

Ductility of polystyrene waste panel

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Abstract. Polystyrene waste panel is one of alternative materials that uses polystyrene waste. This experiment is to utilize the polystyrene waste as a non structural panel to be evaluated the ductility. The specimen consisted of cement 250 kg/m^3 , polystyrene waste was as aggregate, water cement ratio was 0.4 and wire mesh diameter was 0.6 mm with the grid 6 mm x 6 mm placed on the top and bottom of the panels. The polystyrene panels were compressed at 2 MPa. Six specimens had dimension 80 cm length, 30 cm width and the thickness planned were two varieties, they were 0.5 cm and 1 cm. Flexural testing is used to examine load and deflection to measure the ductility. The load and the deflection showed that the maximum load for the specimen with 0.5 cm thickness is 0.4, 0.56 and 0.37. And for 1 cm thickness is 0.4, 0.36, 0.64. It shows that the thickness variation does not give effect on the maximum load. Result showed the average of Displacement Ductility Index of polystyrene waste panels with 0.5 cm thickness was 1.692 and for 1 cm thickness, the average was 4.043. So the average of the panel with 0.5 cm thickness planned is under 1.99 and the panel with 1 cm thickness planned is upper 3, therefore, it is considered imperative for adequate ductility.

1. Introduction

Polystyrene waste panel as one of alternative materials that use polystyrene waste [1]. It is estimated that EPS foam (or polystyrene) products accounts for less than 1% of the total weight of landfill materials, the fraction of landfill space it takes up is much higher considering that it is very lightweight. Furthermore, it is essentially non biodegradable materials, taking hundreds perhaps thousands of years to decompose. Even when already disposed of in landfills, EPS can easily be carried by the win and litter the streets or end up polluting water bodies [2].

Expanded polystyrene waste in a granular form is used as lightweight aggregate to produce lightweight structural concrete with the unit weight varying from 1600 to 2000 kg/m^3 [3].

According to[4] that EPS dosage has the most significant effect on compressive strength of EPS lightweight aggregate concrete, than water and cement ratio, while the content of cement and sand ratio play a comparatively less important part. This experiment is to utilize the polystyrene waste as the material of non structural panel to be evaluated the ductility.

2. Experimental study

This research was done by trying out the mixture in order to get the appropriate composition of the panel. All panels are tested under one point loading scheme based on SNI 03-4154-1996 to get relationship load – deflection.



2.1 Material

The basic materials used in this research are cement, water, polystyrene waste in the form of granules and 0.6 mm diameter wire mesh with grid 6 mm x 6 mm is cut to size of 80 cm x 30 cm. The basic materials as shown Figure 1 other than water.

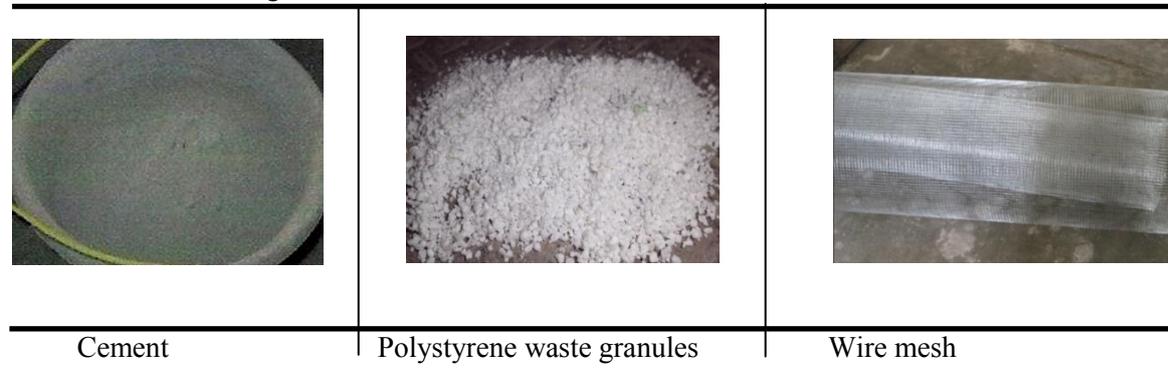


Figure 1. Material for polystyrene waste panel

2.2 Specimen

There are six polystyrene waste panels with two various thicknesses as shown in Table 1 and specimen detail shown in Figure 2.

