Experimental Research on Ferro Foam Concrete I Beams with Different Number of Wire Mesh Layer

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Abstract. The paper presents the experimental study on Ferro foam concrete I beam with different number of wire mesh layers. Ferro foam concrete is alternative materials, which consist of a combination between wire mesh and foam concrete. This material is lightweight and easy to be produced. There are 3 specimens has been tested. Specimens’ configuration was 300 mm height, 150 mm width of upper and lower flange, and 60 mm web with 2200 mm span. The different between specimens was number of wire mesh layers, 2 layers, 3 layers, and 4 layers. Foam concrete used in this research consists of cement, water, foam agent, and 10 % Pozzolan. Compression strength of concrete was 23.23 MPa, and Tensile strength of reinforcement D8 and wire mesh G12.7 were 421 MPa. The specimens were tested using four points loading. Three units of LVDT were placed at a distance of 250 mm and 1000 mm from the support. Based on the results, it was found that the maximum load that can be carried out by specimen was 8.48 Tonf, 8.00 Tonf, and 9.50 Tonf, for 2 layer, 3 layers, and 4 layers, respectively. Maximum deflection for each specimen was 14.01 mm, 13.53 mm, and 21.37 mm, for 2 layers, 3 layers, and 4 layers, respectively. Number of layer in I beam 300.60.60 has no significant effect for the beam in their ability to carried the load.

1. Introduction
One reason for the isolation of a region is the unavailability of the bridge infrastructure. With the isolation of an area of economic growth in the region will move very slowly. Many products from that area cannot be sold, and the people in the area to be so far behind. Many simple bridge build in the village made of wood. Wood is a material which can be easy to be found, and available in the village. Unfortunately, since moratorium logging announced by Aceh Government through governor instruction No. 05/INSTR/2007 on 6 June 2007, wood material is very difficult to be find. To solve this problem, this research gives an alternative material, which is called Ferro foam concrete. Structural and Material Laboratory of Civil Engineering Syiah Kuala University, since 2006 has developed research on Foam Concrete. Foam concrete is a type of Lightweight concrete, which can be produced with different quality [1]. Abdullah [2], pozzolan with certain percentage can give positive influence on compression strength of foam concrete. Based on the research, it is possible to create an alternative material, which is a modification of Ferro cement. The objective of this study is to study experimentally Ferro foam concrete I beam with different number of wire mesh layers. Three Ferro foam concrete I beam with 300 mm height with 2, 3, and 4 wire mesh layers were tested in Structural Laboratory of Syiah Kuala University. This profile has a span of 2000 mm, and 100 mm wingspan.
Foam concrete used in this research consists of cement, water, foam agent, and 10% pozzolan. Average concrete compression strength was 24.23 MPa, and 4217.14 kgf/cm² (421 MPa) for yield strength of reinforcement with D8, and 4200 kgf/cm² (420 MPa) for wire mesh G 12.7. The specimens were tested using four-point loading. Three units of LVDT placed at a distance of 250 mm and 1000 mm from the support. Deflection readings every 100 kg of load increase.

2. Literature Review

2.1. Foam Concrete
Foamed concrete is defined as a light cellular concrete, which can be classified as a lightweight concrete (density of 400–1850 kg/m³) with random air-voids created from the mixture of foam agents in mortar. Foamed concrete is recognized for its high flowability, low cement content, low aggregate usage [1-3], and excellent thermal insulation [4]. Furthermore, the foamed concrete is considered as an economical solution in fabrication of large scale lightweight construction materials and components such as structural members, partitions, filling grades, and road embankment infills due to its easy production process from manufacturing plants to final position of the applications [2, 5-7]. In practice, foamed concrete has been commonly used in construction applications in different countries such as Germany, UK, Philippines, Turkey, and Thailand [8, 9].

2.2. Foam Agent
Foam agents control the concrete density through a rate of air bubbles created in the cement paste mixture. Foam bubbles are defined as enclosed air-voids formed due to the addition of foam agent. The foam agents are commonly synthetic, protein-based, detergents, glue resins, hydrolysed protein, resin soap, and saponin, [13, 15, 16]. The most common foam agents are synthetic and protein based. The protein based foam agents result in a stronger and a more closed-cell bubble structure which permits the inclusion of greater amounts of air and also provides a more stable air void network while the synthetic ones yield greater expansion and thus lower density [7, 10, 17]. The content of the foam agent has a considerable effect on properties of both fresh and the hardened concrete [11, 18]. It is reported that the excessive foam volume results in a drop in flow [14, 19]. However, the flow is significantly affected by mixing time. As reported, the greater the mixing time, the more the entrained air, albeit, prolonged mixing may cause the loss of entrained air by dropping the air content [10, 12].

