Morphology and Composite Characteristics of Lightweight Concrete with Styrofoam Filling Materials

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Abstract. Concrete is made which is a material commonly used for construction and structures in buildings, concrete has many advantages compared to other building materials. However, concrete has one weakness, namely the specific gravity is high enough so that the dead load on a structure becomes large. Several methods can be used to reduce the concrete density, including using lightweight aggregates. One method to make lightweight concrete is by adding Styrofoam waste materials. However, this specific weight reduction is not followed by the addition of concrete compressive strength, so that until now lightweight concrete using Styrofoam is only used for non-structural parts. For this purpose, it is made to find out how much the influence of Styrofoam as a substitute for coarse aggregate on Concrete with the additional percentage of Styrofoam by 0%, 15%, and 35%, and 50% of the weight of the Concrete mixture.

Keywords: Styrofoam, the weight of concrete volume, compressive strength, morphology

1 Introduction

Concrete is part of the development component in the field of construction, technological progress and the economic crisis that occurred in Indonesia, directing infrastructure development in the use of structures with lightweight materials[1]. But overall it does not have an impact on increasing the strength of the structure [2]. In the modern era shows the development of the use of the lightweight material as a structure-forming material will reduce the total weight of a building, thereby reducing the supporting parts and foundations such as in the construction of housing, offices, hospitals and so on.

The development of building construction at this time is influenced by the high global warming, resulting in issues that require, concrete manufacturing technology innovation to answer the challenges of need, including environmentally friendly, thus making construction experts compete in carrying the green building concept. One way to apply the concept of green building is to reuse used material or waste as building materials[3]. This will reduce costs and increase waste usage[4]. By using Styrofoam in the concrete mixture, the total weight of the concrete will be lighter and the use value of styrofoam will increase, but this will affect the strength of the concrete or along with the addition of styrofoam to the concrete mixture[5], [6].

Based on the above, this study aims to evaluate how much influence Styrofoam has in concrete mixtures. The characteristics in question are the morphology of the effect of the

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mixture with the ratio of styrofoam to the volume of concrete which varies from 0%, 15%, 35%, and 50%, keeping it analyzed using SEM.

2 Research methods

2.1 Research Flow Chart

The experiments carried out in the laboratory with the implementation stages in the outline can be seen in the flowchart below, where the experimental steps are described in the form of Flowchart. The material is prepared for mixing by calculating the volume co-composition of the concrete composition material in cubic by using a volume ratio of 1000 kg/m^3, taken from the basic composition of the concrete mix plan [7].

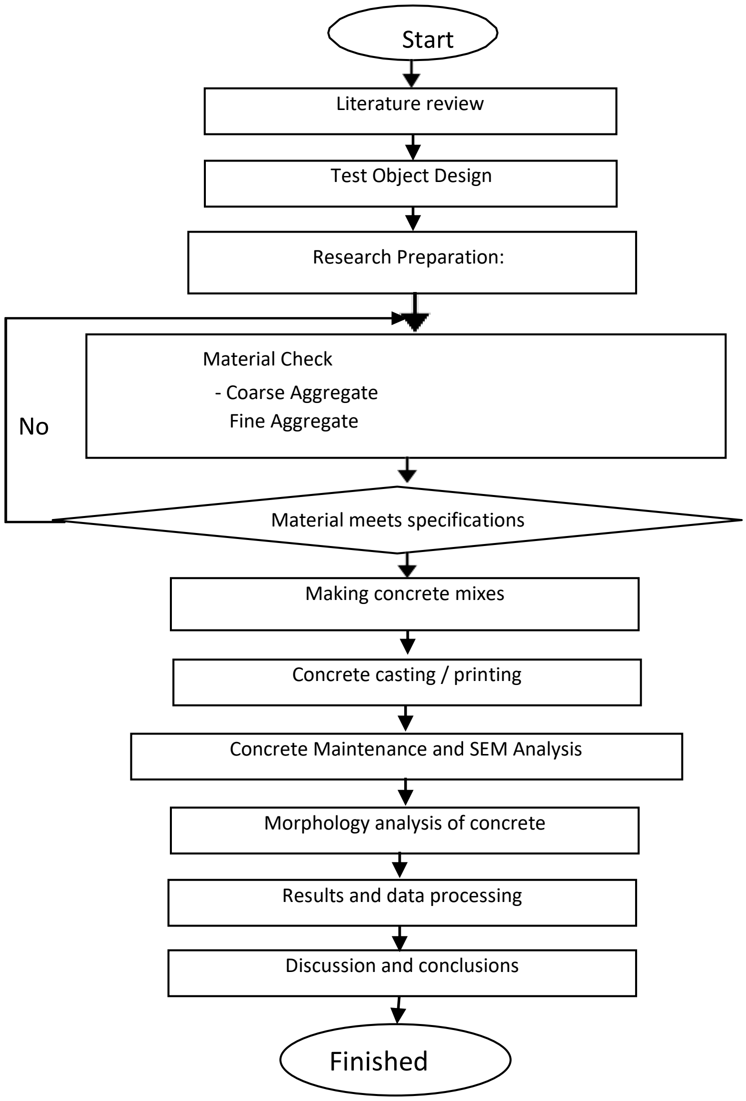

Fig 1. Research flow chart

Table 1. Concrete material composition with a composition of weight (kg)

