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RESEARCH

Guideline -

Fire resistance upgrade of cultural heritage doors

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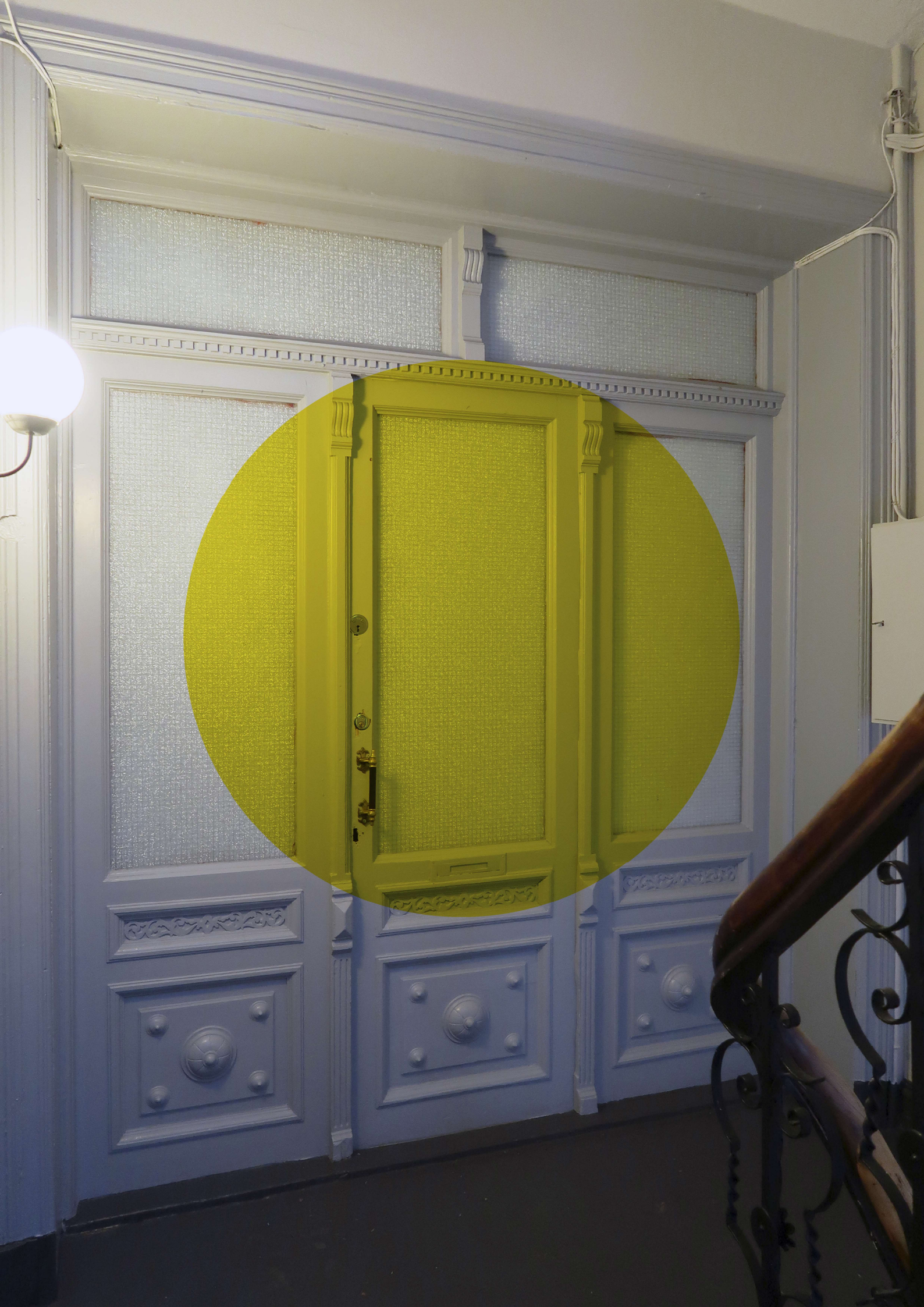

Abstract

Older wooden doors can be one of the weaker points with regards to fire resistance in apartment buildings. This guideline proposes how glass, protective boards, sealing lists, hardware and door frames can be mounted to the door to be expected to achieve a fire resistance of *approximately* 30 minutes (as if the door would be fire resistance tested). The only intended use of this guideline is when changing the door due to antiquarian reasons is not possible or desirable.

