.

Fig. 12.19 Formwork for suspended reinforced concrete slab: (a) traditional formwork for suspended slab; (b) formwork supporting suspended slab; and (c) suspended slab over formwork



Source: (a) Courtesy of Graybuilt Pty Ltd.

Fig. 12.20 Formwork for concrete stairs



Example

Figure 12.23 illustrates an example of a concrete stair. Assume that the rise of flight is 1910 mm and the going of flight is restricted to no more than 2630 mm. Calculate a suitable rise and going.

1. Approx. no. of risers = $1910/170$
 $= 11.23$
 Try 11 risers
2. Rise = $1910/11$
 $= 173.63$ mm rounded to 174

3. Going = $2630/10$
 $= 263$ mm

Check these dimensions in the formula:

$$2R + G = 585 \text{ to } 630$$

$$(2 \times 174) + 263 = 611$$

Therefore, the rise and going are satisfactory.

Fig. 12.21 Timber prop (stairs formwork)

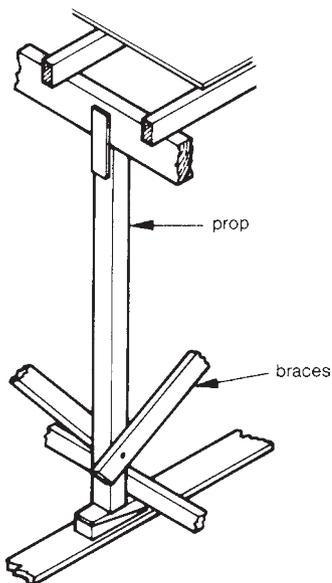
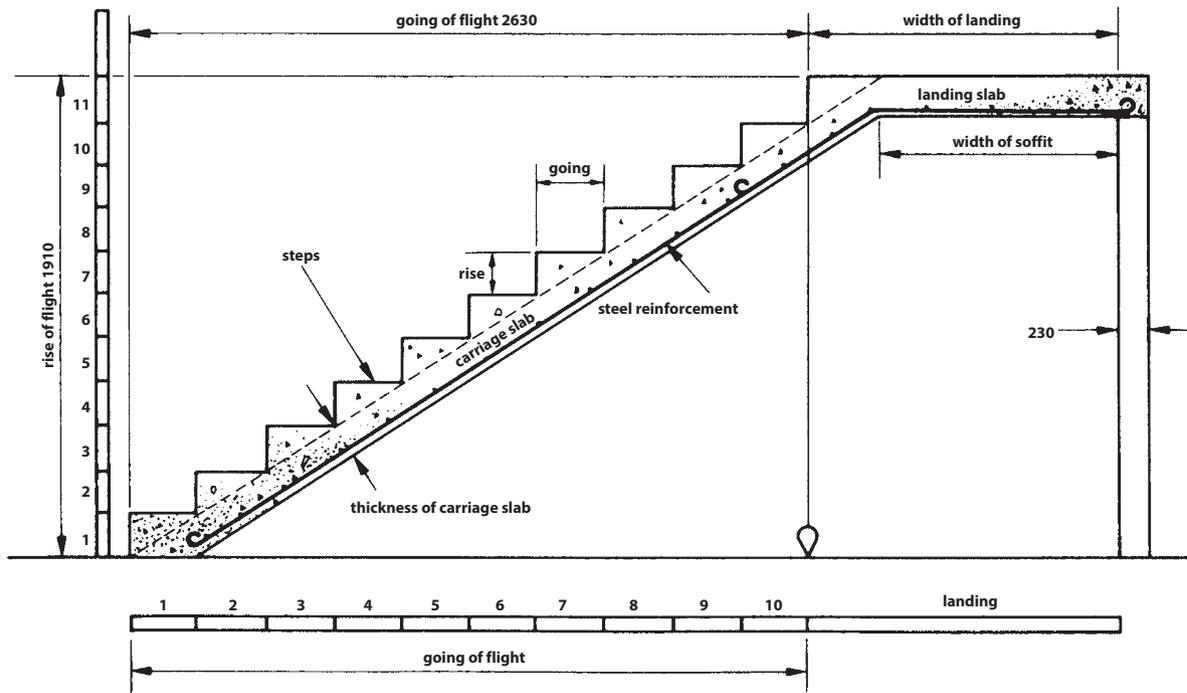


Fig. 12.22 Formed and poured concrete stairs



Source: Courtesy of Graybuilt Pty Ltd

Fig. 12.23 Concrete stairs

Carriage slab

The carriage slab is designed to support the mass of the stair and so it is important that it be made to its correct thickness. No encroachments into this thickness are allowed by undercutting the risers or by a riser shutter that is too wide. The carriage slab is reinforced with steel which must be accurately placed in accordance with the engineer's drawings before the riser **shutters** are finally fixed in position.

the width of the landing slab (x) and the run-out point (y) for the soffit decking, can be measured.

The completed formwork is seen in Figure 12.20. Note how the stringer is placed over the risers and brackets. Alternatively, blocks are fixed to prevent the shutters bulging in the centre. The stringer must then be made rigid by strutting back to a fixed point. The soffit decking is made wider than the stair to permit the string shutters to be fixed and braced back on the outside (Fig. 12.25).

Setting out the string shutter

1. From the bottom of the string shutter, gauge a distance equal to the thickness of the carriage slab.
2. Lay the steel square on the shutter; from the line gauged for the top of the carriage slab, set off the going along the blade and the rise along the tongue. Fix the fence along the bottom edge of the shutter to this setting.
3. Commencing from rise 1 at floor level, set off accurately the number of risers (11 in this example). The last rise will establish the landing level.
4. It is common practice to add a splayed front to the face of the risers—a maximum of 25 mm is permitted. This can be treated in the same way as a nosing and, of course, the same splay must be made to each riser. From the face of the riser, allow for the thickness of the riser shutter and fix cleats to support the shutter (see rise 9, Fig. 12.24).
5. Set out the second string shutter by turning the steel square over and repeating the procedure to form a pair of shutters.
6. From the full-size set-out of the string, other useful dimensions can be measured off. For example, the distances shown as x and y , which will help to establish

Finish to the stair treads

After the structural concrete has been poured and cured, the stair treads can be finished off in a variety of ways. A common finish is cement render, approximately 15 mm thick. It is finished to a non-slip surface, sometimes by the addition of a coarse carborundum grit sprinkled in strips along the stair treads.

The important point to note is that the same thickness of topping must be applied to all treads and landings if the rise in all cases is to remain constant.

The situation can arise where a different thickness of finish is to be applied to the treads than to the landings; if the correct rise is to be maintained to the finished surface, some modification to the structural concrete is called for. Any error caused by a failure to do so usually occurs at the first and last rise.

To think up an extreme and perhaps unlikely example, suppose the top and bottom landings to a stairway are to be finished with stone paving to a total thickness of 50 mm, whereas the stair treads are to be cement, rendered to a thickness of 15 mm.

Fig. 12.24 Set-out of the string shutter

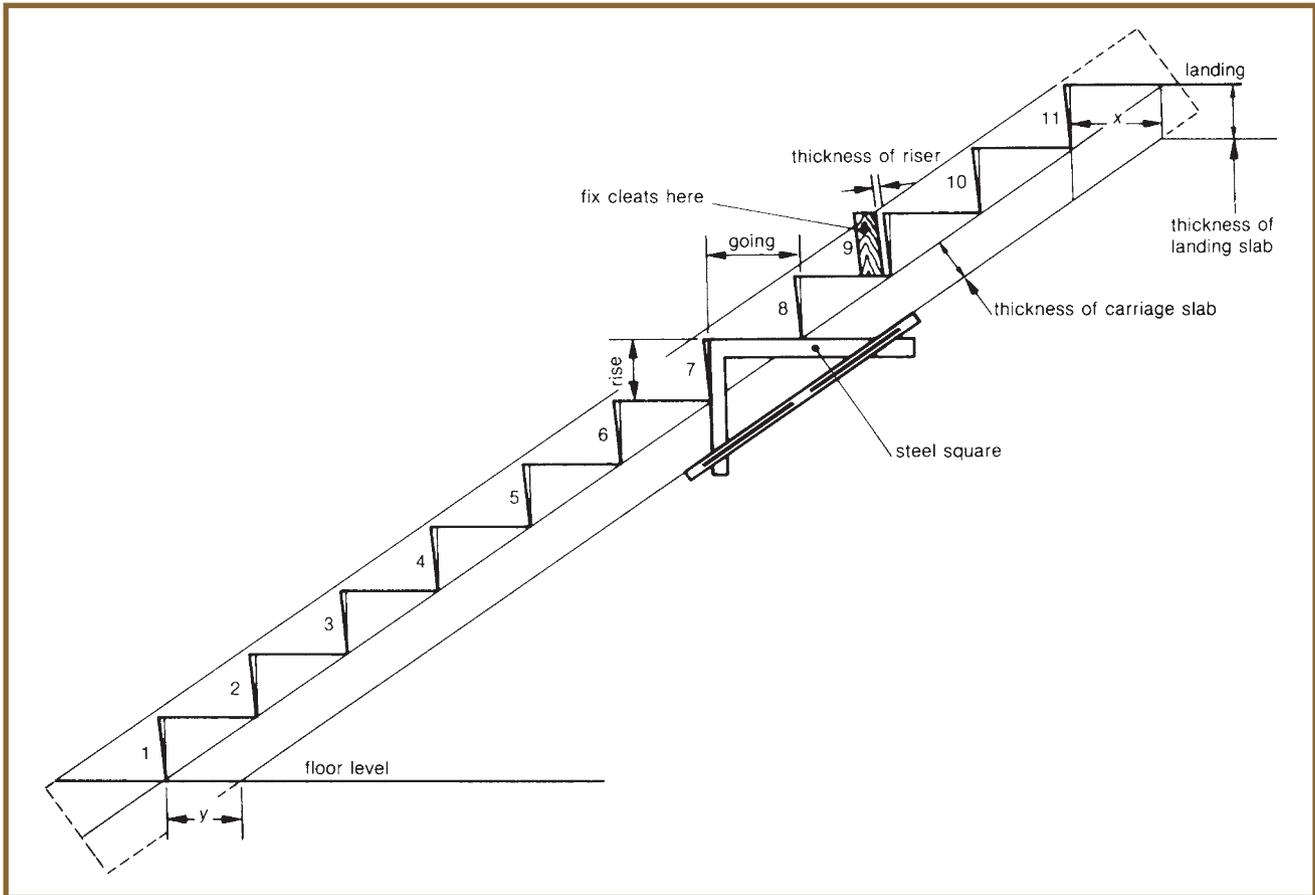


Fig. 12.25 Bracing the string shutter

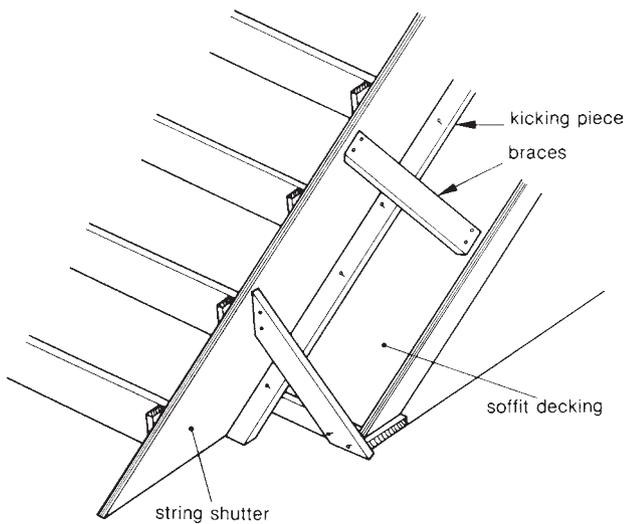


Figure 12.26 shows a vertical section through the first and last risers. Note how the thickness of the finish is shown on the storey rod and the rise of flight is between the finished surfaces.

The adjustment of the set-out of the string shutter is illustrated in Figure 12.27 and described below. First set off

the required number of rises, and if specified, add the splayed face; carry this out in a similar manner as previously described up to step 4 in the procedure for setting out the string shutter.

At rise 1, add the thickness of topping to the tread. From this point, measure down the rise plus the thickness of the stone paving. This will establish the rise of the structural concrete and the line at which the shutter will be cut to length. At the last rise (rise 11 in this example), add the thickness of the topping to the last tread. From this point, measure up the rise and deduct the thickness of stone paving to establish the level of the structural concrete to the landing. Fix cleats to support the riser shutters.

Ramps

Access ramps may be formed in the same way as a suspended concrete slab or carriage slab for stairs with a sloping soffit, but there are standards to be applied from AS 1428 Design for access and mobility regarding the slope angle and dimensions of ramps. The following notes apply to a concrete structure forming a ramp. For details on handrails and supporting posts and any other details for design for access and mobility, please refer to AS 1428, Part 1: General requirements for access—New building work.

Ramps must meet the following requirements:

- Ramps more than 1900 mm long must have a maximum gradient of 1:14.

Fig. 12.26 Finishes to treads and landings

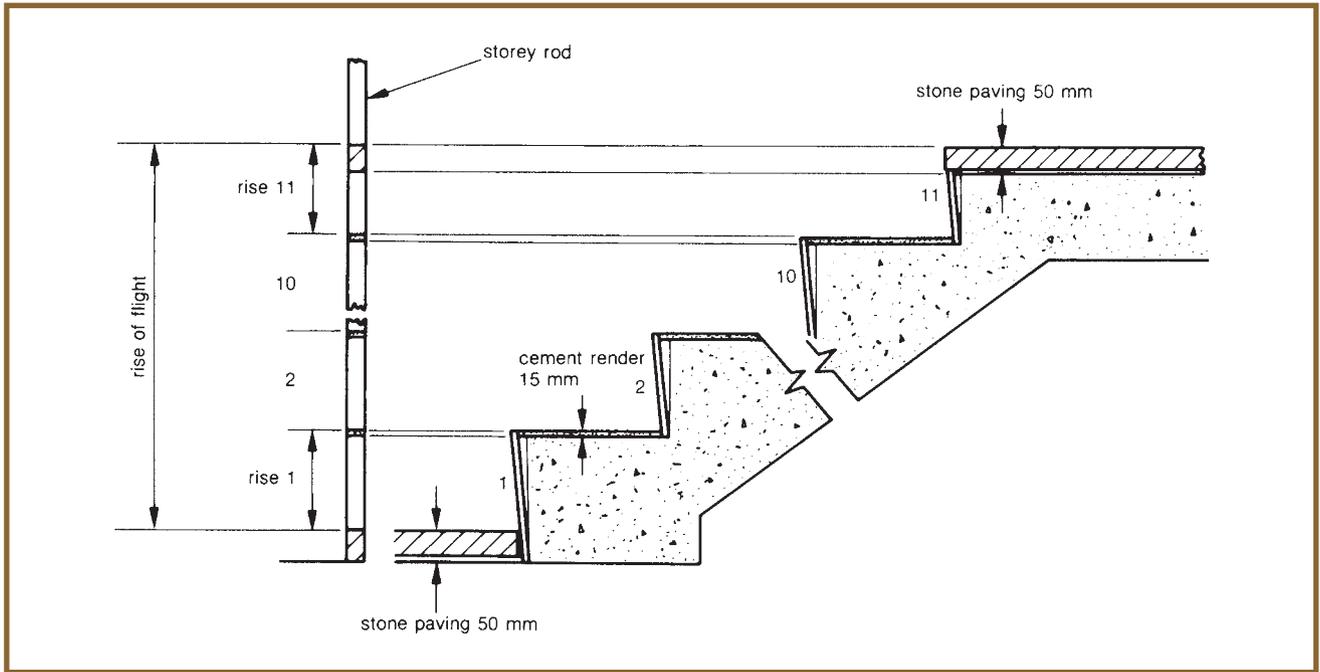
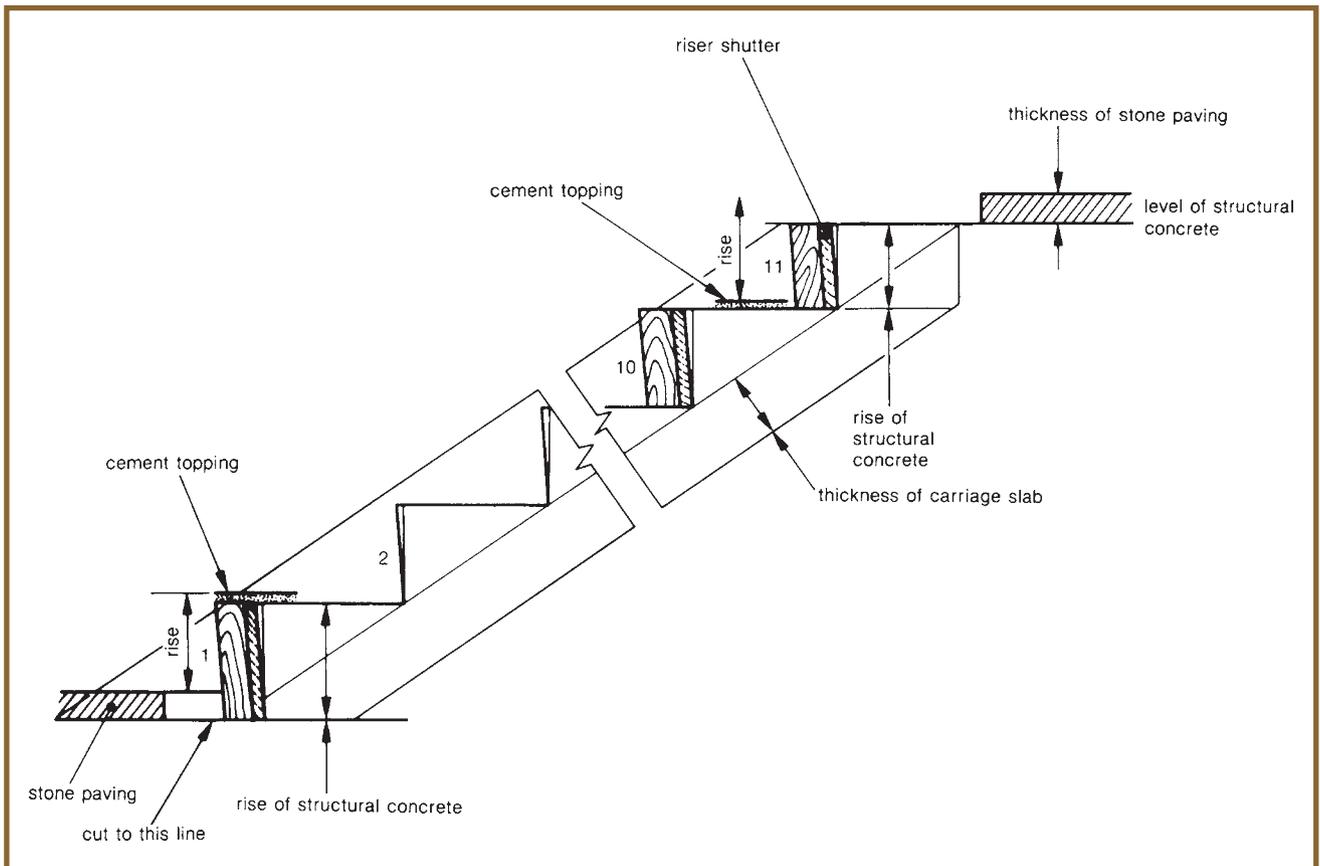


Fig. 12.27 Adjustment of the string shutter



- No section can be steeper than 1:14 and gradients must be constant with a maximum tolerance of 3 per cent.
- Landings must be incorporated at the bottom and top of a ramp with distances between landings not exceeding:
 - 9 m—1:14 grade
 - 15 m—1:20 grade
 Grades between 1:14 and 1:20—intervals are interpolated.
- The angle of approach must be at 90° to the landing for the last 600 mm of the ramp length.
- Ramp handrails on both sides must be between 865–1000 mm above the trafficable surface including transitions and must extend 300 mm into thresholds and landings (except where an inner handrail is continuous), finishing with a 180° bend.
- Ramps must be set back at least 900 mm from property boundaries where a ramp enters a public walkway/thoroughfare so that the handrail and tactile ground surface indicators (TGSIs) don't extend into the thoroughfare.
- Ramps must be set back at least 400 mm from the point where a ramp enters other walkways/thoroughfares so that the handrail doesn't extend into the thoroughfare.

Where ramps include a concrete kerb wall, the following points apply:

- The kerb must be between 65 mm and 75 mm minimum above the finished floor level.
- The kerb must not finish between 75 mm and 150 mm above the finished floor level.
- If the kerb wall finishes at a height greater than 150 mm, there can be no slots or gaps greater than 20 mm in the distance 75 mm to 150 mm above the finished floor.

Threshold ramps

Threshold ramps at doorways that connect with a ramp:

- maximum rise of 35 mm
- maximum length of 280 mm
- maximum gradient of 1:8
- must be located within 20 mm of the door leaf which it serves.

The edges of a threshold ramp are tapered or splayed at a minimum of 45° where the ramp isn't against a wall.

Formwork for a concrete wall

Wall sheeting can be made up in sections of random boards or plywood panels fixed to vertical studs. Horizontal walings are fixed behind the studs and the two sides of the formwork are clamped together at the correct spacing, with some form of wall tie.

Walings can be single, but the double waling, as shown in Figure 12.31, then is a common arrangement. Tie bolts pass between the walings, which are not damaged and can be reused many times. The formwork must be plumbed and stabilised by bracing; in this example, raking struts and a firm sole plate have been used. Adjustable tubular props can also be used as a brace as they are quickly erected and easily adjusted.

The pressure of the liquid concrete acting on the wall formwork is very similar to the column situation. It will tend to force the forms apart, lift the formwork and escape from the

Fig. 12.28 Straight ramp with no change in direction

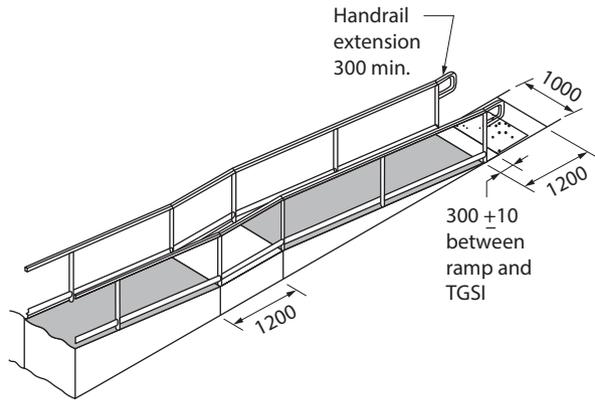


Fig. 12.29 Ramp with 90° return and an internal landing

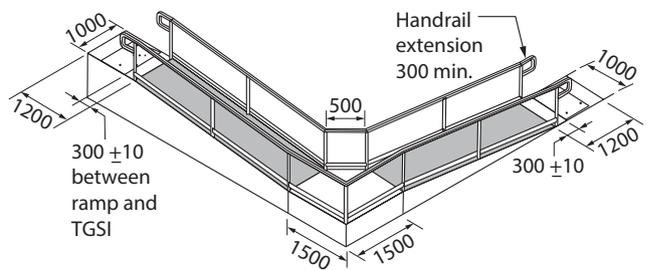
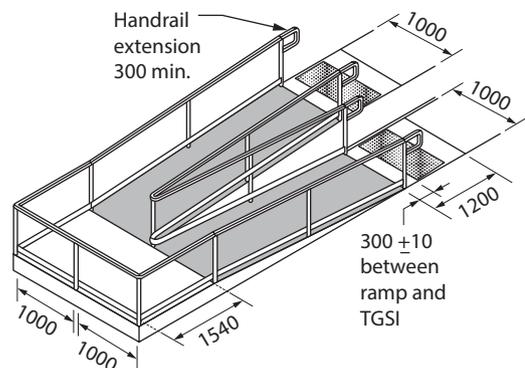


Fig. 12.30 Ramp with landing and 180° return



bottom. It would be wise to think ahead and cast some anchorage points into the footing concrete. The bottom waling can be bolted to the formwork and anchored down to the coil loops provided.

To erect wall formwork, one side is stood in position, plumbed and braced. Steel reinforcement is then placed, and form ties are secured, usually by passing the tie bolts through the formwork. The second side is then erected and form ties are secured by passing tie bolts through the formwork. Check the formwork for plumb and complete bracing.

Form spacers

Form spacers are used to maintain the exact distances between forms or between forms and steelwork. Figure 12.32 shows a type of spacer made from galvanised steel. Spikes enable firm fixing to form timbers and they can be obtained in lengths from 25 mm to 450 mm.

Fig. 12.31 Wall formwork

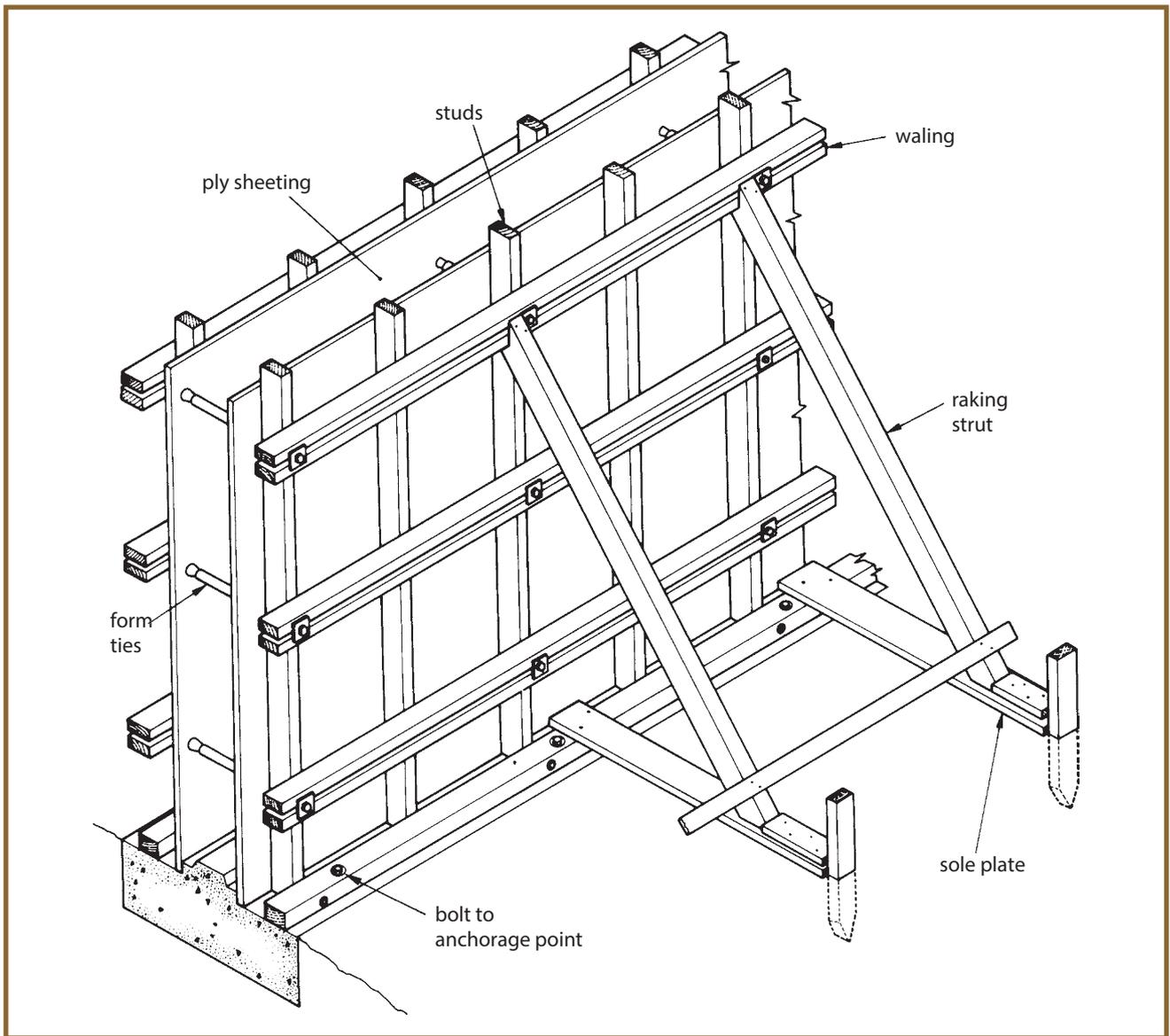


Fig. 12.32 Form spacers

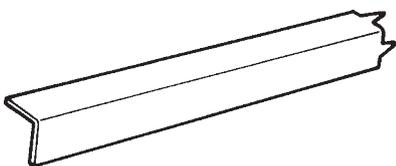
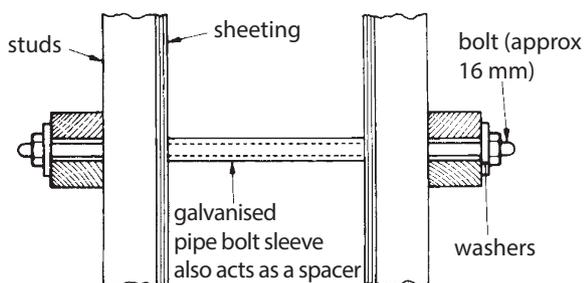


Fig. 12.33 Wall tie (pipe spacer)



Form ties

Form ties are used to tie concrete forms together in walls and beams so that they can resist the pressure of liquid concrete, which otherwise would tend to burst them apart. A tie rod with a galvanised pipe bolt sleeve, which also acts as a spacer, is a simple arrangement. Alternatively, a plastic tube with a separate spacer could be adapted.

The disadvantage is that the pipe spacer remains in the concrete and in many situations this may not be permitted. Besides the objectionable blemish made to the face of the concrete, the pipe spacer will in time corrode; it will also be a likely source of moisture which will penetrate the concrete and corrode the steel reinforcement. A number of different wall tie systems are manufactured, many incorporating a plastic cone which can be removed from the concrete; and the face can be sealed to prevent the entry of corrosive elements.

Snap ties

Snap ties are prefabricated from high carbon wire and act both as ties and spacers (Fig. 12.34). They are quick and easy to apply using a fast assembly wedge. After formwork is removed the ties can be snapped off inside the concrete.

Coil ties

Coil ties are a system of form ties that provide strength, safety and speed. They can be obtained in a large range of sizes to meet the most complex situations.

