2.8 Application of panels in the production of box beams and I-beams

2.8.1 Selection of panels for box beams and I-beams

Timber I-joists comprise a timber flange (typically solid timber or LVL – laminated veneer lumber) and a panel product web (usually OSB – oriented strand board). Box beams are a similar form but with a web on each side of the flanges. Some of the typical forms of timber box beams and I-beams that have been fabricated using wood-based panels are shown in *Figure 2.16*.

Structurally the I-joist works on the principle that the greatest forces in a beam under bending are at the outer faces. Hence, if the stronger tensile and compressive material is positioned at the outside edges, the central zone can be reduced in size as it carries very little of the bending forces. However, the central zone (web) carries the reaction and shear forces.

Most commercially manufactured timber I-joists are of the form 'b' in *Figure 2.16* and use high-grade timber or structural timber composites for the flanges, routed to accept a timber-based panel web (OSB, hardboard or plywood). The web is secured to the flange by an approved weatherproof, structural adhesive within the rout. Some of the other forms of beam can be made with adhesive or mechanical fasteners. Commercially available products are available in a range of sizes; alternatively 'one-off' products can be designed and manufactured for a specific situation. Further information on timber I-joists can be found in TRADA's *Wood Information Sheet 1-42: Timber I-joists: applications and design*[48].

The selection of suitable wood-based panels for box beams and I-beams depends upon a number of factors including:

- the load the beam has to carry
- the ambient environmental conditions.

The selection of panels meeting these requirements is set out in *Table 2.11*. Some typical details for the use

