

Full length article

Detrimental effects of plasterboard joints on the fire resistance of light gauge steel frame walls



Anthony Deloge Ariyanayagam, Sivakumar Kesawan, Mahen Mahendran*

Queensland University of Technology (QUT), Brisbane, Australia

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ABSTRACT

Light gauge Steel Frame (LSF) walls are commonly used in building construction. In general, they are lined with single or double layers of gypsum plasterboards with and without cavity insulation. Gypsum plasterboards act as a thermal barrier to protect the thin-walled steel studs from rapid temperature rise. In these walls, plasterboard joints are located along the studs for ease of construction and are protected by filler materials. During fires, these plasterboard joints crack and open up, and thus allow the stud temperatures to rise rapidly and initiate premature structural failures in LSF walls. This research investigated the detrimental effects of these plasterboards joints on the fire resistance rating of single and double plasterboard lined walls based on the hot flange time-temperature profiles of studs from full scale fire tests. To overcome the detrimental effects of plasterboard joints, the back-blocking technique was used, where plasterboard joints were placed between studs with 150 mm wide plasterboards as back-blocks. Full scale fire tests and numerical studies were performed on single plasterboard lined load bearing LSF wall panels to investigate the improved fire performance by using this technique. They showed that the fire resistance rating of these LSF walls was increased by 25% in comparison to the conventional plasterboard joint arrangement over the studs. This paper presents the details of this research on the detrimental effects of plasterboard joints on the fire resistance of load bearing LSF walls, and the results. It also includes a discussion and results for non-load bearing LSF walls.

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1. Introduction

Light gauge Steel Frame (LSF) wall systems are commonly used in residential and commercial buildings due to many advantages they provide over other wall construction products. LSF walls are made of cold-formed steel frames and are lined with fire protective boards and cavity insulation (Fig. 1). In building construction, they are used as primary load bearing structural members. They also act as fire separating elements to resist the spread of fire and hot toxic gases to adjacent compartments. Fire is considered as one of the severe disasters buildings could be subjected to in their life span. Therefore LSF walls used in buildings should satisfy the necessary fire resistance requirements.

In load bearing LSF walls cold-formed steel stud wall frames provide structural stability, wall linings protect the steel frame from fire by delaying the stud temperature rise, and insulation improves the acoustic and thermal performances. The wall linings also provide lateral restraint to the wall studs, thus prevent minor-axis flexural buckling and twisting, resulting in an increased

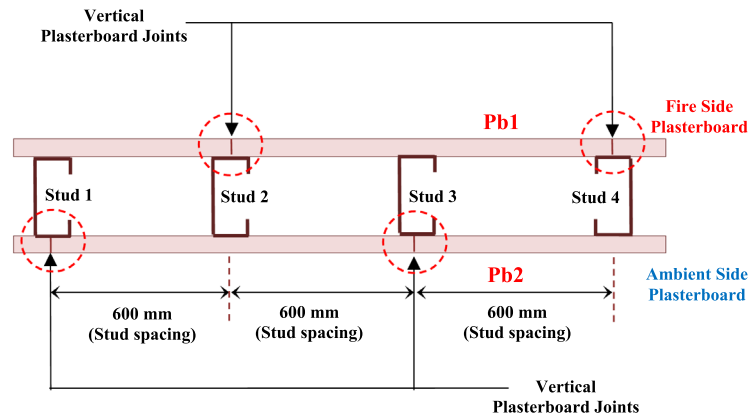
structural capacity of the steel frame. Hence wall linings have an important role in obtaining the required Fire Resistance Rating (FRR) of different LSF wall configurations; single and double layers of plasterboard lined walls with and without cavity insulation.

Gypsum plasterboard is widely used as the common wall lining material in LSF wall construction. The types and thicknesses of gypsum plasterboard used significantly enhance the FRR of LSF walls when subjected to fire from one side as they delay the temperature rise of the stud. The plasterboard type includes specially manufactured fire resistant gypsum plasterboards or the general purpose plasterboards in thicknesses ranging from 8 to 25 mm.