These types of older doors typically have a thickness of 40-50 mm, with glass on the upper part and a thinner wooden door panel on the lower part. For antiquary reasons, the interventions on the doors should be as little intrusive and as reversible as possible.

A total number of four fire tests were performed, with two small door models in each test. Different solutions for mounting of fire resistant glass, gypsum boards and glazing lists were tested. The main conclusions from the fire tests are:

- Glass must have a minimum fire resistance rating of 30 minutes (integrity and insulation) and be securely fastened with steel frames or steel angles
- Thinner parts like fielded wooden panels can be upgraded with stone wool and 12.5 mm robust gypsum boards
- Both intumescent strips and silicone gaskets must be mounted around the door leaf
- The gap between the door frame and the wall must be sealed using stone wool and fire sealant

Table of contents

Preface

The Fire Research and Innovation Centre (FRIC) commenced in spring 2019. The aim is to increase the knowledge within fire safety to make optimal decisions and develop better solutions that provide increased fire safety in buildings. FRIC is led by RISE Fire Research in Trondheim, with NTNU and SINTEF as research partners. FRIC has partners from public organisations, fire safety consultants, producers and suppliers of building products and building installations, and property development and management. The research centre is funded by all partners, in addition to funding from the Research Council of Norway, program BRANNSIKKERHET, project number 294649. (www.fric.no)

This document has been prepared within *Task 5 Solutions for the protection of cultural heritage escape route doors* of *Project 3.1 Novel construction products* within FRIC. It is a continuation of the first and second part of the project, which resulted in the report *Fire performance of escape route doors in cultural heritage buildings A state-of-the-art review* [1] and the report *Rehabilitated escape route doors - Mounting of glass, boards and sealing lists* [2].

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1 Background and premises

This guideline presents possible solutions for mounting glass, protective boards, sealing lists, door frames and door hardware when upgrading the fire resistance of older wooden doors with a cultural heritage value. The guideline deals with intervention on the door itself in cases where this is necessary. The approach is based on small-scale fire testing and knowledge from previous experience.

The following premises and reservations form the basis for the use of the guideline:

- The doors used in small-scale fire testing were of laminated wood and had a thickness of 40 mm. The framework of the door leaf shall be of solid wood and have a thickness of at least 40 mm.
- Upgrading according to the guideline can increase the doors' fire resistance up to *approximately* 30 minutes. Since each door is unique in age, thickness, type of wood, moisture content, etc., there is uncertainty about the actual fire resistance obtained.
- The doors used in small-scale fire testing measured 0.58 m x 1.34 m, whereas the standard door measure often is around 0.9 m x 2.0 m. Higher doors are more subjected to bending during the heat exposure, which may not have been reflected in the test result.
- The doors used in small-scale fire testing were new doors made of laminated wood, not solid wood. However, the charring rate for the two is similar; 0.65 mm/min for solid wood and 0.5 – 0.65 mm/min for laminated wood [6]. The difference is considered not to have significant impact on the result.
- When securing an escape route, the building must be seen as a whole, and compensatory solutions must be considered. See [5].
- The distance from the edge of the door leaf to the glass window opening must give a stable frame and must be considered in each case. The fire resistant glass is usually thicker than normal glass, and therefore heavier, and the maximum size must be considered in each case. The glass used in the fire testing had an area of 0.4 m^2 and weighed 12.6 kg.
- Open cut-outs like letter holes must be sealed to prevent fire spread.