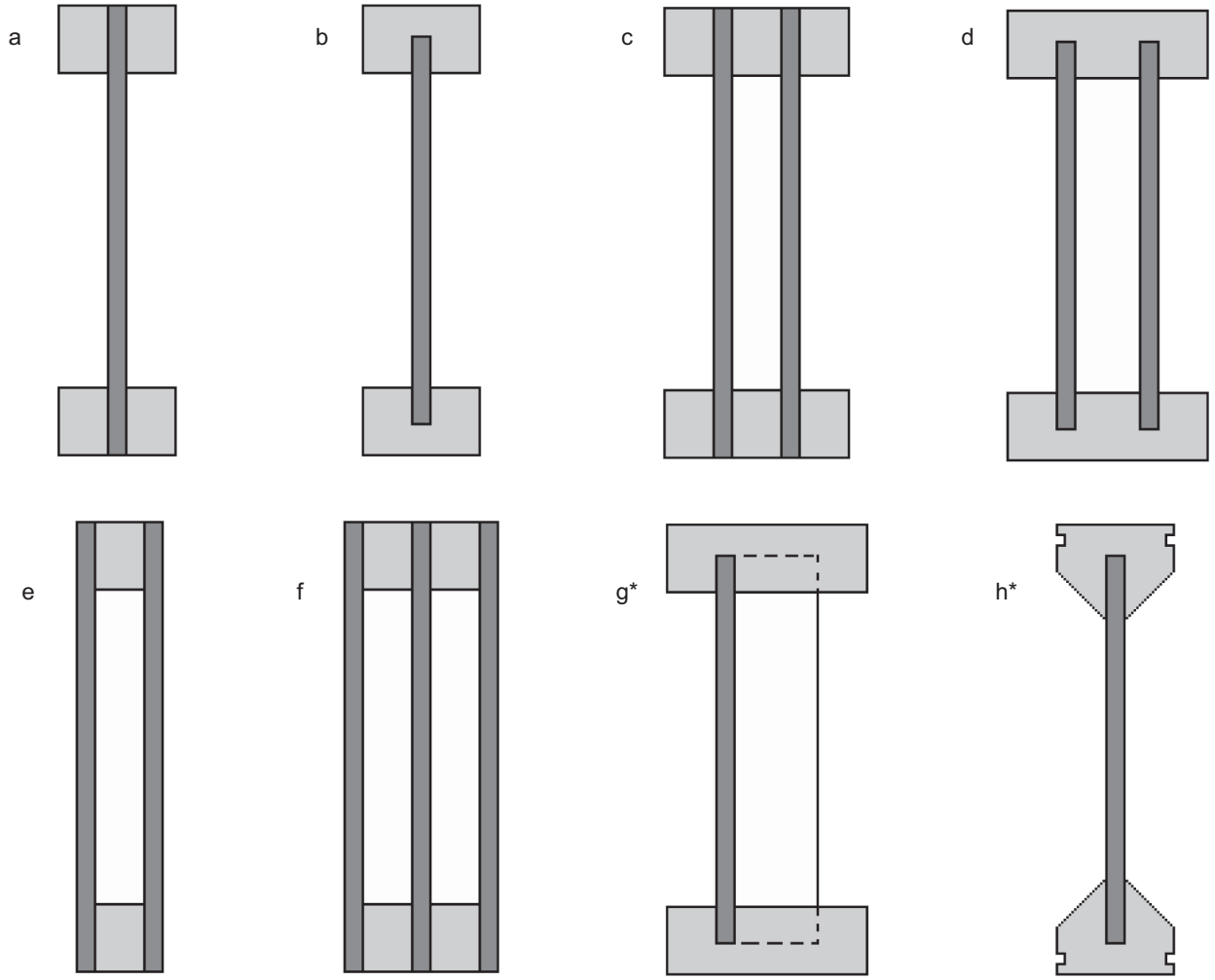

Figure 2.16: Typical forms of timber box beams and I-beams (*patented designs)

a: I-beam – 2 part flange
b: I-beam – 1 part flange
c: double I-beam – 3 part flange
d: double I-beam – 1 part flange
e: box beam
f: double box beam
g: Corply beam* (web zigzags across the flange)
h: Tecton beam*

Table 2.11: Panel grades* for box beams and I-beams

Selection	BEAM WEB	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Box beams and I-beams	1,2	636-2	P5	OSB/3	-	HB.HLA2	-

*The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

of I-joists for both timber frame and masonry construction in single dwellings are shown in *Figure 2.17* and *Figure 2.18*. Note that the drawings are for illustration only and do not show all the constructional details which may be required for a particular floor, such as stiffeners, strutting etc.

2.8.2 The design of box beams and I-beams

There are some aspects of designing with I-joists which require different treatment from solid rectangular timber due to their geometry and the fact that they are a composite assembly of different materials. These affect the actual behaviour of the I-joist in terms of strength and stiffness and the detailing plus handling and storage.

As there is no harmonised European standard for I-joists, the current route to CE marking is by complying with *ETAG 011*[49]. Other certification may be obtained from independent certification bodies. Each I-joist brand therefore has specific strength characteristics, which should be made available by the manufacturer. This contrasts with solid timber which is strength-graded to common grade values presented in British Standards and Eurocodes. Most I-joist manufacturers have comprehensive design and drawing software to produce specifications and cutting schedules.

2.8.2.1 Strength capacity

In common with solid timber, the design strength properties of I-joists may be enhanced where load sharing (as defined in *Eurocode 5*) occurs. However, the enhancement factor established by the third-party certification may differ from that for solid timber. Manufacturers may publish the load sharing factor separately, or may integrate it into their span tables or design software. Strength values determined by a combination of calculation and testing are frequently provided in separate tables for Service Classes 1 and 2. Most timber attains a maximum moisture content of 12% in Service Class 1 and 20% in Service Class 2. I-joists can thus be targeted for both intermediate and ground floors respectively.

2.8.2.2 Control of deflection

The deflection of an I-joist is a combination of strain due to both bending and shear. Unlike solid rectangular sections, shear deflections in I-joists can be over 10% of the total deflection and must be allowed for. For an I-joist under a uniformly distributed load, the maximum mid-span deflection occurs under single span conditions and is given by:

$$W_{inst} = \frac{5F\ell^4}{384EI} + \frac{F\ell^2}{8GA}$$

where W_{inst} is the maximum instantaneous deflection, F is the load per unit length on the beam, ℓ is the span, EI is the bending stiffness and GA is the shear stiffness. Both EI and GA are generally provided by the manufacturer in the certification literature.

