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Subject: Timber frame
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Sole plates in timber frame construction

Sole plates are the first timber frame components installed on site and they are a very important element in a timber frame building. Sole plate installation has a direct effect on the building's service life, line, level and plumb, and contributes to the speed of construction, which is a real advantage of timber frame buildings.

Sole plates serve two main purposes:

- as an accurate jig for setting out the timber structure
- to transfer loads to the foundations through bearing and with the aid of fixings.

This Wood Information Sheet (WIS) is written with conventional timber frame construction in mind. TRADA's *Timber frame construction, 5th edition* [1] describes this form. However, the principles are adaptable to other forms with structural insulated panels, engineered studs, cross-laminated timber and twin stud walls, as described in TRADA's *Innovative timber construction* [2].

If designers, manufacturers and constructors follow the recommendations in this WIS, then the construction of the timber frame should proceed efficiently.

This WIS is an overview of the subject with signposts to more detailed sources that are listed at the end.

Contents

Figure 1: Sole plates laid out on masonry upstands above a beam and block floor

Key points

- If the sole plates are correctly installed, everything that follows should then fit together quickly and correctly.
- In the construction phase the main contractor and frame erector must understand and agree their responsibilities for the installation of sole plates.
- Sole plates must be level and correctly laid out to the sole plate drawing. To achieve this, it is imperative that ground workers understand the importance of the interface between the foundation and the timber frame.
- Timber frame construction normally uses one timber sole plate typically of 38mm thickness.
- If there is significant radon and contaminated land, a gas membrane is placed under the sole plate.
- Owing to their location and inaccessibility, sole plates should be preservative treated.
- To prevent moisture from the ground reaching the inside of the building, the sole plate should be at least 150mm above the external ground level.
- If shims are needed to correct the level, the cross-sectional area of the shims should match that of the studs.
- Sole plates are usually shot fired to the foundation.

Interface between foundation and timber frame

Getting off the ground correctly is the first and one of the most important stages in constructing timber frame buildings and it is well worth spending time getting it right. Everything that follows the sole plates should then fit together quickly and correctly if using the right drawings, timber and ancillary components.

In Timber frame construction 5th edition, Chapter 2 describes the foundations and Chapter 4 describes external wall construction, including sole plates.

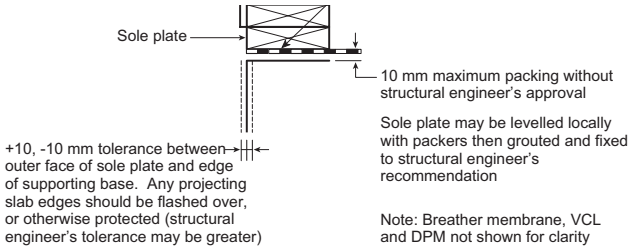

Figure 2: Typical external wall sole plate

Thickness

Typical construction uses one timber sole plate typically of 38mm thickness. Other thicknesses or additional sole plates can be used and it is important to understand what to specify and why. For example, how much will the introduction of horizontal timber affect differential movement? As the usual recommended allowance for differential movement is 1mm for every 38mm of horizontal timber, take account of any additional sole plates in the overall design. Additional sole plates will increase thermal bridging and reduce space available for insulation, so they are now less commonly specified.

Gas

In areas where the presence of radon and contaminated land is significant, a gas membrane must provide a suitable barrier. Joints in the gas membrane must be sealed and the fixing of the sole plates must be gas-tight. If detailing allows, locate the gas membrane well below the area of fixing.

Durability

The need for preservative treatment depends on the durability of the timber used and an assessment of the risk of decay or insect attack. However, owing to their location and the difficulty of remedial work, TRADA Technology recommends the use of a preservative treatment that fixes in the wood, such as the copper-organic types. See architect's task in *Who does what*.

Tolerances

Responsibility for the foundation construction typically rests with the main contractor and therefore it is imperative that they, and their ground workers, understand the interface between the foundation and the timber frame. The dimensional tolerances to which ground workers typically work are often too great for timber frame, hence it is important for all parties involved to be aware of the requirements.

