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# Potential of Using Lightweight Foamed Concrete in Composite Load-Bearing Wall Panels In Low-Rise Construction

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Abstract

This paper will look at the potential of using lightweight foamed concrete (LFC) in composite load-bearing wall panels in low-rise construction. From the experimental verification, as expected the mechanical properties of LFC were reasonably low when compared to normal strength concrete. Nonetheless there was a potential of using LFC as fire resistant partition or as load-bearing walls in low-rise residential construction. In order to demonstrate the feasibility of this proposal, this paper presents a preliminary feasibility study on its fire resistance and structural performance of LFC based system. The objectives of this feasibility is two-fold; to investigate the fire resistance performance of LFC panels of different densities when exposed to fire on one side for different fire resistance ratings based on insulation requirement and to examine whether the composite walling system had sufficient load carrying capacity, based on compression resistance at ambient temperature.

*Keywords: foamed concrete; thermal properties; mechanical properties; composite walling; sandwich panel.*

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## 1. Introduction

Presently the construction industry has shown significant interest in the use of lightweight foamed concrete (LFC) as a building material due to its many favourable characteristics such as lighter weight, easy to fabricate, durable and cost effective. LFC is a material consisting of Portland cement paste or cement filler matrix (mortar) with a homogeneous pore structure created by introducing air in the form of small bubbles. With a proper control in dosage of foam and methods of production, a wide range of densities (400 – 1600 kg/m$^3$) of LFC can be produced thus providing flexibility for application such as structural elements, partition, insulating materials and filling grades.

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LFC has so far been applied primarily as a filler material in civil engineering works. However, its good thermal and acoustic performance indicates its strong potential as a material in building construction. LFC is a cementitious material having a minimum of 20per cent by volume of mechanically entrained foam in the mortar slurry in which air-pores are entrapped in the matrix by means of a suitable foaming agent. The air-pores are initiated by agitating air with a foaming agent diluted with water; the foam then carefully mixes together with the cement slurry to form LFC. Integrating the air-pores into the base matrix gives a low self-weight, high workability, excellent insulating values, but lower strength in contrast to normal weight concrete. LFC can be fabricated anywhere in any shape or building unit size.

This research is concerned with exploring the potential of using LFC as a building material. Although LFC mechanical properties are low compared to normal weight concrete, LFC may be used as partition or light load-bearing walls in low rise residential construction. LFC has very low thermal conductivity, making it a suitable material for building use as insulating or fire resisting material due to its porous internal structure. LFC can also be made to have a reliable amount of compressive resistance, making it possible to use LFC as load-bearing material.

However, the experimental results on compressive properties of LFC indicated that LFC suffered from brittle failure. Therefore, a suitable method of using LFC in load-bearing construction would be to use it in composite action with steel, which has high ductility. This particular section explores the use of LFC in composite action with steel sheeting in lightweight composite walling construction. Should LFC be cast in-situ, the thin steel sheeting can be used as formwork during construction. Because of the low density of LFC, the pressure on the steel sheeting during construction would be much lower than using normal weight concrete, allowing thin steel sheeting to be used. Before such a system can be used in practice, it is necessary to carry out fundamental research to thoroughly investigate its behaviour.

## 2. Specimens preparation

This paper will only presents the results of an experimental investigation into the structural behaviour of a composite panel system consisting of two outer skins of profiled thin-walled steel plates with lightweight foamed concrete (LFC) core under axial compression. The dimensions of the test specimens were 400mm high by 400mm wide by 100mm thick. The short height of the specimens would mean that failure of the specimens would be governed by cross-sectional capacity.

A total of 12 prototype specimens were tested under axial compression. These 12 specimens consisted of two duplicates of 6 types, being two steel thicknesses (0.4mm and 0.8mm) in combination with three edge conditions of the steel sheeting. The density of LFC core was 1000 kg/m$^3$. LFC with density of 1000 kg/m$^3$ was chosen as it was found to have a useful amount of mechanical properties to construct a lightweight load-bearing walling system when in composite action with the profiled cold-formed thin-walled steel sheeting.

The LFC core used in this study was made from Ordinary Portland Cement (OPC), fine sand, water and stable foam in which the details of the constituent materials is shown in Table 1. The main objectives of this research are to determine the thermal properties of LFC at high temperatures therefore only a constant cement-sand ratio of 2:1 and water-cement ratio of 0.5 will be used for all batches of LFC samples made for this research. A higher cement-sand ratio (2:1) was chosen to attain better compressive strength and water-cement ratio of 0.5 was found acceptable to achieve adequate workability. Table 2 gives details of mix proportions used for this research

TABLE 1: CONSTITUENT MATERILAS USED TO PRODUCE LFC

| Constituents | Type |
|---|---|
| Cement | Ordinary Portland Cement (OPC) |
| Sand | Fine sand with additional sieving to remove particles greater than 2.36 mm |
| Stable foam | Noraite PA-1 (protein based) surfactant with weight of around 70 to 80 gram/litre produce from Portafoam TM2 System |

TABLE 2: MIX PROPORTIONS OF LFC

| Target dry density (kg/m$^3$) | Target wet density (kg/m$^3$) | Portland Cement content (kg/m$^3$) | Fine aggregate (sand) content (kg/m$^3$) | Noraite PA-1 surfactant (kg/m$^3$) | w/c ratio |
|---|---|---|---|---|---|
| 1000 | 1136 | 568 | 284 | 34 | 0.5 |

Experimental results include failure modes, maximum loads and load-vertical strain responses. In analysis, full bond between the steel sheets and the concrete core was assumed and the LFC was considered effective in restraining inward buckling of the steel sheets.

