Effect of different layers of confinement with fibermesh on the mechanical properties of lightweight foamed concrete

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Abstract- Hence, this paper focuses on an experimental investigation on engineering properties of alkali resistant fiber mesh reinforced foamed concrete jacket. Two different densities of 600kg/m^3 and 1200kg/m^3 were cast and tested. Three parameters will be evaluated such as compressive strength, flexural strength and splitting tensile strength. The woven fiberglass mesh implemented in this research is a synthetic textile fabric with an alkali resistance characteristic. The lightweight foamed concrete specimens were wrapped with 1-layer to 3-layer(s) of woven fiberglass mesh. Protein-based foaming agent Noraite PA-1 was used to produce the desirable density of lightweight foamed concrete. To get the comparable results, the water to cement ratio was fixed to 0.45 while the cement to sand ratio constant at 1:1.5. The results had indicated that 3-layers of confinement gave the best results for all the three parameters considered in this research. This entire enhancement achieved is due to the confinement of woven fibermesh that existence as a jacket and increase the initial elastic stiffness of lightweight foamed concrete. Fibermesh jacketing on foamed concrete provide substantial gain in strength and deformability. This gain is higher as the number of confining layers increases and depends on the tensile strength of the mortar, which determines whether failure of the jacket will occur due to fibermesh fracture.

Keywords – foamed concrete, concrete jacketing, lightweight concrete, durability, engineering properties

I. INTRODUCTION

The need for advancement of the existing structure members has been tremendous in the past couple of decades, both in non-seismic areas due to weakening and the introduction of more rigorous design necessities, and in seismic areas, where structures designed conferring to old seismic codes have to encounter performance levels essential by current seismic design criterions [1]. One of the most common upgrading techniques for reinforced concrete structures involves the use of jackets, which are aimed at increasing the confinement action in either the potential plastic hinge regions or over the entire member [2]. Concrete jacketing is one of the most frequently used techniques to strengthen foamed concrete and to enhance the ductility. With this method, axial strength, bending strength, and stiffness of the original foamed concrete are increased [3]. It is well known that the success of this procedure is dependent on the monolithic behavior of the composite element. Hence this research focuses on an experimental investigation on engineering properties of alkali resistant fiber mesh reinforced foamed concrete jacket.

II. MATERIALS AND MIX DESIGN

2.1 Ordinary Portland cement (OPC)

The Ordinary Portland Cement (OPC) utilized in this research was supplied by a company known by YTL Cement Bhd. This cement utilized conformed to Type I Portland Cement in accordance to BS 12 Standard [14]. The cement was prepared before mixing and covered it with plastic to avoid hydration process on it. The chemical arrangement of this cement is summarised in Table 1.

Table 1 Chemical compositions of Portland cement

Chemical compound	Portland cement
Mgo	1.50
Al2O3	3.60
SiO2	16.00
SO3	3.10
K2O	0.34
CaO	72.00
Fe2O3	2.90
Na2O	n/d

2.2 Sand

Fine aggregates river sand was used. The sand was dried and sieved through sieve 2.36 mm and treated in accordance with BS 882 to increase the cellular mortar flow features and constancy as in BS12620.

2.3 Water

The water used for this study was potable tap water, free from any dissolved metal or ions that might constrain the setting and hydration process of the cellular mortar mixes. The water was also used to insipid the foaming agent for aeration process.

2.4 Surfactants

In this laboratory exploration, protein based surfactant was utilised as the foaming agent as it is more stable compared to the others available in the market. Based on researcher experiences, protein based surfactant formed tiny bubble size, which can offer more stable and stronger closed bubble structure in the mix. The bubbles were created by the foam making machine with the aid of air compressor by using a surfactant and water at a ratio of 1 to 33. For this research project, the foam density ranged between 58 kg/m^3 and 63 kg/m^3 was used for the production of cellular mortar [4]. It was used to mix with fresh mortar therefore the wet density of the mortar can be controlled via rate of air bubbles generated in the cement paste mix.

2.5 Fibermesh

For this particular study, 160gsm fiberglass mesh also known as textile fabric was used as confinement in this study to enhance the mechanical properties of lightweight foamed concrete. This textile fabric categorized as synthetic fiber that compromising an alkali resistance which can prolong the durability performance of LFC. It is also eco-friendly, lightweight, and flexible (can be form to any form). Figure 1 shows the fibermesh used in this particular study.