2.3. Ferro Foam Concrete
Ferro foam concrete is an alternative material, which consists of a combination between wire mesh and foam concrete. Ferro foam concrete is a type of thin composite material made of foam concrete reinforced with uniformly distributed layers of continuous relatively small diameter, wire meshes. The design and construction of ferro foam concrete almost similar with Ferro cement which is described in two state-of-the-art reports published by the ACI committee 549 [20]. This material will give highly innovative solutions, since the strengths of foam concrete can be achieved more than 25 MPa [21, 22].

3. Methodology

3.1. Material
The material used in this study were cement, pozzolan, water, deform steel reinforcement, foam agent, wire mesh and admixture. Cement used was Portland cement type I production from PT. Semen Padang, Banda Aceh, Indonesia. Laboratory examination of semen is not done because the cement has been considered to meet the Indonesian National Standard (SNI) No. 15-2049-1994 and ASTM C.150-81. Tests done only by visual observation and examination of the wrapping bag friability, as well as the colour of the cement fineness. Natural pozzolan sand used should be cleaned of organic waste and filtered using a 4.76 mm sieve. Sand natural pozzolan is extracted from Ujong Bate sub district, Aceh Besar. Natural pozzolan also examined his physical density, absorption inspection, and fineness modulus. There was also tested in the chemical properties of Research and Testing Laboratories Industry Standards in Banda Aceh The water used in the concrete mix foam is water available at the
Laboratory of Building Construction and Materials Engineering Faculty Syiah Kuala University derived from wells. Foam agent used in this study derived from synthetic foam, which has been treated with chemicals to produce a similar foam lather that can be used as filler mixed concrete. Reinforcement used for tensile reinforcement is reinforcement steel screw with a diameter of 8 mm. Wire mesh used in this study were obtained from the nearest hardware store. Wire mesh, which will be used in this research diameter of 1 mm and 12.71 mm spacing as reinforcement. The rectangular wire meshes and conforms to ASTM A-185. Mix proportion for foam concrete used based on previous research done by Azzani [23]. Table 1 shows mix design for this research.

| Specific Gravity | Cement (kg) | Pozzolan (kg) | Water (kg) | Foam Agent (l) |
|------------------|-------------|---------------|------------|----------------|
| 1.6              | 1028.57     | 160           | 411.43     | 178.71         |

3.2. Detail Specimens
Detail of specimen shown in figure 1. Figure 1(a) shows detail profile I with number of reinforcement, and wire mesh layer. Figure 1(b) shows length of specimen which was 100 mm from the pin and roll support.

3.3. Experimental Setup
The three beams were simply supported and were subjected to two, symmetrically placed, point loads. The distance between the two loading points was kept at 600 mm and 700 mm from the support. The beams were suitably instrumented for measuring deflections at 250 mm and 1000 mm from the support. All the readings from the measurements were recorded using data logging system. Throughout the test, photos were taken for cracking behaviour, failure mode and any other features that were observed. Details of experimental Setup is shown in figure 2.
4. Results and Discussion

4.1. Material Properties
Table 2 shows concrete compression strength of results. Three-cylinder specimen has been tested before I beam specimen tested. Tensile strength result for reinforcement was 4217.136 kg/cm$^2$ (421 MPa), and for wire mesh 4200kg/cm$^2$ (420 MPa).

| Specimen name | $f'_c$ (kg/cm$^2$) | Average $f'_c$(kg/cm$^2$) |
|---------------|---------------------|--------------------------|
| C1            | 24.97               |                          |
| C2            | 23.86               | 24.23                    |
| C3            | 23.86               |                          |

4.2. Load-Deflection Relationship
Load-Deflection relationship shows in figure 3. It can be seen from the figure that the rigidity for all beam almost the same. First crack occurs for I beam 300.60.60 with 2-layer wire mesh when the load was 1.8 Tonf, and almost same for 3 layers and 4 layers. Maximum load that can be carried by the beam 2, 3 and 4 layer is 8.48 Tonf; 8 Tonf; 9.5 Tonf, respectively. After maximum load is reach on each specimen, the load continues to decrease until all specimens’ collapse. The load that can be carried by each beam only slightly different. It can be said that number of wire mesh layer was not so significant for the beam in their ability to carry the load. Maximum deflection for each specimen was 14.01 mm, 13.53 mm, and 21.37 mm, for 2 layers, 3 layers, and 4 layers, respectively.

4.3. Crack Pattern
Crack pattern for each beam shown in figure 4. It shown from the figures that crack pattern and maximum load for each beam. It has the same pattern and all the failure due to crush of concrete from the support. It can be seen from the figure that all the beam has shear failure. Figure 4 Crack Pattern for each Beam.
5. Conclusions
1. Maximum load which can be carried by I beam 300.60.60 with 2, 3 and 4-layer wire mesh is 8.48 Tonf; 8 Tonf; 9.5 Tonf, respectively.
2. Number of layer in I beam 300.60.60 has no significant effect for the beam in their ability to carried the load.
3. All the final failure due to crush of the concrete in the support, all the beam has shear failure.

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