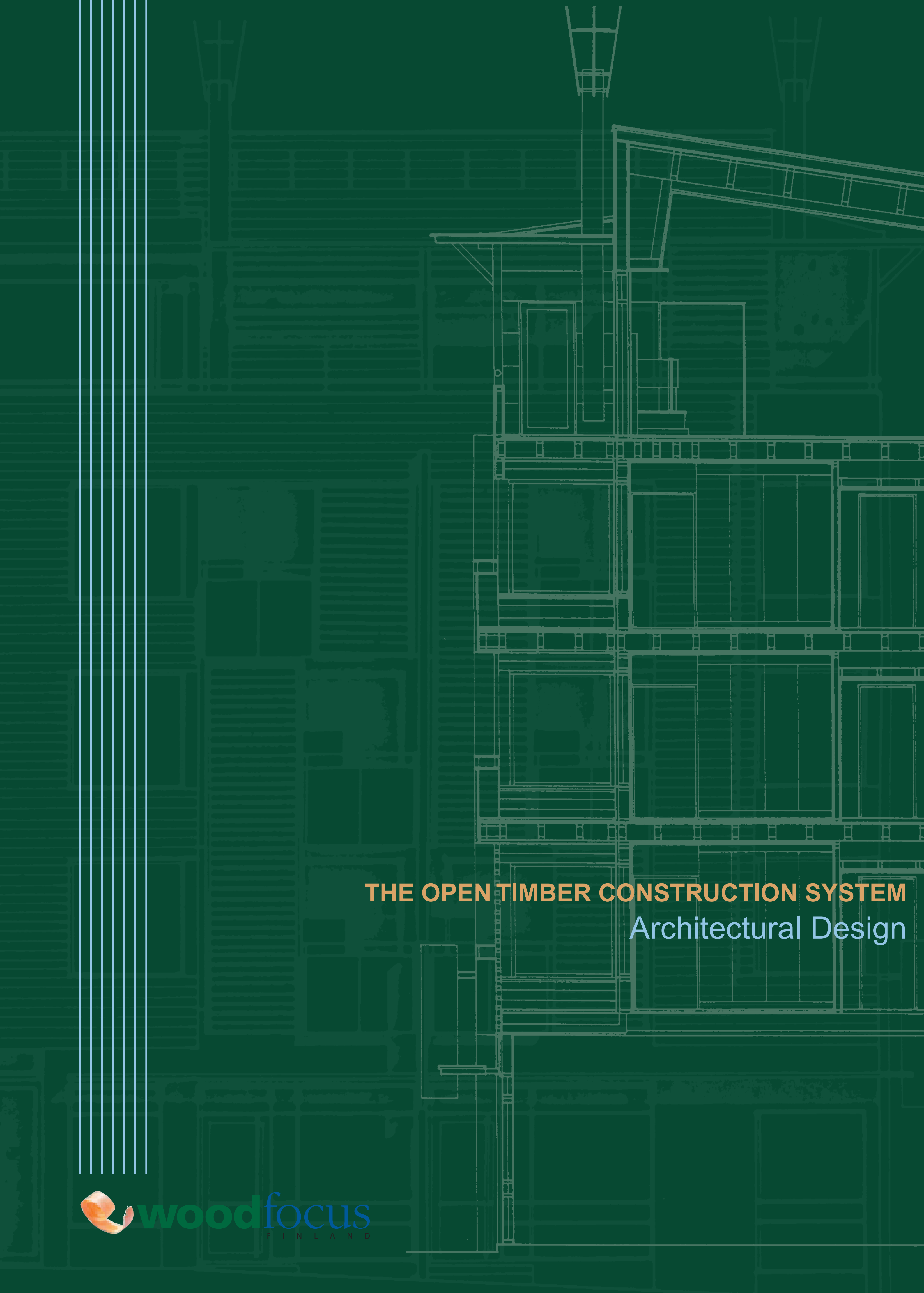

THE OPEN TIMBER CONSTRUCTION SYSTEM

Architectural Design

woodfocus
FINLAND

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The open timber construction system – Architectural Design

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FOREWORD

During the last decade in Finland, substantial progress has been made in the development of new timber construction methods. This progress has resulted in the accumulation of extensive new knowledge on the subject and has increased the use of timber in the building industry. The development to date, after initial experiments with small details within private companies at the beginning of the process, has resulted in the unfolding of a new timber construction system that is based on a joint, general and open industrial standard.

The result is an extensive single system that consists not only of systems related to products, information and manufacturing methods but also of regulations and general design principles that attempt to incorporate all of these factors. The system is based on universally approved principles and is available to all. Its basic construction principles and details cannot be patented or trademarked. Other key characteristics include the compatibility and interchangeability of parts or components within the system. Whenever necessary, a part of the system or a particular product can be replaced by another equivalent product from a different manufacturer. This allows free competition between different parties and different manufacturers' products.

The purpose of this construction system is to provide a competitive and realistic production method that responds to the differing needs of various situations and to the requirements of different clients. The system allows buildings to be designed and realised with the use of industrially manufactured components from various suppliers both separately and jointly.

The development process and its results have also attracted international interest. Consequently, it has been concluded that an international version of this guide is needed. The guide describes a timber construction procedure, which plays a fundamental role within the overall open timber construction system, as it stands in its current level of development. The aim of the guide is to describe and explain the system and illustrate its potential within architectural design.

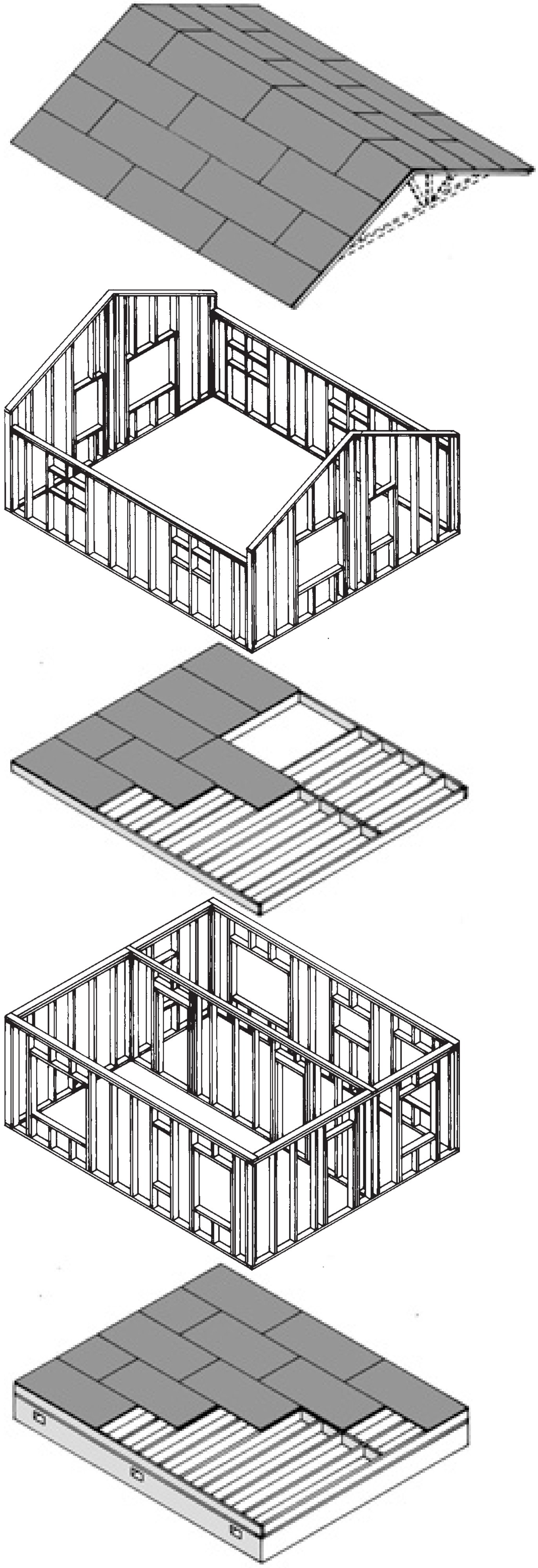
The guide is based on a system that is currently being used in Finland and on Finnish building regulations in general. However, in parts, the guide has deviated from these and therefore it has had to generalise certain issues. It has seemed inappropriate to suggest the use of the Finnish building regulations, as such, within the international context, although the basic ordering principle of the guide, of initially describing the restrictions concerning buildings of different sizes and then offering various solutions to these, still appears useful. A short study of the theory concerning the building system more broadly has also been added at the beginning of the guide. The theory was originally devised for the use of industry in order to facilitate the understanding of the system and to order and control its further development. The guide is meant for free distribution.

May 2003

Mikko Viljakainen

Return address: www.puuinfo.fi/palaute

CONTENTS



INTRODUCTION

The purpose of this guide is to introduce the open timber construction system and to illustrate its impact on the architectural design of a building. Furthermore, it lists those building regulations that affect timber buildings and presents some model structures that comply with these regulations.

The guide is directed towards architects, students of architecture and students of building construction, but it is also suitable as a general handbook for all those working within the field of timber construction. Its aim is to demonstrate the basic design parameters that the timber construction provides. The guide deals mainly with the design of residential buildings. Whenever appropriate, it can also be used as reference in the design of other building types.

The solutions presented in this guide can also be found as dwg-files on www.woodfocus.fi/ammatilaiset -> select puucad.

Contents of the Guide

The guide has been divided into seven chapters. The first one describes the open timber construction system and its principal features. The chapter outlines the structural and construction principles of the system and their impact on architectural design.

The second chapter describes the framing system. This chapter introduces the materials and the dimensions that are commonly used in the frame. It also covers frame components and the basic junction and joinery techniques used within the frame and examines those factors that generally affect the horizontal and vertical dimensions of open timber construction. In addition, it describes the necessary settlement provisions within a timber frame, which have to be made during the architectural design stage, and also presents some model example solutions.

Chapter three discusses the design in regard to fire safety, sound insulation, thermal insulation and damp proofing of timber buildings. The chapter describes their requirements for the structure and introduces design principles formulated to acknowledge these.

The fourth chapter lists the factors imposed by technological services within timber buildings. Chapter five illustrates how the design of a timber building should be represented to the construction site, in order to gain maximum outcome from the overall production.

The sixth and the seventh chapter demonstrate some model structures for detached buildings and apartment blocks.

In order to further complement and develop this guide, Wood Focus Oy wellcomes feedback from its users. Return address: http://www.puuinfo.fi/palaute

Figure 1.(opposite page)
The frame of the building is erected floor by floor. The walls of the ground floor level are assembled on top of the ground floor deck. The next floor is built on the walls of the floor below. The following walls are assembled on the floor previously completed etc.

Notes on translation

The vocabulary and terminology used in timber construction in general, and open timber construction system in particular, differs greatly from one English-speaking country to another. In general, this guide adheres to the British usage, but special note has been made whenever a particular term in one country means something different in another (see for example ‘trimmer’ below). In order to avoid confusion and misunderstanding, a glossary of terms has been added to clarify the vocabulary and to provide other alternative terms (or nearest equivalents), from other English-speaking countries, whenever necessary.

Glossary of terms (Br.=British, Am.= American)

- Cripple stud below or above opening (Br.), spacer (Am.) = Trimmed stud below or above an opening, joining lintel or sill to a sole plate or a wall plate.
- Cripple stud that supports another stud (Br.), jack stud that supports a king stud (Am.) = An extra trimmed stud at the side of an opening attached to a full length stud.
- Headbinder (Br.), wall plate (Br., Am.), top plate (Br., Am.) = The topmost plate of a wall frame.
- Headbinder (Br.) + Wall plate (Br.), double top plates (Am.) = A combination of the two plates at the top of a wall frame.
- Header joist (Br., Am.), rim joist, band joist (Am.) = A joist at the end of floor joists that encloses the floor frame.
- Herring-bone strutting (Br.), truss bracing (Am.), cross-bridging (Am.) = The stiffening of a floor on common joists by bridging between them with pairs of light struts forming crosses.
- Lift shaft (Br.), hoistway (Am.) = The vertical opening in a building through which a lift car and counter-weight travel.
- Nogging (Br.,Am.), dwang (Scotland) = Short horizontal timber usually cut to fit between vertical studs or other structural timbers.
- Parallel grain plywood (Br.), laminated veneer lumber (Am., Br.) = Timber that is produced by bonding together veneers from a log. The resulting panels are then cut into structural sized sections.
- Sill plate (Br., Am.), sometimes cill plate (Br.) = A plate under ground floor joists, on top of sleeper walls
- Sole plate (Br.), bottom plate (Am.) = A plate at the bottom of the wall frame
- Spandrel panel (Br.), gable end truss (Am.) = Roof truss that forms the gable end of a building. (The term spandrel panel is sometimes also used in other contexts).

- Trimmer joist (Br.), header (Am.), bridle (Scotland) = A joist that encloses one side of a rectangular opening in a timber floor, carrying trimmed joists, which are cut from full-length joist to make the opening. Another trimmer joist forms the side opposite and parallel to it. These trimmer joists carry trimming joists.
- Trimming joist, ring joist (Br.), trimmer (Am.), double trimmer (Am.), double stringer (Am.) = A joist parallel to the other joists, possibly thicker. It is usually fixed with another, and carries trimmer joists.
- Verge (Br.), gable end eaves (Am.) = The sloping edge of a pitched roof above a gable.
- Wall plate (Br.), head plate (Am., Br.), top plate (Am.) = A plate under headbinder. Sometimes wall plate is used to describe all the plates within a wall frame.

1 THE SYSTEM

1 THE SYSTEM

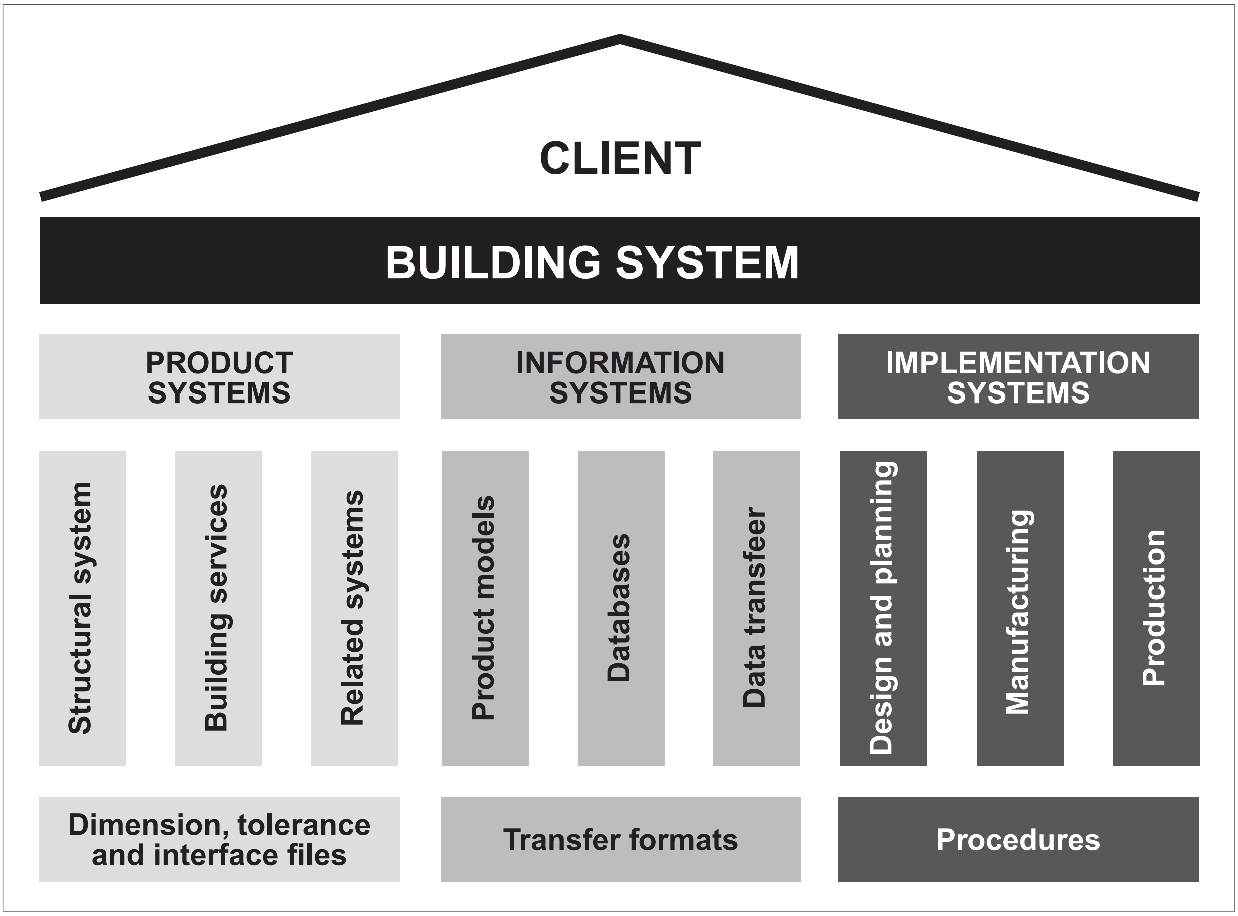


Figure 1 Layout of the Open Timber Construction System

The theory of the open system

By definition the open timber construction system is a construction method within which timber buildings in any given project can be designed and realised by using industrially manufactured, prefabricated components and/or whole elements from various suppliers both separately and jointly.

The aim of the open timber construction system is to establish and promote a basis for designers and builders in their endeavour to meet the needs of clients. In addition, it allows building industry to simplify production processes and to further increase its efficiency. Consequently, and as part of the intended result, it also provides an opportunity to accelerate the competitiveness of the timber construction system and to broaden its market share.

Openness implies that the system solutions are available to all. In addition, it also means that the system is

- open for competition between suppliers. Components within the system are interchangeable.
- open for alternative assemblies.
- open for possible future changes.
- open for the exchange of information.
- open for the integration of components and sub-systems.

The needs of clients define the basis for the construction system. The aim of the open system is to promote a standard, which acts as a frame of reference for designers and builders in order for them to meet the needs of their clients, but which is also appropriate in terms of production processes.

The open timber construction system is a combination of various technical systems and serves design, manufacture and building development in general. It consists of product, information and implementation systems.

Compatibility of the sub-systems is endorsed by the uniformity of the following:

- Language and terminology
- Dimensions and tolerances
- Structural interfaces
- Installation principles and model solutions for technical services
- Model sets of basic components
- Design guidelines
- Data transfer formats

These are consistently utilised by all involved parties. Consequently, the system can only function if it is uniformly and univocally accepted.

Product systems consist of systems associated with structure, building services and other related sub-systems. They determine the basic parameters and interface principles for the further development and manufacture of system products. They are based on generally accepted dimension and tolerance standards, which in turn provide a basis for technical and functional compatibility. Product systems derive from basic system theory and consequently they can be both modular and hierarchical.

Information systems consist of product models, data bases and information transfer systems. Product models are based on the available products and on a uniform data transfer format. Product models form the definition for product attributes. Data bases consist of a hierarchical system within which each level of data is based on the previous. The first level consists of general data bases, such as current building regulations etc. The second level incorporates system principles etc. The third level contains data bases that are particular to each company in question. Consequently, and as a concrete result, the system is equipped with information management and transfer mechanisms, for design and manufacturing processes, which derive from and take into account the intrinsic system principles and products.

Implementation systems consist of operational models for design, manufacture and installation. These operational models define the contents of different procedural operations and their interrelations within the processes. As a result, the implementation systems provide a building process that manufactures products, for which there is a recognised market.

Quality control within the system is based on continuous assessment and improvement. Development of the system is carried out gradually and industrial standards evolve in stages.

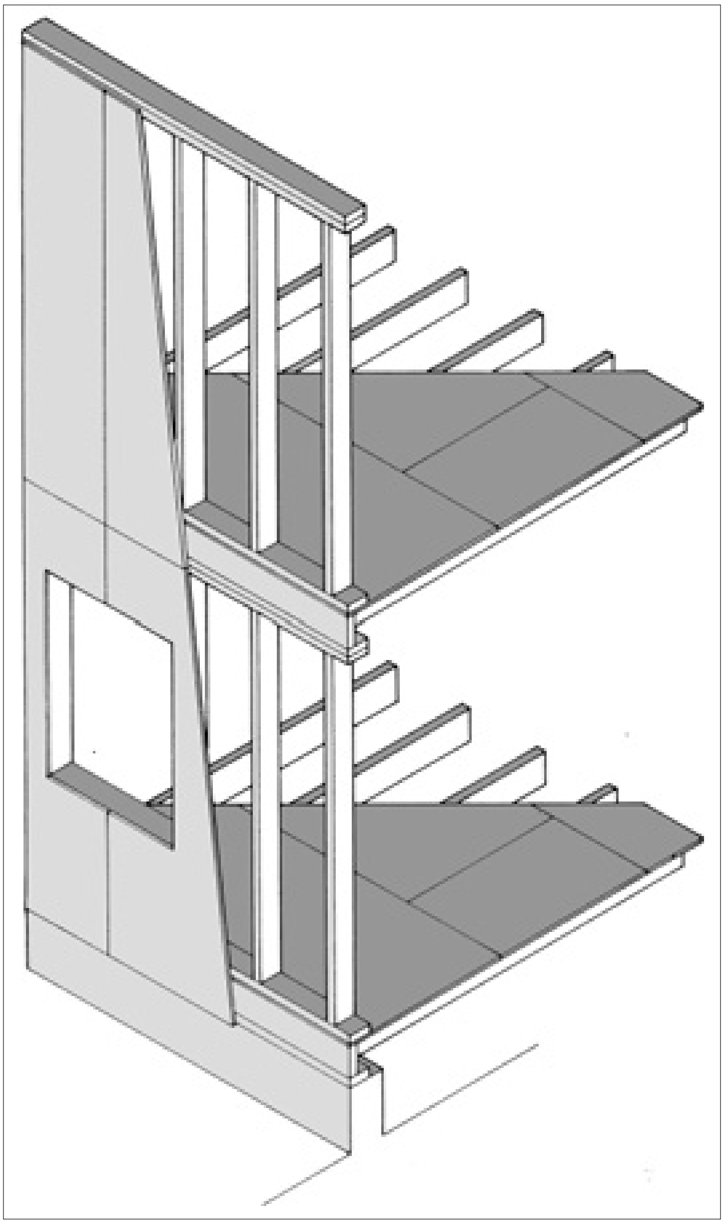


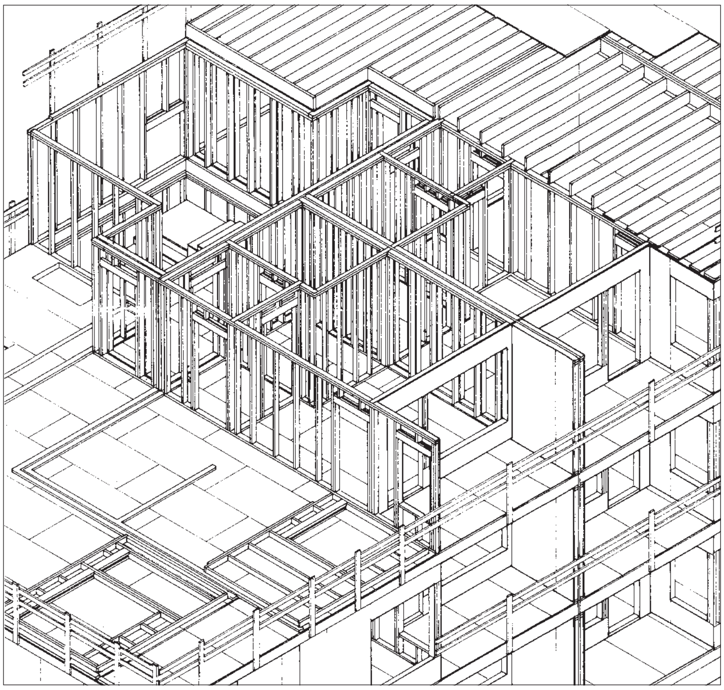
Figure 2. The framing system is based on cut-to-size prefabricated standard components and systematized structural models.

General Characteristics

Open timber construction is a timber framing system with load-bearing walls, within which the design and its realisation are based on the use of standardised framing components and systematized structural models. Other characteristics of the system include:

- Construction process floor-by-floor.
- Logistics i.e. control of material procurement and flow.
- Highly developed construction methods for in-situ and element assembly.
- A design practice that is appropriate to timber building.

The system is a Finnish interpretation of North-American platform construction. Its original name implies the construction process.



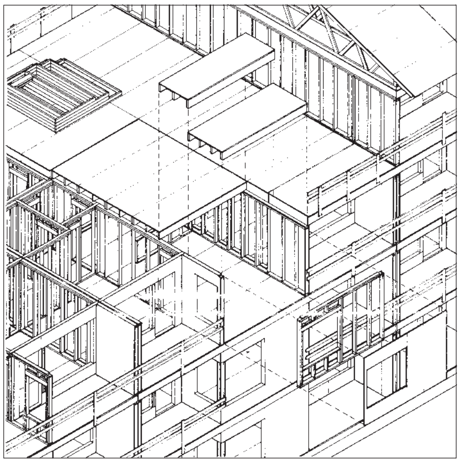


Figure 3 a and b. Walls are assembled horizontally on an erection platform. Alternatively wall frames can be delivered to site as ready assembled framing elements that consist of both load-bearing and bracing structure, whilst framing components and structural model solutions remain the same as in the in-situ building process.

Areas of Application

The system is applicable to detached houses and to apartment blocks in accordance with the appropriate local building and fire regulations. Besides residential buildings, it can also be used for other building types whenever appropriate. It allows for both self-build and professional construction processes.

There is a choice of production method for the system. Buildings can be assembled on site either from standardised components or from larger scale, factory manufactured elements that consist of similar smaller components.

The Construction Principle

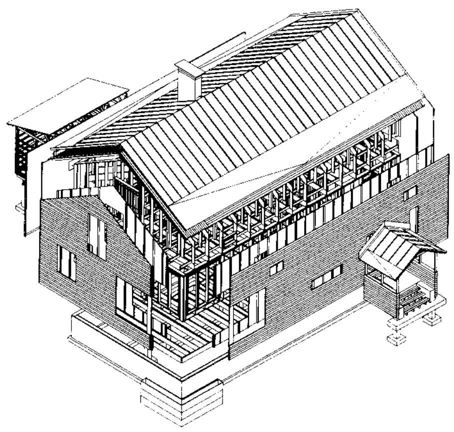
The frame is erected floor-by-floor or storey-by-storey using a method within which horizontal floor levels act as erection platforms for the assembly of the walls of the following floor. The erection starts with the assembly of the ground floor on foundations. This is used as a work base for the ground floor wall frame elements, which are then raised, supported and fixed into place.

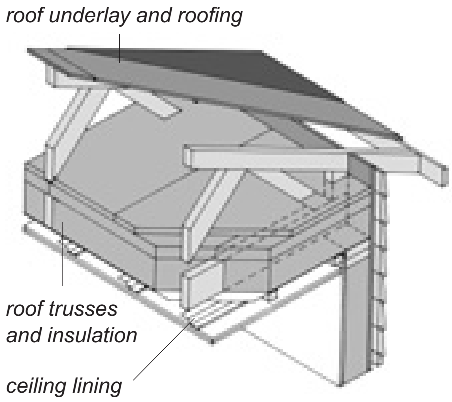
Floor joists are then placed on top of the ground floor wall frames and following that, sub-floor boarding is fixed onto the joists. This provides a new work base for the first floor walls. By repeating the different phases, it is possible to construct multi-storey timber frame buildings.

Roof trusses are fixed in place onto the wall frames of the top floor. The system is also suitable for single storey buildings where roof trusses are fixed onto the ground floor walls.

After the framing phase, construction continues with the installation of the roof and exterior wall cladding. Windows and doors are fixed to the frame. The installation of services, ducts and channels commences as the construction of the frame progresses. Following the installation of services the frame is insulated and interior lining boards are fixed into place for the finishing of surfaces and the interior in general.

Figure 4. The system is appropriate for the construction of detached houses, row houses and apartment blocks.





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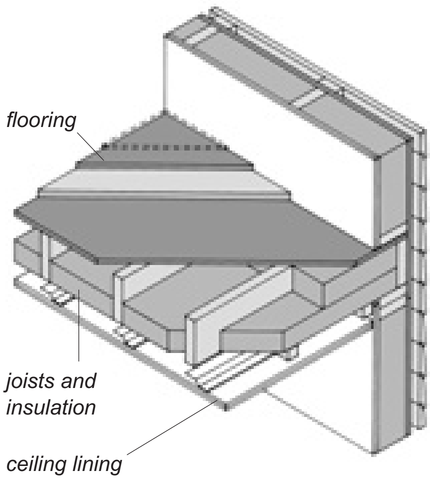

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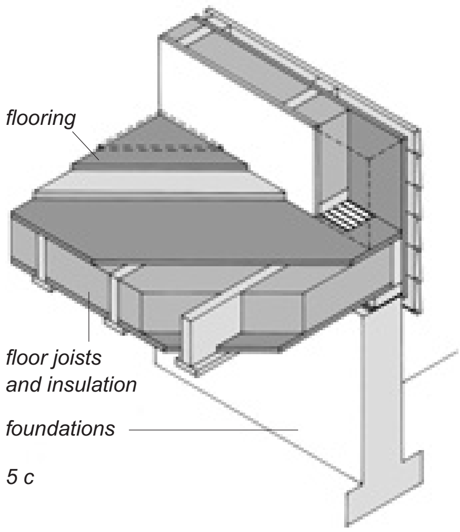


5 c

Figure 5 a, b and c. Structural principle
a. roof trusses
b. intermediate floor
c. ground floor

The Structural Principle

The system consists of load-bearing walls. The external walls and, whenever necessary, some of the internal walls are load-bearing. Other characteristics include the fact that all walls are of standardised height and the consistent rule of fixing horizontal structures on top of wall frames, whereby wall frames do not extend uninterruptedly from the base to the roof.

Ground Floors and Intermediate Floors

The ground floor can be either a suspended timber framed load-bearing floor or a solid reinforced concrete raft. All other floors are timber framed.

In principle, timber framed ground floors and other intermediate floors are similar and consist of joists, sub-floor boarding and header joists (rim joists) that form a band around the joists.

The structural differences between the floor types derive from different thermal, sound and fire proofing requirements, which all affect the various insulation and boarding solutions within the structure.

The flooring finish is laid onto sub-floor boarding. The surface material can be fixed onto the sub-flooring directly or as a so-called floating or buoyant floor in accordance with different sound insulation requirements.

The ceiling lining is attached to the underside of floor joists. Alternatives for lining materials, fixing methods and suspension solutions depend on sound insulation and fire proofing requirements.

The air cavity underneath the ground floor is insulated. The underfloor insulation quilt is supported by sparsely spaced rigid sub-floor battens. The necessity and type of insulation used within other floors depend on sound and fire proofing requirements, which may vary from project to project.

Walls

Walls consist of frame, insulation and cladding. The frame itself comprises of studs, sole plates and head plates. Walls are of standardised height and extend from floor to ceiling in between load-bearing horizontal floor structures.

In principle, load-bearing and non-bearing walls are similar. Their differences lie mainly in differing fire proofing requirements, which affect the choice of insulation and boarding materials.

External Walls

External walls employ a single frame system. The wall surfaces consist of cladding and of breather boards on the outside and of vapour and air barriers on the inside. The frame is also insulated.

External claddings can be chosen from a wide range of materials, including wood, brick, stone, render etc.

The choice of insulation and boarding materials depends on fire regulations, which are particular to any given project.

Internal Walls

In principle, load bearing and non-bearing internal walls are similar. However, materials for the frame, insulation and lining depend on the relevant fire regulations.

Party Walls

Party walls, or compartment walls, between different apartments consist of double frames. In other words, the walls consist of two stud frames, which are separated from one another. The frames are insulated and the walls sheathed. The insulation and boarding materials must be in accordance with sound insulation requirements and fire regulations, and depend on load-bearing factors, such as board rigidity requirements in relation to the strength of the board etc.

Roof

Roofs can either be trussed or couple roofs, i.e. they can either be supported by trussed rafters or with solid rafters that meet at the ridge. The shape of the roof is not restricted. As with all structures, the dimensions, insulation and boarding choices depend on loads and fire regulations.

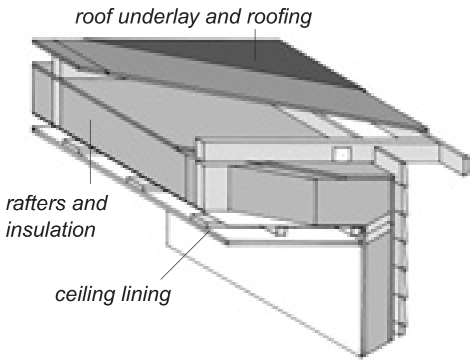


Figure 6 Couple roof

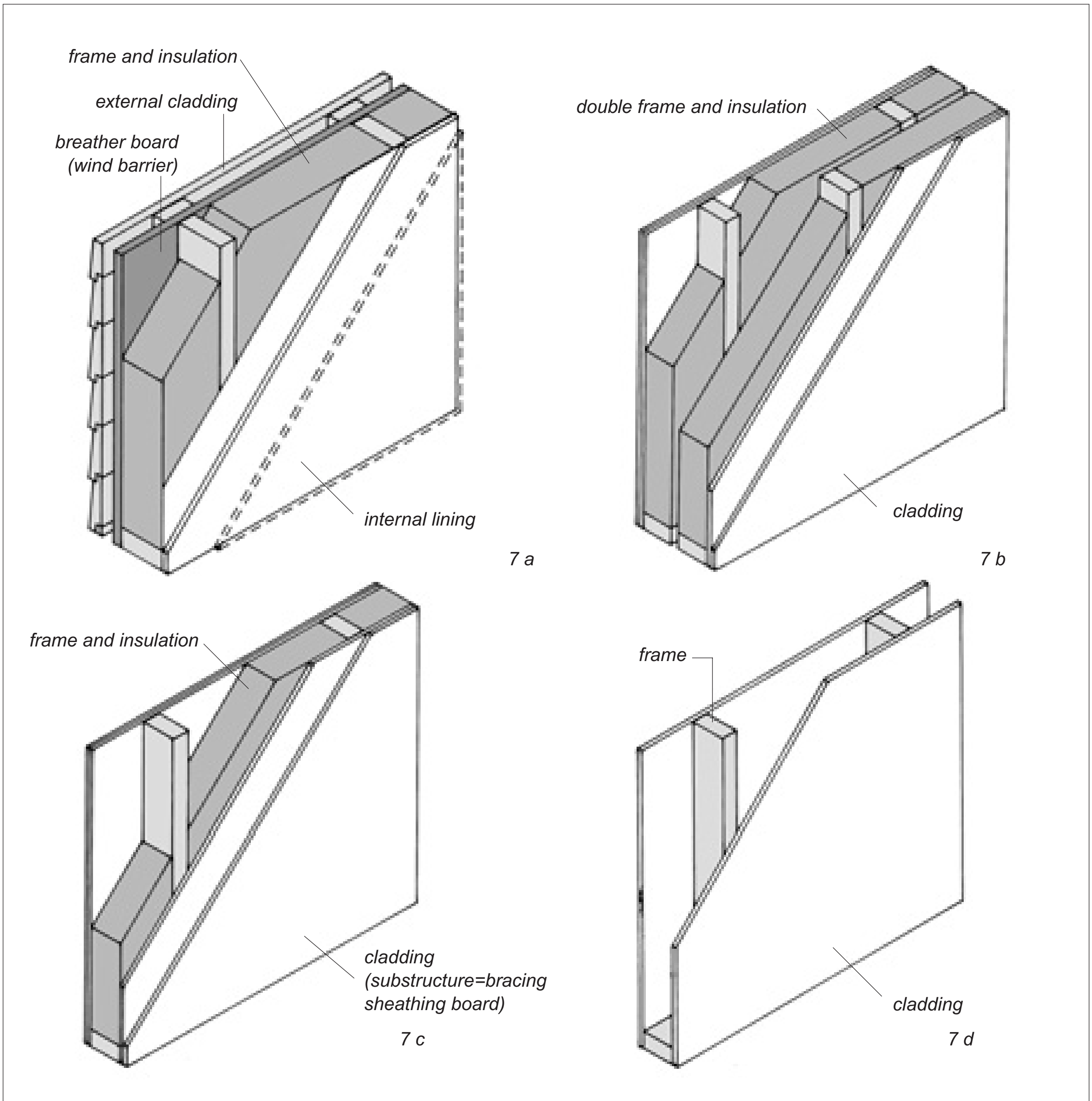


Figure 7 a-d. Wall types
a. external wall
b. party wall
c. internal load-bearing and bracing wall
d. partition

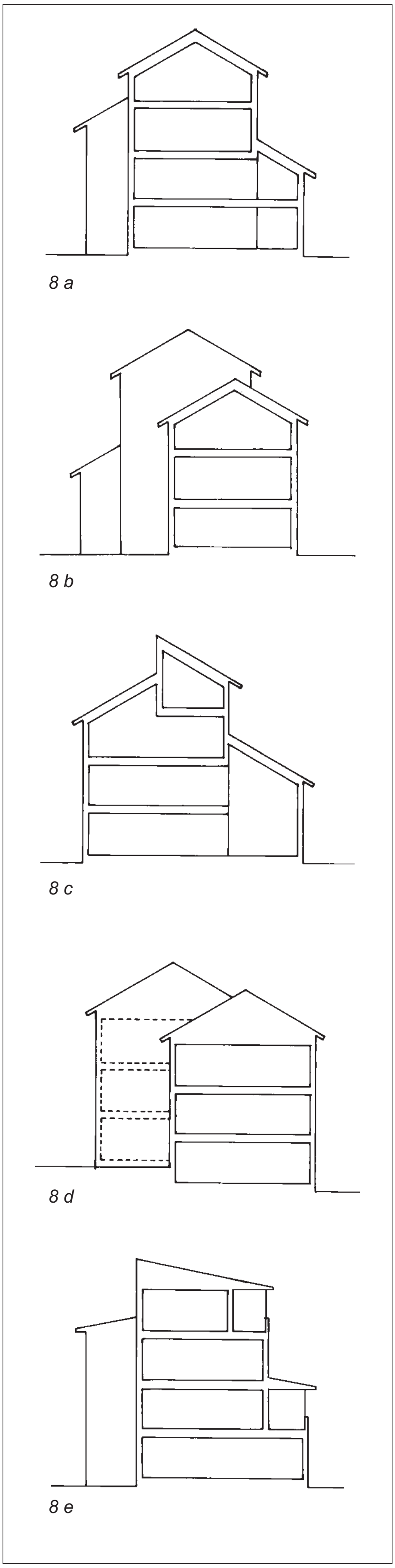


Figure 8 a-e. Alternative sections

The Impact of the System on Architectural Design

Intrinsically, the system allows substantial freedom for architectural design. It is also appropriate for buildings of differing size and type. It provides an opportunity to design architecture that relates to human scale and is enriched with varied forms. The choice for the shape and form of buildings is free.

The chief characteristics of the system, which have a direct impact on architectural design are:

- Vertical dimensioning that is based on standardised components and systematised structural principles.
- Spans that can be achieved by the horizontal frame and the appropriate positioning of the load-bearing structural grid.
- Structural dimensions that derive from the thickness of insulation and boarding choices.

Vertical dimensions, wall heights etc., of both detached houses and apartment blocks are the same. In terms of architectural design, it is important for the designer to be familiar with the standardised components and their junction details in order to retain control of the overall vertical dimensioning.

In principle, horizontal dimensioning is free, as long as spanning distances and the appropriate positioning of the load-bearing structural grid are taken into consideration. Stud and beam positions don’t usually affect architectural design.

The selection of appropriate insulation and boarding materials presupposes the full knowledge of structural requirements and the understanding of the structural models that make it possible to meet them. These structural models determine structural thicknesses, which again affect vertical and horizontal dimensions. In addition, wall thicknesses have a direct affect on floor areas, (e.g. net square meterage etc.).

These factors have been described in more detail in the following chapters.

Building volumes

Due to the horizontal spans that can be achieved by using the system, the overall massing of a building can consist of freely shaped volumes that may vary in size, even to the extent that each room forms its own volume within the design. Because exterior walls are relatively inexpensive in their material expenditure, additional external walls constitute a relatively minor cost implication. Timber structures do not form cold bridges in the overall structure. Small projections and balconies can be cantilevered, and consequently complexity in the architectural form has little impact on foundation expenditure.

Building Section

In spite of the fact that buildings are designed and realised using standardised products and systematised dimensions, the section of a building can be varied in a multitude of ways:

- Roof form is free.
- Top floor may have walls that differ in height and incorporate a sloping ceiling.
- Number of floors in different parts of a building can vary.
- Floor levels between neighbouring compartments or apartments can be positioned at different heights.

Architectural Design Process

The design process of residential buildings is firmly established. The system has little impact on the design process itself, as long as its basic factors are taken into consideration at a relatively early stage in the overall design process.

The designer must be familiar with all the principles of the system and master the use of systematised solutions. On occasions some parts or areas in a building may not be fully realisable in accordance with the overall system. Consequently the guide also includes a paragraph called "Frame Adaptations" that offers some model solutions for those situations.

In the initial sketch phase of design, it is important to examine the various available structural alternatives in close collaboration with a structural engineer, and make decisions on the following:

- The position and type of the structural grid (load-bearing and bracing structures).
- Roof support system.
- Main structural principles for the building envelope (exterior shell and structural grid).
- Intermediate floor support types and sizes, if standardised joists are not to be used (the depth of the support affects architectural design).

When making final choices, the following must also be taken into consideration:

- Location and support of balconies.
- Position of possible projections.
- Position of vertical shafts (in between beams).
- Position of ducts.

On the basis of the previous choices the following are determined:

- The location of and the maximum distance between load-bearing structures.
- Main directions of joists.
- Structural thicknesses that form the basis for the calculation of:
- Gross and net areas.
- Vertical dimensions.

These factors, combined, provide a pivotal basis for the architectural design of an open timber construction building. When the basic factors of the system are taken into consideration at an early stage of the design, the rest of the design can be carried out as usual, making particular, more detailed design decisions at later stages in the process.