Fig. 12.34 Snap tie

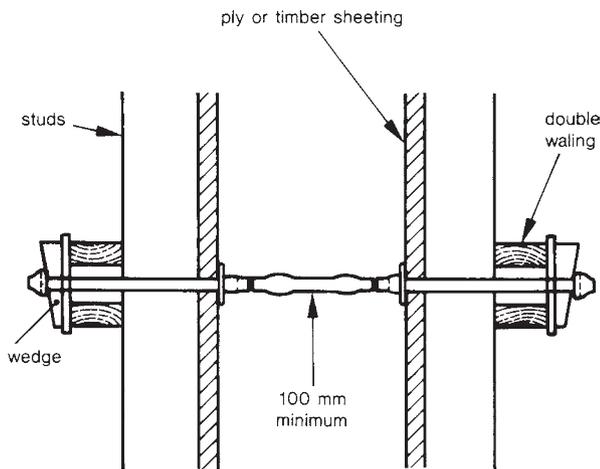
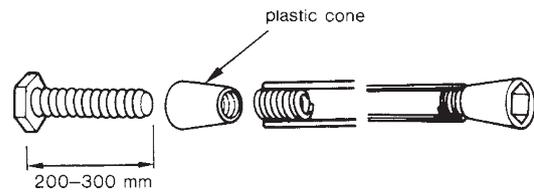


Fig. 12.35 Coil tie



Student research

- With reference to stair construction, define the following terms:
 - rise of flight
 - going
 - stair string
 - tread
 - newel
 - balustrade
- State a formula commonly adopted for calculating a suitable rise and going for a stair.
- Investigate the licensing requirements for formwork installers for each state and territory. Do any still require a formwork licence or 'ticket'?

Composite sheet building materials

Composite sheet building materials are highly processed natural materials. These include:

- composite boards
- plywoods—shuttering, standard, marine and laminated plywood variations
- chipboard and particleboards
- medium-density fibreboard (MDF)
- cement and wood fibre boards
- resins and VOCs
- mineral wools
- vermiculite and perlite
- plastics—PVC, foamed plastics, foamed sheets and elastomers.

Composite sheet products are high-embodied energy materials; however, they use low-grade or raw waste materials. Available in numerous varieties, sizes and thicknesses, they can be fitted to suit a project's requirements with minimal waste, which is one of their great advantages.

Solid masonry

LEARNING OBJECTIVES

- 13.1** Reinforced and unreinforced concrete masonry for residential construction
- 13.2** Aerated autoclaved concrete (AAC) masonry for residential construction
- 13.3** Reinforced concrete masonry retaining walls and basement walls
- 13.4** External coating systems for solid masonry

In Chapter 14 Full Masonry in Volume 1, the majority of discussion was on cavity wall construction with a brief description of solid masonry. The major difference between the two is the use of two separate walls to form a cavity as a barrier to moisture and dampness. Solid masonry construction is **single leaf construction** using a range of products including bricks, natural stone, compressed earth blocks, concrete masonry and aerated autoclaved concrete (AAC).

Concrete masonry has been a feature of construction in Australia since the 1800s, becoming very popular in the 1960s and increasingly used in commercial and medium to high density residential construction in recent years. In this chapter, single leaf concrete masonry and AAC are reviewed and discussed.

Concrete masonry blocks

Concrete masonry is manufactured by placing concrete into steel forms or moulds. The concrete is vibrated and then, after partial setting, the resulting '**green**' blocks are cured in heated chambers for 18–24 hours. This method of manufacturing results in very accurate dimensioning and allows a range of different shapes and types of concrete blocks to be manufactured. This is particularly important for remote areas of Australia as the materials are readily sourced and the blocks can be manufactured comparatively close to those areas where they are required.

Coding of masonry units

The majority of concrete masonry units produced in Australia are identified under a national metric coding system established by the Concrete Masonry Association of Australia (CMAA). This system standardises the dimensional descriptions of masonry units.

Each block is given a code number based on its wall thickness, indicated by the prefix, and unit type and configuration, indicated by the suffix (Fig. 13.1a). For example, the block suffix numbers for 190 mm high, hollow and solid blocks of various lengths are shown in Table 13.1. The dimensions of standard 190 mm high hollow blocks and their related code number is shown in Figure 13.1(b), with the related block series number shown in Table 13.2.

Each series has a range of block lengths, as shown in Figure 13.1(c), which illustrates blocks and their code numbers from the 200 series.

Table 13.1 Block suffix numbers

Block height (mm)	Block type	Block length			
		Full block (390 mm)	$\frac{3}{4}$ block (290 mm)	$\frac{1}{2}$ block (190 mm)	$\frac{1}{4}$ block (90 mm)
190	Hollow	01	02	03	04
190	Solid	31	32	33	34

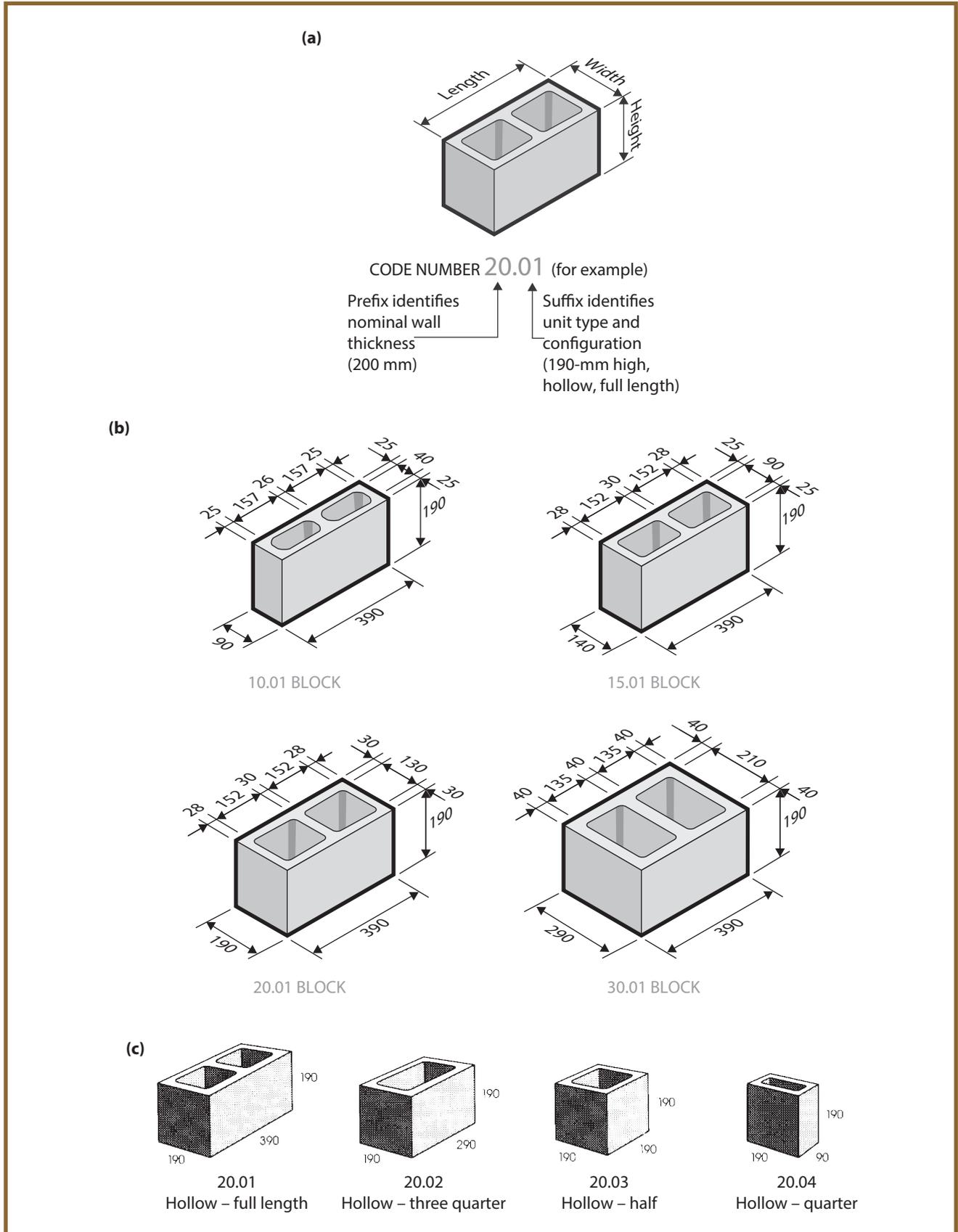
Source: CMAA, September 2000. *Data Sheet 1: National Metric Coding System*, www.cmaa.com.au

Table 13.2 Block series and prefix numbers

Block width (mm)	Block series	Number
90	100	10
140	150	15
190	200	20
290	300	30

Source: CMAA, September 2000. *Data Sheet 1: National Metric Coding System*, www.cmaa.com.au

Fig. 13.1 Coding of concrete masonry units: (a) width, height, length and type; (b) dimensions of standard hollow blocks; and (c) example of coding for different sizes in hollow blocks with 200 Series

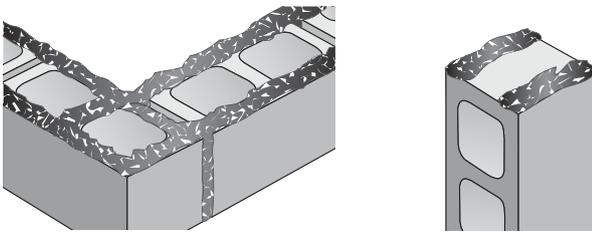


Mortar

The mortar used to lay concrete masonry should be free of clay. Bush sands high in clay content must not be used because it will result in shrinkage, cracking of the mortar and the potential release of salt, causing efflorescence.

Standard mortars for concrete masonry are M3 and M4, with water thickener or lime as a workability agent and to increase bond strength. A typical mix to produce M3 mortar is five parts of sand to one part cement plus methylcellulose water thickener or equivalent. (Refer to Chapter 14 Full Masonry in Volume 1 for more details.) If an additional workability agent is required, lime or a waterproofing additive is recommended rather than an air-entraining plasticiser. This applies to both 'face work' in concrete masonry and concrete masonry that is to be rendered.

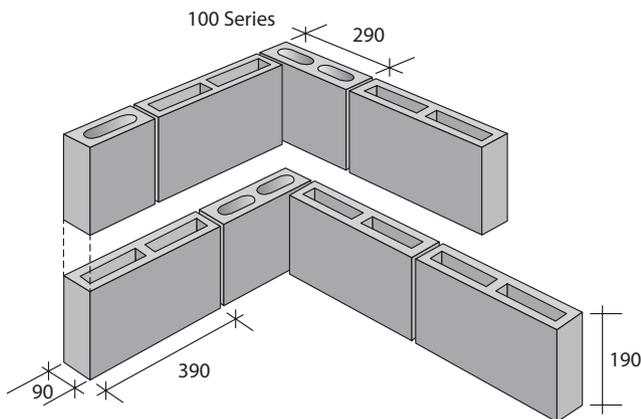
Fig. 13.2 Shell bedding of hollow core blocks



Bonding

Concrete masonry hollow blocks are designed to be laid with a half bond or lap. Specially shaped corner blocks, 1/4, 3/4 and special length blocks are laid at the corner to form half bond or stretcher bond.

Fig. 13.3 Bonding of return corners



Single leaf concrete masonry construction

Concrete masonry block construction is commonly used for the external and internal walls for residential construction in the northern regions of Australia and is used extensively throughout Australia in commercial and medium-density and high-density residential construction. Concrete masonry is also increasingly used in custom built homes where it may be finished with a rendered or textured finish or as high quality masonry with a variety of face finishes.

Despite being single leaf construction, standard building principles apply:

- Wind loads must be considered when designing the wall system.
- Walls must prevent the entry of moisture and dampness.
- Termite control systems must be considered and implemented.
- Footing or slab design is determined by site classification.
- Masonry may require articulation.
- Window and door installation must be detailed to prevent entry of moisture.
- External walls are load-bearing for a trussed or conventional roof.
- Roofing and roof framing must be tied down.

Two construction methods commonly apply: (a) unreinforced; and (b) reinforced concrete masonry (Fig. 13.4).

Unreinforced concrete masonry

Hollow or solid concrete masonry blocks are laid with horizontal joint reinforcement to prevent shrinkage cracking. The blocks are not core-filled. This type of concrete masonry is more commonly used as infill blockwork between reinforced concrete or structural steel framing, as non-load bearing partition walls, for non-load-bearing boundary walls that incorporate decorative concrete masonry blocks and in masonry veneer construction. Joint reinforcement may be done with 3 mm wires embedded in every second bed joint as a way of minimising shrinkage and cracking, while control joints will be required at up to 6 m spacings.

Reinforced concrete masonry

Reinforced concrete masonry is commonly used in basement structures and in retaining walls where all cores are filled and substantial vertical and horizontal steel reinforcement is used to form a reinforced concrete structural wall. It consists of hollow concrete blocks constructed with horizontal and vertical reinforcement placed at required spacings, such as every second course and every block, 400 mm vertically and 400 mm horizontally. The concrete masonry blocks are core-filled with a low slump concrete grout (i.e. a 230–250 mm). This results in a solid reinforced concrete structure.

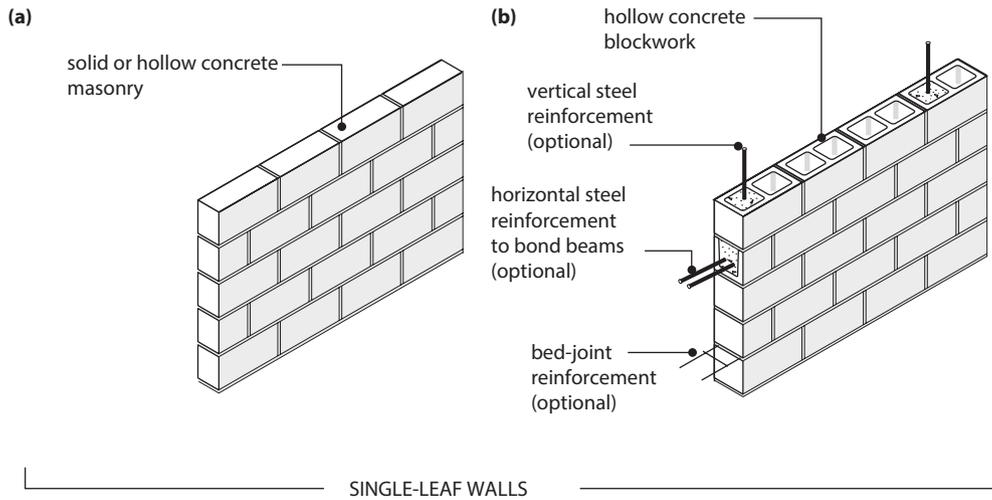
Reinforced concrete masonry may also include partial core-filling to form a structural framework or a grid around sections of unreinforced hollow blocks. Vertical cores are filled at corners and other locations, such as the reveal blocks, and horizontal bond beams are placed at specified spacings—generally at the last course of blocks to support roof framing, under windows greater than 1500 mm in width and at floor levels.

Control joints in reinforced masonry normally are not continuous through a bond beam. According to AS 4773.2 Masonry in small buildings, articulation joints are not required in reinforced masonry providing it is designed in accordance with section 12 of the standard.

Suspended floor construction

For a suspended floor construction, either standard bearer and joist construction or a suspended concrete floor system may be used. **Starter bars** are tied into the reinforcing steel at

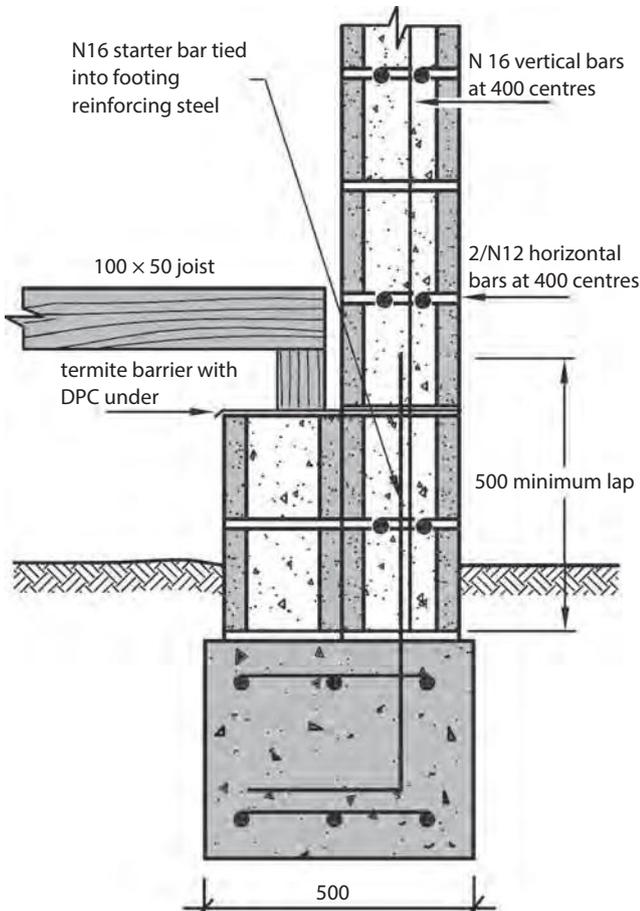
Fig. 13.4 (a) Unreinforced and (b) reinforced single-leaf concrete masonry



Source: Courtesy of Concrete Masonry Association of Australia

centres that coincide with cores that are to be filled with grout (Fig. 13.5). They normally extend from 600–1000 mm above the footing and must be capped to prevent injury. Any termite control barrier or damp proof course (DPC) that is penetrated by starter bars must be sufficiently sealed to prevent termites from entering any adjacent hollow cores. All grout must be properly vibrated or rodded to ensure there are no voids around the vertical starter bars that would allow entry by termites.

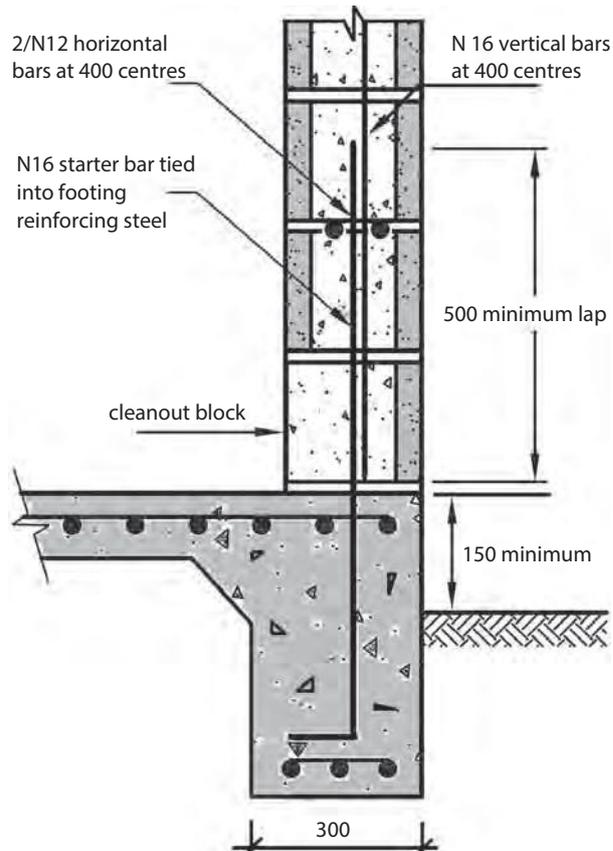
Fig. 13.5 Subfloor masonry



Slab-on-ground construction

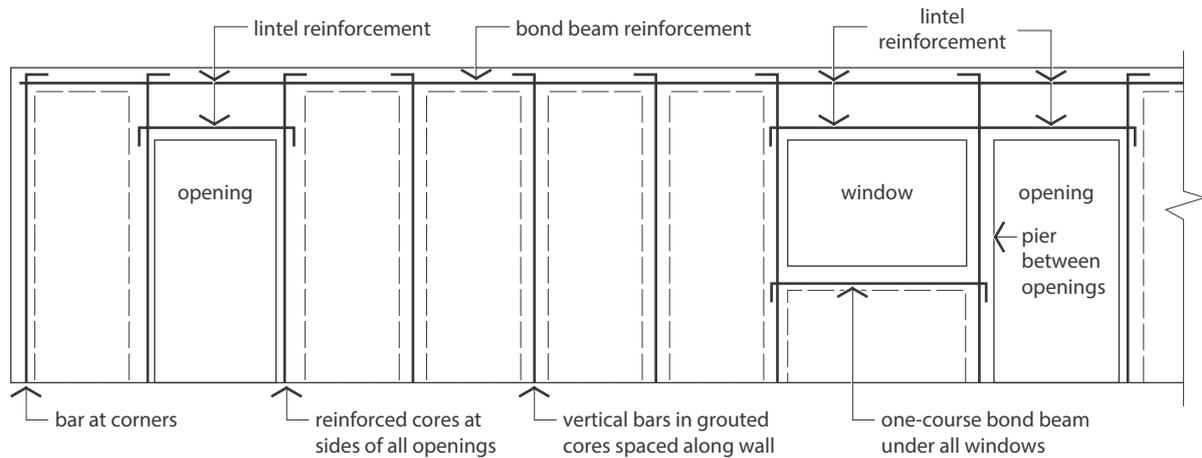
Slab-on-ground construction (Fig. 13.6) and waffle slab construction offer a combined concrete floor and reinforced concrete, edge beam footing system. Internal walls may be load-bearing or non-load-bearing.

Fig. 13.6 Slab-on-ground footing system (starter bars)

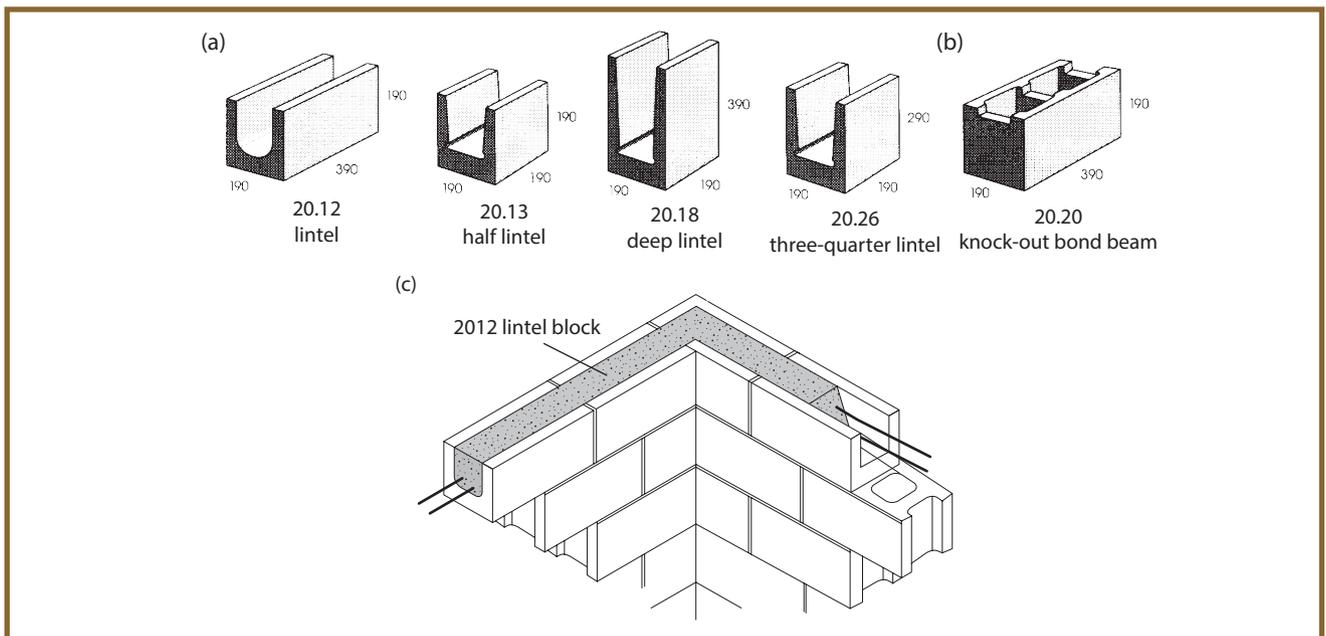


Bond beams and lintels

As the blockwork is constructed, it is core-filled at door and window reveals and at corners. Other cores are also filled, subject to design for wind loading. The vertically filled cores

Fig. 13.7 Typical wall elevation indicating location of core-filling and bond beams

Source: Courtesy of Concrete Masonry Association of Australia

Fig. 13.8 (a) Lintel blocks; (b) a bond beam block (series 200); and (c) a single course bond beam return corner

Source: (a) and (b) Courtesy of Concrete Masonry Association of Australia

are tied to a **bond beam** at the top of the wall and those located under openings greater than 1500 mm. A bond beam may also be located on the first course (Fig. 13.7).

Reinforced concrete masonry lintels are formed over window and door openings to span the openings. They may be laid on temporary beams supported at each end until the concrete has set sufficiently for the temporary support to be removed—normally seven days. Lintel blocks with a ‘U’ shape which have a full base are used. They may be core-filled as work progresses or as all core-filling is carried out.

Doors and windows may be installed as work progresses, but it is recommended to fit them after the blockwork is completed. This allows the external coating to be applied under door and window frames and provides an improved substrate for sealants at openings.

Lintels over openings

Depending on the span of the opening and the loads supported, different sized reinforced concrete lintels are formed (Fig. 13.9).

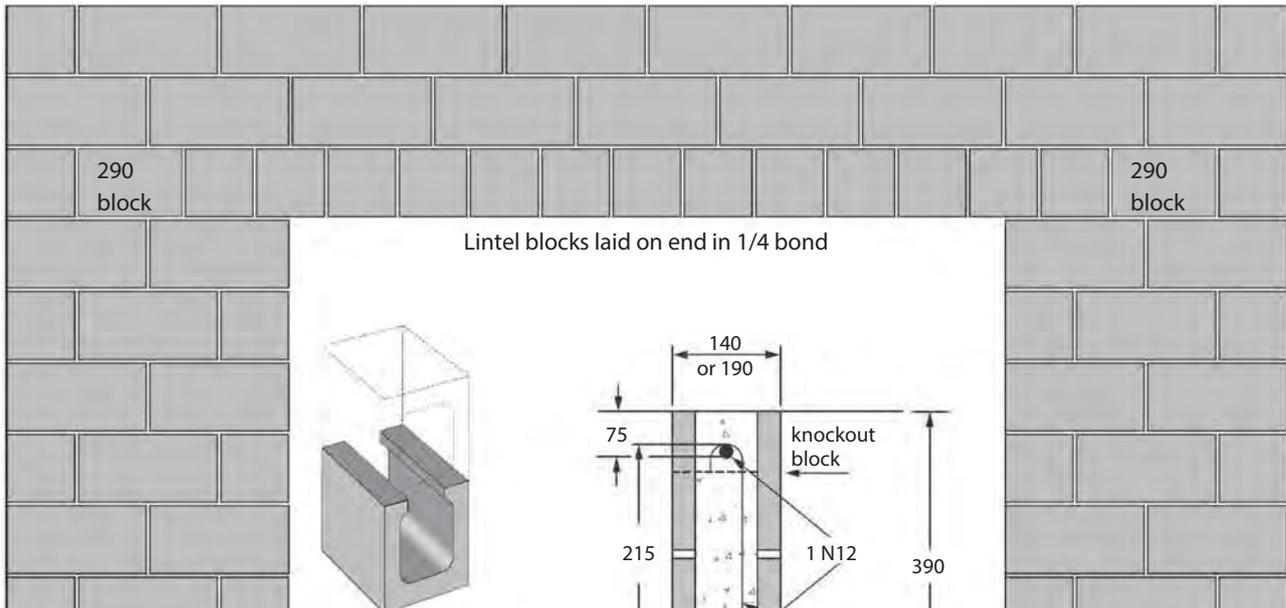
Connecting and tying down roof framing

Threaded steel rods embedded in the bond beam formed at the top of the wall may be used to tie down a top plate to which the roof framing is fastened.

Reinforced concrete masonry retaining walls

A typical arrangement for a reinforced basement wall or for a retaining wall comprises:

- series 200 retaining wall blocks with cleanout blocks at each starter bar
- a single N16 bar or two N12 bars laid horizontally every second course of blocks

Fig. 13.9 Lintels over openings: (a) elevation; and (b) section detail

- vertical N16 bars at 400 mm minimum spacings—1 per block
- maximum height for core-filling between 1500—2000 mm or temporary shoring must be installed.

Retaining walls must be constructed with either 'H' or 'double U'-shaped wall blocks to ensure that the wall is properly core-filled and free of voids (Fig. 13.12b).

Core-filling

- As the wall is constructed, the hollow core of all blocks must be regularly cleaned to ensure that the grout or core-fill will flow down from the point where the grout is pumped into the wall.
- Special cleanout blocks must be laid at all starter bars to facilitate regular cleaning of the cores.
- The vertical reinforcement is placed in position for the full height of the wall resulting in a 600–1000 mm lap of the starter bar.
- Before the core-filling commences, all cores must be clean to ensure a clean tight connection with the footing.
- Cleaned-out openings must be covered with formwork to hold the grout in place as the wall is filled.
- The blocks should be thoroughly wet down on the inside with a hose to prevent the grout from drying

and building up enough to block the cores from being properly filled.

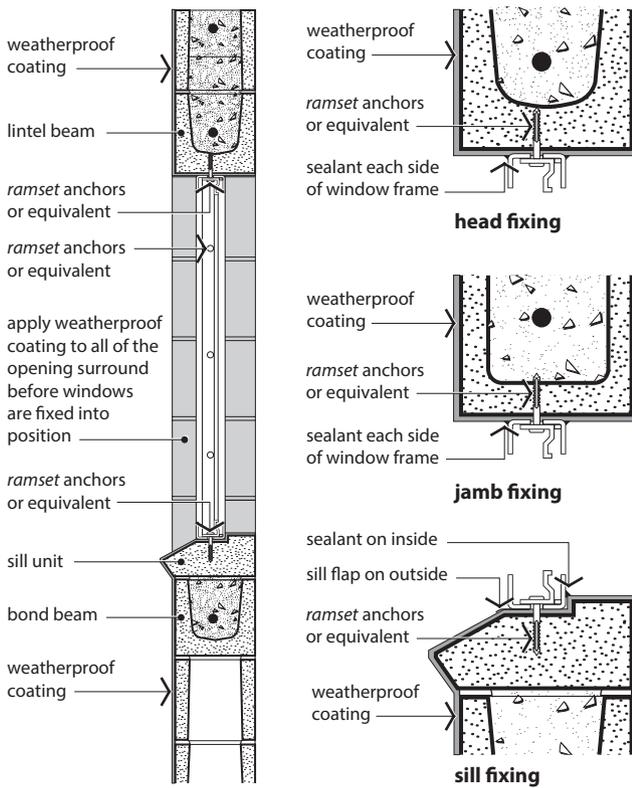
- As the grout is poured, it can be vibrated by applying the vibrator into the cores from the top and tamping and rodding the grout with a vertical reinforcing bar and applying the vibrator to a piece of timber or ply held against the blockwork to prevent damage to it.
- The grout should be placed in layers, ensuring that all cores are filled from the bottom.
- Special attention must be given to cores located at corners due to the overlapping of horizontal reinforcing steel.
- Temporary propping for lintels must remain in place for seven days to ensure lintels do not sag or drop.