In *Eurocode 5* 'instantaneous' deflection is the elastic deflection immediately upon loading. On the other hand 'final' deflection includes creep deflections as well. The instantaneous deflection is usually modified to reach the final deflection for design. The modification factor depends on the load duration and the creep properties of the web material. The value of the modification factor may be quoted within the certification literature, or it may be taken from the design code. It is important to ensure that *Eurocode 5* and *BS 5268* (now withdrawn) design approaches are not mixed.

Under *Eurocode 5*, deflection limits are to be agreed for each project and the Standard provides guidance only. In the UK, the *National Annex to Eurocode 5* specifies a span/250 as an acceptable deflection limit for simply supported floors with a plasterboard ceiling attached. Further guidance on vibration control is also available in *Eurocode 5* and the National Annex.

See TRADA Technology's Engineering Guidance Documents:

- *GD 5: How to calculate deformations in timber structures using Eurocodes*[50]
- *GD 6: Vibration in timber floors (Eurocode 5)*[51].

2.8.2.3 Stability

The efficient shape of I-joists produces a relatively high depth-to-breadth ratio. Therefore, bracing to prevent buckling of the compression flange or rotation of the joist is more important than with solid timber joists.

For example, in England and Wales the requirements for blocking or strutting solid timber I-joists, given in Approved Document A, apply to I-joisted floors, unless the manufacturer of a tested floor system specifically states otherwise. Solid timber blocking and herringbone strutting have also been found to reduce vibrations with frequencies greater than the fundamental frequency. TRADA's *WIS 1-41: Strutting in timber floors*[52] offers further advice.