No	Type of Material Concrete	Normal concrete	15% Styrofoam Concrete	Styrofoam concrete 35%	50% styrofoam concrete
1	Water (kg)	42,8	42,8	42,85	42,85
2	Cement (kg)	181,4	181,4	181,4	181,4
3	Sand (kg)	999,9	849,9	649,9	407,2
4	Gravel (kg)	257,3	218,5	167,1	61128
5	*Styrofoam* (kg)	0	2,87	6,6	9,5

4 Result and Discussions

Based on the results of testing concrete construction materials obtained data that plays a good role in the calculation of the composition of concrete composers also for the calculation of hardness and pull of concrete In **table 2.** listed concrete construction materials that have been tested:

Table 2. Test data for concrete composite

Testing type	Type of material				
	Cemen	**Sand**	**gravel**	**Styrofoam**	**Water**
Specific gravity	3,15	2,4	2,49	0,0236	1
Volume weight	1,27	1,4	1,8	0,0223	0,98

Figure 4.1 Graph of aggregate aggregation gradations From the results of the combination of mixed materials for concrete production there is a combined gradation that gives effect to the strain value and the compressive strength of the concrete made. Material composition Concrete made for 1 m3 required the composition of materials arranged in a ratio of 1: 5: 1 and 0 as shown in **table 3**[8][8][7][5][4][4][3].

Table 3. The composition of material requirements for a concrete mix for 1 m^3

Comparison of composition Concrete mixture	**Concrete Mixture Composition (kg)**				**Water**	**Concrete mass (kg)**
	Cement	**Sand**	**Gravel**	**Styrofoam**		
	1	5	1	0		
1 : 5.0 : 1.0 : 0	181,42	999,99	257,13	0	42,85	1481,39
1 : 4,25 : 0,85 : 0,90	181,42	849,99	218,57	2,87	42,85	1295,7
1 : 3,25 : 0,65 : 2,10	181,42	649,99	167,15	6,69	42,85	1048,1
1 : 2,50 : 0,5 : 3,00	181,42	407,29	128,56	9,55	42,85	769,67

Table 4. The composition of the mixture of concrete constituent materials (kg)

Comparison of composition Concrete mixture	Concrete Mixture Composition (kg)					Concrete mass (kg)
	Cemen	Sand	gravel	Styrofoam	Water	
1: 5.0 :1.0 : 0.0	0,73	3,99	1,03	0	0,17	5,92
1 : 4,25 : 0,85 : 0,90	0,73	3,39	0,87	0,012	0,17	5,172
1 : 3,25 : 0,65 : 2,10	0,73	2,59	0,67	0,027	0,17	4,187
1 : 2,50 : 0,5 : 3,00	0,73	1,63	0,51	0,038	0,17	3,078

To determine the needs of concrete constituent materials per piece of concrete made the concrete shape that we want, and has been done and made with the size of the building and composition with the data below: Dimensions of Concrete: 10 x 10 x 40 cm for Beams with a volume of 4000 cm^3 is equivalent to 0.004 m^3. For making 12 concrete, the required volume is 0.004 x 12 = 0.048 m^3. So that many needs based on the composition of the concrete mixture per fruit are listed in **table 5**.

Table 5. The composition of concrete mixtures (kg) for 12 concrete beams.

Comparison of the the composition of the Concrete mixture	**Cement**	**Sand**	**gravel**	***Styrofoam***	**Water**	**Mass (kg)**
1 : 5.0 : 1.0 : 0	8,76	47,88	12,36	0	2,04	71,04
1 : 4,25 : 0,85 : 0,90	8,76	40,68	10,44	0,144	2,04	62,064
1 : 3,25 : 0,65 : 2,10	8,76	31,08	8,04	0,324	2,04	50,244
1 : 2,50 : 0,5 : 3,00	8,76	19,56	6,12	0,456	2,04	36,936

