Detailing for durability

STEP lecture A14
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Objectives

To set out guidelines relating to the use of timber structural members in a range of climatic conditions and limiting the need for preservative treatment without compromising the load-bearing integrity and durability of the timber or wood-based product.

Prerequisite

A15 Durability - Preservative treatment

Summary

This lecture begins with an examination of the various conditions which favour biological attack by fungi or wood-boring insects (including termites). Particular attention is given to the influence of the geographical zone and its corresponding climate. Practical examples are provided which identify building details to avoid, and forms of construction which are recommended.

Introduction

Timber is susceptible to biological attack whereas metal components may corrode. Biological attack is of two main types:

Fungal attack

This occurs in timber which has a high moisture content, generally between 20% and 30%. Fungi need the presence of water and oxygen to develop and the optimum moisture content varies according to the particular fungal species. The presence of fungal attack can seriously reduce the load-bearing capacity of timber structures. The loss of strength may be variable, depending on type of fungus and the extent of attack. Significant strength loss may be present, even in cases where the appearance of the timber remains largely unchanged.

Where possible, the design of the building should minimise the situations in which structural timbers are subjected to high moisture levels which allow fungal decay. Some fungi, such as Lenzites sepiaria, can survive through dry periods and continue their attack in timbers which are subject to intermittent wetting. Therefore, design should provide conditions which:

- prevent wetting of the timber wherever possible;
- ensure rapid drainage and ventilation of the timber where it is impossible to avoid periods of wetting;
- use timber with sufficient natural durability, or timber treated with an appropriate wood preservative, where it is not possible to avoid exposure to persistent wetting.

Insect attack

This is encouraged by warm conditions which favour their development and reproduction. Termites are particularly aggressive to timber, and are only active in the warmer parts of Europe. Their presence and activity decreases towards the

Northern parts of Europe. The presence of central heating within buildings may encourage the activity and development of insects by maintaining moderate temperatures during the colder parts of the year. Insect larvae may die if subjected to low temperatures. The development of cracks or splits in preservative treated timber which penetrate through the outer treated layer may provide sites for egg laying or the initiation of attack, significantly reducing the value of the treatment.

The natural durability of different timber species in relation to insect attack is variable. In most timbers, the heartwood is normally durable, but the heartwood of different timber species shows various levels of resistance to termite attack. The sapwood region may or may not be durable depending upon the timber species and the insect type. The sapwood of all timbers is considered susceptible to termite attack. EN 350-2 "Natural durability of solid wood - Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe" gives an indication of the durability to insect attack for common timber species (Table 1). In plywood construction, the natural durability may be enhanced by the presence of chemicals associated with modern synthetic resin adhesives.

Commercial name	Hylotrupes	Anobium	Termite
Fir, Norway Spruce	SH	SH	S
Larch, Douglas Fir, Maritimo Pine	S	S	S
Scots Pine, Redwood	S	S	S
Oak, Sweet Chestnut	n/a	S	M
European Beech, Poplar	n/a	S	S

Table 1 *Natural durability of wood species (S: susceptible, SH: heartwood also susceptible, M: moderately durable, n/a: nonapplicable).*

Corrosion of metal components

In normal service conditions, timber is not attacked by acids and bases. Metal components should be protected against corrosion, where necessary if the service conditions can affect their long term performance. Painted or coated metal components may be required to prevent staining of timber elements where appearance is a factor.

Classification of service conditions

The levels of exposure to moisture are defined differently in EC5 and EN 335-1 "Durability of wood and wood-based products - Definition of hazard classes of biological attack - Part 1: General". EC5 provides for three service classes relating to the variation of timber performance with moisture content:

Service class 1 is characterised by a moisture content in components corresponding to a temperature of 20 °*C* and a relative humidity of the surrounding air only exceeding 65% for a few weeks per year (maximum 12% in the timber).

Service class 2 is characterised by a moisture content in components corresponding to a temperature of 20 °*C* and a relative humidity of the surrounding air only exceeding 85% for a few weeks per year (maximum 20% in the timber).

Service class 3 involves climatic conditions leading to higher moisture contents than in service class 2.