Table 1. Specimen dimension

Specimen	Length [cm]	Width [cm]	Thickness planned [cm]
T0.5-1	80	30	0.5
T0.5-2	80	30	0.5
T0.5-3	80	30	0.5
T1-1	80	30	1
T1-2	80	30	1
T1-3	80	30	1

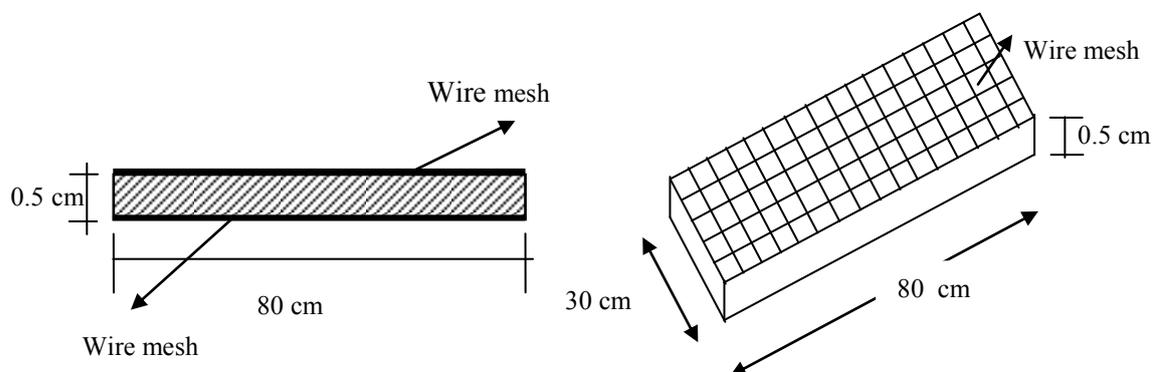


Figure 2. Specimen detail

2.3 Composition

Polystyrene waste panels are made of a mixture of cement, polystyrene waste, and water. After trying out the mixture, it is obtained the appropriate composition as it is shown in Table 2. The cement contented 250 kg/m³, water cement ratio is 0.4 and the unit weight of polystyrene waste is 15.9 kg/m³. Then the panel is compressed 2 MPa. Table 2 shown the composition for polystyrene waste panel after it was tried out the mixture.

Table 2. Composition for polystyrene waste panel

Specimens thick [cm]	Cement content [kg]	Water [liter]	Polystyrene [kg]	Compressing [MPa]
0.5	1.5	0.6	0.1	2
1	3	1.2	0.2	2

2.4 Methodology

First put the wire mesh on the bottom of the mold. Second pour the mixture. Third put the wire mesh on the top and cover it. Then compress it by hydraulic jack at 2 MPa and let it stand for 15 minutes until the specimen is incompressible. The last take it out from the mold and save it for 28 days in a dry state.

2.5 Test procedure

To monitor the behavior of the tested panel under the applied loading, two LVDT were placed on the mid-span to measure the deflection of the test specimen and connected with data logger. Figure 3 show the test of panel (panel T0.5-2). All panels were tested under a one-point loading scheme.



Figure 3. Test Set Up

3. Result and discussion

Table 3. The test result for load and deflection of polystyrene waste concrete

Specimen	Dimension			Maximum Load [KN]	Deflection [cm]
	Length [cm]	Width [cm]	Thickness [cm]		
T0.5-1	80	30	0.61	0.4	7.854
T0.5-2	80	30	0.58	0.56	7.026
T0.5-3	80	30	0.57	0.37	6.970
T1-1	80	30	1.25	0.4	1.304
T1-2	80	30	1.57	0.36	1.874
T1-3	80	30	2.17	0.64	1.425

The test results showed in Table 3, after making tree specimens with 0.5 cm thickness planed, the result obtained of thickness was variety, they were 0.57, 0.58, 0.61 whereas for 1 cm thickness planned, the results were much more different from the plan. They are 1.25, 1.57, and 2.17 cm. It is shown that the thinner specimen the more constant. The maximum load for all specimens was almost the same. The deflection for 0.5 cm thickness was bigger than 1 cm thickness. Therefore, maximum load is not as comparable as the deflection.