For 12 pieces of concrete needed to be tested, the volume of constituent material is required = 0.048 m3 and the composition of the requirements is shown in table 4.10. To determine the needs of concrete constituent materials per piece of concrete made the concrete shape that we want, and has been done and made to the size of the building and composition with the data below: Dimensions of Concrete dimensions: 10 x 20 cm for Cylinders with volume V = 1/4 π D ^ 2 t = 1570 cm^3 is equivalent to 0.001570 m^3. For the manufacture of 45 cylindrical concrete, the required volume is 0.001570 x 45 = 0.07065 m3. So that many needs based on the composition of the concrete mixture per fruit are listed in **table 6.**

Table 6. Cylinder concrete composition (kg)

Comparison of the composition of the Concrete mixture	Cement	Sand	Gravel	*Styrofoam*	Water	Concrete mass (kg)
1 : 5.0 : 1.0 : 0	0,28	1,57	0,40	0	0,067	2,25
1 : 4,25 : 0,85 : 0,90	0,28	1,33	0,34	0,0045	0,067	2,02
1 : 3,25 : 0,65 : 2,10	0,28	1,02	0,26	0,0105	0,067	1,63
1 : 2,50 : 0,5 : 3,00	0,28	0,64	0,20	0,0150	0,067	1,20

Table 7. Cylinder concrete composition (kg) for 45 concrete

Comparison of the composition of the Concrete mixture	Cement	Sand	Gravel	*Styrofoam*	Water	Concrete mass (kg)
1 : 5.0 : 1.0 : 0	12,6	70,65	18,0	0	3,015	104,265
1 : 4,25 : 0,85 : 0,90	12,6	59,85	15,3	0,20	3,015	90,965
1 : 3,25 : 0,65 : 2,10	12,6	45,90	11,7	0,47	3,015	73,685
1 : 2,50 : 0,5 : 3,00	12,6	28,80	9,0	0,67	3.015	54,085

Table 8. Average concrete unit weight test results

Styrofoam Volume (%)	Mass of Average Beam Concrete Unit (kg / m3)	Average Cylinder Concrete Unit mass (kg / m3)	Reduction (%)	
			Balok	Silinder
0	5,920	2,25	0	
15	5,172	2,02	0,12	0,10
35	4,187	1,63	0,29	0,27
50	3,078	1,20	0,48	0,46

Compressive Strength of Concrete

Testing the compressive strength of concrete using UTM machines with a capacity of 1000 KN. The results of the calculation of the average concrete strength can be seen in **Table 9.**

Table 9. Calculation results of concrete strength (MPa)

Styrofoam volume (%)	Test Age (Days)	Average Concrete Strength (MPa)
0	14	20,94
	21	24,25
	28	27,74
15	14	12.69
	21	15.10
	28	17.76
35	14	8.21
	21	11.03
	28	13.12
50	14	4.75
	21	4.94
	28	5.26

The weight inspection of concrete units is carried out when the concrete is 28 days old.

Morphological results from SEM

From the morphological results of the SEM results from Styrofoam mixing of the supporting components of concrete sand and gravel, this material has an effect on the composition composed of the material as shown in the picture above**.** EDX results from the concrete constituent material show that Styrofoam which amounts to 50% of the overall concrete volume looks stiffer. [8], [9],[10]

Thus the results of 50% styrofoam mixture showed that morphology from mixing concrete supporting groups and styrofoam was more dominant.

Thus a mixture of 355% styrofoam is seen that the composition of the mixture for 35% styrofoam is seen to occupy less quantity as seen by **figure 4.3.**