2 Preservation of doors with cultural heritage value

The doors described in this guideline are typically original stairwell doors in older brick apartment houses of cultural heritage value, see Figure 2-1. Such old brick apartment houses have walls of load-bearing bricks, wooden beams and roof structures in wood, and many of them are categorised as cultural heritage. Several wooden apartment buildings have the same kind of

doors. Because of their construction, the old apartment buildings are vulnerable to fire. The yards have floor dividers with wooden beam layers and cavities in the structure. This increases the risk of rapid-fire spreading in the building and the need for fire protection upgrading.

Figure 2-1 typical original stairwell door in older brick apartment house of cultural heritage value. [Photo credit: Jømna]

The stairwell doors are critical elements to prevent fire spread and keep evacuation routes safe. Hence, their function and condition are essential to fire protection in the building. Thirty minutes of fire resistance is the performance usually required for apartment doors to stairwells in pre-accepted solutions according to the Building Regulations [3].

The demand for upgrading arises when a need for risk mitigation or a higher fire safety level for a building is recognised. The upgrading of doors can be part of a buildings fire safety upgrading plan. Increased requirements for fire safety mean that the keeping of such stairwell doors in the old apartment buildings are under pressure, and new fire-rated doors have replaced many old doors.

Different solutions have been presented in guidelines for upgrading the old wooden doors as an alternative to replacement. However, these guidelines have not provided detailed technical descriptions of tested solutions and planning, and execution of the individual measures are assigned to private consultants and contractors. Consequently, the technical steps on doors are of varying quality and standard, sometimes with inappropriate changes causing significant antiquarian losses. This guideline aims to help ensure that the invasive measures taken on the old doors disturb as little as possible of the original material and function satisfactorily as fire protection.

When securing an escape route, the building must be seen as a whole, and compensatory solutions must be considered. In the following, only intrusive solutions are discussed with the aim of increasing the function of such doors as fire barriers. For antiquary reasons, the interventions on the doors should be as little intrusive and reversible as possible. Other important properties of solutions are minimal risk of failure and long service lifetime of products. The solutions suggested are considered to have the potential of a long-life cycle. Any future alterations must be done in accordance with a fire safety maintenance plan for the building.

Fire-retardant surface treatment (FR) has sometimes been proposed for increased fire resistance on thin wood. In this project, the use of FR-paint or varnish has been left out since the possibilities for frequent control on the inside of appartement doors are limited and the risk of failure is considerable due to the complexity of application procedure and maintenance.

Door characteristics

Traditional panelled doors were often made of solid pine wood. The frame parts were usually tapped together with plugs or wedges. These types of doors normally have a thickness of 40-50 mm on the frame part. The upper part of the door leaf is often fitted with glass panels. Many doors also have a glass panel above the door leaf. The lower part of the door leaf often has a wooden panel, about 10 mm in the thinnest parts. Figure 2-2 shows typical terminology used for panelled doors.