Refer to Figure 1, the steel sheeting could have one of the three edge conditions: (a) the steel sheets do not cover the LFC panel thickness (referred to as no stopping edge), (b) the steel sheets cover the LFC panel thickness but were not joined (referred to as with stopping edges), (c) the steel sheets cover the LFC panel thickness and are joined by welding (referred to as welded stopping edge). These three steel sheeting edge conditions were investigated to assess the influence of the steel sheeting in restraining the LFC to improve its ductility. This paper will only present the mechanical property test results.

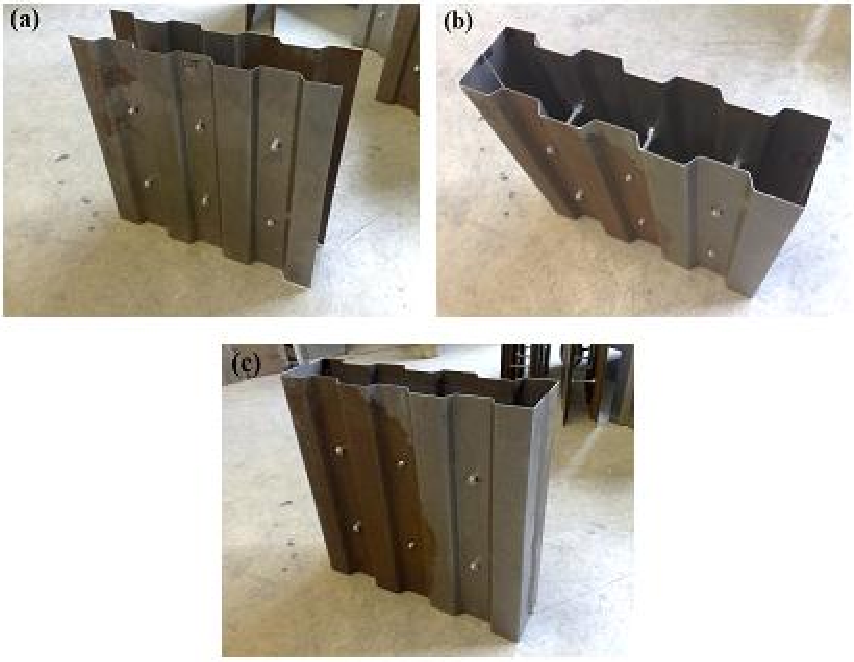


Figure 1: Steel sheeting edge conditions (a) no stopping edge (b) with stopping edge (c) with welded stopping edge

## 3. Axial compression test on composite walling

The specimens were loaded in axial compression and the test was carried out in a universal compression testing machine with a maximum capacity of 2,500 kN after 28 days of casting. The tests were displacement controlled. A number of strain gauges were placed on the specimens and in all cases; the strain gauges were at mid-height (h/2) of the specimen. The top and bottom of the specimens were ground flat prior to testing so as to ensure equal load distribution. In addition to the strain gauges on the sample, the displacement of the loading platen was also recorded to measure axial deformation of the specimen. Observations were made on general behaviour including cracking of concrete, buckling of sheeting and failure mode.

## 4. Results

TABLE 3: SUMARRY OF TEST RERSULTS OF COMPOSITE WALLING UNDER COMPRESSION

| Test no. | Reference * | Steel thickness (mm) | Ultimate strength (kN) |
|---|---|---|---|
| 0 | concrete alone | - | 125 |
| 1 | NSE1 | 0.4 | 161 |
| 2 | NSE2 | | 169 |
| 3 | NSE3 | 0.8 | 240 |
| 4 | NSE4 | | 247 |
| 5 | WSE1 | 0.4 | 175 |
| 6 | WSE2 | | 187 |
| 7 | WSE3 | 0.8 | 263 |
| 8 | WSE4 | | 272 |
| 9 | WE1 | 0.4 | 189 |
| 10 | WE2 | | 207 |
| 11 | WE3 | 0.8 | 285 |
| 12 | WE4 | | 302 |

** NSE = no stopping edge; WSE = with stopping edge; WE = welded edge*

Table 3 listed the ultimate strength (maximum load) of each specimen. Except for tests 9 and 10 which showed a difference of about 10%, other duplicate tests reached very similar ultimate strengths.

Figures 2-7 present the load versus mid-height vertical strain relationships for the six types of specimens. The different strain gauges (S1-S4 and B1-B4) recorded very similar data so only data from one of each set (S1 on the steel surface without any mechanical connectors, B1 on the steel surface between the mechanical fasteners was taken into consideration.

It can be seen from figures 2-7 that in all cases, the strain gauge S1 recorded more elastic strains than B1, indicating participation of the mechanical fasteners. In all cases, the test sample was able to sustain the maximum applied load for a considerable axial deformation. The descending branch of all the load-strain curves was gradual, indicating good ductility of the test specimen.

Table 3 showed that the ultimate strength of the specimens with stopping edge was about 10% higher than those without any stopping edge for both steel thicknesses. Panels with welded steel edges sustained on average 17% more load than those without stopping edge.

Figure 8 compares the load versus mid-height strain (point B1) relationships of the two steel sheeting thicknesses and three edge conditions. As expected, the ultimate load and axial stiffness of the composite panel increases with increasing steel thickness and improved edge condition.