In EN 335-1, five hazard classes are defined with respect to the risk of biological attacks:

Hazard class 1, situation in which timber or wood-based product is under cover, fully protected from the weather and not exposed to wetting;

Hazard class 2, situation in which timber or wood-based product is under cover and fully protected from the weather but where high environmental humidity can lead to occasional but not persistent wetting;

Hazard class 3, situation in which timber or wood-based product is not covered and not in contact with the ground. It is either continually exposed to the weather or is protected from the weather but subject to frequent wetting;

Hazard class 4, situation in which timber or wood-based product is in contact with the ground or fresh water and thus is permanently exposed to wetting;

Hazard class 5, situation in which timber or wood-based product is permanently exposed to salt water.

The examination of these classes shows that service and hazard classes 1 relate to similar conditions as service and hazard classes 2. The service class 3, however, embraces hazard classes 3, 4 and 5. It is in these hazard classes that the risk of biological attack is most severe and requires greatest attention to detail in the building design in order to reduce the conditions of timber exposure to those of the lowest hazard class. Timber in classes 1 and 2 may only require moderate or low levels of natural durability, or relatively light preservative treatments to ensure satisfactory long-term performance.

The risk of attack in hazard classes 4 or 5 excludes the use of glulam where this relies on preservative treatment to the laminations before gluing and assembly, as the subsequent planing necessary to produce a flat surface would remove part of the most effectively treated outer zones. In heartwood regions, where penetration is limited, this may expose portions of untreated core. Suitable supplementary treatment is necessary.

Designing for durability

Many factors come into play concerning the durability of timber. Timber should be installed close to the estimated equilibrium moisture content, appropriate to the building, so that is only necessary to limit moisture variation during the year. Timber which is installed at too high a moisture content or is directly exposed to weathering or where the climate conditions produce wide variations in air humidity is likely to show cracks or splits caused by shrinkage. These can expose unprotected timber in preservative treated material, allowing water and fungal spores to enter or insect eggs to be laid beyond the protected zone.

The designer has to consider moisture variation induced by:

- water in its liquid state,
- high humidity which in turn is affected by temperature.

In the liquid state, water progression in timber is primarily parallel to the grain. This must be taken into account by protecting the ends, either by keeping the timber out of situations where water can rise by capillary action or by treating the end grain in such a way as to limit further moisture intake, for example by applying resins or epoxides.

Examples of some situations which may result in high moisture contents in timber include:

- Moisture will easily penetrate timber placed in warm, damp air, for example in poorly ventilated attics where ventilation shafts emerge.
- Joints between timber elements or between timber and masonry constitute an area where end grain may be exposed to air if shrinkage occurs after drying.
- Condensation can result in timber becoming rot. Condensation can be controlled by insulation combined with a vapour barrier. Drainage should be provided where condensation is likely to occur, e.g. at the base of glass walls.
- Direct wetting will occur in timber in ground contact, in door and window frames and in areas, where wind driven snow may collect. Consideration should be given to the risk of direct wetting in rooms where water is laid on, such as showers, bathroom, kitchens etc. where there may be an overflow or splashing.
- Water may become trapped behind waterproof barriers in walls, in the ground or in mechanical joints, preventing its natural elimination by evaporation. Arrangements should be made to avoid the accumulation of water close to metal plates.
- Wetting risks are increased during storage on site and building erection prior to roofing. Timber stocks should be covered and only be left on the site for the minimum time necessary for erection, and one week at the most, especially in bad weather.

Prevention of fungal attack

In the Decision Making Sequence (see STEP lecture A15), it is possible to limit the preservation treatment to be applied. This decision making sequence applies not to the overall building, but to each individual structural member. If the insect risk exists in all classes in so far as their presence is reported in the region, the risk of cryptogamic attack increases considerably, together with the hazard class.

It is possible to reduce the risk through careful construction details, especially to reduce timber moisture content. It is, on the contrary, impossible to influence the extremes of temperature which depend upon the geographical situation and the risk increases with the raising of mean temperature.

If it is impossible to stop water penetration, is usually possible to provide for a system of rapid water evacuation in order to avoid exceeding the 20% moisture content limit, or to limit the humidified zone. Solutions to this could be provided using a decompression space, a water pipe or a ventilation space.

The moisture content of timber is consequent upon a balance between water absorbed and water evacuated, and can be reduced where arrangements are made to retard uptake and promote evacuation. A good example is metal shoes at bases of columns which raise the timber at least 100 *mm* above the ground level and the cut foot is then left in contact with air. In case of trickling, water does not collect, and if slight absorption of water occurs by capillary, it is evacuated by evaporation at the cut, as soon as the source of moisture disappears.