For concrete foundations TRADA Technology recommends:

- top surface level to +/- 5mm from datum
- length/width within +/-10mm
- diagonals within +/-5mm for up to 10m and +/-10mm for more than 10m.

Timber frame structures can be built on almost any type of foundation. The common types used are conventional strip footing and 'beam and block'. Where beam and block floors are used, take extra care when levelling and inserting shims under the sole plate, due to the possible uneven nature of precambered beams and ill-fitting blocks.

To minimise the risk of timber moisture content rising above the decay threshold of 20%, TRADA Technology recommends that the timber sole plate be installed at least 150mm above the external ground level. *Figure 3* shows how this is achieved with conventional masonry cladding. Chapter 2 of Timber frame construction offers guidance on other forms of construction.

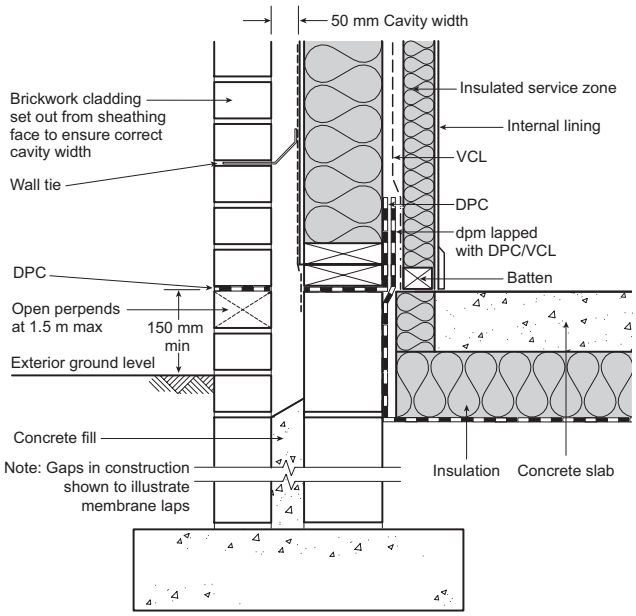

Figure 3: Strip foundations where brick or block cladding is used

In Chapter 6.2 of its 2013 Standard [3], NHBC also recommends 150mm for the lowest timber component but permits relaxation of this rule in exceptional circumstances such as where the site is not subject to a high water table and where the cavity will not have standing water. However, NHBC's solution imposes more onerous drainage requirements.

Where the building's perimeter includes a level threshold, pay extra attention to the foundation design. It is often appropriate to construct a masonry upstand but take care to make sure this is of sufficient strength to be robust during construction and to receive the sole plate fixings. Make allowance for the difference in height of ground floor wall panels and pay attention to the location and lapping of the damp-proof membrane (DPM), damp-proof course (DPC) and vapour control layer (VCL).

Sole plates must be level and correctly laid out to the sole plate drawing. TRADA Technology recommends that, if the foundations are not built to within agreed tolerances, the external wall sole plates be not set back or overhanging by more than 10mm without approval from the structural engineer (see *Figure 2*). Consider also the effect that sole plate overhang will have on cladding installation. An overhanging sole plate reduces the area available for the load of the building to pass into the foundation. A sole plate that is set back from the edge will form a small ledge of foundation on the outside of the sole plate. This ledge can collect water, mortar droppings and other debris and may lead to a blocked cavity and hence a route for moisture to penetrate structural timber elements.

The location of the sole plate on an incorrect foundation may also have an effect on the external wall cavity width. Overhanging sole plates (due to incorrect placement, or the foundation being too small) may reduce the size of the external wall cavity and set back sole plates may increase it, leading to difficulties with provision of fire separation, fixing of claddings and provision of adequate drainage and ventilation. It is advisable for the bricklayers not to install the splash courses to the DPC level until after the sole plate is installed. The masonry cladding can then be corbelled in or out within tolerances agreed by the structural engineer to achieve the correct external wall cavity at DPC/sole plate level.

Installation

The structural engineer (timber frame) specifies timber frame fixings to the foundation. They may be plug and screw, shot-fired or suitable clips or straps. The shot-fired method shown in *Figure 4* is the most common.