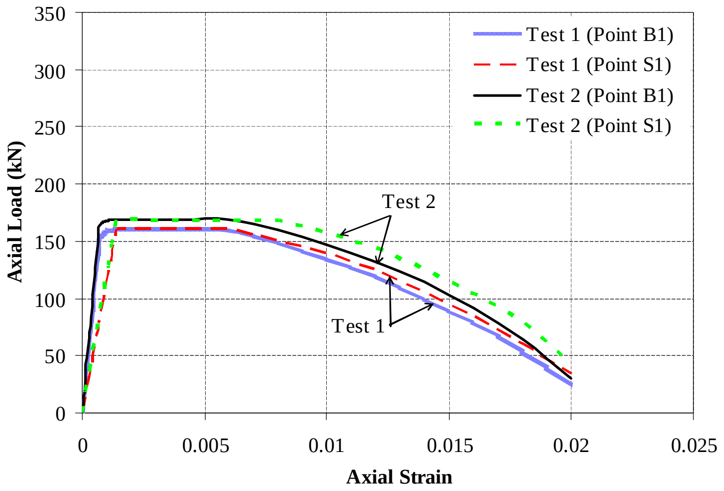


Figure 2**:** Load versus mid-height strain relationships for the panel with 0.4mm steel thickness and no stopping edge

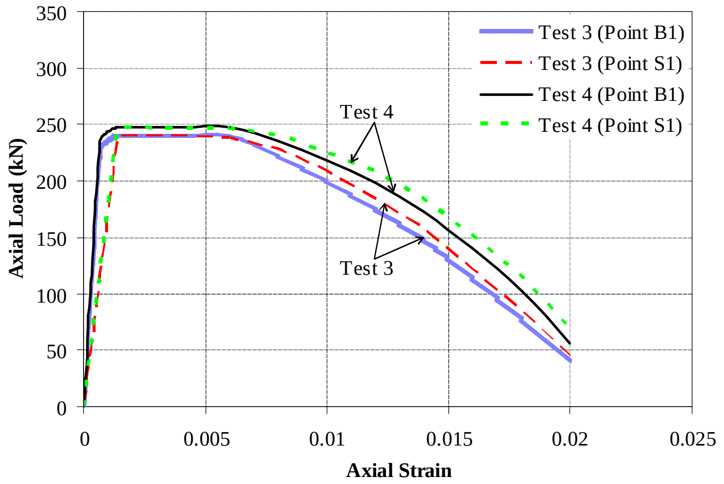


Figure 3: Load versus mid-height strain relationships for the panel with 0.8mm steel thickness and no stopping edge

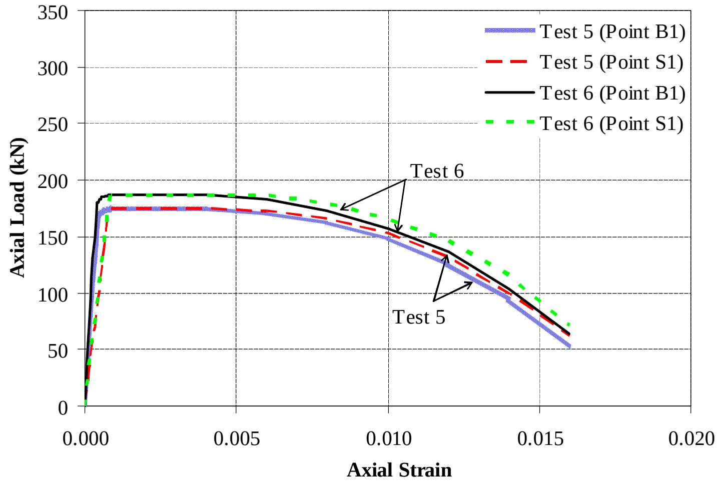


Figure 4**:** Load versus mid-height strain relationships for the panel with 0.4mm steel thickness and with stopping edge

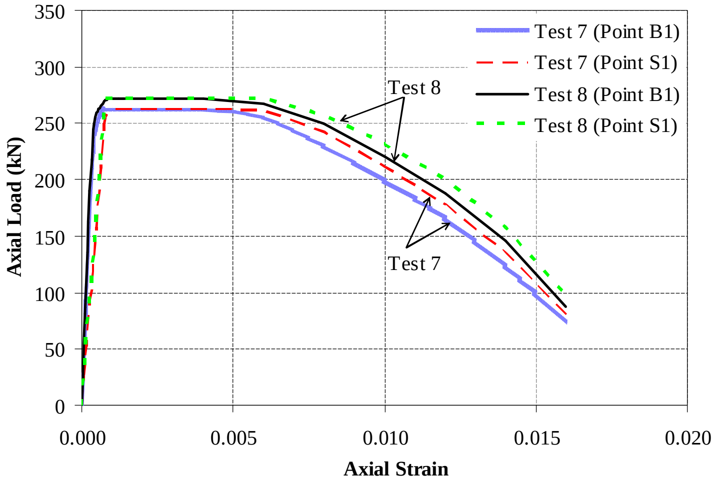


Figure 5: Load versus mid-height strain relationships for the panel with 0.8mm steel thickness and with stopping edge

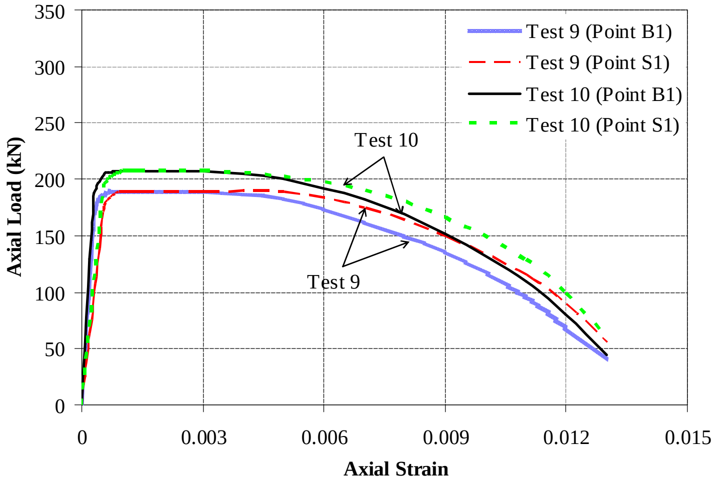


Figure 6: Load versus mid-height strain relationships for the panel with 0.4mm steel thickness and with welded edge