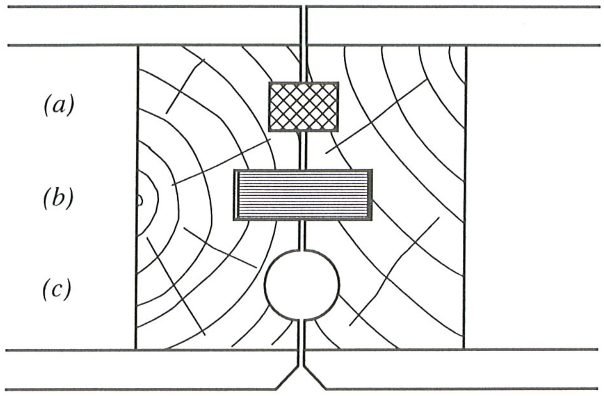

Figure 1 *Wall joint principle in timber construction (a) air-tight joint, (b) mechanical assembly and (c) decompression space.*

In horizontal or oblique members, the existence of longitudinal surface cracks increases the risk of penetration by conducting the water directly towards the inside of the piece, just where it is most difficult to evacuate. As far as possible, timber members must be placed so as to avoid this phenomenon. It is advisable to set the laminations of glulam members with the heart upward as recommended by EN 386 "Glued laminated timber - Performance requirements and minimum production requirements" (see Figure 2). Such oriented laminations reduce the penetration of water into surface cracks and facile drainage when the surface is subject to wetting. For the same reasons, glulam members which curve downwards concentrate water in the lower part without any possibility of evacuation, and fungal attack is more likely to occur.

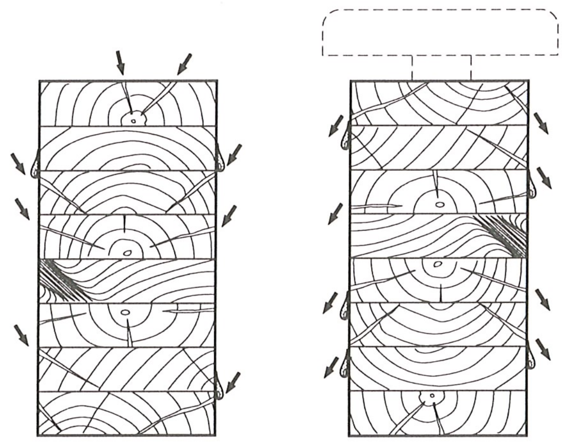

Figure 2 *Disposition of laminations in exterior glulam; left: random orientation of laminations: water penetrates into wood; right: orientated laminations: water can escape (durable or treated timber covering with ventilation space on top).*

Prevention of insect attack

Initially, the natural durability of the selected timber species should be established with respect to the particular insect species to which it may be exposed. It is also necessary to establish whether the particular insect is present in the region in which the timber to be used (see STEP lecture A15). Where a risk of insect attack to the timber exists, the timber must be treated with an insecticidal wood preservative. The application must be carried out before the timber is installed but as far as possible, after any machining or working of the surfaces. If re-working of the timber surfaces on site is needed, preservative treatment should be re-applied to these areas.

For surfaces which can develop significant cracks or splits, and exposed untreated core surfaces, periodic maintenance treatment is required. Consideration must be given to the provision of free access to the timber surfaces. If this is not possible, a more intense preservative treatment should be specified, which penetrates to a depth greater than that to which subsequent cracks are likely to develop. This reduces the risk of the exposure of an unprotected timber core to insect attack.

Where a specific risk of attack by subterranean termites is present, in addition to normal protection by natural durability of wood or preservative treatment, the use of mechanical barriers between the ground and the timber may provide useful protection. This type of termite produces a mud-covered gallery between the termite colony in the ground and the timber components which it attacks. This protection may consists of a preservative treatment of the ground or a mechanical barrier. The use of mechanical barrier or caps enhances the visibility of the gallery if it is developed to a sufficient size to bridge the barrier. Routine maintenance inspections to detect and remove the presence of the galleries is necessary and consideration should be given to the access ability and visibility of surfaces linking the timber component to ground level.

