Construction Materials and Structures
S.O. Ekolu et al. (Eds.)
IOS Press, 2014

doi:10.3233/978-1-61499-466-4-893

Flexural tests of Mi Panels

G. M. BUKASA and M. DUNDU[1]
Department of Civil Engineering Science, University of Johannesburg, South Africa

Abstract. Two series of flexural tests on 2700x600x75 mm Mi Panels are presented. The inner core of these lightweight panels is made from mixing polystyrene beads called Neopor, high strength cement, and water. A chemical is used as binding agent to bond the inner core to the external fibre cement sheets of 4.5 mm thickness. The experimental programme consists of two series of tests with different loading conditions; the first series has line loads at one-third point from each end support and the second series has line loads, at quarter and three quarter span of the panels. All flexural tests are performed to simulate the behaviour of the wall, when subjected to wind loads. Although the panels failed by fracturing, the tests showed that the panels are capable of carrying the required loads.

Keywords. Mi Panel, flexure, fibre cement, polystyrene.

Introduction

Mi Panels are lightweight, ease to construct and requires far less construction materials than conventional building technology, which makes them an excellent choice for remote construction projects. The panels have been used as structural elements in building structures ranging from single (ordinary houses, sheds, factory and warehousing developments) to multi-storey buildings. Mi Panels exists in two different dimensions; 2700x600x75 mm for wall panels and 3000x600x50 mm for roof panels. The interlocking panels comprises of 4.5mm-thick fibre-cement sheeting compressed on either side of an inner core of expanded graphite impregnated polystyrene beads called Neopor, high strength cement, and three proprietary chemicals mixed together, as shown in Figure 1. Delamination of the fibre-cement sheeting is prevented by the chemicals and the method of production. Mi Panels have tongue and groove joints to allow interlocking during construction. All joints are secured with polyurethane glue and are then sealed with a fibre tape membrane.

The South Africa building regulation, SANS 10 400 XA [1], recognizes Mi Panels as alternative building systems among others. The regulation concerning alternative systems, defines that building systems different from the traditional building can be used on condition that it is proved by experimental tests. The aim of this investigation is to determine the flexural strength of similar panels, manufactured by MIBT, South Africa. Preliminary flexural tests of these panels have produced positive results [2].

[1]Corresponding author: University of Johannesburg, Department of Civil Engineering Science, P.O. Box 524, Auckland Park, 2006, South Africa; E-mail. mdundu@uj.ac.za

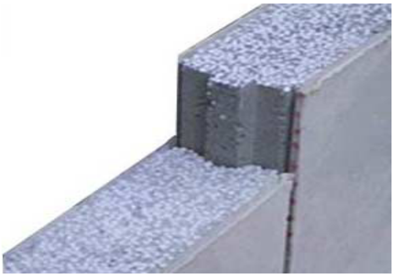


Figure 1. Mi panel

1. Experimental Investigations

Flexural tests were conducted on 2700x600x75 mm Mi Panels using two-point loads to examine the strength. The tests were performed to simulate the behaviour of the wall, when subjected to wind loads. In all the tests carried out, the panels used had the same mix proportion. The test system consists of specially designed supporting rigs and load spreader beams. This test configuration simulates a distributed load, applied to the panel. The tests were carried out using an Instron machine with an actuator capacity of 250 kN, at the rate 1mm/minute. Figure 2 illustrates the flexural test set-up.

Figure 2. Test set-up of panels

The panels were instrumented so that in-plane deflection and strains at mid-span could be measured. The deflection and longitudinal strains were measured by means of a linear variable displacement transducer (LVDT) and strain gauges, respectively. Strains were recorded in order to determine the moment curvature behaviour of the panels. Two strain gauges were used for each panel; one placed on the compression side, and another one on the tension side. The Data-logger was set and connected to computer system in order to record the readings. Each panel was incrementally loaded at the rate of 1mm/min, so that the behaviour and failure patterns of the panel could be well observed.