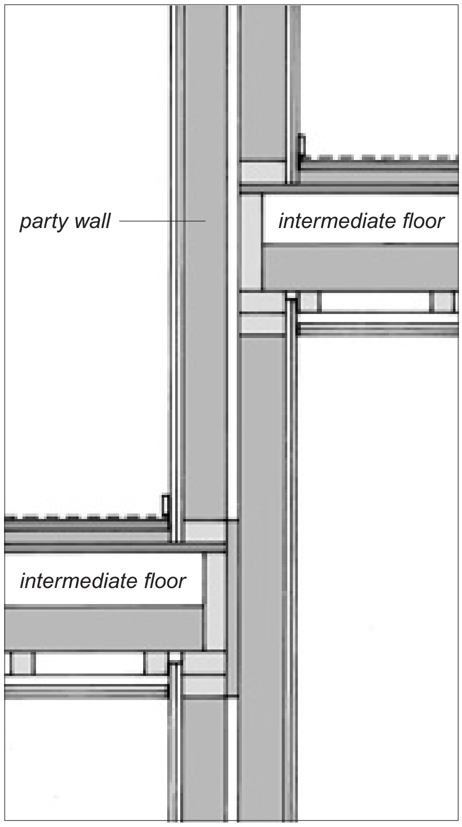


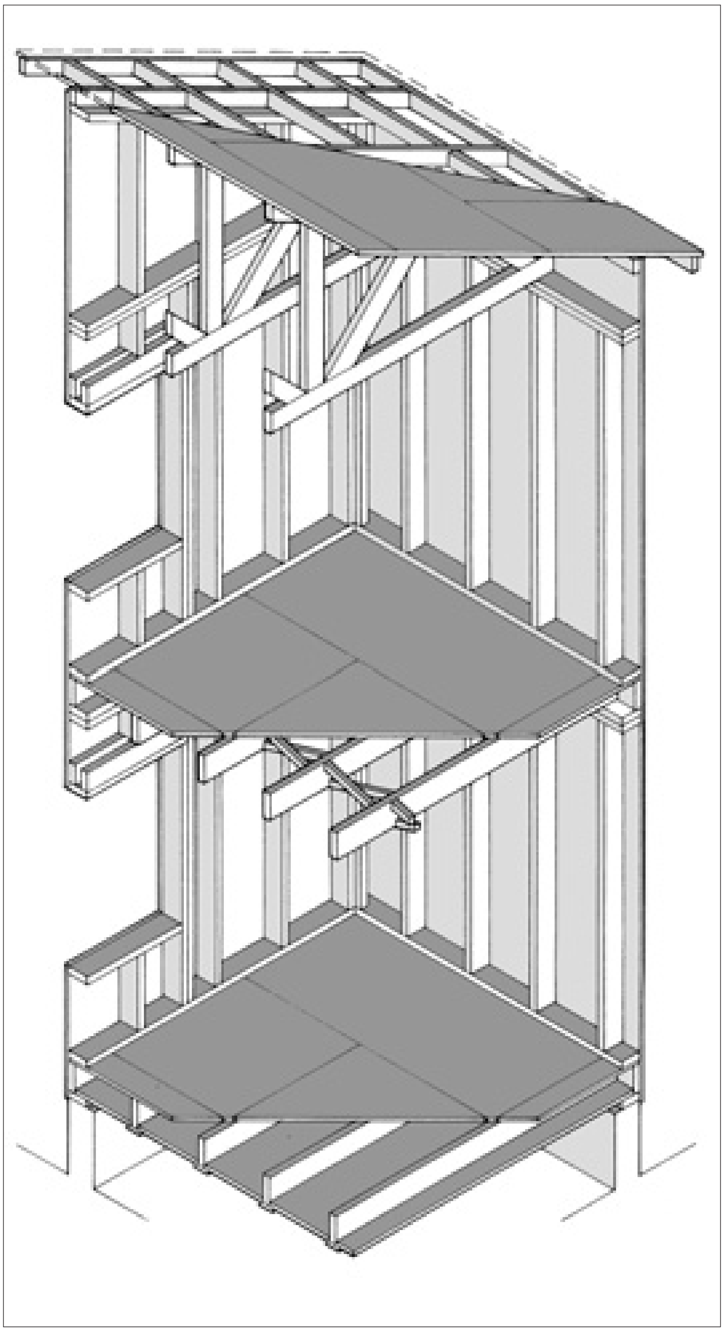
Figure 9. Stepped party wall. Floors of different apartments can be positioned at different heights.

2 STRUCTURAL FRAME AND ARCHITECTURAL DESIGN

2 STRUCTURAL FRAME AND ARCHITECTURAL DESIGN

10 b

Figure 10 a and b. The framing system. The frame can be varied in different ways.
a. Frame and trussed rafters
b. Lowered walls on the top floor and couple roof



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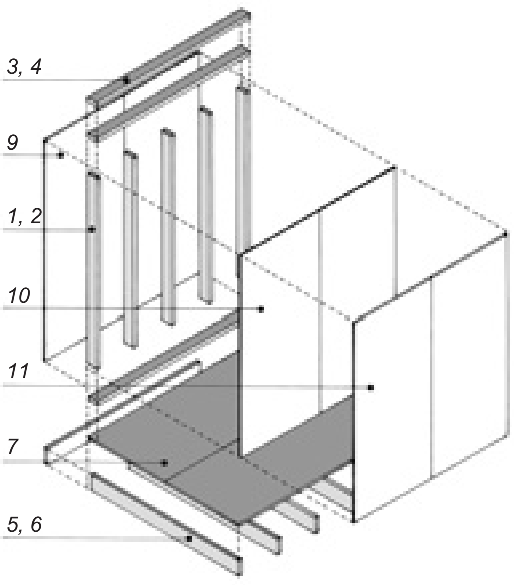


Figure 11. Finnish standard components and their junctions with each other. The table shows the dimensions of standardised products in millimetres. Use appropriate local standard dimensions, whenever different from the dimensions above.

Structural timbers			
Product	*thickness*	*width*	*length*
1. external wall stud	*48*	*172*	*2480/2630*
2. internal wall stud	*48*	*97*	*2480/2630*
3. external wall plates	*48*	*172*	*no limitations*
4. internal wall plates	*48*	*97*	*no limitations*
5. joist	*48*	*220*	*5000...9000/cut-to-size*
6. joist in wet areas	*48*	*172*	*5000...9000/cut-to-size*
Building boards			
7. sub-floor board	*18*	*2400**	*1200*
8. roof underlay board	*15*	*2700**	*1200*
9. breather board			
- porous woodfibreboard	*25*	*1200*	*3000*
- plasterboard	*9*	*1200*	*2750/2700/3000/3100*
10. internal lining plywood	*9*	*1200**	*2600/2750*
11. plasterboard	*13*	*1200*	*2600/2750*

** direction of face ply*

Framing Materials

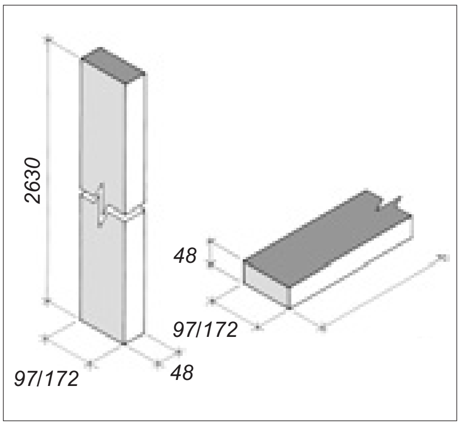
In Finland the system uses standardised and universal, cut-to-size framing components. In practice, this means that similar components can be utilised in projects that differ in character, size and building type.

Standardised framing components are cut-to-size and dimensionally compatible. The basic framing components consist of:

- Wall studs and plates
- Joists
- Building boards

In addition, roof rafters, fixings, wall ties etc. are also required to complete a building frame.

Whenever possible, it is preferable to use standardised, cut-to-size framing components. However, it would not be appropriate or feasible to manufacture standardised products for all purposes, and therefore certain framing components, such as the timbers that form the frame for a window or a door opening, are sometimes cut to the desired size on site.



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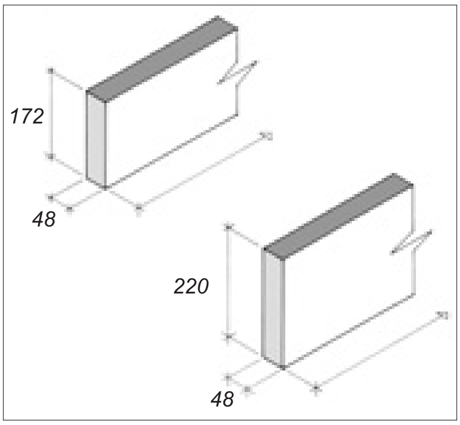

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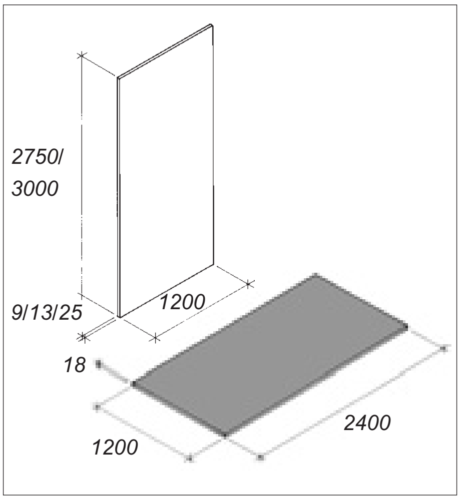


12 c

Figure 12 a, b and c. The dimensions of standardised components (in millimetres) in Finland
a. wall studs and plates
b. joists
c. building boards
Take care always, the local standard dimensions are used.

Framing Timbers

Wall Studs and Plates

In Finland, wall studs are manufactured in two sizes. The dimensions of exterior and interior wall studs are 48 mm x 172 mm and 48 mm x 97 mm respectively. The length of the studs is standardised to 2630 mm.

The dimensions of wall plates are the same as those of wall studs. Their lengths can be selected from normal sawn timber lengths. In addition to these, there is also a 5630 mm long finger jointed wall plate for plates that require unusual continuous spans.

Framing timber in Finland is both square-sawn and rounded off at corners. The studs and plates must always be at least B-graded (appearance grading). In apartment blocks the minimum strength grading of studs and plates must be C18.

Visible posts can also be made of glue-laminated (glulam) timbers or double studs, which are clad with other materials. Wall studs can also be made of glulam timbers or parallel grain plywood (LVL). Glulam and parallel grain plywood (laminated veneer lumber) studs have the advantage of good structural strength and show minor alteration of form over time.

Joists

The dimensions of standardised solid timber joists are 48 mm x 220 mm and 48 mm x 172 mm. The 220 mm deep joists are usually used for both ground floors and intermediate floors. The 172 mm deep joist is used for floors in wet areas. It allows for falls in the floor for draining purposes and leaves enough space for waterproofing on the floor underlay without level changes between dry and wet areas.

Solid timber floor joists are square-sawn (dimension lumber), rounded off at corners and categorized according to their strength. Their strength grading is C24. Long solid joists are finger jointed.

Joists are delivered to site cut-to-size. Alternatively, they can also be brought to site as long timbers, in which case they are cut to size in-situ. This has proven to be both practical and appropriate whenever there is a lot of variation in joist lengths.

Building Boards

In Finland, besides acting as a structural brace, building boards are also used for sheathing and fireproofing. The sizes of building boards conform to systematised vertical dimensions and stud and joist spacing standards.

Sub-floor Boarding

Tongue-and-grooved sub-floor sheets consist of weatherproof building boards, usually 18mm thick softwood plywood, the sizes of which are 2400 mm x 1200 mm. Sub-flooring is fixed onto floor joists so that the direction of the face ply is perpendicular to the joists. It functions as horizontal bracing and as an erection platform for the assembly of walls.

Roof Underlay Boards

Roof underlay consists of weatherproof boards, usually made of 15 mm thick softwood plywood sheets, the long sides of which are tongue-and-grooved. Its dimensions follow the standardised 900 mm c/c spacing of roof trusses or beams, and its size is 2700 mm x 1200 mm.

Breather Boards (Wind Barrier)

In detached houses breather boards can consist of porous woodfibreboards or similar. They are fixed onto the exterior leaf of the frame and they act as insulation, but also as bracing for the frame. Standardised products for use in detached houses include 25 mm thick, 1200 mm x 3000 mm breather boards. The board extends the whole wall height, including wall panel height and deck depth, from one floor surface to another. The standardised 3000 mm board can only be used in buildings where the joists are 220 mm deep and where stud lenght is 2630 mm. The horizontal joint between the boards must allow tolerance for deformation.

If the external cladding comprises wood or some other inflammable material, the recommended breather board should not consist of easily combustible materials or materials that spread fire easily, e.g. plaster boards etc.

Due to settlement in timber structures, it is not usually possible to use breather boards that run the whole height of a storey in apartment blocks. Instead, separate boards are used to cover wall panels and floor deck ends. For use on the wall, there is a standardised 2750 mm high board. For the ends of floor decks, a strip, which corresponds to the spacing of floor joists, is made on site. The settlement of the building is taken into consideration as tolerances within the joints of the strips.

Internal Lining Boards

In detached houses internal lining materials don't usually have to comply with any general regulations, other than those locally imposed to the construction. In apartment blocks, the board must comply with either Euroclass A1 or A2 requirements.

9 mm thick softwood ply is intended for use as underlay sheathing for the finishing materials. Its size is 1200 mm x 2750 mm. It can be used either on all or some walls. For example:

- As backing to fixtures and fittings where it acts as extra support for the finishing components.
- Under plaster board, on walls that are to be tiled, where it strengthens the tile backing.

The board braces the frame and it can also be used as part of boxing for beams, e.g. on lintels etc.

The 13 mm thick plasterboard (1200 mm x 2750 mm) is intended for interior lining. It is not easily inflammable and its surface does not spread fire. In apartment blocks it can also be used for ceiling lining. However, when choosing the boards, always refer to the local firecodes.

Fixings

Fixing include mainly nails and screws. Whenever necessary, steel fastenings and joist hangers can be used.

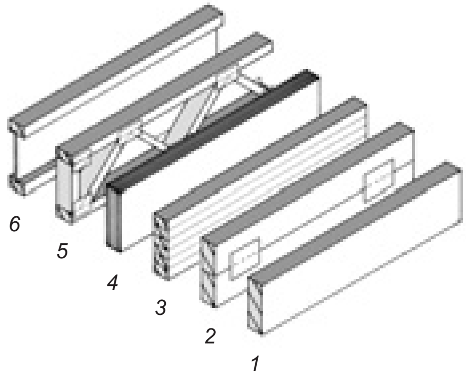


Figure 13. The most common beam (joist) types
1. Solid timber beam
2. Nail plate beam
3. Glue laminated (glulam) timber beam
4. Parallel grain plywood beam/ Laminated veneer lumber
5. Nailplate floor truss (Braced beam)
6. Ply-web beam

In addition to standardised solid timber beams, other beam types and sizes can also be used. These include parallel grain plywood and glulam beams as well as ply-web and nailplate floor trusses (braced beams). However, it is preferable to use only one type and size on any one project at a time.

The choice of the beam type and size affects spans and other technical and performance properties of the joists. The overall cost of the floor structure is also affected by later additions and installations, which in turn are influenced by the type and direction of the joists.

Solid timber beams are more cost effective than other beam types. On the other hand, solid timber beams also cause more deformation in floors. By using other beam materials and types, longer spans are achieved and settlement is decreased.

The use of boxed or enclosed beams usually presupposes the fixing of extra battens to the underside of joists to allow pipes to be taken across joists. In these instances it is preferable to choose the direction of the joists in a way that allows most pipes to be carried parallel to the joists.

When using floor trusses (braced beams), sprinkler and plumbing pipes can be taken in a number of directions. These pipes can also be suspended from the trusses.

When using solid timber, glulam or parallel grain plywood beams, the header joist (rim joist) is usually similar to the beams. With ply-web and braced beams it can also consist of parallel grain plywood.

The Framing Components

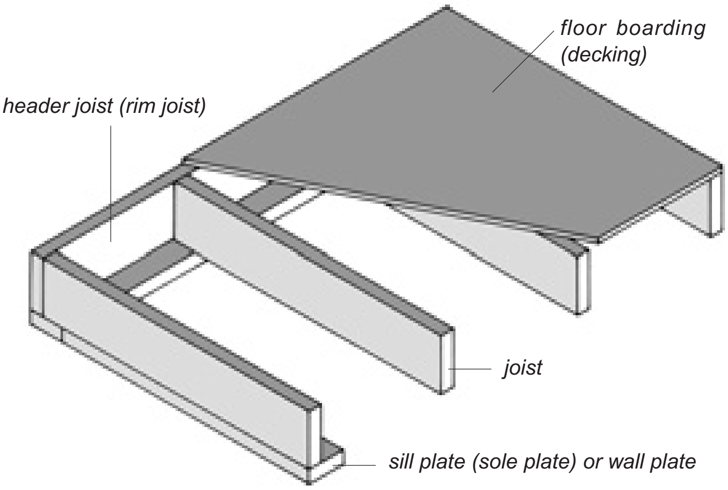
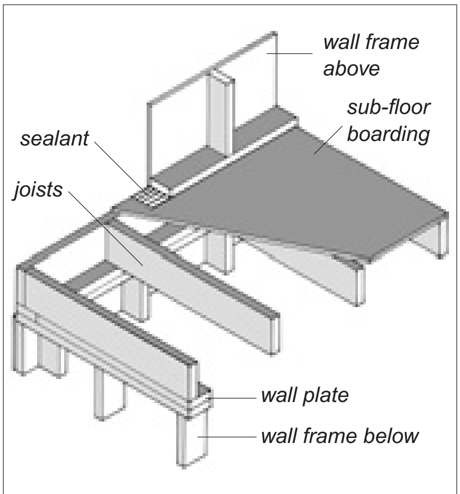
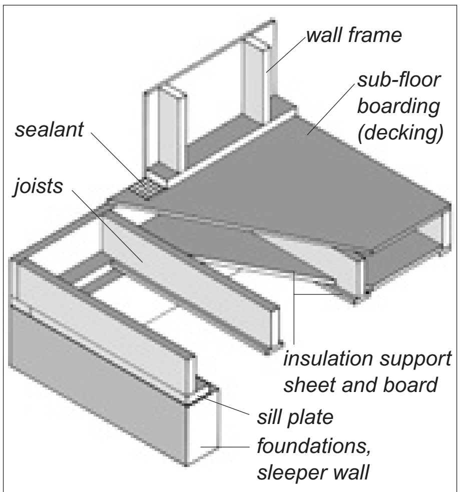


Figure 14. Floor structure

Figure 15 a and b. Floor joists



15 b. intermediate floor joists



15 a. ground floor joists

Ground and Intermediate Floors

The ground floors are usually timber framed suspended floors, but solid reinforced concrete floor slabs can also be used. Intermediate floors are always timber framed.

Timber framed ground floors and intermediate floors are similar in their construction. Their differences lie in different thermal and sound insulation requirements and differing fire regulations. These mainly affect insulation and boarding.

Timber framed floors consist of joists, sub-flooring boards and header joists (rim joists). Besides these, extra bracing is needed in order to reduce vibration in the joists.

Joists act as load-bearing structure. They can be supported either on foundation sleeper walls, other walls or other beams. Usually a joist is positioned on top of a load-bearing structure, but it can also be fixed to the side of a load-bearing element using a joist hanger or equivalent.

The bearing capacity of the joists can be improved by making the spacing of joists denser and/or using joined joists in parallel. The joist spacing is either 600 mm c/c or 400 mm c/c. Whenever necessary, double joists can also be used. The sizes of standardised sub-flooring boards should be taken into consideration when deciding on the required number and spacing of joists.

The spacing or position of joists rarely affects architectural design unless the joists are partly exposed. If this is the case, architectural drawings should show the position of the joists and a note should be made that they must be left uncovered.

The header joist encloses the floor frame on all sides. It transmits loads from walls and prevents the floor joists from buckling. At floor openings the header joist becomes a trimmer joist onto which floor joists are fixed with the use of joist hangers.

Sub-floor boarding is fixed onto floor joists. It works as horizontal bracing for the whole building, but also as an erection platform for the assembly of the walls of the following storey. The sub-floor boarding extends to the outer edge of the external wall frame.

Extra Bracing for Joists

Vibration and deflection are characteristic to timber joist structures. Matched sub-floor boarding that has been firmly fixed onto joists makes the construction more rigid, but further stiffening can be provided between the joists in the form of cross-bracing.

Cross-bracing divides point loads from one joist onto several and evens out the overall load on the joists. It can consist of:

1. Herring-bone strutting
2. Solid timber bracing that is usually of the same height and consists of the same material as the joists.
3. Horizontal battens that are used in conjunction with secondary beams and attached to the lower surface of the joists.

Extra bracing must be positioned between all joists at maximum intervals of 2.1 metres. In practise this means that each span is provided with one extra brace. Noggings are lapped to allow each one to be end-nailed to joists.

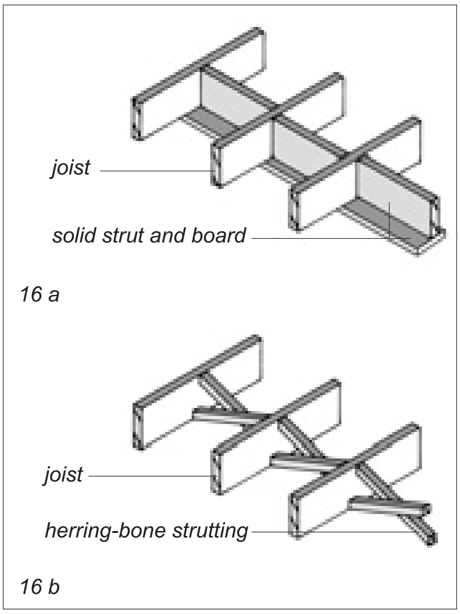


Figure 16 a and b. Cross-bracing of floor joists.
a. using solid timber struts, such as noggings (dwangs)
b. using herring-bone strutting (truss bracing)

Shallow Joists

Shallow joists are used on the floors of wet areas where they allow floor levels between dry and wet areas to be approximately the same. Due to insulation requirements shallow joists cannot be used on ground floors. In order to achieve even floor levels on ground floors, normal joists under wet areas can be lowered or stepped. In blocks of flats sub-flooring boards are often supplemented with other flooring layers making the use of shallow joists in wet areas unnecessary.

When standardised solid timber joists are being used, differences in floor level are evened out via the use of extra sole plates, consequently making it also possible to use standardised wall studs.

Shallow joists must be supported from both ends.

When joining normal and shallow joists, the walls parallel to the joists must be positioned under the shallow joists preventing damp proof course from tearing which can happen as a result of potential settlement within the joists.

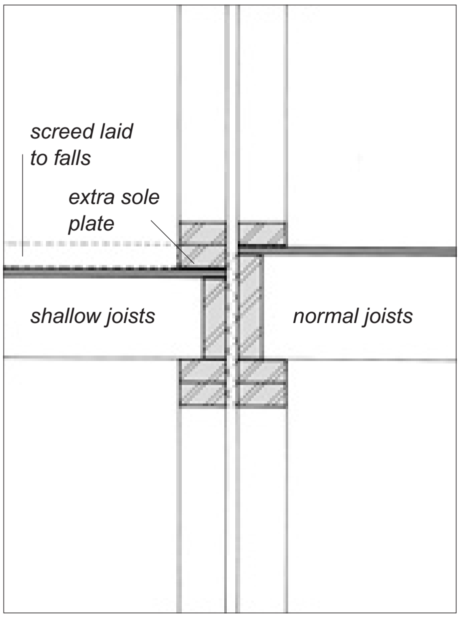


Figure 17. Party wall junction between shallow and normal joists.

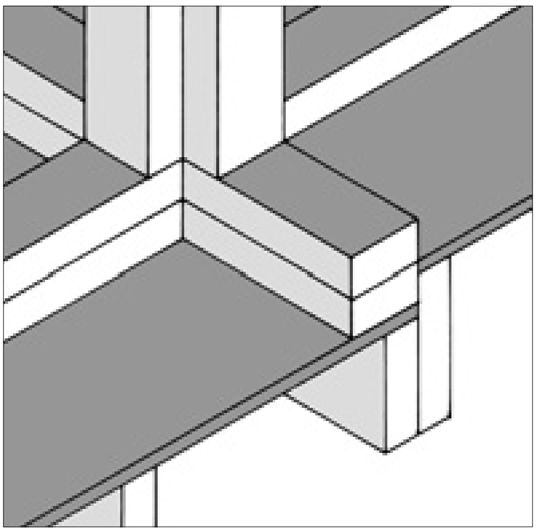


Figure 18. At the junction of high and shallow joists, walls parallel to the joists are positioned under shallow joists.

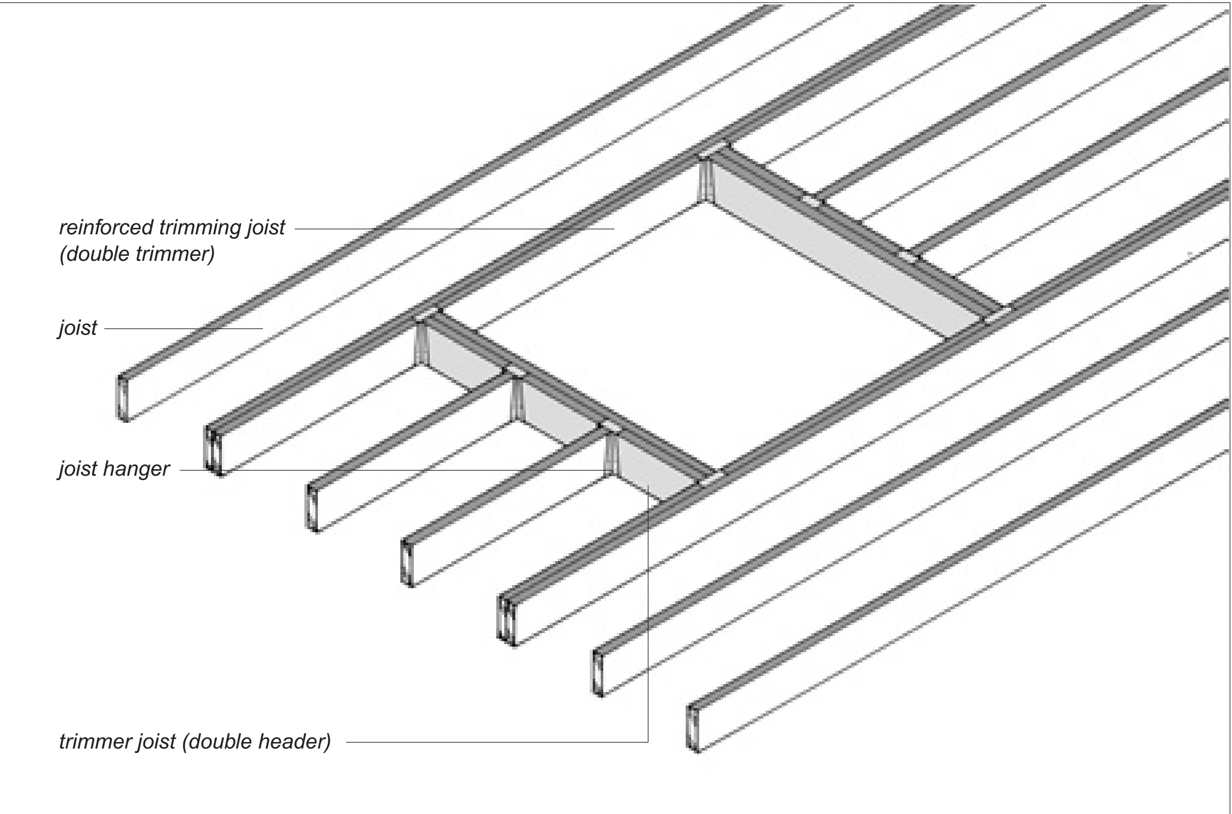


Figure 19. Openings in floor joists.

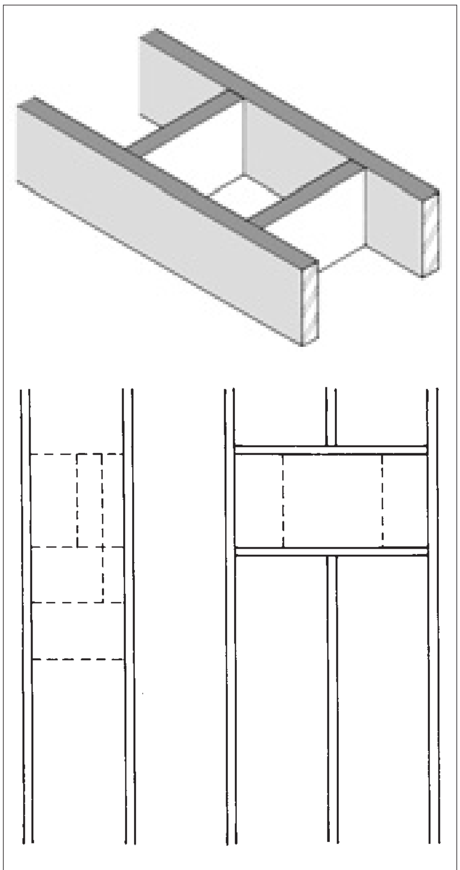


Figure 20 a and b. Vertical shafts are positioned in between joists.

Intermediate Floor Openings

Opening can be made relatively easily in timber floor structures. Openings can be positioned either adjacent to load-bearing walls or within the joists. This is accomplished by cutting short some of the main joists to form an opening and by introducing a thicker trimmer joist, or double header, to transmit the loads to appropriately strengthened joists.

In principle, any opening can be positioned anywhere in the joists. The positions and sizes of openings are not restricted by joists unless the joists are to be exposed and/or positioned in a particular way. Longitudinal openings, such as required by single flight stairs, should not be positioned across the joists unless it is possible to use load-bearing vertical structures at their sides.

Vertical Shafts

Whenever possible, vertical shafts should be positioned in between joists to avoid the cutting of joists and to allow the floor structure to perform fully. If the shaft is large, its shape and direction must be chosen to minimise the necessary severing of joists. In apartment blocks, vertical shafts form separate fire compartments of their own. Shafts must have fire breaks at each floor.

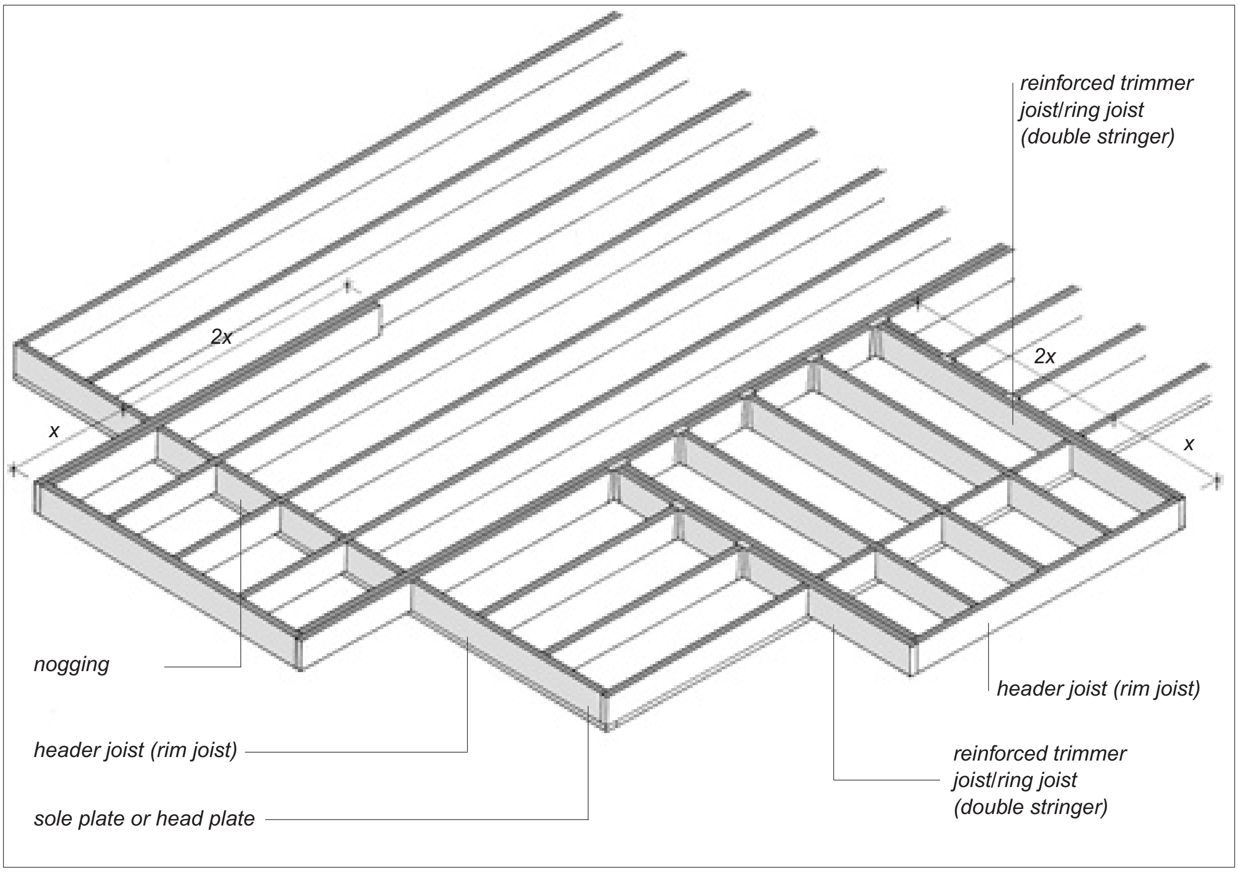


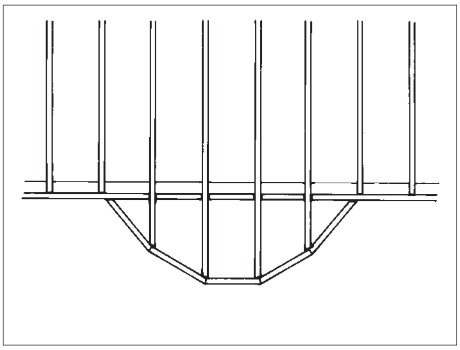
Figure 21. Parallel and perpendicular projections from the joists.

Projections From The Joists

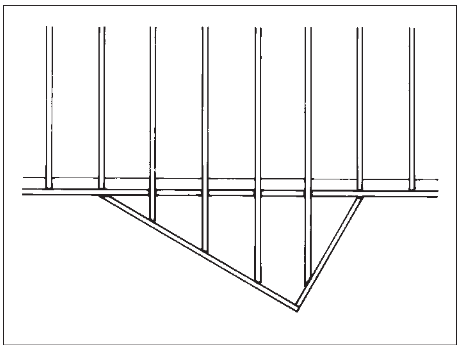
Projections from the joists are used in order to create bay windows, balconies and other overhangs. They are achieved by cantilevering joists across walls or sleeper wall lines.

A projection can be made both parallel and perpendicular to joists. When projecting parallel to the joists, the joists are extended across the wall line and the header joist is moved to the end of the joists. When projections are perpendicular to the joists, the cantilevered joists, or stringers, run at right angles to the main joists. A header joist closes the ends of the cantilevered joists.

The shape of projection can be varied from rectilinear forms to any free form. The maximum length of a projection depends on the type and size of joists, and on the appropriate local fire regulations. When using solid 220 mm deep, standardised joists at 600 mm c/c, a projection can only be 1500 mm long. The extension of a projection requires denser joist spacing or the use of some other joist type. Projections that exceed 2 metres aren't recommended as extra long projections cause deflection and vibration in the joists. The structural dimensions of any projection require individual structural calculation.



22 a. Curved projection



22 b. Angular projection

Figure 22 a and b. The shape of a projection can be varied.

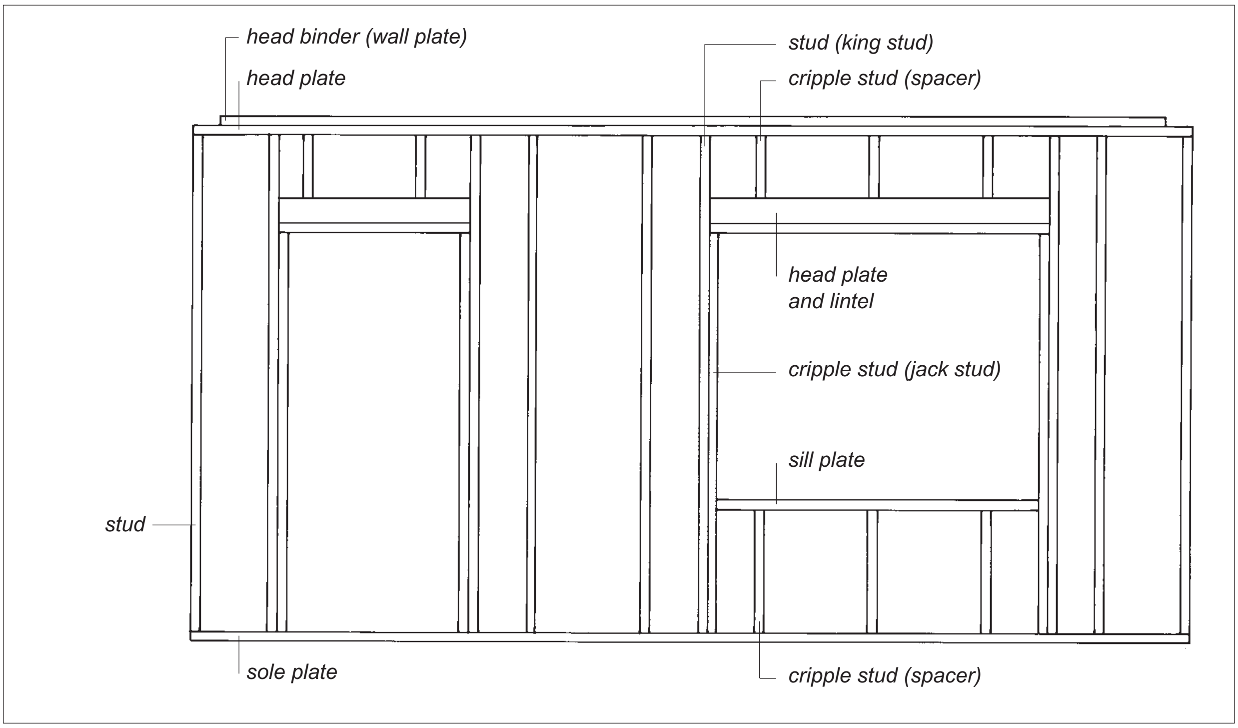
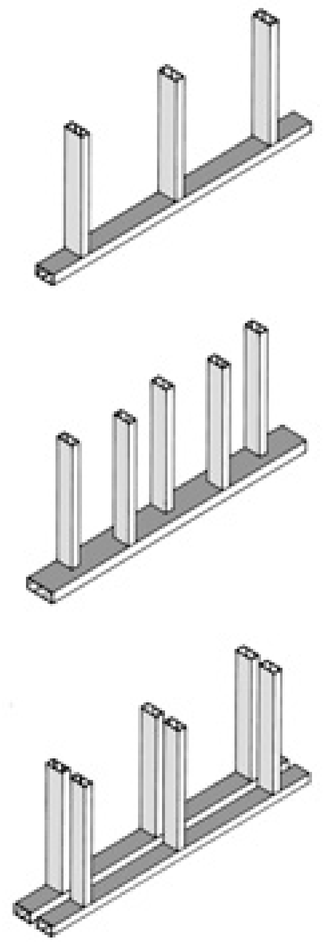


Figure 23. Wall framing components



a

b

c

Figure 24 a, b and c. Frame types
a. single frame
b. zigzag frame
c. double frame

Walls

In principle, the structural frames of load bearing and non-bearing walls are similar. The height of walls is standardised. Walls extend from the surface of sub-flooring board to the underside of the joists of the floor above. Top storey walls that may differ in height are considered an exception to this.

Walls consist of studs, sole and head plates, and door and window frames. Parallel to the framing phase, construction continues with the installation of building boards and breather boards, which provide bracing for the frame.

Wall studs are positioned at 400 mm or 600 mm centres. When necessary, double studs can be used. The load bearing capacity of a wall can be increased either by making the spacing of the studs denser or by using several studs fitted side by side to form double studs at large door or window openings or at the ends of joists.

The position of studs at given centres is determined by the standardised dimensions of building boards, which allow either 300 mm, 400 mm or 600 mm spacing between studs. Studs can also be positioned at more frequent intervals whenever a stronger wall is required. Wet areas require studs to be positioned at either 300 mm c/c or 400 mm c/c.

In general, architectural design is not affected by stud positions. However, it is important to take into consideration the possible need for double studs at door and window openings, and allow provision for their extra dimension.

The wall frame usually consists of one sole plate at the bottom, and a headbinder and a head plate, i.e. two top plates, at the top. If shallow joists are used anywhere, the resultant level differences can be adjusted with the use of extra sole plates.

A head plate joins the studs together whilst a headbinder or a top plate joins all framing elements to each other.

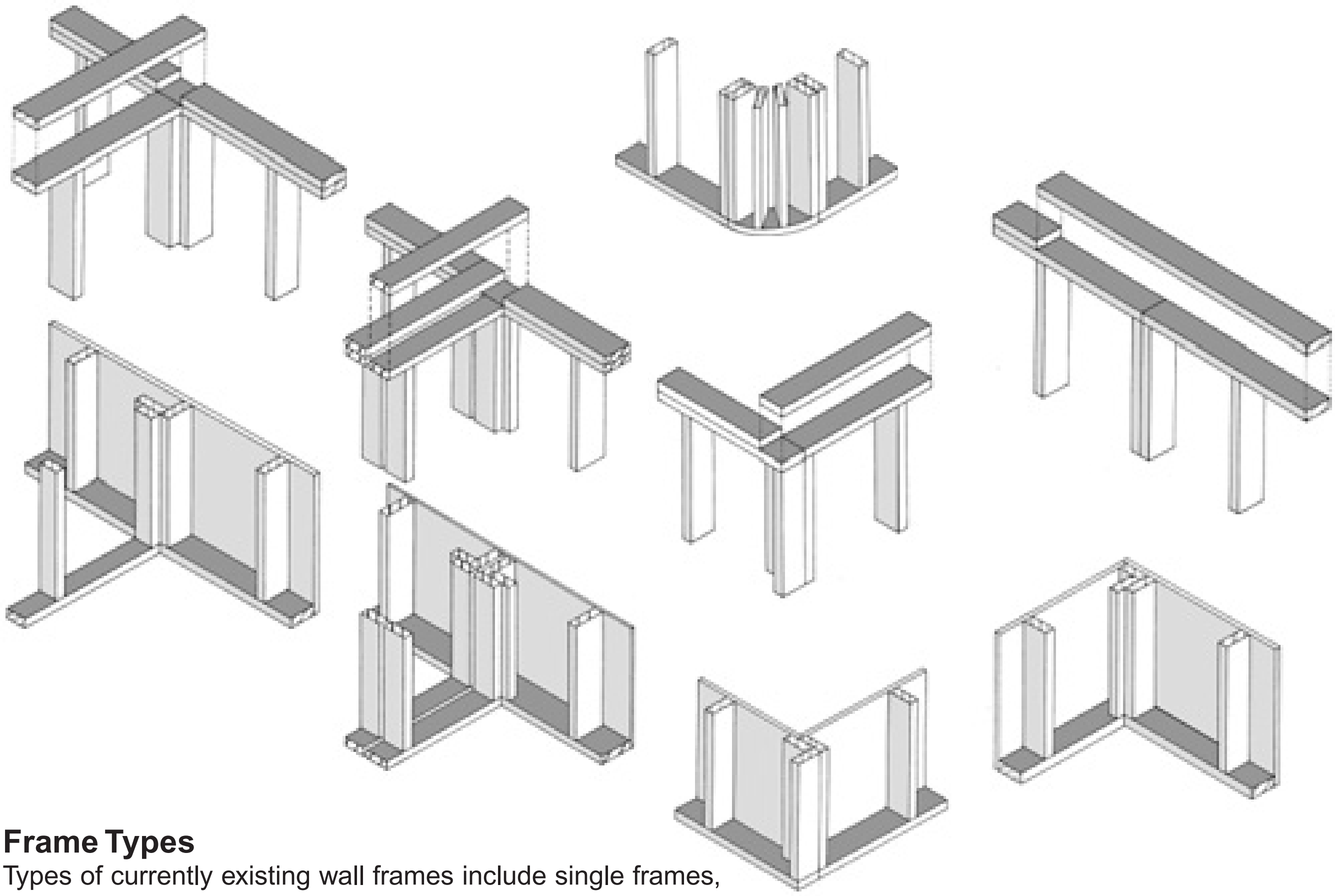


Figure 25 a – f. Wall frame junctions

Frame Types

Types of currently existing wall frames include single frames, zigzag frames and double frames. The single frame is the basic type and therefore most frequently used. It is used for both external walls and partitions.