Resistance to corrosion for metal fasteners and connections

EC5 give examples of minimum corrosion protection or material specifications necessary for different service classes. Some more strict corrosion protection measures may be required, for example in a chemical products store, for salt and fertiliser storage, or in special plants such as phosphoric acid factories where it is essential to use bolts, dowels and steel plates of the appropriate grade of stainless steel.

Fastener	Service Class		
	1	2	3
Nails, Dowels, Screws.	None	None	Fe/Zn 25c*)
Bolts	None	Fe/Zn 12c	Fe/Zn 25c*)
Staples	Fe/Zn 12c	Fe/Zn 12c	Stainless steel
Punched metal plate fasteners and steel plates up to 3 *mm* thick	Fe/Zn 12c	Fe/Zn 12c	Stainless steel
Steel plates over 3 *mm* up to 5 *mm* in thickness	None	Fe/Zn 12c	Fe/Zn 25c*)
Steel plates over 5 *mm*	None	None	Fe/Zn 25c*)

*) For especially corrosive conditions consideration should be given to Fe/Zn 40, hot dip coating or stainless steel.

EC5: Part 1-1: 2.4.3

Table 2 Examples of minimum material or corrosion protection specification for fasteners.

Examination of individual cases

Cladding used for bracing

Claddings are generally considered to be in hazard class 3. Boards are often placed at 45° to provide racking resistance. Surface water is then conveyed preferably towards a "V" cut. A drain pipe must put in place at this spot so as to allow the water to evacuate quickly by gravity or by evaporation at the cut end of the board.

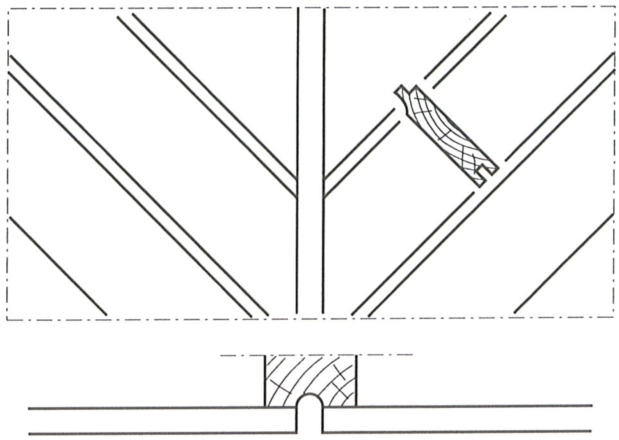

Figure 3 Detailing example for cladding joint with "V" cut.

External columns

These columns are considered to be in either hazard class 2 or in hazard class 3 according to the measures required. The moisture risk is, in fact, very limited if the column is far from the ground. If no precautions are taken, the columns must be considered in hazard class 4.

The base of columns of sheltered but unenclosed structures must be set in place in such a manner as to ensure efficient ventilation and to avoid any entry of water by capillary. The height of the timber above the ground varies with the climate and the risk of accumulated debris at that spot (see Figure 4). The post can be placed on a low wall but, in this case, the bottom end of the post must be treated to avoid the entry of water by capillarity; for example using epoxide resin, rubber paint or asphalt.

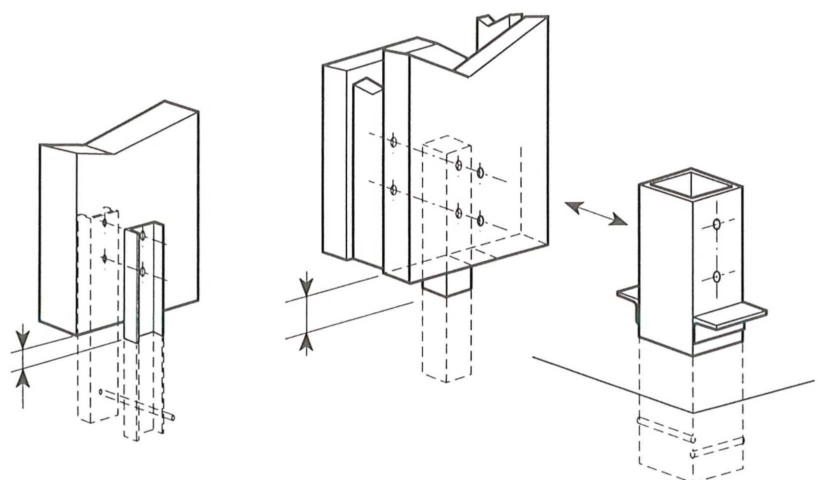

Figure 4 Example of base of exterior columns.

