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Experimental Test Analysis of Light Steel Composite Concrete Panels

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Abstract: The need of innovation in construction technology has driven involved parties within the industry to keep researching for new methods or materials in which could bring efficiency, yet more reliable. In this research, composite concrete panels which has become commonly used, is going to be modified by implementing lightweight steel as its concrete reinforcement. Three model of lightweight steel composite concrete panels were designed and tested for its compressing strength after 14 days. The proposed model was designed for low budget small housing and should be easily implemented. Moreover, all of the model used 1:2:3 concrete mix design without adding addictive solvent or other composite material. The tests result for model A is 5000 KN, for model B is 4600 KN and lastly for model C is 6000 KN. Based on these compressing strength test results, the designed models are able to be implemented for small housing construction.
Key words; compressing strength, light steel

INTRODUCTION

Innovations in the use of additional materials as admixtures in the manufacture of concrete structures are growing and the materials mixed in concrete are also increasingly varied. In this study, concrete panels made from standard materials, namely with a ratio of 1:2:3 with K-225 quality, will be combined with the use of lightweight steel as a substitute for concrete reinforcing iron.

The research method used is to design the composition of the concrete mix for each content and then produce concrete samples in the form of concrete panels to then test the strength of the concrete. Furthermore, an analysis of the test results was carried out and compared the strength of each concrete composition produced.

This study aims to seek optimization between the weight and strength of reinforced concrete structures. It is necessary to understand that cast concrete is formed from various types of material mixtures, such as cement, sand, gravel and water. Each of these aggregates is mixed with different compositions to obtain different concrete qualities. In this case, the government has approved the normal composition contained in the Indonesian Concrete Regulation (PBI) SNI 2847-2019.

However, the use of lightweight steel as a substitute for reinforcement in concrete is still not popular in Indonesia. So that by doing this research it is hoped that it can provide additional alternatives, especially to be able to reduce the production costs of concrete panels and in the end can save on overall construction costs.

This study will analyze the differences in the flexural strength of concrete beams using lightweight steel reinforcement and calculate the differences in the stiffness values. Good quality concrete has several advantages including having high compressive strength, resistance to corrosion or decay by environmental conditions, resistance to weather (hot, cold, sun, rain).

Concrete also has several weaknesses, which are weak to tensile strength, expands and contracts when temperature changes occur, is difficult to be completely waterproof, and is brittle. Furthermore, to be able having a better understanding for the research, the previous related researches were reviewed and constructed as table 1.

Table 1. The previous researches within the subject

No	Title	Year	Author(s)	Methodology
1	Testing Strong Flexible Hollow precast lightweight concrete slab panels with the addition of silica fume	Nov, 2015	Ario, Wahyu, Gumilang	flexural strength precast
2	Utilization of rubber seed as coarse aggregate on the workability and compressive strength of lightweight concrete	July, 2018	Sumiati, Mahmud	Compressing strength test
3	Compressive strength study, strong tensile strength, flexural strength and sound attenuation in lightweight concrete wall panels with plastic pet waste aggregate and sawdust waste	Dec, 2014	Itsna Fauziah Royani, Achmad Basuki, Sunarmasto	compressive strength, tensile strength, flexural strength and sound attenuation
4	Overview of the flexural strength of lightweight concrete panel walls using Styrofoam with wire reinforcement welded mesh netting	2013	Zaim Nur Fahrudin	Compressive strength, bending strength
5	Flexural strength test on coarse aggregated concrete panels pet plastic waste and wire mesh reinforcement	Sept, 2015	Muhammad Fauzan, Ramadhani Achmad Basuki, Agus Supriyadi	experimental method
6	Study of slump value, compressive strength and modulus of elasticity of concrete with sandstone ash as filler	July, 2014	Harnung Tri, Hardagung, Kusno Adi Sambowo, Purnawan Gunawan	compressive strength and modulus of elasticity
7	Value of concrete compressive strength at a certain concrete slump	2015	Fadli M, Van Gobel	Mix design method
8	Characteristics of lightweight concrete with Styrofoam filling material	2015	Agung Fadhilah Putra	compressive strength
9	Microstructural analysis of lightweight concrete combined with fly ash and bottom ash	June, 2021	Fima Berlianda	Experiment method
10	The effectiveness of using mild steel for roof truss structures	2015	H. Duppa	tensile strength

METHODOLOGY

This research were constructed based on methodology as picture in the following flowchart.