The double frame consists of two single frames that have been positioned next to each other. An air gap in between the frames makes the positioning of studs parallel to each other irrelevant. The frame type is used on walls, such as party walls between flats, where good sound insulation is paramount.

The zigzag frame is a hybrid between single and double frames. It consists of single wall plates, which are wider than the studs, and studs at alternating sides of the plates. The zigzag frame is used on walls where sound insulation requirements are higher than usual, such as office spaces, bedrooms etc.

Walls of Non-Standardised Height

Primarily the system uses walls that have been constructed of standardised studs. Whenever necessary, walls of non-standardised height can also be constructed. These may be required for houses where loft spaces are utilised or when the architecture calls for a higher interior space. A specially constructed wall element that forms a full gable end on the top floor can sometimes also replace a spandrel panel.

The manufacturing method for these walls is similar to the methods used for walls of standardised height. The frames are made from normal sawn timber and extra long studs are cut from plate timbers.

Curved Walls

Walls can also be curved. Their manufacture requires the wall plates to be cut from thick building boards to the desired shape. Otherwise their manufacturing process is the similar to normal walls.

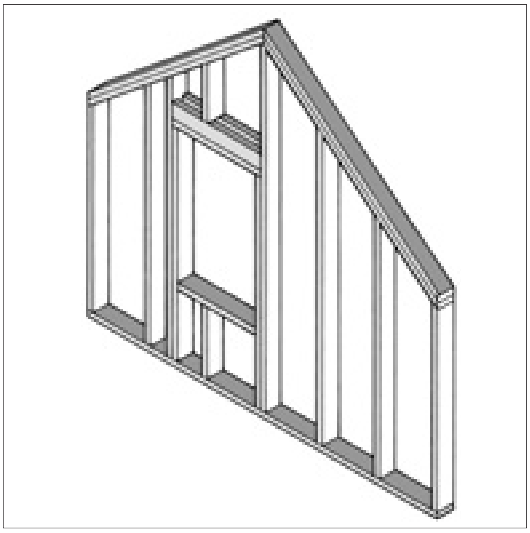


Figure 26. Wall of non-standardised height

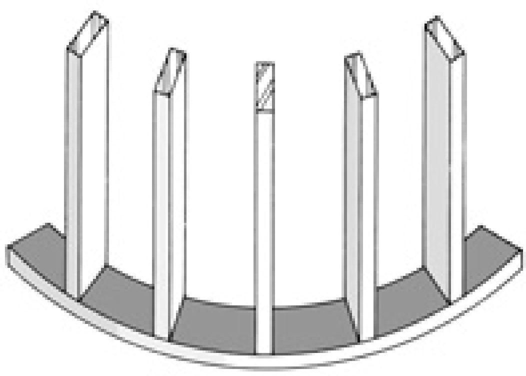


Figure 27. Curved wall

Figure 29. Trussed roof components

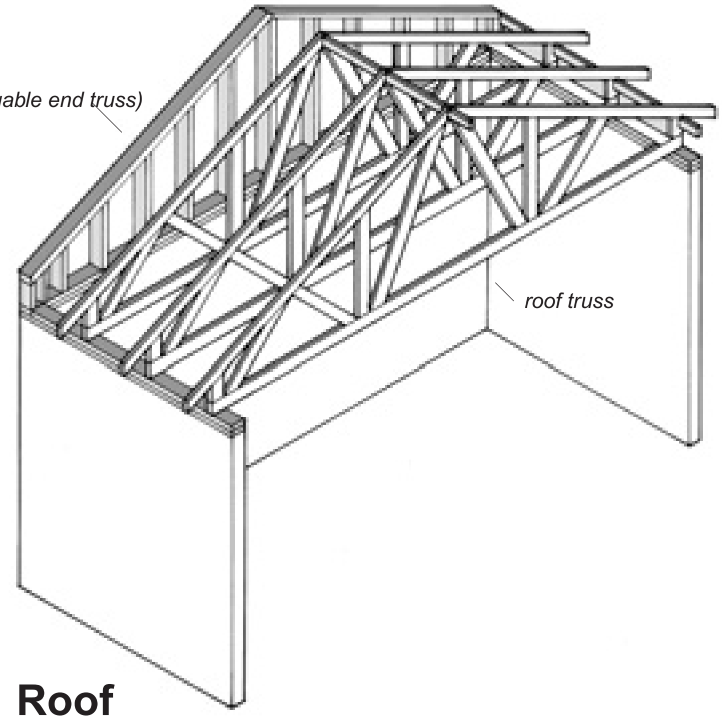
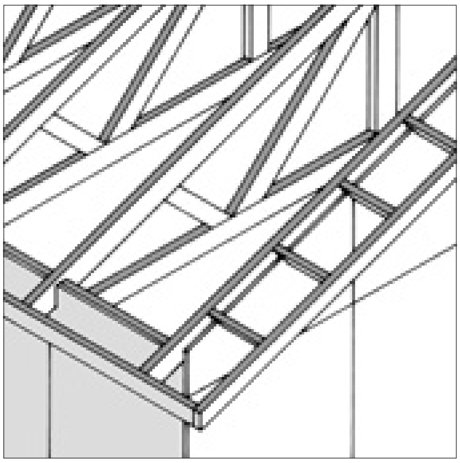
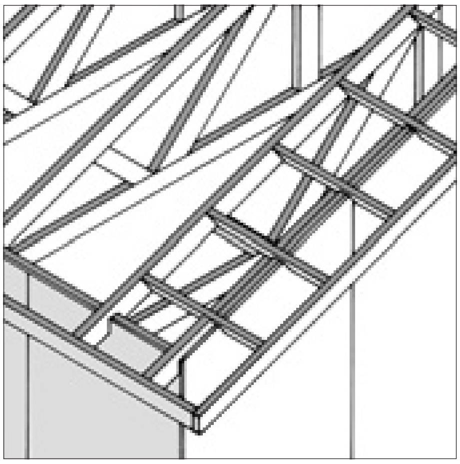


Figure 28 a and b. The eaves and verge of trussed roofs
a. eaves and verge of less that 400 mm overhang
b. eaves and verge of more than 400 mm overhang



28 a



28 b

Roof

Roofs can be made using either solid timber rafters (couple roof) or trussed rafters. The overall system affects neither the choice of rafters nor the shape of the roof (pitched, monopitch etc.).

An apartment block roof must be fire-protected both externally and internally. An adequate allowance for charring is made by making the tie beams of roof trusses or the load-bearing solid rafters thicker.

The recommended distance between rafters is 900 mm, which also corresponds to the standardised sizes of roof underlay boards. The position of rafters must be taken into consideration when the sizes and locations of flues, chimneys and possible dormer windows are determined. As a rule, these penetrations and openings should be positioned to allow normal distances between rafters. The minimum distance between timber rafters and smoke flues must be 100 mm. The position of rafters is also important when the ends of rafters are cantilevered and exposed at the eaves.

Trussed Rafters

Trussed roof consists of trussed rafters, spandrel panels (gable end trusses) and roof underlay boards. In addition, it may also comprise ridge and eaves boards.

The eaves are supported by principal rafters. A projecting verge is supported by roof underlay boards and by cantilevered gable ladders, i.e. purlins or rafters that run perpendicular to the main rafters. Gable ladders can be attached either to the spandrel truss panel or by using a reduced height spandrel truss to the previous trussed rafter. The latter has the advantage of being able to be attached to the trussed rafters on the ground prior to final erection of the rafters. However, the option is only possible for verges that do not extend further than 400 mm. If the roof underlay is made of plywood, the eaves and verges must have fascia boards and bargeboards.

Roof underlay is attached to the top of the rafters. Instead of building boards, it can also consist of sparse boarding or a lath and sarking.

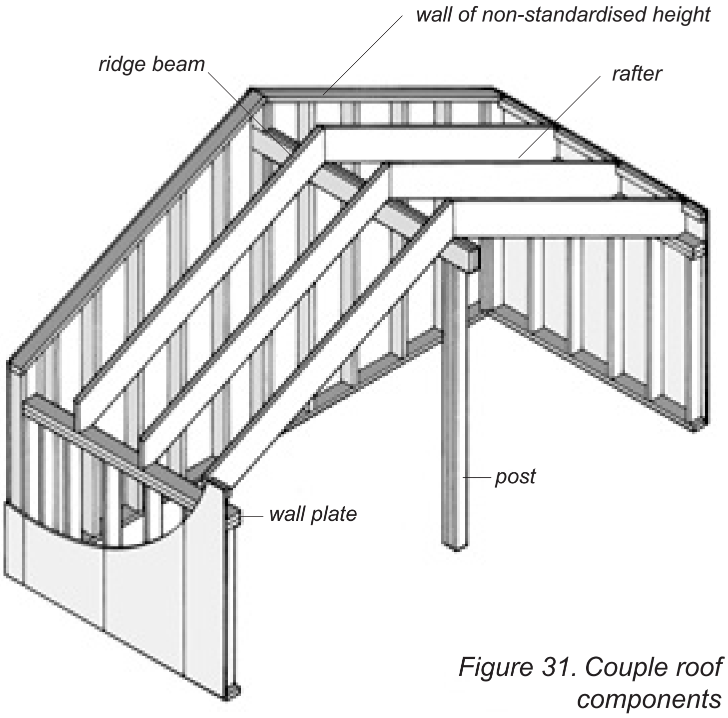
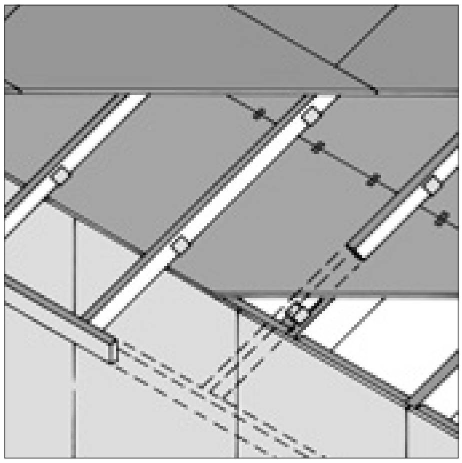
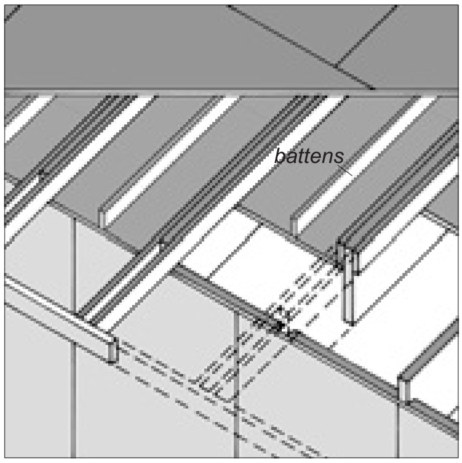


Figure 31. Couple roof components



30 a



30 b

Figure 30 a and b. Eaves support.
a. Breather boards are perpendicular to the rafters and the battens that support the eaves are positioned on top of the rafters.
b. Eaves support are fixed onto the sides of rafters. When breather boards (thickness 12mm) are positioned in between joists parallel to them, infill battens are used in order to prevent breather boards from flexing when the roof is insulated

Couple Roof Rafters

Couple roofs with solid timber rafters are usually used in situations where the height and spaciousness of the interior are to be emphasised. The roof shapes themselves can vary. The use of solid timber rafters, as opposed to trussed rafters, requires a higher number of load-bearing walls or post-beam lines and means that the supporting walls must differ from standardised sizes.

The size of solid timber rafters is determined by roof load, fire regulations and thermal insulation requirements. Couple roof rafters can also consist of braced beams that have been positioned at an angle. The standard distance between rafters is 900 mm, but a spacing of 600 mm c/c is also possible.

The support for the eaves is made either by cantilevering rafters or by using battens, which have been attached either to the top or to the side of the rafters and which also create a ventilation cavity within the roof.

The main ventilation principle in couple roofs uses the height difference within the roof for ventilation – i.e. incoming air from the lower eaves is taken out at the higher eaves, or at the ridge. Whenever necessary, the ridge is supplied with a regular triangular ventilation duct and the gables with extract openings.

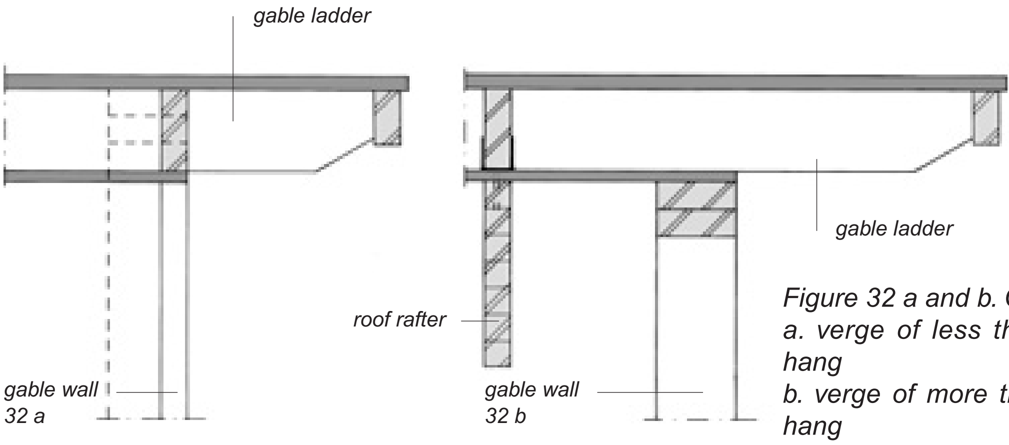


Figure 32 a and b. Couple roof verge
a. verge of less than 400 mm overhang
b. verge of more than 400 mm overhang

Figure 33 a – j. Basic frame junctions
a. ground floor and external wall
b. intermediate floor and external wall
c. roof and external wall
d. ground floor and partition
e. intermediate floor and partition
f. roof and partition
g. ground floor and party wall
h. intermediate floor and party wall
j. roof and party wall

Basic Frame Junctions

The system includes standardised models for the basic structures and for the junctions within the frame. The following images demonstrate how different frame structures are joined to each other. These junction principles apply to detached and row houses as well as apartment blocks. From the architect's point of view, the critical junctions are those where floors and roofs are joined to walls, because they, together with the standardised framing components, determine the basis for the vertical dimensions of a building.

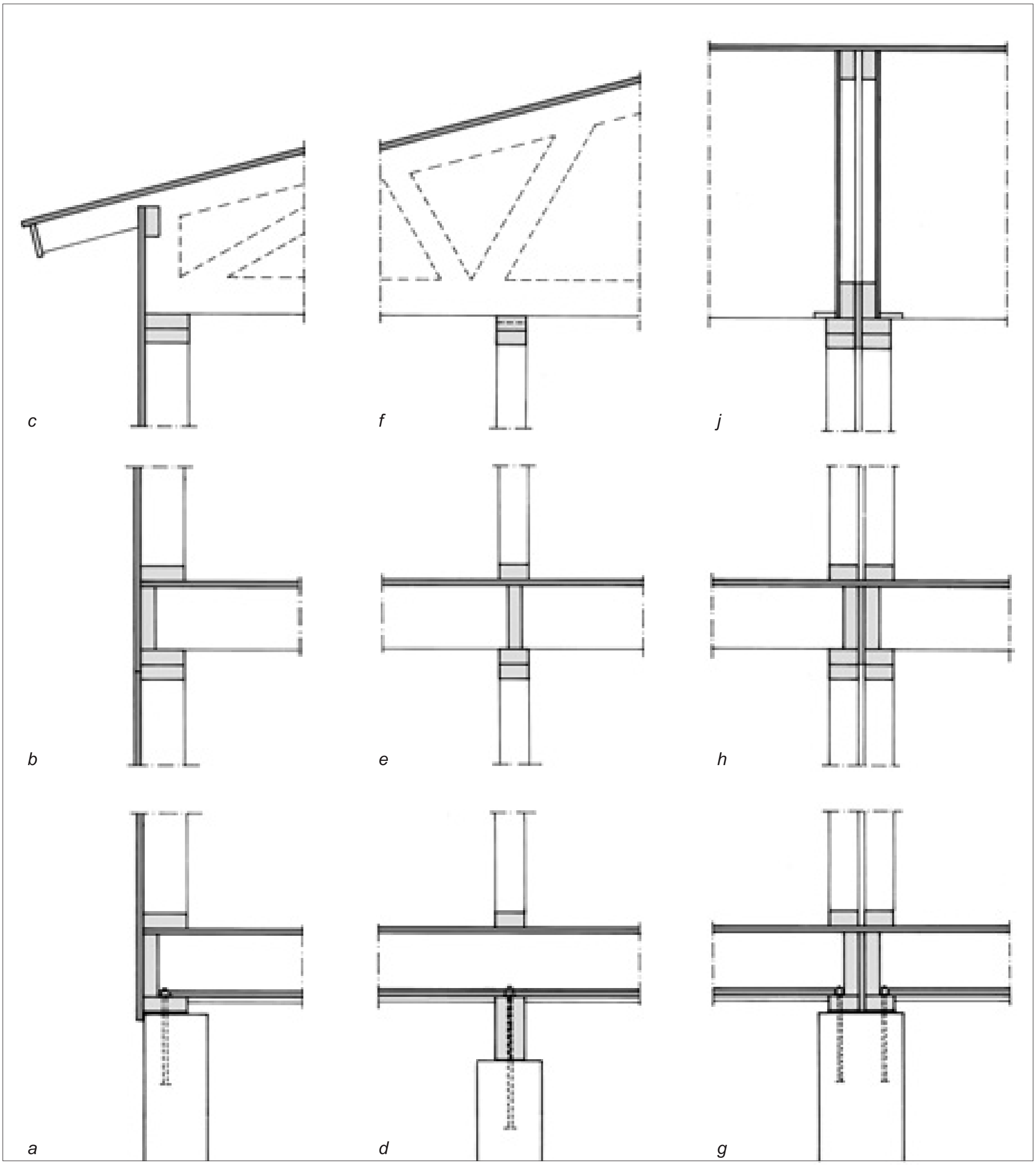
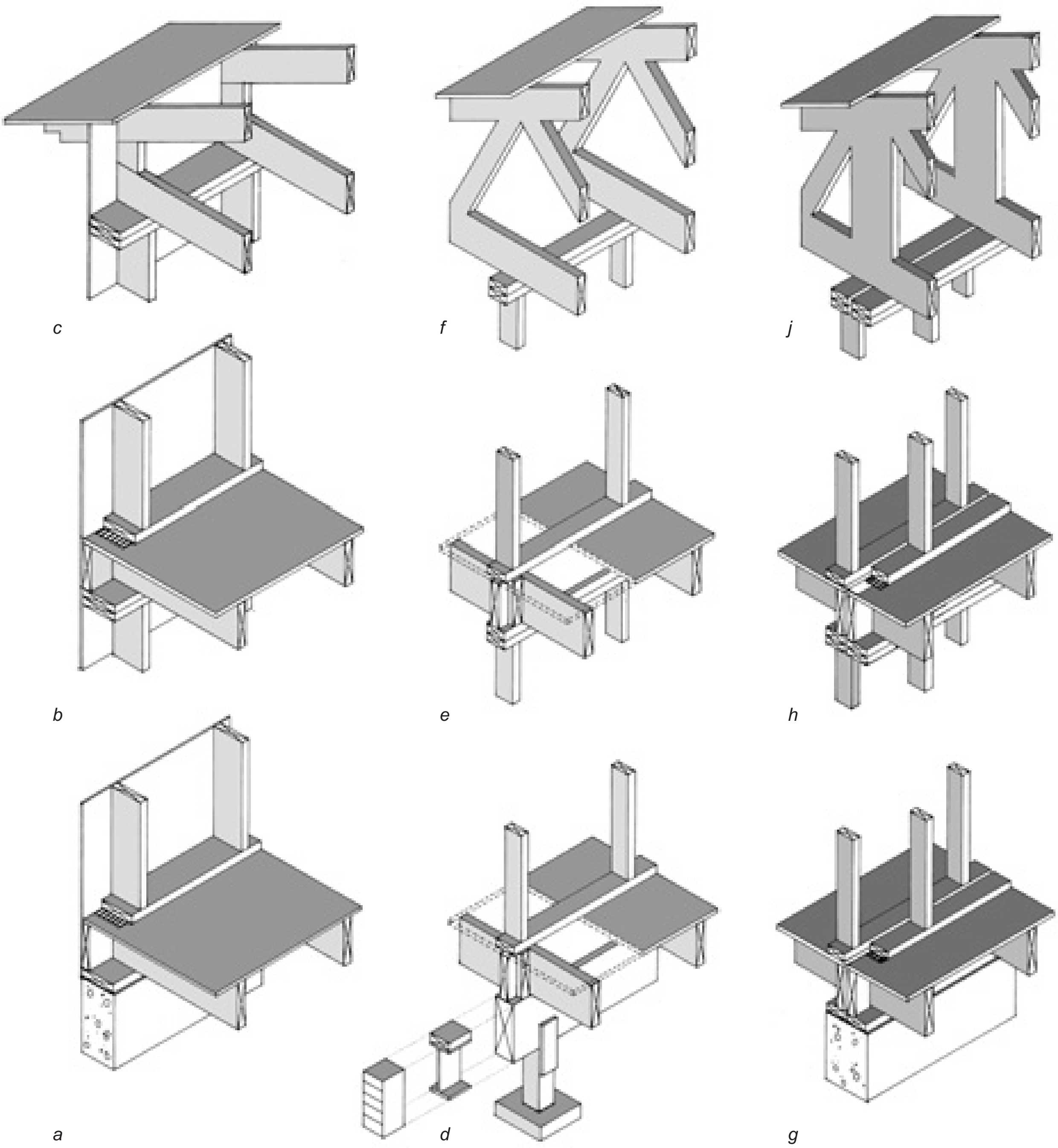


Figure 34 a – j. Basic frame junctions
a. ground floor and external wall
b. intermediate floor and external wall
c. roof and external wall
d. ground floor and partition
e. intermediate floor and partition
f. roof and partition
g. ground floor and party wall
h. intermediate floor and party wall
j. roof and party wall



The Impact of Timber Frame on Architectural Design

It is important for the designer to understand the structural principles, which are inherent to the system, in order to design houses that are appropriate for the system and also to prevent possible structural complications. A building and its spaces must be designed so that they are both appropriate and applicable to the chosen system. The key starting points, set out by the timber framing system for architectural design, include:

- dimensions based on standardised components (mainly vertically).
- position of the load-bearing grid.
- horizontal spans.

Horizontal Dimensions

Basic Principles

In principle, architectural design is relatively free of restrictions imposed by horizontal dimensions, as long as the position of the load-bearing structural grid takes into account the achievable spans within timber construction. The design modules of the frame itself do not restrict architectural design. Internal spaces and rooms can be given any dimensions depending on their functional and other design requirements.

The position of the load-bearing structural grid forms a structural basis for spatial design. The horizontal spans influence the spacing distance between joists. On the other hand, the direction of the load-bearing structures has an impact on joist direction, which in turn affects duct and other installations at a later stage in the construction process.

The Structural Grid

A structural grid that consists of walls or post-beam lines, is characteristic to timber houses as timber joist spans are restricted. In practise, load-bearing structures, i.e. walls or post-beam lines, are required at 4–6 metre intervals depending on the choice of joists. The building and its spaces must be designed to allow for the appropriate position of load-bearing structures.

Load-bearing structures are positioned to allow loads to be transmitted directly from top to bottom, which in practise means that load-bearing walls and/or posts on different floors must line up. Structurally the building must be examined from top downwards. Loads that rest on the roof and the floors must be transmitted to lower walls and beams. These, in turn, must transmit the accumulated loads lower down etc.

Detached Houses

In detached houses external walls are always load-bearing. The number of load-bearing walls depends on the roof support and on the number of floors in the house. These factors have been described in the following.

In single storey detached houses, with trussed roofs, partitions can be placed freely.

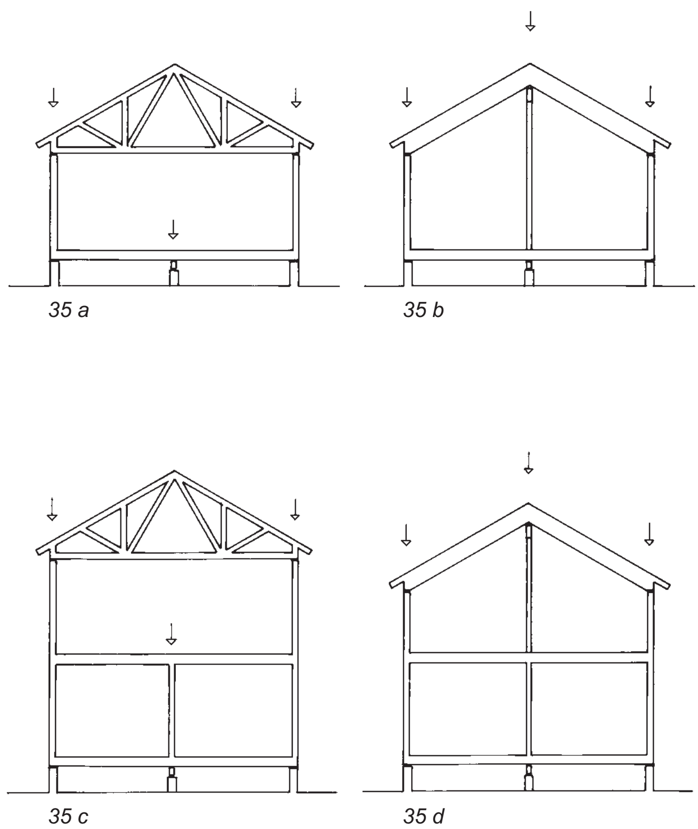


Figure 35 a-d. Structural grid, the requirement and position of load-bearing structures in single storey and two storey houses.

a. Single storey house with trussed rafters. No internal load-bearing walls. Ground floor joists can be supported in accordance with the joists.

b. Single storey house with couple roof. Load-bearing wall is parallel to ridge beam. Ground floor joists' support is positioned in parallel to ridge beam and load-bearing wall.

c. Two-storey house with trussed rafters. Top floor does not require internal load-bearing walls. A load-bearing structure is required on the lower level for intermediate floor joists. Ground floor joists' support is in line with the load-bearing wall.

d. One-and-a-half or two-storey house with couple roof. Upper level load-bearing wall is parallel to ridge beam. On the lower level a load-bearing structure is required for intermediate floor joists. It is positioned in line with the upper level wall. Ground floor support is also positioned accordingly.

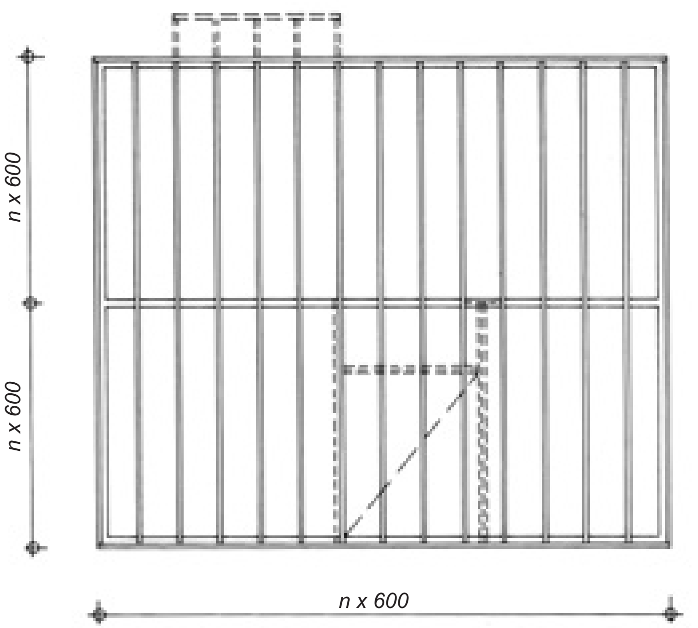


Figure 36. Typical joist choice for a detached house. The long external walls are load-bearing and there is another joist support in the middle of the building. The joists extend over the mid-support without a break.

To eliminate the need to cut or saw building boards, a note must be taken of the fact that the dimensioning must start from the outside edge of the frame (header joist, rim joist) and the distance between the edge joists and the one next to it, is less than other joists spacings (by half the thickness of a joist).

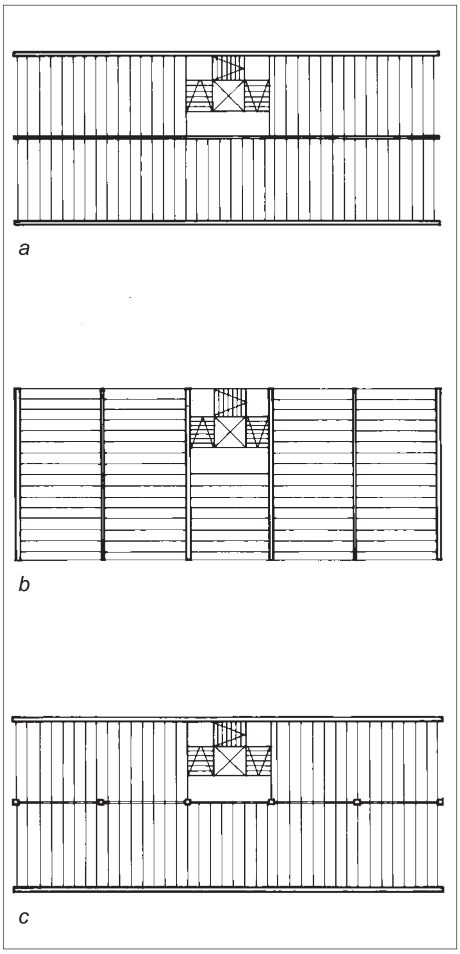


Figure 37 a, b and c. Joist layouts. Alternatives for apartment blocks
a. load-bearing external walls and partition
b. load-bearing partitions
c. load-bearing external walls combined with post-beam line

In two-storey houses, the load-bearing structural grid is determined by the chosen roof structure. Usually trussed roofs require only external walls, in which case partitions can be positioned freely. A couple roof requires a ridge beam, which is supported either by load-bearing walls or posts. The number of these depends on spans and other loads on the roof. If the ridge beam is supported at gable ends, it must be taken into consideration in the design of the gable end openings.

In one-and-a-half storey and two-storey houses, the lower level usually has to have at least one internal load-bearing wall or post-beam line, because the floor joists between ground level and first floor require support in the middle. If the house has trussed rafters, the mid-support can be positioned where it is spatially most appropriate. In houses with couple roofs on the lower level load-bearing wall must be positioned in line with the upper level roof supports.

The ground floor joists usually require support in the middle. It is positioned in line with load-bearing structures above. If they don't exist, the position of the floor support is free and in accordance with what is most appropriate for the floor joists.

Apartment Blocks

In apartment blocks load-bearing structures usually consist of external walls and of some partitions. The direction of the load-bearing walls can be either parallel or perpendicular to the direction of the building or a combination of these. Whenever necessary some or all load-bearing walls can be replaced by posts and beams.

Particular attention must be paid to the position and type of load-bearing structures in apartment blocks, because they play a crucial role in the overall floor area calculations. Even though external timber walls are relatively thin, they have good thermal insulation properties and consequently provide a spatially efficient alternative.

Vertically the position of load-bearing structures follows the same principle in apartment blocks as in detached houses. If the external walls are load-bearing and if the roof consists of trussed rafters, the top floor of does not usually require load-bearing partitions. Couple roofs are usually supported on load-bearing walls that are positioned in line with load-bearing structures on the floors below. Floor joists usually require mid-supports which must line up on all floors.

Spans

Spanning distances depend on the size, spacing and type of joists being used. The load-bearing capacity of joists can be improved by spacing the joists closer to each other or by using double joists, i.e. joists that have been attached to one another.

Standard joists (220mm) span between 4 and 5 metres depending on their spacing and the weight of the floor structure. Parallel grain plywood beams and braced beams that are 300-400 mm deep can achieve spans of approximately 7 metres. Composite joists that combine concrete and timber achieve approximately 6 metre spans.

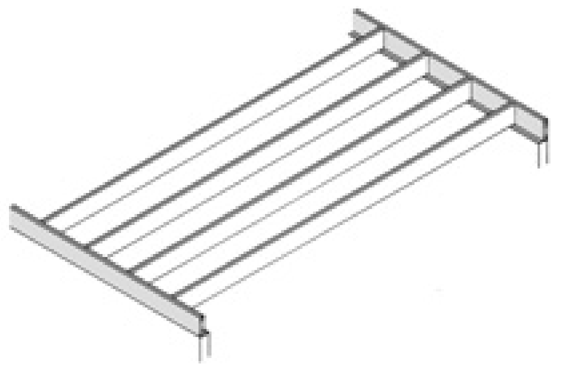
Spans that extend standardised lengths should not be used because they cause vibration within the joists. However, vibration can be reduced by using cross-bracing. In addition, the accumulation of vertical loads on only a few walls can also create problems in dimensioning. The longer the span, the deeper the joists and consequently increased floor heights.

If the design requires a long and open internal space, some of the load-bearing walls can be replaced by posts and beams. Different span dimensions, made possible by the use of different joists, are illustrated in the following tables.

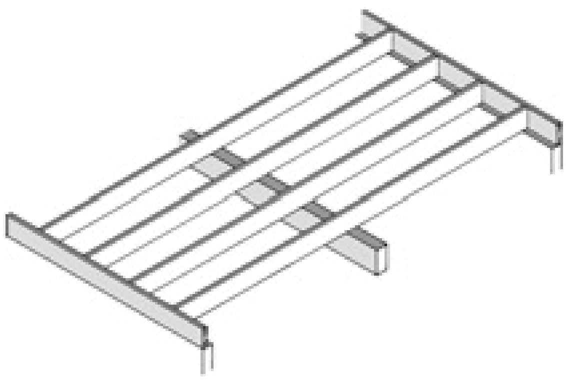
Single span joists
Consist of joists which are supported at each end without mid supports.

Continuous span joists
Consist of joists that are supported at each end and at intermediate positions. The joists are supported at three different points. Spans achieved using this system are longer than those using single span joists.

Directive span dimensions for timber floor structures of both single and continuous spans



38 a



38 b

SINGLE SPAN JOISTS

Joist type and size	Spans at different joist centres		
Solid timber	600 c/c	400 c/c	300 c/c*
48x172	3,0 m	3,5 m	3,8 m
48x220	3,9 m	4,5 m	4,9 m**
Parallel grain plywood			
45x220	4,4 m	4,9 m	5,3 m
45x260	5,2 m	5,6 m	6,0 m
Nail plate beam			
48x300	5,0 m	5,5 m	6,0 m
48x350	5,5 m	6,0 m	6,5 m
Braced beam			
97x400	6,0 m	6,5 m	

CONTINUOUS SPAN JOISTS

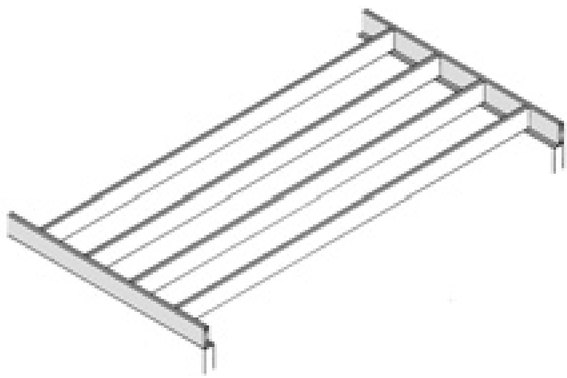
Joist type and size	Spans at different joist centres		
Solid timber	600 c/c	400 c/c	300 c/c*
48x172	3,5 m	4,1 m	4,4 m
48x220	4,5 m	5,0 m**	5,4 m**
Parallel grain plywood			
45x220	4,8 m	5,3 m	5,8 m
45x260	5,5 m	6,1 m	6,6 m
Nail plate beam			
48x300	5,5 m	6,0 m	6,5 m
48x350	6,0 m	6,5 m	7,0 m

g = 0.5 kN/m²
**) 300 mm c/c = double joists 600 mm c/c*
***) when overall length exceeds 9000 mm, joists can be longer than the standardised length*

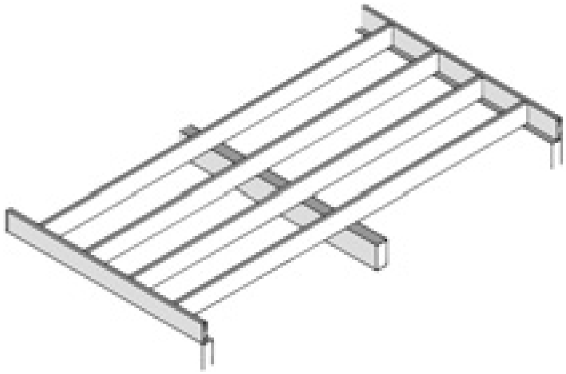
- *Joist timber is strength graded, C24, live load 1,5 kN/m2*
- *The spanning distance depends on the materials, spacing and dimensions of joists, the weight of the structure, live loads, the position and weight of partitions above the floor level and the specific fire rating*
- *The combined effect of floor boards and joists is not taken into consideration*
- *Parallel grain plywood is made by glueing parallel veneers together*
- *Glulam beams are made by glueing battens together*
- *A nail plate beam is a solid timber beam made by using a nail plate and nailing two beams vertically together*
- *Structurally braced beams correspond to trussed rafters*

Figure 38 a and b. The above complies with The Finnish National Design Norm B10, but whenever necessary, local appropriate norms and standards must be followed. Floor structure light (e.g. floating floor).

Directive span dimensions for timber floor structures of both single and continuous spans



39 a



39 b

SINGLE SPAN JOISTS

Joist type and size	**Spans at different joist centres**		
Solid timber	600 c/c	400 c/c	300 c/c*
48x172	2,6 m	3,0 m	3,3 m
48x220	3,4 m	3,9 m	4,3 m
Parallel grain plywood, laminated veneer lumber			
45x220	3,8 m	4,4 m	4,8 m
45x260	4,5 m	5,2 m	5,7 m
Nail plate beam			
48x300	4,5 m	5,0 m	5,5 m
48x350	5,0 m	5,5 m	6,0 m
Braced beam			
97x400	5,5 m	6,0 m	

CONTINUOUS SPAN JOISTS

Joist type and size	**Spans at different joist centres**		
Solid timber	600 c/c	400 c/c	300 c/c*
48x172	3,2 m	3,7 m	4,1 m
48x220	4,2 m	4,8 m**	5,3 m**
Parallel grain plywood, laminated veneer lumber			
45x220	4,7 m	5,4 m	6,0 m
45x260	5,5 m	6,1 m	6,6 m
Nail plate beam			
48x300	5,0 m	5,5 m	6,0 m
48x350	5,5 m	6,0 m	6,5 m

g = 1.5 kN/m²
**) 300 mm c/c = double joists 600 mm c/c*
***) when overall length exceeds 9000 mm, joists can be longer than the standardised length*

- *Joist timber is strength graded, C24, live load 1,5 kN/m2*
- *The spanning distance depends on the materials, spacing and dimensions of joists, the weight of the structure, live loads, the position and weight of partitions above the floor level and the specific fire rating.*
- *The combined effect of floor boards and joists is not taken into consideration*
- *Parallel grain plywood is made by glueing parallel veneers together*
- *Glulam beams are made by glueing battens together*
- *Nail plate beam is a solid timber beam made by using a nail plate and nailing two beams vertically together*
- *Structurally braced beams correspond to trussed rafters*

Figure 39 a and b. The above complies with The Finnish National Design Norm B10, but whenever necessary, local appropriate norms and standards must be followed. Floor structure heavy (e.g. 50 mm concrete screed).