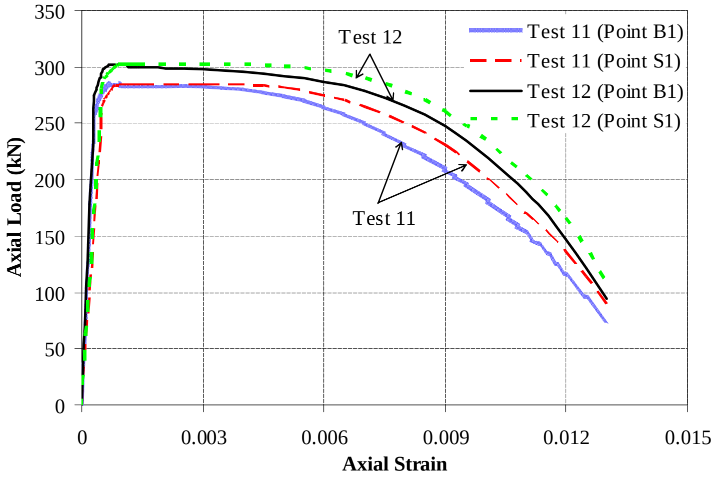


Figure 7: Load versus mid-height strain relationships for the panel with 0.8mm steel thickness and with welded edge

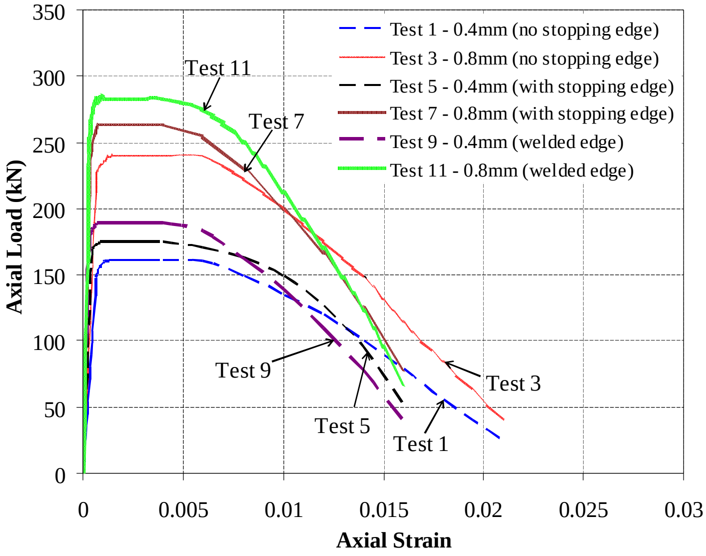


Figure 8: Comparison of load versus mid-height strain (point B1) relationships of the two steel sheeting thicknesses and three edge conditions and also with profiled panels without steel sheeting.

## 5. Discussions

Figure 9 shows a failed sample for all three edge conditions; (a) without stopping edge, (b) with stopping edge and (c) with welded edge. The steel sheeting experienced local buckling before failure, but the LFC core of 1000 kg/m$^3$ density was capable of preventing the panel from inward buckling.

In all cases, failure of the panel was initiated by local buckling of the steel sheeting, followed by crushing of the LFC core. Although the steel sheeting provided some ductility to the panel, the welded steel edges were not able to provide much confinement effect to the LFC panel. There was no separation of the steel sheeting from the LFC core until near failure, indicating that the mechanical fasteners were able to hold the steel sheeting and the LFC core together to enable them to resist the applied load in composite action.

Clearly, if composite walling system using LFC is to be used in real projects, bond between the profiled steel sheeting and the LFC infill should be considered. However, it is expected that because LFC would be less demanding owing to its lower strength than normal weight concrete, the steel sheeting used in composite walling systems using normal weight concrete would still be suitable.

(a) failure mode of panel without stopping edge with outward buckling of steel

(b) failure mode of specimen with stopping edge

(c) failure mode of specimen with welded edge

Figure 9: Failure modes for composite panel without stopping edge

## 6. Feasibility study on fire resistance and structural performance

This research so far has primarily concentrated on developing and validating thermal property models for LFC, characterizes its mechanical properties at high temperatures and concentrated on experimental study of the structural behaviour and ultimate load carrying capacity of a composite walling system under axial compression. From the experimental results, it was clear the mechanical properties of LFC were reasonably low in comparison with normal weight concrete. However there was a potential of using LFC as fire resistant partition or as load-bearing walls in low-rise residential construction.

In turn to exhibit the feasibility of this proposal, this section presents a preliminary feasibility study on the fire resistance and structural performance of LFC based system which will focus on two aspects as follows:

1. Investigating the fire resistance performance of LFC panels of different densities when exposed to fire on one side for different fire resistance ratings based on insulation requirement.