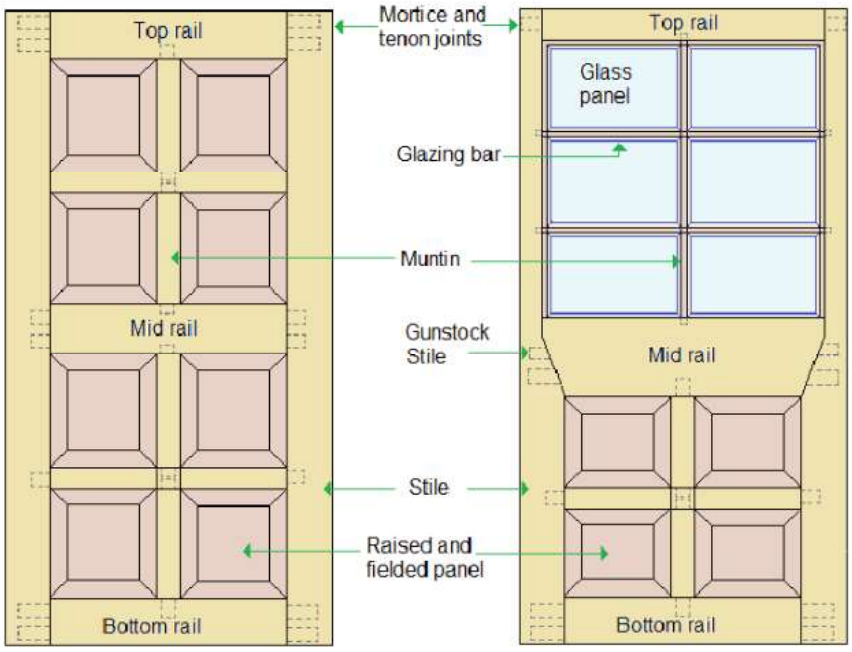

Figure 2-2 typical terminology used for panelled doors [7]

Rich decorations and large glass fields against common areas make these doors a major part of the architectural expression of the building. In the houses that still have the original stairwell doors between apartments and stairwells, these are usually nicely decorated wooden filling

doors, with elaborate mouldings profiles. The glass panel originally used ordinary glass, often with an "acid-etched" decorative pattern. Such glass had very poor fire resistance.

By adding or replacing fire resistant glass the original light openings in the doors and transmitted light in the stairwell can be kept. It is desired to retain the old glass, but if this is not possible due to lack of space it may be removed. Rabbet and mouldings should be modified as little as possible. If mouldings must be loosened from their original position they should be kept and preferably reused on the door leaf.

In the following, a newly developed guideline is presented, based on the results of fire testing of different solutions for mounting of fire rated glass, gypsum boards and sealing lists.

3 Guideline

3.1 Mounting of fire resistant glass

Escape route doors with glass must be upgraded by replacing the glass with a fire resistant glass, which have a fire resistance of minimum 30 minutes for integrity and insulation. There are several ways of mounting the fire rated glass, depending on the available space in the rabbet, and whether the original glass is mounted on the stairway side or on the apartment side of the door.

Figure 3-1 shows a suggestion for how fire resistant glass can be mounted as a replacement of original glass or, if possible, as a supplement on the inside of the original glass:

- If possible, the existing rabbet in the door window frame should be used. If there is too little space for the glass, glazing gasket and steel angles, a deeper rabbet must be milled out. The rabbet should be at least 20 mm in height on all sides to ensure that the fire rated resistant is held in place on the non-fire exposed side of the door, see Figure 3-1. The thickness of the wood on the non-fire exposed side is not critical since it will not be exposed to fire.
- A glazing gasket in silicone is placed close to the rabbet, on all four sides. The glazing gasket holds the glass in place and does not have a fire rated function.
- 15x1 mm intumescent strips is mounted on all four sides around the glass
- Setting blocks of hardwood for glass are placed on all four corners around the glass (corresponding to the 15x15 mm steel angles)
- The fire rated glass is placed on the setting blocks and pushed against the glazing gasket
- 15x15 mm steel angles are placed on the fire exposed side of the glass, to hold it tight. The steel angles and clips are fixed using 40 mm steel screws. The steel angles are placed approx. 100 mm from each corner, then max 300 mm from one another. The screws should be fastened tilted inwards.
- For aesthetic matters, the steel angles may be covered with wooden battens. The battens will not have a function when it comes to fire resistance.