Figure 40. Vertical dimensions using standardised products.
1. Floor height is 3012 mm
2. Wall frame height is 2774 mm
3. Floor deck thickness is 238 mm
4. Room height 2600-2700 mm depending on ceiling and floor finishes

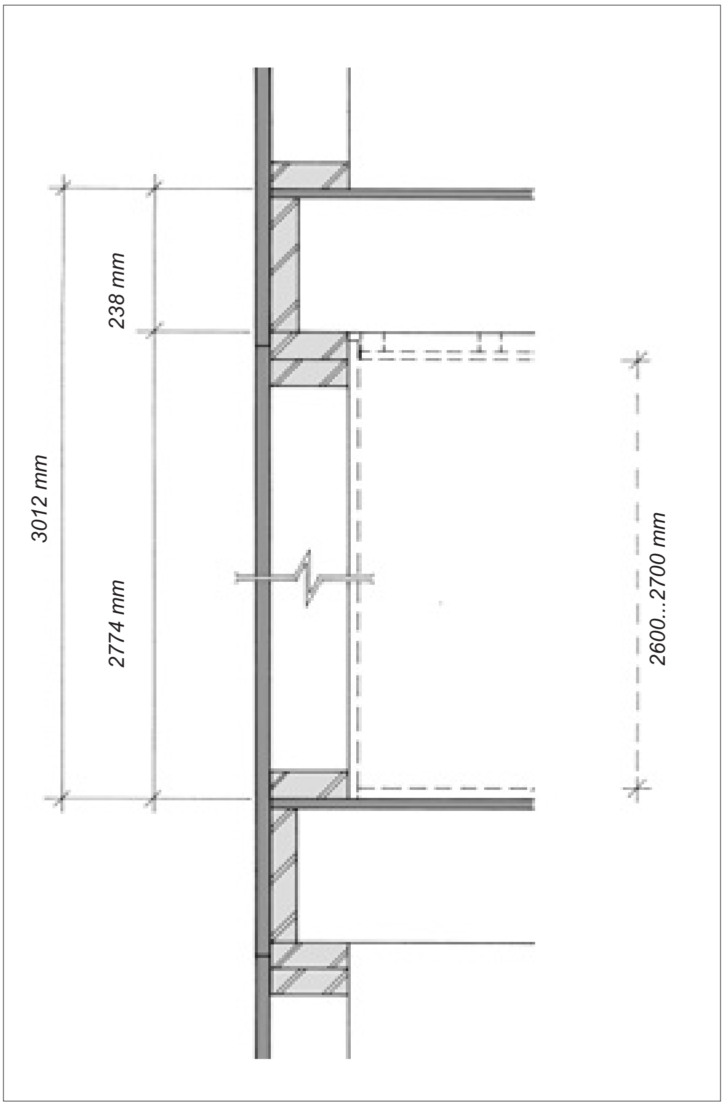
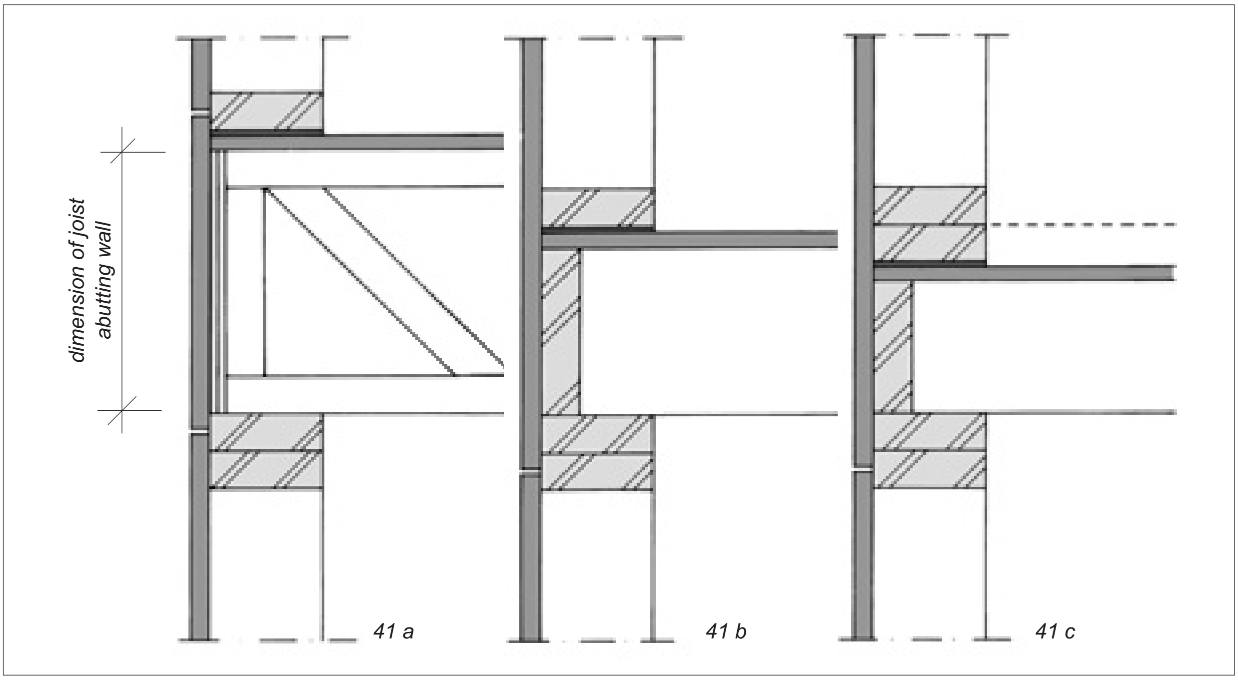


Figure 41 a, b and c. When joist depth increases, floor height increases also. The difference in floor height, as a result of using shallow joists, can be evened out within the wall frame by using an extra sole plate.
a. 350 mm high braced beam
b. standard, 220 mm deep, solid timber joist
c. 172 mm deep solid timber joist



Vertical Dimensions

The vertical dimensions within the frame are determined by standardised components and their junction principles. The components have been dimensioned to allow for the parallel use of the same components in both detached houses and apartment blocks.

The standardised height of the wall frame forms the basis for vertical dimensioning. This dimension is measured from the sub-floor surface to the underside surface of the joists, and using standardised products, it is always 2774 mm.

The floor deck thickness can vary and it is determined by joist depth. It affects floor height, but not room height. Using standardised products, the floor deck thickness is 238 mm and the resultant floor height 3012 mm.

Room height is affected by the thickness of floor and ceiling finishes and their underlay sheathing requirements. Due to sound insulation requirements, floor decks in apartment blocks are usually thicker than in detached houses.

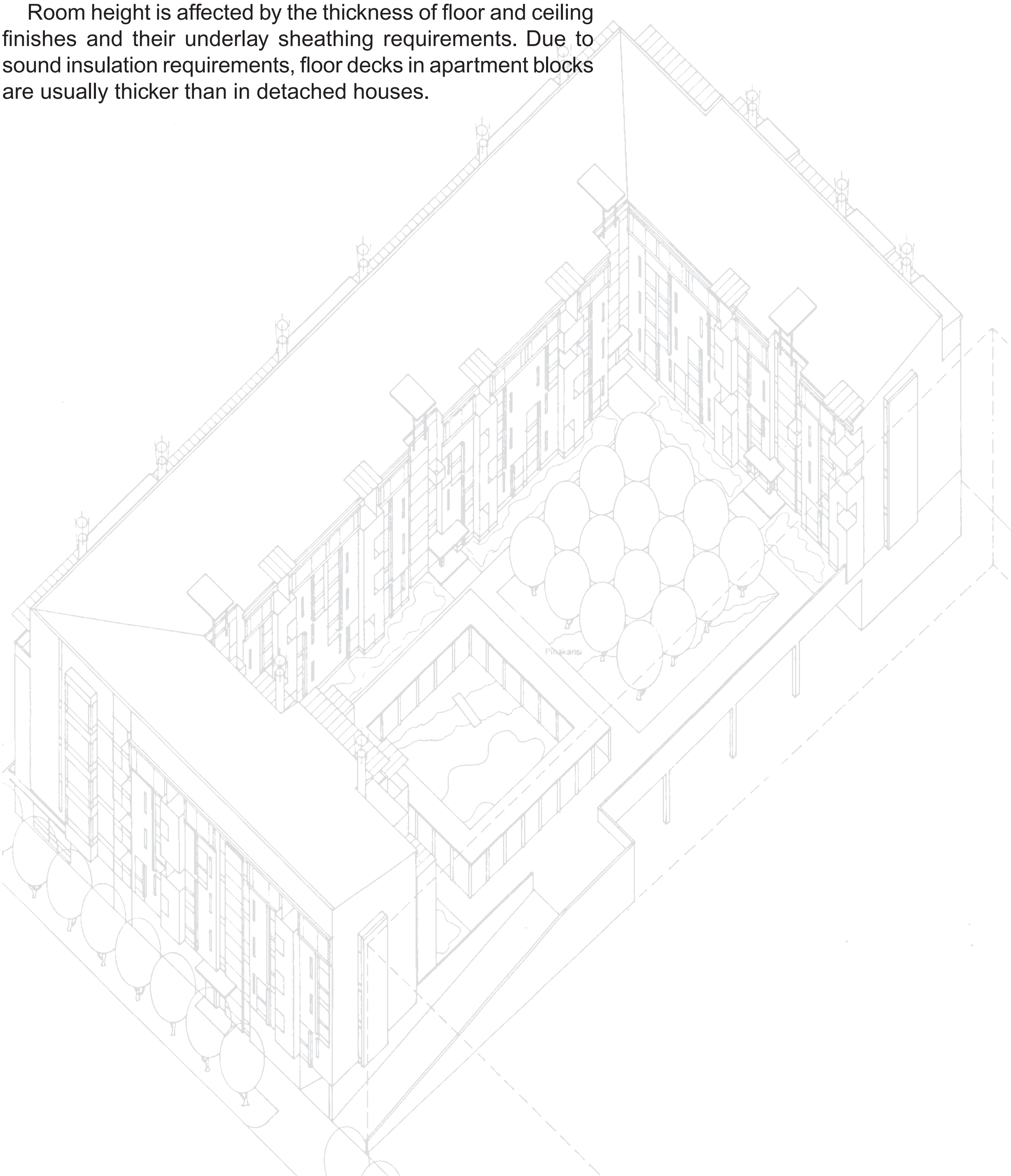
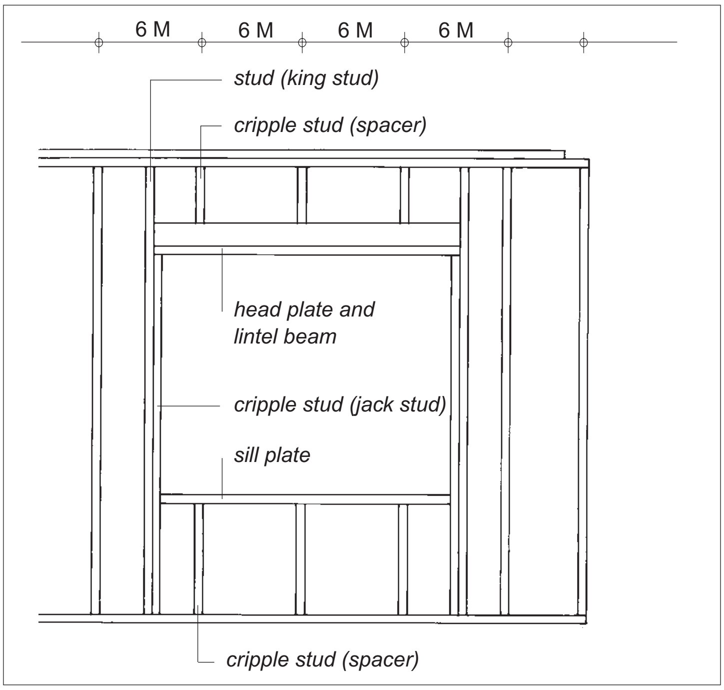


Figure 42. Spacing of studs does not affect the positions of openings. In load-bearing walls, enough space must be left for cripple studs, especially if openings are positioned next to one another or at corners.

In load-bearing walls, the studs that form the sides of the opening may be multiplied in order to retain the load-bearing capacity of the wall. As a rule the number of extra cripple studs at the sides is equal to the number of studs omitted in the opening.



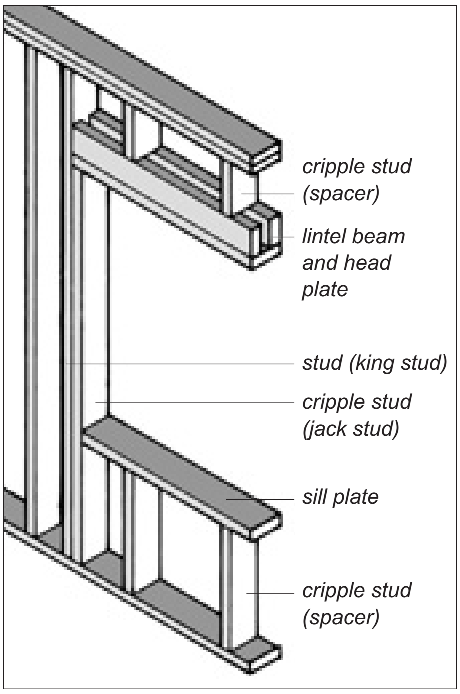


Figure 43. Opening frame

Wall Openings

In principle, wall openings can be positioned freely on wall surfaces. The spacing of studs does not affect the location of openings. The possible need for extra support at the sides of rough openings must be taken into account and enough space must be given to allow the studs to be multiplied, especially if a number of openings are to be positioned side by side or if the opening is situated in a corner.

The size of an opening depends on wall loads and the type of lintel beam used. Lintel beams in external walls can consist of:

- headbinders (wall plates) that have been nailed together
- header joists (rim joists)
- reinforced header joists
- lintel beams positioned on top of the opening.

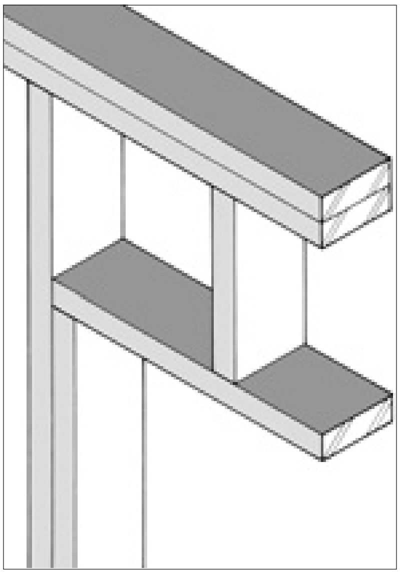
In partitions, lintel beams can consist of:

- headbinders (wall plates) that have been nailed together
- primary beams positioned under joists
- primary beams positioned within joists
- lintel beams positioned on top of the opening

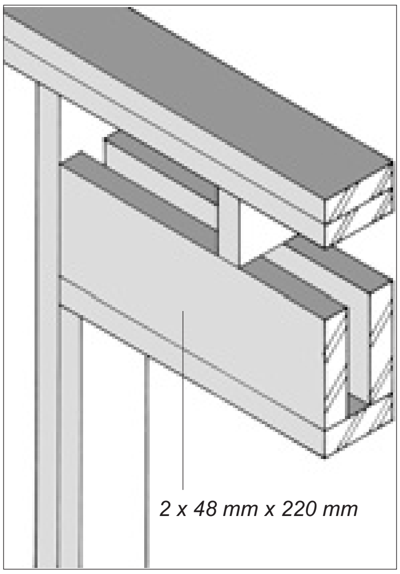
Different choices provide different maximum opening dimensions, which have been illustrated in the enclosed table.

In architectural design documents the lintels are not usually specified. However, the possible lintel beam must be taken into account as an appropriate space reserve above the opening. Header joists can be used as lintels in openings that do not exceed 2 metres in width. When using header joists, floor joists are attached to the header with joist hangers. The advantage of using a header joist is in the free vertical positioning of the opening. If it is not possible to use a header joist as a lintel, a beam is positioned above the opening and this must be taken into account within the vertical dimensions.

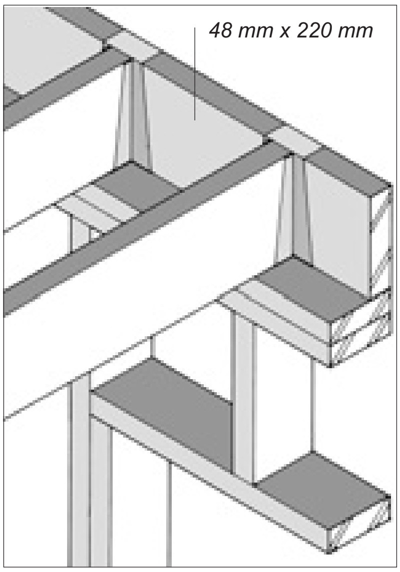
In partitions lintels consists of beams that have been positioned either within the stud wall frame or the joists. A beam above the opening limits the height of the opening. Using a primary beam within the joists renders the vertical position of the opening free of limitations.



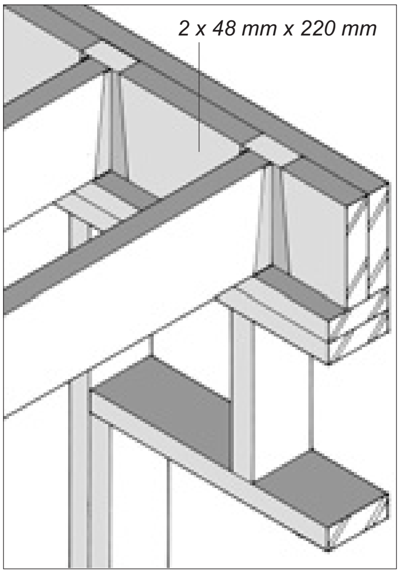
a. Alternative 1: headbinders (wall plates) that have been nailed together form lintel.



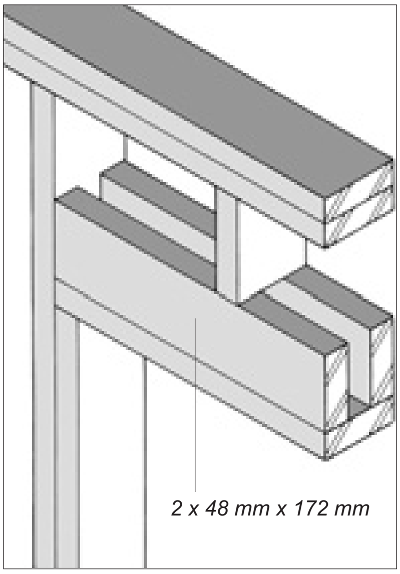
b. Alternative 2: lintel consists of two 48 mm x 220 mm floor joists.



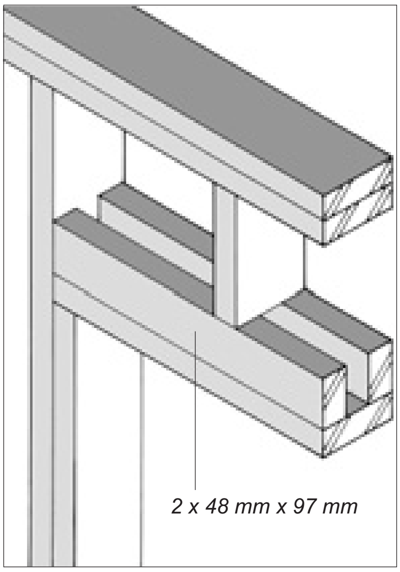
c. Alternative 3: header joist (rim joist) forms lintel.



d. Alternative 4: reinforced header joist forms lintel.



e. Alternative 5: lintel consists of two 48 mm x 172 mm floor joists.



f. Alternative 6: lintel consists of two 48 mm x 97 mm joists (wall plates).

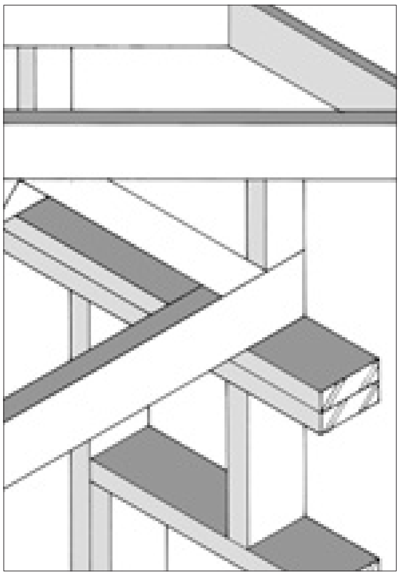
Figure 44 a – f. Maximum widths of window and door openings in external walls (rough opening dimension).

Structure	1 *)	2 **)	3	4	5	6
A) 0.5 kN/m^2	800 mm	2700 mm	2100 mm	2700 mm	1800 mm	1100 mm
B) 1.5 kN/m^2	700 mm	2400 mm	1600 mm	2400 mm	1600 mm	1000 mm

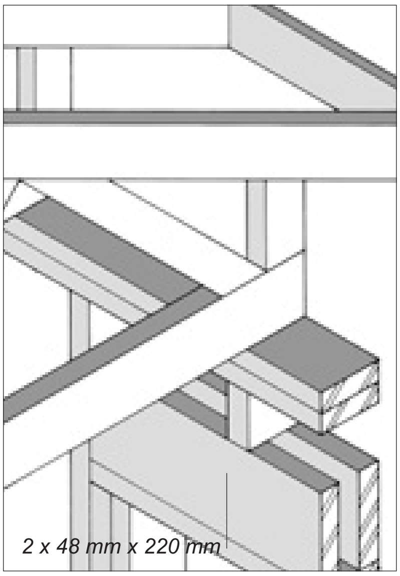
A) Floor structure without concrete screed
B) Floor structure with concrete screed
*) Timber C18
**) Double stud to support beam

- timber C24, medium time category, service class 2
- live load 1,5 kN/m^2
- loading width on floor 2,5 m (=sawn timber spans less than 5 m)
- besides floor, lintel beam is also loaded by wall and window above opening
- fire category R60, 30 minute protection, and R30, 15 minute protection.

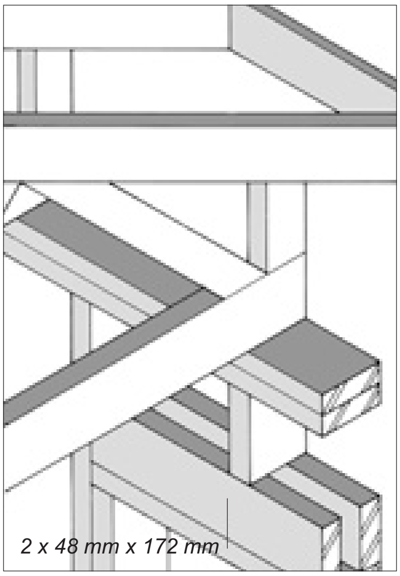
[1]) In case no.3 (header joist in the middle of frame) and in case no.4. the fire resistance of joist hangers must be clarified separately or the joist hangers must be fire proofed.



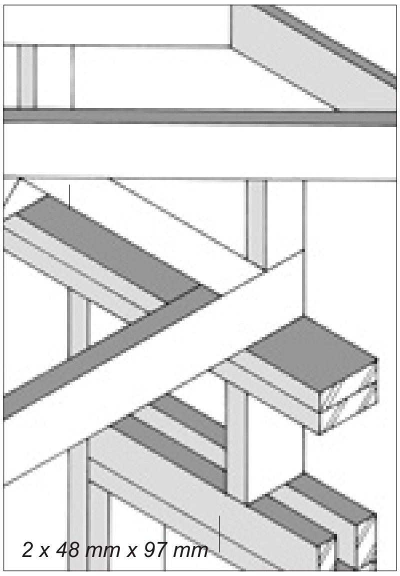
a. Alternative 1: headbinders (wall plates) that have been nailed together form lintel.



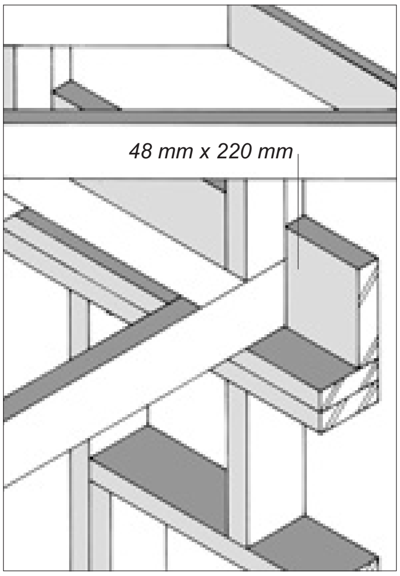
b. Alternative 2: lintel consists of two 48 mm x 220 mm beams.



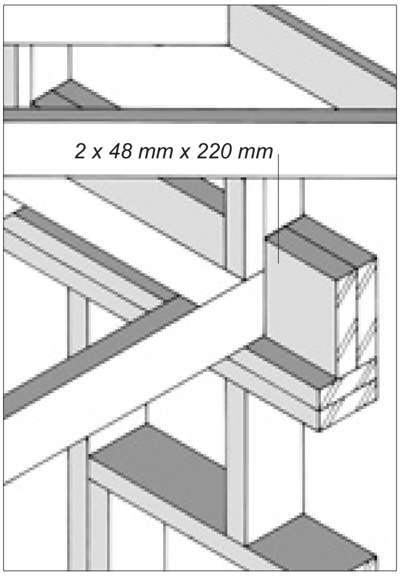
c. Alternative 3: lintel consists of two 48 mm x 172 mm beams.



d. Alternative 4: lintel consists of two 48 mm x 97 mm beams



e. Alternative 5. header joist forms lintel.



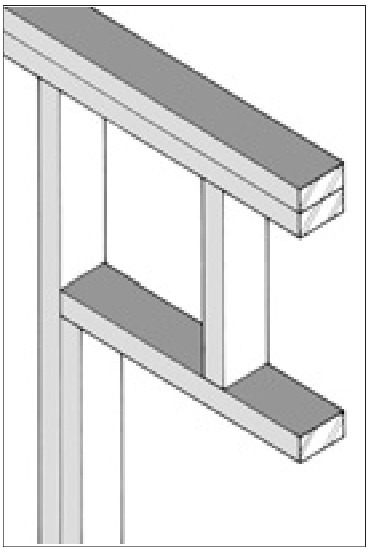
f. Alternative 6: reinforced header joist forms lintel.

Figure 45 a – f. Maximum widths of window and door openings under roof structure (rough opening dimension).

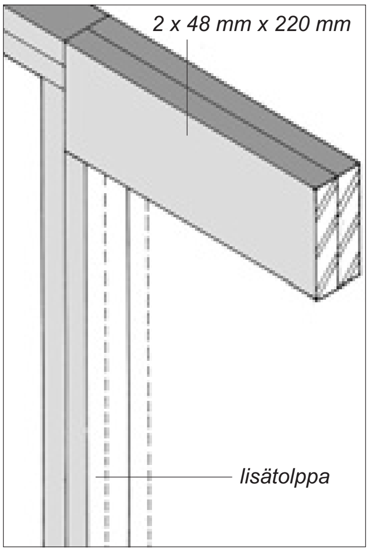
Loading range	Lintel beam span					
	1 *)	2 **)	3	4	5 ***)	6 ***)
3.0 m	900 mm	2500 mm	1700 mm	1100 mm	1400 mm	2500 mm
4.0 m	800 mm	2300 mm	1500 mm	1000 mm	1000 mm	2300 mm
5.0 m	700 mm	2100 mm	1300 mm	900 mm	-	2100 mm
6.0 m	600 mm	1700 mm	1100 mm	700 mm	-	1700 mm

*) Timber C18
**) Double stud to support beam
***) Compression perpendicular to grain at points where the lintel abuts a truss must be checked separately.

- Timber C24, medium time category, service class 2
- Snow load 1,8 kN/m^2
- G = 1,0 kN/m^2 (incl. cement tile roof, when using felt or plastic roofing material, the span can be increased by 10%)
- Fire category R60, 30 minute protection, and R30, 15 minute protection.



a. Alternative 1: headbinders (wall plates) that have been nailed together form lintel.



b. Alternative 2: lintel consists of two 48 mm x 220 mm joists

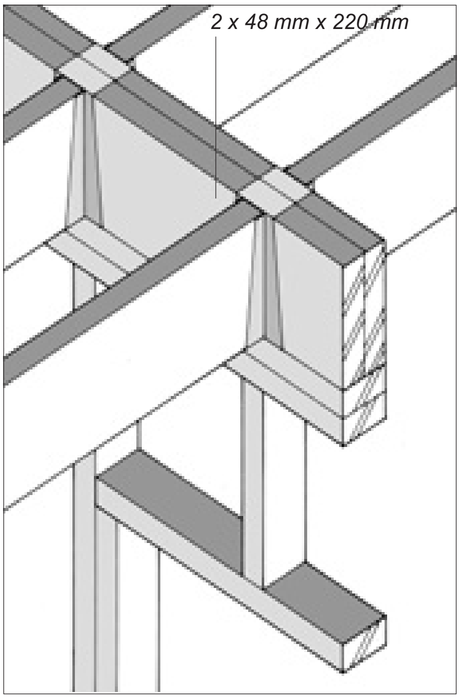
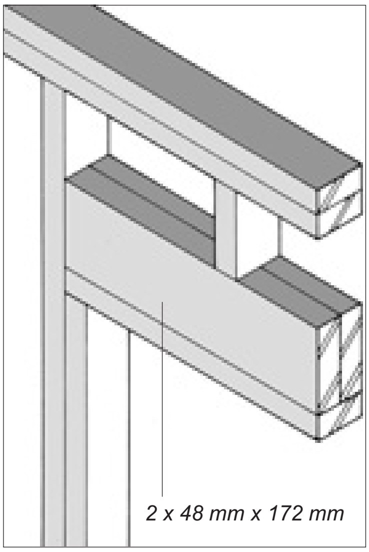
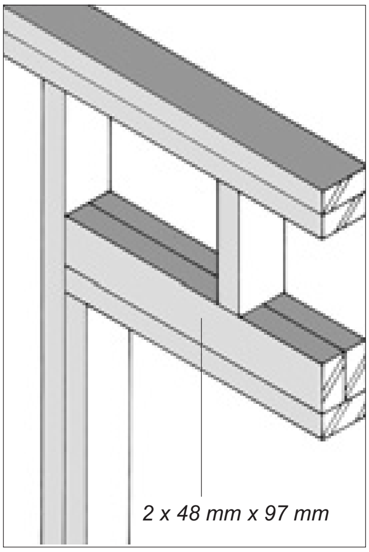


Figure 47. Lintel beams can also be positioned in line with floor joists allowing the opening to extend to the ceiling. This must be taken into account in the joist spans, because it prevents joists from spanning uninterruptedly across load-bearing grid lines.



c.Alternative 3: lintel consists of two 48 mm x 172 mm joists



d. Alternative 4: lintel consists of two 48 mm x 97 mm joists.

Figure 46 a – d. maximum width of openings (rough opening dimension).

Structure	1 *)	2 **)	3	4
A) 0.5 kN/m²	800 mm	2400 mm	1500 mm	1000 mm
B) 1.5 kN/m²	700 mm	2000 mm	1200 mm	800 mm

A) Floor structure without concrete screed
B) Floor structure with concrete screed
*) Load width from the floor 2,5 m (=continuous sawn timber joists, the spans of which are less than 2 m)
**) Timber C24, double stud to support beam.

- Timber C18, medium time category, service class 2
- Live load 1,5 kN/m^2
- Loading width from the floor 5,0 m (=continuous sawn timber joists, the span of which are less than 4 metres)
- The table does not concern openings under roofs.
- Fire category R60, 30 minute protection, and R30, 15 minute protection.

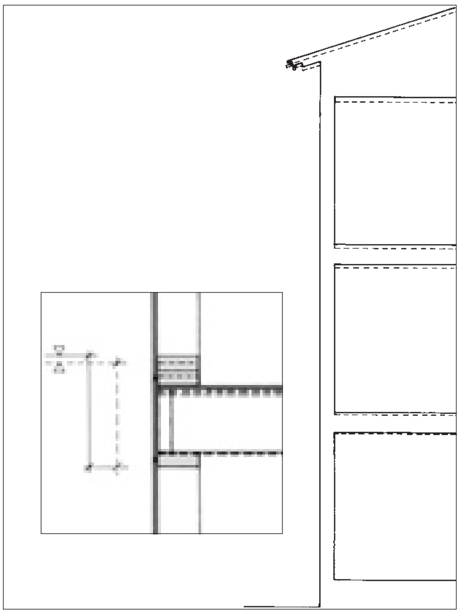
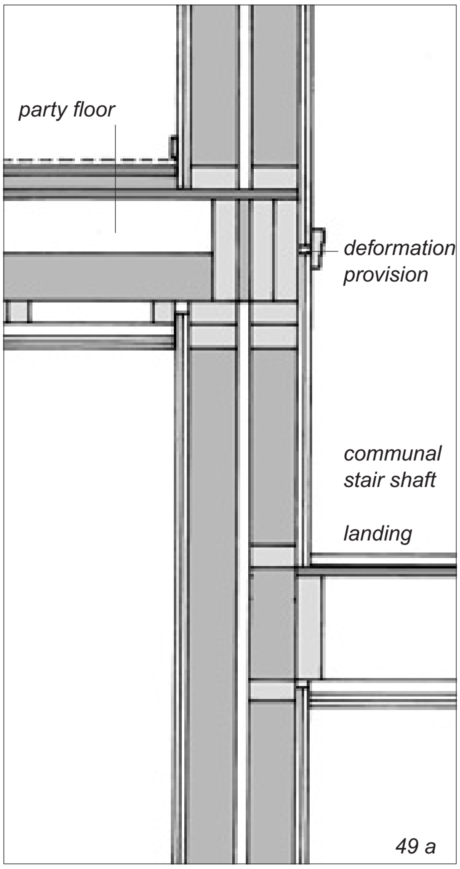


Figure 48. Most of the deformation takes place at intermediate floors

Figure 49 a, b and c. In communal stairwells, the internal lining boards of the shaftwall are often positioned against the ends of intermediate floor decks. When this is the case internal lining boards must allow provision for deformation at the stepped floor level.



Deformation Provision

Deformation is a typical feature within timber buildings. Characteristically timber buildings settle over a period of time. It is the result of the following:

- Shrinking which is the result of timber drying
- Compression of timber due to building mass.

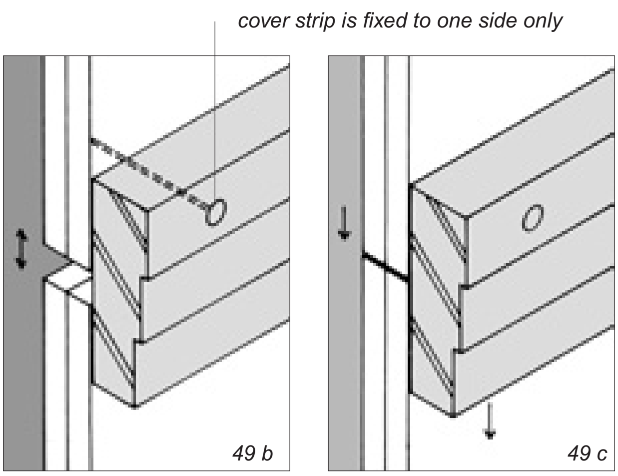
Most of the deformation takes place at intermediate floors decks, which is due to the fact that most of the shrinking process happens in a perpendicular direction to the grain and that the cellular structure of wall plate timbers compresses the most at points where the plates are joined to studs. Measured settlements have varied between 5 and 10 mm per storey. Even though there is more deformation on lower storeys, the cumulative effect of deformation is the most on higher storeys. This is only significant when the timber frame is attached to structures that do not settle over time.

Deformation is taken into account during the structural design process. Vertical dimensioning in architectural design is based on standardised dimensions of the framing components and consequently deformation is not taken into consideration in architectural dimensioning. However, architectural design must provide tolerance for deformation within the junctions of structural elements and at other points where movement could damage surface materials.

Normally deformation does not create problems for internal lining. Deformation in walls is not extensive and the ends of lining boards have tolerance for minor deformation. Joints in ceiling linings are finished with elastic filler and covered with timber strips, which allow for deformation of the floor or the roof above.

Whenever necessary surface materials should have joints that enable structural deformation. Particular attention must be paid to finishing joints in spaces where internal wall lining boards are attached against the ends of intermediate floor decks (e.g. stair shafts).

Structures that create differential vertical movement within the frame include lift shafts, bomb shelters, both of which are usually constructed using aggregated materials (such as concrete, brick etc.), balconies that are supported by a separate frame, and uniform external claddings that extend the entire height of the building. Deformation is taken into consideration in vertical dimensions by dimensioning the building to correspond to the situation after deformation i.e. the height of different components, after deformation, correlates with the desired



specification. Flashings are designed to allow adequate fall even after deformation has taken place.

Due to fire regulations in apartment blocks, ventilation cavities usually require fire stops. These points provide a natural position for deformation tolerances. However, deformation must not hinder ventilation of external cladding, which must be taken into account in vertical dimensions.

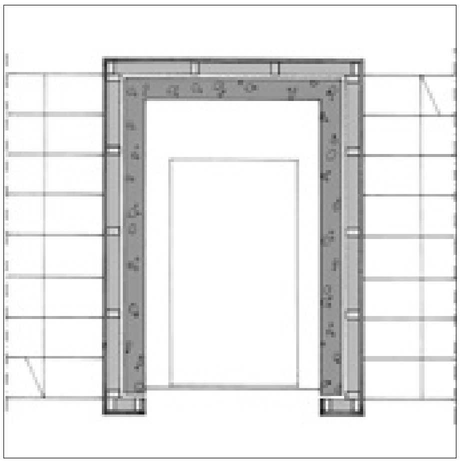


Figure 50. Concrete lift shaft (separated form an independent structure with the frame)

Frame Adaptations

In all timber framed building projects there are situations which cannot be designed and realised in accordance with the standardised models of the system. When this is the case, the project requires special adaptation.

The specific adaptation must be narrowed down to a single manageable design, which has a limited impact on the overall structure. Its junction with standardised components must be clear, its impact must be localised and it must not prevent the use of the system elsewhere. The following paragraphs describe the most common adaptations of the system.

Stair Shafts, Stairs

In principle stair shafts can be constructed using timber framing in accordance with the overall system, but the appropriate local fire regulations must be taken into consideration. The advantage of a timber framed stair shaft is the fact that its vertical structure has similar deformation properties to the rest of the building's frame.

Lifts

A lift shaft can be constructed using either timber, steel, brick or any aggregated material. Due to vibration and differential movement, it is separated from the rest of the building's frame. The deformation differences between the lift shaft and the building's frame are dealt with by using adjustable mechanisms in lift drives and doors.

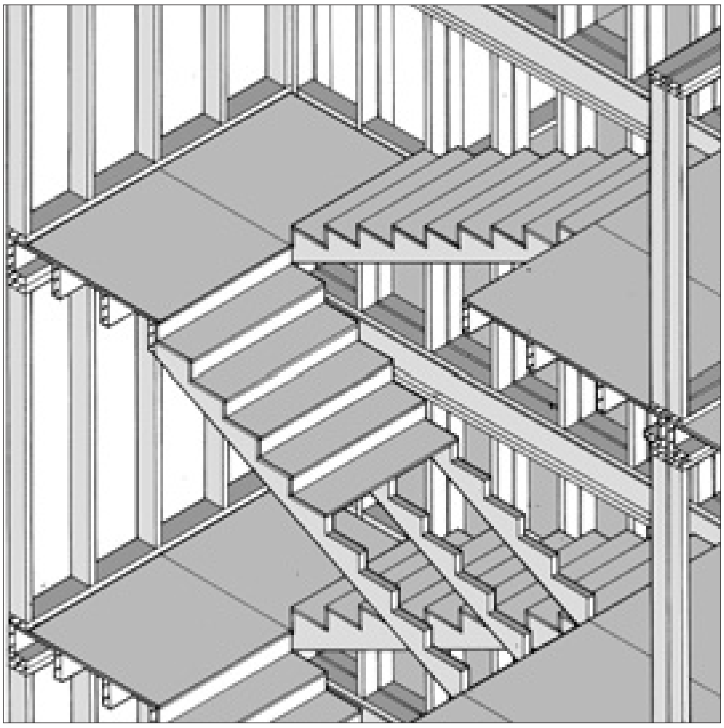


Figure 51. Timber framed stair shaft

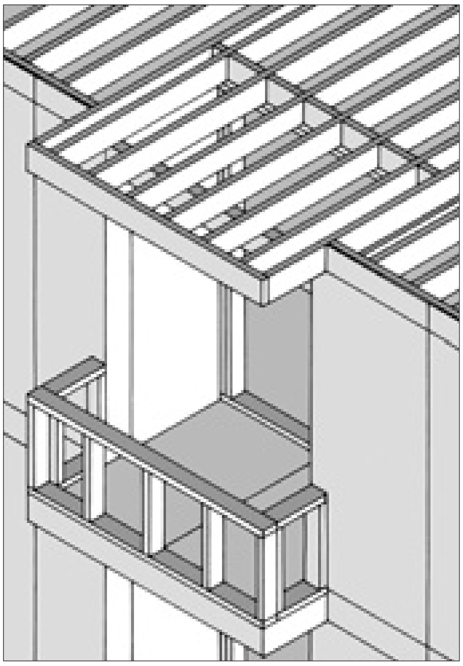


Figure 52 a – e. Alternative balcony supports.
a. Partly cantilevered balcony
b. Cantilevered balcony
c. Balcony with semi-independent supporting frame
d. Independently supported balcony
e. Recessed balcony

Balconies

A balcony forming an exterior space directly associated with a dwelling is an essential feature of residential architecture. Properly designed, a balcony also serves as a reliable emergency exit for wooden apartment blocks. Fire regulations should always be taken into account in the design of balconies.

In wooden apartment blocks balconies can be realised in the following ways:

- as part of the overall frame
- as a projection from the frame
- as structures that are either partly or completely independently supported.

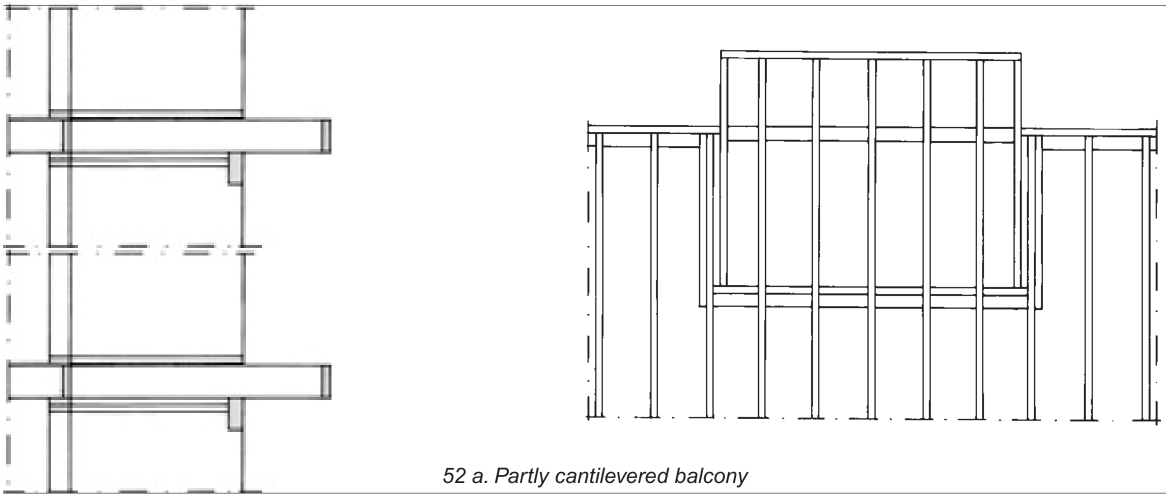
Balconies that form a part of the overall frame can be either completely or partly recessed from the external envelope of the building. They can also be partly projected from the frame.

The structural principle for projected balconies is similar to that of bay-window floors (see also Projections from the joists). Their structure consists of projected intermediate floor joists that extend beyond the load-bearing wall frame in order to form the floor of the balcony. Balconies that are supported by the building frame or projected from it, do not cause potentially harmful settlement differences. The disadvantage of projected balconies is in their limited depth. Projected balconies that extend too far create vibration in joists and defection within the balcony floor slab.

