International Symposium on Protection of Cultural Heritage Buildings from Fire, Kyoto, April 6-7, 2003

Upgrading the fire resistance of floors and doors in heritage buildings

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Heritage fire protection – some considerations

- A property fire risk assessment should be made before any upgrading of structural fire precautions.
- Consider importance and value of items at risk – structure, furnishings, contents.
- Consider importance of site as a revenue earner.
- Have all plausible fire/smoke routes been identified?
- Can fire detection be improved – e.g. can aspirated smoke detection be justified?
- Can in-house staff get to incipient fires in time to extinguish them – what about fires in cavities and fires at high level?
- What fire suppression devices are available for immediate use.
- Can fire safety management be improved – e.g. can 24 hour surveillance be afforded?
- What is attendance time of fire service appliances?
- Has fire plan been considered in sufficient detail. Staff may not be able to remove important items to a place of safety and fight incipient fire at the same time.
- What benefits will structural fire precautions bring?
- Improving fire compartmentation by upgrading the fire resistance of doors and floors (the subject of this presentation) is an important, but small part, of the overall fire safety strategy.
• All attempts should be made to leave the fabric and structure of the building in its original form

• Structural improvements should be invisible if possible. This is sometimes possible, and examples will be shown to demonstrate how to do this for floors and doors
HSE fire risk assessment plan


This plan is concerned with life safety. Similar approach needed for determining precautions against loss of property (loss of building structure and fabric and building contents e.g. furniture and paintings) and loss of business continuity and, of course, loss of cultural heritage.
Stopping fire spread through floor and ceiling cavities
Fire spread routes above ceiling at door position

- Resistance to all fire spread routes should be considered
- Fire resistance of over door panel should not be forgotten
- Cavity barrier above ceiling is necessary and should line up with door position
- Light fittings and other fittings in ceiling may be points of weakness
Flexible ceiling cavity fire barrier using rock wool

- Cavity barrier needed to prevent horizontal fire spread.
- Barrier should be flexible to accommodate relative movements of structure.
- Flexible rock wool skirt can be used to follow movement.
Ceiling cavity barrier using spray material

- Expanded metal mesh is placed in a curved shape in the cavity and fixed to floor and ceiling.
- Lightweight fire protecting spray is applied at sufficiently low density to provide some flexibility.
- Has the advantage that it fills all the gaps. Disadvantage is that it is a wet trade and can be messy, and may involve fibres.
Increasing the fire resistance of floors
Fire resistance test criteria

Furnace enclosure

- Instability or collapse
- Loss of integrity
- Excessive temperature rise
Floor which needs no upgrading

- Fan vaulted brickwork is ideal shape to carry load. Brickwork in compression behaves well in fire provided perimeter restraint exists
- Cast iron columns are fire protected with intumescent spray. Basic form still seen, retaining aesthetics.
Example of historic ceiling

- Clearly unacceptable to apply structural fire protection to underside of this ceiling
- May be possible to increase the fire resistance from above the floor
- Any fire precautions should consider smoke damage as well as a fully developed fire.
- Cavity barriers within floors may be needed.
- Best option is early fire detection (by aspiration) and rapid fire suppression by trained staff.
- In small rooms automatic water spray might be appropriate as fire suppression
• Impossible to upgrade the fire resistance of this ceiling from below without destroying aesthetic
• Cost of closing the building (which houses an important collection of paintings and furniture) unacceptable.
• Is upgrading necessary?
• Could floor be upgraded from above?
Upgrading by adding new ceiling below

- Existing floor boards and ceiling are in poor condition. Access to top and bottom available. Aesthetics not important
- New ceiling can be added using fire protecting ceiling boards and timber battens
- Old ceiling kept in place for thermal protection using chicken wire mesh
- Fixings important
- BRE Digest 208 guides
Charring rate of timber versus radiation intensity

- Charring rate depends markedly on radiation intensity.
- For ISO 834 fire exposure, timber charring rate is in the approximate range 0.6 to 0.9 mm/min according to DD ENV -1-2 and BS PD 7974-3, 2003.
Upgrading timber floor using inset ceiling

- Existing floor of poor integrity. Large beams.
- Inset ceiling considered aesthetically acceptable.
- Inset ceiling can be fire protecting board or plaster (or expanded metal mesh if adequately supported mid-span).
- Residual section of floor beam calculated to be structurally acceptable. Residual section assumed to have room temperature strength. Neutral axis of section has moved.
- Ceiling fastener (e.g. wood screw) needs to allow for charring of batten around fastener.
- Additional timber protection (sheeting) gives integrity against cold and hot smoke.
- Radius of char = char thickness.
Upgrading a timber floor by adding plaster or mineral fibre from the top

- Floor boards are in poor condition with square edges. Historic moulded ceiling also in poor condition – typically plaster on timber lath loosely held with corroded nails.

