Increasing the fire resistance of existing timber floors

Where there is an alteration, extension or material change of use of a building, the period of fire resistance of existing timber floors may need to be increased. This digest explains how periods of up to one hour may be achieved. It discusses the addition of protection to the underside of the ceiling, over the floor boarding and between the joists, and the problems of improving fire resistance when the joists are to be exposed to view from below. Floors which are improved as described should generally give a satisfactory standard of fire performance but the precise improvement depends on the details of construction and the condition of the existing floor. The final decision as to suitability must rest with the relevant enforcing authority.

Methods of protection which have been shown to be suitable when tested or assessed under the appropriate part of BS 476 should be used in preference; but if no such information is available, the recommendations in this digest will provide a guide. Because this guidance can only be of a general nature, few jobs will fall precisely into the simple examples that are given (joist sizes and spacing may differ for example). In most cases, therefore, it can merely alert the reader to the problems that may be met.

Since first publication of this Digest, asbestos insulating board has been withdrawn from the market. Although there are now many types of asbestos-free substitute boards available, they cannot be included in the tables in this digest as there is no generic term that describes them.

Information on the use of alternative specifications (including proprietary products and methods of protection for periods in excess of one hour) can be obtained from the Fire Research Station and relevant manufacturers.

Under BS 476: Part 8 (and its revision, Parts 20-23) which is concerned with a fully developed fire, a floor assembly is judged on the three criteria of:

- stability*: the ability of the specimen to resist collapse/excessive deflection
- integrity: the ability to resist flame penetration
- insulation: the ability to restrict excessive transmission of heat

The period of fire resistance attained in the standard test does not relate directly to the performance of a floor in a real fire. A floor which does not reach an acceptable test performance might nevertheless provide an effective barrier. Since much depends on what can reasonably be required in the individual case, the enforcing authority may be willing to accept floor assemblies that do not reach the appropriate level of fire resistance — particularly where compensatory features exist.

*Loadbearing capacity under BS 476:Parts 20 and 21
As the performance of a floor in a fire is related to attack from beneath, the fire resistance of timber floor constructions will depend primarily on the protection given by the ceiling. Once this has been penetrated, the floor joists and underside of the floor boarding become exposed to the fire. Protection applied from above will be of value only so long as the stability of the floor joists is maintained and such protection remains in place. However, any existing pugging between the joists may offer some increased protection.

Existing ceilings of 15-22 mm plaster on wood lath may possibly contribute up to 20 minutes to the fire resistance of a timber floor under BS 476 test conditions, but this will depend on the condition and key. Therefore a detailed inspection is required before assuming any contribution to the overall fire resistance of the floor. Greater thicknesses of plaster will not necessarily provide additional protection and because of the added weight may well fail earlier than thinner plaster.

Plain-edged floor boarding, or tongued and grooved boarding with significant shrinkage, contributes little to the overall performance of a floor and therefore the period of fire resistance of the floor is effectively the collapse time of the ceiling membrane. Tongued and grooved boarding with closed joints can contribute additional time to integrity and insulation. The addition of a hardboard or plywood surface enables a plain-edged boarded floor (or sub-standard t & g floor) to be considered as a good fitting t & g floor construction for the purposes of its maximum contribution to integrity and insulation.

It is possible to increase the fire resistance of suitable existing timber floors by certain types of suspended ceiling systems but care is necessary to ensure that the assembly of any proprietary system is strictly in accordance with an appropriate tested specification, together with any recommended modifications. Many fire-protecting suspended ceiling systems have been tested to assess the protection they can give to steel beams under fire resistance test conditions. Where assessment of their behaviour under timber floors is possible their contribution is much less because timber is more vulnerable; thicker protection is therefore necessary.

Many of the methods in this Digest will also improve the sound insulation of the floor. If a considerable improvement in sound insulation is required, Digest 293 should be consulted.