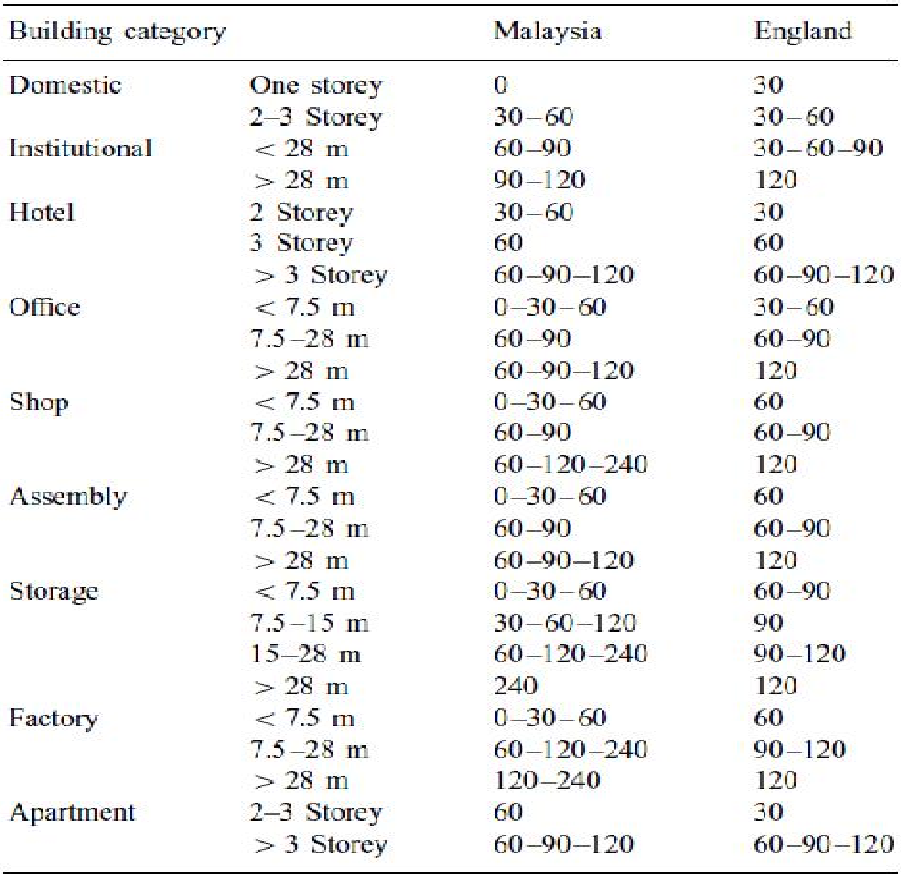
2. Examining whether the composite walling system had adequate load carrying capacity, based on compression resistance at ambient temperature.

### *6.1. Assessment of fire resistance performance in the context of fire requirements standard*

When designing a building, a very significant consideration is how it will behave in fire and ensure the elements of structure will not collapse but remain standing or hold back the fire for a prescribed time. The building regulation stipulates the rules and the degree of fire resistance of the elements of structure. For example, BS 476 [1] dictates the appropriate fire tests for these elements of structure and materials and grades the level of fire resistance. The author planned to develop and utilize this LFC panel system in Malaysia therefore discussion in this section will include the fire requirements stipulated in the Malaysia standard as well. All building constructions in Malaysia have to abide by the fire requirements specified in Part VII of the UBBL [2]. These requirements include the restrictions on spread of flame and fire resistance of structural members.

The Ninth Schedule of the UBBL [2] gives the minimum requirements for fire resistance (in hours) for single-storey (Part II) and multi-storey (Part I) buildings of various types. It also gave the notional fire rating values of various common types of construction. Similar fire requirements standard can also be found in other building by-laws and codes. The minimum statutory fire rating requirements for elements of structure in Malaysia and England are summarised in Table 4, for brevity and easy comparison.

TABLE 4: SUMMARY OF MINIMUM FIRE RATING REQUIREMENT IN MINUTES FOR ELEMENTS OF STRUCTURES IN MALAYSIA AND ENGLAND [3]



| Building category | | Malaysia | England |
|---|---|---|---|
| Domestic | One storey | 0 | 30 |
| | 2–3 Storey | 30–60 | 30–60 |
| Institutional | < 28 m | 60–90 | 30–60–90 |
| | > 28 m | 90–120 | 120 |
| Hotel | 2 Storey | 30–60 | 30 |
| | 3 Storey | 60 | 60 |
| | > 3 Storey | 60–90–120 | 60–90–120 |
| Office | < 7.5 m | 0–30–60 | 30–60 |
| | 7.5–28 m | 60–90 | 60–90 |
| | > 28 m | 60–90–120 | 120 |
| Shop | < 7.5 m | 0–30–60 | 60 |
| | 7.5–28 m | 60–90 | 60–90 |
| | > 28 m | 60–120–240 | 120 |
| Assembly | < 7.5 m | 0–30–60 | 60 |
| | 7.5–28 m | 60–90 | 60–90 |
| | > 28 m | 60–90–120 | 120 |
| Storage | < 7.5 m | 0–30–60 | 60–90 |
| | 7.5–15 m | 30–60–120 | 90 |
| | 15–28 m | 60–120–240 | 90–120 |
| | > 28 m | 240 | 120 |
| Factory | < 7.5 m | 0–30–60 | 60 |
| | 7.5–28 m | 60–120–240 | 90–120 |
| | > 28 m | 120–240 | 120 |
| Apartment | 2–3 Storey | 60 | 30 |
| | > 3 Storey | 60–90–120 | 60–90–120 |

### 6.2. Fire resistance performance of LFC panels

This section presented a limited amount of indicative study to investigate the fire resistance performance of LFC panels when exposed to fire on one side. For simplicity, the fire resistance requirement was based on thermal insulation, where the average temperature on the unexposed surface should not exceed 140$^{0}$C from ambient [1]. For this predictive study, standard fire curve was used as input data and the thermal boundary condition (heat transfer coefficients) was according to [4]. The results were presented as the minimum thickness of the panel for the following different initial densities (kg/m$^3$) of LFC: 650, 800, 1000, 1200, 1400 and 1600. The heat transfer analysis was carried out for 30, 60, 90 and 1200 minutes of the standard fire exposure time.

