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Fire Resistance of Gypsum Board Wall Assemblies

by **M.A. Sultan and G.D. Lougheed**

This Update discusses the importance of various factors in achieving the required fire resistance for walls in multi-family dwellings. The information is based on results from an extensive industry-supported research project carried out by the National Research Council's Institute for Research in Construction (IRC).¹



Figure 1. A gypsum board wall assembly undergoing testing in IRC's propane-fired vertical furnace.

Researchers at IRC set out to determine how the sound transmission class (STC) and the fire-resistance ratings (FRR) of insulated and non-insulated gypsum board wall assemblies would be affected by two different kinds of changes. First, new requirements in the 1990 National Building Code of Canada (NBC) increased the STC between dwelling units from 45 to 50 and second, the standard regulating the use of gypsum board called for the removal of minimum density requirements for gypsum board.

Whole systems, not just materials, were tested to get a complete picture of how various parameters affect acoustic and fire performance, as the achievement of high acoustic performance may

have negative implications for fire performance, or the other way around.

In the fire testing, the assemblies were exposed to heat in a propane-fired vertical furnace. Each assembly was given a fire-resistance rating based on the time it took to fail in any way — structurally, or by exceeding a specified temperature, or permitting the penetration of flames or gases hot enough to ignite cotton waste.²

Influence of Various Factors on Fire Resistance

The influence of the various parameters (see box, page 2) are as follows:

Type of Gypsum Board

Gypsum board with glass fibre in the gypsum core provides better fire resistance than gypsum board without glass fibre. This is due to the fact that the lighter the gypsum board is, the more easily it cracks; and the more cracks it has, the more susceptible it is to disintegration in a fire. The glass fibre in the core helps keep the gypsum board together. When there is more than one layer of gypsum board on each side of the assembly, the presence of glass fibre in the gypsum core has less effect.

In load-bearing assemblies with lightweight regular gypsum board, the presence of the glass fibre in the gypsum board core increased the fire-resistance rating of an assembly with a single layer of gypsum board (with a density of 7.35 kg/m²) on each side by 25 percent compared to the same single-layer assembly with no glass fibre in the gypsum core (with a density of 7.27 kg/m²).

Density of Gypsum Board

The fire resistance of wall assemblies with regular (standard) gypsum board increases as the density of the gypsum board increases.

When non-load-bearing assemblies with a double layer of regular gypsum board on each side (2x2) were tested, an assembly with gypsum board of a higher density (7.82-kg/m²) provided a slightly better

The project investigated the effects of the following parameters on the fire resistance of 22 wall assemblies:

Symmetrical and asymmetrical arrangements of gypsum board. Three different wall assembly arrangements on wood studs and on lightweight-steel studs were studied:

- symmetrical installation (1x1) — one layer of gypsum board on both the fire-exposed and unexposed sides
- asymmetrical installation (1x2) — one layer of gypsum board on the exposed side and two layers of gypsum board on the unexposed side. For all tests performed on asymmetrical assemblies, the side of the wall with the single layer of gypsum board was exposed to fire since this is the more conservative orientation.
- symmetrical installation (2x2) — two layers of gypsum board on each side.

Type, density and thickness of gypsum board. Two gypsum board types were evaluated:

- Type-X, which is a generic name used to designate gypsum board with a specially formulated core that provides a greater fire resistance than regular gypsum board. Both 12.7-mm and 15.9-mm thicknesses were tested.
- Regular gypsum board, 12.7 mm thick with densities (mass per unit area) of:
 - 7.82 kg/m² with no glass fibre in the gypsum core
 - 7.35 kg/m² with glass fibre in the gypsum core. (This lightweight gypsum board was manufactured specifically for this project.)
 - 7.27 kg/m² with no glass fibre in the gypsum core.

Both types conformed to CAN/CSA.A82.27-M91, the standard regulating the use and application of gypsum board.

Resilient channel installation. A resilient channel is a long strip of thin steel with a stepped configuration where one vertical leg is attached to the stud and the other to the gypsum board; it has a total width of about 25 mm. Resilient channels were attached horizontally on either the fire-exposed side or the unexposed side, spaced at 400 mm on centre perpendicular to the wood studs. The gypsum board was then attached to the resilient channels. The purpose of these channels is to provide a discontinuity so that sound is less able to be transmitted through the assembly.

Type of insulation. Glass fibre, rock fibre, and cellulose fibre insulation were tested.

Stud type and arrangement. The wood-stud walls tested included both load-bearing and non-load-bearing assemblies, although all steel-stud walls tested were non-load-bearing. The wood-stud configurations included single, double and staggered rows. A single plate was used for assemblies with single and staggered studs and double plates were used for assemblies with double studs.

fire-resistance rating than an assembly with gypsum board of a lower density (7.35-kg/m²).