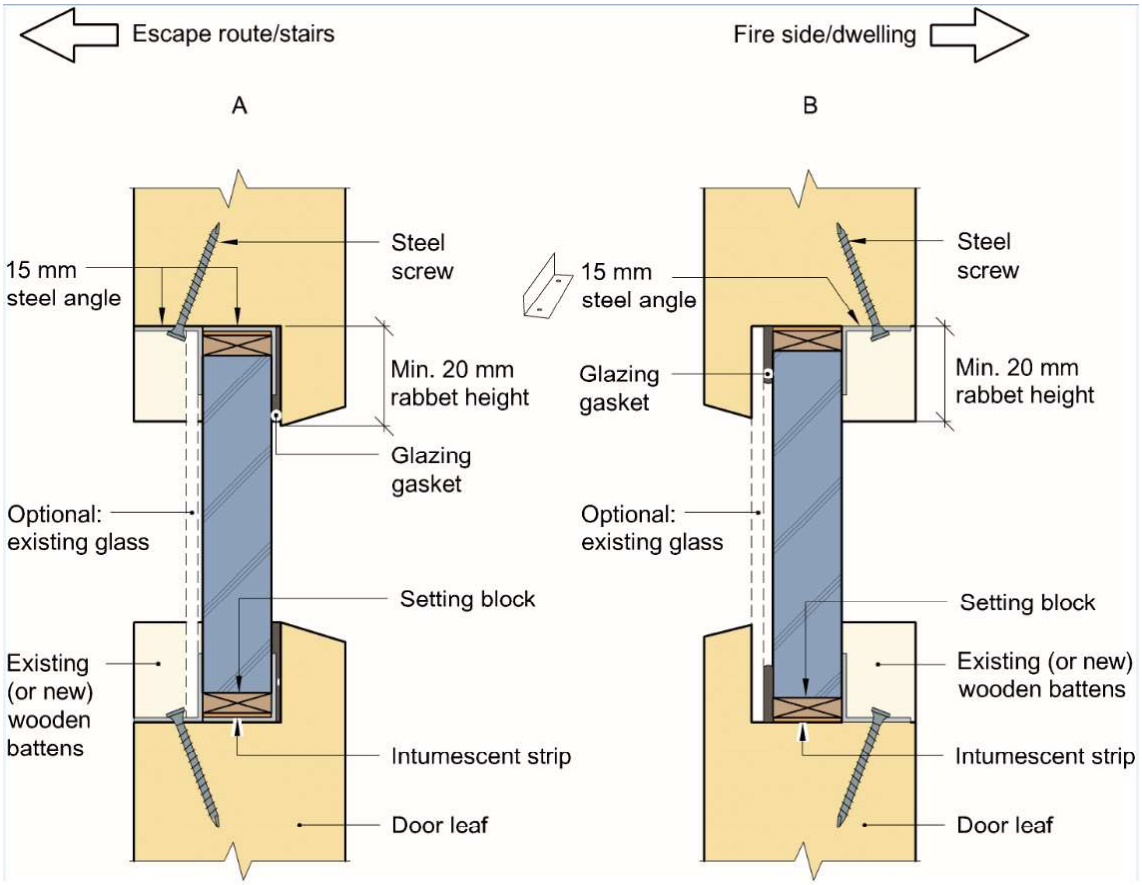

Figure 3-1 Possible ways of mounting fire rated glass

- Alternative A: Fire resistant glass mounted in the rabbet on the stairway side of the door, fastened with wooden battens (new or existing) and steel angles on both sides of the glass. When the wood on the fireside of the door has burned away, the steel angle will still hold the glass in place.
- Alternative B: Fire resistant glass mounted in the rabbet on the apartment side of the door, fastened with wooden battens and steel angles on the apartment side of the glass. See Figure 3-2 for mounting details.
- Indoors where the existing glass is fastened with glazing putty, both alternative A and B can be used.