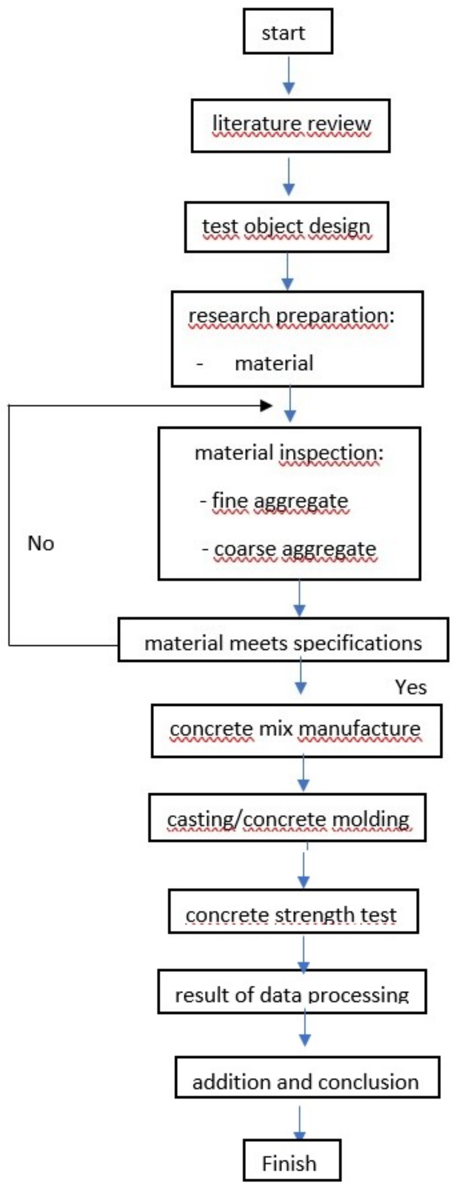

Figure 1. Flowchart of the research

In general, the research were conducted in two main stages, which firstly mixture design and model casting (concrete molding) and secondly laboratory tests. The first stage was held in Universitas Narotama's laboratory and for the second stage were in Politeknik Negeri Malang.

The proposed models design are lightweight steel composite concrete panel with module size of 60 cm in length and 33 cm in height (as figure 2). There were three module casted and tested after 14 days.

The data were taken when the tested modules deflexed and cracked during the compressive test. The data is the maximum force (P) and converted to determine concrete compressive stress (fc).

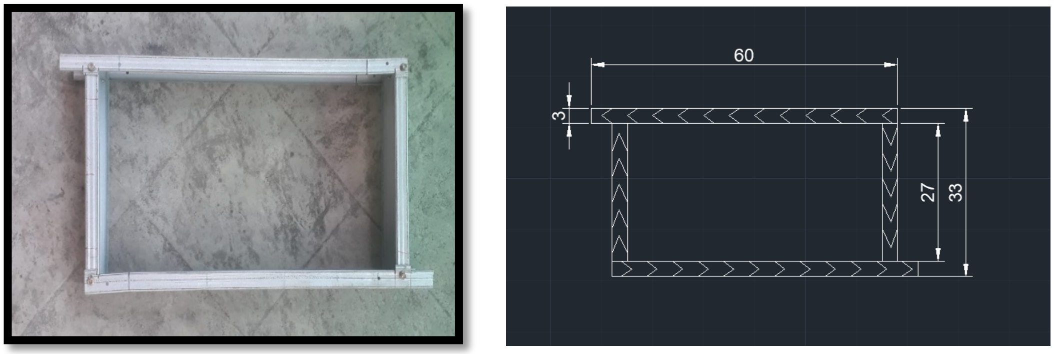

Figure 2. Light steel module for Composite concrete panel

Figure 3. Composite concrete panel module

Figure 4. The process of concrete panel fabrication

The frame work for the concrete panel is shown in figure 3 and as figure 4 is the process of concrete panel fabrication. These processes were conducted in Universitas Narotama Surabaya.

RESULTS AND DISCUSSION

Mix Design and Aggregate Characteristic Tests

Firstly, the research determined the mix design and aggregate tests. This research is important in order to have a good concrete mix for the designed model. The results are shown as in table 2 for the recapitulation of fine aggregate test and as in table 3 for the recapitulation of coarse aggregate test. The combine aggregate gradation is illustrated as in table 4.

Table 2. Recapitulation of Fine Aggregate Test Results

SIEVE		STAY ON THE SIEVE		% CUMULATIVE	
NUMBER	mm	gram	%	Stay	Through
4	4,76	34	8,01%	8,01%	91,99%
8	2,38	40	9,43%	17,45%	82,55%
16	1,19	79	18,63%	36,05%	63,9%
30	0,59	102	24,05%	60,14%	39,85%
50	0,297	82	19,33%	79,48%	20,52%
100	0,149	63	14,85%	94,34%	5,67%
Pan	0	22	5,18%	100%	0
Cumulative					
	Fm sand = 424				

Table 3. Recapitulation of Coarse Aggregate Test Results

TESTS	UNIT	RESULTS	SPEC INTERVAL	Results
Dampness of broken stone	%	0,01%	Max. 2%	Fulfill
Absorption of crushed stone against water	%	2,6%		Fulfill
The volume weight of crushed stone				
1. With poke	gr/cm^3	1,49	1,4 – 1,9	Fulfill
2. Without poke	gr/cm^3	1,43	1,4 – 1,9	Fulfill
Cleanliness of crushed stone against mud	%	0,2%	Max. 2%	Fulfill
Specific Gravity of Crushed Stone	gr/cm^2	2,22		Fulfill

