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Factors Governing Fire Resistance of Loadbearing Steel Stud Walls

V. K. R. Kodur and M. A. Sultan
Institute for Research in Construction
National Research Council Canada
Ottawa, Ontario, Canada, K1A 0R6

Abstract

This paper presents the effect of various factors on the fire resistance of loadbearing, gypsum board protected, steel stud wall assemblies. A detailed experimental study was conducted to evaluate the fire resistance of 14 full-scale steel stud wall assemblies. Both single row and double row steel stud configurations with installation of gypsum board on each of the exposed and unexposed sides, and with and without insulation in the cavity, were considered in the experimental program. The insulation used were glass, rock and dry blown cellulose fibers.

Data from the experimental program is used to determine the effects of stud-spacing, shear membrane, load intensity, resilient channel installation, insulation type and gauge thickness of studs on the fire resistance of gypsum board protected, steel stud wall assemblies. Details of the results, including the temperatures and deflections, measured during the fire resistance tests, are presented.

Introduction

In recent years, steel stud framing has found wide application in residential buildings. Loadbearing steel stud wall assemblies form part of steel stud framing and are often used as party walls in townhouses and as party and corridor walls in multi-unit low-rise construction. Consequently, in Canada, they are required to meet fire resistance requirements. There is very limited information on the fire resistance performance of such assemblies in the literature and in the building codes.

To generate necessary fire resistance information, a major collaborative research project was initiated with eight industry partners to develop fire resistance ratings for various types of wall assemblies. One of the major components of this project is loadbearing steel stud wall assemblies. Fourteen full-scale fire resistance tests were conducted to determine the effects of various parameters on the fire resistance of loadbearing gypsum board protected, steel stud wall assemblies. Test parameters included stud-spacing, shear bracing, load intensity, gauge thickness, resilient channel installation and insulation type.

Results from the studies show that the insulation type and stud-spacing has a significant influence on the fire resistance of steel stud wall assemblies. Details of the results, including the temperatures and deflections measured during the fire tests on gypsum board protected, steel stud shear wall assemblies, will be presented in the paper.

Experimental Program

To determine the effects of various parameters on the fire resistance of gypsum board protected, steel stud wall assemblies, a detailed experimental study was undertaken. The experimental program consisted of fire tests on 14 full-scale steel stud wall assemblies. Systems tested were replicates of wall assemblies commonly used in North America. Thirteen of the wall assemblies were provided with steel cross-bracing to enhance lateral resistance while the fourteenth wall assembly was provided with an OSB shear membrane. All assemblies were protected with Type X gypsum board on both fire exposed and unexposed sides. The various details for each of the walls such as depths, number of layers of gypsum board, resilient channels and insulation type are given in Table 1.

Results and Discussion

The results of the 14 full-scale fire resistance tests are summarized in Table 1 in which the time and mode of failure are given for each assembly. For all wall assemblies, the unexposed surface temperature (average of single reading temperatures) at the time of structural failure was below the temperature failure criteria. All wall assemblies failed structurally through excessive deflection.

Results from the tests have indicated the main factors, which significantly influenced the performance of the wall assemblies, were the number of gypsum board layers, the presence of resilient channels, stud-spacing and the type of insulation in the wall cavity. From Table 1, it can be seen that the effect of stud spacing has a significant influence on the fire resistance of the steel stud wall assembly. The stud-spacing in Wall Assembly F28 was 610 mm while in F38 it was 406 mm. The assemblies were loaded with corresponding design loads. The failure in Assembly F28 occurred at 74 minutes while in Assembly F38, the failure resulted in 59 minutes (see Table 1). These results indicate that stud-spacing has a significant influence on fire resistance of loadbearing steel stud walls, with 610 mm spacing having higher fire resistance than 406 mm spacing. This could be attributed to factors such as load redistribution that occur during the later stage of fire exposure.

The type of insulation also played a major role on the performance of the steel stud walls exposed to fire. Results from fire resistance tests F27, F31, F37 and F38 can be used to determine the effect of insulation type on the fire resistance of loadbearing (single row) steel stud walls (see Table 1). These wall assemblies were of a similar configuration except for the type of insulation. The uninsulated wall Assembly, F37, provided the highest fire resistance of 77 minutes. The failure of the glass fiber insulated wall assembly (F27) occurred at 56 minutes, while the failure of the rock fiber (F38) and cellulose (F31) insulated wall assemblies occurred at 59 and 71 minutes, respectively. These results suggest that maximum fire resistance can be obtained in a steel stud wall assembly with no insulation in the cavity. Further, the use of rock fiber insulation provides a higher fire resistance compared to glass fiber insulation, but a lower fire resistance compared to cellulose fiber insulation.