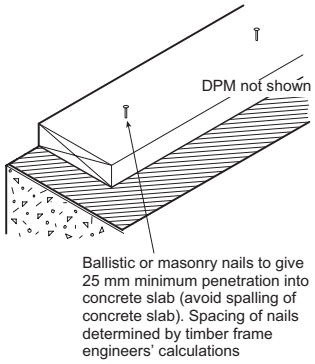

Figure 4: Typical sole plate fixing using nails

Take care to match the sole plate fixing to the foundation as often a block upstand is used which will fracture when it is incorrectly installed and specified by the foundation engineer. The interface between the foundation engineer and timber frame engineer is critical in this aspect.

The method in *Figure 5* minimises puncturing of any gas proof membrane.

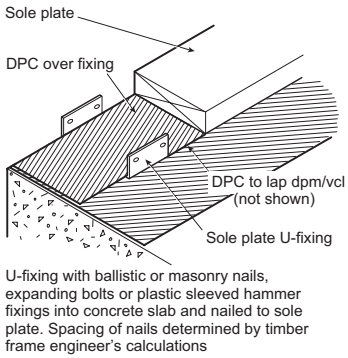

Figure 5: Typical sole plate fixing using sole plate anchors

If uplift is significant, the structural engineer (timber frame) will specify additional holding down straps, such as those shown in *Figure 6*.

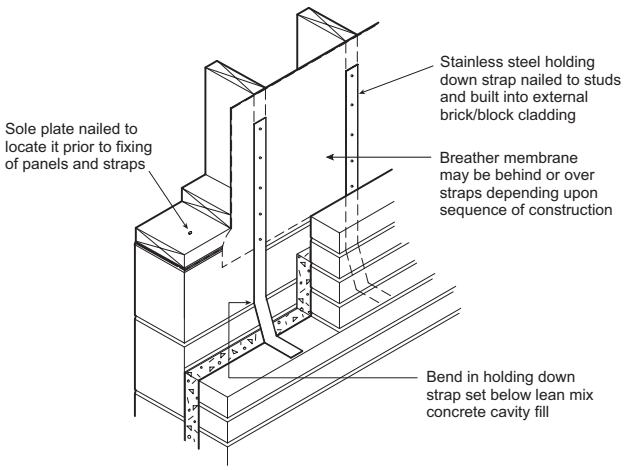

Figure 6: Holding down straps to resist uplift

Timber frame manufacturers and their erection crews are often faced with problems of slab tolerance and their contract usually ensures that responsibility rests with the main contractor. Often a representative from the timber frame manufacturer/erector will visit a site before the timber frame is delivered and check both levels and dimensions to ensure that the slab meets specification.

A sole plate of treated timber is laid on the slab separated with a DPC strip between. The laying out of sole plates follows the timber frame manufacturer's plan of the building; sole plates are generally located at the base of internal and external walls and so the full size plan of the building is produced when all sole plates are in position.

Load transfer

Any areas that are out of level must be identified and corrected, normally using structural shims. Specify shims that are made of inert material, typically plastic, and suitable for the compression loadings and of sufficient durability. Install shims into gaps, typically at the same centres as the studs in the wall panels and of the same cross sectional area as the studs. In effect they are mini studs transferring the load to the foundations.

For effective load transfer, the cross-sectional area of the shims should match that of the studs. But some timber frame erectors install sufficient spacers to only level the sole plate, relying on grout or packing to support the building. The main contractor is usually responsible for installing additional shims or structural grout to meet their contractual obligations of supplying a level foundation. For the benefit of the timber frame and to prevent later problems with differential movement, adequate support must be installed, not ignored. It is sensible to clarify responsibility for undertaking this work.

Options for packing of sole plates

The correct alignment and permitted packing of sole plates affects:

- the effective transfer of the superstructure weight to the foundation
- the erection of the timber frame within permitted tolerances of line, level and plumb
- thermal bridging and possible airtightness.

In the construction phase the main contractor and frame erector must understand and agree their responsibilities for the installation of sole plates. If the foundation or sole plate packing is not within the specified tolerances, responsibility for proceeding beyond the sole plate rests with whichever party issues written instructions. As the consequences are largely structural, TRADA Technology recommends that the structural engineer (timber frame) instructs what remedial actions to take.