Window and door installation

Refer to Figure 13.10.

1. Weatherproof all external walls, including window reveals, before the windows are fixed.
2. Fix windows with Ramset ED642 anchors, or equivalent. Before the anchor is inserted, the hole should be filled with sealant.
3. Seal the whole perimeter of the window frame on the inside and the jamb and head sections on the outside with Sikaflex 15LM or equivalent.
4. Fix and seal door frames as set out for windows, but use Ramset ED655 anchors or equivalent.

Fig. 13.10 Window installation details



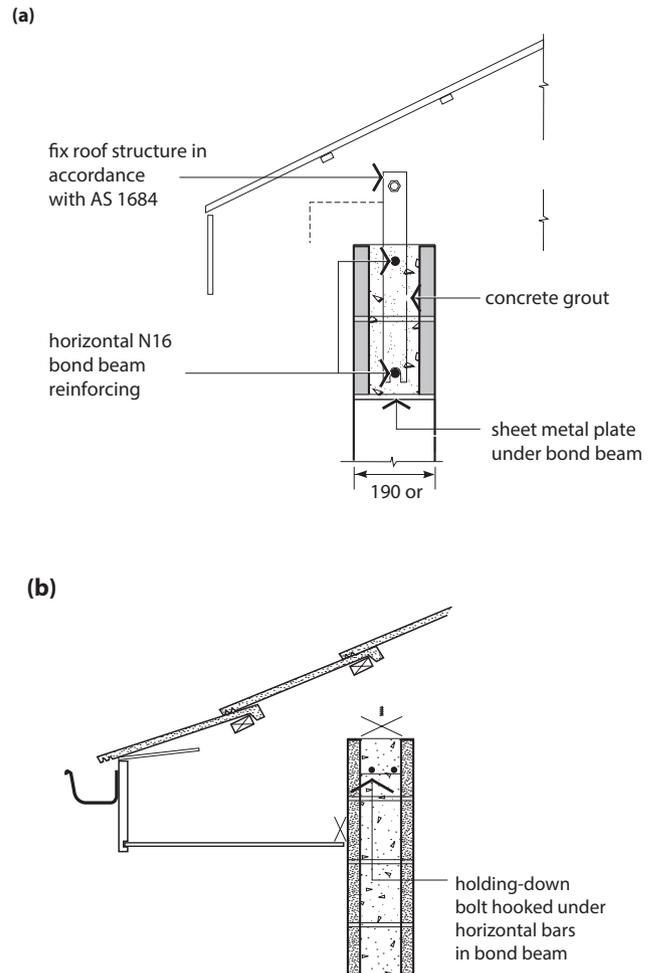
Source: (a) and (b) Courtesy of Concrete Masonry Association of Australia

Estimating quantities of materials

As for other masonry wall systems, the area of the walling is calculated including openings. Openings are then deducted to provide the actual square metres of masonry. The following information and amounts are then applied:

- Allow 12.5 blocks per square metre for blocks with nominal dimensions 400 mm long × 200 mm in height, which includes mortar joints.
- Allow 1 m³ of corefill per hundred 200 series retaining wall blocks and pro-rata amounts for 150 series (75% or 0.75 m³/100 blocks) and 300 series (150% or 1.5 m³/100 blocks)
- Total all special sizes and convert to standard blocks and deduct this amount from the total of blocks required. Add up to 10% for waste for specials; that is, one for every 10 maximum.
- All blocks including specials should be scheduled according to the block coding system.
- Allow 2.5% for waste on blocks.
- Allow 0.75 m³/1000 blocks for mortar using shell bedding—around the same as for standard bricks.
- Reinforcing steel should be totalled in lineal metres and then converted to tonnes.

Fig. 13.11 Tie down for roof framing: (a) cleat cast in place and fixed to rafter; (b) rafter fixed to top plate retained with a hold-down bolt



Source: (a) and (b) Courtesy of Concrete Masonry Association of Australia

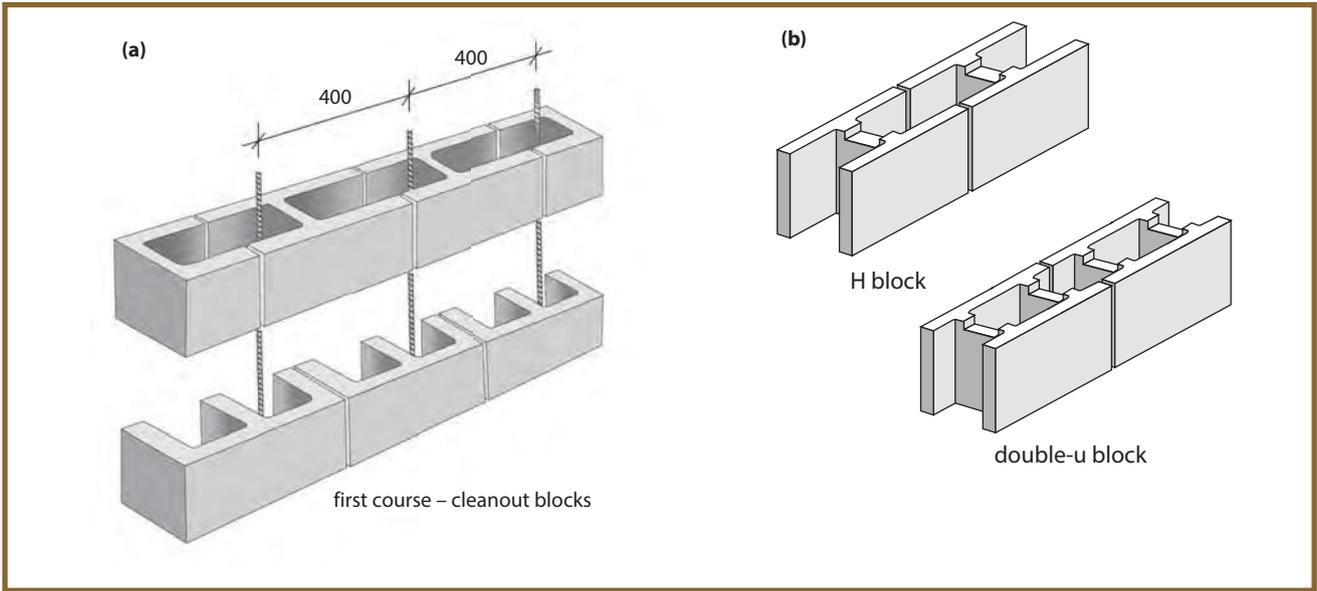
- Steel should be scheduled according to length, classification and by shape if it has been bent to a special size and shape.

Autoclaved aerated concrete (AAC) block construction

Lightweight concrete is increasing in popularity and is now a commonly used wall system for high rise apartment buildings. However, solid **autoclaved aerated concrete (AAC)** blockwork has been popular in residential construction in Australia since its introduction by Hebel in the late 1980s.

Solid masonry load-bearing walls constructed with AAC require attention to detail to ensure that the system is properly implemented. The blocks are laid with a 2–3 mm thin

Fig. 13.12 Retaining wall construction: (a) cleanout course detail; and (b) H and double-U retaining wall blocks



Source: (b) Courtesy of Concrete Masonry Association of Australia

Fig. 13.13 Section through a reinforced concrete masonry retaining wall

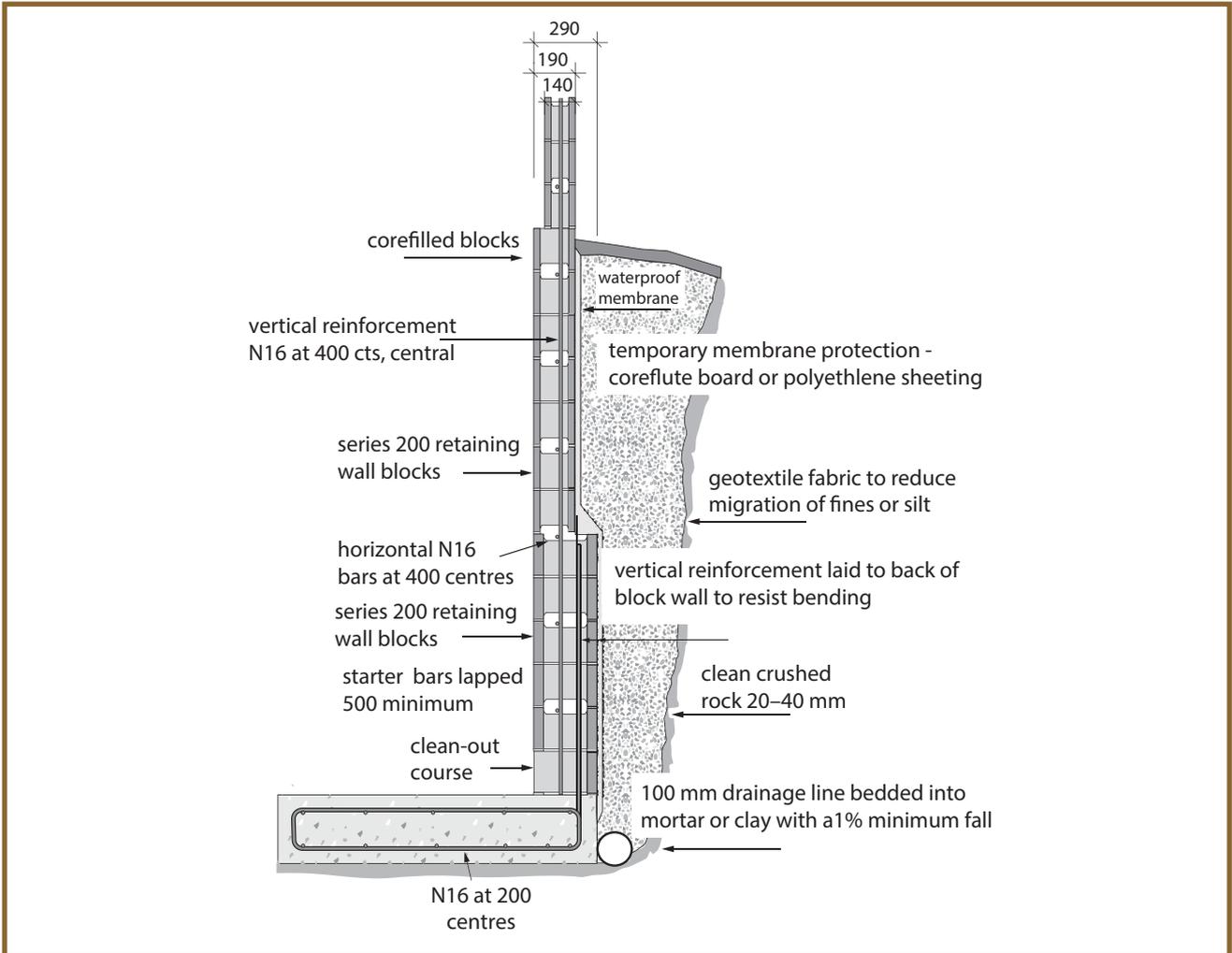


Fig. 13.14 Blockwork ready for core filling

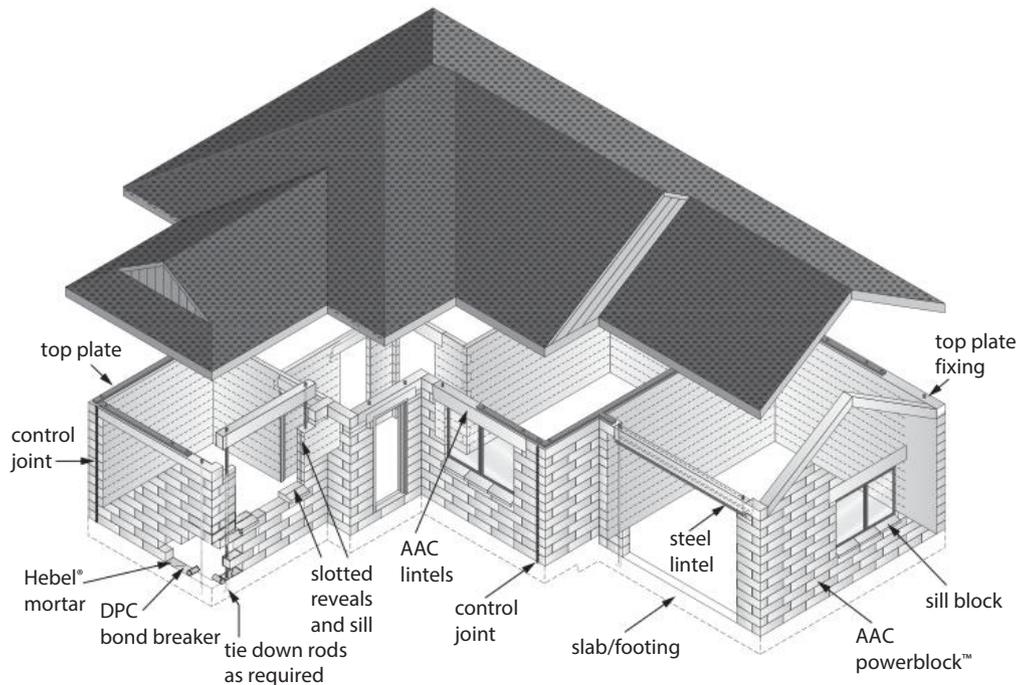


Source: iStockphoto

bed adhesive mortar as opposed to a cement mortar joint of 10 mm. The first course may be laid in cement mortar to obtain a perfectly level and straight wall. The blocks can be laid with

specialist tools and are easily cut with a tungsten carbide-tipped handsaw. They are normally bonded when laid with a minimum lap of 100 mm.

Fig. 13.15 Solid masonry residential construction using AAC blocks



Source: Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full..

Footings and subfloor details

The footing systems for AAC walling is normally specified by a structural engineer based on the site soil classification and the loads to be supported by the foundation.

The slab-on-ground footing system indicated in Figure 13.16 requires a DPC to be placed under the first course of blockwork while the exposed edge of the slab must be at least 75 mm above the ground for termite control. Physical and chemical termite barriers can also be placed under the first course of blockwork or around the perimeter of the slab and underneath the slab as for cavity wall or masonry veneer construction (see Chapter 13 Masonry Veneer Construction in Volume 1).

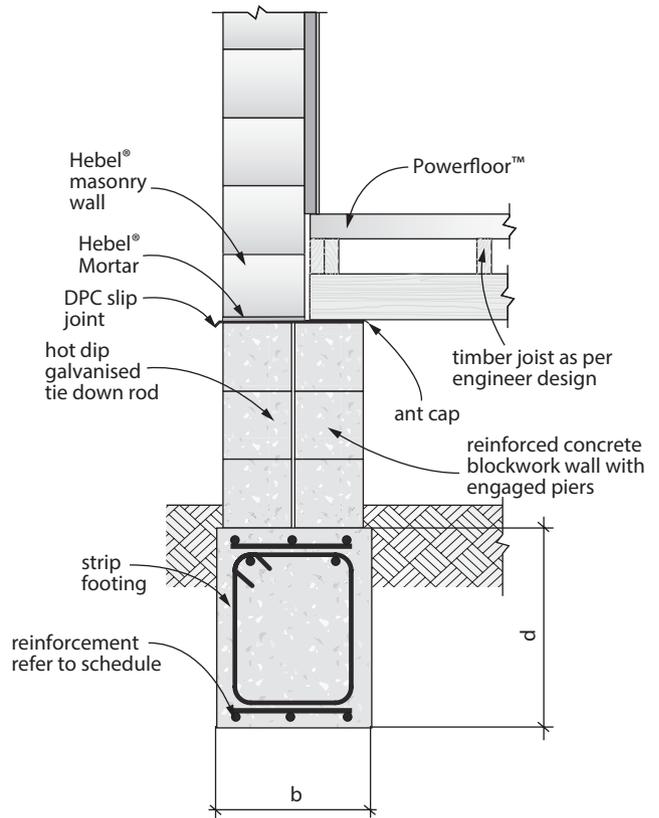
The strip footing system with a suspended floor supported by timber bearers and joists, as shown in Figure 13.17, requires a DPC course and termite barrier at bearer height. The DPC also creates a bond breaker between the AAC and the different materials built to bearer height.

Ventilation should also be installed as close as possible to the bearer height. This can be reasonably achieved with a wire mesh cement framed vent installed at spacings that provide ventilation up to 6000 mm²/m (see Chapter 13, Volume 1, Table 13.1 and Figure 13.9).

All masonry up to bearer height must be either exposure grade clay bricks or concrete masonry. AAC masonry cannot be laid in contact with the ground.

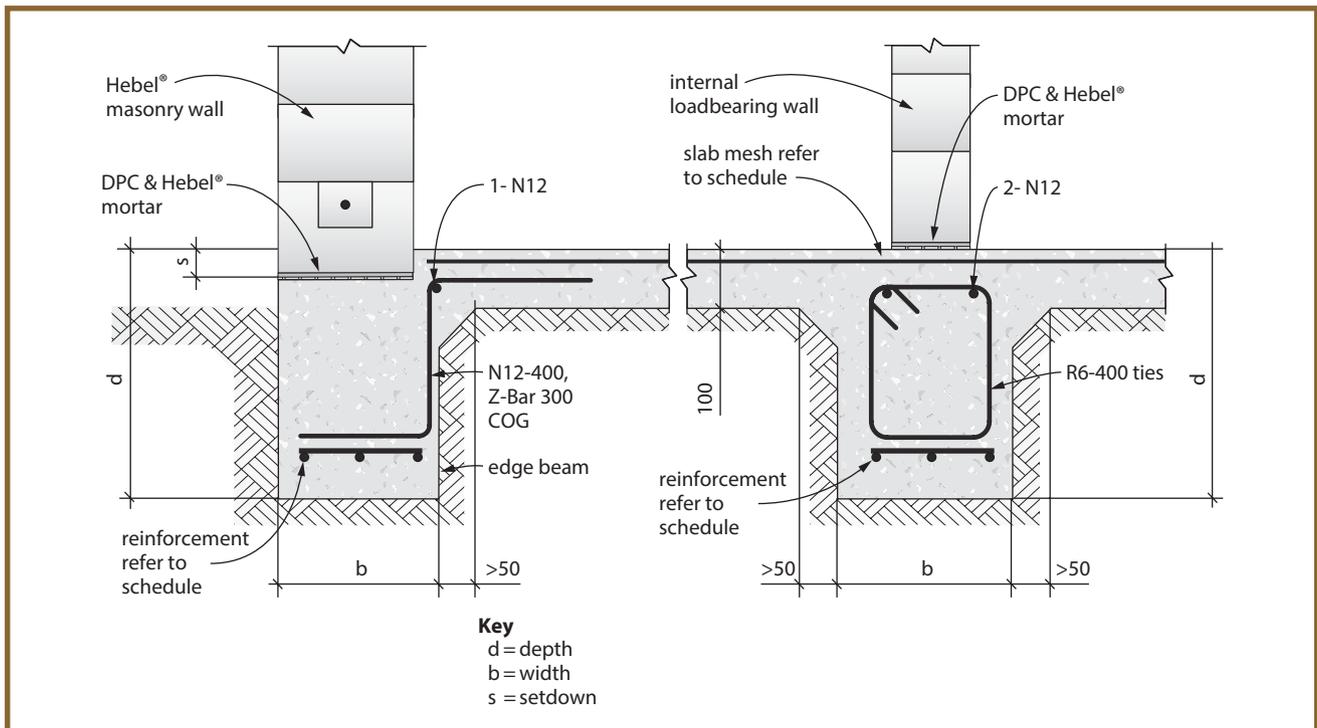
A tie bar may be embedded in the footing and continued up to the top plate as a tie bar. The **starter bar** is joined to a tie bar and inserted through a 50 mm circular hole bored through the blocks as work progresses.

Fig. 13.17 Strip footing and suspended floor system



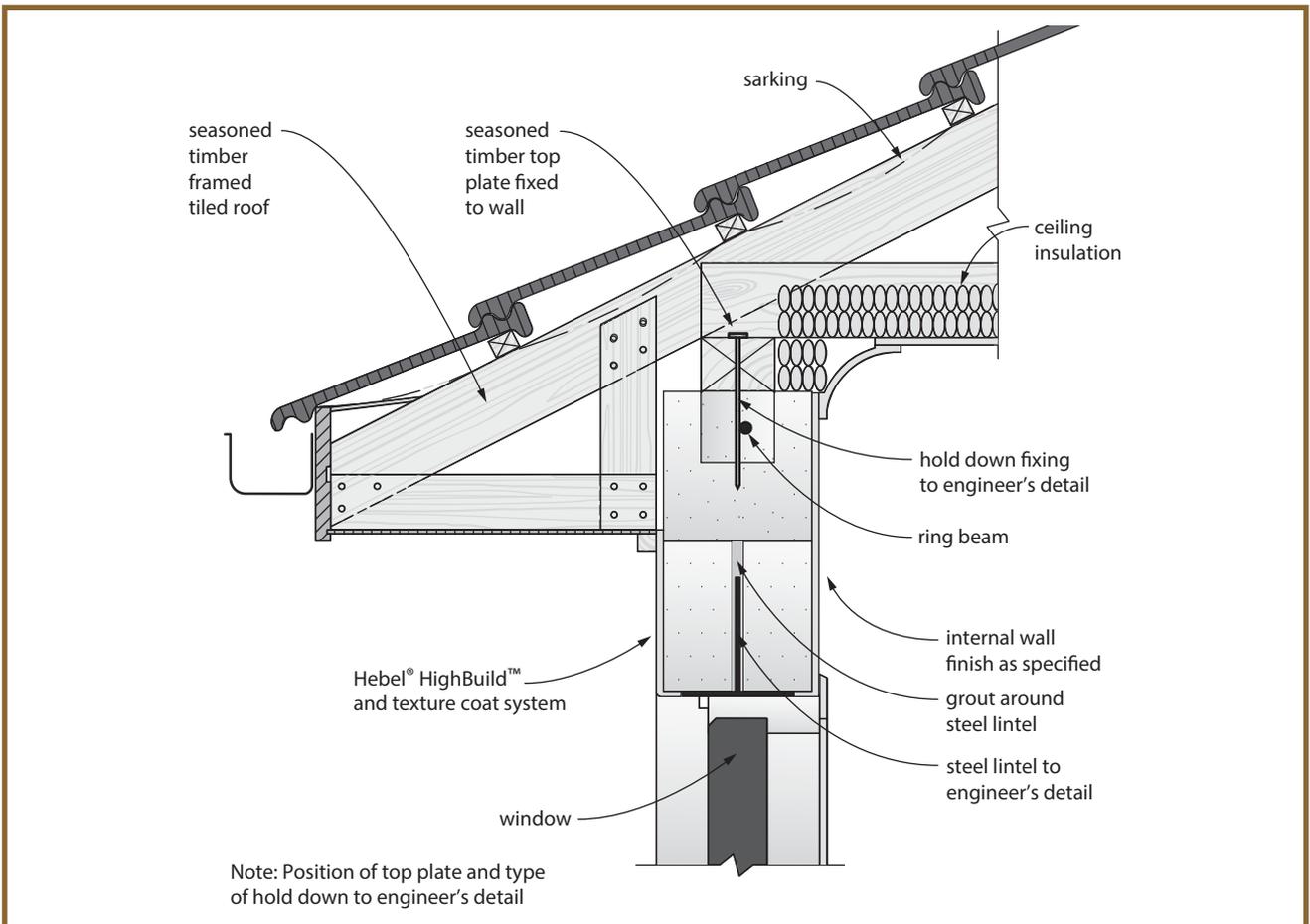
Source: Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

Fig. 13.16 Slab-on-ground footing system



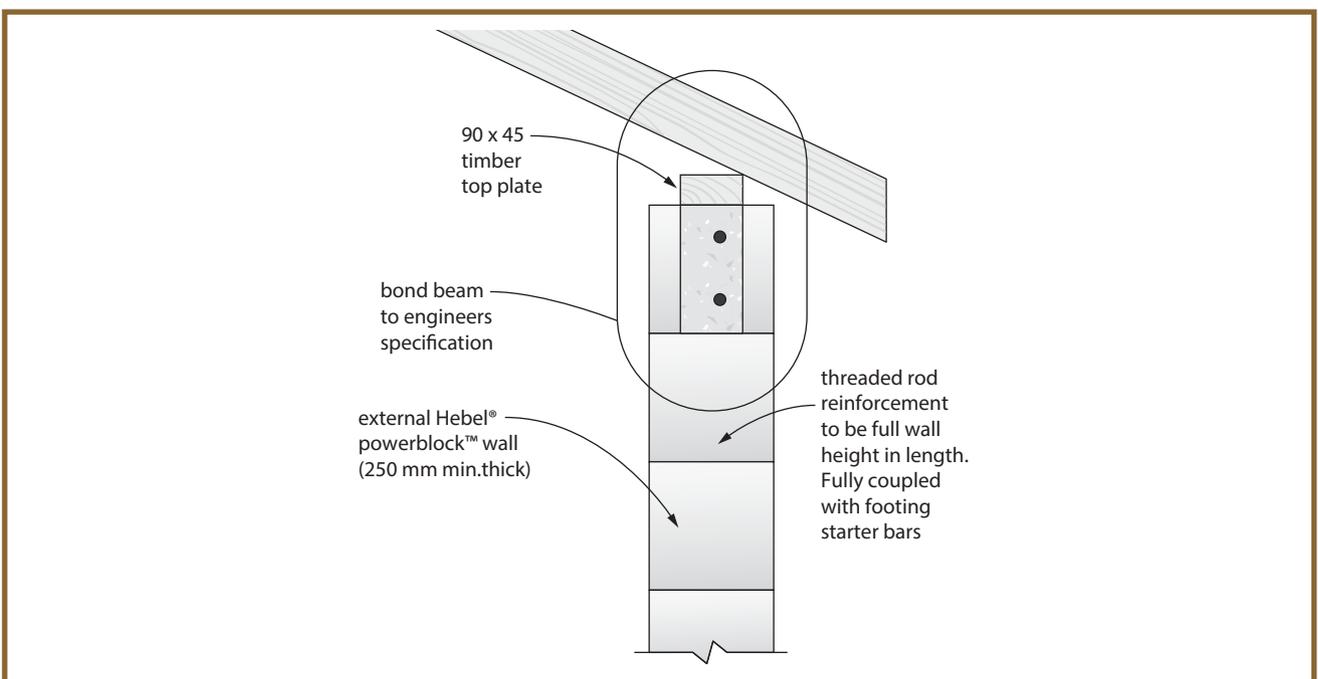
Source: Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

Fig. 13.18 Roof framing, ring beam and lintel details



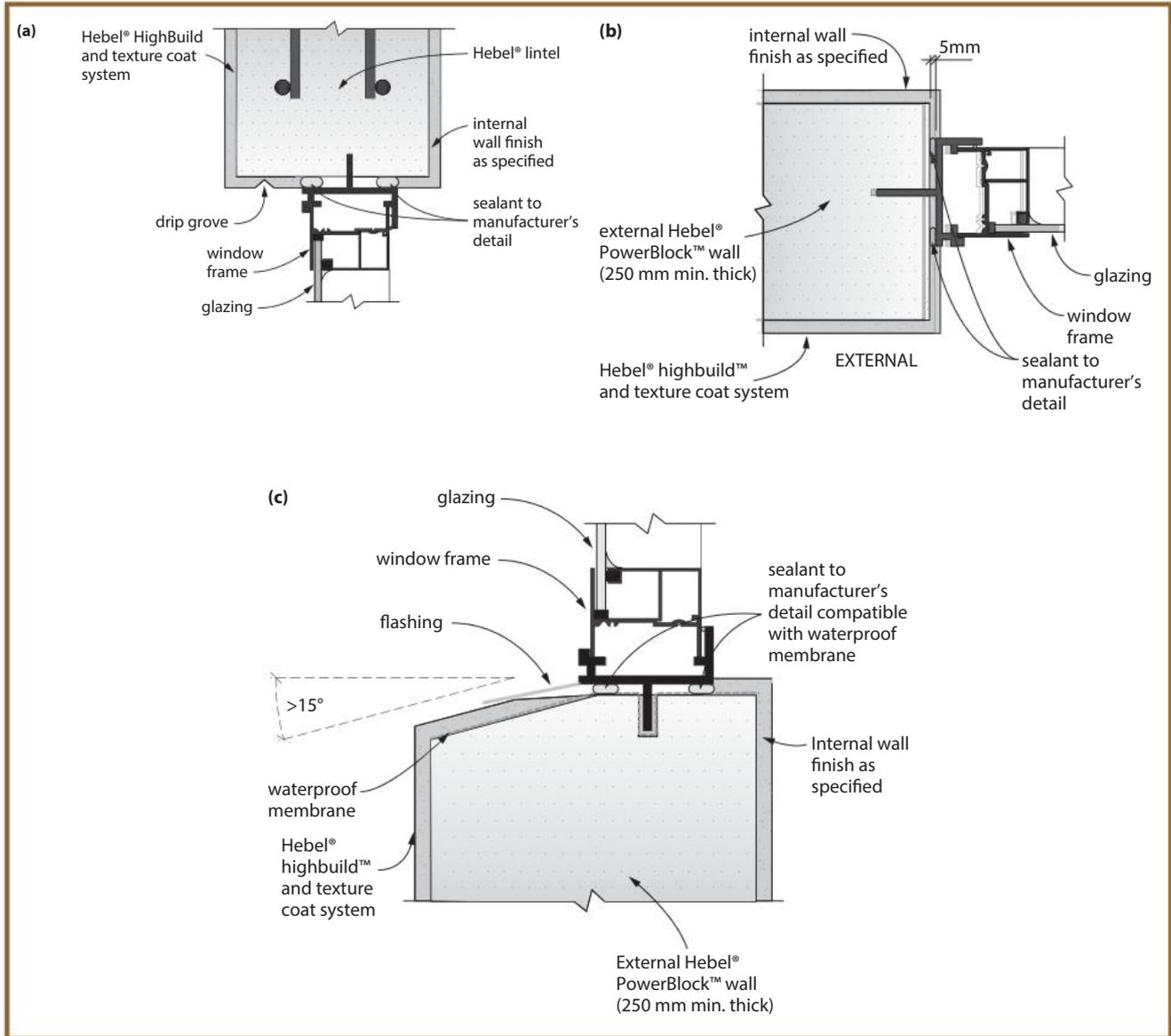
Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

Fig. 13.19 Bond beam detail for raked/cathedral roof framing



Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

Fig. 13.20 Aluminium window fixing and finishing: (a) window head section detail; (b) window reveal detail—plan view; and (c) window sill section detail



Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

Ring beams and bond beams

Ring beams must be formed in the first course and in the last course of blocks for conventional and trussed roofing to tie the wall together horizontally, to facilitate tie downs for the roof framing and to distribute the roof load. With raked or cathedral ceilings, the ring beam for the last course is replaced with a bond beam 100 mm wide and 200 mm deep with two N12 bars placed in the top and bottom of the bond beam to resist the outward thrust of the roof

Door and window requirements

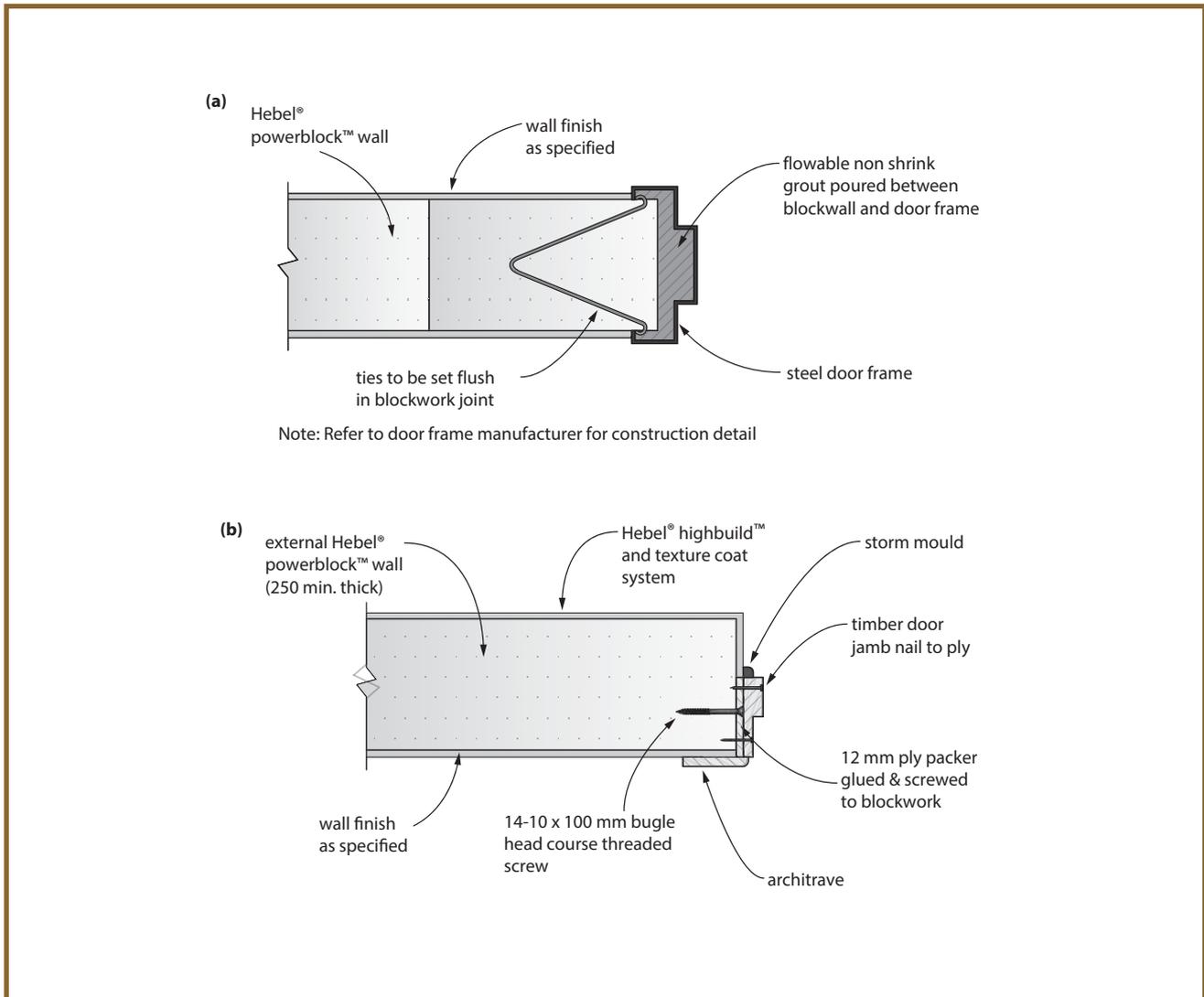
Doors and windows offer a point of entry for moisture and must be properly sealed and fixed in place. The final painted surface coating in conjunction with sealants is the only barrier

to moisture. As the blockwork is constructed doors and windows must be tied in to the wall at a maximum of 300 mm spacings vertically and 600 mm horizontally. Aluminium windows allow the masonry to be cut to form a slot into which the fin of the window is located at the sill, up and down the reveals and at the head of the window.