Details of the results, including figures showing the temperatures and deflections measured during the fire tests on gypsum board protected, steel stud wall assemblies, will be presented in the paper. Data from the experimental studies will be used to discuss the additional effects, such as number of stud rows, load intensity, gauge thickness, and resilient channel installation on the fire resistance of gypsum board protected, steel stud wall assemblies.

Summary

Full-scale fire resistance tests were conducted to determine factors governing the fire resistance of gypsum board protected, loadbearing steel stud wall assemblies. Based on the results from the tests, the following points can be summarized:

1. The type of insulation has a significant effect on the fire resistance of loadbearing steel stud walls. Wall assembly without insulation provides higher fire resistance compared to an insulated assembly.
2. The stud spacing has a significant influence on fire resistance of loadbearing steel stud walls, with 610 mm spaced walls having higher fire resistance compared to 406 mm spaced walls.
3. In loadbearing gypsum board protected steel stud wall assemblies, replacing a gypsum board layer with OSB shear membrane, results in a significant decrease in the fire resistance of the assembly.
4. The double row steel stud walls have higher fire resistance compared to single row steel stud walls.
5. For the loadbearing steel stud wall assemblies installation of resilient channels, on the fire-exposed side, slightly decreases fire resistance by about 7%.
6. Steel stud walls with "MSG 20 light" gauge studs provide slightly higher fire resistance compared to walls with "MSG 20" gauge studs.

Table 1. Steel Stud Wall Assembly Parameters and Fire Resistance Test Results

Wall Ass.	Stud Rows	Shear Resistance		Stud Spacing	Gypsum Board Layers	Gypsum Board Thickness[2]	Insulation Type	R.C.	Applied Load	Fire Resistance	Mode of Failure
		Membrane	Cross Brac.	(mm)	(Exp./ Unexp.)	(mm)			(kN)	(min)	
F25	2	-	Y	406	1x1	15.9	-	-	156.7	35	LB
F26	2	-	Y	406	2x2	12.7	RFI	-	156.7	84	LB
F27	1	-	Y	406	2x2	12.7	GFI	Y	78.4	56	LB
F28	1	-	Y	610	2x2	12.7	RFI	Y	52.4	74	LB
F29	1	Y[1] Exp.	-	406	1x2	12.7	GFI	Y[3] Unexp	78.4	33	LB
F30	2	-	Y	406	2x2	12.7	-	-	156.7	100	LB/OB
F30R	2	-	Y	406	2x2	12.7	-	-	156.7	102	LB/OB
F31	1	-	Y	406	2x2	12.7	CI	Y	78.4	71	LB
F34	1	-	Y	406	1x1	15.9	RFI	-	78.4	31	LB
F35*	1	-	Y	406	2x2	12.7	GFI	Y	78.4	68	LB
F36*	1	-	Y	406	2x2	12.7	GFI	Y	70.9	63	LB
F37	1	-	Y	406	2x2	12.7	-	Y	78.4	77	LB
F38	1	-	Y	406	2x2	12.7	RFI	Y	78.4	59	LB
F39	1	-	Y	406	2x2	12.7	-	-	78.4	83	LB

Note: *All steel studs in wall assemblies F35, F36 are of "MSG20 Light" gauge with nominal 0.84 mm thickness
All steel studs in all other wall assemblies are of "MSG20" gauge with nominal 0.912 mm thickness
Y – Yes Y[1] – 12.7 mm OSB [2] – Type X Gypsum Board Y[3] – Unexposed side
GFI – R-12, Glass Fiber Insulation RFI – R-13, Rock Fiber Insulation CI – Cellulose Fiber Insulation (dry blown)
Exp. – Fire Exposed Side Location Unexp. – Unexposed Side Location R.C. – Resilient Channel
LB – Local Buckling (Structural Failure) OB – Overall Buckling (Structural Failure) kN – Kilo Newton