Figure 1. Fibermesh of 160gsm used in this research

III. EXPERIMENTAL SETUP

The axial compressive strength tests were conducted up to the age of 28 days. Compressive strength is tested using cube specimens of 100mm x 100mm x 100mm according to BS EN 12390-3:2009 as been shown in Figure 2. Flexural test is also conducted up to the same age of 28 days. The flexural strength is done using prism specimens of 100mm x 100mm x 500mm according to BS ISO 1920-8:2009. The setup for flexural test is shown in Figure 3. In addition, tensile splitting test was done by referring to the ASTM C496 standard. The specimen size used was 100mm in diameter and 200mm in height cylinder (refer Figure 4).

Figure 2. Setup for compression test according to BS-EN 12390

Figure 3. Setup for 2-point bending test according to BS-EN 1521

Figure 4. Setup for splitting tensile test in accordance to ASTM C496

IV. RESULTS AND DISCUSSION

4.1 Compressive Strength

Figures 5 and 6 display the axial compressive strength results for 600 kg/m^3 and 1200 kg/m^3 densities correspondingly. From both figures, it can be clearly seen that 3-layer of fibermesh jacketing lead to highest compressive strength. Overall, it may be concluded that textile-mortar confining jackets provide substantial gain in compressive strength and deformability. This gain is higher as the number of confining layers increases and depends on the tensile strength of the mortar. Fibermesh jacketing on foamed concrete provide substantial gain in compressive strength and deformability [5]. This gain is higher as the number of confining layers increases and depends on the tensile strength of the mortar, which determines whether failure of the jacket will occur due to fiber fracture or debonding [6].

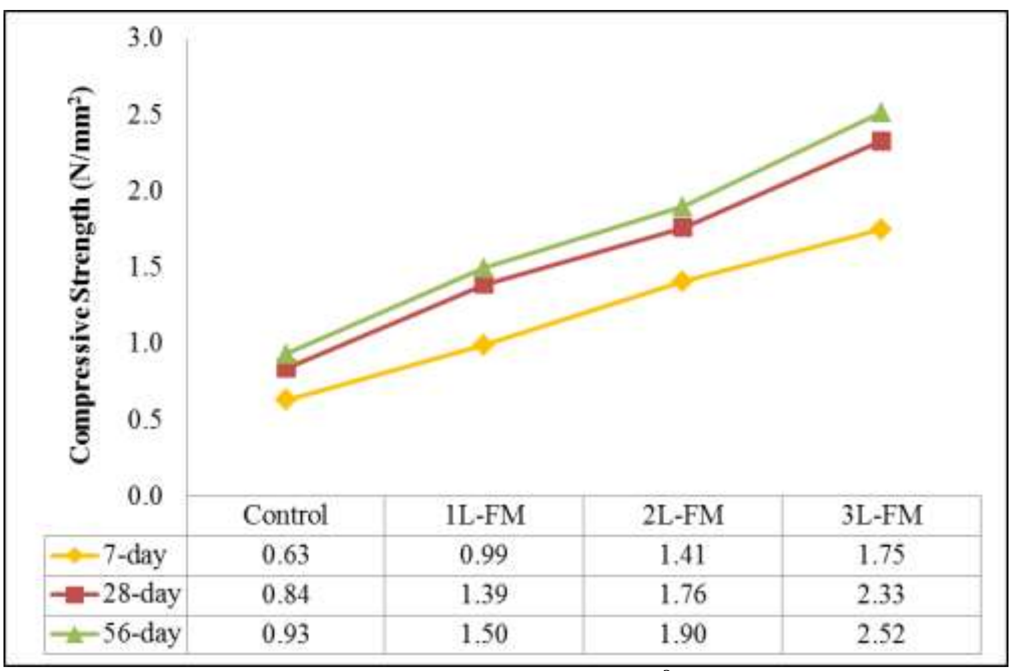
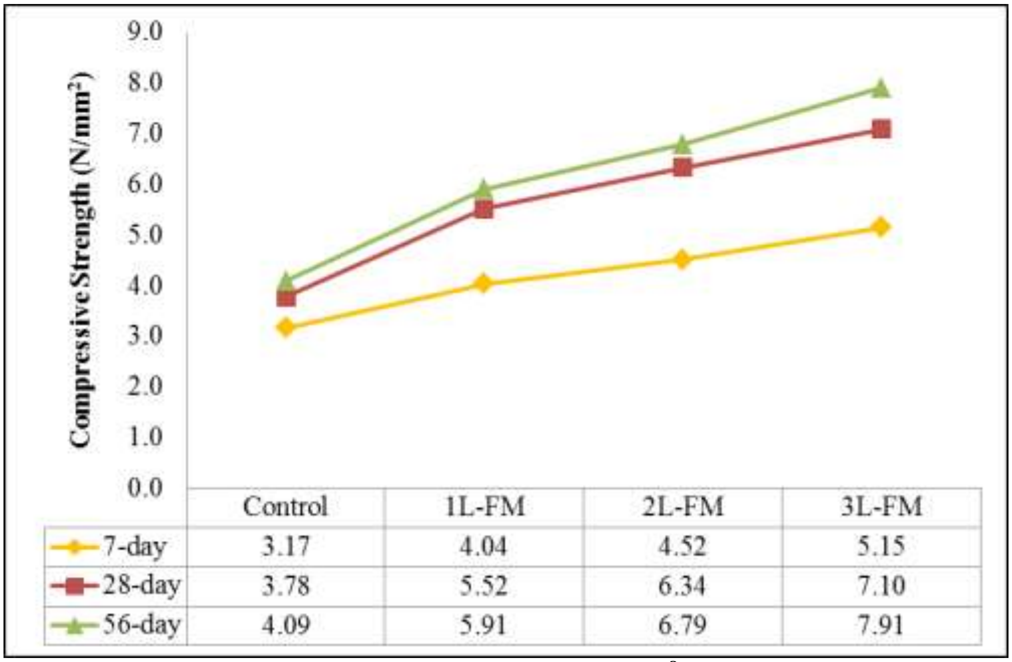


