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FLEXURAL BEHAVIOR OF GEOPOLYMER FERROCEMENT ELEMENTS

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ABSTRACT

The purpose of this experimental investigation is to study the flexural behavior of fly ash-based geopolymer ferrocement elements. Ferrocement composite is a rich *Geopolymer mortar* mix of 1:3 with W/B ratio of 0.416. The alkaline activators used consist of Sodium hydroxide and sodium silicate. The length of ferrocement elements was chosen as 760 mm, width 150 mm and depth of the section was 30 mm, Nine number of rectangular slab were prepared with different meshes such as Square woven, Square welded and Expanded metal mesh. The number of layers in each mesh was varied from single, double and triple layers. The specimens were cured for 28 days by ambient curing. Based on the test results, load vs deflection curves were down. The effectiveness of the Square woven, Square welded and Expanded metal mesh were compared.

Keywords: Geopolymer mortar; fly ash; sodium hydroxide; sodium silicate; ferrocement.

1. INTRODUCTION

Ferrocement is widely used in many part of the world. High tensile properties and high tensile strength, high resilience and ductility, high resistance to cracking, ability to undergo large deflection before collapse, high impact resistance and high toughness, high strength to weight ratio makes it a versatile material. Though the ferrocement slabs and related products are used in India for both structural and non structural purposes there are no standard for test and design procedure are not available. Hence, an attempt has been made to study the behaviour of ferrocement elements in flexure.

The primary objective of this study was development of viable housing components, which could be used as multipurpose structural elements. Experimental study was carried

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out on ferrocement slab element. In this context, multipurpose structural elements are meant as ferrocement element, which can act both as floor and wall elements. Ferrocement slab stiffened by square and rectangular section was found to be a suitable shape for multipurpose elements. In this investigation, ferrocement element having the shape of rectangle was chosen.

2. OBJECTIVES

The main objective of the present investigation is to study the behavior of Geopolymer Ferrocement slabs (replacement of cement with 100% activated flyash).

- Geopolymer mortar of 1:3 with varying w/b ratio of 0.376, 0.386, 0.396 & 0.416 was cast to study the compressive strength.
- The optimum strength achieved was for the w/b ratio 0.416.
- Geopolymer ferrocement slabs were cast for 0.416 w/b ratio.
- The ultimate load carrying capacity and deflection of slabs with different meshes were studied.

2.1 Materials Used

- Fine aggregate: Locally available river sand conforming to Grading zone II of IS: 383–1970.
- Fly ash: Obtained from Mettur Thermal Power Plant, Mettur. Confirming to IS: 3812 Part 1 – 2003 as mineral admixture in dry powder form.
- Water: Potable water.
- Alkaline Activators:
    - Sodium hydroxide

  Generally the sodium hydroxides are available in solid state by means of pellets and flakes. In this investigation the sodium hydroxide pellets of 16 molar concentrations where used.

    - Sodium Silicate

  Sodium silicate also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate 2.0 with gel form is used.
- Wire meshes: Square woven, Square welded and Expanded metal mesh