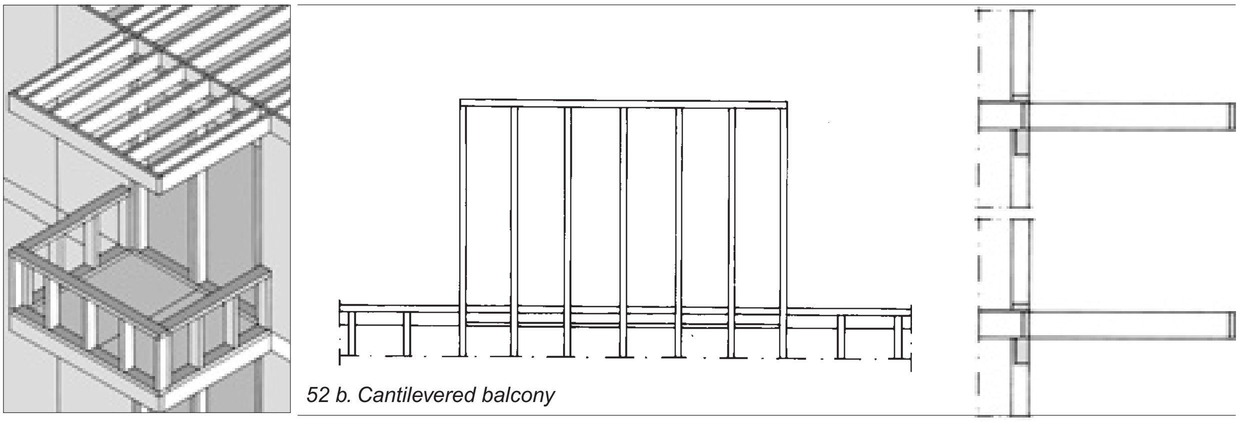
In balconies with semi-independent supporting frames one end of the balcony floor joists is supported by the building's frame. Independently supported balconies have entirely separate frames from the rest of the building.

Balconies should be provided with separate support whenever they are deep and consequently when their supporting joists are long. Special attention must be paid to the settlement differences between the independently supported balcony and the floors within the building.

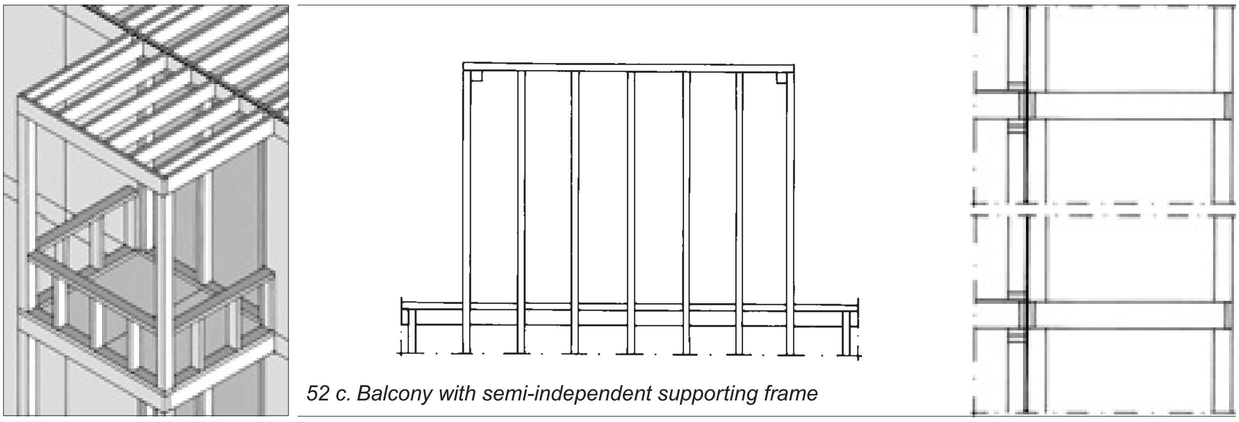
Balcony rails and balustrades can be constructed out of timber. Balconies must be protected from severe weather conditions by using canopies, partitions and other structures, in order to prevent water and dampness penetrating the frame and the external wall claddings below. Further attention must be paid to the fact that the balcony floor has adequate fall to allow water to flow out and the balcony to dry. Waterproofing of the balcony slab can be made using waterproof membranes, metal sheeting or appropriate weatherproof plywood.



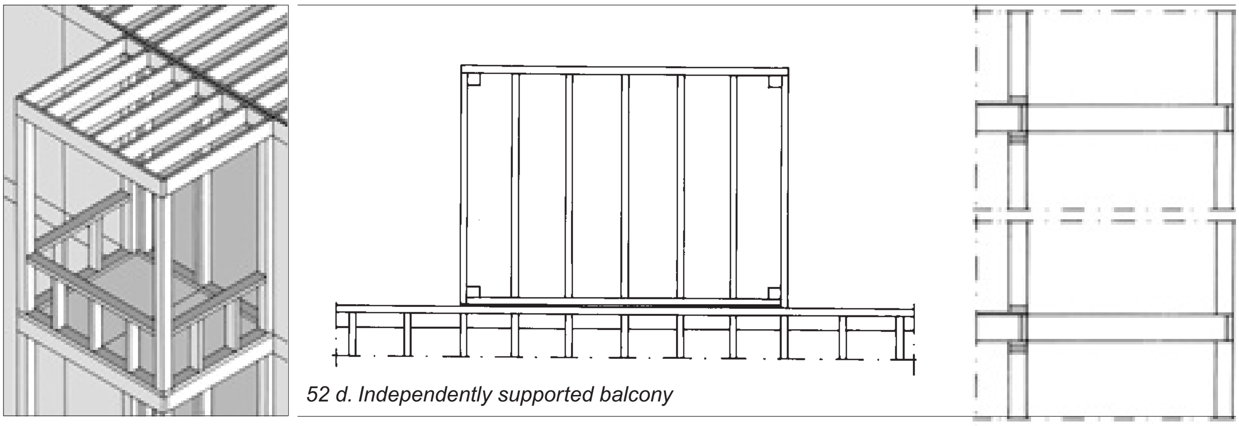
52 a. Partly cantilevered balcony



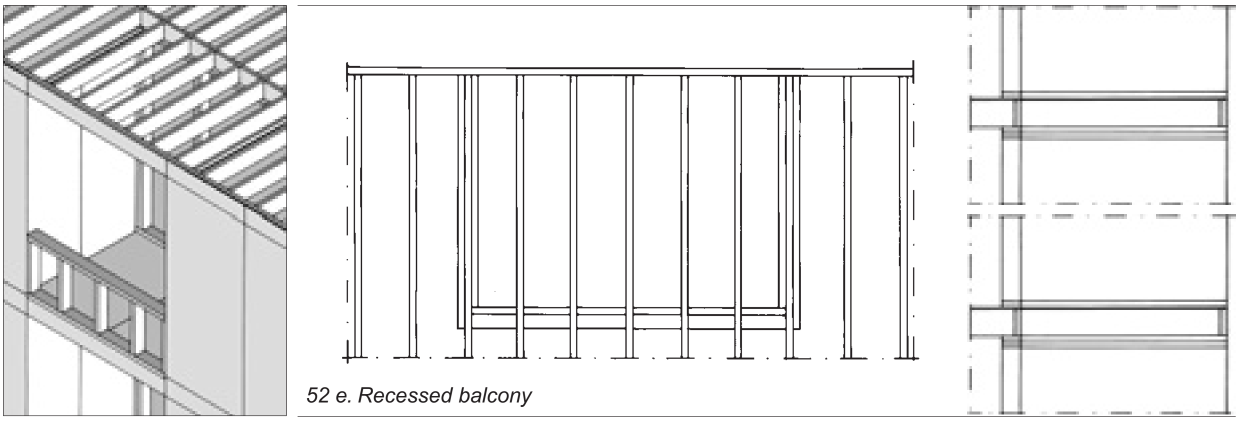
52 b. Cantilevered balcony



52 c. Balcony with semi-independent supporting frame



52 d. Independently supported balcony



52 e. Recessed balcony

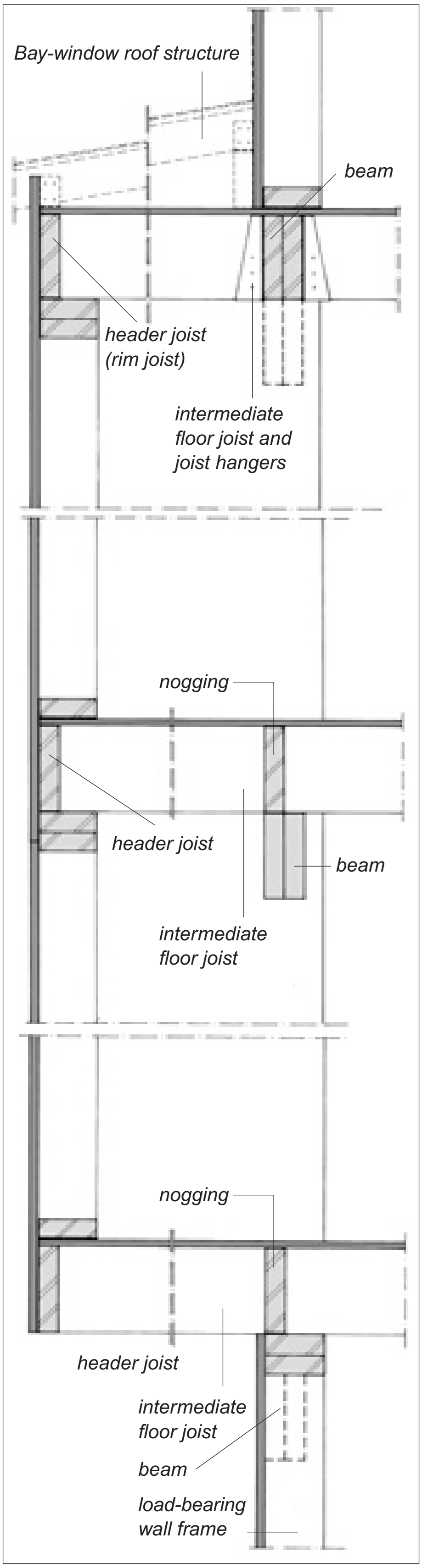


Figure 54. Section through a bay-window

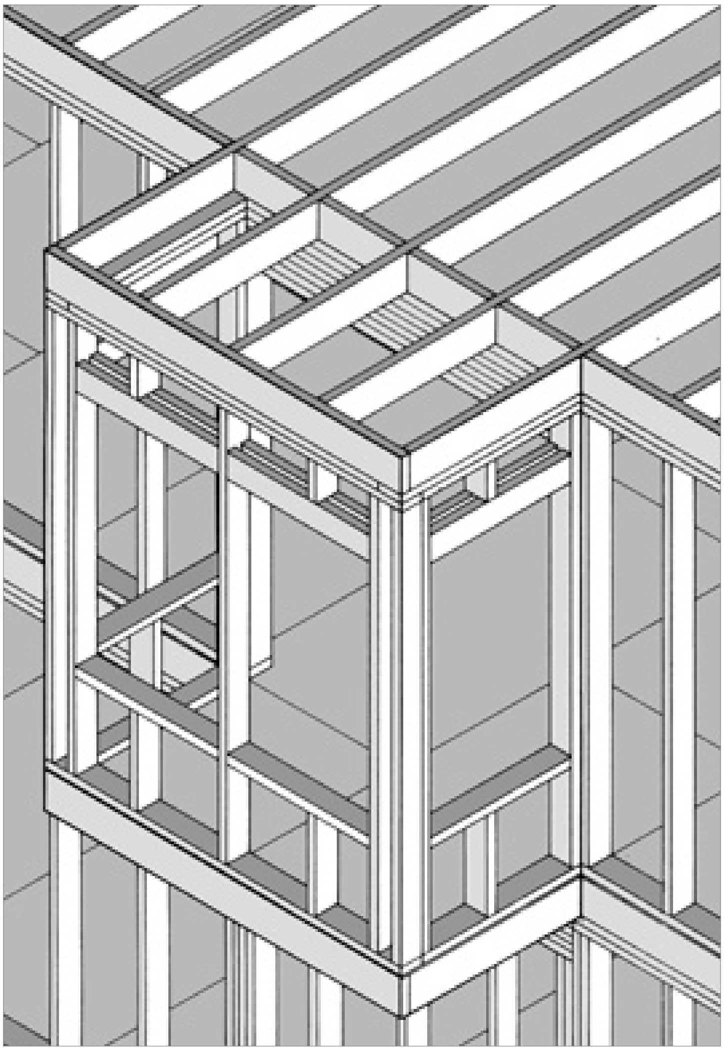


Figure 53. Bay-window frame

Bay Windows

In timber buildings the externals walls can be shaped into various forms with a relatively minor cost implication. Bay windows can be used to further enhance the atmosphere and comfort of a dwelling, they can open particular vistas or improve internal light qualities. Further more, bay windows have an impact on the overall external appearance of a building by creating rhythm and accent on otherwise plain elevations. Besides architectural reasons, differently clad bay windows can also be used to create subtle fire breaks on the elevation.

Bay windows are constructed by cantilevering floor joists from the external wall frame (see paragraph 'Projections From The Joists'). Standardised solid floor joists (48 mm x 220 mm) at 600 mm centres allow cantilevers up to 1500 mm.

Bay window walls comply with standard wall structures. When the aim is to create particularly slender corners or other details to bay windows, it is recommendable to construct the window as a full floor height projection in between two cantilevered intermediate floor joists.

Dormer Windows

Dormer windows are constructed above roof structure using timber frames. The form of the window is free, but the design should include appropriate provision for water drainage.

The framing of a dormer window follows the same principles as the rest of the building frame, its external walls being similar in construction to other external walls etc.

Smaller dormer windows are fitted into the rafter spacing so that, if possible, unnecessary trimming of rafters can be minimised, whereas in larger dormer windows it cannot be avoided. The openings are made following the same basic principles as when making openings to intermediate floors. The positioning of trimmers and trimming rafters must take into account the desired internal height and the shape of the ceiling.

Particular attention must be paid to thermal insulation and the consistency of the weatherproofing, especially in the joints of the dormer window.

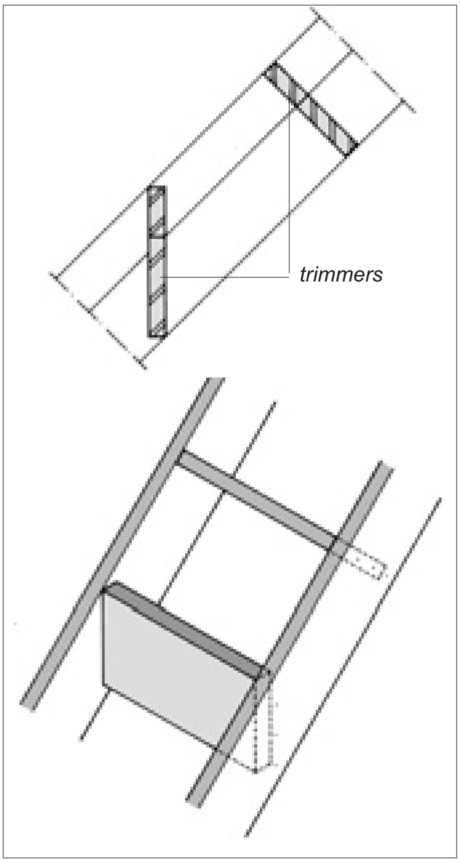


Figure 55 a and b. Openings for vertical shafts, dormer windows etc. are made similarly to intermediate floor openings.

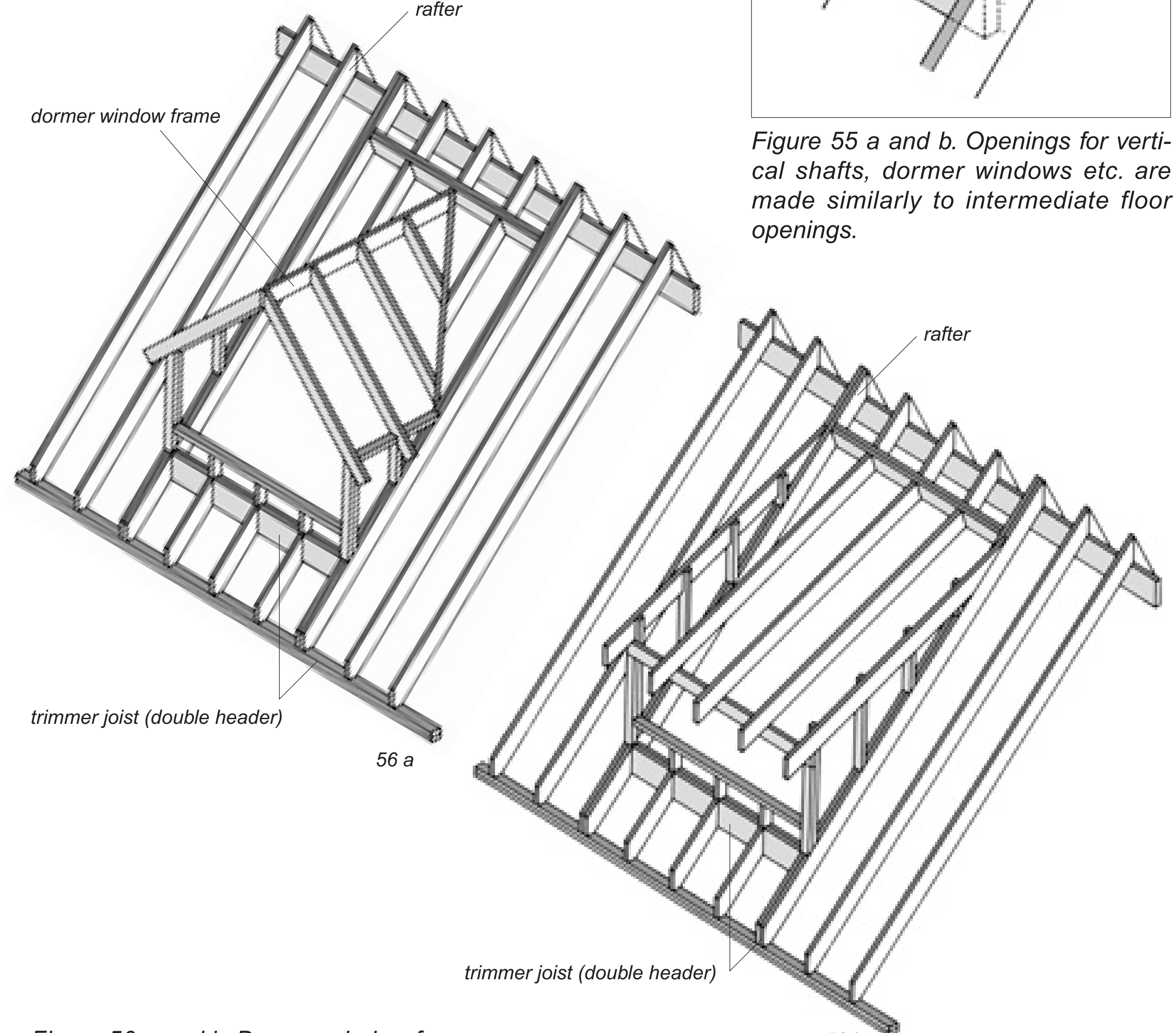
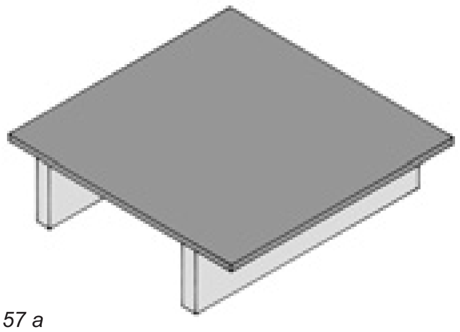


Figure 56 a and b. Dormer window frames
a. Double pitched
b. Monopitched

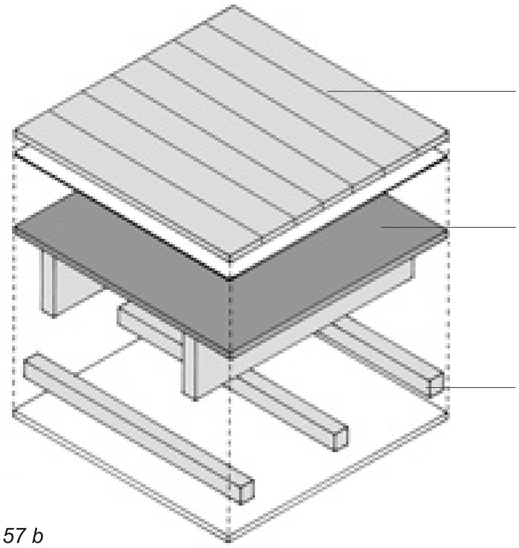
3 INSULATION AND SHEATHING ALTERNATIVES

3 INSULATION AND SHEATHING ALTERNATIVES

The choice of insulation materials and boarding affects the fire resistance, and sound and thermal insulation properties within the structure. Different situations, which share similar structural systems, can be treated using a wide range of boarding and insulation alternatives. Inherently the basic frame system is characterised by the fact that it is repeatable from one project to another, yet it can be varied in accordance with differing requirements between detached houses and apartment blocks, using different insulation and boarding materials.



57 a



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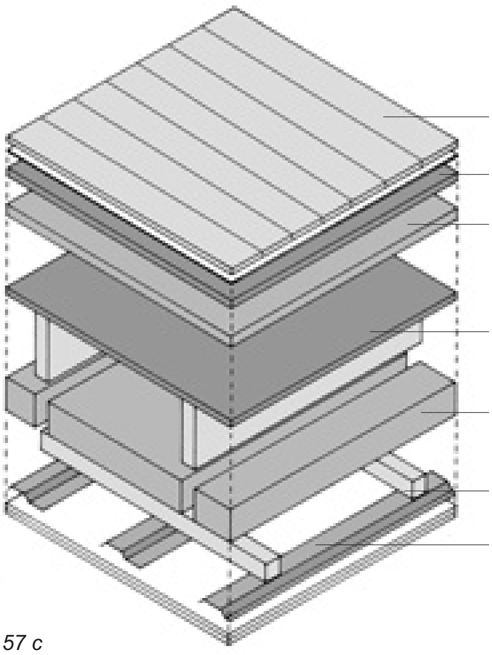


57 c

Figure 57 a, b and c. In accordance with the structural principles of the system, the basic frame structure can be repeated from one building to another. The differing requirements between detached houses and apartment blocks, set out by fire and other related regulations, are met by choosing individually appropriate insulation and boarding materials.
a. intermediate floor frame
b. structural layers within the intermediate floor frame of a detached house
c. structural layers within the intermediate floor (party floor) of an apartment block

Fire Safety

Regulations

The performance properties of building components is described using the following symbols:
R = load-bearing capacity
E = integrity
I = insulation capacity

By combining the letters, the varying performance requirements set out for different building components can be disclosed (R, REI, EI). The required performance properties are given specific performance periods, which may be any of the following: 15, 30, 45, 60, 120, 180 or 240 minutes.

In case of fire load-bearing and/or bracing building components must sustain a certain load capasity, specific to the given fire resistance time of any individual building.

Compartmented areas within a building must prevent fire from spreading from one compartment to another for a specific required period.

Material classes are symbolised by using the following: A, B, C, D, E and F. Even though an attempt is currently being made to unify regulations, there are still many variations between different countries. Therefore, during the design process, at least the following design aspects must be re-referred back to appropriate local regulations:

Fire Category, Safety Classes or similar

- the correct fire category of the building, according to its use and size.
- fire category affects the structural fire resistance requirements and also all of the following, as listed below.

Fire Resistance Requirement

- in low rise buildings, i.e. for buildings of a maximum of two storeys, the requirement concerning fire resistance is usually EI 30
- in taller buildings, of more than two storeys, the requirement is usually REI 60

The maximum number of storeys

- this varies according to different countries. In some countries a building is regulated by its height, in others by its number of floors.

Possible limitations to the overall floor areas

- they may be based on the use of the building and on the number of floors.

Compartment requirements

- in apartment blocks, individual apartments form compartments
- unless regulations state otherwise, in REI 60 category buildings the roof space must be compartmentalised using category EI 30 structures in line with compartments on floors below. In EI 30 category buildings, category EI 15 is adequate for roof spaces.

Classification requirements for finishing materials

- usually they are determined by the building's use and number of floors
- if the external cladding is made of timber or other inflammable material, in buildings that are more than two storeys high, the breather membrane should consist of materials that comply with Euroclasses A1 or A2.

Sprinklers

- sprinklers may alter maximum permitted floor areas and the choice of materials.

Typical example structures that comply with the different regulations are presented and illustrated at the end of this guide. Due to the variations in calculation principles, related to various regulatory classifications and categories between different countries, the given ratings are only indicative.

Restricting fire from spreading along the surface of an external wall and within ventilation cavity

Fire can be prevented from spreading along the surface of an external wall and within a ventilation cavity by vertically compartmentalising the ventilation cavity at 120 cm intervals and by limiting the cavity to extend to no more than one storey at a time. In the area of limitation the cavity may be no more than 20% of the free cavity. Consequently, if the cavity is compartmentalised, the usual requirement, which states that the continuous surface of the external cladding at each floor must be broken by using fire stops (e.g. 200 mm projections) at regular intervals, does not apply. Local authorities must always be consulted where the choice of design solutions concern fire regulations.

Horizontal compartmentalising means that the ventilation cavity is divided into vertical sections by breaking the width of the cavity with a barrier, a thick batten or similar. This prevents the fire from spreading horizontally within the ventilation cavity.

Limiting the ventilation cavity at each floor means that the depth of the cavity is reduced, but airflow is not completely obstructed. By reducing the gap, the otherwise resultant chimney effect within the cavity is obviated and the vertical spread of fire through the cavity delayed.

Sound Management

Regulations

Due to the fact that sound insulation requirements in detached and row houses differ inherently from those in apartment blocks, they have been discussed separately in the following paragraphs.

Detached Houses

There are no particular regulations relating to sound insulation in detached houses. However, for reasons of comfort, structural sound insulation within detached houses can be improved by applying the methods used in apartment blocks.

Insulation in party walls, between two semi-detached houses, is similar to that used in party walls between row houses.

Row Houses

In row houses, it is essential to create sufficient sound insulation between adjoining houses. This is realised by using double frames in party walls and by separating load-bearing horizontal frames, internal cladding and ceiling lining boards between neighbouring occupancies, at all party wall junctions.

Party Walls

Party walls between adjoining apartments are constructed by using of two separate stud frames, with a 20 mm air gap between them. The gap is broken at each floor deck level with a non-flammable insulation material or equivalent fire stop, in order to prevent the chimney effect. The cavities within the frame are packed with sound absorbent insulation. Depending on the appropriate local fire regulations, sound insulation requirements and bracing properties of a building, party walls are sheathed using either single or double sheeting.

Party walls between apartments, and the junctions between them and other compartment walls, external walls, ground floors and the roof, must be airtight. Structural frames within party walls and external walls are separated from sub-floor frames by using resilient sealant compounds or elastomeric sealants, e.g. EPDM rubber strips etc., which reduce vertical flanking transmission of impact noise within the frame.

Intermediate Floors in Row Houses

In row houses, intermediate floor joists between adjoining occupancies are separated at party walls in order to prevent flanking sound transmission. If the floor finish is attached directly onto sub-floor boarding, the sub-floor boarding must also be disconnected at wall junctions, which in turn affects the design of the overall bracing of the building.

Intermediate floors within houses do not have to comply with any specific sound insulation requirements. For reasons of comfort, sound insulation properties within these floors can be upgraded by using the same methods as in apartment blocks.

Apartment Blocks

Horizontal sound insulation within apartment blocks is usually realised employing the same principles as used in row houses. The most relevant difference between the two lies in the fact,

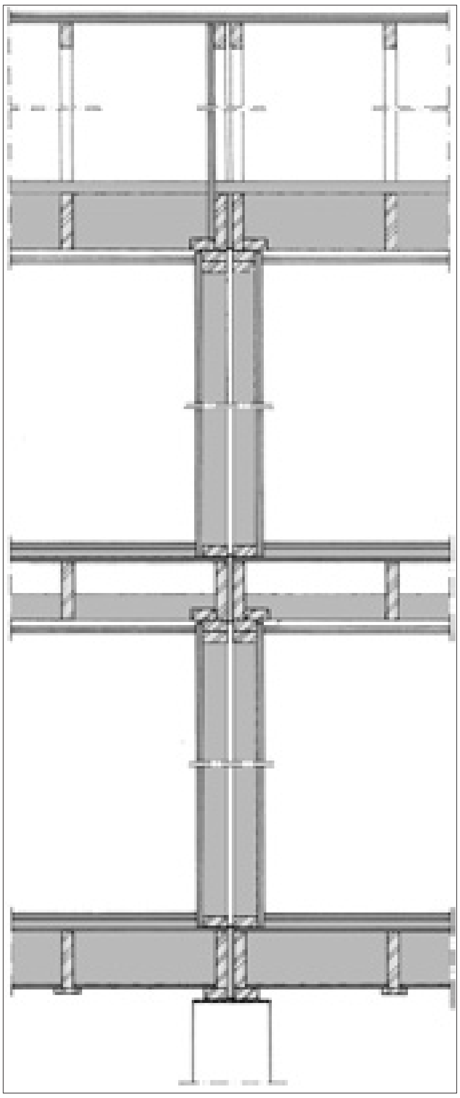


Figure 58. Section through party wall. Structural frames have been separated from each other.

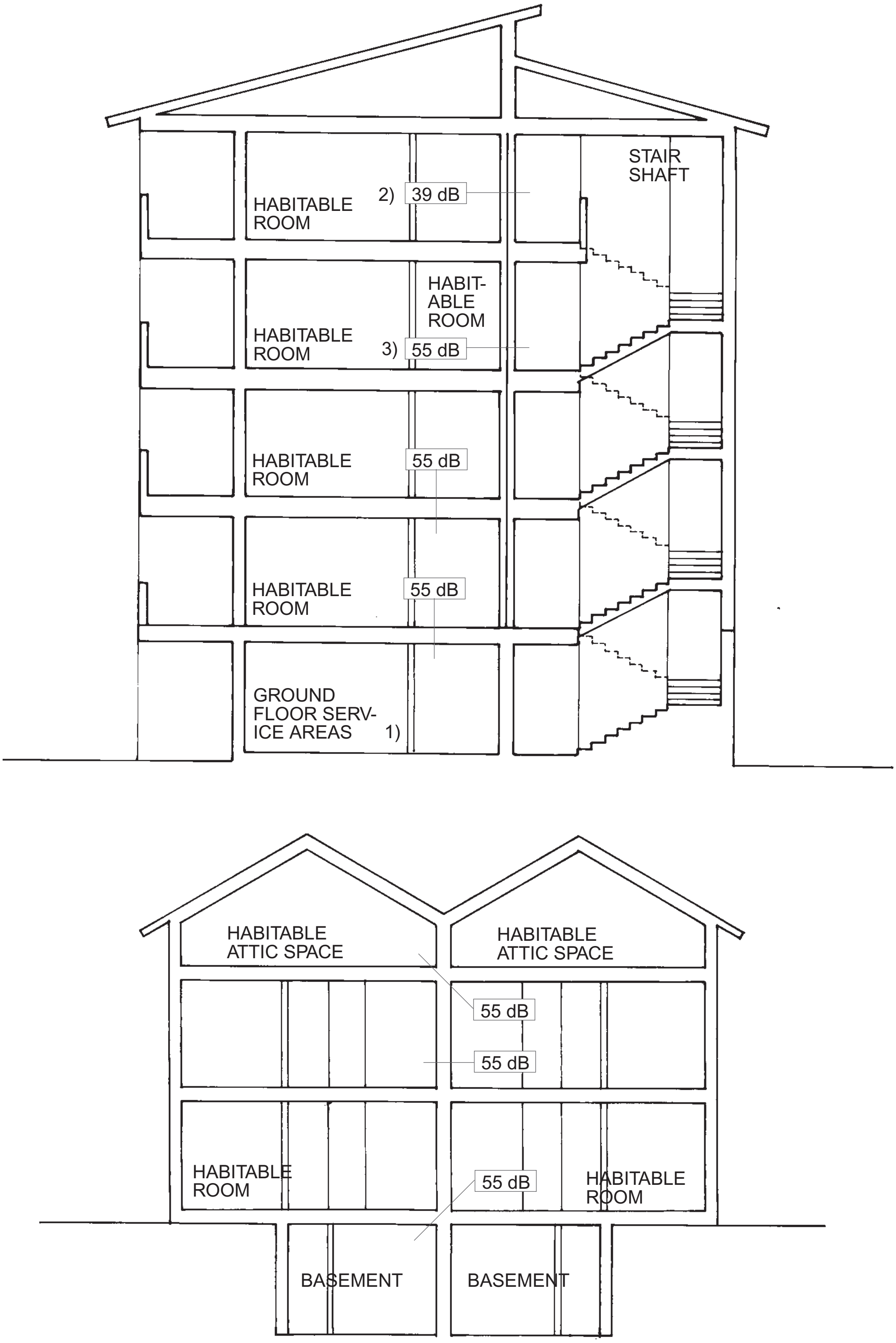


Diagram no.9 Minimum (currently valid in Finland) sound reduction factor of airborne noise (dB) in residential buildings.

1. *Service areas, such as heat distribution centres, saunas, boiler rooms, dens and storage spaces.*
2. *The minimum sound reduction factor of doors or door combinations must be 30dB.*
3. *Vertically the minimum sound reduction factor between a habitable room and a stair shaft should be 55 dB.*

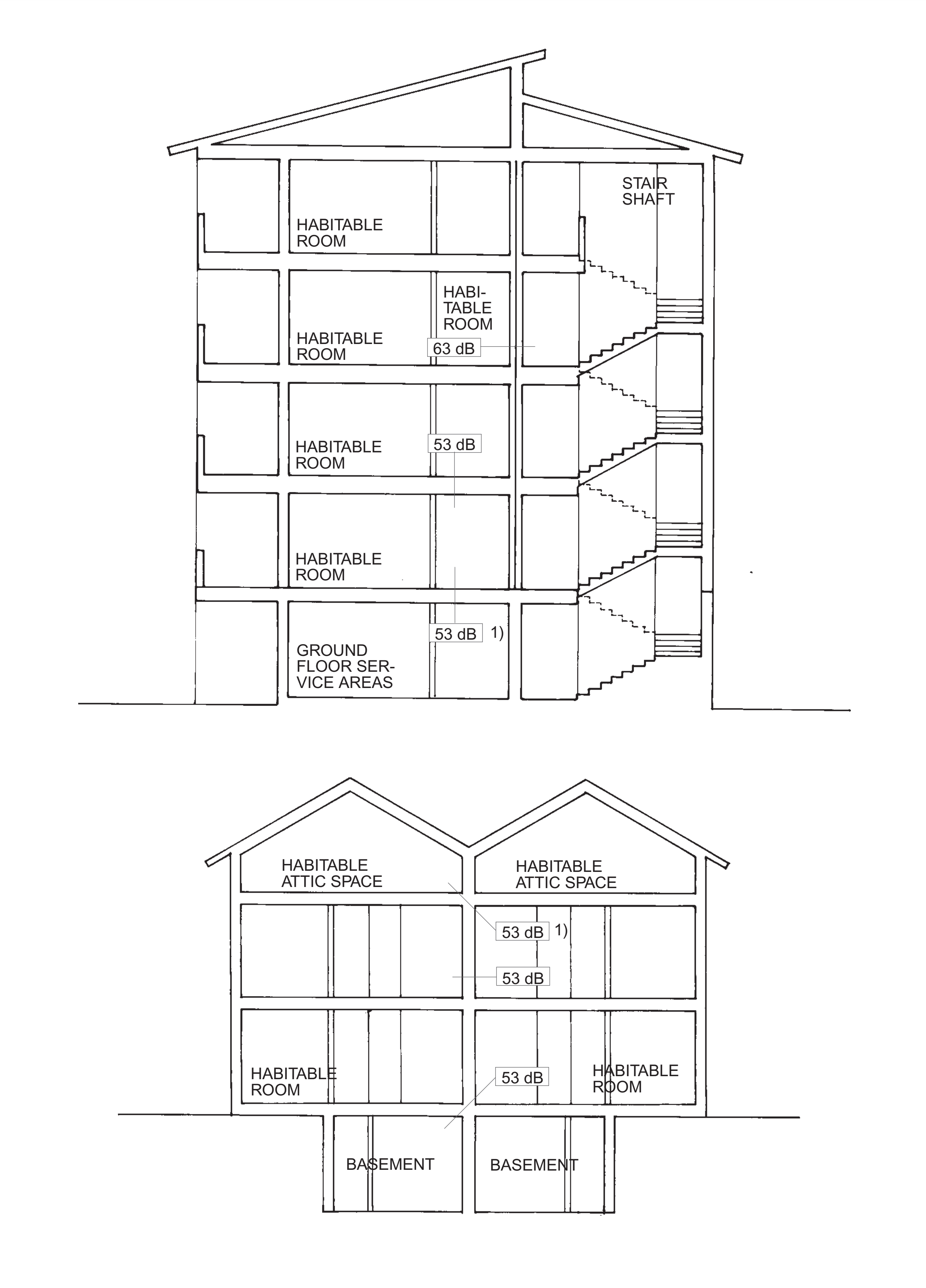


Diagram no.10 Impact sound insulation regulatory requirements (currently valid in Finland) in apartment blocks and row houses or other linked houses (maximum impact sound factor (dB))

1)Regulations do not apply to occasionally occupied spaces, such as service and maintenance areas, storages, garages or equivalent.

that in apartment blocks, the horizontal frames between adjoining apartments cannot be completely separated. Vertical sound insulation within party walls requires a specific intermediate floor structure, which is particular to apartment blocks and structurally more complex than in row houses. Special attention must also be paid to fixings, insulation and the placement of ducts and other pipes and flues within the frame.

Party Walls in Apartment Blocks

Party walls between different apartments are similar to party walls in row houses. The appropriate local fire regulations concerning timber framed apartment blocks must be taken into account in the choice of insulation, cladding and sheathing materials.

Intermediate Floors in Timber Framed Apartment Blocks

In timber framed apartment blocks, intermediate floor joists are disconnected between adjoining occupancies, i.e. abutting joists are severed at party walls in order to prevent flanking sound transmission. However, due to bracing requirements within apartment blocks, sub-flooring board should not be cut at party wall junctions. This presupposes either the use of floating floor decks or the provision of sufficient mass in the finishing floor layers.

Airborne and impact noise insulation regulations for the intermediate floors of timber framed apartment blocks presuppose the following:

- intermediate floors are sufficiently heavy or
- intermediate floors consist of layers of which the top layer, attached to sub-floor boarding, is floating and
- ceiling linings below floor decks are attached to the frame above using resilient fixings, such as special acoustic ‘spring-type’ bars and
- junctions and penetrations through walls etc. are sealed using appropriate sealing compounds and
- intermediate floor cavities incorporate an absorbent insulation blanket.

The appropriate local fire regulations concerning timber framed apartment blocks must be taken into account in the choice of insulation and finishing materials.

Floating floors can be constructed using either building boards or floating screed over insulation layers. If the casting floor is sufficiently thick, it can also be laid directly on sub-floor boarding. A composite structure of both timber and concrete is also possible.

Casting floor can consist of either concrete, fibrous concrete or gypsum. Out of these, concrete performs the best due to its mass. The thickness of the floating floor insulation layer depends on the floating floor type.

In addition, the sound insulation of a dwelling can be upgraded by the use of the following methods:

- noise from external sources can be reduced by using double boarding layers on the internal leafs of external walls and on the roof.
- Internal walls can incorporate an absorbent insulation blanket, and particular attention can be paid to the sealing of the wall junctions.

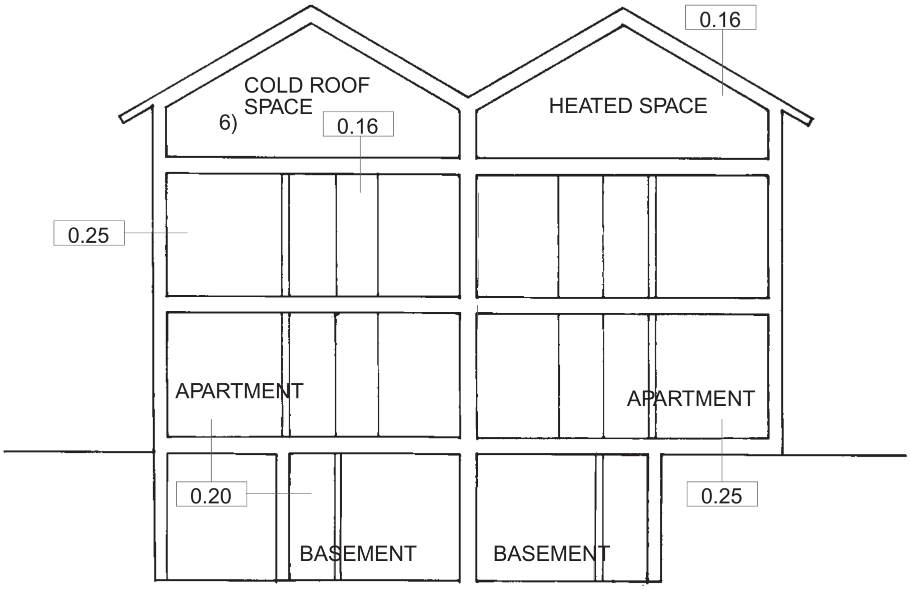


Diagram no.11 Finnish U-value requirements for different structures.

Thermal Insulation and Damp Proofing

Thermal insulation is fitted to fill the cavity completely. The installation must be carried out in accordance with manufacturer's instructions and the general requirements concerning installation of thermal insulation associated with its type approval. In order to prevent injected insulation material from sinking within the cavity, it is recommended that the installation work is carried out by manufacturer's authorised and trained personnel who have the appropriate professional skills.

Thermal Insulation

Thermal insulation can consist of both mineral wool and wood fibre. The choice of insulation material is determined by the appropriate fire regulations.

Wood fibre insulation can be either in the form of semi-rigid batts or blown cellulose fibre. In ground and intermediate floors, and in roofs, blown insulation is usually dry-blown into the structural cavity. Walls are more commonly insulated using the wet-spraying method. The procurement of blown fibre insulation usually includes installation.

Mineral wool insulation is usually installed in semi-rigid batts or quilts. It is also possible to install it in the roof by blowing. The batt dimensions comply with standardised 600 mm c/c stud and joist spacing. Whenever necessary, the batts can be sawn to fit the space between joists or studs.

In suspended ground floors, the space between floor joists is filled with insulation. The insulation quilt is usually supported by a special support board beneath it. If necessary, it is also possible to install thermal insulation under the joists (e.g. extra insulation).

Thermal insulation is fitted to fill the cavity completely. The installation must be carried out in accordance with manufacturer's instructions and the general requirements concerning installation of thermal insulation associated with its type approval. In order to prevent injected insulation material from sinking within the cavity, it is recommended that the installation work is carried out by manufacturer's authorised and trained personnel who have the appropriate professional skills.

Important
The humidity of external and internal air is transmitted to structures via diffusion, created by different vapour pressure levels, or via convection i.e. airflow, which is the result of differences in air pressure. Structures must be designed and realised to allow the vapour resistance of different material layers to be gradually diminished from the inside outwards, which in turn makes it possible for dampness within structures to be dispersed and ventilated outwards. Two vapourtight membranes within a structure must never be positioned in a manner that prevents potential dampness between them from being extracted.