Number and Arrangement of Gypsum Board Layers

Increasing the number of layers on each side from one to two improves the FRR.

Using an asymmetrical assembly (1x2), however, offers no particular advantage over that of a symmetrical (1x1) assembly for a load-bearing wall assembly since it must be assumed that the fire will start on the single-layer (weakest) side.³ Thus, the fire-resistance rating for an asymmetrical (1x2) assembly is comparable to that of the symmetrical (1x1) assembly. While the asymmetrical arrangement can help achieve a higher STC, it does not improve the FRR.

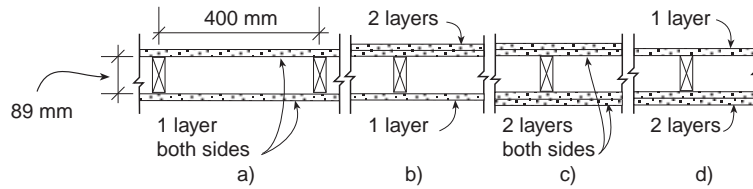
In load-bearing (wood) assemblies with glass fibre insulation in the wall cavity and with resilient channels, a symmetrical assembly with a double layer of 12.7-mm thick gypsum board (2x2) provided a 55-percent increase in the FRR as compared to an asymmetrical (1x2) assembly.

Thickness of Gypsum Board

Increasing the thickness of the gypsum board layer does not appear to improve the FRR when resilient channels are present on the single-layer side.

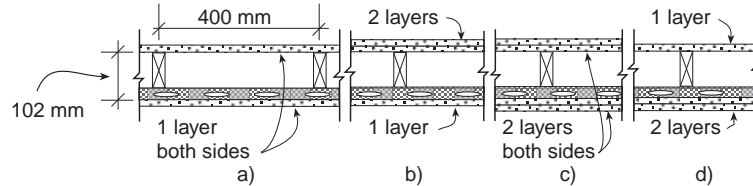
When load-bearing asymmetrical assemblies (1x2) with glass fibre insulation in the wall cavity and resilient channels located on the side with the single layer of gypsum board (fire-exposed side) were tested, changing the Type-X gypsum board thickness

Basic Wall Configurations Tested



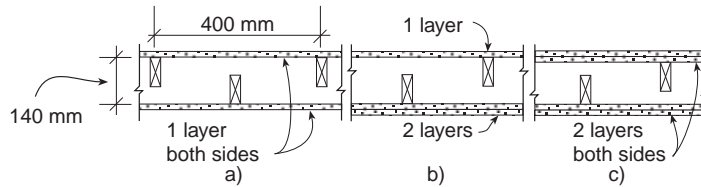
Wall construction 1. **Single wood studs**

- one or two layers of gypsum board
- 38-mm x 89-mm studs
- with or without absorptive material
- one or two layers of gypsum board



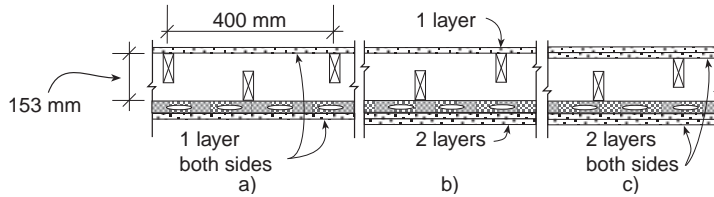
Wall construction 2. **Single wood studs with resilient channels**

- one or two layers of gypsum board
- 38-mm x 89-mm studs
- with or without absorptive material
- resilient channels on one side
- one or two layers of gypsum board



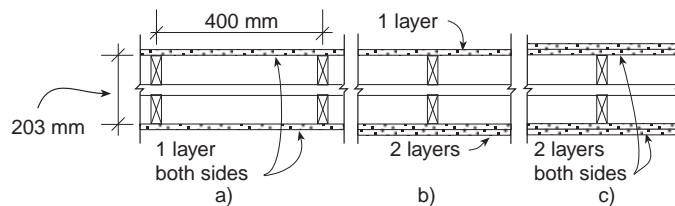
Wall construction 3. **Staggered wood studs**

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs staggered on common 38-mm x 140-mm plate
- with or without absorptive material
- one or two layers of gypsum board



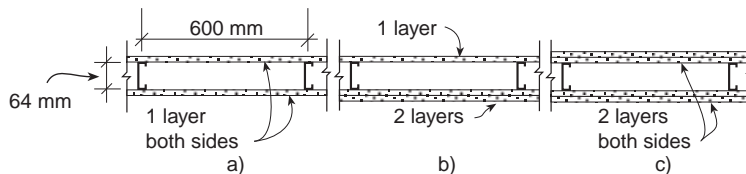
Wall construction 4. **Staggered wood studs with resilient channels**