Doors must be carefully fixed to the lightweight walling using frame ties or a large gauge bugle headed screw. Door ties must be placed at a maximum of 300 mm centres.

Control joints

Control joints are also an essential feature of AAC construction due to the response of the material to temperature changes and shrinkage of concrete over time (Fig. 13.22). Control joints are

Fig. 13.21 Door frame fixing details: (a) steel door frame and (b) timber door frame

Source: Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

generally installed at no more than 6-m spacings and care must be taken to ensure they are maintained plumb and that they are continuous through any external or internal render system.

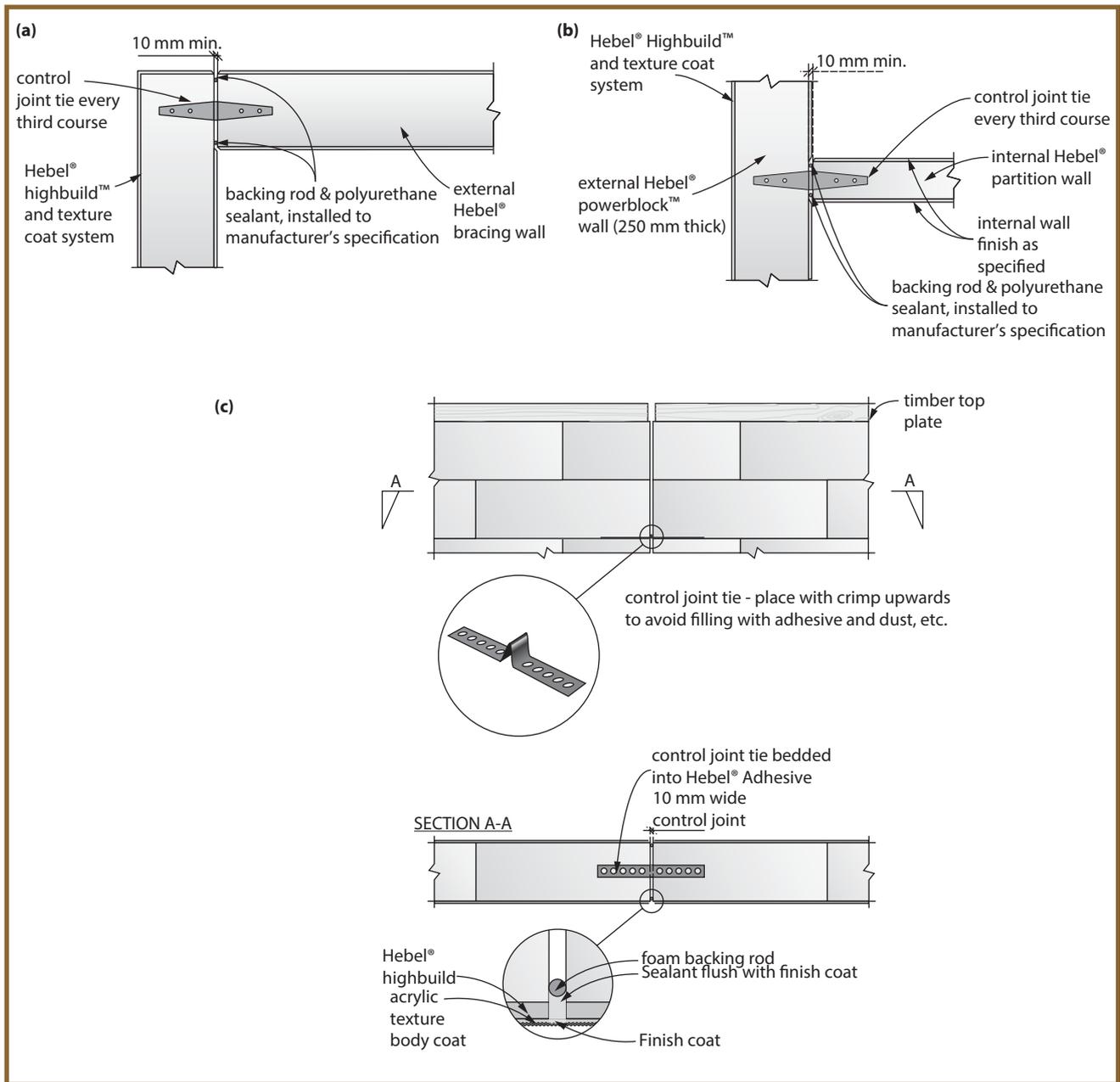
Where possible, control joints are located in alignment with the vertical reveals of window and door openings and are continuous at the bottom and top of openings as per normal building practice. Expandable ties are used to connect the masonry sections together and control joints must be installed at all corners and all junctions to account for differential lateral movement of walls.

Finishing solid masonry external surfaces

The final external finish plays an important role in solid masonry as the waterproofing membrane prevents moisture and dampness from entering.

- Cement render should be applied over concrete masonry no earlier than 28 days after the blockwork is completed, including core-filling, to reduce shrinkage cracking. Alternatively use acrylic render. A durable painted finish can be achieved by applying a sealer coat followed by two coats of acrylic paint. The paint should be applied with a roller with a long nap around 22 mm.
- AAC manufacturers recommend the use of a proprietary high build render and that traditional sand cement renders not be used. External coatings must comprise a high build acrylic texture coat and finish elastomeric paint membrane. This is critically important to apply as this system acts as a waterproof membrane preventing the entry of moisture through a lightweight and highly porous material.

Fig. 13.22 Control joints: (a) corners; (b) junctions; and (c) control joint detail



Courtesy of CSR Building Products Ltd. Note: These details are extracts from the Hebel Design and Installation guides. When these details are considered in the field, the guides must be read in full.

- Care should be taken when applying any render system to ensure that control joints are maintained directly over their location in the AAC. Failure to do this will result in membrane damage as expansion/contraction movement cracks the render coating.
- All control joints must be kept plumb and a consistent thickness as external coating layers are built up.

Student research

Review the following two documents and determine if there are any similarities in construction principles for these two different solid masonry systems:

1. Hebel, 2009. *Hebel® PowerBlock™ Design and Installation Guide*, (www.hebelaustralia.com.au/Documents/HEB1607_BlocksDIG_080412.pdf)
2. CMAA 2012, *MA55—Design and Construction of Masonry Buildings* (7th edn), www.cmaa.com.au.

Mineral-based building resources

There are numerous building materials that incorporate non-renewable mineral content. These include:

- stone—marble, slate, granite, basalt
- aggregates
- sands
- earths—rammed earth (pise), adobe (mud brick), compressed bricks and blocks, cob, lightweight earth, turf roofs
- fired bricks and tiles, silicate bricks
- cements, cement sheets
- lime, lime-based products
- bitumen, bitumen-based products
- concrete, concrete blocks, concrete products
- gypsum-based products
- glass, glass fibre
- metals—steel, stainless steel, copper, aluminium, zinc, lead
- inorganic paints and coatings.

The use of minerals in building products has often come at an extremely high environmental cost, with contaminated run-off and pollution from processing, finishing and transportation. Add to this considerable fossil fuel use in their production and the result is a high-embodied energy level for each. It is therefore important, if possible, to limit the amount of these materials—however, as you can imagine, this is not an easy task.

Arch construction

LEARNING OBJECTIVES

- 14.1 Circle geometry
- 14.2 Single-centred arches
- 14.3 Multicentred arches
- 14.4 Arch centres

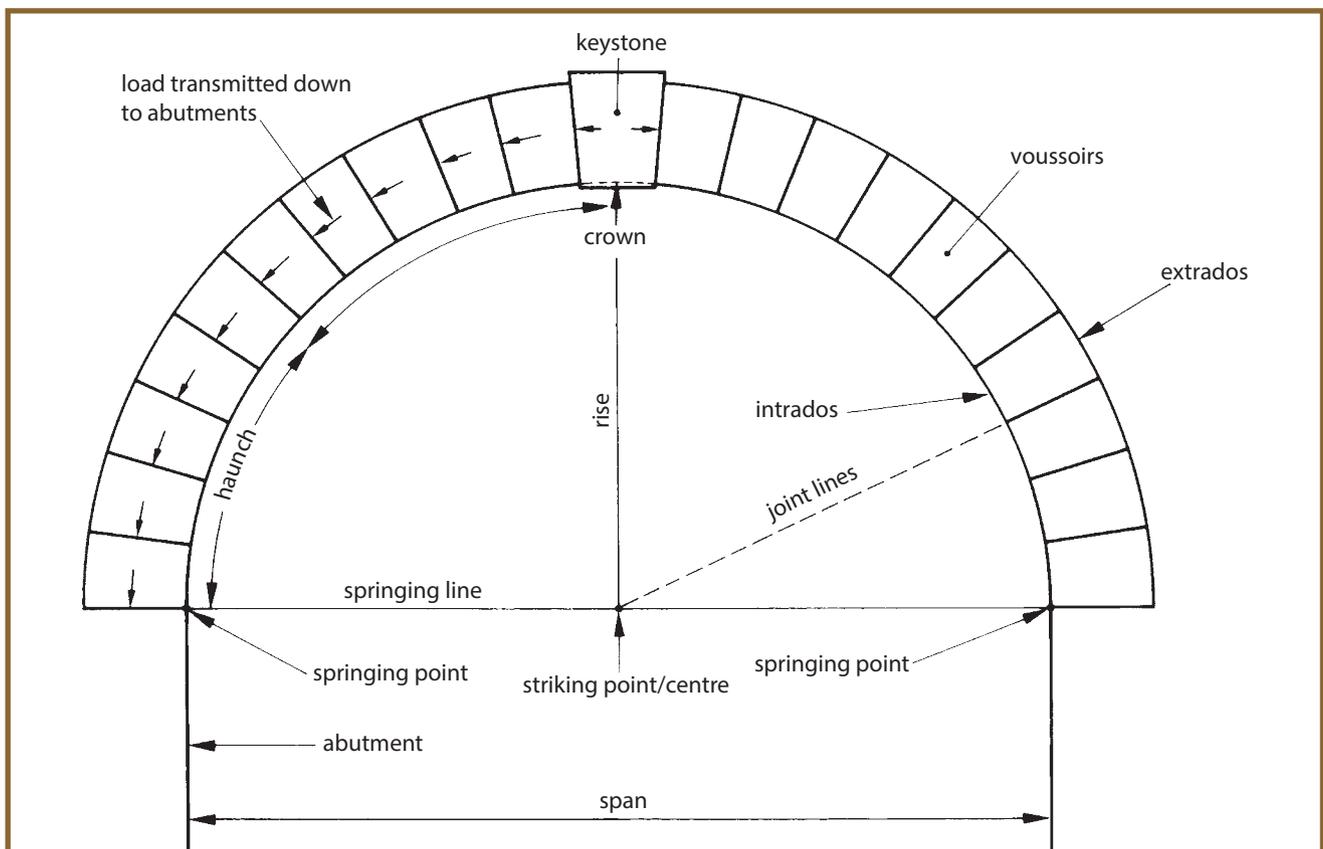
Arches are still used in new building work but their importance today is closely aligned to reproduction of facades for historical buildings, reproduction of building styles in new development and the maintenance of historical buildings. They are also used in refractory brickwork for high temperatures furnaces including brick kilns and glass, steel and nickel furnaces.

The construction of arches remains an important part of apprentice training, especially as the stock of buildings requiring ongoing maintenance continues to grow.

Terminology

The parts of an arch are shown in Figure 14.1.

Fig. 14.1 Masonry arch details



As indicated in AS 4773.2–2010 Masonry in small buildings, the following apply, unless otherwise specified:

- The rise is not less than one-quarter of the span.
- There must be at least 300 mm brickwork above the arch.
- Abutments are no less than the width of the span.

Arch categories

Arches are categorised in the following types:

- *Single-centred arches*—have a single **striking point** or centre
- *Multicentred arches*—have more than one centre or striking point
- *Gauged arches*—constructed with **voussoirs** or arch bricks that are cut or molded to a wedge shape and the joints are parallel

Fig. 14.2 (a) A segmental arch; and (b) a Tudor arch



Fig. 14.3 Gauged and bonded semi-circular arch

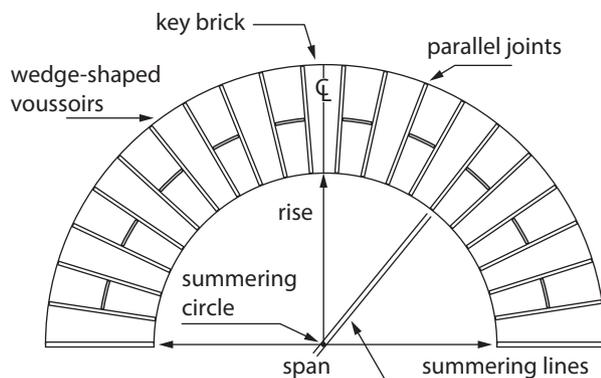
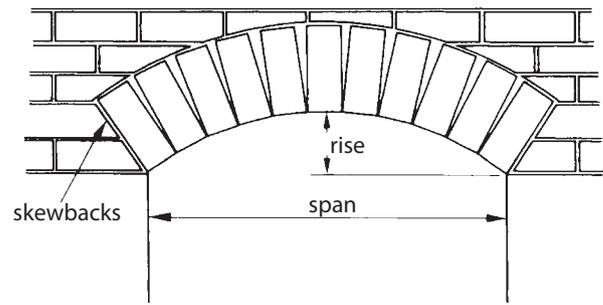


Fig. 14.4 Rough arch



- *Rough arches*—the voussoirs remain square, causing the joints to be wedge-shaped.

Setting out a rough arch

Before commencing to lay the arch bricks, they should be set out around the arch centre to determine the size of the joints. Alternatively set an arch brick as the key brick and mark a gauge on the intrados (top of the arch centre) from the key brick to either the skewback or the first arch brick laid on the skewback. To draw the actual arch brick, a summering circle the width of an arch brick (76 mm) is drawn around the striking point/arch centre and summering lines are drawn representing each side of the arch brick (Fig. 14.5).

When the thickness of the joints between arch bricks becomes excessive as the arch face increases in depth, the joints can be minimised by laying the bricks in rings, 110 mm in depth, provided the arch is at least a full brick thick. Alternate rings will have a key joint instead of a key brick (Fig. 14.6).

Arch set out

The shape of an arch should be set out accurately on strict geometrical lines. Bending a length of plastic or thin timber to

Fig. 14.5 Setting out the gauge for a rough arch

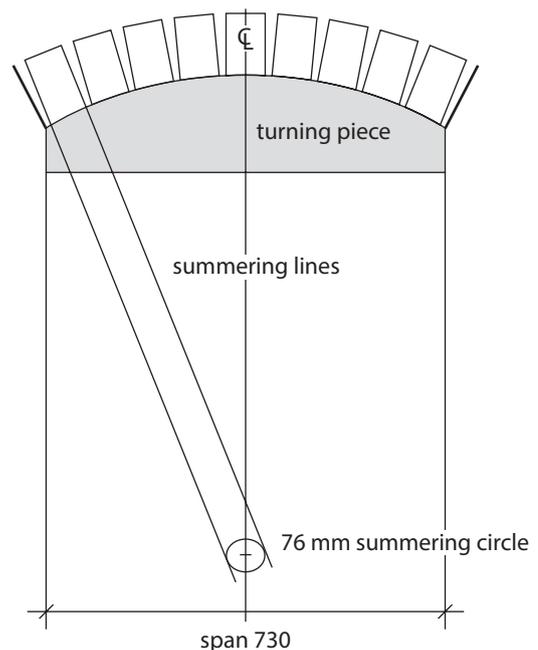
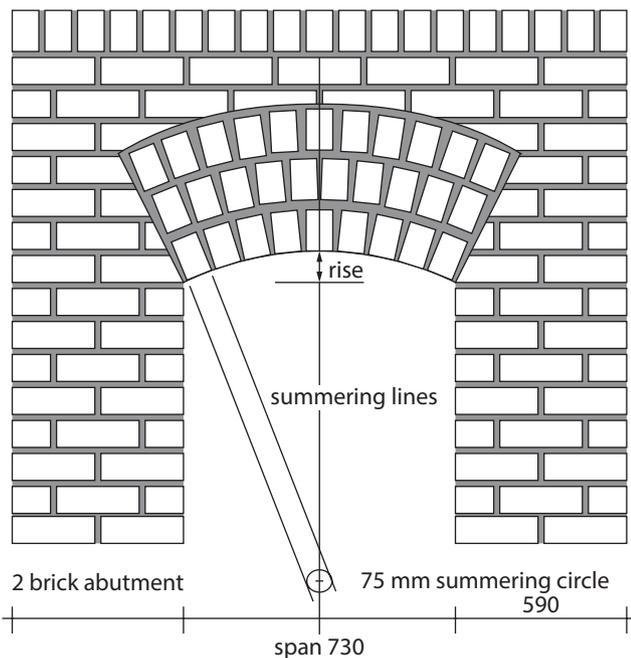


Fig. 14.6 Rough 110 segmental arch with three rings



When setting out an arch, draw the arch to full size on a sheet of plywood or MDF. The arch centre or turning piece is then made to the same dimensions and can be placed on the arch setting out to allow the arch bricks to be checked for accuracy after they have been cut.

an irregular curve is shoddy workmanship and demonstrates a lack of understanding of one of the most essential skills for all building workers—circle geometry. For a competent building tradesperson, setting out a regular curve or circle is simple but the result is excellence.

The circular lines of an arch can be drawn using trammel heads fixed to a straight edge or long level. An alternative is to use a straight edge with a builders pencil taped securely to the straight edge and a nail driven through the other end.

Fig. 14.7 Trammel heads fixed to a timber batten

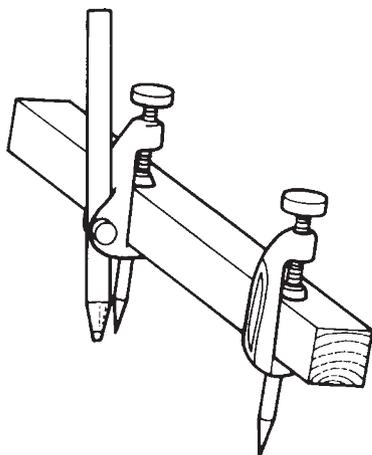
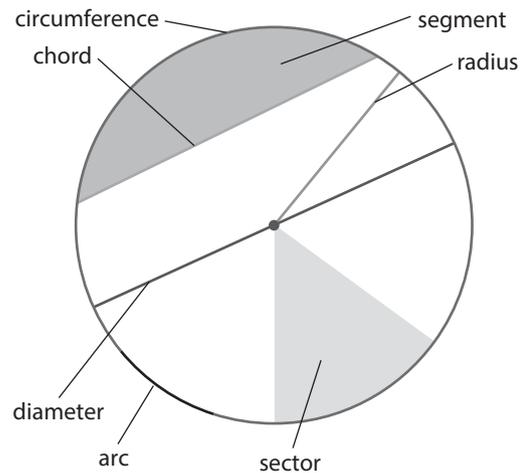


Fig. 14.8 Circle geometry



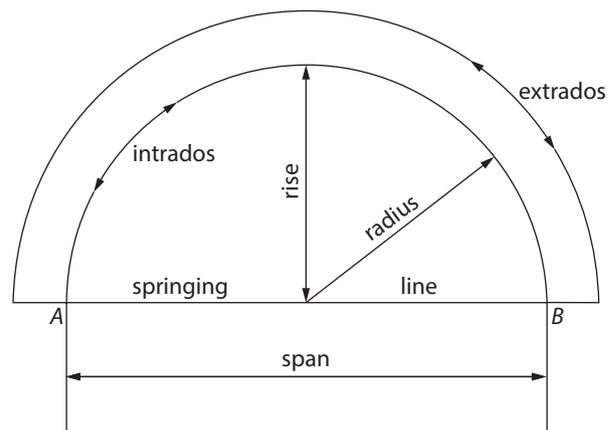
Semicircular arch

To draw the intrados of the semicircular arch, bisect the span *AB* to obtain the radius and the centre; the rise, of course, will be half the span. Extend the radius by the depth of the arch face to draw the extrados.

Segmental arches

A segment is that part of a circle bounded by an arc and its chord (see Chapter 4 Trade Calculations and Drawings,

Fig. 14.9 Semicircular arch



Volume 1). When applied to an arch, the segment is described by its span and rise. From this information, the radius of the circle can be obtained so that the curve of the segment can be drawn.

Setting out a segment by calculation

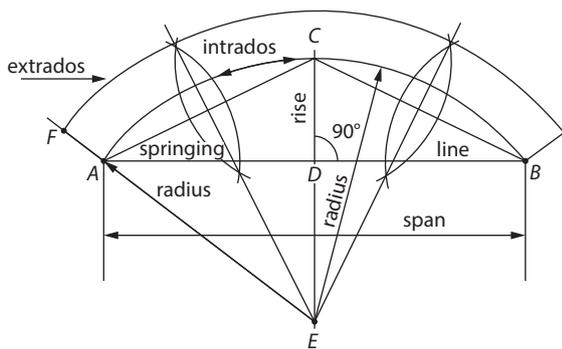
The radius (*r*) of a segment can be calculated, given the span and rise, and using the following formula:

Setting out a segmental arch

The geometrical method to set out a segmental arch is illustrated in Figure 14.10.

1. Bisect the span *AB* along the springing line at point *D* with a **perpendicular** line.
2. Continue the centreline down to a point past the estimated centre of the circle
3. Measure the rise from *D* to *C*.
4. Bisect the lines *AC* and *CB*, with perpendicular bisectors meeting at *E* on the centreline.
5. *AE* then becomes the radius of the curve and will join points *C* and *B*.
6. The depth of the arch face *AF* is added to *AE* to allow the extrados to be drawn from *F*.

Fig. 14.10 Geometrical method to set out a segmental arch



The two perpendicular lines that bisect *AC* and *CB* must meet on the centreline otherwise the setting out is incorrect.

$$r = \frac{(\frac{1}{2} \text{ span})^2 + \text{rise}^2}{2 \times \text{rise}}$$

Example: Calculate the radius of a segmental arch if the span is 2400 mm and the rise is 600 mm.

$$r = \frac{1200^2 + 600^2}{2 \times 600} \text{ or } r = \frac{1.2^2 + 0.6^2}{2 \times 0.6}$$

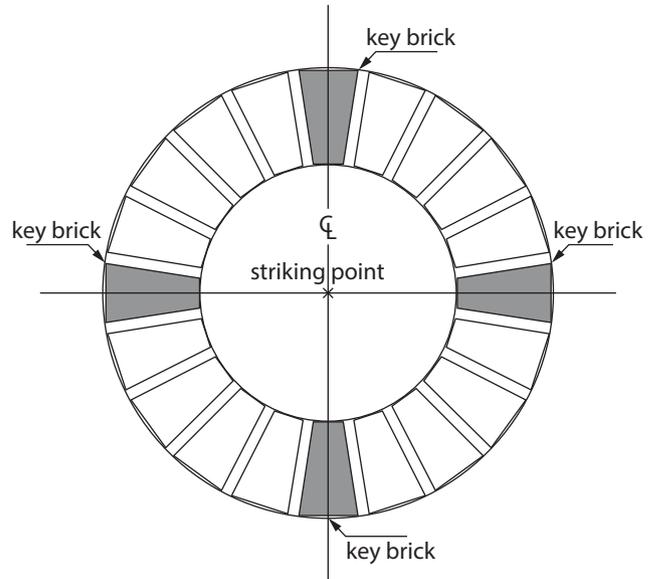
$$= \frac{1.44 + 0.36}{1.2} = \frac{1.8}{1.2} = 1.5 \text{ m (or 1500 mm)}$$

Wheel arches

Wheel arches have been a feature of homes during many periods of Australian architecture such as Old Colonial, Victorian, Federation, Inter-war, Post War and Late Twentieth Century. Wheel arches are set out with four key bricks: two

aligned to the horizontal centreline and two aligned to the vertical centerline. Setting out is similar to a semi-circular arch with the exception of the four key bricks.

Fig. 14.11 Wheel arch



Setting out

Draw a circle with a specified radius to form the intrados. The diameter is the span. The extrados is drawn by adding the depth of the arch to the radius. The internal circle can be cut out and used to construct the arch centre.

Bonded wheel arches must have a stretcher face for the four key bricks and therefore are gauged in multiples of eight. Wheel arches that are not bonded are gauged in multiples of four.

Establishing the correct gauge

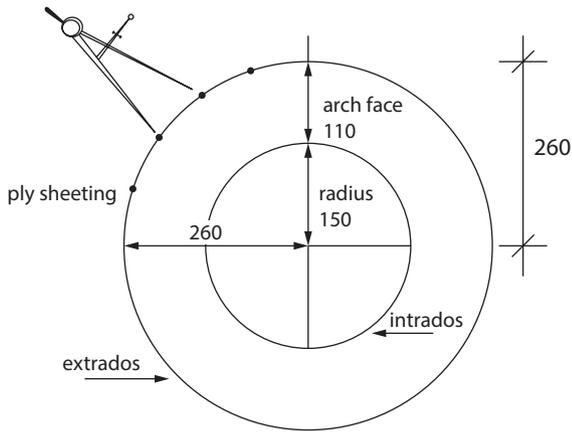
Calculate the circumference of the extrados using πD and divide by 86 mm (76 mm + 10 mm). This figure is then adjusted allowing for combinations of four or eight for bonded wheel arches, to determine how many arch bricks are actually required. The extrados length can now be divided by the number of voussoirs required to determine the actual size of each voussoir and the joint between them.

This example is based on a span of 300 mm and a single ring with a 110 mm face depth, and a circumference of extrados $C = \pi D$

- $C = 3.14 \times (300 + 110) = 1287$
- $1287/86 \text{ mm (brick depth } 75 + 10 \text{ mm joint)} = 14.97$ arch bricks—say 16 arch bricks
- $1287/16 = 80.44 \text{ mm}$ including a joint
- Allowing for an 8.44 mm joint results in an arch brick 72 mm wide at the extrados.

The same method can be used to calculate the width of the arch brick at the intrados.