Definitions

Vapour Diffusion
The even dispersing of different internal and external vapour pressure levels between different sides or parts of a structure. Vapour attempts to move away from the space where its pressure level is higher into a space where the pressure is lower. Usually the pressure is higher in the more humid space (g/m^3).

Vapour Convection
Transmission of water vapour in airflow. Airflow results from differences in air pressure between two sides of a structure.

Vapour Resistance
A capacity in a substance to resist diffusion of water vapour.

Construction Humidity
Humidity that is accumulated within a structure and structural materials during construction and that exceeds the predicted humidity levels of the building's subsequent occupancy.

Waterproofing, tanking
A material layer and its seams, which are impervious to water (and resistant to water pressure), and which prevent

In warm ground floors (the air cavity is ventilated by using internal extract air), insulation is installed against the ground and sleeper walls. The insulation material must be then chosen appropriately (e.g. lightweight aggregate).

External walls are usually insulated internally, which is taken into account within the junctions of the frame. In timber framed walls thermal insulation is packed between studs. If the insulation cannot be installed subsequent to the erection of the frame, it must be installed during the erection phase.

The space between intermediate floor joists is insulated up to 500-600 mm from the external perimeter wall, and when the joists are parallel to the external wall, the nearest joist cavity to the wall is insulated completely. Insulation elsewhere in the intermediate floor deck depends on the requirements concerning fire resistance and sound insulation.

The choice for the insulation of the roof is determined by the roof rafters that are being used. In trussed roofs, the insulation is positioned in between the trusses and supported by vapour and air barriers and by the battens of the ceiling lining. The battens must be appropriate densely positioned. The support of quilt or batt insulation must not allow the insulation to be compressed in between the supporting battens. Batt insulation cannot rely only on the support of the thin air and vapour barriers.

In couple roofs, insulation is positioned in between rafters, against breather boards. A sufficient ventilation cavity must be left above it. Whenever necessary, the ridge of the couple roof can be designed to accommodate a level shelf in order to provide adequate ventilation for the roof.

Vapour and Air Barriers

Separate vapour and air control barriers are used for external walls and for the roof. In intermediate floors and party walls an air barrier is sufficient. In addition, ground floors require a material layer that acts as a vapour and air barrier, but usually a well attached, matched sub-flooring board together with the floor finish above, provide a sufficient vapour and air control barrier.

Vapour barriers, or vapour control layers (vcl), consist of either one or several material layers, the main function of which is to prevent harmful diffusion of water vapour from the internal space into the structure. The reason for the required vapour barrier stems from the principle that the vapour resistance level of the structural layer on the warmer side of thermal insulation must be at least five times the respective level of the structural layer on the cold side. If this is not the case, the structure must be provided with a separate vapour barrier in order to meet the requirement.

Vapour barriers can consist of plastic film (polythene sheet), foil, lining paper or card, building board, wallpaper, paint layers etc. either on their own or jointly. The type of vapour barrier is specified in the structural design documents. The vapour barrier is always positioned on the warm side of thermal insulation. Prior to installation, the humidity, accumulated during construction, must be checked in order to guarantee that it is not too high for it to be potentially harmful to install vapour barriers at that moment.

The main function of an air barrier is to prevent harmful airflow and vapour convection across a structure. As a system the air control barrier must be airtight. Its seams, edges, perforations etc. must be appropriately sealed, i.e. they must be durable and tight. The airtightness of an air barrier is a significant factor, because, and especially during colder months, the humidity brought in contact with the structure from the interior, via airflow, could be manifold compared to vapour diffusion. Usually a vapour barrier also performs as an air barrier.

The barrier material, together with its joints, must have a minimum lifespan of 50 years.

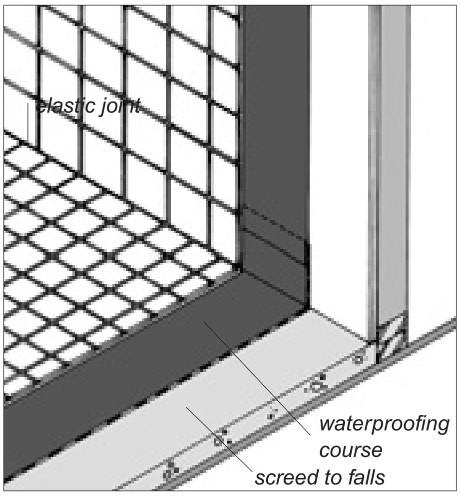
Vapour and Air Barriers at Junctions Between External Walls, Ground Floors, Intermediate Floors and The Roof

In junctions between external walls and intermediate floors, the vapour or air barrier is turned to extend to the underside of the joists by approx. 500 mm and the cavity is further insulated the same distance. At ground and intermediate floors, the barrier within the wall is turned to extend onto the sub-flooring board by approx. 150 mm.

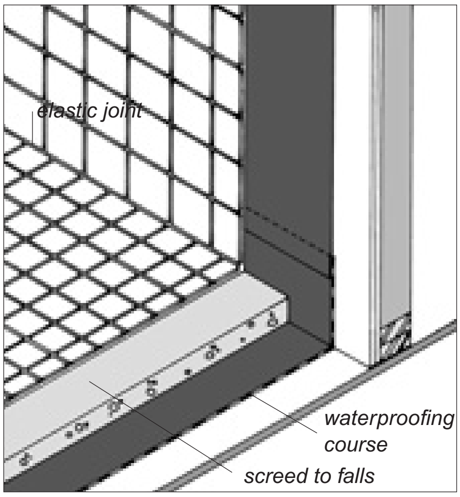
The air and vapour barrier of the roof is attached to the underside of roof rafters. It is always installed prior to the installation of air and vapour barriers within walls, and overlapped by them by approx. 300 mm.

Ceilings, Walls and Floors Of Wet Areas

The walls and floors of wet areas always consist of a waterproofing (tanking) layer which, together with its joints, is impervious to water and resistant to water pressure and prevents water (and also vapour) from potentially harmfully penetration into the structure. It is positioned on the internal face of the frame, e.g. under tiling. When using a waterproofing course, the vapour



60 a



60 b

Figure 60 a and b. Concrete screed to falls on a wet area floor.
a. waterproofing course on top of the concrete screed
b. waterproofing course under the concrete screed

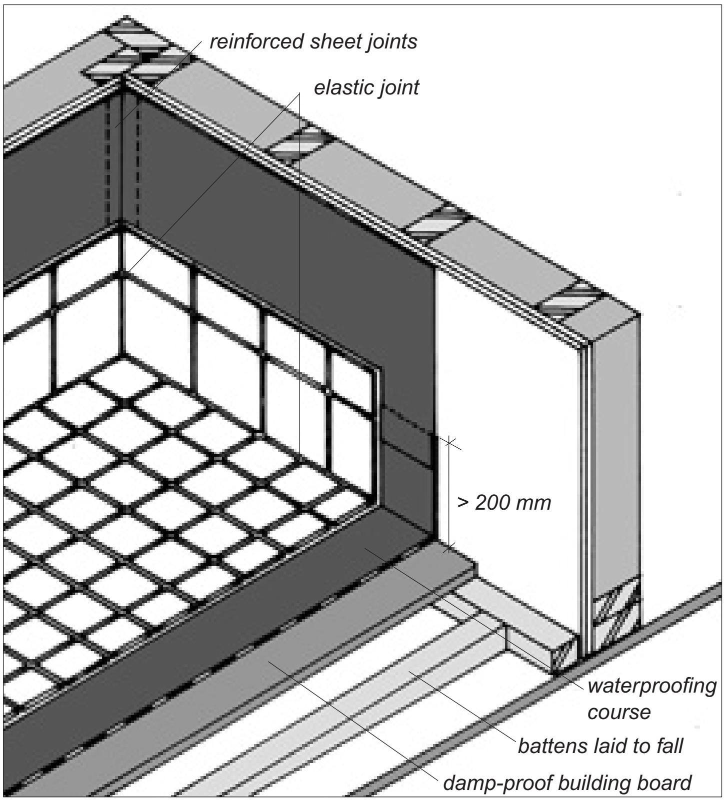


Figure 59. The wet area floor in a detached house can be constructed using timber. Battens are positioned on top of the sub-flooring and they form the fall to the finished floor. A damp-proof building board is screwed on top of the battens. Waterproofing is laid on the board and turned up the wall by approximately 200 mm from the level of the finished floor and overlapped with the waterproofing course within the wall.

barrier between internal lining board and thermal insulation must be omitted. The waterproof course must also be resilient to the possible movement of the structure underneath.

On the floor, a waterproof course can be positioned either under the floor finish or, when using concrete screed, under the screed. If the floor is not provided with underfloor heating, the waterproof membrane must always be positioned on top of the screed.

Waterproofing is turned up the wall by approx. 200 mm from the level of the floor finish and overlapped with the waterproofing course within the wall assuring that the joint is completely watertight and the water running down the walls does not find its way beneath the waterproofing course of the floor. The only permissible perforations of the waterproofing course of the floor are those made for drainage and soil pipes. The junction between the waterproof membrane and the floor drains (wet rooms) must be sufficiently tight to ensure that water is not allowed to penetrate structures below the waterproofing course even if the water level within the drain is higher than the junction itself.

In the ceiling, a vapour barrier, of sufficient vapour resistance, can also be used. It is positioned on the underside of joists and overlapped with the waterproofing course in the walls by approx. 150 mm.

Suspended Ground Floors

The ground level of the access void, under the suspended ground floor deck, need not be above the level of the ground surrounding the building. However, the air cavity under the ground floor deck must be designed not to allow water to accumulate under the building. The foundations and the air cavity can be drained in the following ways:

- by directing rainwater and other surface water outwards, away from the building.
- by sloping the ground level surrounding the building down, away from the building.
- by using a top ground layer adjacent to the building that does not allow water to permeate easily.
- by using rainwater drains etc.
- by using subsurface drains in the ground around the sleeper walls and air cavity.
- by insulating and damp-proofing the ground level below the air cavity.
- by providing sufficient ventilation for the cavity.

In buildings that have basements, the sleeper walls are tanked.

The dampness rising from the ground is removed by using subsurface drains and a ground cover surface of lightweight aggregate, such as gravel or crushed stone that prevents capillarity.

The cavity must be sufficiently ventilated. Ventilation can be arranged either via openings in the void or by blowing internal extract air first into the cavity and then to the outdoors (warm ground floor). Using external air for ventilation is a more commonly used method.

In externally ventilated cavities all pipes and ducts must be insulated. The foundations must contain a sufficient number of ventilation openings. The number and position of these openings must be designed in accordance with local ground conditions.

The benefits of a warm ground floor include the following:

- dampness is not condensed within the cavity.
- the ground remains unfrozen and frost-resistant.
- the temperature differences in the floor are minimal and the feeling of draught is obviated.
- the ground floor structure does not require thermal insulation because the insulation is positioned against the ground and sleeper walls.

The air that is used to ventilate the cavity must be prevented from having contact with cold areas in order to avoid condensed dampness and the growth of harmful mildew. The warm ground floor must be designed and constructed with particular care in order to prevent the above.

All cavities must be provided with accessible hatches that allow easy inspections and maintenance.

4 SERVICES (HEATING, PLUMBING, VENTILATION AND ELECTRICAL INSTALLATIONS)

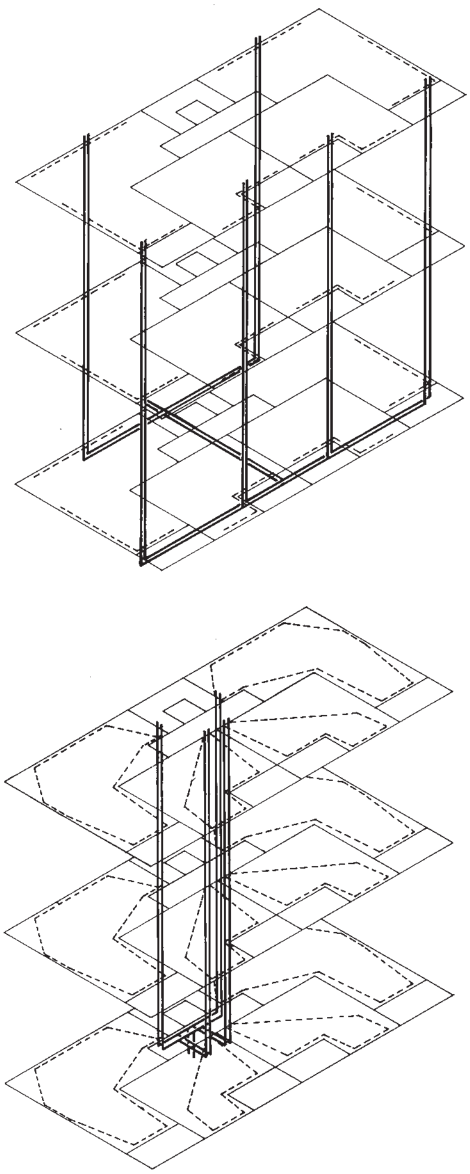


Figure 61 a and b. Position for vertical service cores – dispersed and centralised alternatives.
Example: water central heating.

Diagram 12. The hierarchical titles used for service channels and equipment.

Central units
Service risers (vertical risers)
Room distribution (horizontal and vertical distribution channels within apartments from vertical risers to appliances)
Appliances

4 SERVICES (HEATING, PLUMBING, VENTILATION AND ELECTRICAL INSTALLATIONS)

Installation of service systems within timber framed apartment blocks is no different to other types of construction. The material of the building's frame has no impact on central units and appliances. The insulation within party floors and walls in timber framed buildings allows for individual energy metage per apartment. Particular attention must be paid in the construction phase to the tight fitting of any pipework that passes through structures.

Heat Distribution

Central heating risers are positioned either in central cores e.g. adjacent to stair shafts, or on external walls, from where the services are distributed to rooms and fed to individual radiators. The metage per apartment presupposes central positioning. In addition, centralised risers provide more flexibility in design and preclude unnecessary perforations of the structure.

The room distribution pipes can be positioned either within the frames of intermediate floors and walls or within the insulation layer of a floating floor. Surface installations are also possible. Room distribution pipework consists of steel, copper or plastic pipes, of 15 to 20 mm in diameter.

Plumbing

Sanitary pipework is distributed to individual apartments from either a central core that is adjacent to stair shafts or service ducts, positioned next to wet areas. Individual metage per apartment presupposes a central core, with centralised distribution to different users.

Soil pipes require more space than supply pipes, and they may also be subject to sound insulation regulations. Minor waste water pipes from kitchen sinks etc. are run on the underside of joists, above a suspended ceiling. Foul water pipes, from toilets, are run on the underside of joists, above a suspended ceiling and, whenever necessary, enclosed as separate fire compartments. Horizontal soil pipe runs within apartments should be avoided due to potential acoustic problems.

Soil pipes can consist of PVC or cast iron pipes. For acoustic reasons, cast iron pipes are recommended for horizontal runs and bends in the pipework.

Ventilation

Mechanical ventilation consists of an air extract system, which can be individually boosted in each apartment, or of a supply-and-extract system, which can be either centrally or locally controlled. From the point of view of ventilation, the envelope encasing an apartment must be airtight, especially if the mechanical ventilation system can be controlled locally. The differences in air-pressure between apartments must not be allowed to cause odours etc. to travel from one apartment to another.

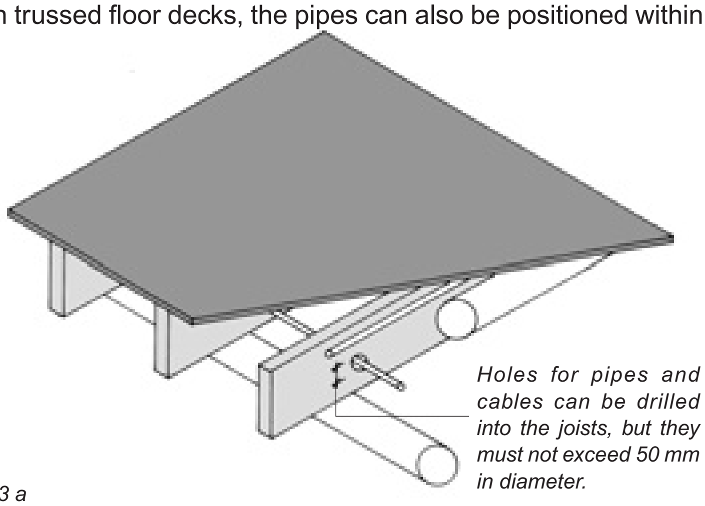
Electrical Installation

Electrical systems within timber framed buildings does not differ from other types of construction. However, the installation of electrical systems within a timber framed construction is substantially easier than within other types of structures. Similar to pipework, electrical cables can be encased in conduits within insulation or in the top screed on top of sub-flooring boards. Penetrations must be tightly sealed. In party walls, electrical fittings, such as sockets etc. are usually located at different positions on either side of the wall.

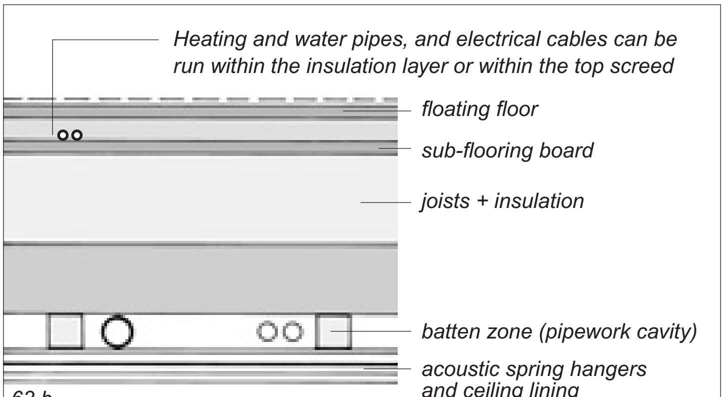
Automatic Sprinkler Systems

Possible sprinkling must be taken into account in the design phase in order to allow space for the central fire-extinguishing mechanism, and the sprinkler pipes and valves.

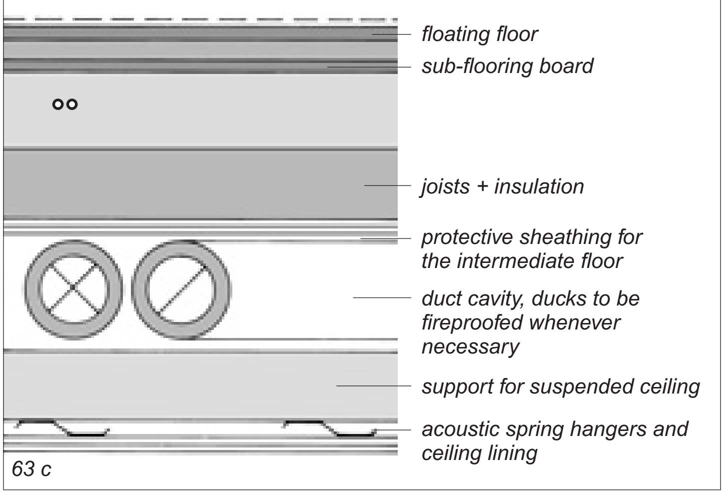
Sprinkler pipes are run in the batten zone, under floor joists. In trussed floor decks, the pipes can also be positioned within



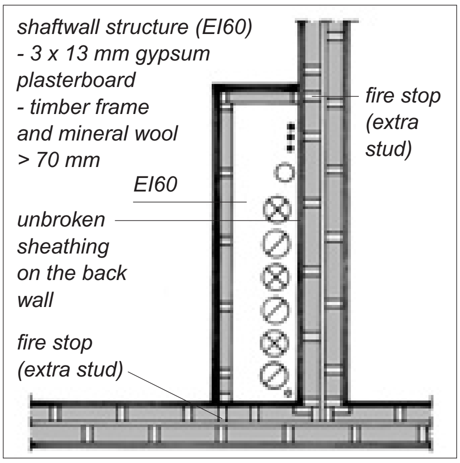
63 a



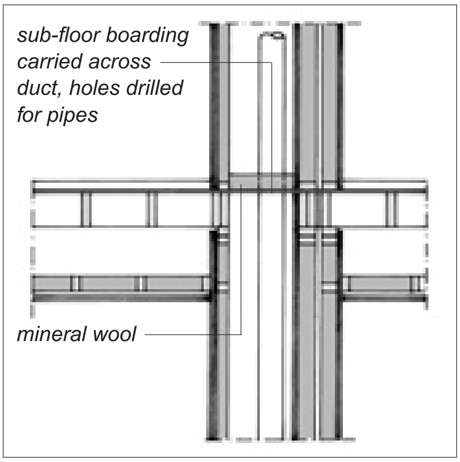
63 b



63 c



62 a



62 b

Figure 62 a and b. Horizontal and vertical section of a vertical service riser.

Figure 63 a, b and c. Pipes are carried mainly under joists in the batten zone. Sprinkler and soil pipes can also be positioned in between joists. Holes for pipes and cables can be drilled into the joists, but they must not exceed 50 mm in diameter.

Heating and water pipes, and electrical cables, encased in protective conduit, can also be run on top of the sub-flooring, either within the insulation layer or the top screed of within a floating floor. The benefits for this installation include ease and shorter cable and pipe runs.

5 ARCHITECTURAL AND STRUCTURAL REPRESENTATION

5 ARCHITECTURAL AND STRUCTURAL REPRESENTATION

General

Architectural presentation drawings follow a standardised format. A design document must be prepared in accordance with current legislation and regulations.

Representation of Timber Structures

In architectural drawings, it is not necessary nor practical to present standardised structures in full. They can be drawn using two lines with the appropriate structures coded with lettering or numbering. The drawing can be clarified by using different graphic tones to symbolise different structural types. Points which deviate from the standardised solutions should be referred to in separate detail drawings.

Structural Dimensions

It is recommended that a drawing showing the dimensions of the frame is prepared for the building site. If the process requires a separate structural plan, prepared by the structural engineer, it is the architect who provides the engineer with the dimensions.

Structural dimensions are provided via a normal working drawing. The drawing should show the following:

- the positions of wall frames, using structural dimensions
- the location of openings as structural opening dimensions. The dimensional lines are distinguished from each other i.e. positions of walls and openings are shown via separate measurements.
- codes for the structural types used.
- furnishings and fittings if they require separate support that has not been taken into account by the structural type.
- exposed joists or beams.

Whenever necessary, all other markings can be omitted, especially if there is not to be a separate drawing showing the structural frame. The architect must not indicate the following on the plan:

- stud positions or double studs at openings etc.
- beams or joists if they are to be encased in other structures.

If there is not to be a separate structural drawing, the plan should be drawn up in association with the structural designer. The structural designer will make a note of any possible extra studs, joists etc.

A separate structural drawing is always prepared by the structural engineer.

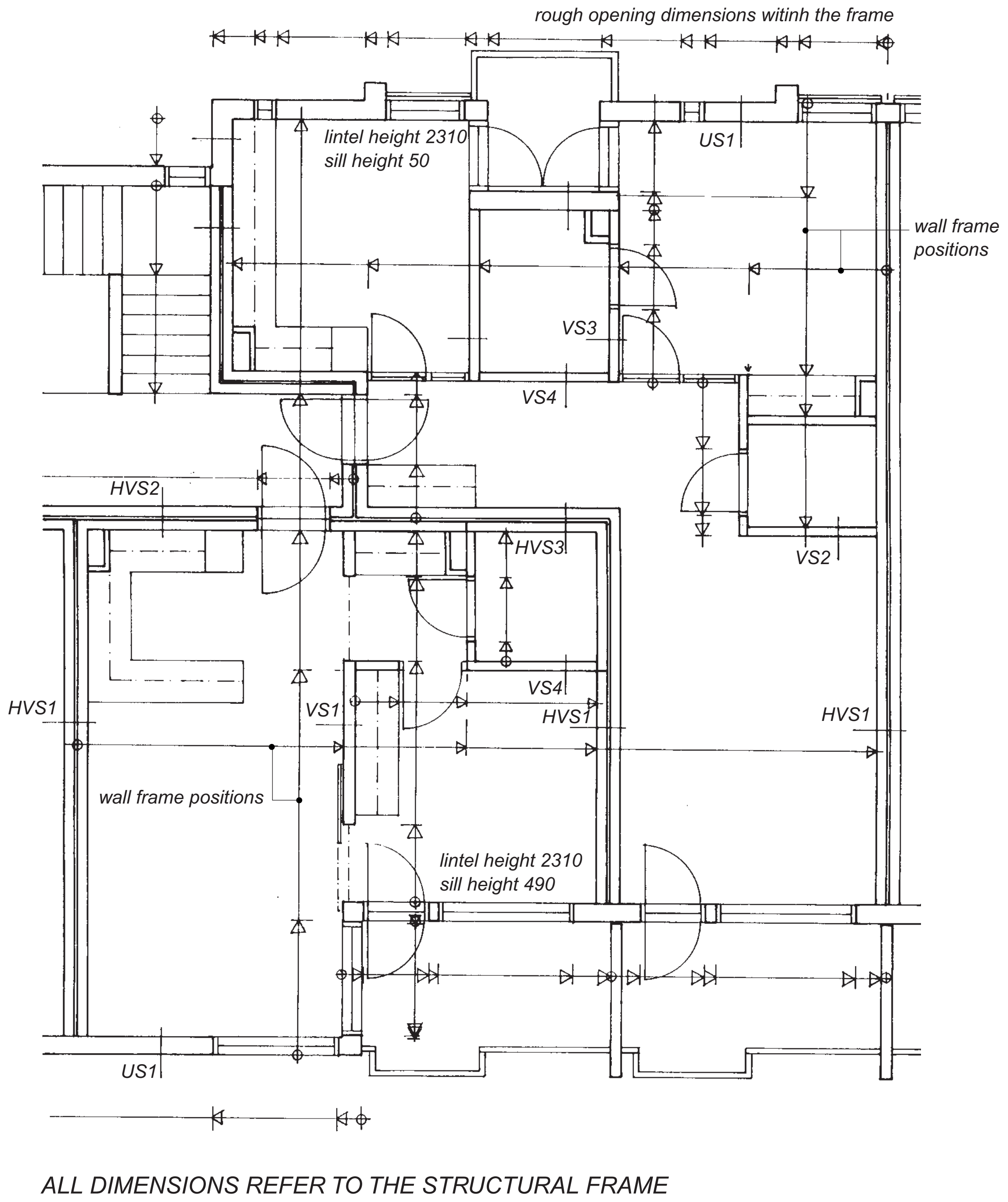


Figure 64. Plan showing structural dimensions. The positions of wall frames have been shown as a separate measurement from opening dimensions. In addition, the drawing also shows structural types and the lintel and sill heights of openings. NOTE: Structural dimensioning is not the same as a structural frame drawing, which is provided by the structural designer. The beginning and ending measurements have been illustrated in the next figure. Whenever structural dimensions have been included, it must be stated by using the following text: ALL DIMENSIONS REFER TO THE STRUCTURAL FRAME.

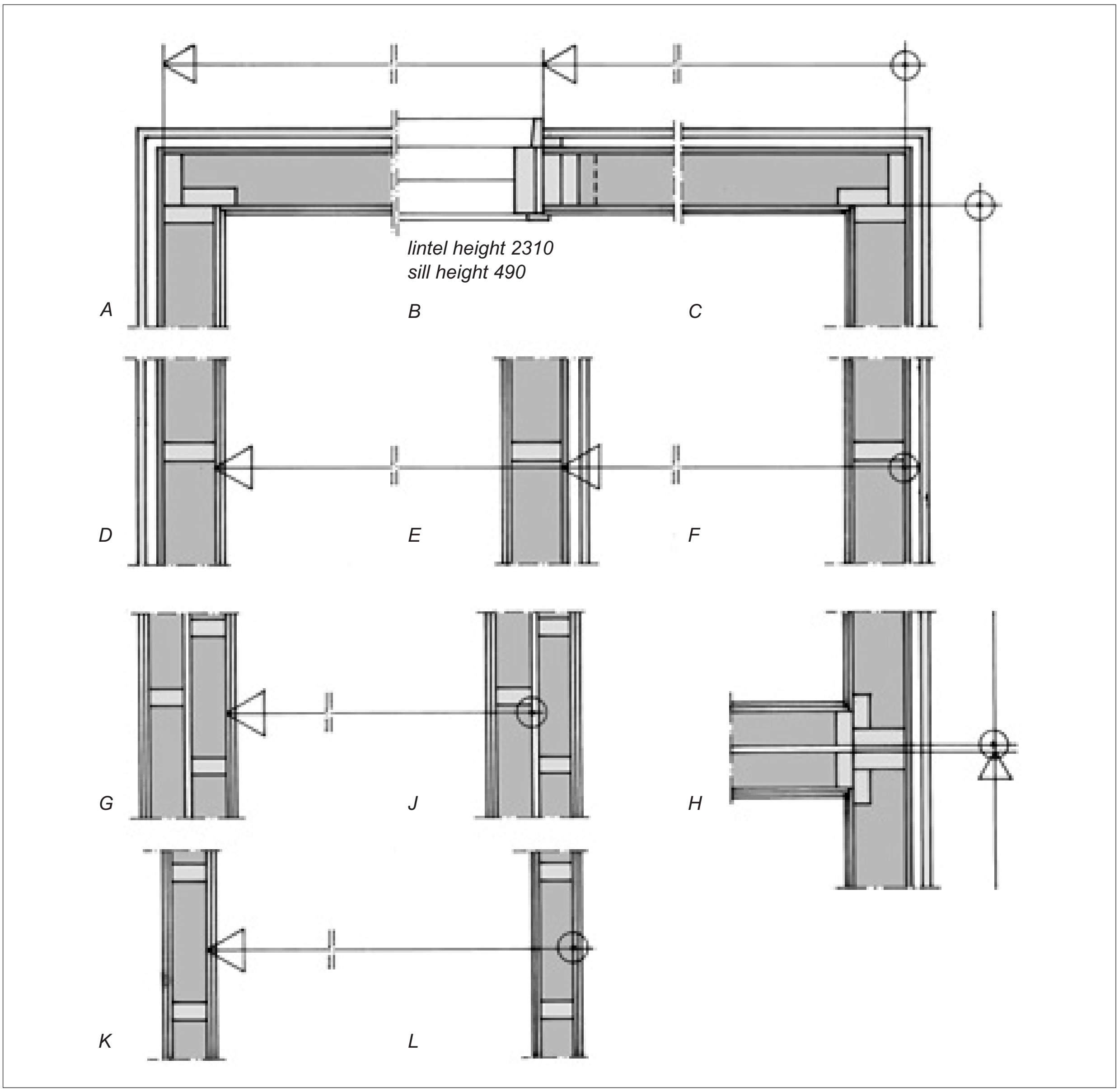
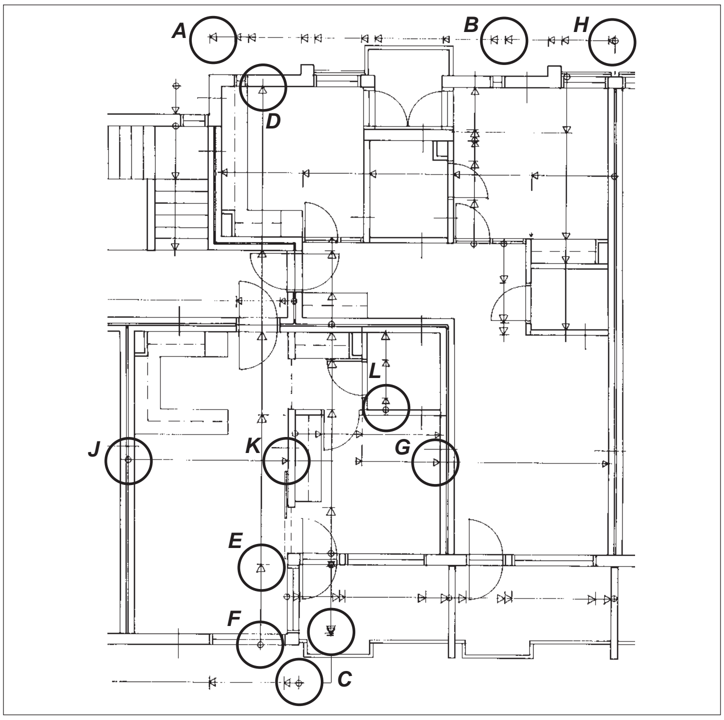


Figure 65 a and b. Measuring points for structural dimensioning.



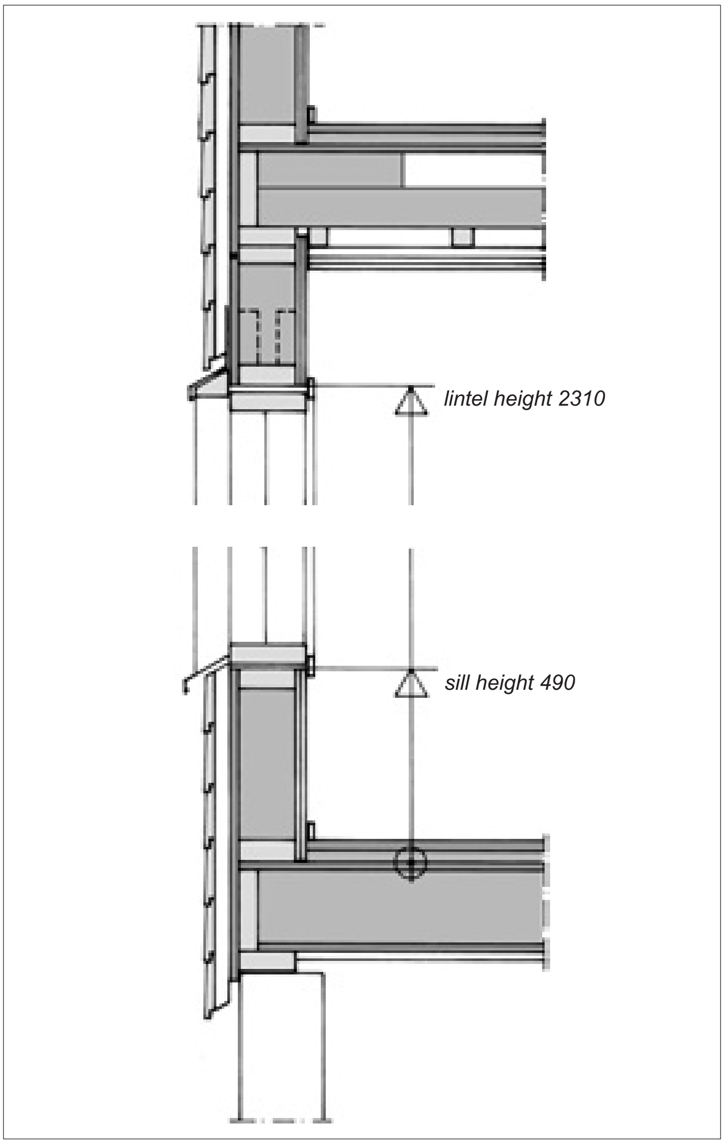


Figure 66. Opening heights.
- *sill height from sub-floor board*
- *lintel height from sub-floor board*

Note: Opening heights are given from sub-flooring board, not from the finished floor. The dimensioning of openings allows provision for caulking.

The starting point for structural dimensioning is the outer edge of the external wall frame (studs). This is also the outer edge of header joists and sub-flooring boards, which makes it an appropriate starting position for the overall dimensioning of a building.

The following dimensional principles must be conformed to:
- structural frame (grid) dimensions
- running dimension anti-clockwise
- opening heights
- sill height from sub-floor board
- lintel height from sub-floor board

Note: Opening heights are given from sub-flooring board, not from the finished floor. The dimensioning of openings allows provision for caulking.

The use of structural frame dimensions must be stated in the drawings with the following text: ALL DIMENSIONS REFER TO THE STRUCTURAL FRAME.

In design adaptations that are based on IT-technology, the walls are shown using four lines, the inner line meaning the surface of the frame and the outer line the finished surface of the structure. This also allows alternative surfaces to be independently dimensioned.

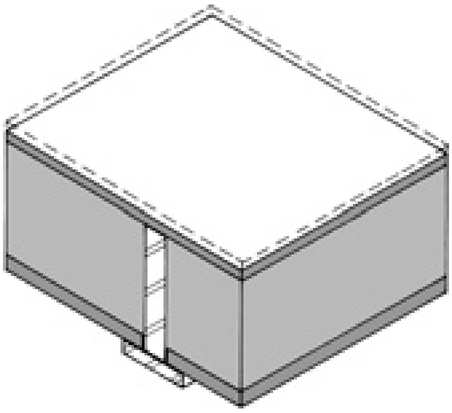
6 MODEL EXAMPLE STRUCTURES

Timber Structures for REI 60 Category Apartment Blocks

Timber Structures for EI 30 Category Houses

6 MODEL EXAMPLE STRUCTURES

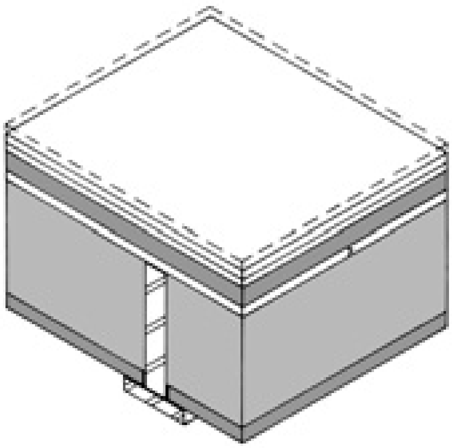
Timber Structures for REI 60 Category Apartment Blocks



Suspended timber ground floor AP1

1. Floor finish
2. T&G building board (e.g. 18 mm softwood ply)
3. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
4. 195 mm thermal insulation, Euroclasses A1 or A2
5. 25 mm breather board
6. Support for floor infill

The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.

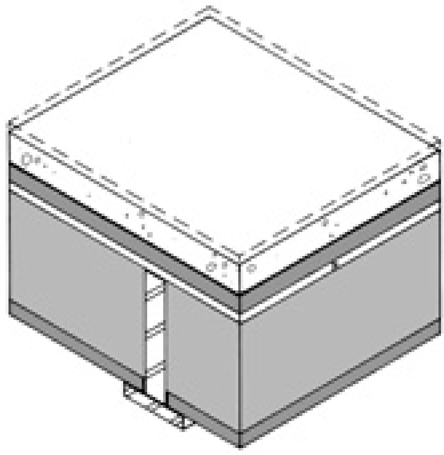


Suspended timber ground floor AP2

1. Floor finish
2. Double or triple plaster board with glued overlapped seams/ 22 mm T&G building board
3. 30 – 50 mm rigid mineral wool, (density 145 – 170 kg/m3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. 195 mm thermal insulation, Euroclasses A1 or A2
7. 25 mm breather board
8. Support for floor infill

The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.

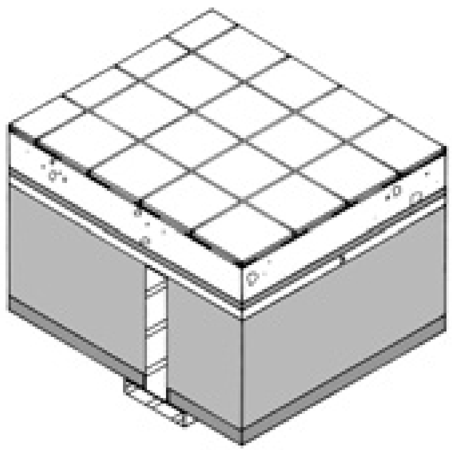
Suspended timber ground floor AP3



1. Floor finish
2. Approx. 50 mm concrete screed
3. 30 – 50 mm rigid mineral wool, (density 80 – 100 kg/m3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. 195 mm thermal insulation, Euroclasses A1 or A2
7. 25 mm breather board
8. Support for floor infill

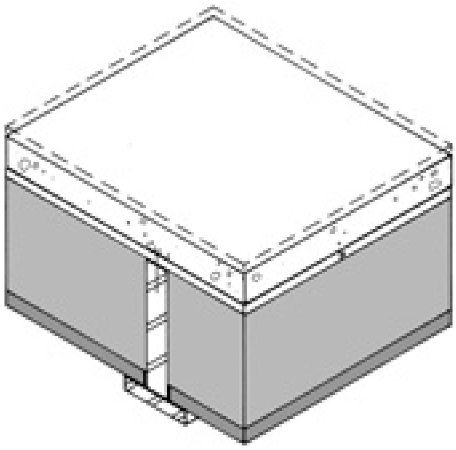
The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.

Suspended timber ground floor for wet areas AP4



1. Ceramic tile + adhesive plaster
2. Waterproof course
3. 50 – 70 mm concrete screed
4. 10 mm sealed polyethylene membrane *
5. T&G building board (e.g. 18 mm softwood ply)
6. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
7. 195 mm thermal insulation, Euroclasses A1 or A2
8. 25 mm breather board
9. Support for floor infill

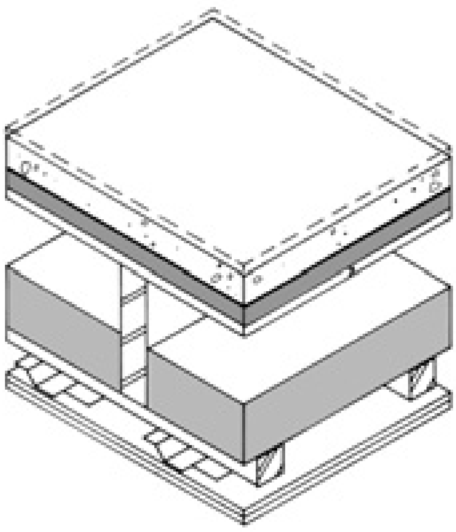
The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.
*Sealed insulation is always used for floating wet area floors.



Suspended composite ground floor AP5

1. Floor finish
2. 50 – 60 mm concrete screed, attached to sub-flooring board
3. T&G building board (e.g. 18 mm softwood ply)
4. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
5. 195 mm thermal insulation, Euroclasses A1 or A2
6. 25 mm breather board
7. Support for floor infill

The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.

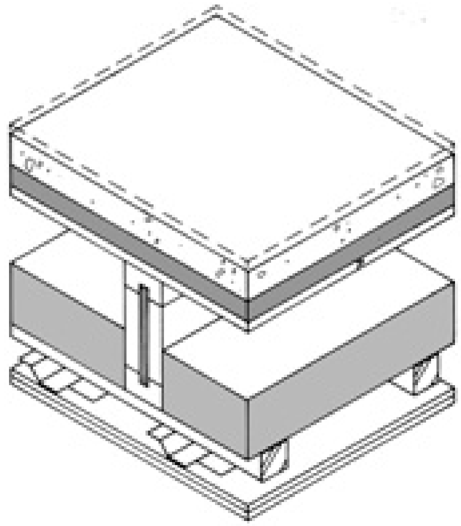


Timber floor VP 1 (REI 60)

1. Floor finish
2. Approx. 50 mm concrete screed
3. 30 – 50 mm rigid mineral wool (density 80 – 100 kg/m^3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, Euroclasses A1 or A2
7. Perpendicular battens (space for sprinkler pipes)
8. Acoustic spring hanger (400 mm c/c)
9. Double building board, class/category in accordance with local requirements.

Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB

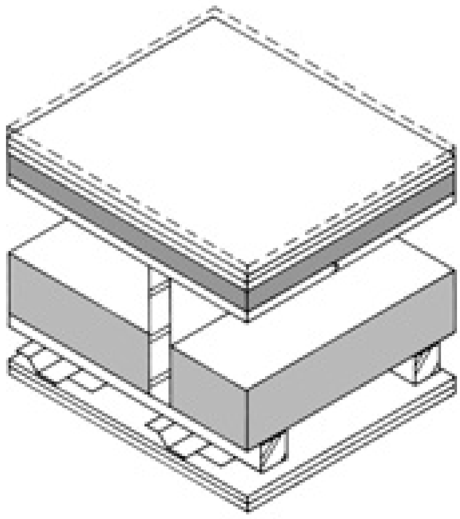
Timber floor VP 1B (REI 60)



1. Floor finish
2. Approx. 50 mm concrete screed
3. 30 – 50 mm rigid mineral wool (density 80 – 100 kg/m^3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. Joists (ply-web beams or equiv.), dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, Euroclasses A1 or A2
7. Perpendicular battens (space for sprinkler pipes)
8. Acoustic spring hanger (400 mm c/c)
9. Double building board, class/category in accordance with local requirements.

Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB

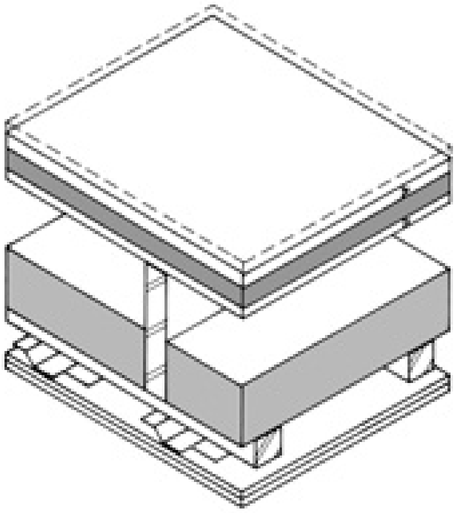
Timber floor VP 2 (REI 60)



1. Floor finish
2. Double or triple gypsum chipboard with glued overlapping joints
3. 30 – 50 mm rigid mineral wool, (density 145 – 170 kg/m^3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, Euroclasses A1 or A2
7. Perpendicular battens (space for sprinkler pipes)
8. Acoustic spring hanger (400 mm c/c)
9. Double building board, class/category in accordance with local requirements.

Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB

NOTE!
Due to the lightness of the intermediate floor, the impact sound resistance of VP2 is less than that of the previously illustrated floors (VP1 and VP1B). However, it is possible to achieve similar sound resistance levels to these previously presented examples using the VP2 structure provided that flanking transmission is minimised by taking extra care both in the design and realisation of the junctions between the intermediate floor and other structures, such as walls etc.

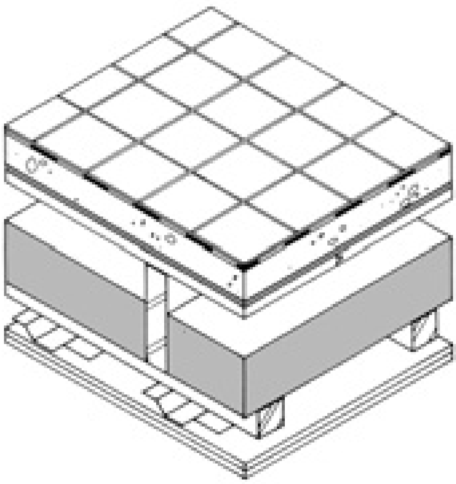


Timber floor VP 2B (REI 60)

1. Floor finish
2. 22 mm T&G chipboard or plaster board
3. 30 – 50 mm rigid mineral wool, (density 145 – 170 kg/m^3 depending on type)
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, Euroclasses A1 or A2
7. Perpendicular battens (space for sprinkler pipes)
8. Acoustic spring hanger (400 mm c/c)
9. Double building board, class/category in accordance with local requirements.

Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB

NOTE!
Due to the lightness of the intermediate floor, the impact sound resistance of VP2B is less than that of the previously illustrated floors (VP1 and VP1B). However, it is possible to achieve similar sound resistance levels to these previously presented examples using the VP2B structure provided that flanking transmission is minimised by taking extra care both in the design and realisation of the junctions between the intermediate floor and other structures, such as walls etc.

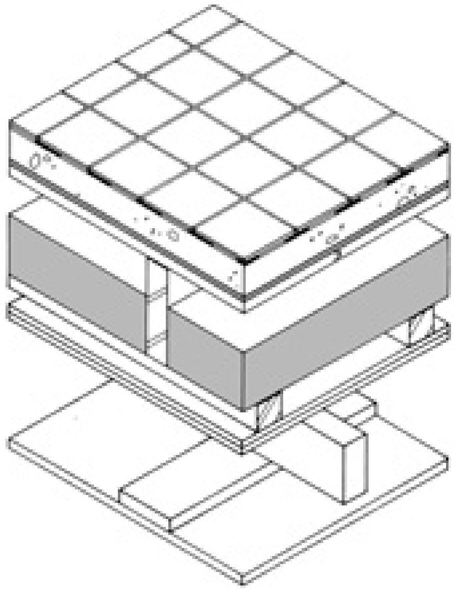


Timber floor for wet areas VP 3 (REI 60)

1. Ceramic tile + adhesive plaster
2. Water proof course
3. 50 – 70 mm concrete screed, falls to a floor drain
4. Sealed polyethylene membrane*
5. T&G building board (e.g. 18 mm softwood ply)
6. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
7. Min. 100 mm insulation, Euroclasses A1 or A2
8. Perpendicular battens (space for sprinkler pipes)
9. Acoustic spring hanger (400 mm c/c)
10. Double building board, class/category in accordance with local requirements.

Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB
*Sealed insulation is always used for floating wet area floors.

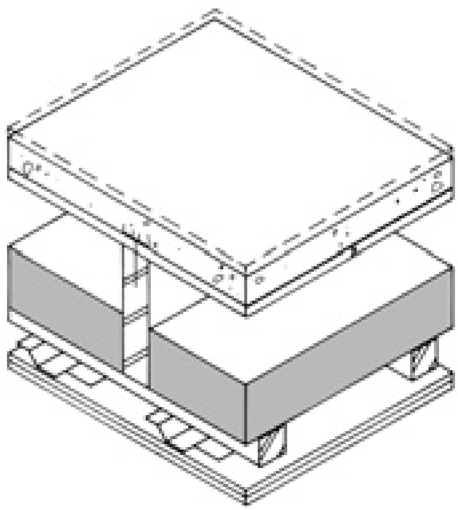
Timber floor for wet areas VP 4 (REI 60)



1. Ceramic tile + adhesive plaster
2. Waterproof course
3. 50 – 70 mm concrete screed, falls to a floor drain
4. Sealed polyethylene membrane*
5. T&G building board (e.g. 18 mm softwood ply)
6. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
7. Min. 100 mm insulation, Euroclasses A1 or A2
8. Perpendicular battens (space for sprinkler pipes)
9. Acoustic spring hanger (400 mm c/c)
10. Double building board, class/category in accordance with local requirements.
11. Ventilated air space, dimensioned in accordance with the spatial requirements of heating, plumbing and air-conditioning
12. 48 mm x 97 mm support battens for ceiling lining
13. 25 mm x 100 mm underlay battens for ceiling lining, 400 – 600 mm c/c
14. Ceiling lining

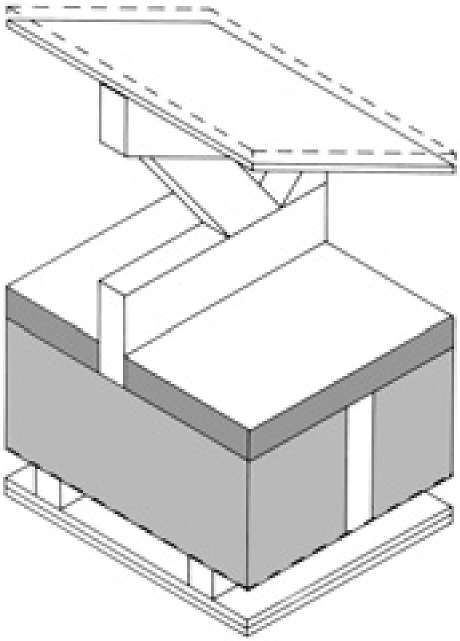
Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB
*Sealed insulation is always used for floating wet area floors.

Composite floor VP 5 (REI 60)



1. Floor finish**
2. 50 – 60 mm concrete screed, attached to sub-flooring board
3. T&G building board (e.g. 18 mm softwood ply)
4. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
5. Min. 100 mm insulation, Euroclasses A1 or A2
6. Perpendicular battens (space for sprinkler pipes)
7. Acoustic spring hanger (400 mm c/c)
8. Double building board, class/category in accordance with local requirements.

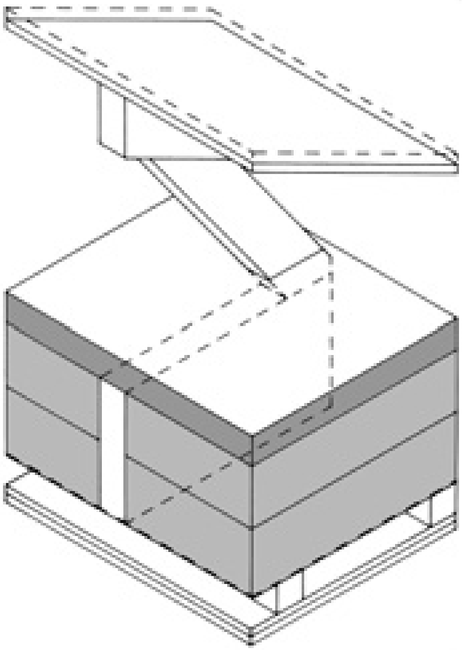
Air-borne sound insulation factor R'w 58 dB
Impact noise insulation factor L'n,w 53 dB
**The choice of floor finish must take into account the impact noise factor of chosen floor materials and flanking sound transmission. Finishing materials may consist of cushioned vinyl flooring intended for domestic use or other equivalent soft material.



Timber roof YP1 (REI 60)

1. Roof and underlay
2. Roof truss
3. 50 mm thermal insulation, with breather membrane surface, Euroclasses A1 or A2
4. 300 mm thermal insulation, Euroclasses A1 or A2, and 48 mm x 220 mm load-bearing ceiling joists, dimension and spacing to be calculated for each individual project
5. Vapour barrier
6. Perpendicular battens (space for sprinkler pipes)
7. Double building board, class/category in accordance with local requirements.

The structure meets with thermal insulation requirement U < 0.16 W/m^{2}K
This solution is particularly suitable for situations where load-bearing partitions are parallel to roof trusses.

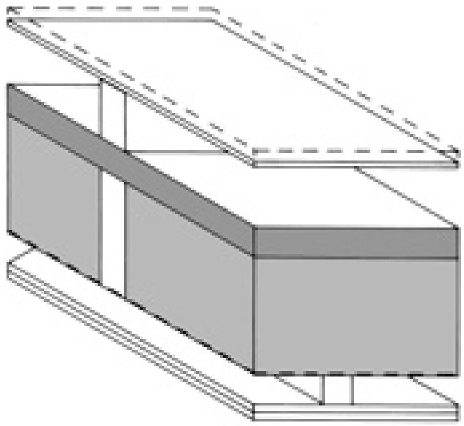


Timber roof YP2 (REI 60)

1. Roof and underlay
2. Roof rafter, upper chord of roof truss
3. 50 mm thermal insulation, with breather membrane surface, inflammable or almost inflammable
4. 300 mm thermal insulation, Euroclasses A1 or A2
5. Ceiling joist, lower chord of roof truss, with adequate provision for charring in case of fire
6. Vapour barrier
7. Perpendicular battens (space for sprinkler pipes)
8. Single or double building board, class/category in accordance with local requirements.

The structure meets with thermal insulation requirement U < 0.16 W/m^{2}K
In the solution, the lower chord of the roof truss performs as load-bearing structure in a fire situation.

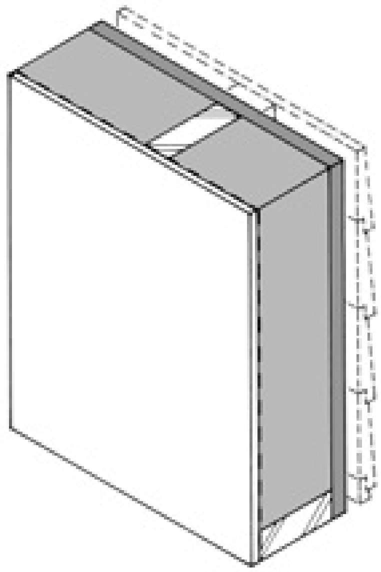
Couple timber roof YP3 (REI 60)



1. Roof and underlay
2. 48 mm x 97 mm counter battens (ventilation cavity)
3. 50 mm thermal insulation, with breather membrane surface, Euroclasses A1 or A2
4. 300 mm thermal insulation, Euroclasses A1 or A2, and load-bearing roof rafters, dimension and spacing to be calculated for each individual project
5. Vapour barrier
6. Perpendicular battens (space for sprinkler pipes)
7. Single or double building board, class/category in accordance with local requirements.

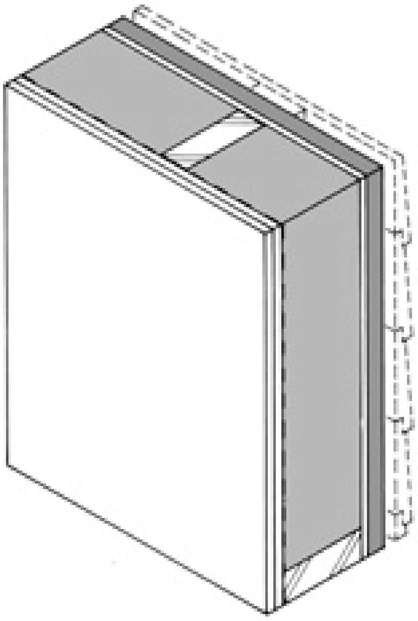
The structure meets with thermal insulation requirement U < 0.16 W/m²K

Load-bearing external wall US1 (R 60)



1. External cladding
2. Ventilation cavity
3. Breather board
4. 172 mm thermal insulation, Euroclasses A1 or A2, and 48 x 172 mm load-bearing frame, dimension and spacing to be checked for each individual project
5. Vapour barrier
6. Building board (whenever necessary)
7. Building board, class/category in accordance with local requirements.

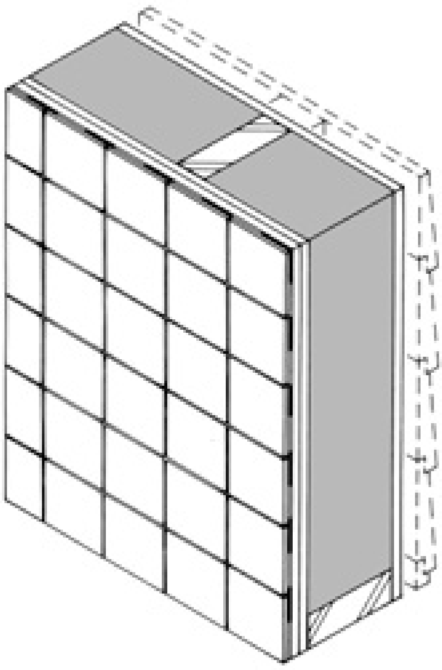
The structure meets with thermal insulation requirement U < 0.25 W/m²K.



Load-bearing external wall US2 (R 60)

1. External cladding
2. Ventilation cavity
3. 25 mm weatherproof mineral wool
4. Breather board, e.g. softwood ply
5. 172 mm thermal insulation, Euroclasses A1 or A2, and 48 mm x 172 mm load-bearing frame, dimension and spacing to be checked for each individual project
6. Vapour barrier
7. Building board (whenever necessary)
8. Building board, class/category in accordance with local requirements.

The structure meets with thermal insulation requirement U < 0.25 W/m^{2}K.



Load-bearing external, wet area wall US3 (R 60)

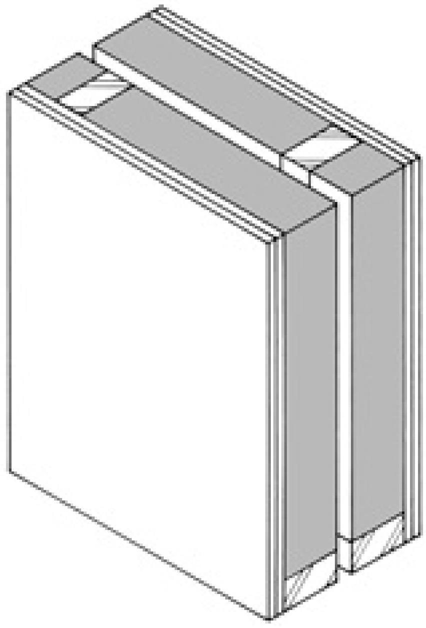
1. External cladding
2. Ventilation cavity
3. Breather board
4. 172 mm thermal insulation, Euroclasses A1 or A2, and 48 mm x 172 mm load-bearing frame, dimension and spacing to be checked for each individual project
5. Building board (whenever necessary)
6. Building board, class/category in accordance with local requirements.
7. Waterproof course, attached to vapour barrier of adjoining structures
8. Ceramic tile + adhesive plaster

The structure meets with thermal insulation requirement U < 0.25 W/m^{2}K.

Load-bearing party wall VS1 (REI 60 / EI 60)

1. Building board 13–25kg/m^2
2. Building board, whenever necessary
3. 97 mm insulation, Euroclasses A1 or A2, 48 mm x 97 mm party wall load-bearing frame, dimension and spacing to be checked for each individual project
4. 20 – 50 mm air cavity, fire break at each storey level

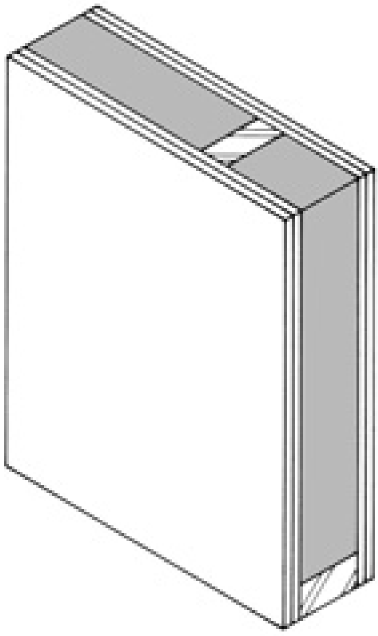
Air-borne sound insulation factor R’w ~ 60 dB
Bracing building boards are usually attached on both sides of the wall.

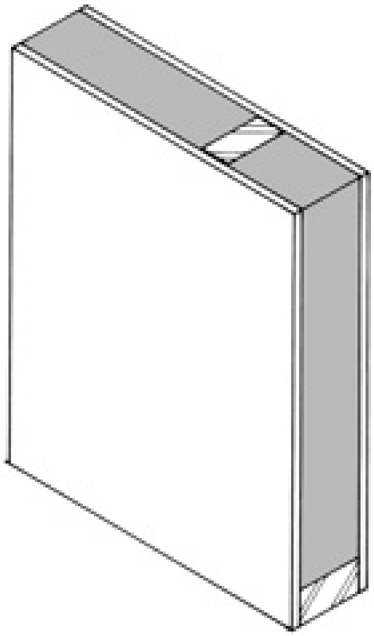


Load-bearing partition VS2 (REI 60)

1. Building board
2. Building board **
3. 97 mm insulation, Euroclasses A1 or A2, 48 mm x 97 mm load-bearing frame, dimension and spacing to be checked for each individual project

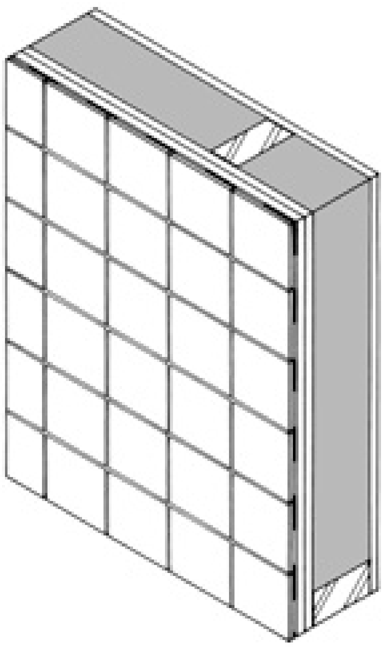
Air-borne sound insulation factor R’w   47 dB
**) The combined protection period of the board must be 45 min. (e.g. fireboard and normal plaster board)





Non-bearing partition VS3

1. Building board
2. 97 mm insulation, Euroclasses A1 or A2, 48 mm x 97 mm partition frame, dimension and spacing to be checked for each individual project

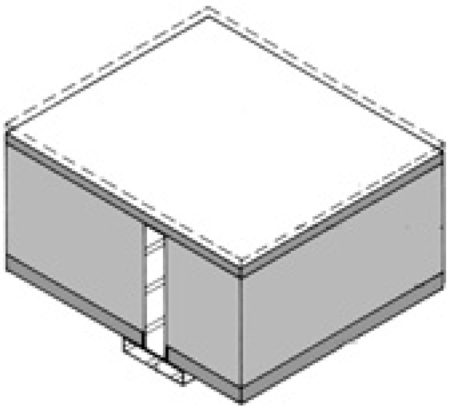


Non-bearing partition between dry and wet areas VS4

1. Building board
2. 97 mm insulation, Euroclasses A1 or A2, 48 mm x 97 mm partition frame, dimension and spacing to be checked for each individual project
3. Building board
4. Waterproof course, attached to adjoining vapour barriers
5. Ceramic tile + adhesive plaster

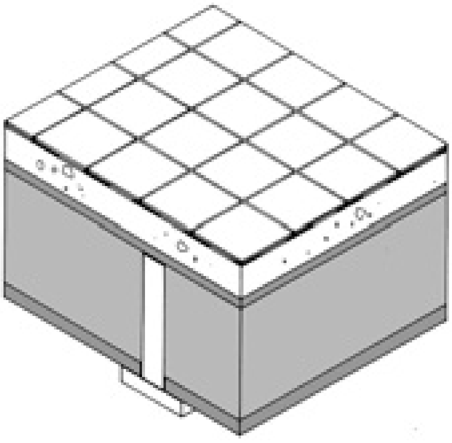
Timber Structures for EI 30 Category Houses

Suspended timber ground floor AP1



1. Floor finish
2. T&G building board (e.g. 18 mm softwood ply)
3. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
4. 195 mm thermal insulation, Euroclasses A1 or A2
5. 25 mm breather board
6. Support for floor infill

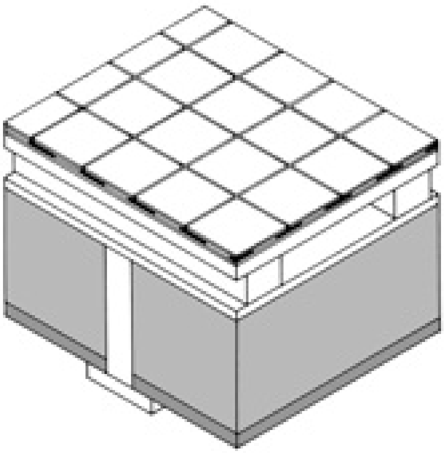
The structure meets with thermal insulation requirement U < 0,22 W/m^{2}K
Minimum height of ventilated air space is 800 mm.



Suspended timber ground floor for wet areas AP2

1. Ceramic tile + adhesive plaster
2. Waterproof course
3. 50 – 70 mm concrete screed
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. 195 mm thermal insulation, Euroclasses A1 or A2
7. 25 mm breather board
8. Support for floor infill

The structure meets with thermal insulation requirement U < 0,22 W/m²K
Minimum height of ventilated air space is 800 mm.
Whenever necessary the joists can be positioned at a lower level from joists elsewhere in order to avoid the difference in floor level between dry and wet areas.



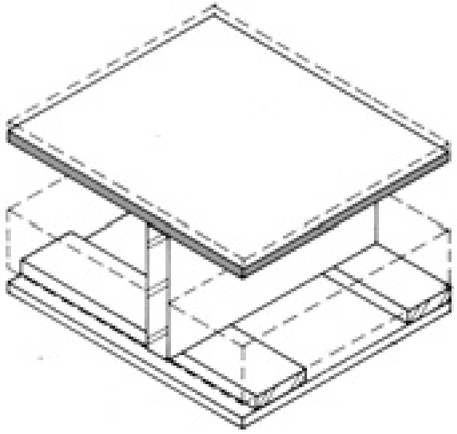
Suspended timber ground floor for wet areas AP3

1. Ceramic tile + adhesive plaster
2. Waterproof course
3. Damp-proof building board, falls to drain created by battens
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. 195 mm thermal insulation, Euroclasses A1 or A2
7. 25 mm breather board
8. Support for floor infill

The structure meets with thermal insulation requirement U < 0,22 W/m²K
Minimum height of ventilated air space is 800 mm.
Whenever necessary the joists can be positioned at a lower level from joists elsewhere in order to avoid the difference in floor level between dry and wet areas.

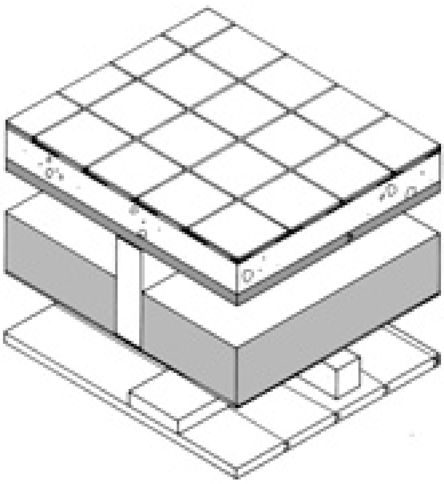
Timber floor VP 1 (REI 30)

1. Floor finish
2. T&G building board (e.g. 18 mm softwood ply)
3. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
4. Min- 100 mm insulation, whenever necessary
5. 45 mm x 45 mm battens, 300 mm c/c
6. Internal finish, boarding or lining

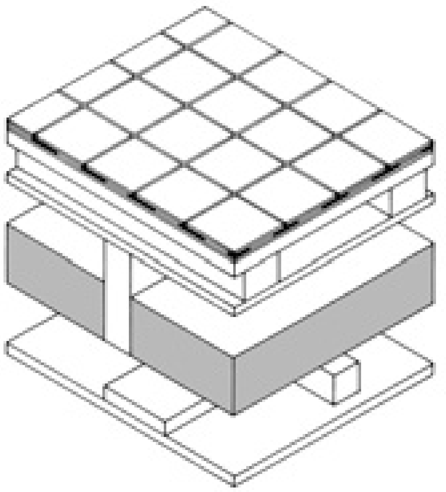


Timber floor for wet areas VP 2 (REI 30)

1. Ceramic tile + adhesive plaster
2. Waterproof course
3. 50- 70 mm concrete screed, falls to a floor drain
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, whenever necessary
7. Ventilated air space, dimensioned in accordance with heating, plumbing and air-conditioning space requirement
8. 48 mm x 97 mm support battens for ceiling lining
9. Air barrier
10. 25 mm x 100 mm underlay battens for ceiling lining, 400 – 600 mm c/c
11. Ceiling lining



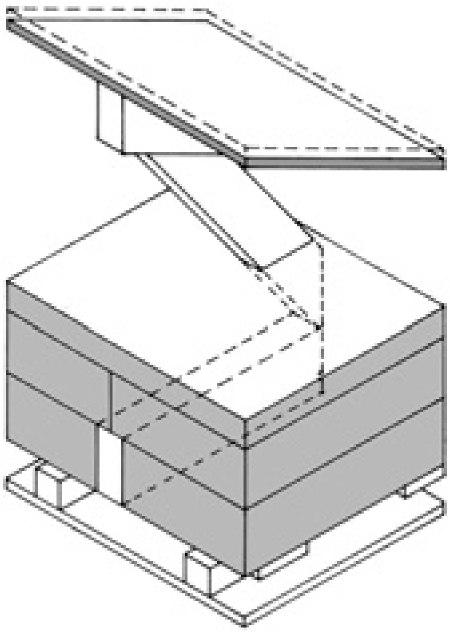
Whenever necessary the joists can be positioned at a lower level from joists elsewhere in order to avoid the difference in floor level between dry and wet areas.



Timber floor for wet areas VP 3 (REI 30)

1. Ceramic tile + adhesive plaster
2. Waterproof course
3. Damp-proof building board, falls to drain created by battens
4. T&G building board (e.g. 18 mm softwood ply)
5. 48 mm x 220 mm joists, dimension and spacing to be checked for each individual project
6. Min. 100 mm insulation, whenever necessary
7. Ventilated air space, dimensioned in accordance with heating, plumbing and air-conditioning space requirement
8. 48 mm x 97 mm support battens for ceiling lining
9. Air barrier
10. 25 mm x 100 mm underlay battens for ceiling lining, 400 – 600 mm c/c
11. Ceiling lining

Whenever necessary the joists can be positioned at a lower level from joists elsewhere in order to avoid the difference in floor level between dry and wet areas.

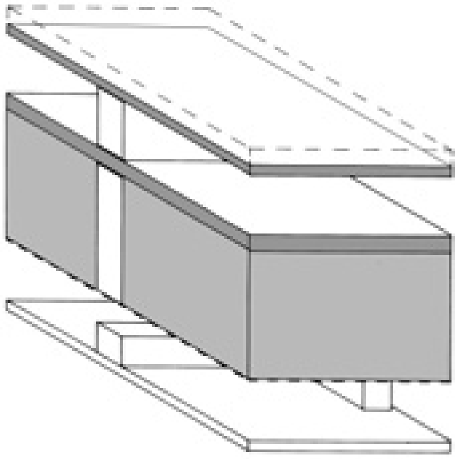


Timber roof YP1 (REI 30)

1. Roof and underlay
2. T&G softwood ply
3. 350 mm thermal insulation, with breather membrane or board surface
4. Roof truss
5. Vapour and air barrier
6. Perpendicular battens (space for electrical wiring)
7. Internal finish, either boarding or lining

The structure meets with thermal insulation requirement U < 0.16 W/m²K
In the solution, the lower chord of the roof truss performs as load-bearing structure in a fire situation.

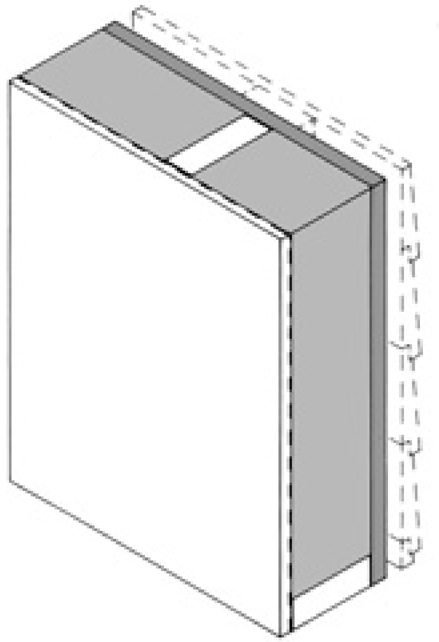
Couple timber roof YP2 (REI 30)/ Timber roof with sloping ceiling



1. Roof and underlay
2. T&G softwood ply
3. 48 mm x 97 mm counter battens (ventilation cavity)
4. 25 mm breather board / 25 mm thermal insulation
5. 300 mm thermal insulation and load-bearing roof rafters, dimension and spacing to be calculated for each individual project
6. Vapour and air barrier
7. Perpendicular battens (space for electrical wiring)
8. Internal finish, either boarding or lining

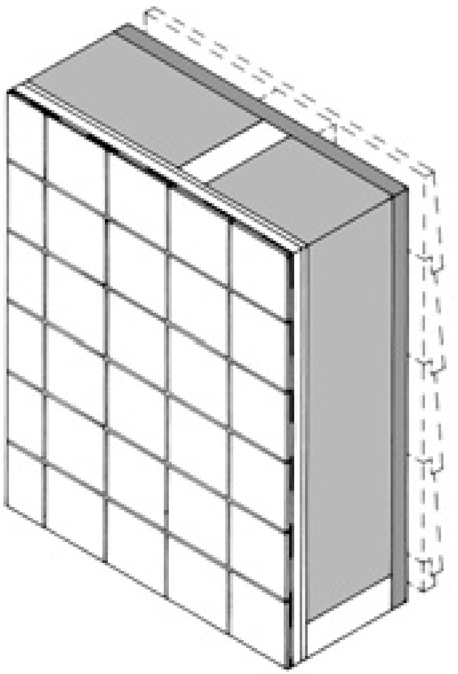
The structure meets with thermal insulation requirement U < 0.16 W/m^{2}K

Load-bearing external wall US1 (R 30)



1. External cladding (minimum thickness of external cladding boards is 21 mm)
2. Ventilation cavity
3. 25 mm breather board (weather proof porous fibreboard)
4. 172 mm thermal insulation and 48 mm x 172 mm load-bearing frame, 600 mm c/c, dimension and spacing to be checked for each individual project
5. Vapour barrier
6. 9 mm building board (whenever necessary)
7. Internal finish, either boarding or lining

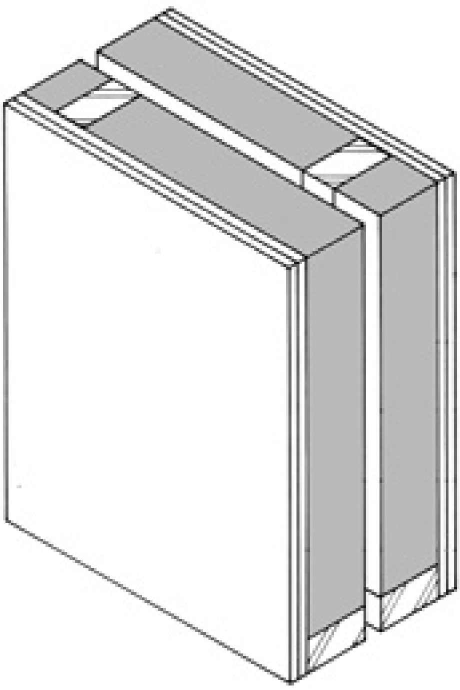
The structure meets with thermal insulation requirement U < 0.25 W/m^{2}K



Load-bearing external, wet area wall US2 (R 30)

1. External cladding (minimum thickness of external cladding boards is 21 mm)
2. Ventilation cavity
3. 25 mm breather board (weather proof porous fibreboard)
4. 172 mm thermal insulation and 48 mm x 172 mm load-bearing frame, 300 mm c/c, dimension and spacing to be checked for each individual project
5. 9 mm building board (whenever necessary)
6. Waterproof course, attached to vapour barrier of adjoining structures
7. Ceramic tile + adhesive plaster

The structure meets with thermal insulation requirement U < 0.25 W/m^{2}K.



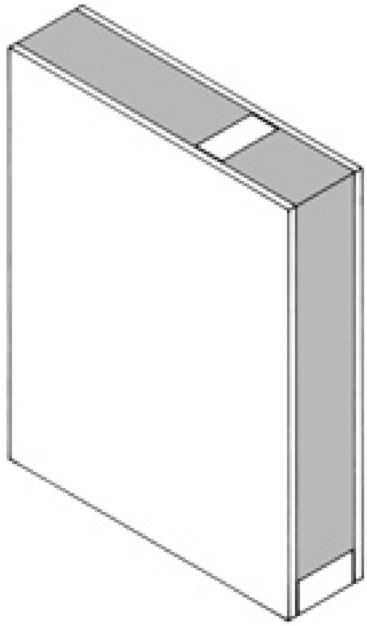
Load-bearing party wall VS 1 (REI 30 / EI 30)

1. Building board, 13–25kg/m^2
2. 9 mm building board, whenever necessary
3. 97 mm insulation and 48 mm x 97 mm party wall load-bearing frame, dimension and spacing to be checked for each individual project
4. 20 mm air cavity, fire break at each storey level

Air-borne sound insulation factor R'w ~ 60 dB
Bracing sheathing usually attached on both sides of the wall.

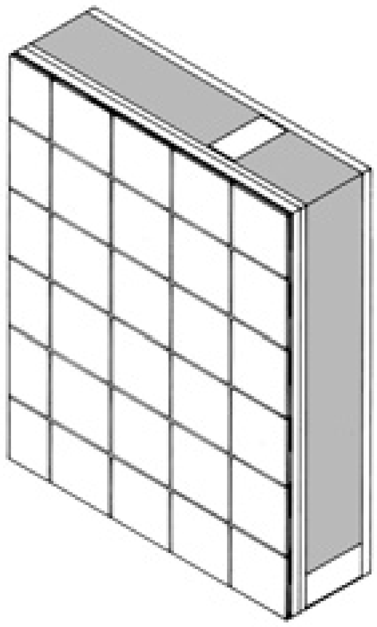
Non-bearing partition VS 2

1. Building board or internal lining board
2. 97 mm insulation, whenever necessary, and 48 mm x 97 mm partition frame, dimension and spacing to be checked for each individual project



Non-bearing partition between dry and wet areas VS 3

1. Building board or internal lining board
2. 97 mm insulation, whenever necessary, and 48 mm x 97 mm partition frame, dimension and spacing to be checked for each individual project (e.g. 400 mm c/c)
3. 9 mm building board, whenever necessary
4. Waterproof course, attached to adjoining vapour barriers
5. Ceramic tile + adhesive plaster



7 JUNCTION DETAILS

Details for REI 60 Category Apartment Blocks

Details for EI 30 Category Houses

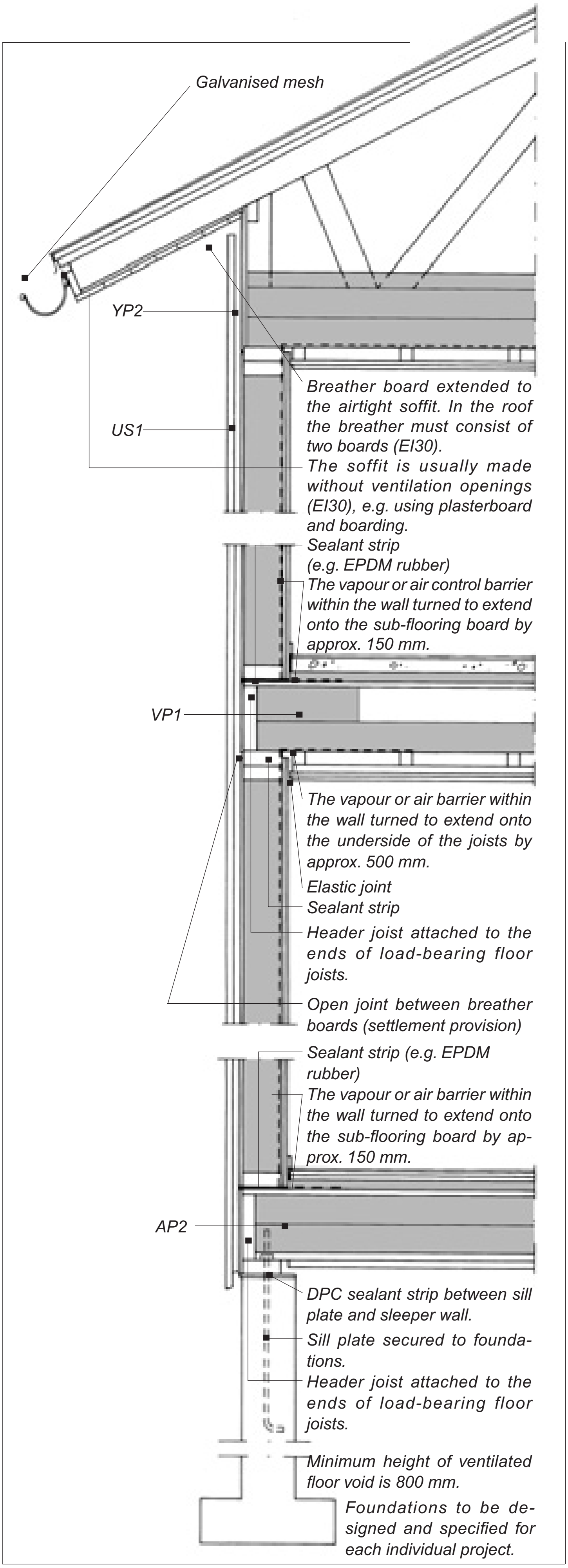
Junction between external wall (US1) and roof (YP2).

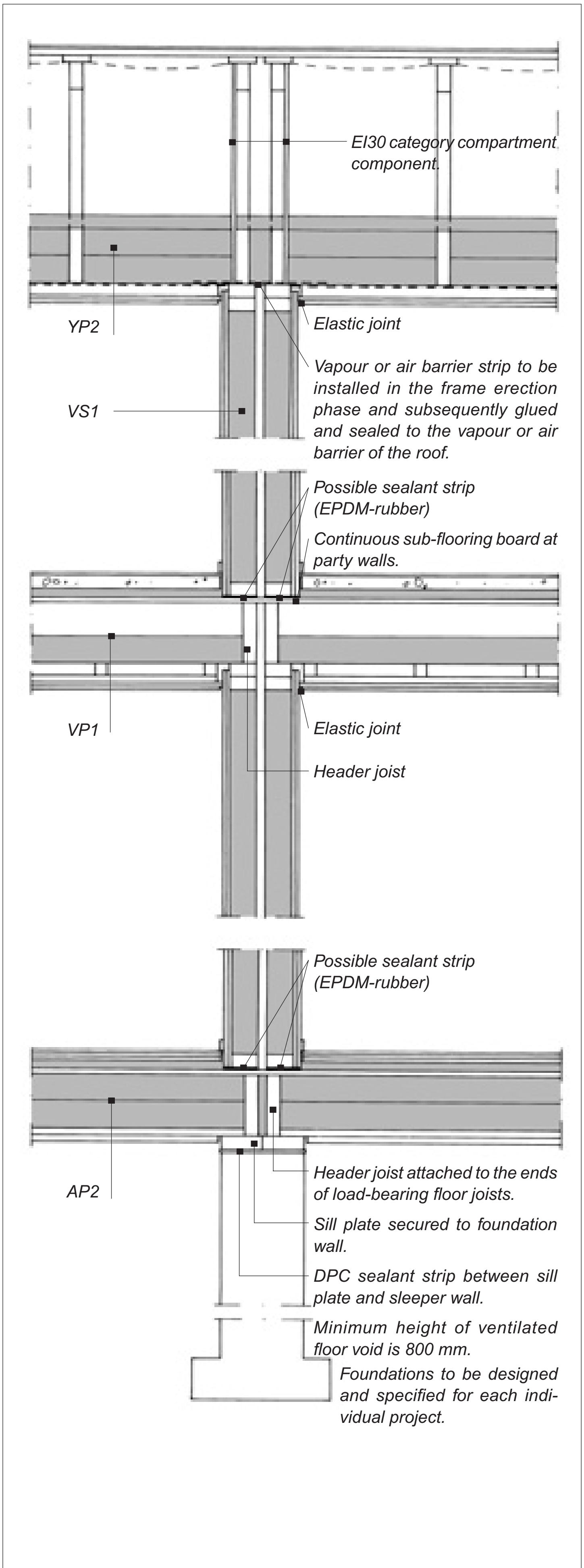
Roof void must be divided into compartments in accordance with local fire regulations. The element, that divides the roof void, must be built into the roof structure (to the underside of the roofing material). The void within the eaves must also be divided into sections.