Figure 1. Ingredients of geopolymer mortar

Figure 2. Geopolymer mortar

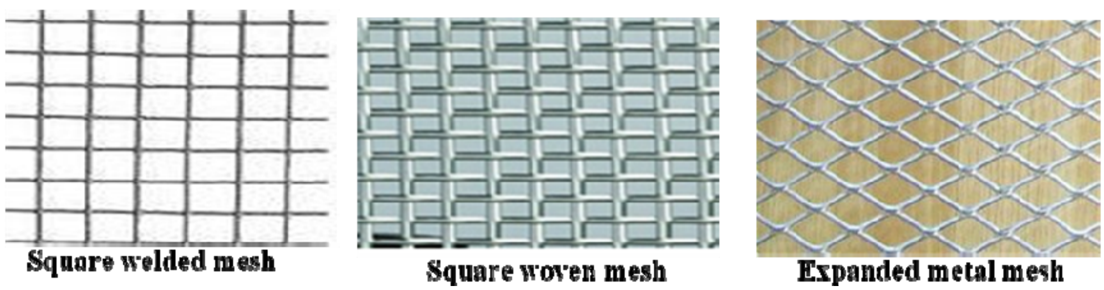

Figure 3. Different Types of Mesh

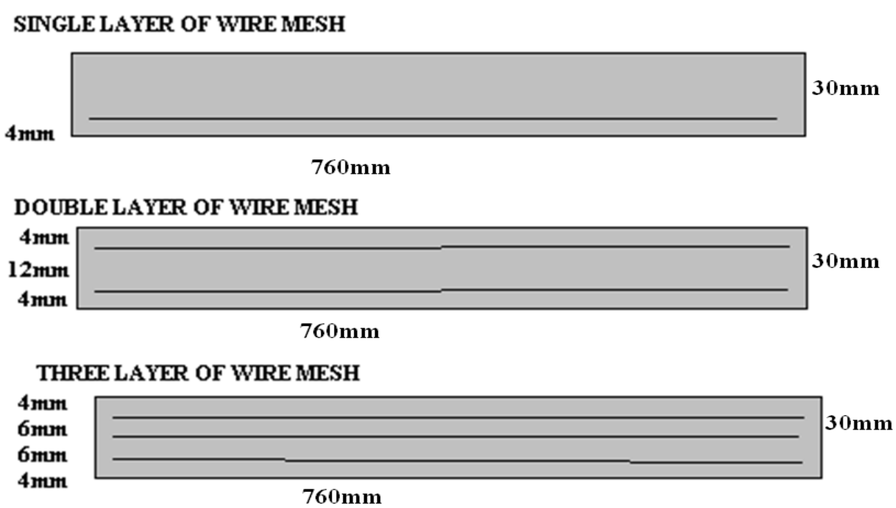

Figure 4. Different layers of wire mesh

3. EXPERIMENTAL METHODOLOGY

3.1 Geo-polymer Mix

The Geo-polymer mortar mix is prepared with the mix proportion of 1: 3. The W/B ratio is varied from 0.376, 0.386, 0.396, and 0.416. The compressive strength study on Geopolymer mortar cubes showed that optimum result is for the W/B ratio 0.416.

3.2 Preparation of Binder Solution

Binder solution plays a vital role in the binding of the fly ash based geopolymer mortar. Binder solution is a mixture of Sodium Hydroxide and Sodium Silicate. In this investigation the sodium hydroxide pellets in 16 molar concentrations were used. Binder solution is mixed 24 hours prior to the mixing of mortar.

3.3 Specimen Preparation

The size of mould which we have utilized in this project is 760 x 150 x 30 mm.

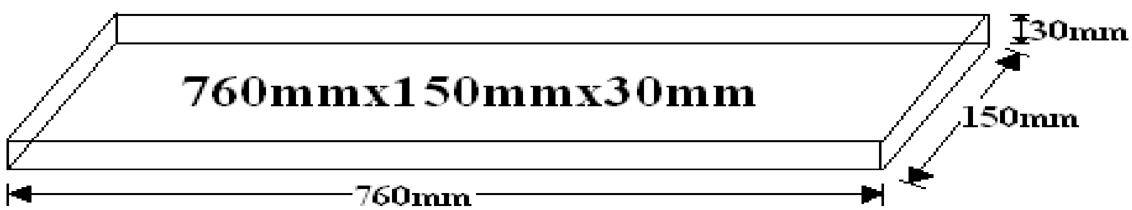

Figure 5. Dimensions of slab

3.4 Properties of Wire Mesh

The shape of woven and weld mesh are square and the expanded mesh has a demand shape, each mesh has 15 x 15mm opening size, the length and width of the meshes are chosen as 760 x 150mm. Thickness of joint in each mesh 7.22mm and the dia of wire is 1.5mm. The meshes are available in role form, they have density of above 0.9 g/cm^3, tensile test conducted on the meshes indicate they have tensile of structural of about 34.5Mpa.