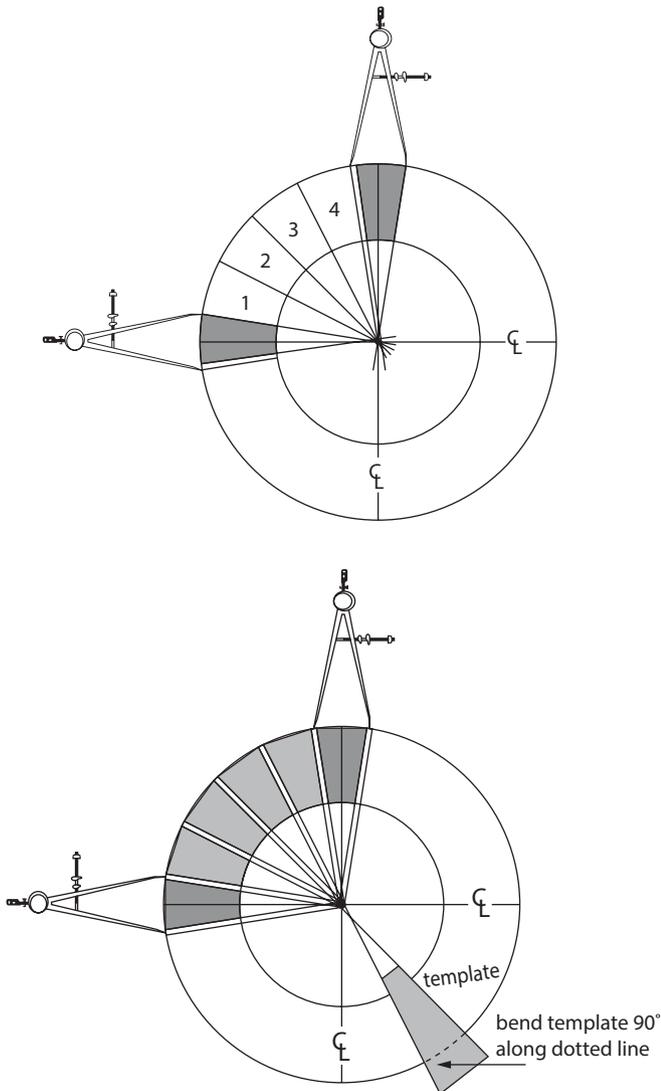
Fig. 14.12 Establish the correct gauge



Steps

- Set out arch full size on a sheet of ply
- Establish gauge by dividing quadrant into multiples of 4 + 1
- Gauge cannot be greater than 86 mm
- Deduct joint size from divider measurement for width of arch brick at extrados

Fig. 14.13 Steps for setting out the gauge for the top half of the arch



Step 1

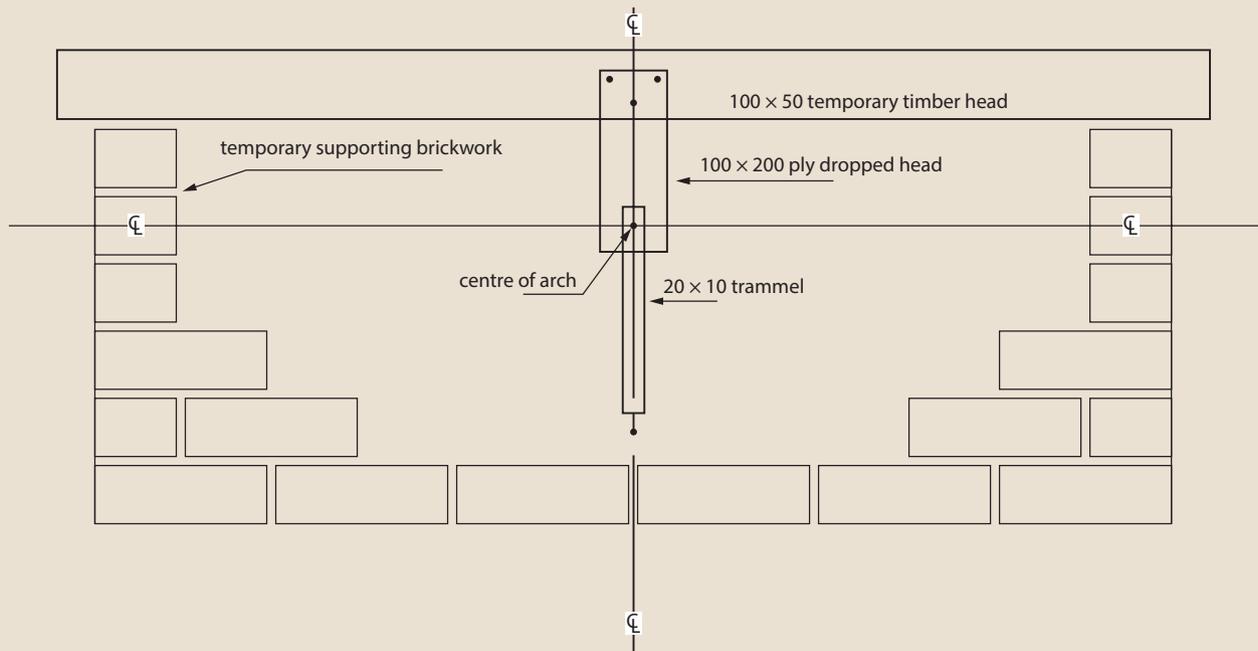
- Draw 2 key bricks centrally on each centreline by extending lines from the extrados to a 10 mm summering circle
- Mark out the gauge between the key bricks around the extrados starting from the side of one key brick and finishing on the same side at the other

Step 2

- Start from a key and set out the remaining joints between each arch brick around the extrados
- Extend lines from the extrados to the summering circle
- Repeat process for remaining quadrant

Constructing the wheel arch

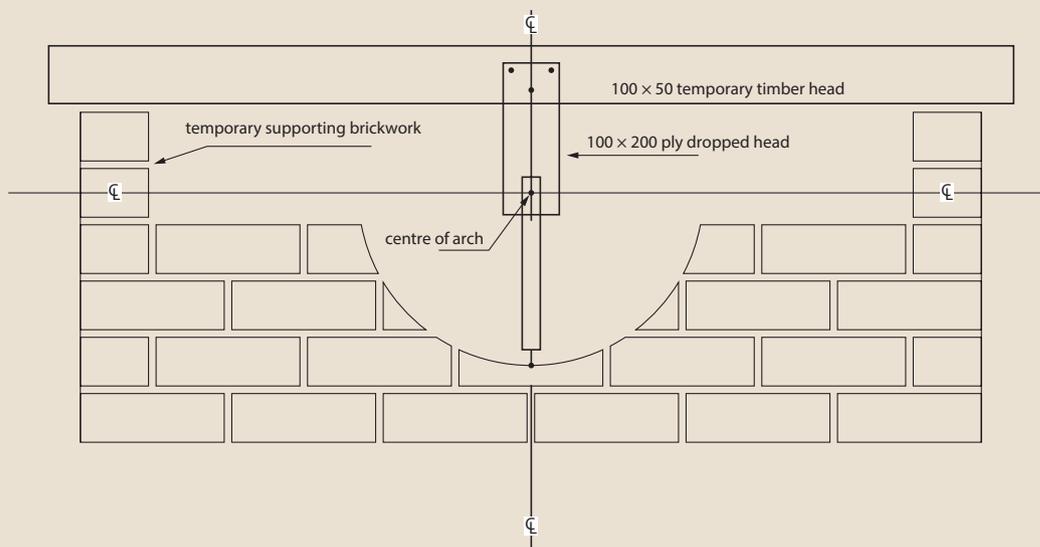
Fig. 14.14 Setting up a trammel



To construct a wheel arch:

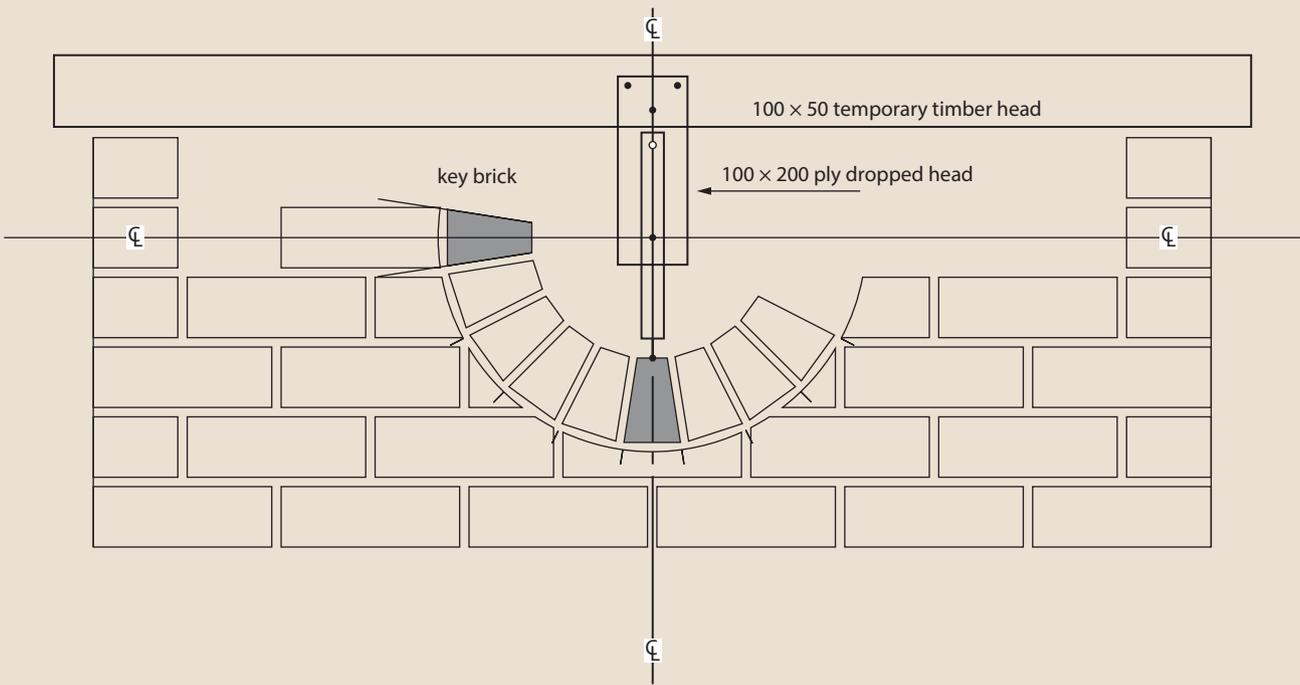
- A vertical centreline is set out on a timber head.
- A short piece of timber batten or plywood approximately 100 × 200 mm is fixed through its vertical centreline to the centreline on the timber head.
- The timber head is then set up above the location for the arch so that the vertical centreline of the arch is aligned to the vertical centreline on the plywood or batten.
- The horizontal centreline of the arch is then drawn through the vertical centreline to provide the centre of the arch.
- A timber trammel measuring 20 × 10 × the required length is fixed through its centreline and the centre of the arch. The distance from the arch centre to the point of the trammel must equal the radius plus the depth of the arch face plus 10 mm for a joint.
- Drive a nail into the end of the trammel to form a point.

Fig. 14.15 Cutting in the invert



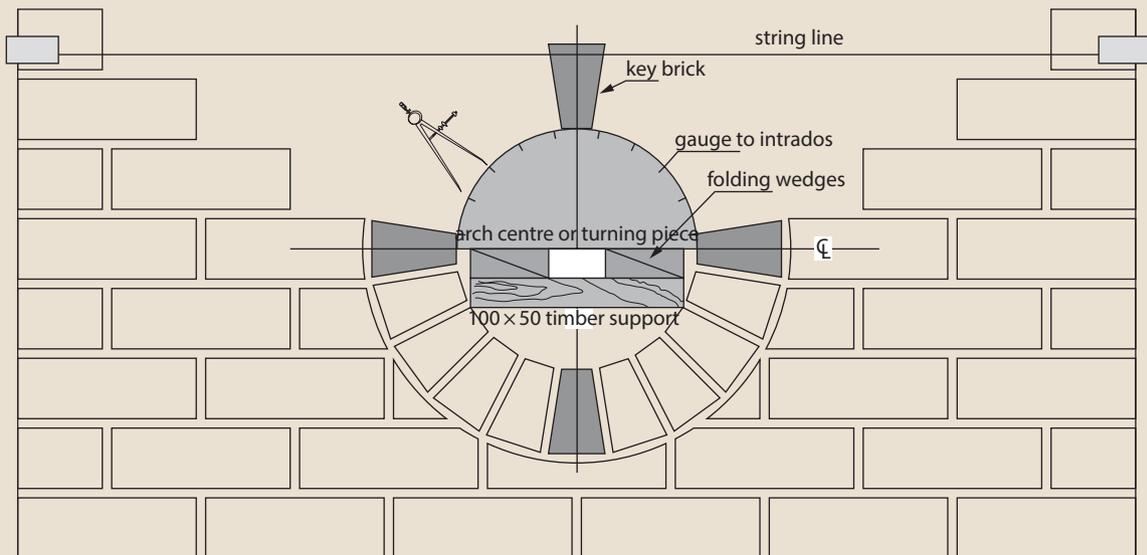
- The trammel is used to mark the bricks that will be cut to form the inverted section of brickwork that the lower section of the wheel arch is laid into.
- The point of the trammel is used to determine the shape and size of each creeper cut, taking into account the joint between the arch bricks and the creeper cut (Fig. 14.15).

Fig. 14.16 Laying the invert

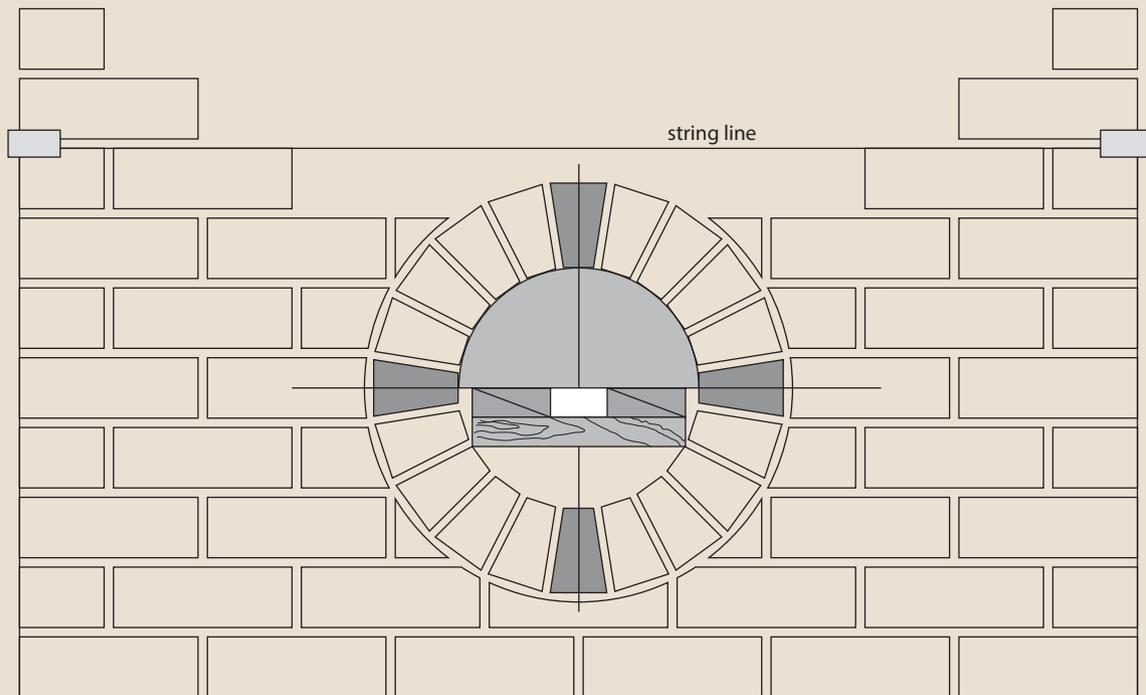


- The arch gauge is marked around the two bottom quadrants by gauging between the location of the lower key brick and the two key bricks on each side.
- The trammel is shortened by 120 mm (110 face + 10 mm joint) to provide the line and shape of the intrados.
- As the arch bricks are laid they must be checked to the end of the trammel for alignment to the intrados and for alignment to the centre of the arch (Fig. 14.16).

Fig. 14.17 Gauging the upper semi-circle



- Remove temporary timber head when lower section (invert) is completed.
- Set up arch centre or turning piece so that arch centre is aligned to the horizontal centreline.
- Set out location of remaining key brick and gauge arch brick spacings along the top of the arch centre (intrados).
- Build up corners and commence laying arch bricks to a string line to maintain alignment (Fig. 14.17).

Fig. 14.18 Laying the upper semi-circle

- Set last three bricks in place without joints to check gauge and make final adjustments to joints.
- Lay last three arch bricks including key brick, ensuring joints are even and full and that each bricks sits squarely on the arch centre.
- Mark creeper bricks by measuring from a tight string line to the arch extrados and allowing for the correct size joint between the cut brick and the extrados.
- Cut and lay creeper bricks to a string line. (Fig. 14.18)

Gothic arches

Gothic arches are a group of pointed arches that originated in France and became a prominent feature of northern European architecture. A typical example is the *equilateral arch* (Fig. 14.19).

The arcs forming the arch spring from two centres which lie on the springing line. In the example shown in Figure 14.19 they are the actual springing points. Other arches in the group are the *lancet arch* and the *obtuse* or *depressed arch* where the rise is varied by altering the position of the centres along the springing line.

Segmental Gothic arch

The segmental Gothic arch is set out in a very similar way to the previous gothic arches but the striking points are below the springing line and are located when the centerline of the span for each separate segmental curve is drawn until it strikes the abutment on the opposite side of each segmental curve.

Tudor (or four-centred) arch

The Tudor arch, or the four-centred arch, is a later development of the Gothic arch; as the name implies, the curve of the arch is drawn from four separate centres.

Three-centred arch

The three centred arch is based on three circles that provide three striking points or centres. There are two common normals and the arch shape is similar to a semi-elliptical arch. (Fig. 14.19)

This arch provides a comparatively low rise which is less than half the span but the springing bricks do not require a skewback. These arches are often used over wide openings such as a garage door

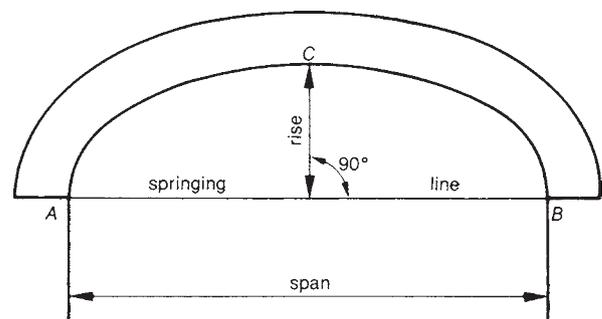
Fig. 14.19 Semi-elliptical arch

Fig. 14.20 Equilateral arch

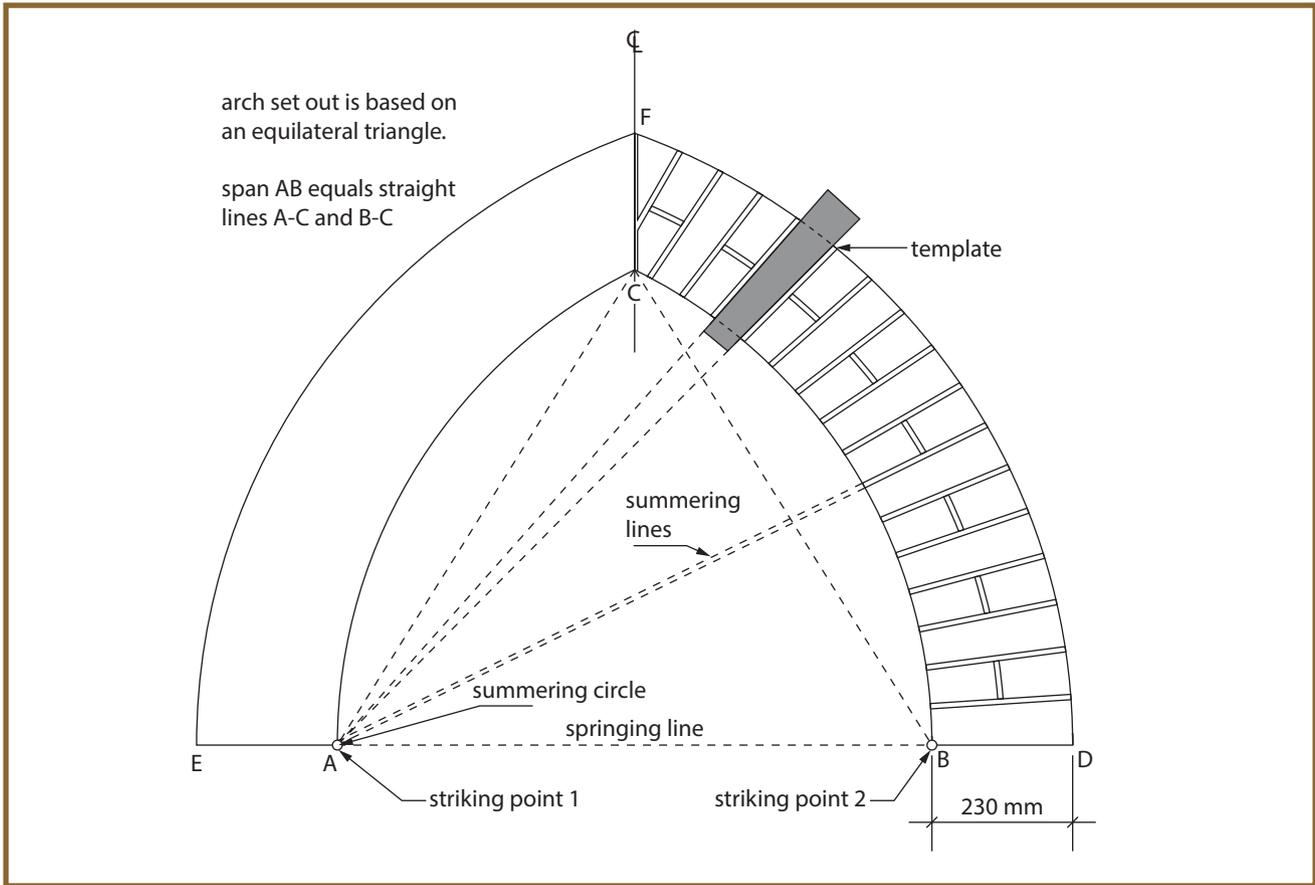


Fig. 14.21 Lancet Gothic arch

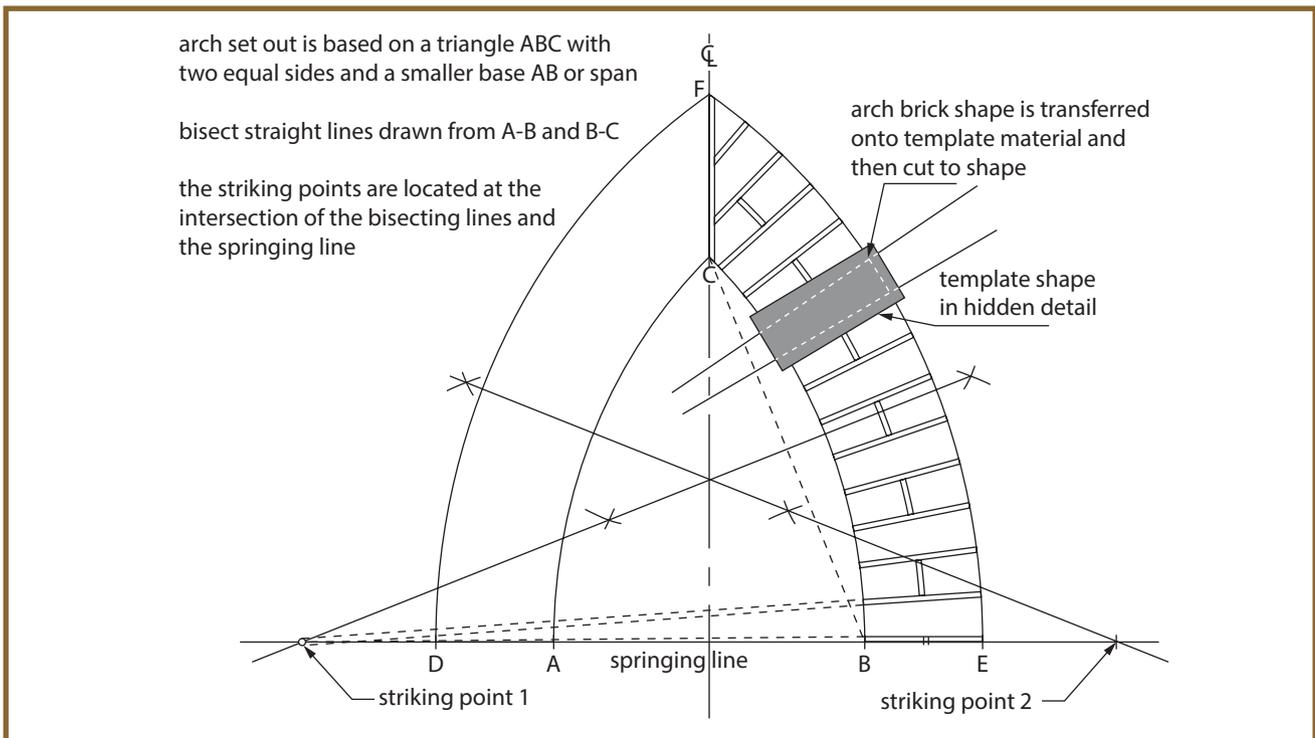


Fig. 14.22 Depressed Gothic arch

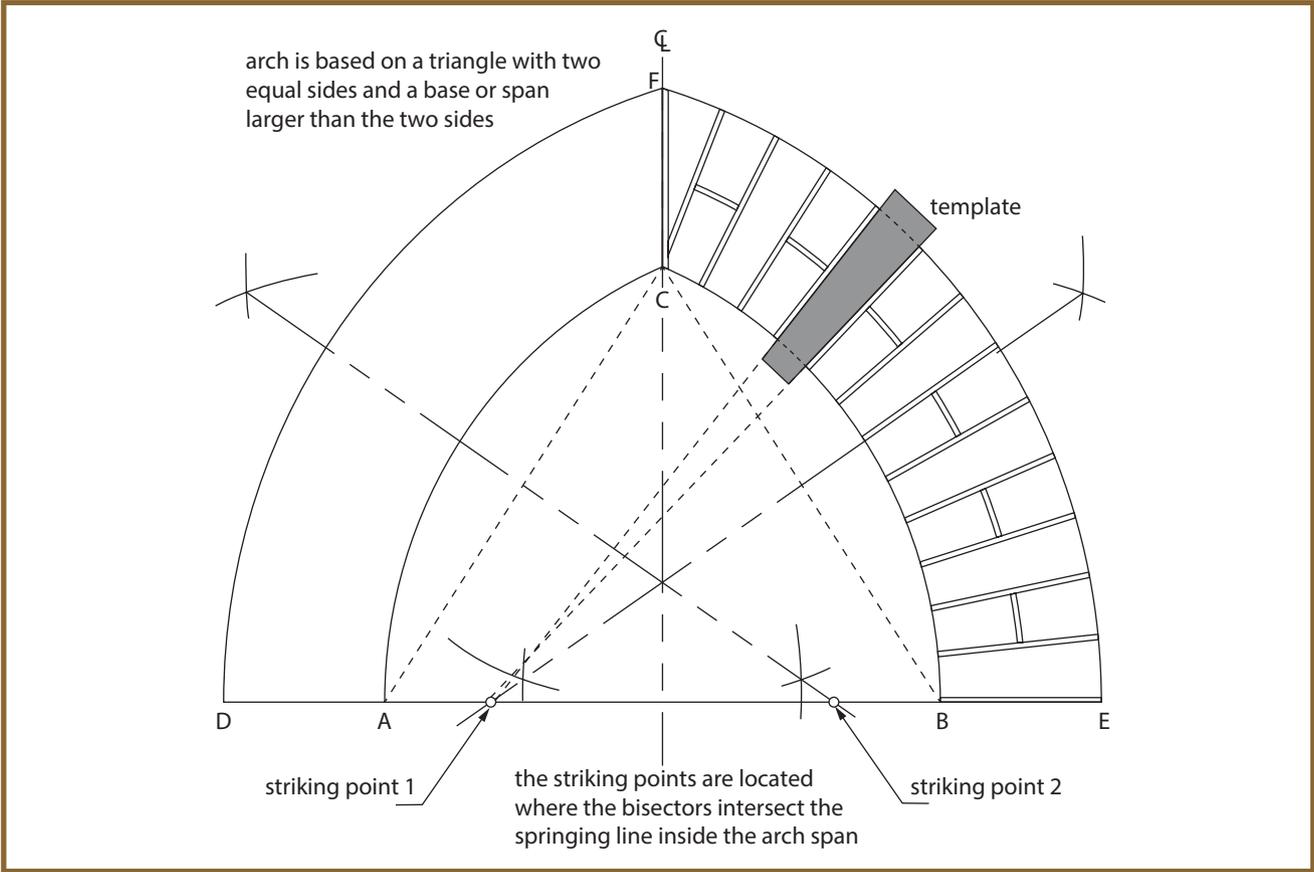
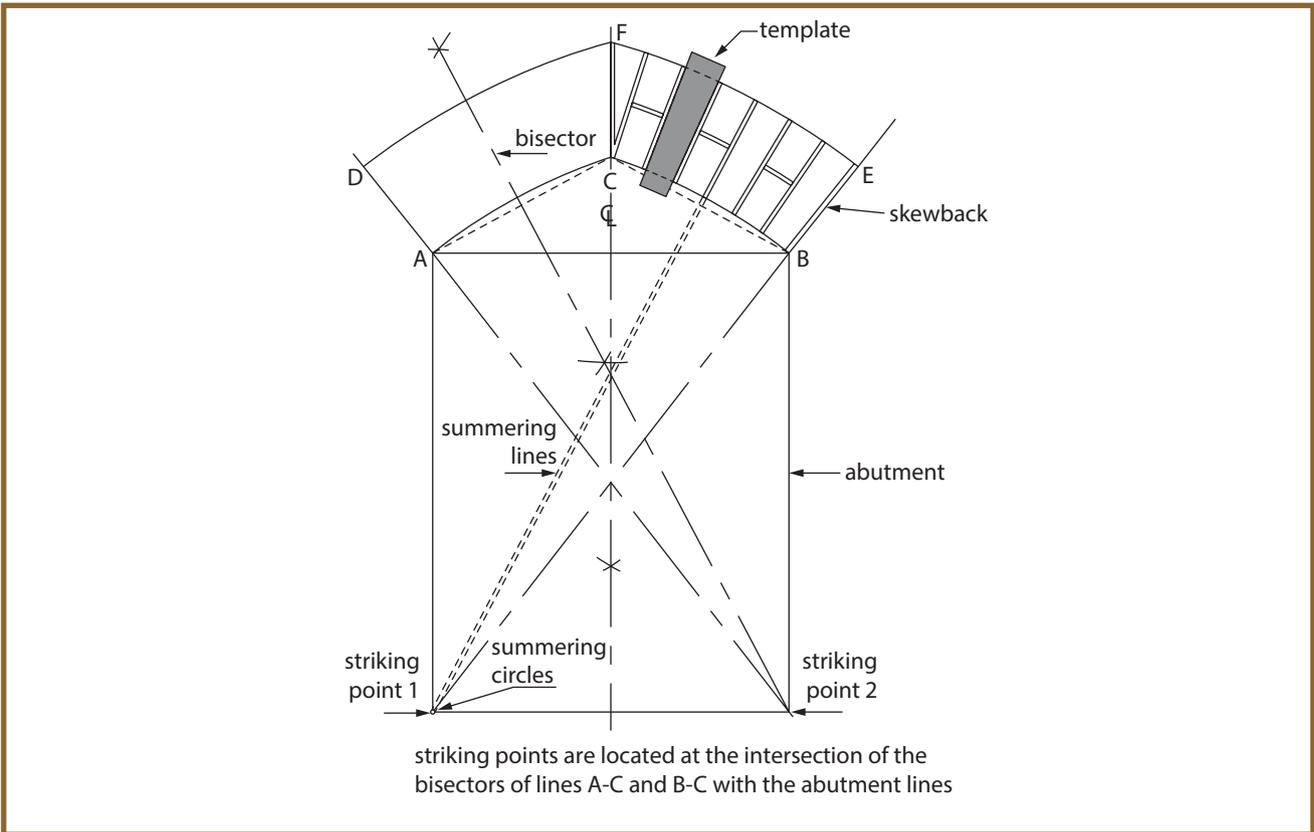