Figure 5. Compressive strength of foamed concrete of 600kg/m^3 with different layers of jacketing

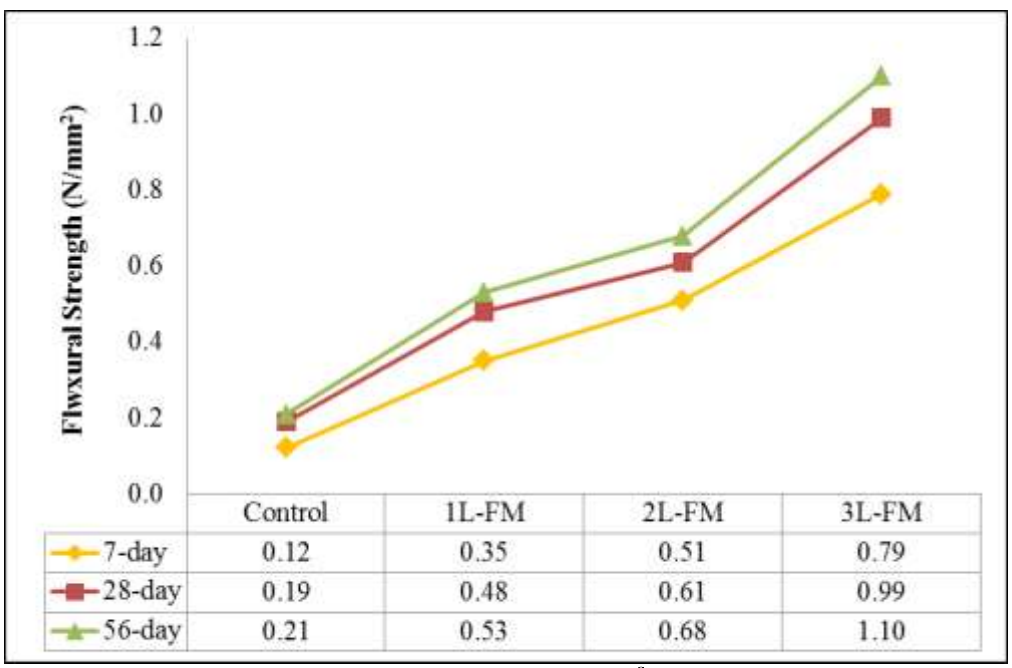


	Control	1L-FM	2L-FM	3L-FM
7-day	3.17	4.04	4.52	5.15
28-day	3.78	5.52	6.34	7.10
56-day	4.09	5.91	6.79	7.91