4. CASTING OF ELEMENTS

Casting of the elements included the fabrication of slab. Weld mesh were cut to appropriate dimensions to suit the configuration of square elements. The weld mesh were placed at the appropriate position to make the slab. The element were cast using the plastering techniques on the level floor of casting yard using very simple wooden formwork. The mould was placed on the level platform of casting yard after applying a thin coat of oil. Five millimetre of mortar, equal to the cover of reinforcement laid over the oiled surface. The weld mesh was placed over this mortar layer inside the wooden mould. Then mortar was placed over the cage and finished to exact dimensions by using trowel and straight edge.

Figure 6. Casting of elements

5. TESTING OF ELEMENTS

The rectangular ferrocement elements were tested to study their flexural behaviour. The general testing arrangement, test set up, instrumentation and testing procedure are explained in the following section. The element was made ready for necessary instrumentation and observation of readings. After arranging the necessary arrangement to measure the strain at middle span, dial gauge were mounted below at middle of the span. The deflection measurements were taken from the middle points.

5.1 Testing Procedure

Testing is done by a specially made frame for 760mmx150mm size. The slab is fixed and the load applied to the slab is uniformly distributed load .The loading is done by bricks. The slab is kept on the frame and linear variable differential transducer .LVDT is set below the center part of slab. The load is applied gradually on the slab, for every 20kg of load application the corresponding reading should be taken through (LVDT) the load should be gradually increased and load is done till the failure. The first crack load corresponding to that was noticed as the first crack load. The failure load is noted and corresponding deflection is also noted the slab failed due to flexure .The load and deflection reading is taken and the graph is drawn against load vs deflection.

5.2 Flexure Test on Ferrocement

Ferrocement specimens were tested in accordance with the applicable provision standard testing methods for flexural strength of ferrocement, using a fixed supported slab with uniformly distributed load. An experimental load-deflection curve of ferrocement with clearly defined transition point (i.e., cracking, yielding, and ultimate) are shown in Figure 7.