Fig. 14.23 Segmental Gothic arch



striking points are located at the intersection of the bisectors of lines A-C and B-C with the abutment lines

Fig. 14.24 Tudor arch or four-centred arch

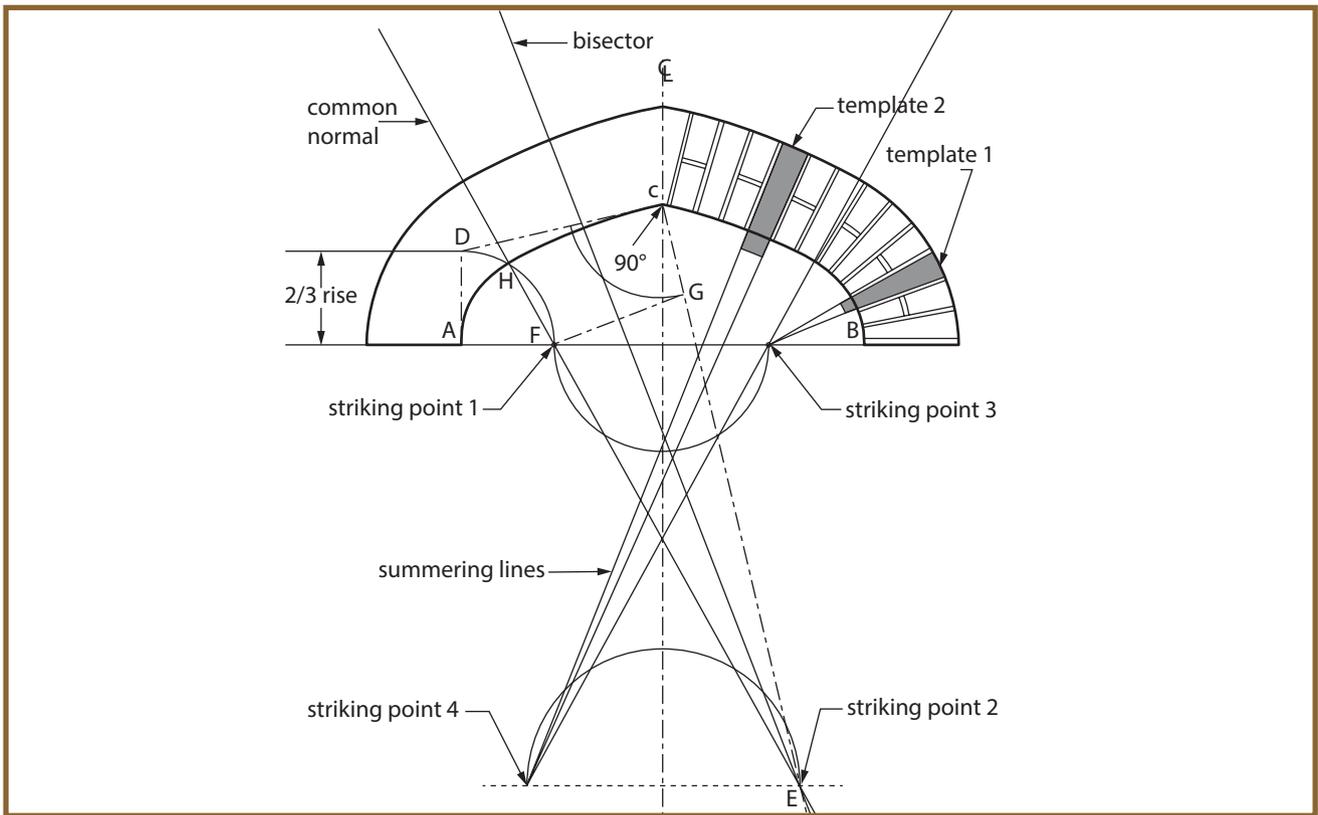
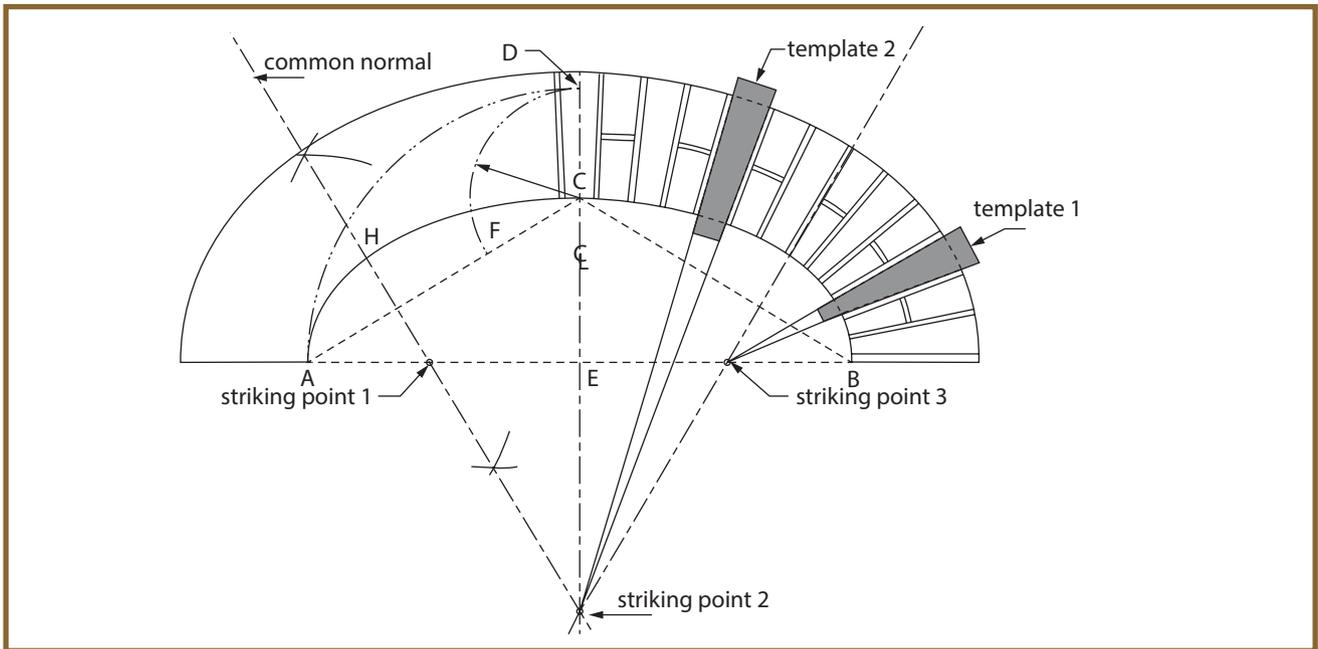


Fig. 14.25 Three-centred arch



Flat arches

There are a number of arches that may be referred to as a flat arch including a Camber arch, arches with a flat extrados and a curved intrados, and a Jack arch.

Jack arches were an alternative to constructing a Camber arch, which requires detailed setting out prior to construction. They were not necessarily constructed as face brickwork, but often plastered. When constructed as face brickwork, a Jack arch provides an option to the Camber arch and can be constructed with a bonded face or constructed with concrete masonry blocks.

Constructing a Jack arch over an opening

The arch is set out by fixing a piece of 90 × 45 timber at the bottom of an opening and driving a nail into the timber at the centre of the opening. This establishes the striking point or arch centre. A string line is then drawn from the nail through the springing point to provide the angle for the skewbacks. The distance between the top of the two skewbacks is then gauged to provide a key brick and an even number of arch bricks. The joint between the bricks can be varied between 7–10mm. Standard bricks 230 × 110 × 76 will only permit an arch face of around two courses unless the arch face is bonded.

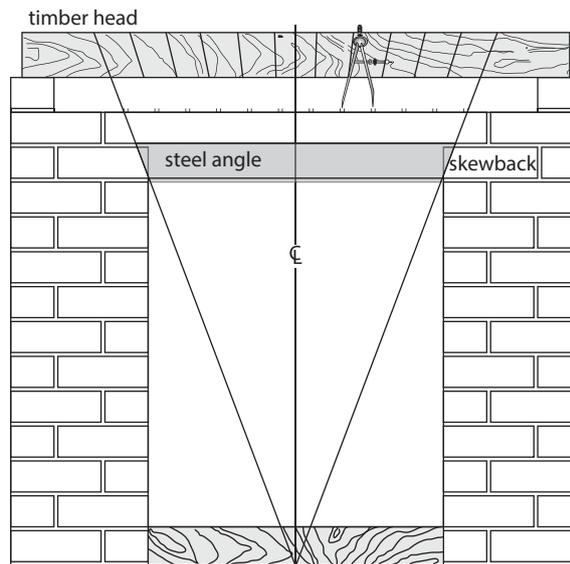
Once the arch exceeds a span of 900 there is a need to build it with a slight camber at the intrados to prevent the illusion of the arch soffit sagging.

Fig. 14.26 Camber arch



Fig. 14.27 Jack arch construction: (a) setting out and establishing the gauge; (b) marking, cutting and laying the arch bricks; and (c) the completed arch

(a)

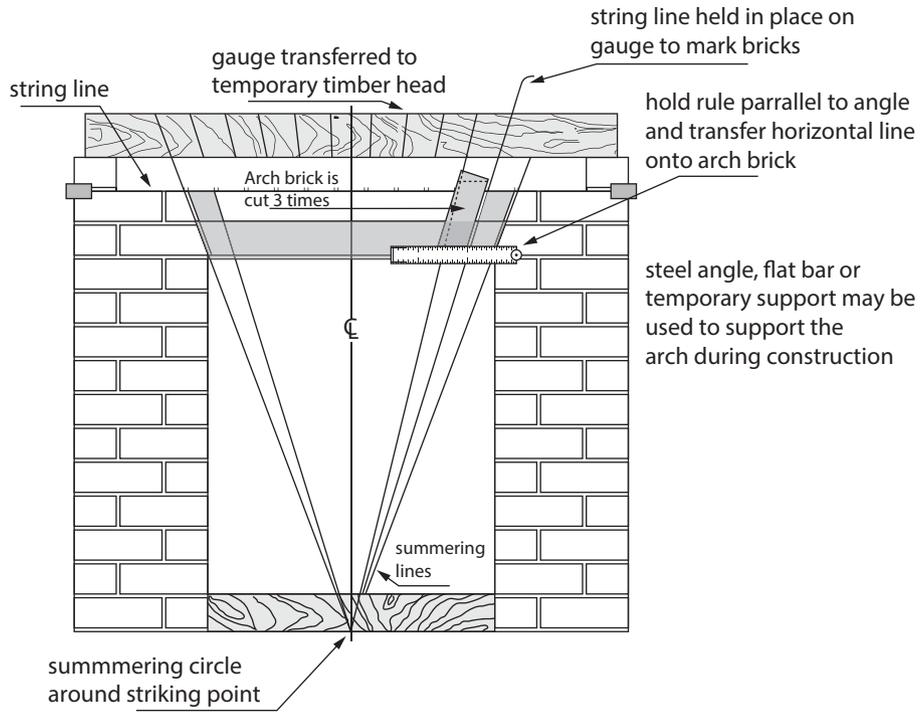


Establish the most suitable gauge between the top of each skewback by calculation or with dividers. Eleven arch bricks required

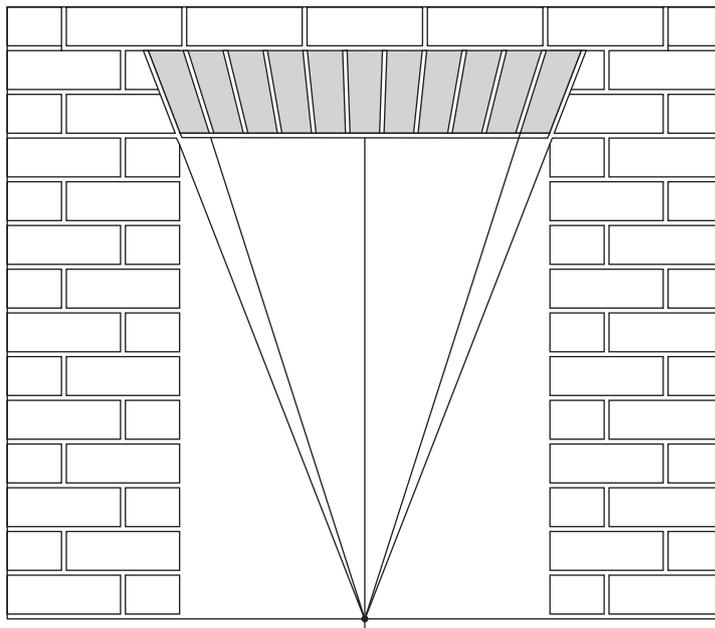
Transfer the skewback lines onto a temporary timber head and divide this distance by 11 bricks to extend the gauge onto the head

(Continued)

(b)



(c)



Arch centres

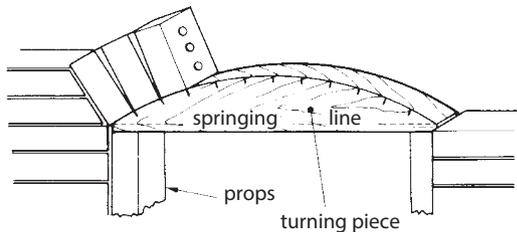
Arch centres provide a temporary support for the construction of an arch. The design and construction of a centre depend on the span, the mass and the thickness of the arch and its shape. The centre must be able to support the mass of the arch without movement or deflection, and must be fixed on its supports in such a way that it cannot be easily disturbed. At the same time, consideration must be given to its method of adjustment and removal.

Turning piece

The simplest form of centre is a *turning piece* which can be used on 110 mm walls for segmental arches of shallow rise. The turning piece consists of a solid piece of timber, up to 75 mm thick.

When the brickwork reaches the level of the springing line, the centre is set up on props and braced securely. The spacing of the bricks forming the arch—the *gauge*—is set out on the turning piece by the bricklayer as shown in Figure 14.27.

Fig. 14.28 Turning piece



Arch centres

A simple arch centre can be quickly constructed by using a sheet of 6–20 mm structural plywood as a smooth surface for setting out the arch and for the manufacture of the centre. This allows all geometry to be shown on the arch centre and facilitates gauging and alignment of the arch bricks to the striking point and summering circle or summering lines.

As the arch bricks are laid it is possible to 'sight' down the bedding face of the arch brick (or use a string line or straight edge) and align it to the setting out on the arch centre.

- Using temporary nails or screws, fix a piece of ply behind the plywood used to set out the arch.
- Mark a parallel line 100 mm below the springing line and cut the two pieces of plywood simultaneously.

Fig. 14.29 Archcentre



- Fix the two pieces together with 90–140 × 35 framing pine between them so that the extrados of each sheet is square to the other.

An alternative construction method is shown in Figure 14.29. Here the ribs are built up by laminating together solid material, approximately 25 mm thick. From the full-size set-out, templates are prepared to mark out and cut the various rib sections which overlap each other and are nailed together. The bottom tie is essential, as the centre will tend to spread at this point as the load is applied.

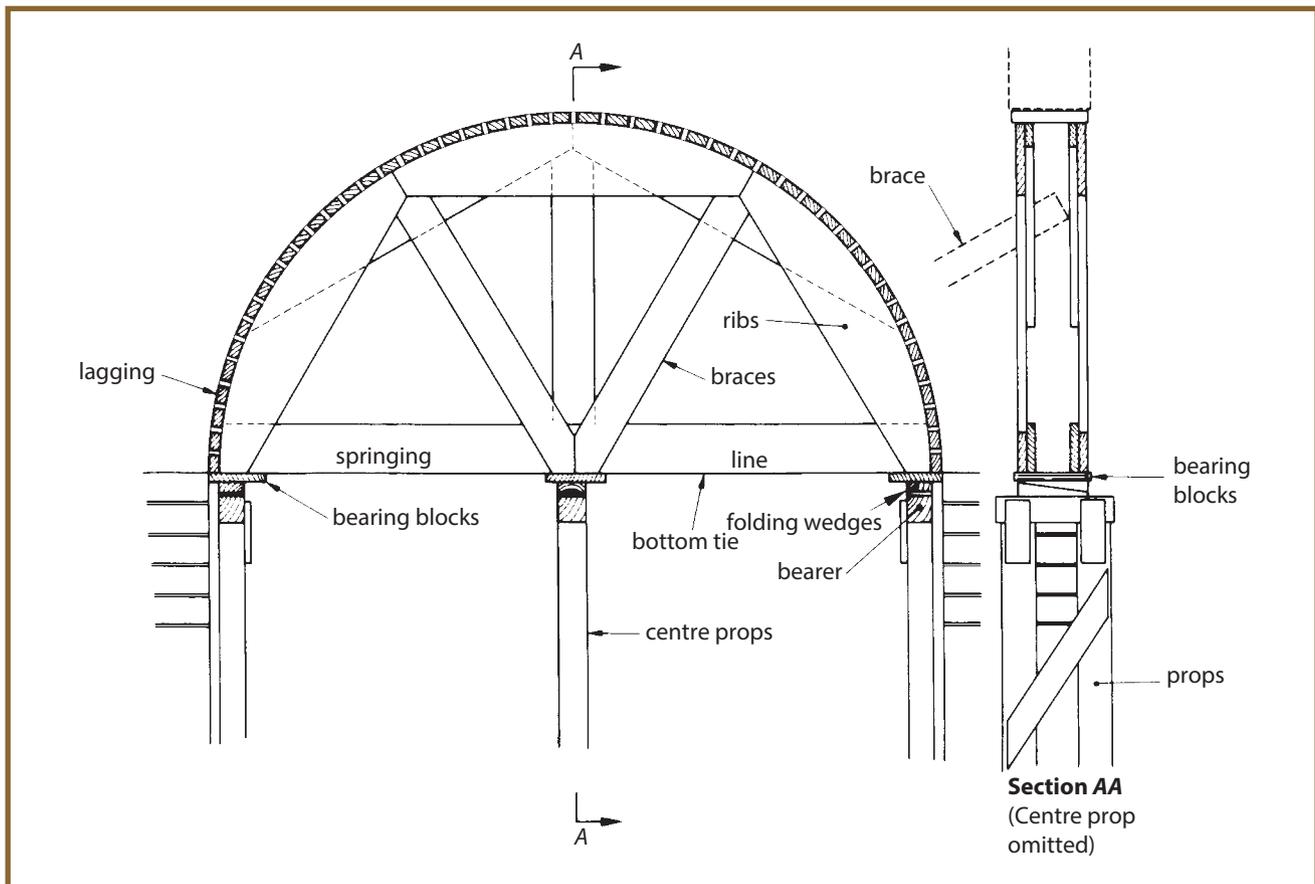
As the span and load increase, the ribs will have to be built up from a greater number of sections and some internal support may become necessary, particularly near the crown of the arch where the load is the greatest.

Supporting the centre

Centres are supported on props placed inside the jambs of the opening. These props must be sufficiently strong to support the loads, securely braced supported by **sole plates**.

Folding wedges should be used to level the arch centre and locate it in the correct position to facilitate removal of the centre when the arch is completed.

If the arch has been constructed properly and all joints are full and have achieved initial set, it is possible to carefully ease and then remove the centre. However, it is preferable to allow at least 24 hours. This will allow minor pointing and cleaning of the brickwork at the intrados as the mortar will not have fully hardened.

Fig. 14.30 Centre for a greater load

Student research

Taking into account the requirements of reinforced concrete masonry construction (see Chapter 14 Solid Masonry, Volume 1), set out a gauged and bonded semicircular arch using 200 series concrete blocks with a span of 2410.

1. How would you core-fill and reinforce such a structure?
2. Calculate the measurements of the arch blocks.

Refer to the Concrete Masonry Association of Australia for assistance (www.cmaa.com.au).

The Building Code of Australia

The Building Code of Australia (BCA) has the standing of building regulations throughout all states and territories through links in the various governments' legislation. The BCA ensures a high standard of consistency across Australia (some state governments, however, make variations to the BCA to accommodate local conditions).

The BCA contains technical requirements for the design and construction of buildings to achieve a minimum standard in particular areas like structure, fire safety and health. Different types of buildings are classified, for example, Class 1—single dwellings, meaning detached housing, townhouses, terrace houses, small guest houses, and Class 9—hospitals, theatres and schools.

The BCA comprises two volumes. Volume 1 covers commercial, industrial and public buildings and Volume 2 covers houses and other outbuildings. Volume 2 also includes structural design, energy efficiency, site preparation, footings and slabs, masonry, framing, roof and wall cladding, glazing, fire safety, health, safe movement and access.

The BCA is performance based. This means it defines the minimum levels of performance that must be met. The performance, however, allows flexibility in how the level of performance is achieved. This means that alternative solutions to design, materials and construction can be approved by the government authority, usually local or shire councils. Thus, it provides a dual approach—it defines a high degree of certainty along with a high degree of flexibility to take alternate approaches on the understanding that any different proposal must achieve the performance requirements of the BCA.

PART 6

Sustainable building

Chapter 15 Approaches to sustainability in construction

Lisa Jeffery

I completed the Certificate IV in Residential Drafting in 2007 and starting out working for myself, drafting for local builders in Darwin, Palmerston and the surrounding rural areas. I have since completed a Certificate IV in Training and Assessment and am now delivering the Building Design and Drafting courses at Charles Darwin University.

The drafting course taught me how to use AutoCAD to draw up plans that are designed with sound construction techniques, particularly for the cyclonic conditions, and using materials that are energy efficient and have a low embodied energy. The design side of the course had a strong focus on passive cooling so I was able to determine when it was best to use low thermal mass materials, like steel-framed walling and CFC cladding, or high thermal mass materials, like concrete blocks, to keep the heat out of shaded rooms.

My parents recently built their own house in a new subdivision of Palmerston and they needed an energy efficient design. A student designed them a house that barely needs air conditioning – even in the recent wet season. The design has high thermal mass blockwork that is amply shaded by the roof overhangs and the slab-on-ground really keeps the floor temperature cool.

High set, tinted louvre windows stop the glazing from letting too much heat in but the cross flow ventilation is captured all year round. The ventilated split-pitch roof over the central atrium allows all the hot air to rise up and out rather than getting trapped inside. We hardly need any mechanical cooling at all, despite having a poor orientation with the long sides of the house on the east and west sides due to the block of land it is built upon.



Approaches to sustainability in construction

LEARNING OBJECTIVES

- 15.1 Sustainability in construction
- 15.2 Legislation and sustainability
- 15.3 Sustainability practices on the building site
- 15.4 Sustainability terminology

The world is undergoing a period of intensified resource stress, driven in part by the scale and speed of population growth, the demand for raw materials from emerging economies and the increasingly high prices for those materials. In the modern world, the interface between the construction of a physical building and the impact on the environment (urban or rural, even the country and the planet) constitutes the field of sustainable development.

In this chapter we look at approaches to sustainability in construction primarily through legislated minimum requirements and sustainable building practices.

Sustainability in construction

Sustainable building is the term commonly used to describe the activity of building design and construction carried out according to sound environmental principles. This includes the effect of construction and building on the environment during all building phases—from the amount of energy used in the production of building materials and the waste produced during construction to the use of ecologically non-toxic substances and the eventual demolition of the building and the recycling of its materials. Sustainability in the built environment must also be taken into account during the planning of new developments, the extent of land exploited in development areas and the amount of roads and transportation needed to service the development.

Not every new building needs to be designed by an architect or be high-tech to be classified as sustainable. It is by being guided by the simple ideas and basic principles of building design and construction that we can ensure that environmentally friendly buildings become the norm. A building ‘consumes’ energy (see Fig. 15.1).

Strategies for sustainability

All types of construction have positive and negative aspects. For example, a timber building is easier to insulate but a masonry building is better suited to utilising passive solar gain; a timber building can be built from locally grown materials but one built from bricks could be recycled and used again. The choice

Fig. 15.1 Sustainable buildings—built with the environment in mind



Source: iStockphoto

of design, construction and materials must by necessity be related and based on environmentally sound principles for it to be classified as sustainable.

Strategies for energy efficiency include:

- designing for low-energy use by utilising superinsulation, airtightness and ventilation control; active and passive solar energy; day-lighting and solar control; efficient cooling and heating systems; and efficient lighting and appliances
- using low-embodied energy materials, preferably those locally sourced, relatively unprocessed and originating from a renewable resource, and limiting the use of high-energy materials.

Strategies for material use include:

- using unprocessed materials in the first instance such as solid timbers and natural stone, earth and clay and fibres and using local materials, if available
- using materials that can be re-used such as soft mortars for bricks and blocks, screw fixings, and limiting glues and composite materials

- minimising the use of new materials by revamping buildings for new uses, refurbishing whole buildings or building components and using recycled materials, if feasible
- using materials that will form a healthy interior environment, such as organic surface coatings, natural fibres, and not using formaldehyde glues in sheet products.

The energy consumption of buildings is our most significant issue if we are to reduce their environmental impact. Close to 20 per cent of all energy used in Australia is done so in the construction and operation of buildings. As much as 60–70 per cent of this energy could be saved by energy conservation strategies such as bulk insulation, double glazing, airtightness in specific climatic zones, use of passive design approaches, efficient heating and cooling systems (active systems), efficient appliances and landscaping to provide shade or wind protection appropriate to our different climatic zones.

Conservation strategies adopted by governments have been introduced through the following:

- building and design standards (e.g. BCA, Building Code of Australia; BASIX, building sustainability index)
- certification of trades processes and labelling programs (e.g. the Green Star program; WERS, the Windows Energy Rating Scheme)
- taxation incentives (e.g. insulation subsidies).

Energy conservation is as much about choosing the appropriate energy source as it is about saving that energy. In modern buildings, energy usually takes the form of electricity, predominantly supplied by the national grid and generated from fossil fuel combustion (coal or gas), hydropower or gas supplied from a natural reserve or as a product of fossil fuel combustion (coal gas).

A building 'consumes' energy (Fig. 15.2):

- through the manufacture of building materials and components (*embodied energy*)
- in the distribution and transportation of building materials and components to the construction site (*grey energy*)
- in the construction of the building itself (*construction energy*)
- in the operation of the building, its systems and appliances each year (*operating energy*).

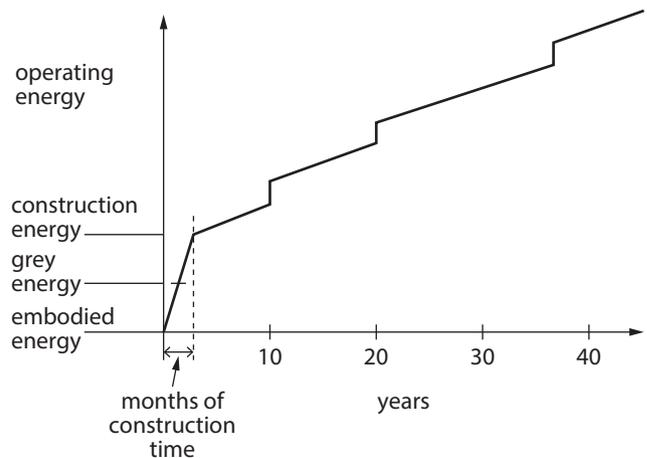
These types of energy are defined below:

- *Embodied energy* is the amount of energy used to extract and process a building material. It is expressed by the amount of carbon released into the atmosphere by the manufacturing process. The objective of a sustainable approach to building is to select materials and components that minimise this type of energy. The most straightforward way of doing this is to select materials that are used in their raw state (timber, stone, compacted earth), recycled (steel, crushed brick and concrete) or processed close to the building site.
- *Grey energy* is that energy consumed in transporting building materials from the manufacturer or quarry to the construction site. By supporting local industry and using local materials, this energy can be minimised. Where the building site is at a distance from the supply sources, the

energy cost will be higher. This type of energy is termed as 'grey' because it is usually not seen or accounted for.

- *Construction energy* is the energy used in the construction of the building itself and is the smallest energy component used in the overall building process. Like grey energy, it is often overlooked; however, this energy is important for running a construction site, avoiding waste generated by poor building procedures and the uneconomic use of water and irresponsible disposal of demolished or unused materials, along with general health and safety measures.
- *Operating energy* is the energy used in the operation of the completed building, along with its systems and appliances. This is the greatest amount of energy consumed and occurs after the building is handed over to the owner. This energy use receives the most attention by energy conservation measures such as building design strategies, the selection of materials and efficient heating and cooling systems, lighting and appliances. Operating energy is closely tied to the climatic zone in which the building is built, and the response to design and construction taken to minimise energy consumption will vary from climatic zone to climatic zone; however, generally every building will require some seasonal heating or cooling and day-to-night ventilation.

Fig. 15.2 Average embodied and operating energy usage for a house



Source: Adapted from Your Home website, 2013, *Embodied energy*, www.yourhome.gov.au/materials/embodied-energy

Making buildings low energy

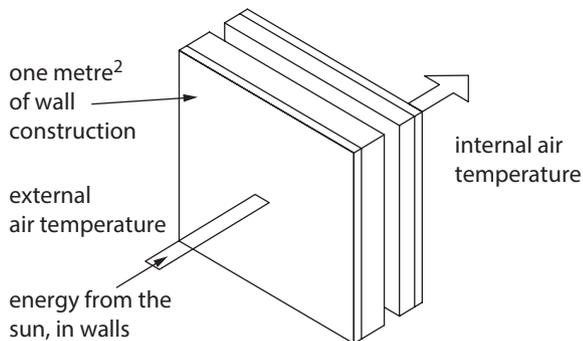
Low-energy buildings usually refers to a building's operating costs, that is, the amount of energy and the cost of it for heating or cooling a building to a comfortable temperature for human habitation. A low-energy building needs to be matched to the climatic zone in which it is built and requires sufficient thermal insulation to prevent heat gain or loss through the building envelope. Table 15.1 shows by building element a comparison between the approximate heat loss/gain for a traditional and a low-energy house in Sydney. As you can see, low-energy design practices save a large amount of energy.