---

In many cases it may be considered more convenient to replace an existing ceiling because of the likelihood of damage during upgrading work or because of the inability of the existing structure to carry any additional weight.
METHODS
Protection added to the underside of the existing ceiling
Table 1 shows the additional protection required to upgrade some
typical existing floor constructions to either a half-hour or one-hour
period of fire resistance. Although added layers can increase the
performance of a floor, available fixing methods may not be able
to carry the extra weight.

No contribution is assumed from the existing ceiling for the one-
hour specifications.

Table 1 Protection added to underside of existing ceiling

<table>
<thead>
<tr>
<th>Required period of fire resistance</th>
<th>Existing ceiling</th>
<th>Additional protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-hour</td>
<td>(i) 13 mm fibre insulating board with gypsum plaster finish</td>
<td>12.5 mm plasterboard</td>
</tr>
<tr>
<td></td>
<td>(ii) 9.5 mm plasterboard with gypsum plaster finish</td>
<td>9.5 mm plasterboard (x3)</td>
</tr>
<tr>
<td></td>
<td>(iii) 15-22 mm plaster on wood or reed lath</td>
<td>12.5 mm plasterboard on battens (see fixing)</td>
</tr>
<tr>
<td>One-hour</td>
<td>(iv) 9.5 mm plasterboard with gypsum plaster finish</td>
<td>13 mm lightweight</td>
</tr>
<tr>
<td></td>
<td>(v) 12.5 mm plasterboard with gypsum plaster finish</td>
<td>plaster (metal lathing grade) on metal lath</td>
</tr>
<tr>
<td></td>
<td>(vi) 15-22 mm plaster on wood or reed lath</td>
<td></td>
</tr>
</tbody>
</table>

With plaster finishes to lath, the dimensions given are those from the face of the lath.

1 If floor boarding is good fitting 21 mm tongued and grooved (or equivalent)
2 Supports not to exceed 450 mm
3 If floor boarding is plain edged (or badly fitting t & g)
Protection applied from above

Table 2 gives constructions which can be used if protection must be added from above: for example, where an ornate ceiling is to be retained or where access cannot be gained to the storey below.

The methods involve either filling between the joists after lifting the floor boards or applying an additional floor finish above the existing boards (or both). In both the methods of joist infill described, it is essential that the protective material is in intimate contact with the sides of the joists in order to protect them from burning for as long as possible. Particular care should be taken at cornices. The added protection must be independently fixed and supported so that it will not fall when the existing ceiling collapses.

No contribution is assumed from the existing ceiling for the one-hour specifications.

Table 2 Protection applied from above

<table>
<thead>
<tr>
<th>Required period of fire resistance</th>
<th>Existing construction</th>
<th>Additional protection (see key below)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floor boarding</td>
<td>Ceiling</td>
</tr>
<tr>
<td>Half-hour</td>
<td>(i) none (e.g. existing roof space)</td>
<td>9.5 mm plasterboard with gypsum plaster finish</td>
</tr>
<tr>
<td></td>
<td>(ii) plain edged</td>
<td>15-22 mm plaster on wood or reed lath (in sound condition)</td>
</tr>
<tr>
<td>One-hour</td>
<td>(iii) plain edged</td>
<td>9.5 mm plasterboard with gypsum plaster finish</td>
</tr>
<tr>
<td></td>
<td>(iv) plain edged</td>
<td>15-22 mm plaster on wood or reed lath</td>
</tr>
<tr>
<td></td>
<td>(v) 21 mm good fitting tongued and grooved</td>
<td>15-22 mm plaster on wood or reed lath</td>
</tr>
</tbody>
</table>

With plaster finishes to lath, the dimensions given are those from the face of the lath.