TABLE 5: INDICATIVE LFC MINIMUM THICKNESS FOR DIFFERENT FIRE RESISTANCE RATINGS FOR FIRE EXPOSURE FROM ONE SIDE

| LFC Dry density (kg/m$^3$) | Minimum LFC thickness (mm) for fire resistance rating of | | | |
|---|---|---|---|---|
| | 30 minutes | 60 minutes | 90 minutes | 120 minutes |
| 650 | 21.0 | 36.7 | 50.1 | 60.5 |
| 800 | 22.0 | 38.0 | 51.2 | 61.8 |
| 1000 | 23.1 | 39.1 | 52.3 | 63.2 |
| 1200 | 24.0 | 40.0 | 53.0 | 64.2 |
| 1400 | 26.9 | 43.5 | 55.9 | 67.4 |

Table 5 summarises the simulation results, presenting the minimum thickness of LFC required to achieve different fire resistance ratings for different densities. It was clear from Table 5 that as far as insulation performance was concerned, the lower the LFC density, the better. This was attributed to the lower thermal conductivity of lower LFC as shown in Figure 10. Although Figure 10 indicated steeper upward trend in lower density LFC due to greater void size, less water inside lower density LFC would reduce the initial thermal conductivity considerably so that within the practical range of temperature, the thermal conductivity of lower density LFC was lower.

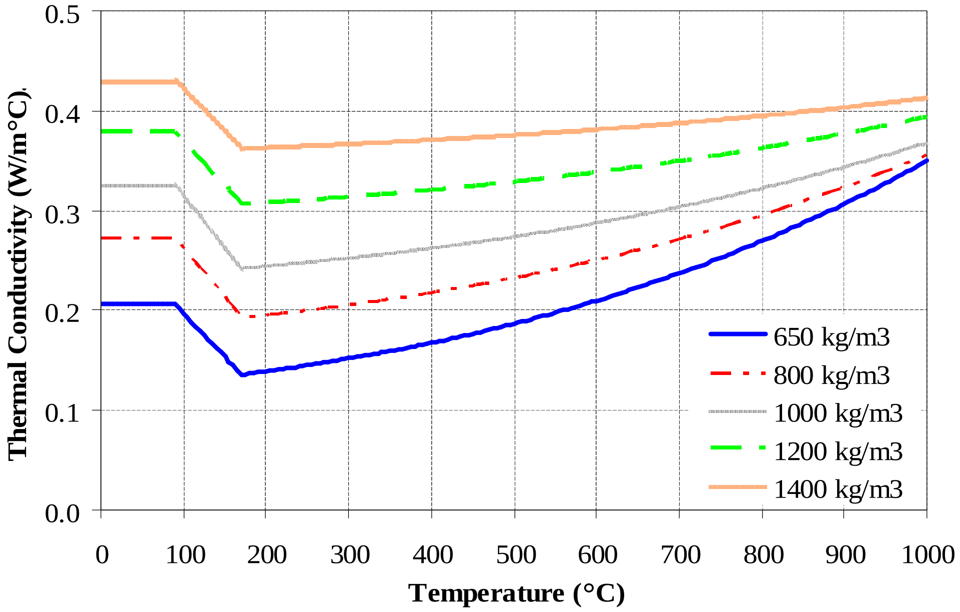


Figure 10: Thermal conductivity-temperature curves for all the densities used in this parametric study

The results in Table 5 indicated that although increasing LFC density would increase its specific heat, thus allowing more heat to be absorbed in LFC, as far as the unexposed surface temperature is concerned, which was used to assess insulation fire performance, thermal conductivity plays a more important role so that using higher density LFC had no advantage. The minimum thickness values in Table 5 were not particularly onerous. In fact, a single layer of 650 kg/m$^3$ density LFC of about 21 mm would achieve 30 minutes of standard fire resistance rating, more or less similar to gypsum plasterboard. This value is encouraging for application of LFC in building construction as fire resistant partitions.

From the indicative study results on LFC panels shown in Table 5, it can be concluded that if LFC panel of 100mm thickness of any density (650 to 1400 kg/m$^3$) was to be used in construction, it was able to meet the various fire rating requirements stipulated by the UBBL [2] for thermal insulation. For domestic construction, a fire resistance rating of 30 minutes can be easily met by LFC panels.

### *6.3. Feasibility of using LFC based composite walling system*

TABLE 6: DESIGN OF PROTOTYPE COMPOSITE PANEL

| Description | Unit | Value |
|---|---|---|
| Slab thickness | mm | 150 |
| Dead load (partitions and finishes) | kN/m$^2$ | 1.5 |
| Imposed loads (floor) | kN/m$^2$ | 2.5 |
| Self weight of slab (with normal weight concrete) | kN/m | =0.15*24*5=18.0 |
| Partition and finishes | kN/m | =5*1.5=7.5 |
| Characteristic dead load, $G_k$ | kN/m | =18+7.5=25.5 |
| Characteristic imposed load, $Q_k$ | kN/m | =5*2.5=12.5 |
| Design load, F | kN/m | =(1.4*25.5)+(1.6*12.5)=55.7 |
| Self weight of the panel (100 mm thick wall of 1000 kg/m$^3$) | kN/m | 3.2 |
| Load carried by Panel 1 | kN/m | 55.7 |
| Load carried by Panel 2 | kN/m | 114.6 |
| Load carried by Panel 3 | kN/m | 173.5 |
| Load carried by Panel 4 | kN/m | 232.4 |

The potential market for this composite walling system is low-rise residential construction. The practicability of this system was examined by analysing the investigation to verify whether the composite walling system has sufficient load carrying capacity. It was proposed to construct the interior load-bearing walls by using 100mm thick composite walls with 0.4mm steel sheeting, as tested in this research (presented in section 2). Figure 11 showed the elevation section of a four-storey residential building and the floor span is 5m. Table 6 summarizes the applied loads on the interior walls (panels 1-4) supporting different floors.

Table 7 compared the applied loads (per 0.4m) on the different panels with the available panel strengths (per 0.4m) based on the experimental results in Table 3. It was expected that the 3m wall panel as proposed in Figure 11 will have a lower strength than the

400mm high test panels due to buckling. This will be further examined in section 6.4, based on flexural buckling resistance. However, the results in Table 7 clearly indicated the 100mm thick panel with 0.4mm steel sheeting has sufficient cross-sectional resistance for four floors.