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs staggered on common 38-mm x 140-mm plate
- with or without absorptive material
- resilient channels
- one or two layers of gypsum board



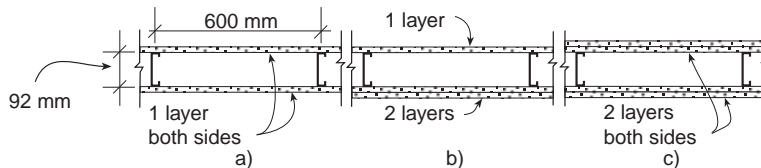
Wall construction 5. **Double wood studs**

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs on separate 38-mm x 89-mm plates set 25 mm apart
- with or without absorptive material
- one or two layers of gypsum board



Wall construction 6. **Non-load-bearing steel studs (64 mm)**

- one or two layers of gypsum board
- 31-mm x 64-mm non-load-bearing studs
- with or without absorptive material
- one or two layers of gypsum board



Wall construction 7. **Non-load-bearing steel studs (92 mm)**

- one or two layers of gypsum board
- 31-mm x 92-mm steel studs
- with or without absorptive material
- one or two layers of gypsum board

from 12.7 mm to 15.9 mm did not improve the fire-resistance rating. However, the fact that the fire-resistance rating did not improve with the increased thickness was mainly due to the ignition of the wood studs, caused by the penetration of the hot gases through the unprotected gypsum board butt joints. The gap between the studs and the gypsum board, created by the presence of the resilient channels, acted as a passageway through which the flames and hot gases spread after entering the cavity.

When resilient channels are not used, the FRR of the same assembly can be improved from 25 minutes to 40 minutes by increasing the thickness of Type-X gypsum board from 12.7 mm to 15.9 mm.

Installation of Resilient Channels

In some cases, resilient channels can help to improve the fire resistance of the assembly; however, locating these channels on the single-layer side may significantly decrease the fire resistance of the assembly.

In the asymmetrical (1x2) load-bearing assemblies with rock fibre insulation and resilient channels, the assembly with resilient channels installed on the double-layer side provided an 11-percent better fire-resistance rating than the same assembly with resilient channels installed on the single-layer (fire-exposed) side.

Type and Installation of Insulation

Rock fibre insulation installed in the cavity of the wall assembly contributes significantly to its fire resistance. To maximize the benefits of insulation on the fire-resistance rating, it is important to install the insulation tightly between the studs.

When the rock fibre insulation was installed in non-load-bearing assemblies in this way, it provided a 60-percent better fire-resistance rating (100 minutes) than when it was installed loosely (60 minutes).

In non-load-bearing asymmetrical (1x2) steel-stud assemblies, the installation of either glass fibre or cellulose fibre (wet sprayed) insulation did not affect the fire-resistance rating.

Type of Stud

The type of stud used in non-load-bearing walls is insignificant for assemblies with two layers of gypsum board on each side.

In non-load-bearing assemblies with a double layer of gypsum board on each side (2x2), the assembly with wood studs provided a slightly better fire-resistance rating than assemblies with steel studs. (Assemblies with one layer of gypsum board on each side were not tested, because they did not meet STC criteria.)

Arrangement of Studs

There are no particular benefits in terms of fire performance in using staggered studs or double studs instead of single studs, although these configurations can help enhance acoustic performance.

Impact on the Industry

As a result of this project and the related project by IRC's Acoustics Laboratory on the STC of wall assemblies, the fire- and sound-resistance ratings of wall assemblies in Part 9 of the 1995 NBC have been updated and augmented from 17 listed assemblies in the 1990 Code to over 160 in the 1995 Code.

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1. The project was supported by a consortium that included Canada Mortgage and Housing Corporation (CMHC), Canadian Sheet Steel Building Institute (CSSBI), Cellulose Insulation Manufacturers Association of Canada (CIMAC), Forintek Canada, Gypsum Manufacturers of Canada (GMC), IRC, Owens Corning Fiberglas Canada Inc., and Roxul Inc.
2. Since the NBC stipulates the required fire-resistance rating as well as the type of construction that an assembly used in a particular occupancy and location must have, and since there are no fire-resistance ratings of less than 45 minutes included in the Code, assemblies that had a FRR of less than 45 minutes were considered to have failed.
3. However, for a non-load-bearing assembly, a 1x2 assembly provides a better fire resistance than a 1x1 assembly.

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