Table 1: Typical responsibilities for packing to sole plates

Action	Responsiblity
Line and level of the support foundation	Main contractor
Sole plate line and level	Timber frame erector
Permanent packing or grout under sole plate	To be agreed – usually the main contractor
Line and level check	none

There are three methods for packing sole plates – packing and bedding methods for single sole plates and a packing method for double sole plates.

Option 1 – Spacers, packing and structural grout fill

Install spacers so that the sole plates are secure, level and able to support, without noticeable deflection, the first lift of the timber frame (wall and floor structure, or wall and roof structure in a single storey). Spacers will remain in place for the life of the building.

Once the first lift is complete, place approved structural shims (inert and compression tested) under each load point of the timber frame (studs and post locations) for transfer of vertical loads. Free-flowing, non-shrinkable grout may be needed for sliding resistance. If grout is installed correctly, structural shims may not be needed.

Option 2 – Bed sole plates

Provide a continuous level support for the sole plate, such as a structurally approved non-shrinkable mortar bed, prior to the installation of the sole plate. The bedding must be located according to the sole plate setting out drawing.

Option 3 – Packing between double sole plates

Fix and secure a lower-level sole plate to the contours of the foundation with no gaps between. If gaps do occur, seek approval of proposed remedial work from the structural engineer (timber frame).

Install shims between the lower-level and upper-level sole plates so that the upper-level sole plates are secure, level and able to support, without noticeable deflection, the first lift of the timber frame (wall and floor structure, or wall and roof structure in a single storey).

Once the first lift is complete, place permanent shims (inert and compression tested) under each load point of the timber frame (every stud and post location). Fixings must provide sliding resistance.

Fill the gap between the two sole plates with a suitable material to minimise thermal bridging at external walls, and at party walls to minimise the transfer of sound.

Who does what

This section lists the typical tasks and responsibilities of designers, manufacturers and constructors associated with sole plates. However, these are not necessarily the same in all project teams. Whatever working practice is adopted, it is important to clarify the responsibilities of all parties at the project design stage.

Design phase

Architect

- Design the wall layout.
- Determine the external timber frame wall dimension. 38mm x 140mm timber is the most common size.
- Determine the overall twin-leaf party wall thickness, typically achieved by 2 x wall thickness, plus party cavity width.
- Determine the location of door and window openings.
- Incorporate a level threshold detail where required, which may require an upstand for external walls.
- It is best practice to ensure that the lowest external wall timber sole plate is at least 150mm above external ground level. Incorporate a masonry or concrete upstand, of appropriate robustness, if required. Internal wall timber sole plates may also require an upstand to ensure they can dry and ventilate adequately post construction and in use.
- Ensure the sole plate and external timber can breathe by maintaining the external cavity with ventilation and drainage. Unlike brick and block construction, there is not usually a cavity tray at sole plate level.
- Determine preservative treatment of timber required. This is explained in TRADA's *WIS 2/3-16: Preservative treatment for timber – a guide to specification* [4]. Follow the guidelines in *BS 8417 Preservation of wood. Code of practice* [5] and *BS EN 335-2 Durability of wood and wood-based products. Definition of use classes. Application to solid wood* [6].
- Specify a DPC between sole plate timber and foundation. This specification is typical of that used with masonry construction. Note that the DPC acts as a gasket around shot-fired fixings that go through the sole plate to the foundation.
- Determine whether building control require the installation of radon or contaminated gas membrane. The Health Protection Agency (www.hpa.org.uk) defines radon-affected areas. Precautions are described in the BRE Reports No 211 *Radon: guidance on protective measures for new dwellings* [7] and No 212 *Construction of new buildings on gas-contaminated land* [8]. Fix gas membrane tape to the underside of sole plate anchors. The tape acts as a gasket around shot-fired fixings that go through the sole plate anchor and the membrane. The sole plate is then fixed through the upstand of the anchor.
- Take account of thermal bridging via the sole plate and air tightness (which can be affected by the quality of sole plate bedding and packing.