Additional protection
1 Not less than 60 mm mineral fibre insulating material (formed from crushed rock or blast furnace slag) laid between the joists and fixed to the joist sides. New floor to be tongued and grooved, 25 mm nominal boarding or 15 mm plywood or chipboard.
2 Not less than 3.2 mm standard hardboard Type S to BS 1142:Part 2 (or 4 mm plywood) nailed at not more than 150 mm centres on the line of joists to the existing floor to break joint; joints to coincide with the line of the joists.
3 19 mm lightweight aggregate gypsum plaster (metal lathing grade) trowelled between joists in conjunction with expanded metal lathing or chicken wire well turned up and fixed to the joist sides or continuous over joists. To prevent staining the existing ceiling, polythene sheet can be placed before the plaster infill.

Note: In methods 1 and 3 the nails or staples should penetrate into the joist sides to a minimum depth of 20 mm.
Protection leaving existing joists exposed

Table 3 gives information about flooring and protection between joists which will provide a half-hour period of fire resistance with the joists exposed. Additional methods of construction are to be included in BS 5268:Section 4.2.

The joists should be of a size which will enable them to retain their structural stability even after some charring of the timber has occurred. Table 4 shows the amount of charring which may occur with different timbers under the heating conditions of the standard method of test, provided no dimension is less than 25 mm. From this, the reduction in size of the joist can be calculated (residual section). When using the table, an allowance (a radius approximately equal to the calculated depth of charring) needs to be made for increased depth of charring at arisings. For periods of 30 minutes or less, where the least dimension of the residual section is not less than 50 mm, rounding is insignificant and may be disregarded.

To calculate the loadbearing capacity of the residual section, normal practice applies except that the stresses should not exceed 2.25 x the permissible long-term dry stresses given in BS 5268:

- Part 2 when the minimum initial breadth of the section is 70 mm or greater, or 2 x the permissible long-term dry stresses when this dimension is less than 70 mm. Deflection should not exceed \( \frac{1}{30} \) of the span.

If there is insufficient sacrificial timber to maintain structural stability for the full period of fire resistance, the amount of joist permitted to remain can be reduced by adjusting the position of the ceiling protection relative to the depth of the joists. It is permissible to build up joists to provide sacrificial timber. If this is done, at least 10 minutes extra allowance for charring should be provided and the screw fixings should be countersunk at least 6 mm with the holes made good.

<table>
<thead>
<tr>
<th>Required period of fire resistance</th>
<th>Existing boarding</th>
<th>Protection between joists</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) square edged (any thickness)</td>
<td></td>
<td>2 layers of 12.5 mm plasterboard with joists staggered</td>
</tr>
<tr>
<td>(ii) 15 mm t &amp; g plywood</td>
<td></td>
<td>9.5 mm plasterboard(^\text{1)}) with 5 mm gypsum board finish plaster</td>
</tr>
<tr>
<td>(iii) 21 mm good fitting t &amp; g</td>
<td></td>
<td>12.5 mm plasterboard</td>
</tr>
<tr>
<td>(iv) square edged overlaid(^*)</td>
<td></td>
<td>12.5 mm plasterboard</td>
</tr>
</tbody>
</table>

1. Supports not to exceed 450 mm centres
2. Not less than 3.2 mm standard hardboard Type S to BS 1142:Part 2
   (or 4 mm plywood) nailed at not more than 150 mm centres on line of joists to break joint. Joints to coincide with line of joists.

---

**Diagram:**
- **Additional protection** (not shown)
- **Floor boarding**
- **Timber battens — not less than 2.5 mm, nailed**
- **Ceiling protection**

---

5
Table 4 Charring rates of timber *from BS 5268: Part 4: Section 4.1 (an amendment is being prepared)*

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth of charring on each face exposed to fire in:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 mins</td>
</tr>
<tr>
<td>All structural species listed in Table 1 of CP 112:</td>
<td>20 mm</td>
</tr>
<tr>
<td>Part 2: 1971, except those listed below</td>
<td></td>
</tr>
<tr>
<td>Western red cedar</td>
<td>25 mm</td>
</tr>
<tr>
<td>Oak, utile, kersing (gurjun), teak, greenheart, jarrah</td>
<td>15 mm</td>
</tr>
</tbody>
</table>
**FIXING**

Effective fixing of the additional protection is of paramount importance. When fixing below an existing ceiling, screws or nails must penetrate new work and be driven into the joists to a depth which will ensure that the ceiling remains in place during the intended period of protection. Nailing should be carefully done to minimise the damage to the existing ceiling but it must be accepted that some damage will be done, especially to old wood or reed lath and plaster ceilings. The new work, including fixings, will be supporting some of the weight of the existing ceiling.