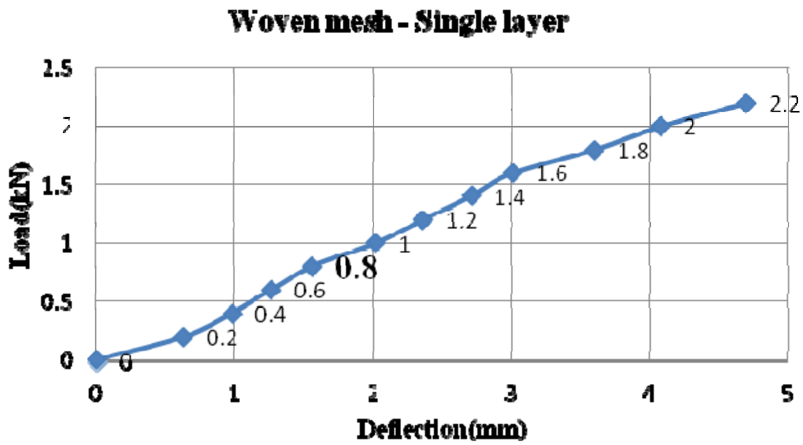

Chart 5.1. Load vs deflection curve of woven mesh-Single layer

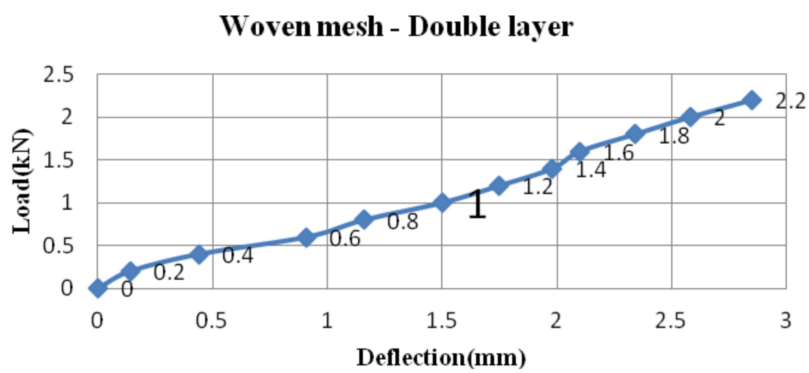

Chart 5.2. Load vs deflection curve of woven mesh-Double layer

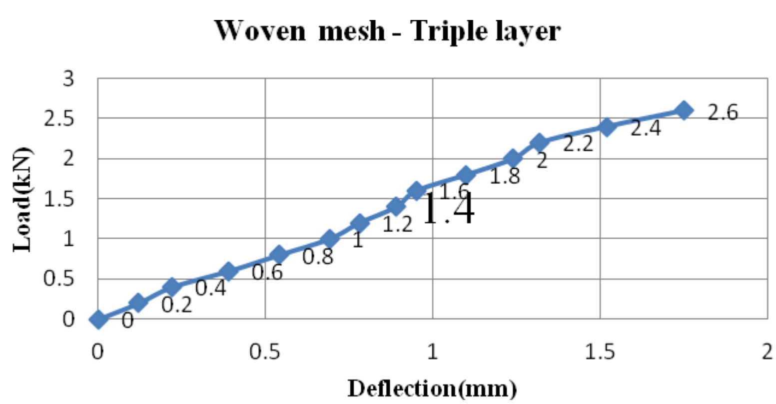

Chart 5.3. Load vs deflection curve of woven mesh-Triple layer

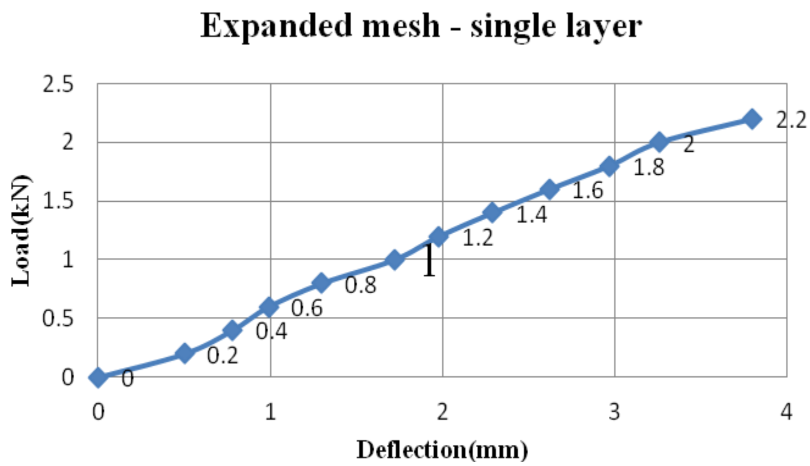

Chart 5.4. Load vs deflection curve of expanded mesh - Single layer

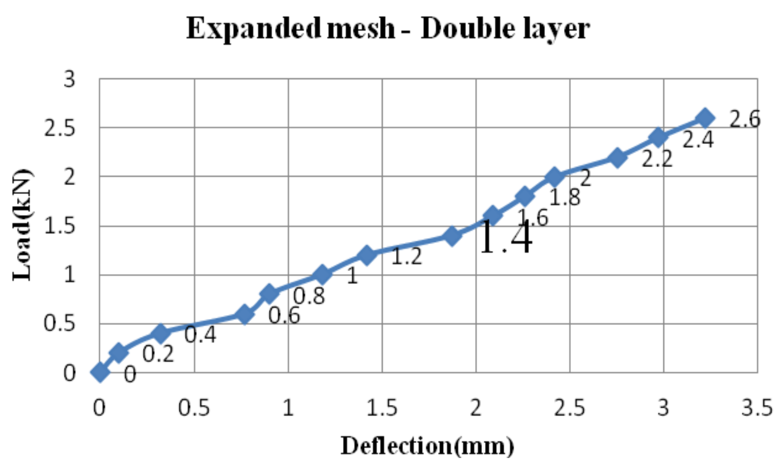