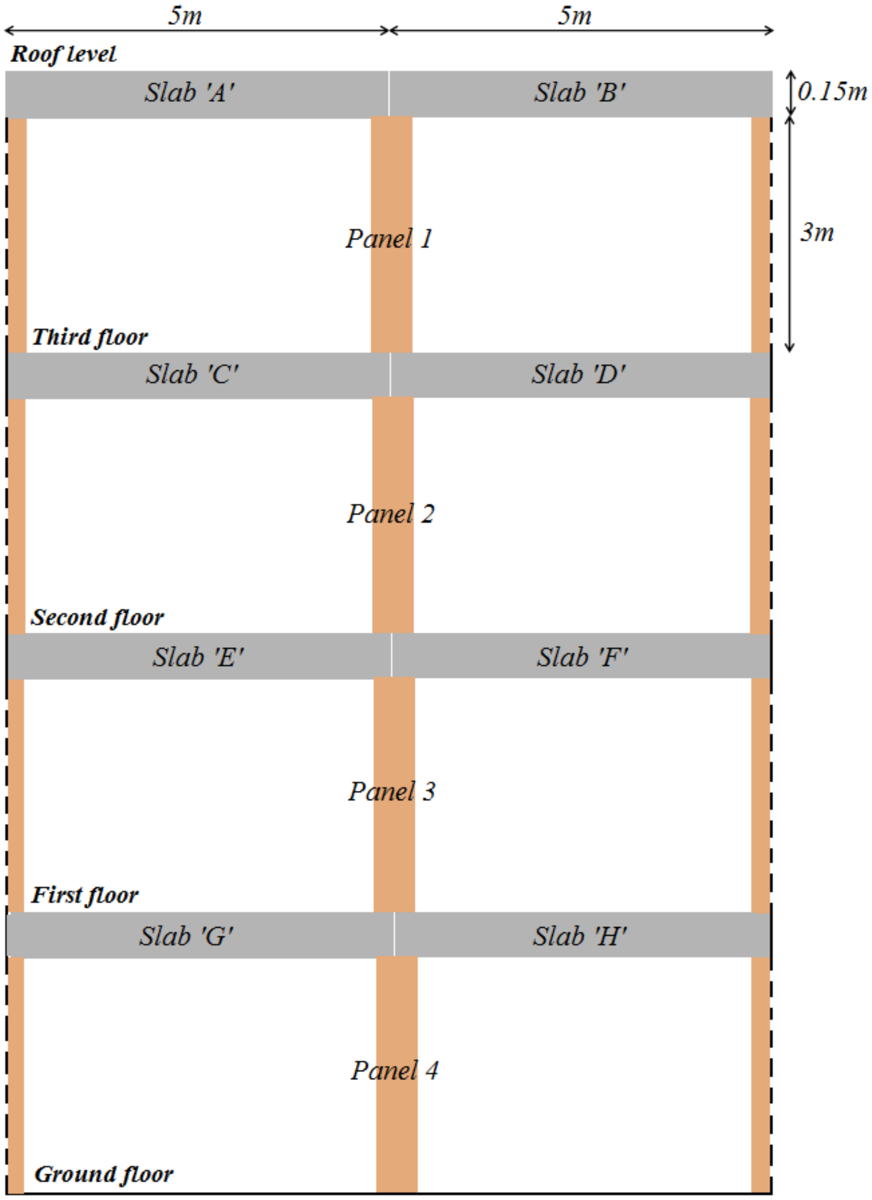


Figure 11: Arrangement of LFC composite wall panels for a four-storey residential building section.

TABLE 7: ASSESEMENT OF ADEQUECY OF 100 MM THICK WALL WITH 0.4 MM THICK STEEL SHEETING

| Description | Required load carrying capacity per 0.4m wide (kN) | Wall adequate based on average experimental results in Table 3 | | |
|---|---|---|---|---|
| | | no stopping edge (165kN) | with stopping edge (181kN) | with welded stopping edge (198kN) |
| Panel 1 | = 0.4*55.7 = 23 | √ | √ | √ |
| Panel 2 | = 0.4*114.6 = 46 | √ | √ | √ |
| Panel 3 | = 0.4*173.5 = 70 | √ | √ | √ |
| Panel 4 | = 0.4*232.4 = 93 | √ | √ | √ |

### *6.4. Effect of slenderness ratio on load carrying capacity of composite walling system*

It was expected that the strength of the proposed composite walling system will decrease increasing height due to buckling effect. The flexural buckling resistance of panel under compression may be calculated using the well-known Euler equation [5] given below:

$$P_{cr} = \frac{p^2 EI}{L_p^2} \qquad (1)$$

where $P_{cr}$ is the critical buckling load; $EI$ $(=E_s I_s + E_c I_c)$ is the flexural rigidity of the composite cross section with $E_s$ and $E_c$ being the Young's modulus of steel and LFC respectively and $I_s$ and $I_c$ being the second moment of area of the steel sheeting and LFC core respectively about the centre of the composite cross-section. $E_s$ = 200,000 N/mm$^2$ and $E_c$ = 3,300 N/mm$^2$. $L_p$ is the length of composite panel.