- Access only from the upper face. Upgrading process: temporarily remove some floor boards, place damp proof sheet, fix expanded metal to sides of joists, pour in lightweight plaster, replace floor boards, apply timber sheeting to improve integrity and resistance to smoke flow if necessary.

- Added ceiling of plaster and metal lath must remain in place after historic ceiling falls away. Damp proof sheet must be pushed tightly into corners so that new plaster protects faces of joists

- Can floor carry additional weight? Can ceiling carry wet mass of plaster? (OK when dry and rigid)
Upgraded floor using poured plaster
Kenwood library ceiling by Robert Adam

- Early fire detection and suppression essential
- Major risk is of fire starting above ceiling in roof space. Aspiration could deal with detection in roof space and at high level under ceiling.
- How deal with fire above ceiling? Fire fighting a problem?
Increasing the fire resistance of timber doors
Historic door and ceiling.

- Fire risk assessment essential. Objective should be early fire detection and immediate fire suppression – this is a question for fire safety management. Why is structural fire protection necessary?
- Necessary structural fire protection must be unseen.
- Can intumescent be used for improving fire integrity at door edges and at thin areas of door face? Can door be dismantled to allow hidden improvements to be made?
Bowing of timber door in fire

- Bowing will be constrained by hinges and latch
- Timber door will bow towards the fire due to shrinkage of fire-exposed face. Extent of bow depends on design, thickness and grain direction
- Failure of integrity will occur at top of door first because a) top of door is in hottest environment, and b) outward flow of hot gases causes charring of door frame
Fire behaviour of glazed door

- Radiation through glass should be considered (ignition of nearby surfaces on unexposed side)
- Top of door is in most severe environment
- Intumescent seal at door edges will prevent emission of hot gases but not cold smoke flow
- Cold smoke can extensively damage contents of heritage building. Use smoke seals on door edges if aesthetically acceptable
Timber panelled door

- The thin edge of each panel is the line of fire integrity weakness, especially for the panels near the top of the door.
- This moulded panel door is in daily use in a London museum. A spare identical door has been fixed to the face of the other door, but it looks better than a boarded door. The resulting door is heavier and required new heavy hinges to be fitted. Aesthetics were important.
- UK BRE Digest 220 gives guidance on timber fire doors
Mahogany doors in Kenwood House

- Doors have an area of weak fire integrity around panels
- High quality of fire safety management essential
- Value of works of art inestimable.
- Self portrait of Rembrandt valued at £5m several years ago
Mahogany panelled door
Failure of fire resistance of panels in panelled door

• Panels near top of door most likely to fail – environment most severe
• Timber chars at approximately 0.8mm/min in standard ISO 834 fire resistance test
• Panel edge can char away allowing passage of fire, or
• retaining bead can char away or its fastening may fail allowing panel to fall out
Upgrading timber door with fire protecting board

- Fire protecting board applied to fire risk side using nails or screws.
- Greatly improves fire integrity and insulation performance
- Unacceptable in heritage buildings
- Makes door heavy and may require more or bigger hinges and relocation of hinges
Upgrading timber door with fire resisting glass

- Adding panel(s) of wired glass or non-wired glass of proven integrity (e.g. Pyran) to door will improve integrity at panel edges.
- Glass will have little effect on thermal transmission so insulation performance of door may be inadequate (but this may be unimportant).
- Method of fixing glass panels needs special consideration to allow for different thermal movement of timber and glass.
Upgrading timber door using intumescent system

- Intumescent paint or varnish can improve fire resistance (and flame spread)
- Intumescent must be compatible with existing coating (or existing coating should be removed). Adopt manufacturer’s instructions
- May need notice saying the coating should not be removed or improperly cleaned - fire safety management important
- Perhaps only thin portions of door need be so treated
Upgrading timber door panels with steel strip inserts

- Fire integrity can be improved (but not insulation) using this method.
- Door is dismantled (beadings around one face removed), panel edges are slit (partly or fully), steel strips are inserted, and door assembled again.
- Suitable for unpainted doors of outstanding appearance (e.g. varnished mahogany doors) where no other upgrading method is adequate.
Use of door edge seals
Intumescent door edge seals

- Existing door sets (i.e. door and its frame) can be upgraded with intumescent strips by making groove in edge of door and/or frame and placing preformed intumescent strips.
- Door edge gap should preferably not exceed 3mm.
- Seal positions in door and frame should not be reversed (to allow for door bowing).

**Intumescent strip requirements**

| FR 30/20 | strips not essential |
| FR 60/45 | strips in door edge or frame |
| FR 30/30 | strips in door edge or frame |
| FR 60/60 | strips in door edge and frame |
Heat and smoke seals for double swing doors

- Extruded aluminium section incorporating intumescent materials and a neoprene smoke seal is fixed into a groove in door edges along sides and top with metal nails. Neoprene seal needs to be checked occasionally to ensure good condition and fit.
- In a fire the aluminium soaks up the heat and causes the intumescent to swell early, before the neoprene smoke seal is damaged.
• Electrically operated door hold-open device
• Break glass call point
The end