Table 15.1 Approximate heat loss/gain for house (Sydney)

External envelope elements	Traditional house	Low-energy house
Air movement/leakage	25%	15%
Floor	10%	2%
Roof	15%	6%
Walls	25%	15%
Windows	25%	13%

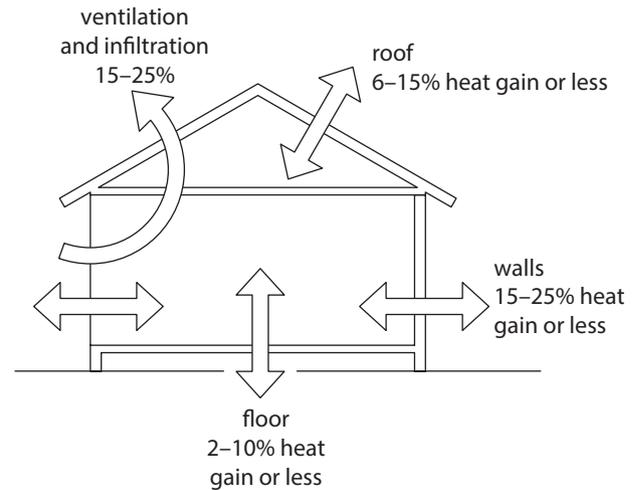
Every construction material has some ability to conduct heat. This thermal conduction value is called its *U-value* (sometimes expressed as an R-value, which is a reciprocal of the U-value, or $U = 1/R$). The U-value describes the flow of heat (usually air) passing through a one-square-metre part of the external envelope of the building, for example, a wall constructed in the brick veneer (Fig. 15.3).

The lower the U-value (or higher the R-value), the less the heat gain or loss moving through the wall from outside to inside. In order to achieve a particular interior thermal comfort level, the thickness of the wall would be increased as needed. In practice this does not happen, but a combination of different materials and bulk insulation is used in the construction of the wall to achieve the comfort level.

Fig. 15.3 U-value—the flow of heat through the external envelope

The greatest heat gains or losses are usually caused through air leakage of the external envelope. In traditional buildings this was usually through poor fitting windows and doors and uninsulated walls, roofs and floors. In a low-energy building greater attention is paid to the airtightness of the external envelope, which can reduce heating and cooling bills by increasing the efficiency of the insulation. An insulation layer is as effective as its airtight sealing.

Airtightness is a 'barrier' (a vapour barrier) made up from the combination of interconnected materials, sealed joints and components in the building envelope to provide a barrier against air leakage from outside to inside and vice versa. Air leakage through the building envelope accounts for up to one-third of heat gain and loss in modern buildings (Fig. 15.4). In humid environments, air leakage of warm air causes condensation to

Fig. 15.4 Heat gained or lost through the building envelope

occur within the building envelope, leading to mould growth in structural members, particularly in lightweight construction.

Energy conservation at all stages gives the greatest reduction of the impact of a building on the environment. The most important energy measures for achieving low operating energy are:

- using efficient thermal insulation on the external envelope of the building—the roof, walls, windows and floor; use either reflective foil or bulk insulation depending on the climatic zone
- ensuring that thermal or heat bridges are eliminated
- depending on the climate zone (see the Building Code of Australia), to construct either an open external envelope or an airtight external envelope, using a design that minimises heat gain or loss through its orientation and through natural or mechanical ventilation
- using energy efficient windows and glazing
- installing efficient heating and cooling systems that have the lowest energy consumption
- using thermal mass in the colder climatic zones.

Legislation and sustainability

State and territory governments in Australia, along with building industry agencies, have taken steps to address the major impacts of waste on the environment and the overuse of resources in construction through enacting legal frameworks, regulations and practices to govern sustainability on building sites. The commonwealth legal framework is that of the overall country, ensuring protection of the natural (land protection, water resources, biodiversity) and cultural (Indigenous culture, heritage works) environments. In addition, the Commonwealth provides advisory information and assessment tools for all those in the construction industry. These include:

- the Building Code of Australia
- standards for the use and composition of materials and practices (e.g. AS 1684 Residential timber-framed construction)
- energy efficiency guides

- waste management handling guides
- voluntary accreditation schemes, such as NABERS (the National Australian Built Environment Rating System) and Green Star.

State governments provide practical legal regulations for the building industry in each state, such as:

- applicable building standards
- health, sanitary and workplace safety standards
- environmental protection, for example, environmental protection Acts such as the *Environmental Protection Act 1994* (Qld)
- specific state and territory regulations, for example, ACTHERS (the ACT House Energy Rating Scheme), BASIX (the Building Sustainability Index, NSW) and 5 Star Plus (WA).

The local government focus for buildings is:

- planning and building permits to undertake works
- waste disposal and recycling of materials
- the provision of utility services such as water and sewerage.

Other bodies that operate within the building industry offer training, accreditation and information guides on procedures for sustainable practices for tradespersons and builders. These include:

- state and territory Masters Builders Associations (e.g. the Master Builders Association of NSW: www.mbansw.asn.au)
- the Master Plumbers' and Mechanical Services Association of Australia: www.plumber.com.au
- the National Electrical Contractors Association: www.neca.asn.au
- Housing Industry Association Ltd: www.hia.com.au
- Safe Work Australia: www.safeworkaustralia.gov.au
- Keep Australia Beautiful: www.kab.org.au
- EcoSpecifier: www.ecospecifier.com.au
- Good Environmental Choice Australia (GECA): www.geca.org.au
- Sustainable Choice: www.lgsa.org.au
- ECO-Find: www.ecobuy.org.au.

Sustainability practices on the building site

Storage of materials

Many materials are delivered to a building site during the construction phase. On a large building or multi-housing development the amount of materials to be handled can be extremely large. Thus the sensible placement and secure storage of materials until they are needed is critical. The construction sequence of the project is aided by the logical placement of materials, which eliminates the double handling of materials and improves the efficiency of the work flow.

Good storage decisions are crucial to reduce material wastage due to loss or damage. These include the following considerations:

- placing a waterproof cover over materials to protect them from the weather.
- separating materials into different groups relevant for each trade.

Fig. 15.5 Logical placement of building materials



Source: iStockphoto

- establishing enclosed storage areas (e.g. wire cages) to reduce accidental physical damage to materials; protect delicate and fragile materials; and contain loose materials, for example, sawdust, sand and gravels.
- providing a support structure for relevant materials to prevent distortions such as the warping, bowing and twisting of timber.
- establishing a safety enclosure for hazardous materials and substances and ensure PPE and related safety data sheets are available.
- erecting barriers during the construction phase to prevent heavy downpours from washing away loose material and waste and stopping polluted run-off entering the stormwater system.

Conservation of energy

The amount of energy used on a building site during construction is called *construction energy*, as mentioned on page 197. While small in comparison to the operating energy used over the building's life, it still counts for the builder during construction. The main energy source for construction sites is electricity, which in remote locations is generated via diesel or petrol from a generator.

Sources of energy waste are commonly:

- the use of old or inefficient equipment
- leakage from compressed air and LPG equipment that has been left on
- electricity from equipment being left on when not in use, including work lights, computers, air conditioning and vacuum equipment
- blunt equipment such as power saws, routers, drills, cutters, etc.

Dealing with waste materials

A distinction needs to be highlighted between waste materials and site rubbish. Waste on a building site usually comprises timber off-cuts, sawdust, plastic packaging materials, metal trimmings and broken glass. Site rubbish comprises domestic rubbish, paper wrapping, plastic cups, empty bottles and the like.

Table 15.2 lists the most common waste on building sites.

Table 15.2 Common waste on building sites

Liquid waste	Solvents; contaminated water from the wash down of equipment; rainwater run-off; any other liquid
Metal	Off-cuts, nails, straps, paint canisters, cans
Paper	Cardboard, packaging, boxes, documents
Plastics	Packaging and wrap, straps, Pownail strips, bottles, solid foams, Corflute sheets
Solid waste	Concrete, bricks, tiles, ceramics, plaster, render, sand
Timber	Off-cuts, sawdust, MDF, plywood protection sheets

The builder or site supervisor is responsible for waste materials and site rubbish. The separation of these rubbish types is an important part of good site management (Fig. 15.6).

Fig. 15.6 Building waste and site rubbish should be separated



Source: iStockphoto

Site management

Across Australia, state and local laws require that a building site is clean and ordered to both protect the environment and the workers on site. On-the-spot fines for site litter and larger fines for waste material and pollution from a site into the immediate environment can be issued by local governments and state agencies. Good site management can eliminate this occurring and produce a professional image for the building industry. Other positive outcomes of good site management include the following:

- A well-organised and clean site is a safer workplace.
- Clients will equate an efficient site with good workmanship.
- A clean and efficient site will save money for the client, the builder and each individual tradesperson by minimising material damages and site accidents.

Sustainability terminology

It is important to identify, source and use environmentally and socially responsible materials and products. Table 15.3 lists common sustainability terms to assist with this goal.

Table 15.3 Common sustainability terms

Access	Inclusive design principles should be used to cater for all disabled people and all those with specific needs
Biodiversity	The variety of all living things; the different plants, animals and micro-organisms, the genetic information they contain and the ecosystems they form
Carbon dioxide (CO ₂)	A greenhouse gas that is colourless and non-toxic; a product of burning fossil fuels and the main contributor to climate change
Climate change adaption and mitigation	Commonly thought of as extreme weather events such as drought, storms, cyclones, heavy rains and floods caused by the increase in greenhouse gases in the atmosphere brought about by the burning of fossil fuels
Conservation	Preserving the resources we have and using them in a cautious manner that does not deplete them for future generations
Ecological footprint	A measure of human demand on the earth's ecosystems
Ecosystem	An area of natural habitat that contains living organisms. One ecosystem interacts with another, so a disturbance in one will affect another
Embodied energy	The amount of energy used to manufacture and process a building material; measured by the amount of CO ₂ released by the process to extract it and manufacture the material
Embodied water	The volume of fresh water used to produce a particular product, measured at the place where it was produced
Energy	Energy comes in many forms and can be converted from one form to another. Energy is always conserved, as governed by thermodynamic laws
Environment	All that surrounds us: air, earth, water, vegetation
Environmental management	The strategic arrangements made to reduce the environmental impacts of a development or an organisation's operations
Environmental site analysis	An assessment of a building site for its vulnerability to flooding, rainfall run-off, bushfire, habitat contamination and endangered species
Fossil fuel	A naturally occurring substance created over millions of years that is used as a fuel
Greenhouse gases	Natural and human-made gases that absorb and re-emit infrared radiation. The main gases are water vapour, carbon dioxide, methane, nitrous oxide and hydrofluorocarbons

Health and wellbeing	Buildings should promote healthy environments and lifestyles for users. This includes workplace health and safety for all site workers and the promotion of healthy lifestyles through eliminating hazardous substances, health checks and extended education programs
Job safety analysis	An assessment of a building site to identify hazards and risks to workers' health
Life cycle	A series of changes in the life of a material or building component or system. Included is the cost of acquiring the product, installing the product, operating it, repairing it over its useful life and disposing of it
Natural materials	Materials of zero-embodied energy found in nature requiring no processing. These include tree trunks and branches, tree bark, tree wattles, and mud, clays, stones and grasses
Natural resources	Raw materials available for human activities, e.g. forests are a resource for timber
Processed materials	Materials subjected to high-energy or chemical processes, such as reconstituted timber products including hardboards and chipboards; manufactured bricks, including clay, concrete and silica lime products; roofing tiles including terracotta clay-based tiles; and concrete/cement products
Pollution	Contamination of the environment or an ecosystem by substances that are harmful to living organisms
Supporting communities	Consideration of the effect of a building development on the local community. The building industry needs to become involved and establish how development will improve an area
Sustainability	The ability to continue activities without exhausting the available resources or degrading the environment. This includes economic, social and natural aspects

Sustainable development	A development or building project that meets the needs of the present without adversely affecting the ability of future generations to meet their needs
Synthetic materials	Materials (usually of high-embodied energy) that have little or no natural content. These include the category loosely called plastics
Transport and mobility	Consider opportunities for sustainable transport of workers and materials throughout the building phase. Priority of walking, cycling and public transport should be emphasised
Trade and labour standards	Consider if clients, contractors and supply chains are meeting accepted labour standards. Ensure there is no exploitation of cheap labour and that acceptable working conditions are provided
Waste	Materials that are surplus to those needed for a project. These need to be minimised by re-using, recycling and recovering throughout the construction phase and across the supply chain
Worked natural materials	Materials (of low embodied energy) that occur naturally but are mechanically worked to make them more useful in building, such as split and sawn timber, dressed timber, slates, dressed stone, lime and gypsum
VOC	Volatile organic compounds. These compounds become a colourless and pungent gas at room temperature, which causes watery eyes and nausea, skin irritations and difficulty in breathing

Student research

Make a list of businesses in your local area that sell recycled building materials and note the kinds of materials that each one sells.

Sustainability and suppliers

It is important that the suppliers you use act in a sustainable manner and meet the basic standards of environmental performance. Just as you are applying sustainability principles to your trade, you should expect that others in the supply chain do the same. The majority of the highest environmental impact occurs in the supply chain beyond your control.

Recommended sustainability expectations for suppliers:

- They are proactive in improving the sustainability aspects of their products.
- They comply with relevant Australian Government policies.
- They look to reduce the environmental and social impacts associated with the use of their products.
- They are innovative and constantly seek out areas of improvement for the sustainability of their products.
- They are interested in improving sustainability in the supply chain of their products.
- They are responsive to your questions on sustainability.

Glossary

1/3 fixing method a method of fixing plasterboard ceiling sheets where extra fixings are placed at 1/3 spacings across a plasterboard sheet together with adhesive spaced between these fixings

A

AAC autoclaved aerated concrete. Lightweight concrete that is manufactured by adding aluminium paste to the sand, lime and cement mix. This causes a chemical reaction which releases gas bubbles into the mix and aerates the concrete making it lighter

abutments the jambs of the wall or pier supporting the arch

awning sash top pivoted sash

B

backblocking technique applied to reinforce the joints between sheets of plaster by fixing smaller pieces of plasterboard behind the finished surface but over joints between plasterboard sheets

backpropping after formwork has been dismantled, all concrete previously supported by the formwork is stripped and temporary props are installed underneath it to allow work to continue on the new floor above

barefaced mortise-and-tenon joint a mortise and tenon that has only one shoulder

blockboard see *coreboard*

bolection moulding moulding that finishes higher than the framing

bond beam a course or courses of blockwork that are core filled with concrete poured around reinforcing steel to form a reinforced concrete beam. The beam may support roof framing and may also tie a series of vertical core filled blocks together to form a concrete framed structure.

bullnose step the curve to the first riser in a flight of stairs

butt hinge hinge commonly used for fitted doors

butt joint two flat surfaces brought into contact and secured with nails, screws or adhesives

butt joints when two sheets of plasterboard are butted together and there is no recessed edge to reduce the height of reinforcing tape and joint material above the plasterboard surface

butter a term used to describe how a trowel or a similar tool is used to apply an adhesive or mortar coating in a swiping motion to materials to be laid or fixed in place

C

carcase the basic unit of furniture and fitments

casement sash side-hinged sashes

codes of practice practical guides to achieving the health, safety and welfare standards required under WHS legislation. They represent the lower tier of the WHS hierarchy which includes the Act, the Regulation and codes of practice. They must be approved as a code of practice and are admissible in court proceedings. Compliance with an approved code of practice is considered to demonstrate compliance with WHS legislation

construction work defined in the Model Regulations as any work carried out in connection with the construction, alteration, conversion, fitting out, commissioning, renovation, repair, maintenance, refurbishment, demolition, decommissioning or dismantling of a structure

conventional fixing method the conventional method of fixing plasterboard sheets is to fix around the perimeter of the plasterboard sheet with screws or nails while the internal

area of the board is laid against adhesive placed onto metal or timber framing that is to be 'plastered or lined'

coreboard plywood type with central core of timber strips bonded together

creeper cuts the bricks cut into the extrados of an arch

crown the upper half of the arch

D

daylight line the edge of daylight seen through a window

dead load permanent load due to weight of materials

door (flush) smooth-faced door

door (hollow core) a door with infill of expanded cardboard

door (solid core) a door with blockboard infill

doorset door plus frame (jamb)

double mortise-and-tenon a joint used where a rail is much wider than the stile

double-hung sash vertically sliding sashes

dovetailed tee halved joint a halved joint where one half is dovetailed into the other

dowel borer horizontal boring machine for dowelling

dowelled joints framing and carcass joints using dowels fitting into mating holes

dowelling jig a metal guide to boring dowel holes

draw boring preparing holes for draw pin, where one is slightly offset to draw a joint together

draw pin a wooden peg used to draw a joint together after draw boring

drop stripping a high risk practice that does not comply with the formwork code of practice. Formwork is partially dismantled and then dropped as a single item rather than a section at a time.

duty of care a reasonable and responsible person is expected to act cautiously and with foresight and logic while being attentive to the potential for damage or injury to others. To act otherwise would be considered negligent

E

extrados the external circumference of an arch

F

face work first quality masonry work—bricks or blocks—that is finished with a clean 'face' free of mortar smears and the joints are properly finished e.g. round iron finish. Face work masonry is the final finish. There are no surface coatings and the masonry is seen. The face side of a brick or block is the side that is laid level and plumb

false deck the extension of a formwork platform of deck beyond the formwork that will actually support poured concrete and is used as a scaffolding or work platform

fanlight a sash placed over a door opening

feather a tongue used to join timber

fox wedges wedges concealed in a stump mortise-and-tenon joint

framed and panelled door a frame-type door with panels fitted to grooves or rebates

framed ledge door a framed door sheathed with vertical boards

franking projection on stile in a sash joint

furring channels U-shaped sections of light gauge steel that are fixed to the underside of a floor so that suspended plasterboard ceilings can be fixed to them and supported

G

glazing fitting of glass to sashes

glazing bar bar dividing glazing in sashes into small sections

going the horizontal distance covered by a step
going of flight the total horizontal distance covered by a flight of stairs
green blocks concrete masonry blocks are made by placing wet concrete into a mould. After the initial set the concrete block is released from the mould and cured in a heated chamber. Freshly moulded blocks are given the term 'green'. The same term applies to masonry walls after they have been laid and the mortar has not properly set. Wet, partly set mortar or concrete has a dark green appearance

H

half-lapped joint a joint where the two members' thicknesses are halved (halved joint)
handrail bolt a heavy duty joiner of timber in length
hanging door fixing a door and its hardware into its frame
Harmonisation a process applied by the state, territory and federal governments to provide consistency in the implementation of legislation across different state and territory and commonwealth jurisdictions. With WHS this has meant the development of model legislation by the Commonwealth to be adopted by the states and territories
haunch the part of the arch from the springing line to the crown
haunch the portion of tenon left near shoulder to prevent rail from twisting in stile; part of arch from springing line to crown
haunched mortise-and-tenon framing joint to ends of stile
head top horizontal member of door jamb
head trimmer (head) beam supporting load over a window or door opening in wall framing
high risk construction work hazardous construction work that has the potential to harm the health and safety of people or to damage plant and equipment. Specific activities that are defined in the regulations require a relevant SWMS
hopper sash bottom-pivoted sashes
horn waste left on stile while joint is being worked

I

inlay moulding moulding that finishes below the level of the framing
intrados or soffit the internal circumference or underside of an arch

J

jamb lining milled to fit into door opening and rebated to accept door

K

key the central voussoir in masonry arches; it is often decorated in a distinctive way
knockdown fitting a clamping device for assembly of carcass framing

L

lightweight truss common timber domestic-type truss
live load load to the use of an area
long and short shoulder mortise-and-tenon a joint where the shoulders are of different lengths
low angle of incidence a reference to the low angle of a light source that lights a finished surface area, such as painted plasterboard. The lower the angle of incidence, the more likely that shadows will highlight surface imperfections

M

MDF board see *medium-density fibreboard*
medium-density fibreboard manufactured board of wood pulp with added adhesives
mortise board a holding device on a bench for timber being mortised or chopped
mortise gauge a marking tool with two spurs to mark out mortises
mortise-and-tenon joint framing joint for stiles and rails
mouldings timber ornamentation
mullion vertical divide between sash of window
muntin vertical frame members dividing door panels into smaller sections

N

nap a reference to the length of the pile on a paint roller
nogging horizontal blocking fitted between studs to hold studs straight and for fixing linings
nosings the front edge of the tread

O

overlaid door a cabinet door fitted over carcass
overlay hinge hinges for overlaid doors

P

panelling fixing of plywood sheets to walls
particleboard manufactured material formed by bonding together flakes of wood and pressing them into a dense sheet
piano hinge a continuous hinge
plasterboard a layer of set gypsum or plaster between two layers of heavy duty paper to form a board which is used to line wall and ceiling framing
principal contractor a person who has management or control of a workplace where construction work is undertaken. Under WHS legislation they have specific responsibilities. Additional responsibilities are applied once the value of the construction work reaches \$250 000
progressive collapse the effect of formwork collapsing from one point through to another with the mass of collapsing concrete, reinforcing and wet concrete causing damage to adjacent formwork structures and causing those to also fail

R

rail horizontal member connecting stiles
reinforced concrete masonry contains embedded reinforcing steel that imparts the strength and characteristics or reinforced concrete. In the case of hollow masonry blocks that are core-filled, the blockwork acts as a formwork
rise of flight the total vertical distance covered by a flight of stairs
rise the vertical height of the arch from the centre of the springing line to the underside of the crown. Also, the vertical distance covered by a step
riser shutter the board retaining the concrete for the rise of the stair
riser the board forming the vertical face of the step
rough-in 'the rough in' of gas, water, drainage and electrical services is the initial installation of these services before the final fittings are connected and the services are commissioned

S

sash cramp a cramp for cramping wide joinery items
sash joint a modified mortise-and-tenon joint for stiles and rails

saw kerfing a method of bending timber by a series of close saw cuts

scribed joint a joint where mouldings intersect, where one member is fixed and the other mitred at half the angle of intersection and then cut out by coping saw to the contour formed

shiplap timber milled for one member to overlap the next

shoulder line the line on rail where it meets the face of the stile

shutter normally a reference to the 'plywood' used to form the internal mould and finish of formed concrete

simulated panel door solid door where design is routed into panel

single leaf construction a single load-bearing masonry wall with no cavity to prevent moisture entering a building. The wall supports the roof framing and must be waterproofed with an external coating to prevent internal dampness

site safety audit a methodical process of identifying and listing all potential work hazards in a workplace and then identifying appropriate risk management strategies that have been or need to be applied

skewbacks the immediate sloped masonry that supports the bricks of a segmental arch

skirting moulding to cover the joint between floor and wall lining

slip-tongue joint a joint used for joining segments in curved work

soffit decking formwork in contact with the underside of the stair and landing

span the horizontal distance between the abutments

springing line the horizontal line from which the arch commences; the points at each end of the spring line are referred to as the *springing points*

starter bars steel reinforcing bars that are left protruding above finished concrete or core-filled concrete masonry. They allow different phases of work to be completed at different times. As a new section of work is started the starter bars overlap and connect with the steel reinforcement in the new section to structurally connect two different phases of concrete or reinforced concrete masonry

stile vertical side member of a frame

stopped housed joint a joint where the housing is stopped short at face edge

stretcher bond bonding in masonry is the lap of one block or brick over another to strengthen the wall. When the lap is equal to

half the length of the masonry units being used it is termed 'stretcher bond' or 'half bond'

stringer a member laid over the top of the formwork which supports brackets that prevent the riser shutter bulging in the centre

string shutter provides fixing at each end for the riser shutter and retains the concrete at the sides of the stair

substrate underlying layer that a surface finish, such as paint, plasterboard or ceramic tiles, is applied or fixed to

T

tongue and groove jointing system for timber boards where one side is grooved to allow the insertion of a tongue from the adjacent board

tongued and trenched joint a joint where a tongue on one piece engages a trench in the other

traffic control plan for the construction industry, a traffic control plan documents the steps to be taken to minimise the risk of motor vehicle related accidents and interruption of traffic flow adjacent to where building or construction work is being undertaken

transom a horizontal member dividing doors or sashes in window or door frames

traversing planing diagonally across a board

twin mortise-and-tenon a joint used where rails and stile are very thick

U

unreinforced concrete masonry masonry that has no embedded reinforcing steel to increase the tensile strength of the masonry but may have embedded joint reinforcement to stop joint cracking

V

voussoirs the arch bricks forming the arch; voussoirs are supported by mutual pressure from their neighbours; the joints in voussoirs should always be normal to the curve of the arch

W

wedge allowance space provided for wedges, as in mortise-and-tenon joints

wind load load due to wind action

A

AAC block construction, *see* autoclaved aerated concrete block construction
 access, sustainability, 200
 adjustable screw jacks, 156
 airtightness, 198
 aluminium window, 176
 angle box joints, 85
 AQF, *see* Australian Quality Framework
 arch centre, 182, 187, 191–3
 arch construction
 categories, 181
 set out, 181–7
 terminology, 180–1
 architraves, 49
 astragal moulding, 125
 Australian Quality Framework (AQF), 151
 autoclaved aerated concrete (AAC) block construction, 171–2
 solid masonry residential using, 173
 awning sashes, 98–9
 axle pulleys, 111

B

backblocking
 butt joint in plasterboard wall lining, 61
 of joints, 57–8
 backpropping, 152
 baluster, 130
 balustrade, 130
 barefaced mortise-and-tenon, 76, 77
 bath, installation of, 37–8
 BCA, *see* Building Code of Australia
 beam centre, 151
 benchtops, laminated timber, 148
 bending moment, 22
 bending timber, 123–4
 bullnose step, 123–4
 laminated thin veneers, 124
 saw kerfing, 124
 spacing of cuts, 124
 bevel, setting, 89
 biodiversity, 200
 biscuit joints, 84–5
 biscuit machine, 140
 block prefix number, 165
 block series number, 165
 block suffix number, 165
 bolection moulding, 116
 bolt with cross dowel, 141
 bond beams, 167–9, 176
 for raked/cathedral roof framing, 175
 bonded semi-circular arch, 181
 box square, 105
 bracing, in pole frame construction of trusses, 28–9
 Building Code of Australia (BCA), 34, 129–30, 194
 building materials, logical placement of, 199
 building sites, common waste on, 200
 built-in units, dimensions of, 138
 bullnose step, 123–4
 butt gauge, 48, 49
 butt joints, 61, 85
 in ceilings, backblocking, 63, 64
 over framing, 59
 recessed joints and backblocked, 58–9
 with slip tongue, 140
 buttons, for fixing, 95, 96

C

cabinet drawers, 143–5
 dovetailed drawers, 144
 mass-produced drawers, 145
 mechanical drawer runners, 144
 overlaid drawer, 143–4
 rebated drawer fronts, 144
 camber, 24
 carbon dioxide (CO₂), 200
 carcass construction, 139–41
 carcass dowelled joint, 140
 carcass joints, 85–93
 butt joint, 85
 dovetail joint, 88–93
 dowelled joint, 87–8
 housed joint, 86–7
 mitred joint, 86
 shelf support, 87
 tongued and tenoned joint, 85
 carriage slab, 159
 casement sashes, 98
 casement window sash, rods
 for, 104
 cauls, 124
 cavetto moulding, 125
 ceilings
 backblocking of butt joints in, 63
 combined fastener adhesive system for, 62
 lining installation, 62–3
 sheets, 40
 cellulose insulation, 69
 circular column, formwork systems
 for, 154
 climate change, adaptation and mitigation, 200
 closed string, 130
 CMAA, *see* Concrete Masonry Association of Australia
 CO₂, *see* carbon dioxide
 codes of practice, 4
 coding of masonry units, 165, 166
 coil ties, 164
 commonwealth legal framework, 198
 communities, supporting, 201
 composite sheet building materials, 164
 compression, 22
 concealed hinges for particleboard, 141–2
 concrete beam, formwork for, 152, 153
 concrete column, formwork systems
 for, 153–4
 Concrete Masonry Association of Australia (CMAA), 165
 concrete masonry blocks, 165–7
 bonding, 167
 coding of masonry units, 165, 166
 mortar, 167
 concrete slabs, formwork for, 155–6
 concrete stairs
 formed and poured, 158
 formwork for, 157–60
 concrete wall, formwork for, 162–4
 connector plates, 24
 conservation, 200
 conservation of energy, 199
 construction, *see* arch construction; carcass construction; door construction; Jack arch construction; single leaf construction; slab-on-ground construction
 construction energy, 197, 199

construction work, 3–4
 control joints, 176–8
 conventional fixing method, 63
 core-filling, 170
 using concrete line pump, 173
 cornices, 63
 correct gauge, 183, 184
 cramps, sash, 95, 108
 cross dowel, bolt with, 141
 cupboard doors, *see* timber cupboard doors
 Cupolox dome system, 155
 curved formers, 124
 curved section, constructing, 119–21
 curved work
 formers for, 124
 joints for, 121–3
 cut string, 130
 cyma recta moulding, 125
 cyma reversa moulding, 125