2. Test results

The panels failed by fracturing. For the first six tested panels, with the load applied at one-third of the span (Series 1), failure occurred at mid-span, whilst for the 4 panels, with the load applied at one-quarter from each support (Series 2), half of the panels failed at mid-span and the other half failed at the point where loads were applied. No visible cracks were observed before global flexural failure and no debonding occurred between the inner core and the external fibre cement sheeting during the bending test. In addition, no considerable in-plane deflection was experienced in all tested panels until global failure occurred.

Tables 1 and 2 shows the total load, line load, experimental (Exp.) moment and experimental pressure, applied on the 2700x600x75 mm panels, and the expected maximum unfactored wind pressure. The failure load value exhibited by the specimen varied from 2.48 kN to 2.97 kN when the specimens were subjected to one-third loading condition (Series 1) and from 3.60 kN to 4.87 kN when one-quarter loading was applied (Series 2). It is obvious that the load increased as the applied point loads moved towards the supports. These loads generated experimental pressure values greater than the theoretical wind pressure values. The maximum unfactored wind pressure is determined based on SANS 10160 [3], as shown in Equation 1.

$$
\begin{aligned}
p_z &= K_p V_z^{\,2} \times \left(C_{pe} - C_{pi}\right) \\
&= K_p \left(K_r K_z V\right)^2 \times \left(C_{pe} - C_{pi}\right)
\end{aligned}
\tag{1}
$$

where, K_p is site altitude above sea level (taken as 0), V_z is the characteristic wind speed at height z (m/s) , K_r is the mean return period correction factor (taken as 50 years), K_z is the wind speed multiplier, V is the wind speed, C_{pe} is the external wind pressure coefficient and C_{pi} is the internal wind pressure coefficient. The calculation in Eq. (1) assumes that the height is 5m and the terrain category is 3 (suburbs, towns, suburbs, wooded areas, industrial areas). Based on the results from Eq. (1), it is clear that the theoretical wind pressure is far much smaller than the experimental pressure (Exp. Pressure), resisted by the panels.

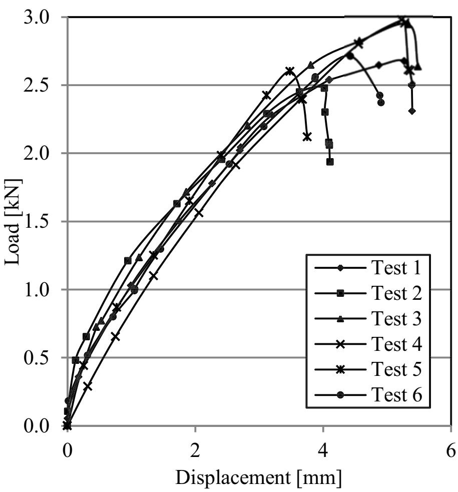
Table 1. Flexural loads of Series 1 tests

Test	Total load (kN)	Line loads (kN/m)	Exp. Moment (kNm)	Exp. Pressure (kN/m^{2})	Wind Pressure (kN/m^2)
1	2.68	4.47	1.11	1.79	0.55
2	2.48	4.13	1.03	1.65	0.55
3	2.94	4.90	1.22	1.96	0.55
4	2.97	4.95	1.23	1.98	0.55
5	2.60	4.33	1.08	1.73	0.55
6	2.71	4.52	1.12	1.81	0.55

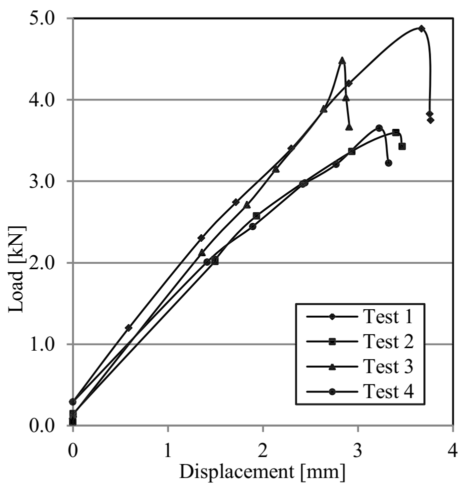
Table 2. Flexural loads of Series 2 tests