Chart 5.5. Load vs deflection curve of expanded mesh-Double layer

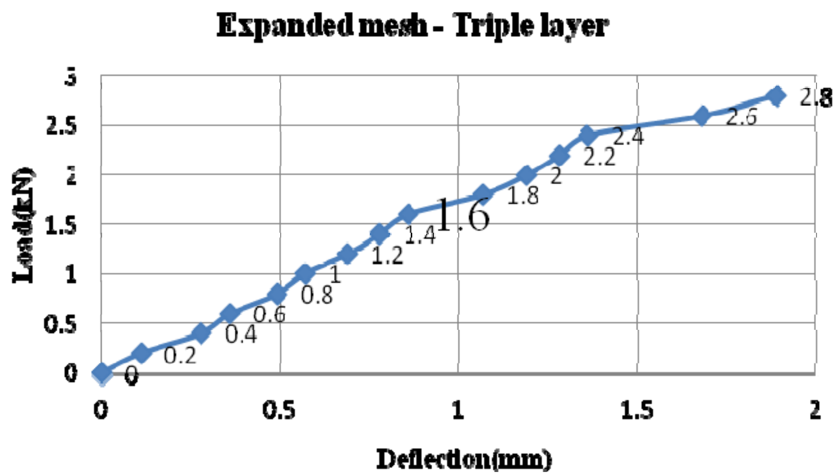

Chart 5.6. Load vs deflection curve of expanded mesh-Triple layer

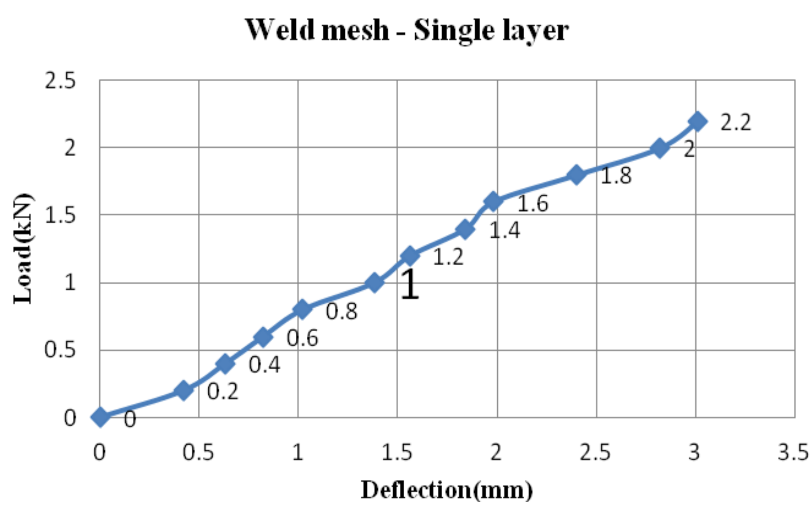

Chart 5.7. Load vs deflection curve of weld mesh-Single layer

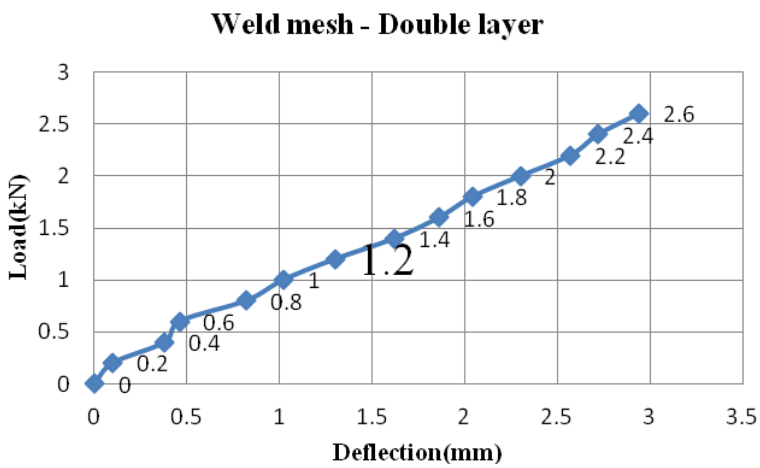

Chart 5.8 Load vs deflection curve of weld mesh-Double layer

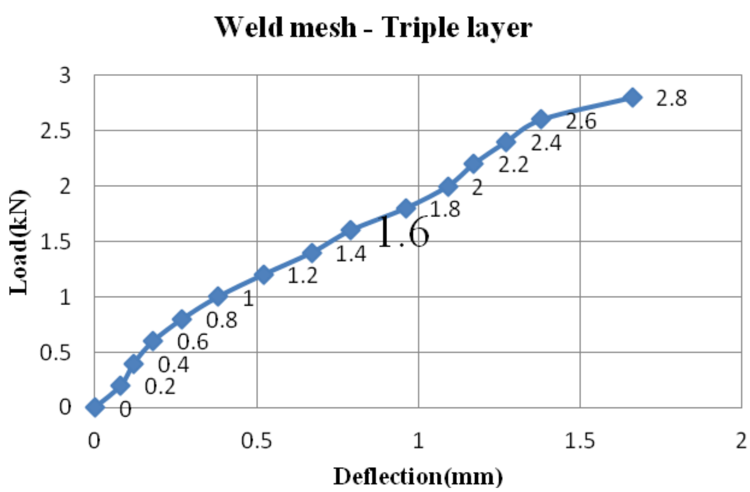