With wood or reed lath and plaster ceilings, where the added protection is to incorporate boarding, chicken wire should be securely fixed under the ceiling and the ceiling battened out to receive the new boarded protection. This ensures that should the existing plaster become detached, its weight is not transferred to the added protection. The battens also overcome the problem of an existing uneven plaster surface. This method may reduce sound insulation at some frequencies.

The lengths of nails and screws should be determined according to the method of protection selected. Nails for plasterboard should be galvanised and be of the correct specification where boards are to be plastered. Table 5 gives recommended fixings. The table assumes that the plasterboard is fixed directly to the joists. In practice, therefore, an allowance may have to be made for the thickness of the existing ceiling, which in some cases may make this method impracticable. Metal lathing should be fixed at 100 mm centres with galvanised clinch headed nails and should be spaced away from the background by some suitable means to give a 6 mm gap. Alternatively, ribbed lath or an appropriate proprietary brand should be used.

All new plaster requires a proper key: either plasterboard (or similar) or metal lathing. The use of bonding agents is not recommended in connection with ceilings contributing to the fire resistance of a floor. Although the minimum width of joists (for example) are given, the recommended ‘trade’ practice should apply - in respect of minimal backing, edge clearance of nails, etc.

---

Table 5  Recommended fixing for plasterboard with no allowance for existing ceiling

<table>
<thead>
<tr>
<th>Thickness of plasterboard</th>
<th>Nail length</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 mm</td>
<td>30 mm</td>
<td>150 mm centres</td>
</tr>
<tr>
<td>12.5 mm and 15 mm</td>
<td>40 mm</td>
<td>150 mm centres</td>
</tr>
<tr>
<td>19mm-25mm</td>
<td>60 mm</td>
<td>150 mm centres</td>
</tr>
</tbody>
</table>
British Standards Institution

BS 476 Fire tests on building materials and structures
  Part 8:1972 Test methods and criteria for the fire
  resistance of elements of building construction
  Part 20:1987 Method for determination of the fire
  resistance of elements of construction (general
  principles)
  Part 21:1987 Methods for determination of the fire
  resistance of loadbearing elements of construction

BS 1142 Specification for fibre building boards
  Part 2:1971 Medium board, medium density
  fibreboard (MDF) and hardboard

BS 1191 Specification for gypsum building plasters
  Part 1:1973 Excluding premixed lightweight plasters
  Part 2:1973 Premixed lightweight plasters

BS 1230 Gypsum plasterboard
  Part 1:1985 Specification for plasterboard
  excluding materials submitted for secondary
  operations

BS 1369 Steel lathing for internal plastering and
  external rendering
  Part 1:1987 Specification for expanded metal and
  ribbed lathing

BS 5268 Structural use of timber
  design, materials and workmanship (Revision of
  CP112:Part 2)
  Part 4 Fire resistance of timber structures
    Section 4.1:1978 Method of calculating fire resistance of
    timber members
    Section 4.2 Methods of calculating fire resistance of timber
    stud walls and joisted floor constructions (in preparation)

CP112 Code of practice for the structural use of timber
  Part 2:1971 Metric units (see BS 5268 Part 2)

Building Research Establishment

Digest 293 Improving the sound insulation of separating walls and
  floors

MORRIS, W A; READ, R E H; COOKE, G M E. Guidelines for
  the construction of fire-resisting structural elements.