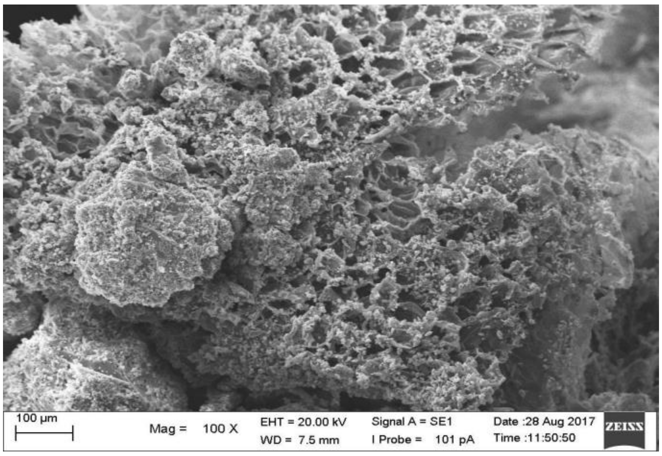

Fig 2. Mixing styrofoam with a composition of 50**%**

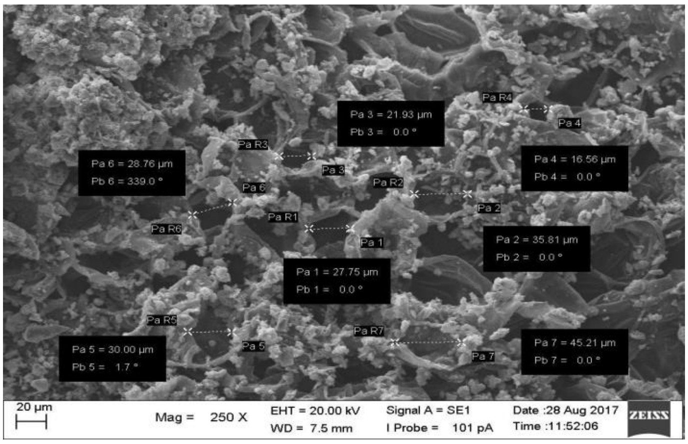

Fig 3 Styrofoam mixture with a composition of 35%

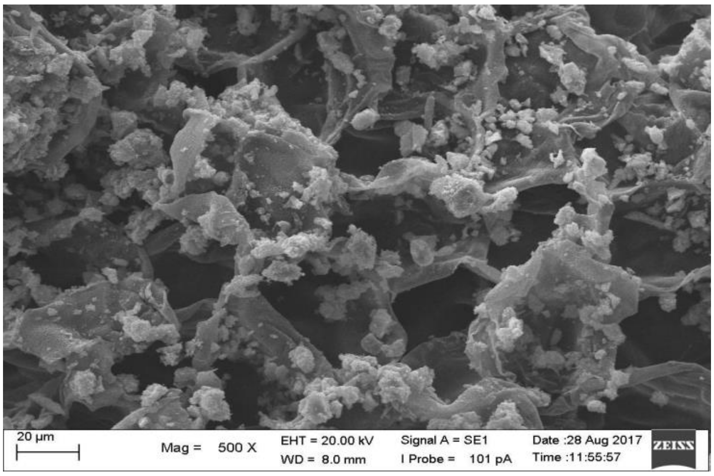

Fig 4. Styrofoam mixture with a composition of 15 %

Thus a mixture of 15% styrofoam is seen that the composition of the mixture for 15% styrofoam is seen to occupy less quantity as seen by **Figure 4.4.**

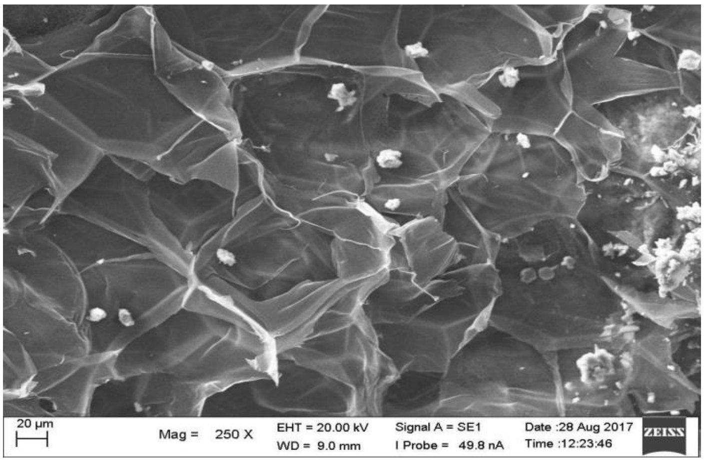

Fig 5. Styrofoam mixture with a composition of 0 %

From the results of SEM, the Styrofoam composition has not played a role in the constituent components of concrete, so there is no morphology of Styrofoam in **Fig 5.**

5 Conclusions and recommendations

5.1. Conclusion

The addition of 35% styrofoam from the volume of concrete can be categorized as lightweight concrete with a maximum weight range of 1900 kg / m3. The compressive strength of concrete is influenced by the volume of styrofoam in the concrete mixture. Where the greater the volume of styrofoam, the lower the compressive strength produced. The compressive strength values with 0%, 15%, 35%, and 50% styrofoam volume on average at 28 days were 27.74 MPa, 17.76 MPa, 13.12 MPa, and 5.26 MPa. From the results of the split tensile test, it was found that the greater the volume of styrofoam the lower the split tensile strength produced by the maximum reduction of normal concrete by 62.46% in the volume of 50% styrofoam. For flexural strength test, the percentage decrease in flexural strength at 15%, 35%, and 50% of styrofoam volume increase on normal concrete blocks was 18.76%, 30.83%, and 44.54% respectively. So that the greater the volume of styrofoam added to the concrete, the lower the value of the flexural strength produced. Morphology from styrofoam I concrete constituent material can be seen that styrofoam which amounts to 50% of the overall concrete volume looks stiffer. [10]

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