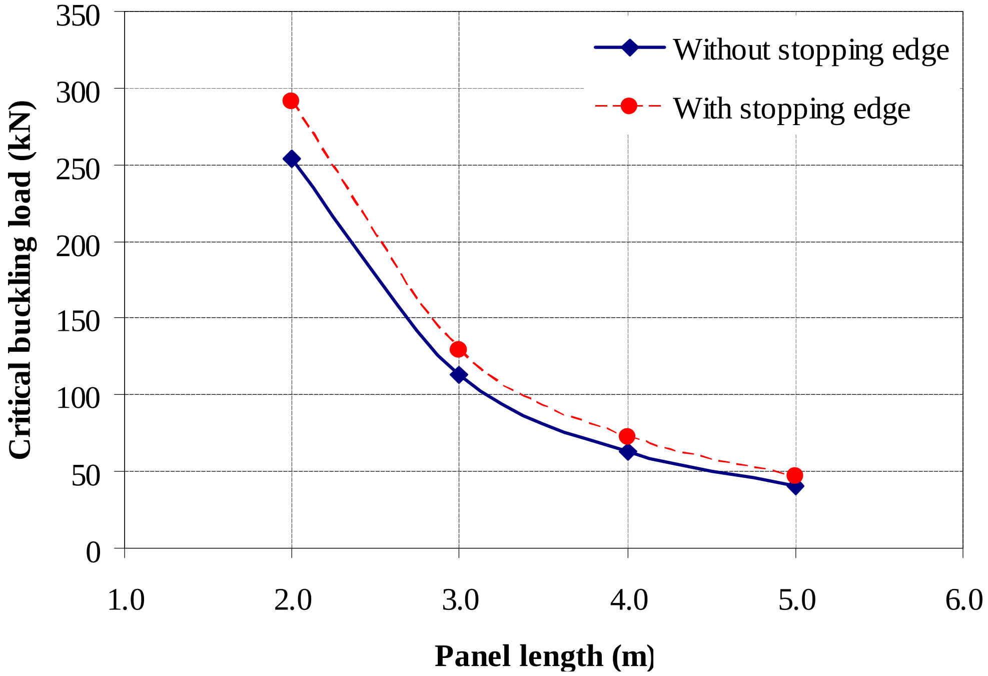


Figure 12. Relationship between critical load and panel height, panel width=400mm

Figure 12 clearly compared the buckling resistance of 400mm wide panels of two types of construction (with or without stopping edge) for panel heights ranging from 2m to 5m.

TABLE 8: ASSESEMENT OF ADEQUECY OF 100 MM THICK WALL WITH 0.4 MM THICK STEEL FOR DIFFERENT PANEL LENGTHS

| Panel length (m) | | 2.0 | 3.0 | 4.0 | 5.0 |
|---|---|---|---|---|---|
| Length-width ratio | | 5.0 | 7.5 | 10.0 | 12.5 |
| Edge condition | Required load carrying capacity per 0.4m wide | Wall adequate based on critical buckling load calculation | | | |
| No stopping edge | Panel 1 (23kN) | √ | √ | √ | √ |
| | Panel 2 (46kN) | √ | √ | √ | x |
| | Panel 3 (76kN) | √ | √ | x | x |

| | | | | | |
|---|---|---|---|---|---|
| | Panel 4 (93kN) | √ | √ | x | x |
| With stopping edge | Panel 1 (23kN) | √ | √ | √ | √ |
| | Panel 2 (46kN) | √ | √ | √ | √ |
| | Panel 3 (76kN) | √ | √ | x | x |
| | Panel 4 (93kN) | √ | √ | x | x |
| Welded edge | Panel 1 (23kN) | √ | √ | √ | √ |
| | Panel 2 (46kN) | √ | √ | √ | √ |
| | Panel 3 (76kN) | √ | √ | x | x |
| | Panel 4 (93kN) | √ | √ | x | x |

Table 8 listed the applied loads (per 0.4m) for the different panels of the indicative building shown in Figure 11 with the calculated buckling strengths (per 0.4m) for different panel heights. The results showed that if the panel height does not exceed 3m, which would be sufficient to cover most cases of residential construction, the proposed panel system would have sufficient load carrying capacity. For heights of 4 and 5m, the proposed panel construction would not be sufficient for three storeys, but would be sufficient for one or two storey residential construction. For such heights, the panel thickness and steel sheeting thickness could be increased to increase the panel load carrying capacity. The main conclusion was that the LFC based composite walling system could be designed to resist the applied loads in low-rise residential construction.

## 7. Conclusions

The following conclusions may be withdrawn from this study:

1. From structural tests on LFC based composite walling system consisting of two outer skins of profiled thin-walled steel sheeting with LFC core under axial compression, for steel sheeting thicknesses of 0.4mm and 0.8mm respectively, it was found that all the specimens demonstrated good ductility, giving gradual reduction in load carrying capacity at increasing deformation. Failure of the composite walling was instigated by outward local buckling of the steel sheeting which was followed by concrete crushing of the LFC core. LFC was able to provide sufficient support to prevent the steel sheeting from inward buckling.
2. Edge detailing of the LFC based composite walling system had some influence on the ultimate strength of the system. Covering the edges of the panels with steel sheeting improved the panel strength. Welding the steel sheeting at the edges (referred to as welded edge) to form a closed tubular construction gave higher load carrying capacity than without joining them (referred to as with stopping edges). Compared to LFC panels without the steel sheeting covering the edges, the load carrying capacities of panels with stopping edge and with welded edge were about 10% and 17% higher.
3. The indicative study of fire resistance performance of LFC construction under standard fire exposure from one side has concluded that LFC has outstanding insulation performance for fire resistance and offers a practicable alternative to gypsum as the construction material for partition walls. For instant, a single layer of 650 kg/m$^3$ density LFC of about 21 mm would achieve 30 minutes of standard fire resistance rating, more or less similar to gypsum plasterboard.
4. The results of a feasibility study on structural performance of composite panel system has confirmed it would be possible to design LFC based composite walling system to resist typical floor loads in low rise residential construction. For example, using 100mm LFC core and

0.4mm steel sheeting would give sufficient load carrying capacity for the construction of 4 storey buildings with 3m storey height.

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