Figure 6. Compressive strength of foamed concrete of 1200kg/m^3 with different layers of jacketing

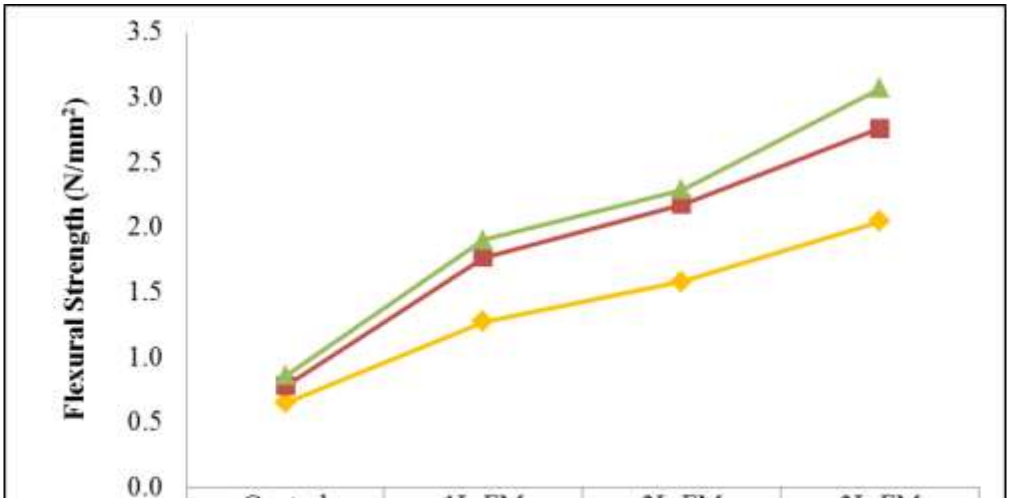
4.2 Flexural Strength

On the other hand, Figures 7 and 8 displays the flexural strength results for 600 kg/m^3 and 1200 kg/m^3 densities correspondingly. Same results were obtained as per axial compressive strength. From both figures, it can be clearly seen that 3-layer of fibermesh jacketing lead to highest flexural strength. Properly designed textiles under flexural load combined with inorganic binders have a good potential as strengthening materials of reinforced concrete members [7].



	Control	1L-FM	2L-FM	3L-FM
7-day	0.12	0.35	0.51	0.79
28-day	0.19	0.48	0.61	0.99
56-day	0.21	0.53	0.68	1.10

Figure 7. Flexural strength of foamed concrete of 600kg/m^3 with different layers of jacketing

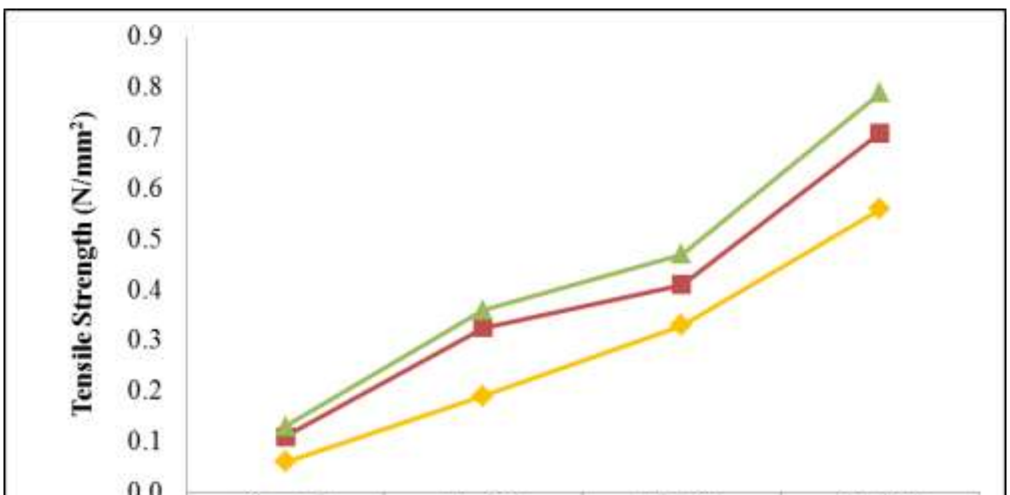


	Control	1L-FM	2L-FM	3L-FM
7-day	0.65	1.28	1.58	2.05
28-day	0.78	1.77	2.18	2.76
56-day	0.86	1.90	2.29	3.07