Edge beams

These members are usually considered to be in hazard class 4. They are exposed outdoors to rain and sun and indoors to an atmosphere which is often hot and damp. The classification can be improved by providing a ventilated surface covering, e.g. by a protruding roof, and by ensuring that the external coating is more permeable to water vapour than the inner coating (see Figure 5).

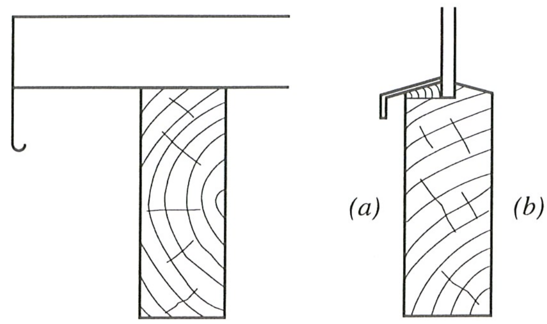

Figure 5 *Edge beams, detailing for limited penetration of water; left: eaves, right: (a) vapour permeable and water-tight film, (b) vapour-tight film.*

Special case of swimming pools

These constructions are subjected to moisture hazards from several sources: water splashes, from the pool or floor-washing, condensation on the glass partitions with dripping on the inside, rainwater on the outside, and with water accumulation on a level with the lintels. Great attention must be paid to leading this water towards the outer face of the timber, or to limiting its contact for example, by placing, the base of the timber posts sufficiently above the ground. When all precautions are taken, timber, in swimming pools, can be considered in hazard class 2, otherwise they must be treated according to hazard class 3 or 4.

Bridges and gangways

These can be bare or covered. In the case of uncovered bridges and gangways, their classification in hazard class 3 or 4 is essential. In the case of covered bridges and gangways, the classification may be lowered to hazard class 2, especially if precautions are taken to coat horizontal beams open to driving rain or sun. Special attention must be paid to the protection of cantilever joints where these exist. In all cases care must be taken to reduce water accumulation due to rain and other causes.

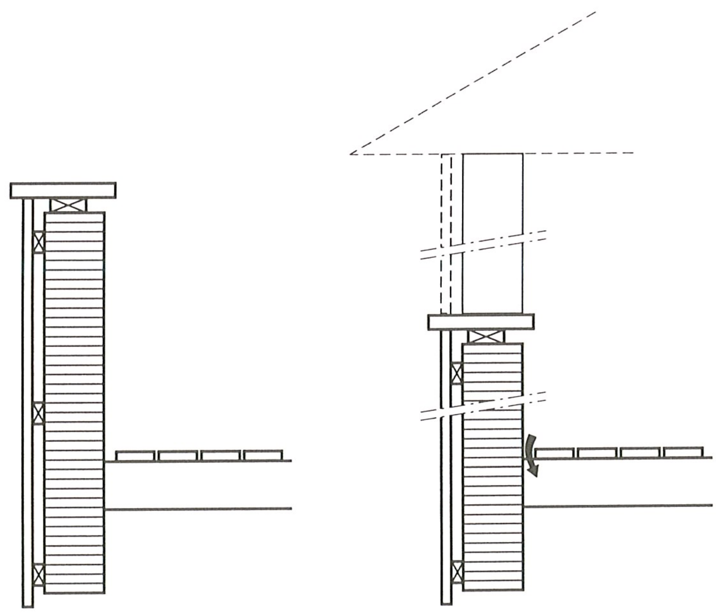

Figure 6 *Protection of bridge timber.*

Concluding summary

- If it is not possible to use durable naturally heartwood , the most important point for preservation against insect attack is to assure a continuous barrier with a preservative treatment.

- In order to limit use of preservative treatment against fungi attacks, it is necessary to prevent water ingress.

- It is essential to provide a suitable outlet for water and water-vapour in the event of accidental penetration of water.

- If it is impossible to ensure that moisture content is below 20%, the treatment prescribed for hazard class 3, 4, or 5 should be applied. In this case it must not be forgotten that machining takes off the most important part of treatment, e.g. by planing.