D

damp proof course (DPC), 168, 174
 daylight line, 101
 depressed gothic arch, 189
 depth stops, 83
 diagonal bracing, 155
 “Direkta” screws, 141
 dog-leg mitre, 126
 door block, 45
 door construction, 114
 door frame
 fixing details, 177
 semicircular-headed
 construction of, 119–20
 joints for, 120
 sash for, 120–1
 door hanging, 45–9
 butt gauge, 48, 49
 fitting and hinging of doors, 47–8
 fitting, jamb with loose stop, 48
 slide-in door sets, 45–7
 door types, 114–17
 cupboard, 143
 four-panel, 115
 framed and panelled, 115–16
 framed ledge, 114–15
 joinery, 114
 simulated panelled, 116–17
 doorsets, 41–5
 door types, 42
 jamb linings, 42–4
 fixing, 44–5
 standard dimensions of door opening, 41–2
 double-hung windows, 99
 set-out rod for, 113
 spiral spring balance in, 113
 double mortise-and-tenon, 75–6
 dovetail drawers, 144
 dovetail joints, 88–93
 alternative method for making, 92–3
 common, 88–90
 lapped, 90–2
 dowel borer, 84
 dowel jig, 83
 dowel with cam, 141
 dowelled carcass joints, 140

dowelled joints, 80–4, 87–8, 121–2
 for curved work, 122
 making, 82–4

DPC, *see* damp proof course

draw boring, 134

draw pins, 120

drawer fronts, rebated, 144

drawer runners, mechanical, 144

drawers

cabinet, 143–5

dovetailed, 144

mass-produced, 145

precut, 145

unit, 137

drip groove, 100

drop stripping, 152

dutch gable roof, 26, 27

duty of care, 3

E

ecological footprint, 200

ecosystem, 200

edge plasterboard ceiling lining,
 recessed, 54

embodied energy, 197, 200

embodied water, 200

energy, 200

grey energy, 197

energy conservation, 197, 198

energy consumption of buildings, 197

energy efficiency, strategies for,
 196–197

energy waste, sources of, 199

environment, 200

environmental management, 200

Environmental Protection Act, 199

environmental site analysis, 31, 200

equilateral arch, 188

exterior door openings, 52

external angle corner bead, 57

external open-riser stair, 131–3

F

'face work,' in concrete masonry, 167

false deck, 151

fanlight, 119

fasteners, 55–6

faults in mortise-and-tenon joint, 73, 74

FC fabrications, *see* fibre cement fabrications

feathers, 124

federal *Work Health and Safety Act 2011*, 151

fibre cement (FC) fabrications, 151

field, 116

filler units, 137

fillet moulding, 125

finger gauging, 104

fixed sashes, 98

fixing, 40

table tops, 95–6

fixing jamb linings, 44–5

flat arches, 187

flat-dowel joint, 140, 141

flax insulation, 69

flush doors, 42

footing systems for AAC wall system, 174

form spacers, 163

form ties, 163

formaldehyde, 148

formply, 151, 153

formwork

for circular column, 154

for concrete column, 153–4

for concrete slabs, 155–6

for concrete stairs, 157–60

for concrete wall, 162–4

design, 152–6

finish, 152

for lightweight concrete beams, 152

materials, 151

modular, 150

for slab-on-ground construction, 155

soffit, 152

standards, 151–2

for suspended reinforced concrete, 155–6

fossil fuel, 200

framed ledge door, 114–15

framing joints, 72–84

framing members, 72

franking, 102, 107

friction stay, 98

G

gable roof, 25

gambrel roof, *see* dutch gable roof

gauged arches, 181

gauging, 78

lapped dovetail joint, 91

glass, 113

float, 113

thicknesses for windows, 113

glass line, 101

glazing bars, 101

glazing, of windows, 113–14

with glazing beads, 114

with putty, 114

good storage decisions, 199

gothic arches, 188

gouges, scribing, 107

graphic set-out, 15–17

'green' blocks, 165

green carpenter, role of, 7

greenhouse gases, 201

grey energy, 197

grooved panelling, 41

H

half-lapped joint, 80

hand basin installation, 65

hand tools, 55

handrail bolt, 122

handrails, 130, 136

hanging doors, *see* door hanging

haunch, 73, 76

splayed, 76

head, of window, 100

health

and safety legislation, 2–3

and wellbeing, 201

hemp insulation, 69

hinges for particleboard, 141–2

concealed, 141–2

piano, 142

hipped roof, 26

with oblique end, 10–14

calculations, 14

distances and side cuts, 14

obtaining under purlin bevels, 14

rafter lengths, 11–13

roof bevels, 11–12

setting out of wall plates, 10–11

of unequal pitch, 14–18

erecting, 17–18

graphic set-out, 15–17

hollow core blocks, shell bedding of, 167

hollow core doors, 42

honeycomb doors, *see* hollow core doors

hopper-type sash, 99

horizontal sliding sashes, 99

horn, 72

housed carcass joint, 140

housed joints, 86–7

I

inlay mouldings, 116

interior fittings, 137–48

interior timber stairs, 133–6

interior wall sheeting, 40–1

plasterboard, 40

plumbing and straightening wall

frames, 41

plywood, 41

internal joinery, 137–48

internal plasterboard, three-coat paint

systems for, 65–8

intersecting roofs, 26, 27

J

Jack arch construction, 187, 192

jamb linings, 42–4

job safety analysis (JSA), 5–6, 31, 201

jointing, 93

internal and external corner, 59

joints, 72–84

angle box joints, 85

biscuit, 84–5

butt joint, *see* butt joints

carcase, *see* carcase joints

control joints, 176–8

for curved work, 121–3

dowelled, 122

light plywood tongue, 122

using handrail bolt, 122

dovetail, 88–93

dowelled, *see* dowelled joints

dowelled carcase, *see* dowelled carcase

joints

feather, 93

flat-dowel, 140, 141

framing, 72–84

franked, 102

half-lapped, 80

haunched mortise-and-tenon, 72–5

housed carcase joint, 140

housed joints, 86–7, 140

loose tongue, 93

machine-made sash joint, 102

mitre, 63, 86

for mouldings, 125

mortise-and-tenon, *see* mortise-and-tenon joint

for mouldings, 125–6

dog-leg mitre, 126

mason's mitre, 126

mitre joints, 125

scribed joint, 125–6

rebated carcase, 140

recessed joints, *see* recessed joints

- sash, 102
 assembly, 108
 cleaning, 109
 cutting, 103
 marking out, 105–6
 scribed, 50, 125–6
 slip-tongue, 121
 stump mortise-and-tenon, 77
 tongued and trenched, 85
 twin mortise-and-tenon, 77
 for widening boards
 cleaning, 95
 gluing up, 95
 jointing boards, 93–5
 matching boards, 93
- JSA, *see* job safety analysis
- K**
- KD fittings, *see* knockdown fittings
 king post, 22
 king rod, 22
 kitchen cupboards, 137–9
 dimensions, 138
 measuring up for, 138–9
 knockdown (KD) fittings, 140–1
- L**
- labour standards, trade and, 201
 laminated plastic sheets
 fixing, 146–8
 trimming, 147
 laminated thin veneers, 124
 laminated timber, 125
 benchtops, 148
 fixing to carcass, 148
 mitre of corners, 148
 laminated veneer lumber (LVL), 151
 lancet gothic arch, 188
 landings, arrangements of, 130
 laundry tub installation, 69
 lay bars, 101
 ‘lazy Susan’, 137, 138
 legislation and sustainability, 198–9
 levelling base frames, 157
 life cycle, 201
 lifting, 27–8
 light plywood tongue, 122
 lights, 101
 lightweight timber, 23–4
 lintels, 168–70, 175
 load, 22–3
 dead, 22
 live, 22
 wind, 22
 lock rail, 115
 long and short shoulder mortise-and-tenon, 76
 low angle of incidence, 56
 low-energy buildings, 197–8
 LVL, *see* laminated veneer lumber
- M**
- machine-made sash joint, 102
 masonry arch, 180
 masonry units, coding of, 165
 masonry walls, using adhesive, 61
 mason’s mitre, 126
 mass-produced drawers, 145
 MDF, 182
 mechanical drawer runners, 144
 medium density fibreboard core
 doors, 42
 metal dowel, with cam, 141
 mineral-based building resources, 179
 minimum overhead clearance, flight of stairs, 130, 131
 mitigation, climate change adaptation and, 200
 mitre joints, 63, 86, 125
 mitre template, 107
 mobility, transport and, 201
 modular formwork systems, 150
 mortar, 167
 mortise-and-tenon joint, 72–7, 134
 barefaced, 76, 77
 double, 75–6
 double barefaced, 76, 77
 faults in, 73, 74
 haunched, 72–5
 long and short shoulder, 76
 making, 77–9
 modifications to, 73–5
 stump, 77
 twin, 76, 77
 mortise gauge, 121
 setting, 78
 mouldings, 116, 124–8
 astragal, 125
 bolection, 116
 box square for, 105
 cavetto, 125
 diminishing, 127
 enlarging width, 126
 and thickness, 127
 inlay, 116
 joints for, 125–6
 dog-leg mitre, 126
 mason’s mitre, 126
 mitre joints, 125
 scribed joint, 125–6
 ovolo, 125
 planted, 116
 raking, 127–8
 development of, 128
 scotia, 125
 torus, 125
 traditional, 125
 mouse, 111, 112
 mullion, 100
 multicentred arches, 181
 muntin, 115
- N**
- nail plates, 23, 24
 nap, 65
 natural materials, 201
 natural resources, 201
 newel string, 130
 nosing, 130, 134
- O**
- obtuse arch, 187
 1/3 method, 63
 operating energy, 197
 Oregon (Douglas fir), 151
 organic insulation materials, 69
 overlaid drawer, 143–4
 ovolo moulding, 125
- P**
- panels, door, 115–16
 flat-sunk, 116
 flush, 115–16
 raised, 116
 paper-backed gypsum plaster sheeting, 54
 particleboard, hinges for, 141–2
 patent column formwork, 154
 PERI AW stopend system, 153
 Personal Protective Equipment (PPE), 55
 piano hinge, 142
 pipe spacer, 163
 pivot-hung sash, 99
 plasterboard, 40, 54
 blocks, backblocking of butt joints in ceilings, 63
 direct fixing to masonry walls, 61–2
 tools, 55
 types of, 54–5
 plasterboard finish, 56–60
 backblocking of joints, 57–8
 jointing procedure, 58–60
 levels of, 56–7
 plasterboard internal lining systems, 54–6
 accessories, 56
 fasteners, 55–6
 hand tools, 55
 jointing and finishing systems, 55
 PPE, 55
 specialised equipment, 55
 types of, 54–5
 plasterboard wall linings, 60–2
 direct fixing of plasterboard to masonry walls, 61–2
 fastener fixing to timber/metal wall framing, 61
 fixing linings to timber/steel wall framing, 60
 sheet layout for, 61
 plastering for recessed joints, 58
 platform floor, 35
 plumb, checking walls for, 138
 plumbing, 41
 plywood, 41
 plywood tongue, use of, 122
 pocket piece, 109
 pollution, 201
 polystyrene forms, waffle slab using, 155
 polyvinyl chloride (PVC), 151
 PPE, *see* Personal Protective Equipment
 precut drawers, 145
 principal rafters, 22
 processed materials, 201
 progressive collapse, 151
 PVC, *see* polyvinyl chloride
- R**
- rafter lengths, 11–13
 rails, 72, 102
 effective width of, 75
 marking out, 106
 and stile, joint between, 75
 ramps, 160, 162
 rebated carcass joint, 140
 rebated drawer fronts, 144
 recessed joints
 and backblocked butt joints, 58–9
 plastering for, 58

reinforced concrete masonry, 167, 168
 removal of forms, 153
 ring beam, 175, 176
 ripping, tenon, 78, 79
 riser, 130, 134
 rods
 for casement window sash, 104
 for double-hung window with spiral spring balances, 113
 for framed ledge door, 114–15
 for kitchen cabinets, 145
 marking out from, 105–8
 setting out, 102–5
 Rondo battens, backblocking of butt joints in ceilings, 63
 roof bevels, 11, 12, 15
 roof framing, 175
 connect to, 169–70
 roof trusses, 22–31
 roofing, 10–21
 hipped roof, *see* hipped roof
 scotch valley roof construction, 18–20
 rotating circular shelf, 137
 rough arches, 181
 rough-in, 54

S

safe work method statement (SWMS), 5–6
 Safety Regulations 2011, 151
 sash cords, repair of, 109–12
 sash parts, 101
 lay bars, 101
 light, 101
 rails, 102
 stiles, 102
 sash stock, 101
 sash winders, 99
 sashes, 100–1, 120–1
 awning-type, 98–9
 casement, 98
 cramp, 95, 108
 fixed, 98
 marking out, 105–8
 for semicircular-headed door frame, 120–1
 vertical sliding, 109–13
 sash-stile groove for spring balance, 113
 saw kerfing, 124
 SBS, *see* sick building syndrome
 scaffolding, 151
 scotch valley roof construction, 18–20
 scotia moulding, 125
 scribed joint, 50, 125–6
 segmental arches, 183
 segmental gothic arch, 187, 189
 semicircular arch, 182
 semicircular-headed door frame, 119–21
 sheet lifting equipment, 56
 shell bedding of hollow core blocks, 167
 shiplap, 41
 shower base, installation of, 35–7
 shower recess, wet area lining system for, 66
 shutters, 159, 160
 string
 adjustment of, 161
 bracing, 160
 setting out, 159
 sick building syndrome (SBS), 39

sill, 100
 single-centred arches, 181
 single leaf concrete masonry
 construction, 167–71
 bond beams and lintels, 168–9
 core-filling, 170
 quantities of materials, estimation, 171
 reinforced concrete masonry, 167, 168
 retaining walls, 170
 roof framing, 175
 connect to, 169–70
 slab-on-ground construction, 168
 suspended floor construction, 168
 unreinforced concrete masonry, 167, 168
 window and door installation, 171
 single leaf construction, 165
 sinking, 39, 100
 site management, 200
 site safety checklist, 5
 site sustainability audit, 31
 skirting, 50
 slab, carriage, 159
 slab-on-ground construction, 155, 168
 slab-on-ground footing system, 174
 slide-in door sets, 45–7
 slip-tongue joint, 121
 snap ties, 164
 soffit decking, 157
 soffit formwork, 152
 sole plate, 193
 solid core doors, 42
 solid masonry, 165–79
 concrete masonry blocks, 165–7
 external surfaces, 177, 179
 residential construction, using AAC blocks, 173
 single leaf concrete masonry construction, 167–71
 solid-rebated window frame, 100
 spiral spring balances, 112–13
 set out for, 113
 stairs, 130
 bullnose step, 123–4
 concrete, formwork for, 157–60
 construction, 129–36
 cutting out, 133
 dimensions, 129–31
 external open-riser, 132–3
 fixing, 133
 general layout of, 129
 interior timber stairs, 133–6
 setting out, 132–3, 135–6
 terminology, 130
 standard dimensions of door opening, 41–2
 standard floor unit, 137
 starter bars, 168, 174
 concrete column, 154
 steel square, use of, 132, 133
 steel trusses, 29
 stiles, 72, 102
 joint between top rail and, 75
 marking out, 105–6
 straightening wall frames, 41
 striking point, 181
 string, stair, 130
 setting out, 132–3, 135, 136
 stump mortise-and-tenon joint, 77
 substrates, 56

suspended ceiling systems, accessories for, 57
 suspended floor construction, 168, 174
 suspended reinforced concrete, formwork for, 155–6
 sustainability, 201
 audit, 31
 in construction, 196–8
 legislation and, 198–9
 practices on building site, 199–200
 and suppliers, 202
 terminology, 200–1
 sustainable building, 196
 sustainable development, 201
 SWMS, *see* safe work method statement
 synthetic materials, 201

T

table tops, fixing, 95–6
 telescopic frame, 155
 tenon, ripping, 78, 79
 tension, 22
 three-centred arch, 187, 190
 three-coat paint systems for internal plasterboard, 65–8
 first coat—sealer, 65
 preparation, 65
 second and third coats—finishing, 65–8
 threshold, 52
 threshold ramps, 162
 throating, 100
 tie beam, 22
 timber building, 196
 timber cupboard doors, 143
 plywood-panelled, 143
 timber-framed buildings, 52
 timber/metal wall framing, fastener fixing to, 61
 timber panelling, 41
 timber prop, 158
 timber/steel wall framing, fixing linings to, 60–1
 tongue panelling, 41
 tongued joint, 85
 topping coats, 55
 torus moulding, 125
 trade and labour standards, 201
 traditional timber staircase, 133, 134
 trammel, 185
 transome, 119
 transport and mobility, 201
 traversing, 95
 tread, 130
 trench, cutting, 80, 81
 trenched joint, 85
 triangular pitch board, to string, 132
 trims, 49–52
 architraves, 49
 exterior door openings, 52
 fixing, window openings, 50–2
 skirting, 50
 trusses, 22–31
 bracing, 28–9
 camber, 24
 construction, on site, 23–4
 designs, 23
 dutch gable roof, 26–7
 erection, 28–30

- fixing, 24–5, 29
- forces, 22–3
- gable roof, 25
- hipped roof, 26
- intersecting roof, 26, 27
- king post, 22
- king rod, 22
- lifting, 27–8
- principles, 22–3
- roof shapes and truss layouts, 23–7
- storage, 27–8
- wall framing support, 24
- Tudor (or four-centred) arch, 190
- turning block, 123
- turning piece, 182, 191, 192
- twin mortise-and-tenon joint, 76, 77

U

- U-value, 198
- underside of stairs, view of, 135
- unequal pitch, hipped roof of, 14–18
- unreinforced concrete masonry, 167, 168

V

- vanities, installation of, 39
- veneer trimmer, 147
- vertical sliding sashes, 99, 109–13
- volatile organic compounds (VOC), 148, 201
- voussoirs, 181

W

- waffle slab, using polystyrene forms, 155
- wall formwork, 163
- wall framing, 62
- wall linings, plasterboard, 60–2
- wall plates, setting out of, 10–11

- wall string, 130
- wall tie (pipe spacer), 163
- waste materials, 201
 - dealing with, 199–200
- waterproofing, 63–5
- weathering, 100
- wedge allowance (WA), 72, 76
- wedges, 72, 73
- wellbeing, health and, 201
- wet area, 34–9
 - bath, installation of, 37–8
 - lining systems, 65
 - set out of, 34–5
 - shower base, installation of, 35–7
 - sinks, installation of, 39
 - vanities, installation of, 39
- wheel arches, 183–6
- WHS act, *see* Work Health and Safety Act 2011 (Cth)
- widening boards, using biscuits, 84
- window frames, 98
 - finishing, 100–2
- window manufacture, 100–2
- window parts
 - head, 100
 - mullion, 100
 - sill, 100
- window sash, 98
- windows, 98–102
 - aluminium, 176
 - box-frame, 109
 - repair of, 109–12
 - replacing sash cords, 111–12
 - glazing of, 113–14
 - with glazing beads, 114
 - with putty, 114

- head of, 100
- manufacture
 - sash joint, 102
 - sashes, 100–1
 - solid-rebated window frame, 100
 - window frames, finishing, 100–2
- types, 98–9
 - awning sashes, 98–9
 - box frame, 109
 - casement sashes, 98
 - double-hung, 99
 - fixed sashes, 98
 - hopper-type sash, 99
 - horizontal sliding sashes, 99
 - pivot-hung sash, 99
 - vertical sliding sashes, 99

- wood fibre insulation, 69
- wood wool insulation, 69
- wooden runners, 104
- wool insulation, 69
- work health and safety, 2–7
 - analysing workplace hazards, 4–5
 - legislation, regulations and codes of practice, 2–4
 - management plan, 7
 - SWMS and JSA, 5–6
- Work Health and Safety Act 2011 (Cth) (WHS Act), 2, 3
- worked natural materials, 201
- workplace hazards, analysing, 4–5
 - risk categories, 5
- worktops, 145–8

Y

- yoke, 153–4

WORKSHEET CHAPTER 1 Work health and safety

Date

Student

1 Identify and list the key components of the national safety framework of legislation and guidelines.

2 List two of the aims of the *WHS Act 2011*.

3 Which chapter in the *WHS Regulation 2011* addresses the specific work health and safety needs of the construction industry?

4 When must a principal contractor be engaged on a construction project?

5 What is the difference between the *WHS Act* and the *WHS Regulation*?

6 What is the definition of construction work according to the *WHS Regulation*?

7 What are the duties imposed on the principal contractor by the WHS Regulation?

8 What duties are imposed on workers by the WHS Regulation?

9 What is the first step in analysing safety hazards in the workplace?

10 What type of construction work requires the use of a safe work method statement in accordance with the WHS Regulation?

WORKSHEET CHAPTER 2 Advanced roofing

Date _____

Student _____

1 Why do the level differences measurements need to be found for the side cuts of hip and creeper rafters?

2 What is meant by 'level shortening'?

3 Explain why the distance from the acute angle corner of the oblique end to the centring rafter is equal to half the end plus half the offset.

4 Why are the walls for an unequally pitched roof at different heights?

5 At what angle must the rule be held when marking off the shortening distance for the crown end rafter as measured from the plan?

6 Which two roofs are covered in this chapter?

7 In setting out an unequally pitched roof, what is the reason for moving the XY line down to the fascia line?

8 Explain, using relevant diagrams, how the true length of the common rafters to an unequally pitched roof can be calculated.

9 Describe, using sketches if necessary, a practical method by which the unequally pitched hip in an unequally pitched roof can be marked to length and fixed.

10 What is the best method to determine the length of the hip rafters?

WORKSHEET CHAPTER 3 Roof trusses

Date _____

Student _____

1 What advantages does trussed roof framing have over conventional trussed framing?

2 What is meant by the following terms?

a live load _____

b wind load _____

c compression force _____

d bending moment. _____

3 What documentation is usually required by local building authorities before approval is granted for the use of roof trusses in any construction?

4 Why are lightweight timber trusses built with a camber in the bottom chord?

5 Why may it be necessary to strengthen the wall framing that supports girder trusses?

6 Describe the precautions that should be adopted to protect lightweight timber roof trusses from damage during storage and lifting.

7 Describe briefly in point form both the procedure for erecting lightweight timber roof trusses and the safety precautions that should be taken.

8 Describe two forms of wind bracing used with lightweight timber roof trusses.

9 When erecting trusses for a hip roof, what is the first truss to be positioned?

10 Why is it necessary to have clearance between the bottom chords of trusses and internal walls?

WORKSHEET CHAPTER 4 Wet areas

Date _____

Student _____

1 List three types of wet areas.

2 What Australian Standard deals with waterproofing?

3 How is the height of the checkout for a shower base calculated to suit a platform floor?

4 What needs to be installed in the corner of the shower recess before the wall lining is installed?

5 What are two methods for a shower base to be bedded down to a floor?

6 How can the height of the bath tub be determined?

7 What is the dwarf wall on the end of a bath called?

8 List three reasons extra noggings are installed into bathroom walls.

9 Once the wall linings and the tile underlay are installed, what needs to be applied to the walls and floor?

10 List four trades that have jobs to do in the construction of a bathroom.

WORKSHEET CHAPTER 5 Internal fixing

Date _____

Student _____

1 Where plasterboard is used as an interior lining, show, by sketch if necessary, how the board is fixed to the wall studs and how flush joints are made.

2 What are the standard sizes for single doors?

3 Select one type of flush door and describe its construction.

4 When making up a set of door jambs, how would you determine the length of the stile?

5 When fixing a set of door jambs, how would you ensure that the head will be level?

6 Indicate in a sketch what distances must be gauged to hinge a door correctly to a rebated jamb using butt hinges.

7 In what sequence should architraves around a door be installed?

8 What general procedure should be adopted when fixing skirting boards to a room? Give an example.

9 Describe the joint you would use to join a skirting board at an internal corner.

10 What is the function of the following members when used to finish around a window opening?

a architrave _____

b nosing _____

c elbow lining _____

d apron mould _____

WORKSHEET CHAPTER 6 Internal linings

Date

Student

1 Who is responsible for any final deviation from minimum tolerances for finished plasterboard surfaces?

2 What level of finish for plasterboard would be best for a semi-gloss decorative finish in dark green on a feature wall?

3 What is an acceptable level of finish for plasterboard surfaces inside wardrobes, and why?

4 What length of ring shank nail is required for 10 mm plasterboard fixed to softwood framing? What length would you use for 13 mm plasterboard, and why?

5 Internal linings for bathrooms must meet specific requirements in terms of fixing. What are these requirements and why are they needed?

6 Butt joints between horizontal wall sheets may be formed over a stud. What is the difference between a butt joint over a stud and a butt joint between studs?

7 When must recessed joints in ceiling linings be backblocked?

8 Explain the difference between backblocking for ceiling sheets when the sheets have a recessed joint and when they have a butt joint.

9 Should plasterboard sheeting be fixed directly to the lower member of a roof truss? Explain your answer.

10 In reference to Figure 6.27, which shows an unenclosed shower over a bath, if a half-screen was fitted to the side and against the wall where the shower head is located, what impact would this have on the extent of waterproofing required? Explain your answer.

WORKSHEET CHAPTER 7 Joinery joints and products

Date

Student

1 Where would a haunched mortise-and-tenon joint be used, and why is it suitable in this situation?

2 When setting out dowels on the end of a rail, what is the minimum distance the dowels should be kept from the edge?

3 Show how the pins for a common dovetail joint would be set out on the end of a piece of timber 100 mm × 12 mm.

4 What are three methods of joining boards to make a wide piece of timber?

5 What joint is used to lengthen a piece of timber?

6 How does a bridle joint differ from a mortice-and-tenon joint?

7 Describe briefly how the dowel jig would be set up for boring dowel holes.

8 How would a mortise gauge be set when gauging a mortise-and-tenon joint?

9 How is a tabletop held down to the frame?

10 What are two forms of dovetail joints?

WORKSHEET CHAPTER 8 Window and door construction

Date _____

Student _____

- 1** List five types of windows and indicate for each type how the sashes operate within the frame.

- 2** Draw the profile of a typical casement window sill; name each part and state its purpose.

- 3** Illustrate with a sketch what is meant by the description 'a six-light sash with two vertical bars and one lay bar'.

- 4** What is the purpose of a joiner's rod?

- 5** What views are shown on the rod for most joinery items?

6 What information is required on a cutting list?

7 What information must be provided to select the correct spiral balance for a pair of vertical sliding sashes?

8 List five steps carried out when renewing cords to a pair of box-frame sashes.

9 List five types of panels that can be found in doors.

10 Draw a horizontal section through a framed and panelled door, incorporating the following features: plough grooves, raised panels, muntin, bolection mouldings, inlay mouldings.

WORKSHEET CHAPTER 9 Curved work and mouldings

Date

Student

1 In a door frame, what is the purpose of a transome?

2 Why are full-sized elevations necessary when preparing a rod for making up a curve-headed door or window frame?

3 How can excessive waste be avoided when cutting out curved segments from planks?

4 What is meant by the term *draw boring* as applied to curved joinery items?

5 By means of sketches, name and illustrate at least three joints suitable for joining curved segments as would be found in a curve-headed window sash.

6 List three methods that can be used to bend timber.

7 Describe and illustrate with sketches, if necessary, how a stair riser could be bent around a curve by means of saw kerfing.

8 Set out the outline of the following traditional mouldings:

a ovolo

b astragal

9 Illustrate and describe the following:

a the dog-leg mitre

b the mason's mitre

State two situations where the development of raking mouldings is necessary.

WORKSHEET CHAPTER 10 Stair construction

Date _____

Student _____

1 With reference to stair construction, define the following terms:**a** rise of flight _____
_____**b** going _____
_____**c** stair string _____
_____**d** tread _____
_____**e** newel _____
_____**f** balustrade _____
_____**2** State a formula that is commonly adopted for calculating a suitable rise and going for a stair.

3 Show the necessary calculations to determine a suitable rise and going for a stairway with a rise of flight of 2140 mm and no restrictions on the going.**4** What is the minimum height for a handrail above the nosings?

5 Show how a pitch board is used to set out a stair string.

6 Show in a sketch how strings are set out in pairs.

7 Draw a vertical section through the tread, riser and nosing of an interior stair. Where is a newel placed relative to the riser?

8 Which document details the dimensions and relevant information for stair design and construction?

9 List two items that can be used to set out a staircase string.

10 State which type of stair would generally be used:

a outside a building _____

b inside a building _____

WORKSHEET CHAPTER 11 Internal joinery

Date _____

Student _____

1 What type of prefabricated units usually form the basis of a domestic kitchen installation?

2 State a suitable dimension for the following:

a height to hanging rail of wardrobes _____

b depth of wardrobes _____

c width of kitchen benchtops _____

3 State four checks that should be carried out when measuring up an area for the installation of prefabricated units.

4 What advantages are there in using knockdown fittings in carcass construction?

5 What type of hinges are used when fitting an overlaid door?

6 Where is a piano hinge often used?

7 In what way is the bottom usually fixed into a cabinet drawer?

8 Illustrate, with sketches, four edge finishes that can be applied to kitchen benchtops.

9 Describe how a large sheet of laminated plastic could be lined up accurately over a benchtop prior to fixing with a contact adhesive.

10 Describe briefly how a rod can be set out for interior cupboard units.

WORKSHEET CHAPTER 12 Formwork for stairs and ramps

Date _____

Student _____

1 What are the main drivers of changes to formwork systems?

2 List three different types of materials used to manufacture formwork and the type of formwork system manufactured.

3 Can formwork be used as scaffolding to install formply? Explain your answer.

4 How many people are permitted to check underneath suspended formwork as concrete is being poured?

5 List the three most important safety issues when suspended formwork is constructed. Why have you chosen these issues?

6 If a single sheet of formply were to burst just before the concrete pour has been completed, what should be done immediately?

WORKSHEET CHAPTER 13 Solid masonry

Date

Student

1 What is the code for a hollow 300 series $\frac{3}{4}$ block?

2 When placing the bed joints on hollow concrete blocks, is it necessary to place mortar on the cross-webs?

3 How is a stretcher bond or half bond set out at with an external corner using series 150 blocks?

4 What is the difference between reinforced and unreinforced concrete masonry?

5 What type of reinforcement is used in unreinforced masonry and what type is used in reinforced masonry?

6 Where is the reinforcement generally located in reinforced concrete masonry?

7 What is the slump for the concrete used to core-fill hollow masonry blocks?

8 Why is the drainage line behind a retaining wall located at the base of the footing?

9 Where are controls joints located in AAC wall systems and what are the maximum spacings between control joints?

10 How is the roof framing tied on to the AAC wall system?

WORKSHEET CHAPTER 14 Arch construction

Date _____

Student _____

1 Define the following terms as applied to a masonry arch:

a span _____

b rise _____

c springing line _____

d intrados _____

e voussoirs _____

f key brick _____

g extrados _____

h striking point _____

i summering circle _____

2 How does a *rough arch* vary from a *gauged arch*? _____

3 Calculate the radius of a segmental arch of span 1640 mm and rise 450 mm.

4 Draw a part-drafted sketch to show the outline of a 230 rough segmental arch. Include setting out geometry.

5 Draw the set-out for a Tudor arch with a span of 730.

6 On a suitable surface, such as plywood, set out an ellipse with a major axis of 700 mm and a minor axis of 400 mm using the pins and thread method. At any point on the circumference, draw a normal and a tangent.

7 Set out the outline of a depressed Gothic arch with a span of 730. Include setting out geometry.

8 Set out the outline of a segmental Gothic arch with a span of 730. Include setting out geometry.

9 Set out the outline of a 230 bonded wheel arch with a span of 610. Include all arch bricks.

10 When erecting the centre, what provision must be made so that it can be adjusted and removed readily?

WORKSHEET CHAPTER 15 Approaches to sustainability in construction

Date _____

Student _____

1 What is 'embodied energy' in a building material?

2 What strategies for using construction materials can aid sustainability?

3 What is 'sustainability' in relation to building construction?

4 What is the most effective energy-saving measure for achieving low-operating energy in a building?

5 What are the energy use phases of a building?

6 Name two energy strategies that can reduce energy consumption in buildings.

7 Name four critical practices to ensure sustainability on the building site.

8 Name the Commonwealth Government's main legal document that governs building construction throughout Australia.

9 Which person on a building site is responsible for waste management?

10 List three good storage decisions that reduce material wastage on a building site.