Chart 5.9. Load vs deflection curve of weld mesh-Triple layer

Figure 7. Load Vs Deflection Comparison Between Different Mesh Types With Different Layers

From the graph triple layer has less deflection compared to single and double layers.

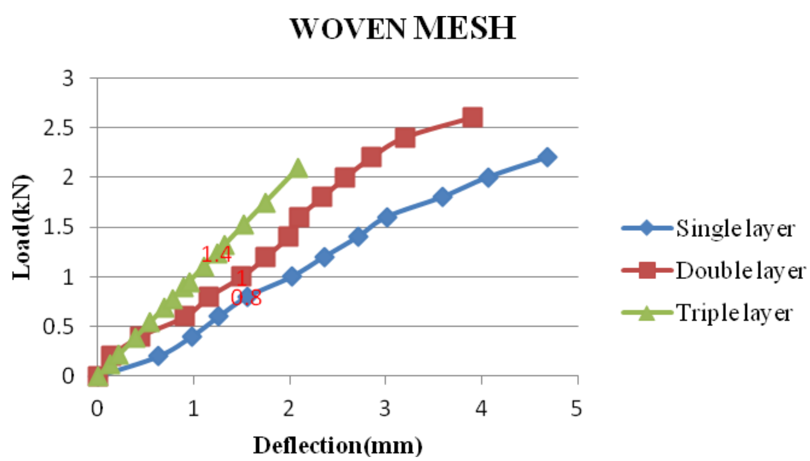

Chart 5.10. Load vs deflection curve for different layers of woven mesh

Initial crack for the Triple layer occurred at 1.4kN, double layer occurred at 1kN and single layer occurred at 0.8kN.

