



## WATER ABSORPTION OF STYROFOAM CONCRETE

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### ABSTRACT

Styrofoam concrete in this paper is a concrete that made from aggregates that derived from waste pieces of styrofoam as a substitute for coarse aggregate in order to reduce the weight of the concrete. Volume composition ratio of sand and bits of styrofoam as the fine aggregate is 60:40. Styrofoam concrete has a weight only 1510.86 kg / m<sup>3</sup> and can be used as a building wall material. Styrofoam concrete also possesses a waterproof ability, because the water absorption capacity is only 11.97%.

**Keywords:** water absorption, lightweight concrete, styrofoam.

### INTRODUCTION

Most of the current building using concrete as its main component. This is not surprising because the concrete has advantages when compared to other materials. Some concrete advantages include relatively cheap, have high compressive strength, corrosion resistant, relatively simple in construction, and relatively resistant to fire. However, concrete has one weakness that the unit weight is high enough so that the dead load on a structure to be great. While as average mass of modular brick unit was found to be 1.8 kg and mass density came out to be 1.06 g/cm<sup>3</sup> [1]. Therefore it is necessary to develop concrete with light weight to reduce the weight of the building. Earthquake loads that work will be smaller because the weight of the structure is reduced, so that the structure will be safe and suitable for residential buildings in the earthquake area. [2]

Basically all kinds of lightweight concrete produced with a large number of air content [3], both within and between the grain aggregate benchmark. In connection with that there are three basic types of lightweight concrete:

- Lightweight aggregate concrete
- Concrete foam
- No fine aggregate concrete

Other classification/grouping of lightweight concrete in accordance with the intended use / function is shown as below:

**Table-1.** The division of lightweight concrete according to usage and requirements.

	Type lightweight concrete	Weight per volume (kg / m <sup>3</sup> )	Compressive strength (MPa)
Neville and Brooks (1987) [4]	Lightweight concrete retaining heat (Insulating Concrete)	<800	0.7 to 7
	Lightweight concrete for masonry (Concrete Masonry)	500-800	7-14
	Lightweight concrete structure (Structural Lightweight Concrete)	1400 - 1800	> 17
Dobrowolski (1998) [5]	Concrete with low density (Low-Density Concretes)	240-800	0.35 to 6.9
	Medium-strength lightweight concrete (Moderate-strength Lightweight Concretes)	800 - 1440	6.9 to 17.3
	Lightweight concrete structure (Struktural Lightweight Concretes)	1440 - 1900	> 17.3
SNI 03 - 3449-2002 [6]	Lightweight concrete for very light structures	<800	-
	Lightweight concrete for lightweight structures	800 - 1400	6.89 to 17.24
	Structural lightweight concrete	1400 - 1860	17.24 to 41.36



The compressive strength lightweight concrete is low, therefore it is not recommended as main structures such as columns and beams, or if will be applied only for a lightweight structure. Lightweight concrete also can be used as a non-structural element such as walls of buildings.

Wall is the largest component in the building, so if the wall has a light weight it can affect the overall weight of the building. However, the light weight is not enough, must have a waterproof capability as well. The walls are not water resistant would be damp and dangerous to health. Exposure to water-damaged indoor environments and subsequent fungal and bacterial growth leads to a variety of symptoms that are often overlooked by the medical profession [7]. Thus it is necessary to study the composition of lightweight concrete wall but also has a waterproof capability.

### RESEARCH METHODOLOGY

The research was done by experimenting / testing in the laboratory. The weight of styrofoam is light enough, only 15kg/m<sup>3</sup> [8]. Any aggregate with a particle density of less than 2000kg/m<sup>3</sup> or dry loose bulk density less than 1200 kg/m<sup>3</sup> is defined as lightweight [9]. So that this research was intended to take advantage of styrofoam waste as a substitute for coarse aggregate so that concrete has a lighter weight. Volume composition ratio of sand and bits of styrofoam as the fine aggregate is 60:40. This study uses assumptions and limitations are as follows:

1. The amount of Styrofoam used as a lightweight concrete mix is 60% of the aggregate volume with cement content of 300 kg / m<sup>3</sup>.
2. Portland cement is used types of Composite Cement (PCC).
3. Water cement ratio (w/c ratio) for concrete Styrofoam, at the initial planning set at 0.5.
4. Styrofoam that is used for the specimen is from styrofoam waste that is shaved / crushed by machine, and in dry conditions at the time of blending / concrete mixing.
5. Fine aggregate (sand) taken from the Progo river, Yogyakarta.