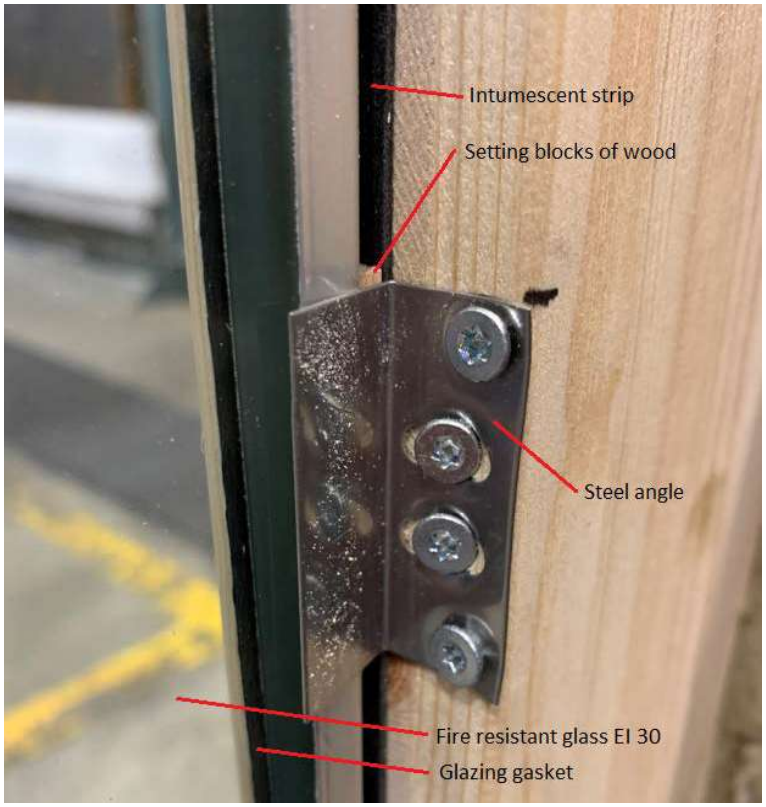

Figure 3-2 Detail of mounting of fire resistant glass with steel angles. The steel angles can be hidden behind wooden battens for aesthetic reasons.

If there is not enough space available inside the door window frame for the 15x15 mm steel angles, it is a possible solution to mount the fire resistant glass flush with the inside of the door (on the apartment side of the door). Figure 3-3 shows the solution. The glass must be held in place with a 30 mm steel frame fixed with 40 mm steel screws. See Figure 3-4 for mounting details.

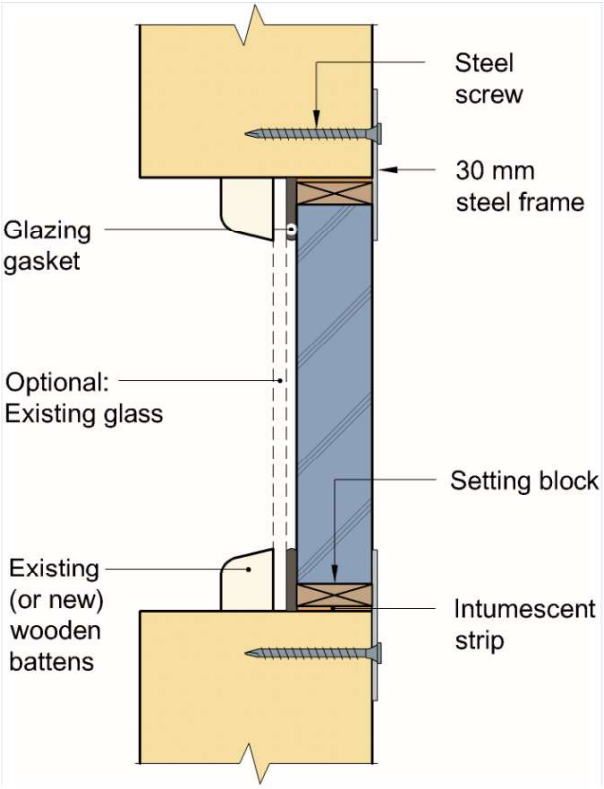

Figure 3-3 Mounting of fire resistant glass inside rabbet with steel frame on the apartment side of the door.