Junction between external wall (US1) and intermediate floor of a dry area (VP1).

Junction between external wall (US1) and ground floor of a dry area (AP2).

Ground floor joists are perpendicular to the wall. The void underneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.





Junction between party wall (VS1) and roof (YP2).

Roof void must be divided into compartments in accordance with local fire regulations. The compartments are further divided into sections of maximum 400 m2 using E15 building components. The element, that divides the roof void, must be built into the roof structure (to the underside of the roofing material).

Junction between party wall (VS1) and intermediate floor (VP1).

The intermediate floor joists are perpendicular to the party wall. Joists are discontinued at wall junction in order to prevent flanking sound transmission.

Junction between party wall (VS1) and ground floor (AP2).

Ground floor joists are perpendicular to the wall. Joists are discontinued at wall junction in order to prevent flanking sound transmission.

The void underneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.

Junction between load-bearing partition (VS2) and roof (YP1).

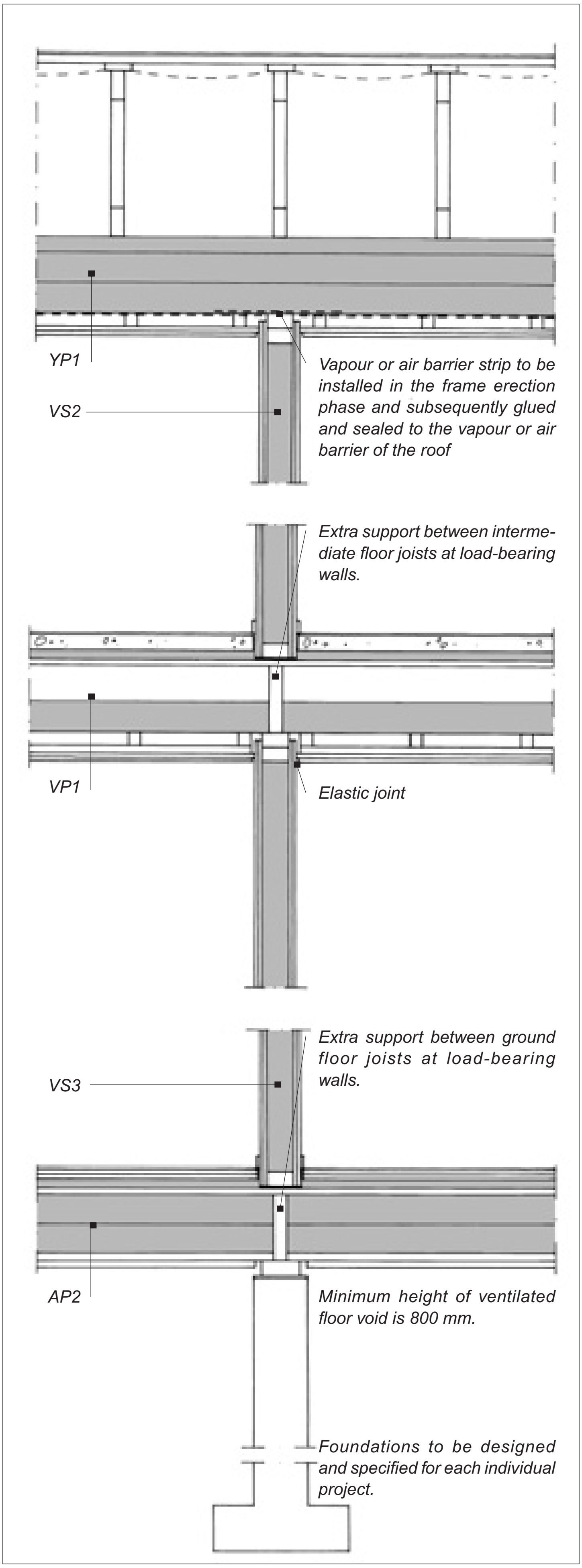
Roof rafters perpendicular to partition. The ceiling joists can be either single span or continuous.

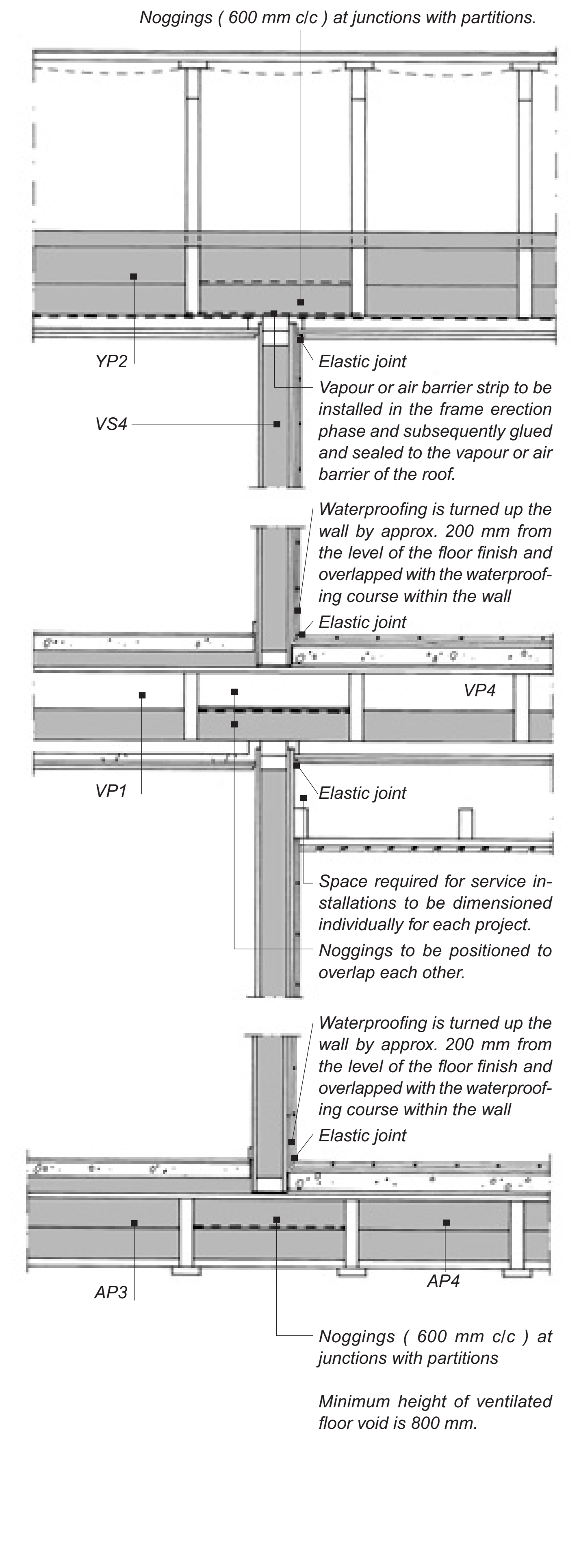
Junction between load-bearing partition (VS2) and party floor (VP1).

Intermediate floor joists can be either single span or continuous.

Junction between non-bearing partition (VS3) and ground floor of dry areas (AP2).

The void beneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.





Junction between non-bearing partition of a wet area (VS4) and roof (YP2).

Roof rafters are parallel to partition. The junction between a partition and the roof can also be resilient.

Junction between non-bearing partition of a wet area (VS4 and) and intermediate floor of a dry area (VP1) and intermediate floor of a wet area (VP 4).

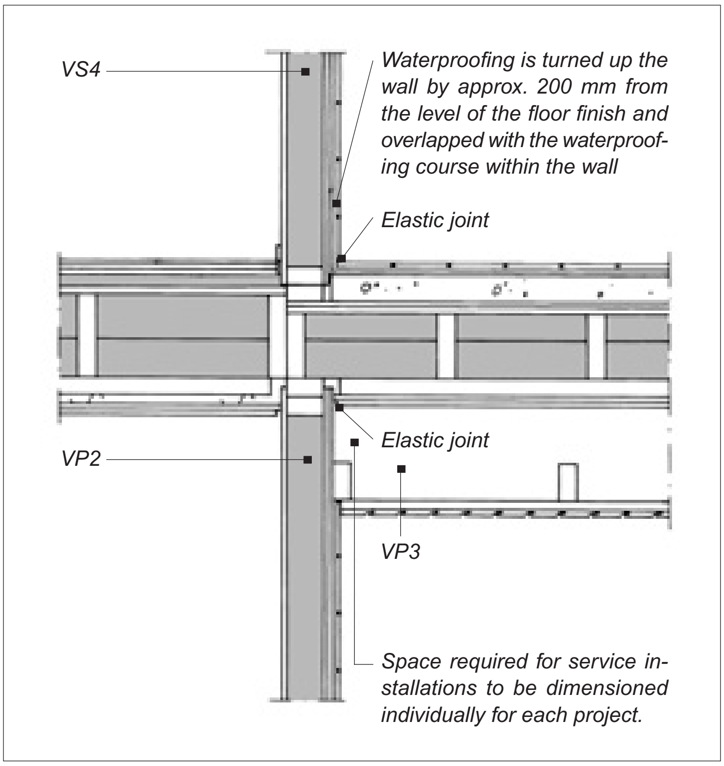
The insulation layer of the floating floor in the illustration is 50 mm thick on the dry area and 10 mm on the wet area. Respectively, the thickness of the concrete screed on the wet area is more than that of the dry area. This allows for the floors to be approximately level. The junction between the partition and the intermediate floor can be made resilient.

Junction between non-bearing partition of a wet area (VS4) and ground floor of a dry area (AP3) and ground floor of a wet area (AP4).

The void beneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.

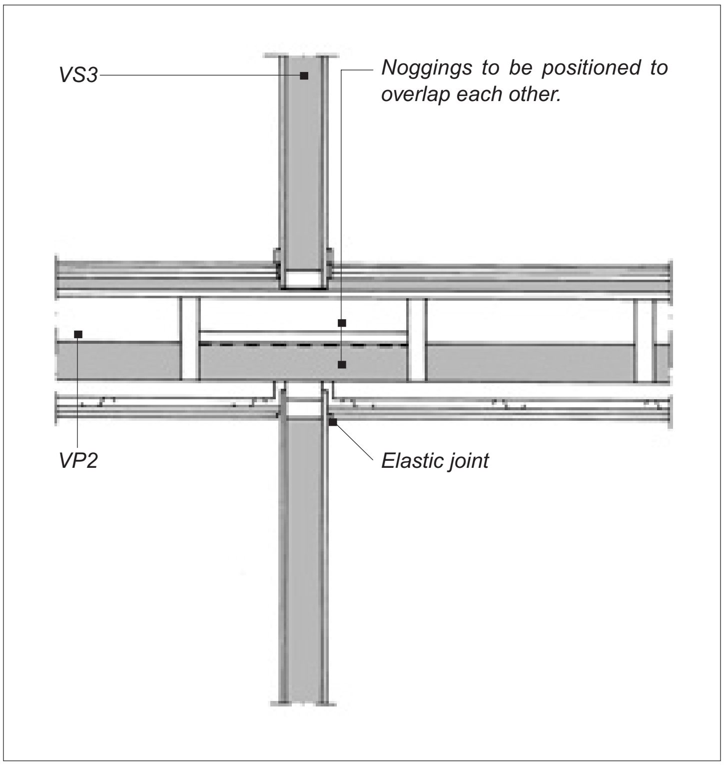
Junction between wet area partition (VS4) and wet are party floor (VP3)

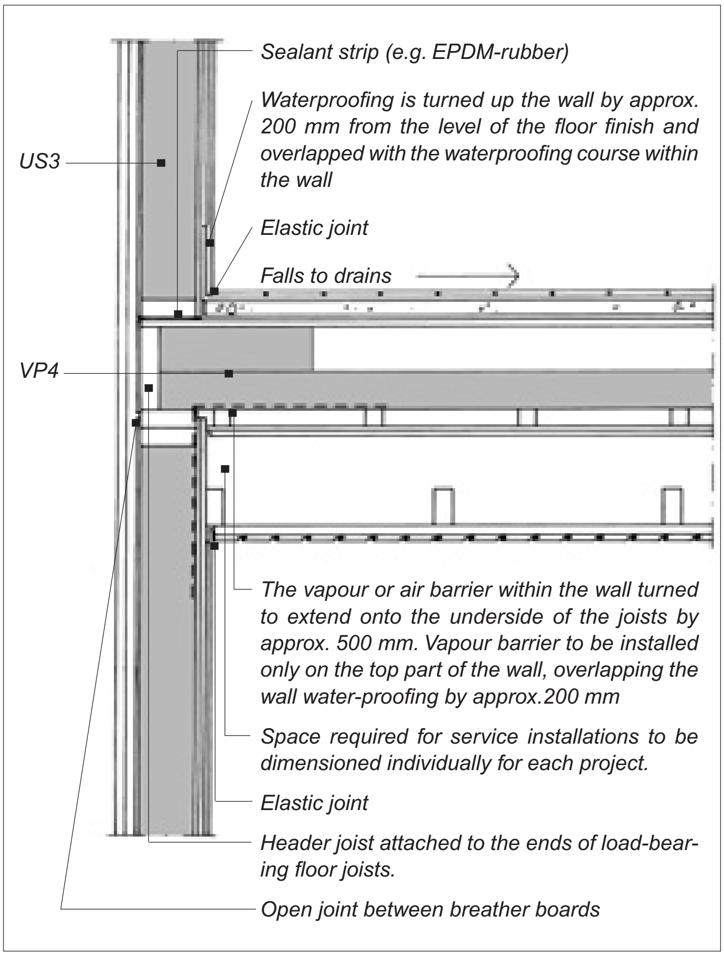
In the example, the intermediate floor joists of the wet area are lower than joists in dry areas. This allows the floors to be approximately level.



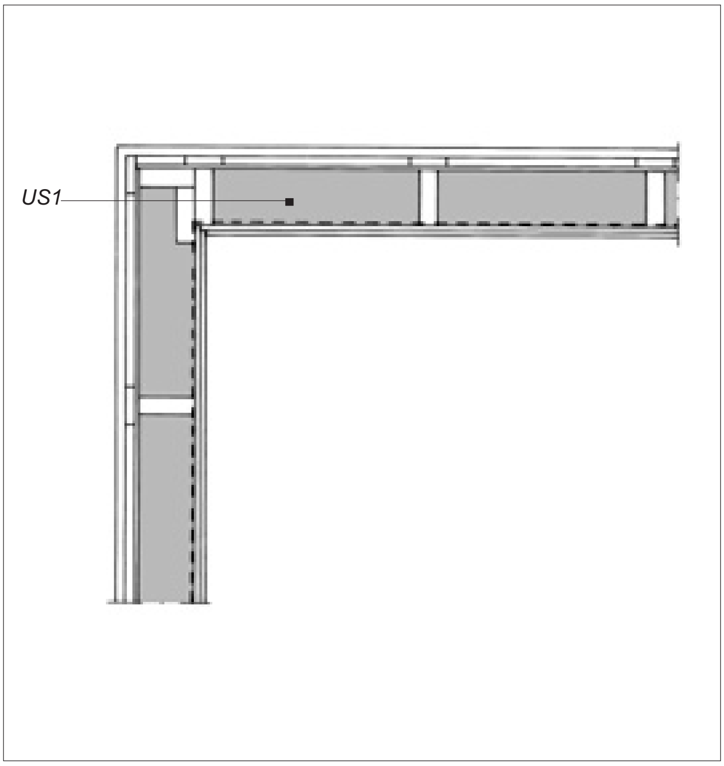
Junction between non-bearing partition (VS3) and party floor (VP2).

In the example, the intermediate floor joists are parallel to the partition.





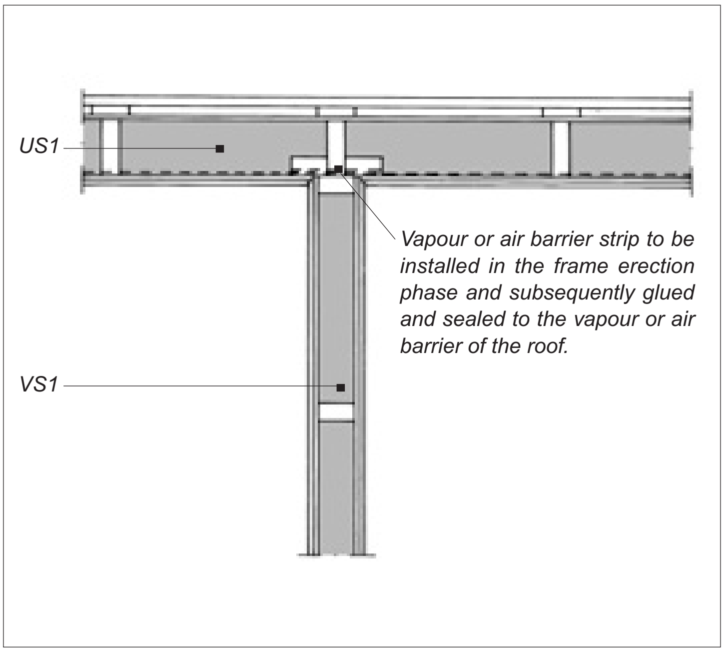
Junction between external wall of a wet area (US3) and intermediate floor of a wet area (VP4)



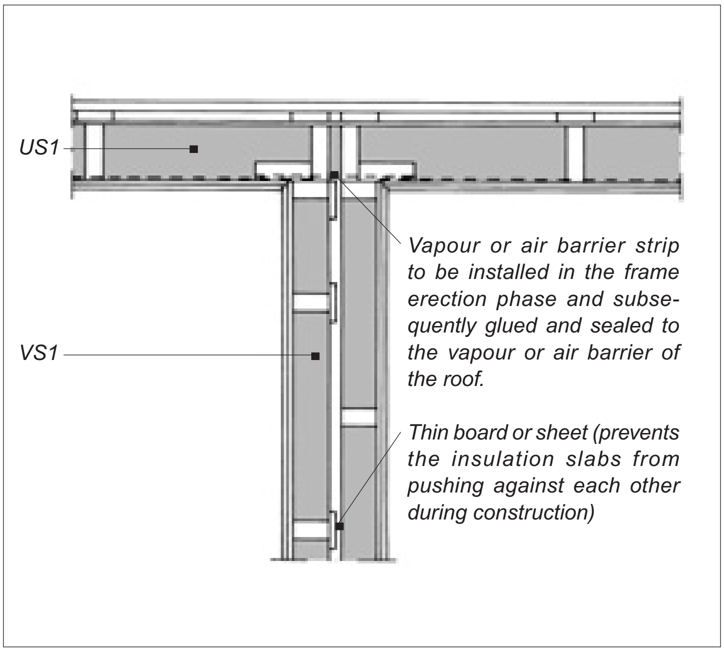
External wall corner, horizontal section.

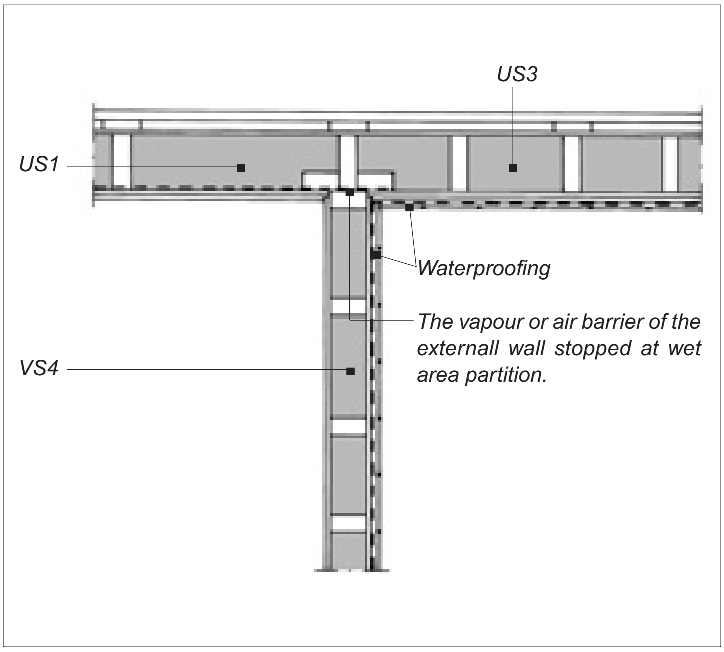
Junction between load-bearing partition (VS2) and external wall (US1), horizontal section.

Similar principle to be employed in the junction between non-bearing partition (VS3) and external wall.



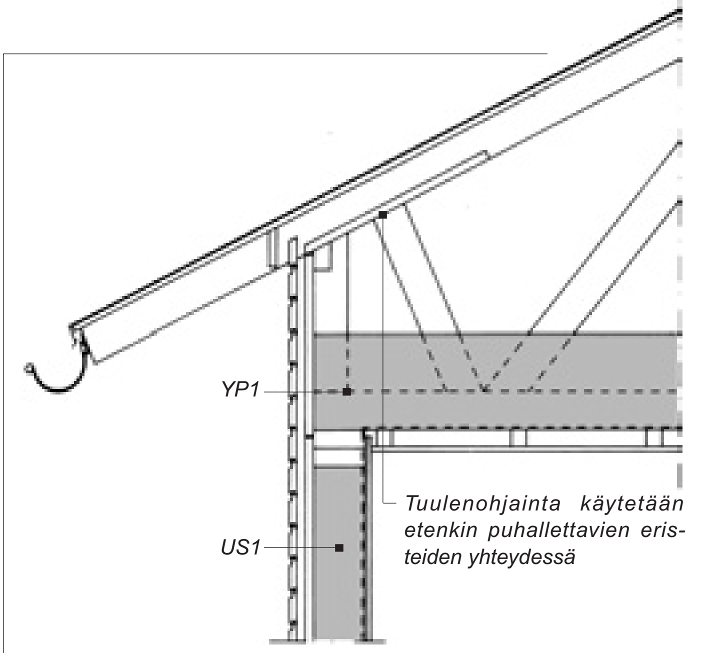
Junction between party wall (VS1) and external wall (US1), horizontal section.





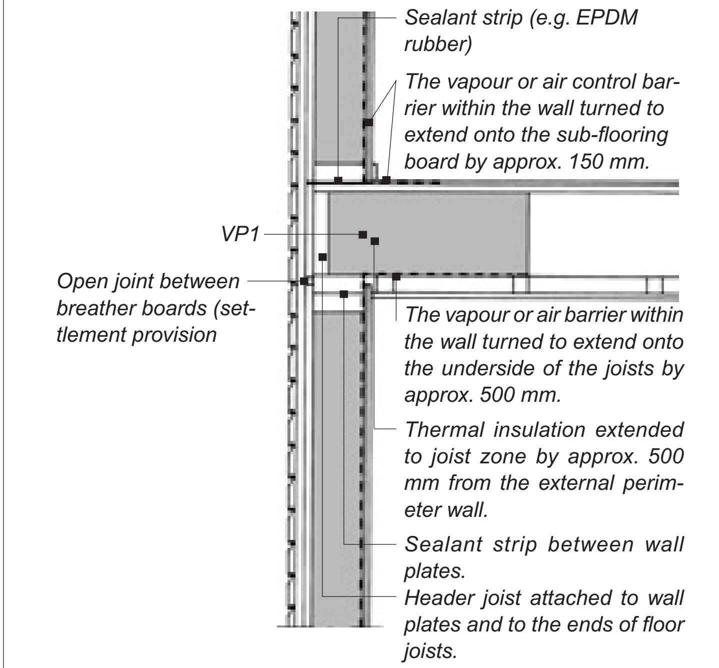
Junction between wet area partition (VS4) and external wall (US1 and US3), horizontal section.

Details for EI 30 Category Houses

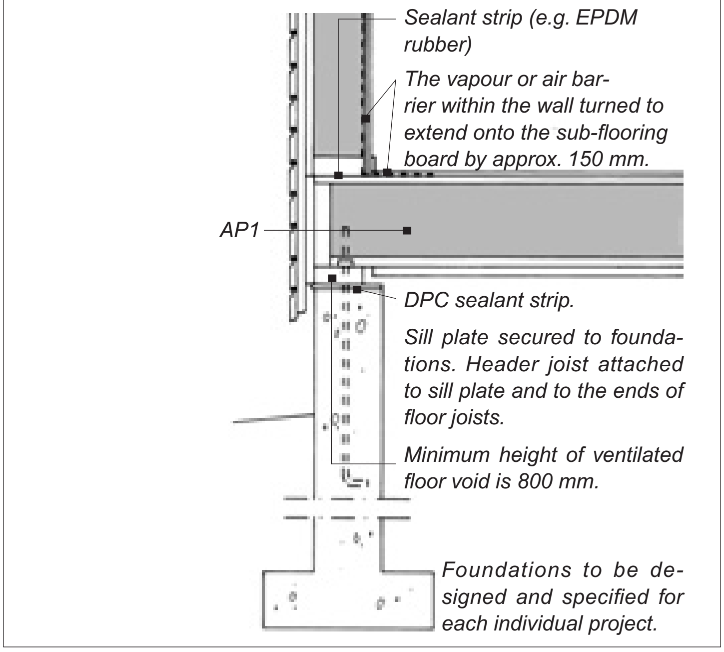


Junction between external wall (US1) and roof (YP1).

Roof void must be divided into compartments in accordance with local fire regulations and following the compartmentalisation of the floors beneath. The element, that divides the roof void, must be built into the roof structure (to the underside of the roofing material). The void within the eaves must also be divided into sections.
If the spacing of the roof trusses is 900 mm c/c, three top plates can be used whenever necessary.



Junction between external wall (US1) and intermediate floor of a dry area (VP1) between floors of a single dwelling.



Junction between external wall (US1) and ground floor of a dry area (AP1).

Ground floor joists are perpendicular to the wall.

The void underneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.

Junction between non-bearing partition of a wet area (VS3) and roof (YP1).

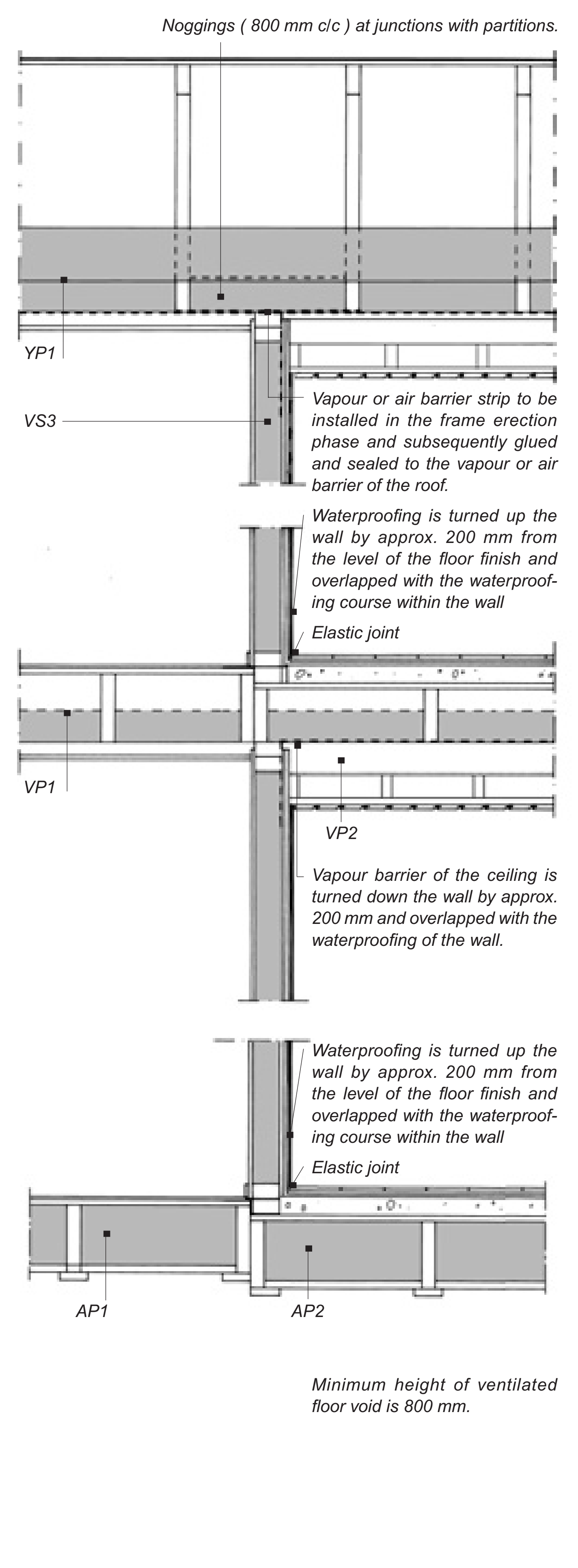
Roof rafters are parallel to partition.

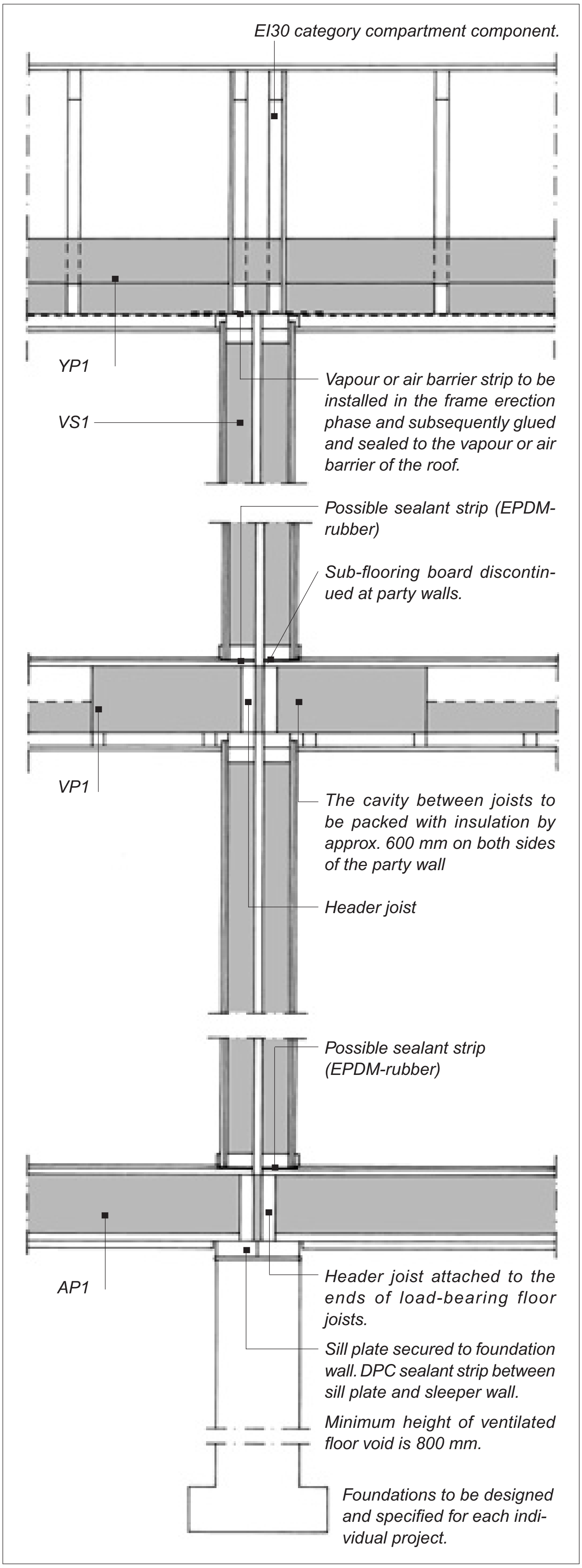
Junction between non-bearing partition of a wet area (VS4 and) and intermediate floor of a dry area (VP1) and intermediate floor of a wet area (VP 4) within a single dwelling.

In the illustration the joists in the wet area less deep than the joists in the dry area. This allows for the floors to be approximately level. The waterproofing course on the wet area walls is overlapped with the waterproofing on the floors, or the waterproofing must form a seamless watertight envelope around the wet area in order to prevent water from running down the walls beneath the waterproofing course of the floor.

Junction between non-bearing partition of a wet area (VS3) and ground floor of a dry area (AP1) and ground floor of a wet area (AP2).

The void beneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.





Junction between party wall (VS1) and roof (YP1).

Roof void must be divided into compartments according local fire regulations. The element, that divides the roof void, must be built into the roof structure (to the underside of the roofing material).

Junction between party wall (VS1) and intermediate floor (VP1) within a single dwelling.

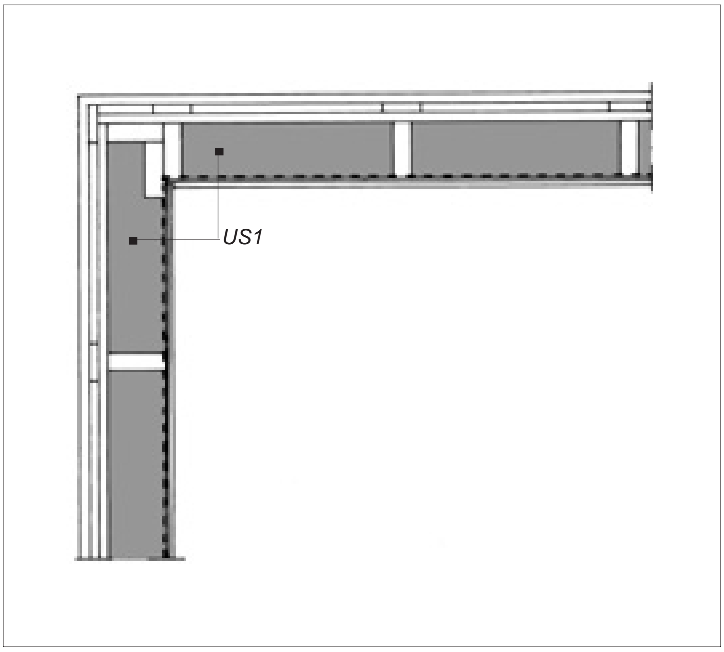
The intermediate floor joists are perpendicular to the party wall. Joists and sub-flooring are discontinued at wall junction in order to prevent flanking sound transmission.

Junction between party wall (VS1) and ground floor (AP1).

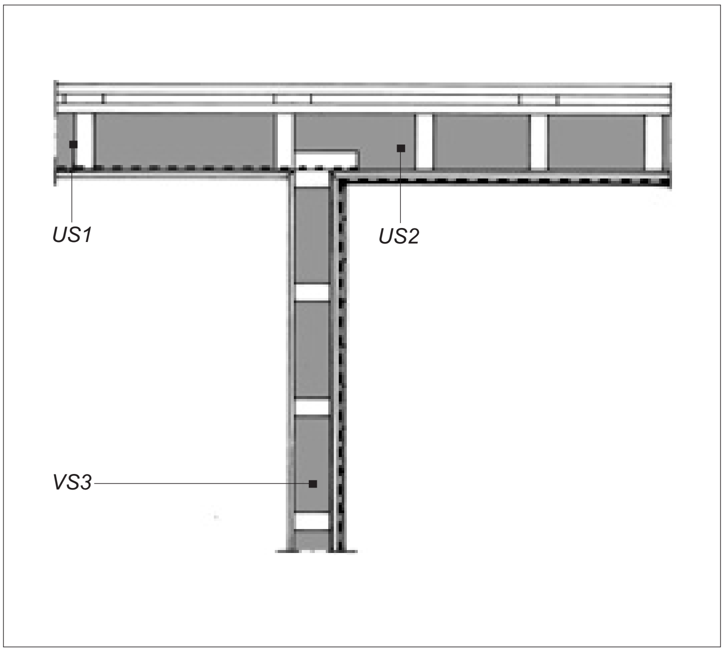
Ground floor joists are perpendicular to the wall. Joists and sub-flooring are discontinued at wall junctions in order to prevent flanking sound transmission.

The void underneath must be designed and constructed to allow efficient ventilation, to exclude water from the space and to prevent the evaporating dampness within the space from damaging either the performance or the long-term durability of the structure.

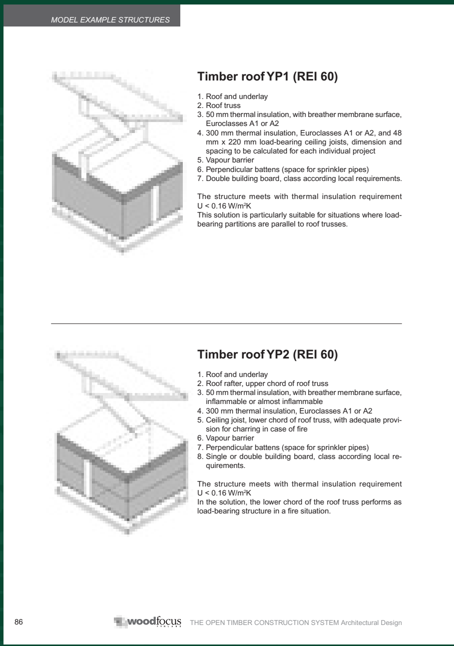
External wall (US1)corner, horizontal section.



Junction between wet area partition (VS3) and external wall (US1 and US2), horizontal section.



THE OPEN TIMBER CONSTRUCTION SYSTEM
Architectural Design



MODEL EXAMPLE STRUCTURES

Timber roof YP1 (REI 60)

1. Roof and underlay
2. Roof truss
3. 50 mm thermal insulation, with breather membrane surface, Euroclasses A1 or A2
4. 300 mm thermal insulation, Euroclasses A1 or A2, and 48 mm x 220 mm load-bearing ceiling joists, dimension and spacing to be calculated for each individual project
5. Vapour barrier
6. Perpendicular battens (space for sprinkler pipes)
7. Double building board, class according local requirements.

The structure meets with thermal insulation requirement U < 0.16 W/m²K
This solution is particularly suitable for situations where load-bearing partitions are parallel to roof trusses.

Timber roof YP2 (REI 60)

1. Roof and underlay
2. Roof rafter, upper chord of roof truss
3. 50 mm thermal insulation, with breather membrane surface, inflammable or almost inflammable
4. 300 mm thermal insulation, Euroclasses A1 or A2
5. Ceiling joist, lower chord of roof truss, with adequate provision for charring in case of fire
6. Vapour barrier
7. Perpendicular battens (space for sprinkler pipes)
8. Single or double building board, class according local requirements.

The structure meets with thermal insulation requirement U < 0.16 W/m²K
In the solution, the lower chord of the roof truss performs as load-bearing structure in a fire situation.

86 woodfocus THE OPEN TIMBER CONSTRUCTION SYSTEM Architectural Design

Esimerkkisivu rakennetyypeistä

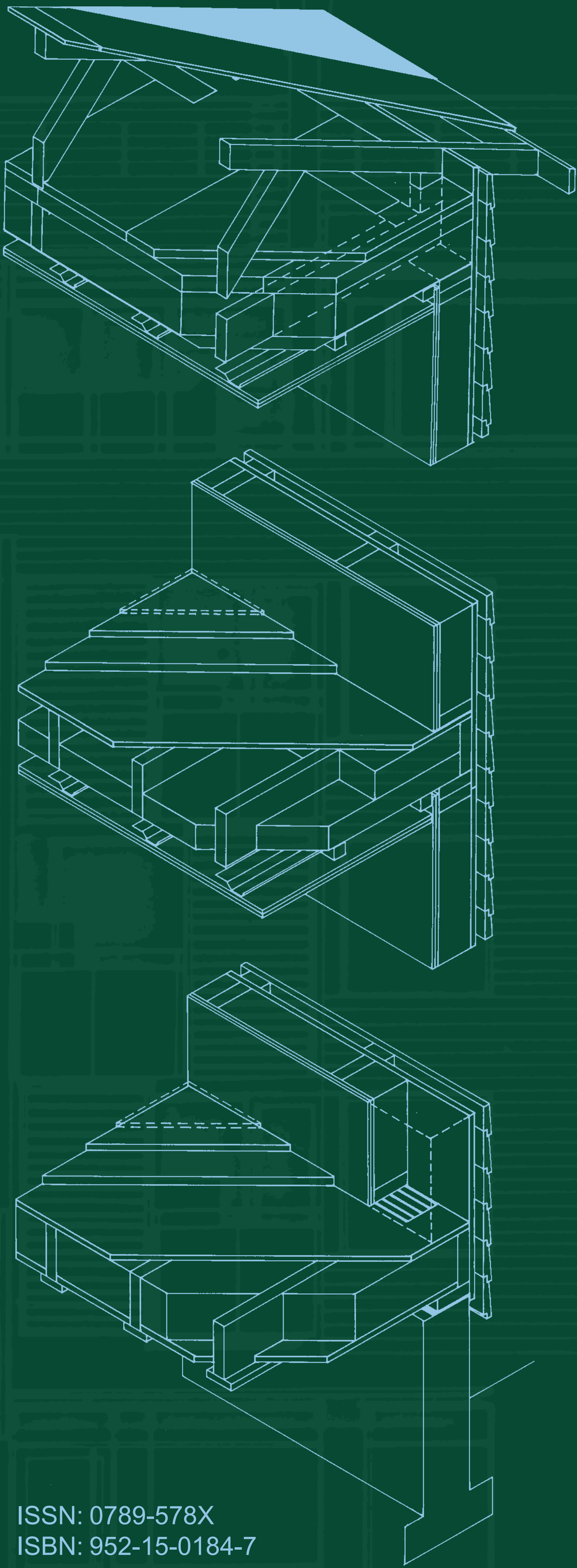
This guide introduces and describes the open timber construction system. In addition it also lists those building regulations that affect the design and construction of timber buildings and presents some model structures that comply with these regulations.

The guide is intended primarily for the use of architects and students of architecture or building construction. Its aim is to demonstrate the parameters and potential that the open timber construction system provides for the design of buildings.

The guide deals mainly with the design of residential buildings. However, whenever appropriate, it can also used as reference in the design of other building types.

The guide is divided into the following seven chapters:

1 THE SYSTEM
2 STRUCTURAL FRAME AND ARCHITECTURAL DESIGN
3 INSULATION AND SHEATHING ALTERNATIVES
4 SERVICES (HEATING, PLUMBING, VETILATION AND ELECTRICAL INSTALLATIONS)
5 ARCHITECTURAL AND STRUCTURAL REPRESENTATION
6 MODEL EXAMPLE STRUCTURES
7 JUNCTION DETAILS



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