In the making of the analysis and processing of test results, use the following formula:

- a) Weight of concrete (styrofoam concrete and mortar)

Bulk density was calculated by the equation (1)

$$w = \frac{W}{V} \quad (1)$$

Where,

$w$  : Unit Weight (kg/m<sup>3</sup>)  
 $W$  : Specimen weight (kg)  
 $V$  : Specimen volume (m<sup>3</sup>)

- b) Water Absorption Test (styrofoam concrete and mortar)

Water absorption is calculated by equation (2)

$$P = \frac{W_b - W_k}{W_k} \times 100\% \quad (2)$$

Where,

$P$  : Percentage of absorbed water (%)  
 $W_b$  : Weight of specimen after water immersion for 24 hours (kg)  
 $W_k$  : Absolute dry weight of the specimen before soaking water (kg)



**Figure-1.** Styrofoam concrete (left) and mortar (right).

### ANALYSIS AND DISCUSSIONS

This section will explain the results of the testing that has been done in the laboratory. Results of laboratory tests that will be analyzed based on the theory, regulations / standards and codes and other references.

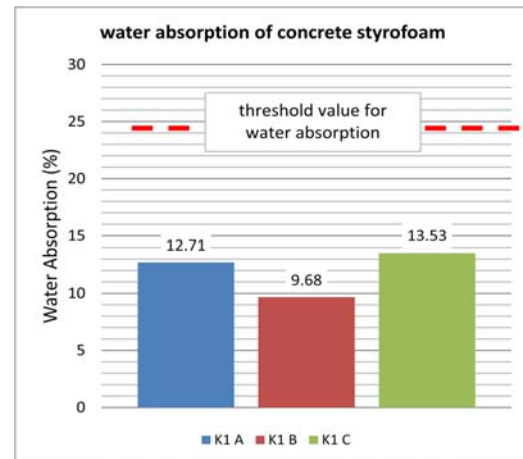
#### Styrofoam concrete testing results

Styrofoam concrete specimen using cubes specimen (50x50x50) mm<sup>3</sup>. The test results for bulk density of Styrofoam Concrete (weight per volume) and water absorption level are explained below:

**Table-2.** Dimension and weight of styrofoam concrete specimen.

Specimen number	Dimensional objects test				weight per volume
	Length (mm)	Width (mm)	Height (mm)	Weight (gram)	(kg/m <sup>3</sup> )
K.1A	49.1	50.5	50.3	189	1.515,38
K.1B	50.2	51.4	49.9	198	1.537,79
K.1C	51.7	49.8	50.8	195	1.490,91

If averaged, it will get the value of the unit weight for styrofoam concrete: 1510.86 kg/m<sup>3</sup>. Based on the explanation above, the concrete-styrofoam classified as lightweight-concrete that made from lightweight aggregate. General Requirements Code for Building Materials in Indonesia requires the maximum water absorption for concrete / mortar is 25% (maximum value/threshold) [10]. The test results conducted on the water absorption of the concrete styrofoam cube specimen that the average water absorption is 11.97%. Therefore, this styrofoam concrete has a waterproof capability.

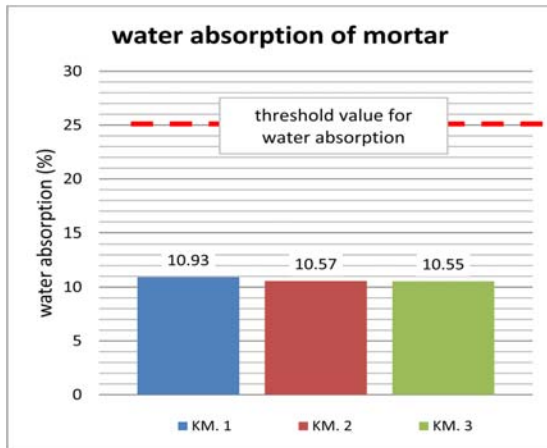
**Figure-2.** Diagram of the water absorption test results for styrofoam concrete.

#### Mortar testing results

Mortar specimen using cubes specimen (50x50x50) mm<sup>3</sup>. Mortar composition (PC and fine aggregate) is 1:2, with w/c ratio = 0.5. This composition is common used in order to make a waterproof wall plaster. The test results for bulk density of mortar (weight per volume) and water absorption level are explained below:

**Table-3.** Dimesion and weight of mortar specimen.

Specimen Code	Dimensional objects test				weight per volume
	Length (mm)	Width (mm)	Height (mm)	Weight (kg)	(kg/m <sup>3</sup> )
KM.1	49.7	49.6	50.1	269	2178.09
KM.2	50.7	50.2	50.7	278	2154.39
KM.3	49.9	50.3	49.4	265	2137.23



**Figure-3.** Diagram of the water absorption test results for mortar.

If averaged, it will get the value of the unit weight for mortar: 2156.57 kg / m<sup>3</sup> and the average of water absorption for mortar is 10.68%.

## CONCLUSIONS

From the results of research and discussion that has been described can be concluded as follows:

Styrofoam concrete content weight: 1510.86 kg / m<sup>3</sup>, while the weight of the contents of the concrete mortar 2155.70 kg / m<sup>3</sup>.

The test results conducted on the water absorption of the test specimen concrete cube styrofoam is 11.97%, while the water absorption test results conducted on mortar cube specimen is 10.77%.

Weight content can be reduced up to 30%, but the difference in water absorption is only 1.2%.

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