Test	Total load (kN)	Line loads (kN/m)	Exp. Moment (kNm)	Exp. Pressure (kN/m^2)	Wind Pressure (kN/m$^{2)}$)
1	4.87	8.12	1.52	3.25	0.55
2	4.48	7.47	1.40	2.99	0.55
3	3.65	6.08	1.14	2.43	0.55
4	3.60	6.00	1.13	2.40	0.55

Figure 3 shows the in-plane load-deflection graphs of the panels. It is evident from Figure 3(a) that Series 1 graphs are largely non-linear. The behaviour of Series 2 graphs consists firstly of a linear response followed by a non-linear response. The small inelastic behaviour in Series 2 is only exhibited as the applied load approaches the maximum capacity of the panels. Since the composition of all the panels are the same, this load-deflection response was influenced by nothing else except the loading positions.



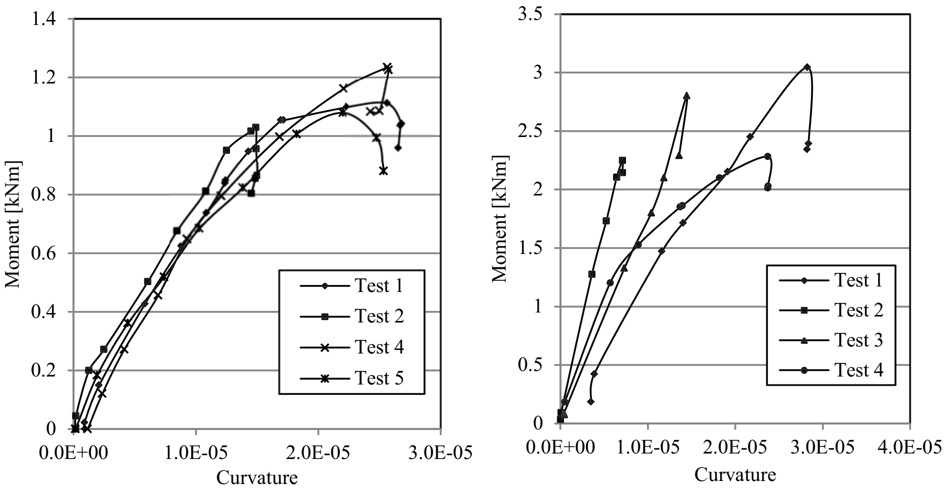
(a) Series 1



(b) Series 2

Figure 3. Load-deflection graphs

The moment-curvature relationships of Series 1 and 2 panels are shown in Figure 4. Notice that the moment-curvature for Test 3 and 6 were removed from Figure 4(a), since they were significantly distorted. Curvature was calculated from the strain readings at the top and bottom fibre cement sheets. Series 1 graphs are non-linear and Series 2 graphs are linear. Non-linearity only became visible in Series 2 graphs when the applied load approached the capacity of the panels. These characteristics are similar to the load-deflection curves in Figure 3. In general, the maximum moments were achieved at low strain values because the panel could not sustain a significant vertical deflection.



(a) Series 1 (b) Series 2

Figure 4. Moment-curvature graphs

3. Conclusions

This paper presents experimental studies on the flexural strength and behaviour of 2700x600x75 mm Mi Panels. Based on the results from the tests, it is clear that the theoretical wind pressure, calculated using the South African loading code, is far much smaller than the experimental pressure, resisted by the panels. The maximum deflections at mid-span as well as strains are small. This has negative implications on the ductility of the panels. Despite this deficiency, Mi Panels possess the required strength and can be used as alternative building system.

Acknowledgments

The authors wish to express their appreciation to MIBT South Africa for their generous donation of Mi Panels without which these tests could not have been conducted.

References

[1] SANS 10400, South African standard code of practice for the application of the national building regulations, South African Bureau of Standards, Pretoria, South Africa, 2011.
[2] M. Dundu and G.M. Bukasa, Compression and flexural tests of Mi Panels. *International Conference on Civil and Environmental Engineering* (CEE'2013), Nov. 27-28, Johannesburg, South Africa, 2013.
[3] SANS 10160, South Africa standard code of practice for the general procedures and loadings to be adopted in the design of buildings. South African Bureau of Standards, Pretoria, South Africa, 1989.