Figure 8. Flexural strength of foamed concrete of 1200kg/m^3 with different layers of jacketing

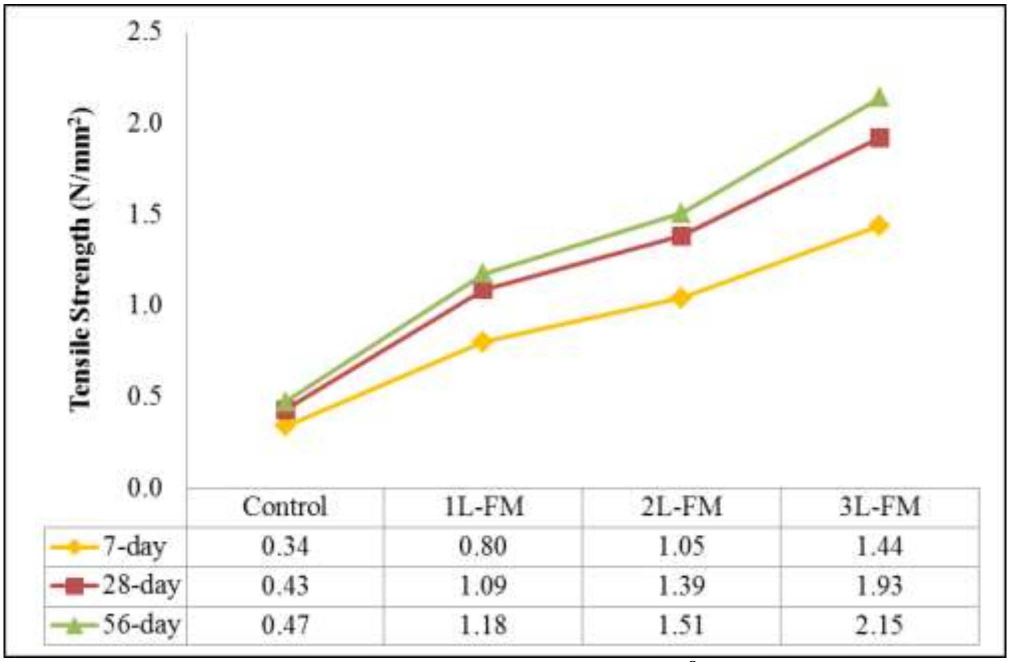
4.2 Splitting Tensile Strength

Figures 9 and 10 show the splitting tensile strength results for 600 kg/m^3 and 1200 kg/m^3 densities respectively. From both figures, it can be clearly seen that 3-layer of fibermesh jacketing lead to uppermost splitting tensile strength. Under tensile load, foamed concrete jacket developed vertical cracks which grew slowly but progressively [8]. When the peak stress point was reached the cracks became wider till the failure moment [9].



	Control	1L-FM	2L-FM	3L-FM
7-day	0.06	0.19	0.33	0.56
28-day	0.11	0.33	0.41	0.71
56-day	0.13	0.36	0.47	0.79

Figure 9. Splitting tensile strength of foamed concrete of 600kg/m^3 with different layers of jacketing



	Control	1L-FM	2L-FM	3L-FM
7-day	0.34	0.80	1.05	1.44
28-day	0.43	1.09	1.39	1.93
56-day	0.47	1.18	1.51	2.15

Figure 10. Splitting tensile strength of foamed concrete of 1200kg/m^3 with different layers of jacketing

V. CONCLUSION

From this study, it may be concluded thatfibermesh confining jackets provide substantial gain in compressive strength and deformability. Additionally this confinement was characterized by reduced effectiveness, when compared with FRP jackets. The reduction in effectiveness is quite small in terms of strength and more notable in terms of ultimate strain. Fibermesh jacketing on foamed concrete provide substantial gain in strength and deformability. This gain is higher as the number of confining layers increases and depends on the tensile strength of the mortar, which determines whether failure of the jacket will occur due to fiber fracture or debonding.

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