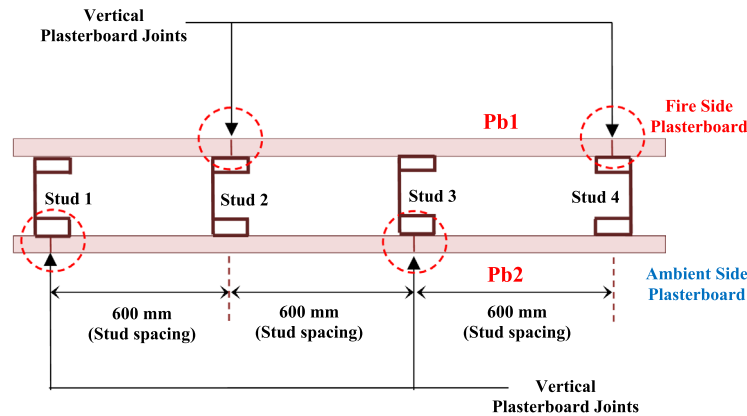
Gypsum plasterboards have moisture in them. Gypsum crystal consists of free water and chemically combined water. Its chemical formula is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, known as Calcium sulphate di-hydrate. The moisture in gypsum plasterboard is important because it contributes to the excellent fire resisting behaviour than other wall lining boards. When heated, gypsum plasterboard undergoes two reactions in which the moisture is removed. Significant energy is required to evaporate the free water and to release the water in the crystal structure. Due to this water evaporation process from gypsum plasterboards stud temperature rise is delayed when exposed to fire. This was observed as plateaus at nearly 100 °C in the

* Corresponding author.

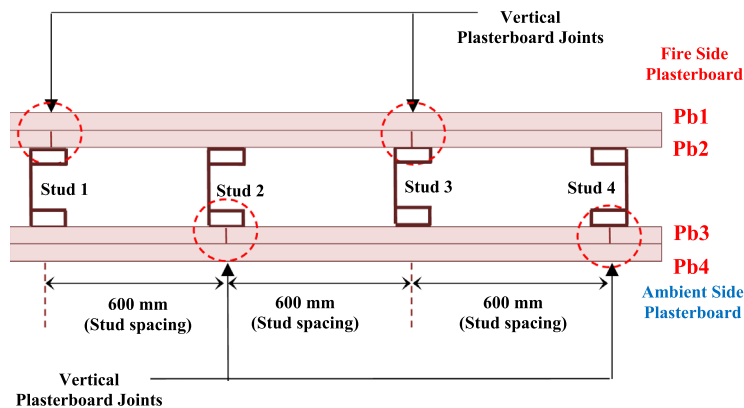
E-mail address: m.mahendran@qut.edu.au (M. Mahendran).



(a) Single plasterboard lined LSF walls made of channel sections



(b) Single plasterboard lined LSF walls made of hollow flange channel sections



(c) Dual plasterboard lined LSF walls LSF walls made of hollow flange channel sections

Fig. 1. Plasterboard joints along the studs in LSF walls.

stud time-temperature graphs of previously conducted fire tests [1–3] of LSF wall panels as shown in Figs. 2 and 3. This process is known as dehydration of free water and chemically bound water in gypsum plasterboards, and is an important process in the event of a fire. Other materials present in gypsum plasterboard such as glass fibre, vermiculite and perlite additives improve the durability and the performance when exposed to fire conditions. Considerable research studies have been conducted and are in progress to improve the fire resistance properties of gypsum plasterboards further while new plasterboards are being manufactured in many

countries. This will ultimately improve the FRR of LSF walls. However, plasterboard joints are inevitable in the construction of LSF walls and considered as the weakest element in regard to the FRR of LSF wall panel.

In general, the board joints in single gypsum plasterboard lined LSF walls are located vertically over the studs (along their length – Fig. 1). Recent experimental studies [1–3] conducted on the fire performance of load bearing LSF walls have shown that plasterboard joints over the studs significantly influenced the stud temperature rise (Figs. 2 and 3). In these load bearing LSF wall fire

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