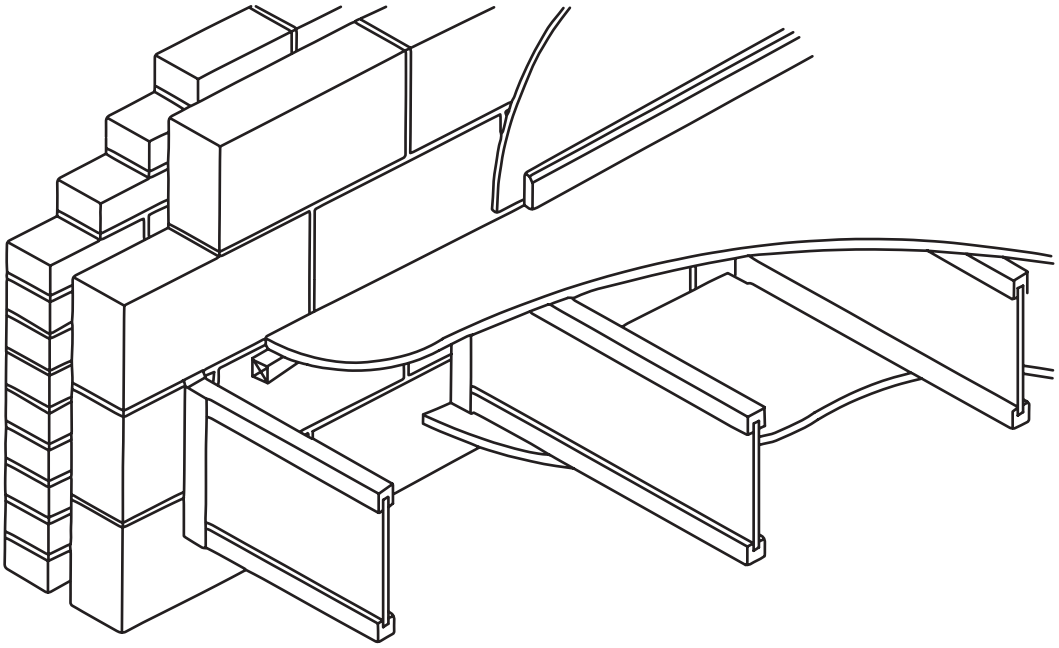

Figure 2.17: I-joists in block wall construction

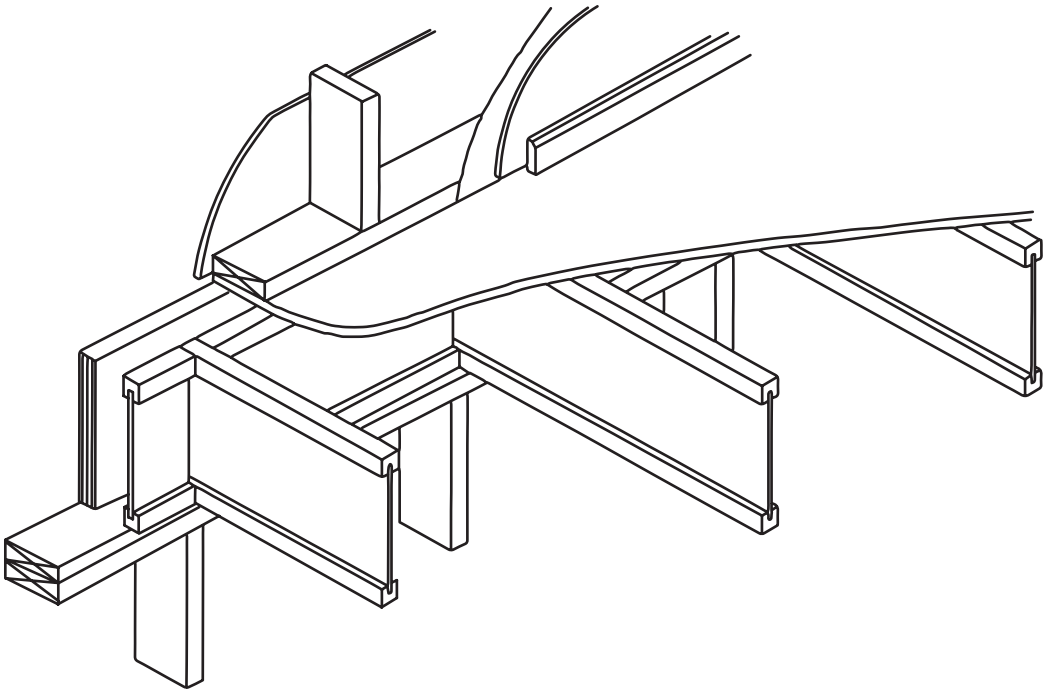

Figure 2.18: I-joists in timber frame construction

2.8.3 Storage and installation of box beams and I-beams

For commercial systems, it is important that the manufacturer's guidance on storage and installation is followed but some general advice can also be given.

As with all wood-based products, box beams and I-beams are affected by changes in moisture content and are generally only suited for use in Service Class 1 or 2 conditions. They should be stored in dry conditions, clear of the ground and protected from direct wetting. Beams should generally be handled and stacked in the vertical position, rather than flat.

Beams can be cut with normal woodworking tools and can be fixed in position with nails or screws. Alternatively, specific joist hangers are also available for some commercial products.

If holes need to be cut in the web, for services etc, it is important that these are accounted for in the engineering design or are within limits set by the manufacturer.

2.8.4 References

1 WIS 1-42: Timber I-joists: applications and design, TRADA Technology, 2012

2 ETAG 011: Guideline for European technical approval of light composite wood-based beams and columns, European Organisation for Technical Approvals, January 2002

3 Guidance Document 5: How to calculate deformations in timber structures using Eurocodes, 2nd edition, ISBN 1900510480, TRADA Technology, 2006

4 Guidance Document 6: Vibration in timber floors (Eurocode 5), ISBN 1900510057, TRADA Technology, 2008

5 WIS 1-41: Strutting in timber floors, TRADA Technology, 2011

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