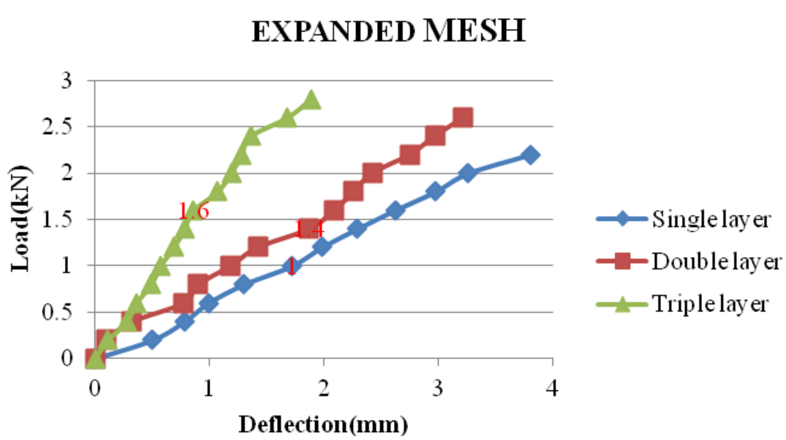

Chart 5.11. Load vs deflection curve for different layers of expanded mesh

Initial crack for the Triple layer occurred at 1.4kN, double layer occurred at 1kN and single layer occurred at 0.8kN.

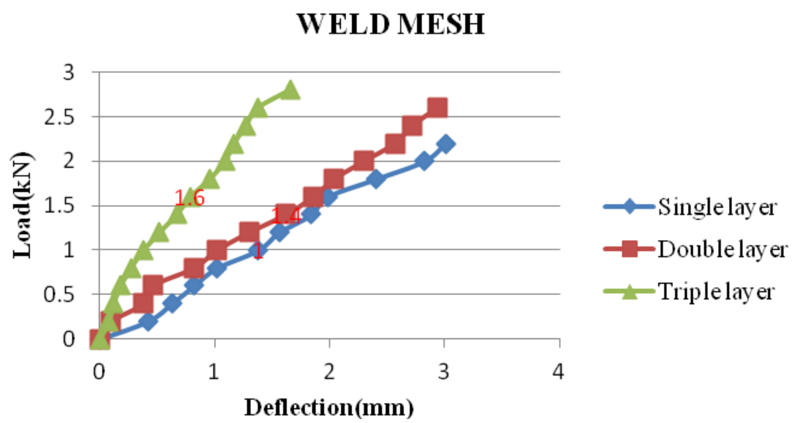

Chart 5.12. Load vs deflection curve for different layers of weld mesh

Initial crack for the Triple layer occurred at 1.6kN, double layer occurred at 1.4kN and single layer occurred at 1kN.

6. CONCLUSION

➢The ferrocement structural elements involved in this study are having a simple cross section and it can be fabricated easily with the help of simple formwork.

➢Increasing the number of steel mesh layers from 1 to 3 caused a substantial increase in flexural strength and energy absorption to failure.

➢It was observed that the linear first stage ceases with the initiation of cracking in mortar on the tension force. The load carrying capacity of the specimens, however, continues to increase because the meshes start carrying additional load. with further increase in load, the tension face of the specimen starts cracking following by cracking of the compression face and finally forming a major failure of the compression face and finally forming a major failure crack at the middle of the specimen.

➢It was also observed that the flexural strength of the section increasing the number of wire mesh layers. This is because of the increased percentage of steel meshes in the specimens and the increased depth of mesh layers from the neutral axis. For the same number of mesh layers, it was found that the strongest configuration in both elastic and inelastic ranges results from the smallest spacing because of the increase in volume fraction of the mesh in longitudinal and transverse direction of the specimens.

➢From this study it can be considered the Weld mesh is resulted in significant improvement in their flexural behaviour compare to woven and expanded mesh. The use of weld mesh in the ferrocement structure gives more strength and significant improvement to the ferrocement.

➢Load deflection curve exhibited three distinct stage under flexural loading such as the pre-cracking stage, post-cracking stage, the post yield stage. Well distributed cracks formed on the slab especially in the loading point.

➢The experimental test results obtained from the flexural test on ferrocement elements indicate that the serviceability criteria of deflection and crack width are less than 0.005mm.

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