Aggregate Combined Gradation

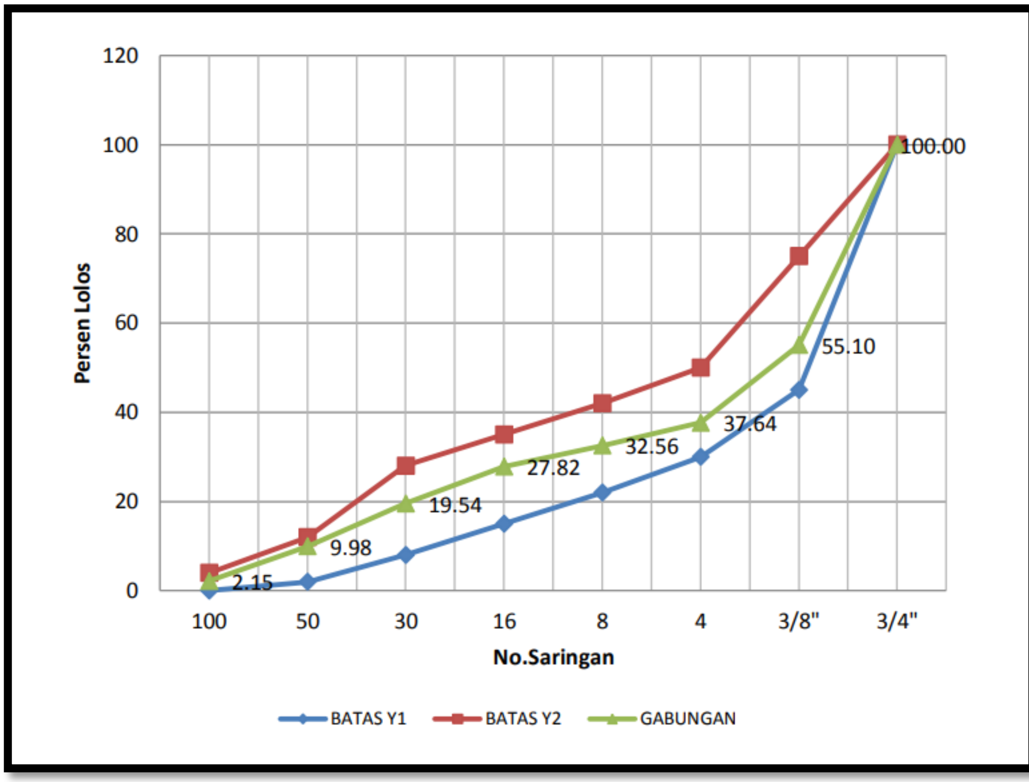

Figure 4. Aggregate combined gradation graph

Slump Test

To find out the level of viscosity of the concrete mix, a slump test was carried out. It was noted average of 12,3 cm.

Concrete Unit Weight

Checking the concrete unit weight is carried out when the concrete is 14 days old and testing the unit weight of concrete is known that each type of concrete is made of three pieces.

Table 4. Concrete Unit Weight

No.	Concrete Type	Module Type	Weight (Kg)
1.	Lightweight Steel Composite Concrete Panel	A	62
		B	62,4
		C	61,8

As we can see from the table 4, there are differences in weight value. It might be the case of the weather, temperature and air humidity surrounding the tested modules during those 14 days.

Concrete Compressive Strength

The 1000 KN compressive Strength unit test was used to test the designed modules. The result was as shows in table 5.

Table 5. The concrete compressive strength result

No.	Concrete Type	Module Type	Days	Compressive Strength (KN)
1.	Lightweight Steel Composite Concrete Panel	A	14	5000
		B	14	4600
		C	14	6000

CONCLUSION

1. Based on the results of the composite concrete panel strength test on the quality of the concrete planned using light steel panels without using a series of reinforcing bars, the compressive strength for model type A, B and C are 5000 KN, 4600 KN and 6000 KN respectively.

   In addition, the sand test obtained results for sand humidity of 0.77%, sand absorption in water of 17.9%, the volume weight of sand without a joist was 1.56 gr/cm3, with a vibration of 1.76 gr/cm3, with a vibration of 1.71 gr /cm3, cleanliness of sand against mud 2.6%. Coarse aggregate test results found that the humidity of crushed stone was 0.01%, the absorption of crushed stone to water was 2.6%, the volume weight of crushed stone without being jostled was 1.49 gr/cm3, with joist gr/cm3, the cleanliness of crushed stone against silt 0.2%, crushed stone specific gravity 2.22%.

2. Based on the results of the compressive test of concrete panels made of light steel, we can recommend it for the manufacture of small-scale and low budget houses.

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