Figure 3-4 Detail for mounting of 30 mm steel frame. The steel frame can be hidden behind wooden battens for aesthetic reasons.

If there are several smaller panes of glass held by glazing bars in the door, and there is not enough space available inside the door window frame, it is a possible solution to mount the fire resistant glass on the outside and letting a 12.5 mm robust gypsum board take the weight of the glass. Figure 3-5 shows the solution. The glass must be held in place with a 30 mm steel frame fixed with 40 mm steel screws.

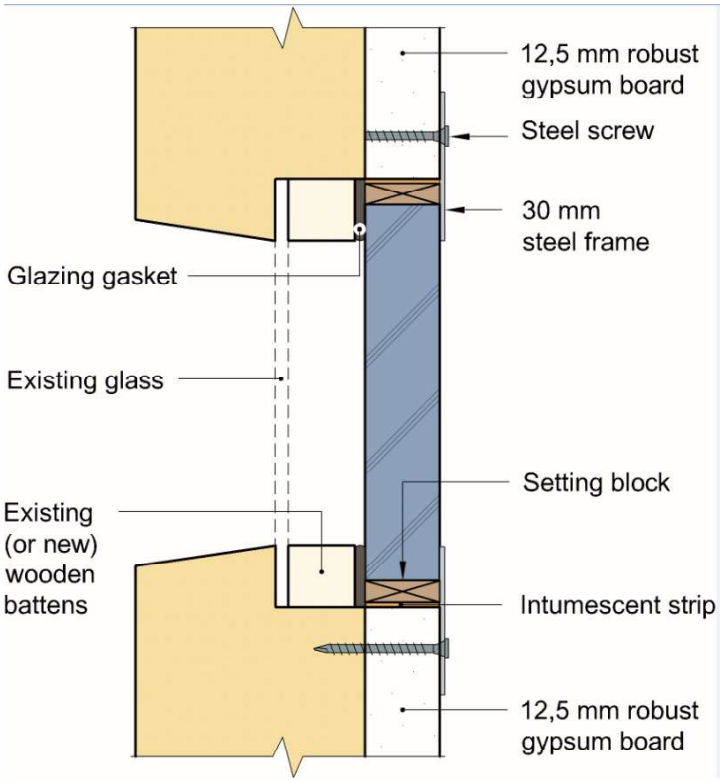

Figure 3-5 Mounting of fire rated glass outside rabbet with steel frame

Examples of products that can be used for mounting of glass are shown in Figure 3-6.

Figure 3-6 Glazing gasket (left) and intumescent strip (right)

3.2 Mounting of protective boards

A protective board covering placed on one side is an alternative when you want to keep the door leaf's appearance on one side, for example, towards stairwells. If the wooden panel is at least 21 mm thick, you can fill in the thinner parts of the wood filling with pressure-resistant stone wool, which is cut and glued with wood glue and fastened as shown in Figure 3-7.

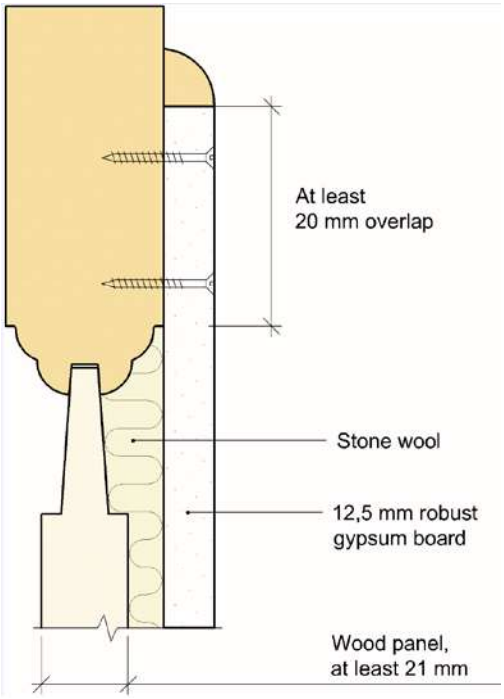

Figure 3-7 One-sided covering on door leaves when the wood panel is at least 21 mm. The solution is based on [4].