Structural engineer (foundations)

- Design the foundations to accommodate sole plate fixings in consultation with the structural engineer (timber frame).
- Design the upstand if required. This may be required due to the type of floor finish and/or to ensure the lowest sole plate timber is at least 150mm above the external ground level.

Structural engineer (timber frame)

- Specify grade and/or strength class of timber as determined by design to the relevant timber design standard, currently *Eurocode 5* [9]. Typically 38mm x 140mm C16 timber is used.
- Determine point load locations.
- Calculate all loading involved including vertical, horizontal and uplift.
- Specify correct fixings required according to the type of foundations in consultation with the structural engineer (foundations). Take into consideration any gas membrane.
- Determine tolerances with foundation (including overhang and setting back of the sole plate).
- Specify suitable packing shims and fixing options for load transfer when foundations are not level.

Manufacturing phase

Frame manufacturer

- Determine lengths and cutting list.
- Ensure timber treatment is in line with specification and treat cut ends.
- Produce drawings showing length, width and diagonals for sole plate setting out. Show door, window and point loads to ensure proper load transfer and fixing.
- Ensure sufficient lapping of double sole plates (if used). Typically 600mm is used as a minimum lap wherever possible.
- Adjust wall heights if structural grout (minimum thickness 5mm) is specified between the sole plate and foundation.

- In the event that foundations are not level to within agreed tolerances, determine responsibility with main contractor for supply and installation of packing and structural grout.
- When supplying structural shims, they must be inert, durable and appropriate to the specified compression.
- Supply the correct width of DPC to tie into DPM/VCL.

Construction phase

Main contractor

- Specify tolerances for foundations to the ground workers (See TRADA Technology's recommendations under Tolerances).
- To ensure the correct cavity width, do not build the splash course (masonry external leaf) until after the sole plate is installed.
- Ensure correct fitting of gas membrane if required.
- Determine responsibility with the timber frame manufacturer for packing and structural grout in the event that foundations are not level to within agreed tolerances.
- When supplying and installing structural grout, it is vital that the correct material is installed between foundation and membrane to the full surface area of sole plate.
- Incorporate holding down straps in the foundation if specified.

Erection crew

- Use grid lines to ensure sole plates are installed in the optimum position on the foundation and subsequent floor levels. On the foundation mark 90° grid lines that extend down the side of the foundation for transferring grid lines onto floor decks above.
- Report to the timber frame manufacturer if the top surface level, length, width and diagonal of foundations are not within the specified tolerances.
- Identify the highest point on the foundation to use as datum. This is particularly important for a complete block of flats or row of terraced buildings. If the foundation is phased, make sure each subsequent phase is equal to or lower than the first.
- Correctly install DPC between foundations and all timber sole plates with 100mm minimum laps. Ensure any gas membrane is not damaged during installation.
- Fix the sole plate down at foundation high point.
- If required in the contract, ensure that all packing is installed to correct specification. If gaps greater than agreed tolerances occur between foundation and sole plate, report this to the structural engineer(timber frame).
- Pack and fix sole plate at structural engineer's specified centres with correct shims and fixings. Pack each point load (packing width equal to point load width).
- If specified, it is vital that the correct structural grout is installed between foundation and membrane to the full surface area of the sole plate.
- Fix sole plate butt joint ends together to manufacturer's specification.
- Ensure sufficient lapping (at least 600mm) if double sole plates are being used.
- Cut the sole plate to ensure that it does not span external or party wall cavities.
- Brush all site cut ends with preservative.
- Ensure correct fitting of holding down straps if specified. These are specified on buildings that have high uplift or sliding forces.
- Ensure the sole plate and its fixings are installed to specification.
- The door openings are usually cut out after the first floor deck is installed and all the ground floor walls are fixed to the floor joists. For this reason, take care to ensure sufficient fixings of the sole plate next to door openings, as fixings can sometimes be removed with the sole plate if not installed correctly.

Acknowledgement

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Our aim

To provide members with the highest quality information on timber and wood products to enable them to maximise the benefits that timber can provide.

What we do

We seek to achieve this aim through active and on-going programmes of information and research. Information is provided through our website, an extensive collection of printed materials and our training courses.

Research is largely driven by the desire to update and improve our information so that it continues to meet our members' needs in the future.

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