If the wood panel is thinner than 21 mm, at least 20 mm of stone wool must be inserted between the panel and the covering. See Figure 3-8. At the thinnest, the wood panel must be at least 9 mm thick. If there is not enough space for the stone wool, a distance list must be mounted. The screw length must be adapted to the thickness of the distance list. Type of screws used must be in accordance to the gypsum board suppliers mounting instructions.

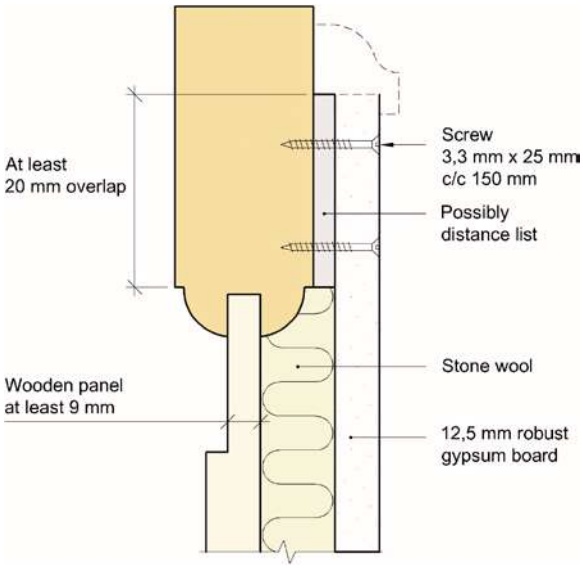

Figure 3-8 One-sided covering on door leaves when the wood panel is less than 21 mm. The solution is based on [4].

Because of the heavy use of an entrance door, it is recommended to use 12.5 mm robust gypsum boards as covering. These boards are expected to have a fire resistance equal to 15 mm fire gypsum board and 12.5 mm fibre gypsum board; approximately 30 minutes. See Figure 3-9 for mounting details.

Figure 3-9 Detail for mounting of stone wool and robust gypsum board on wood panel

3.3 Mounting of sealing lists

There are two alternatives for smoke sealing around the door; intumescent strips or smoke lists. Intumescent strips expand on heat and will only work when the temperature in the fire room has become high enough. Cold smoke early in the fire development will escape the intumescent strip. Therefore, a smoke list to stop the cold smoke must be mounted in addition. Both types of lists must be milled into the frame of the door leaf or into the door leaf to ensure they sit correctly and provide a robust solution. See Figure 3-10 for mounting details.

The smoke lists should be made of silicone (silicone does not melt during the early stages of fire).

Figure 3-10 Detail for mounting of intumescent strip and smoke list

3.4 Door frame

The area between the door frame and the wall can be a weak point in the construction. An example of how to make a fireproof connection between the door frame and the wall is given below:

- The size of the gap between the frame and the wall can be approximately 10-20 mm.
- Fill the gap with stone wool
- Finish by adding fire sealant along the gap on both sides of the door.

3.5 Door hardware

The building hardware has an important role during a fire to ensure that the door leaf can maintain the integrity. General rules to consider are:

- The latch and the core of the handle shall be made of metal with a melting point of at least 850 °C, for example steel. The latch should have a grip of at least 12-13 mm.
- Hinges should be considered and may have to be replaced by more robust ones, especially if a fire resistant glass or gypsum board is mounted due to the increase in weight. It could also be considered to add an extra hinge to the top of the door leaf to supplement existing ones.
- Where door closers are installed, they may need to have the connection points reinforced due to the potential higher weight of the door leaf. Any connection points shall not be allowed to pass through the door leaf.

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