Displacement ductility index is defined as the ratio of deflection at ultimate load to deflection at yield point. The value of ultimate load, according to [5], is 0.8 from maximum load and [6] mentioned that the deflection at yield point can get from the load intersection where the load reached 75% ultimate load. As shown in Figure 4 below.

$$\mu = \frac{\Delta u}{\Delta y} \quad (1)$$

Where μ is the displacement ductility index, Δu is the lateral deflection at ultimate load and Δy is the lateral deflection when yield is first reached.

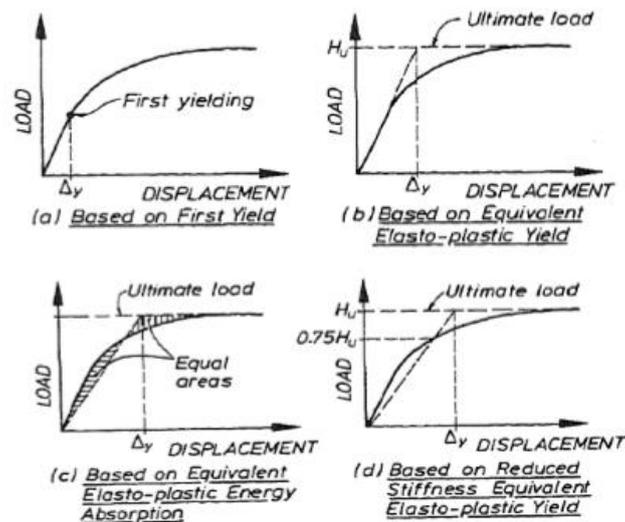


Figure 4. Deflection on the yield point

According to [7] mentioned that the displacement ductility index, $\mu\Delta$, in the range of 3 to 5 is considered imperative for adequate ductility especially for seismic design and redistribution of moments. Generally, high ductility ratios indicate that a structural member is capable of undergoing large deformations prior to failure.

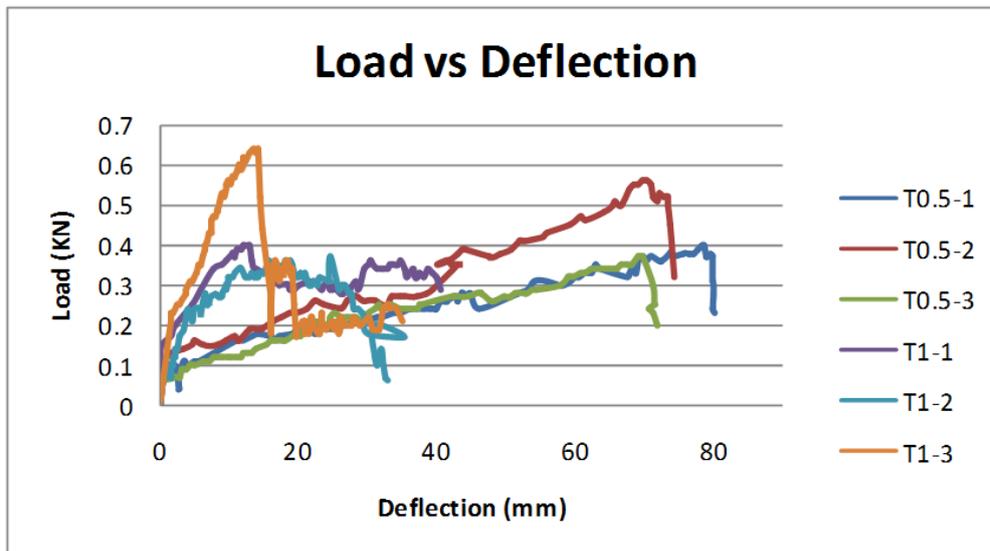


Figure 5. Load vs Deflection

From the figure 5, the load and the deflection show that the maximum load for the specimen with 0.5 cm thickness is 0.4, 0.56 and 0.37. And for 1 cm thickness is 0.4, 0.36, 0.64. It shows that the thickness variation does not give effect on the maximum load.

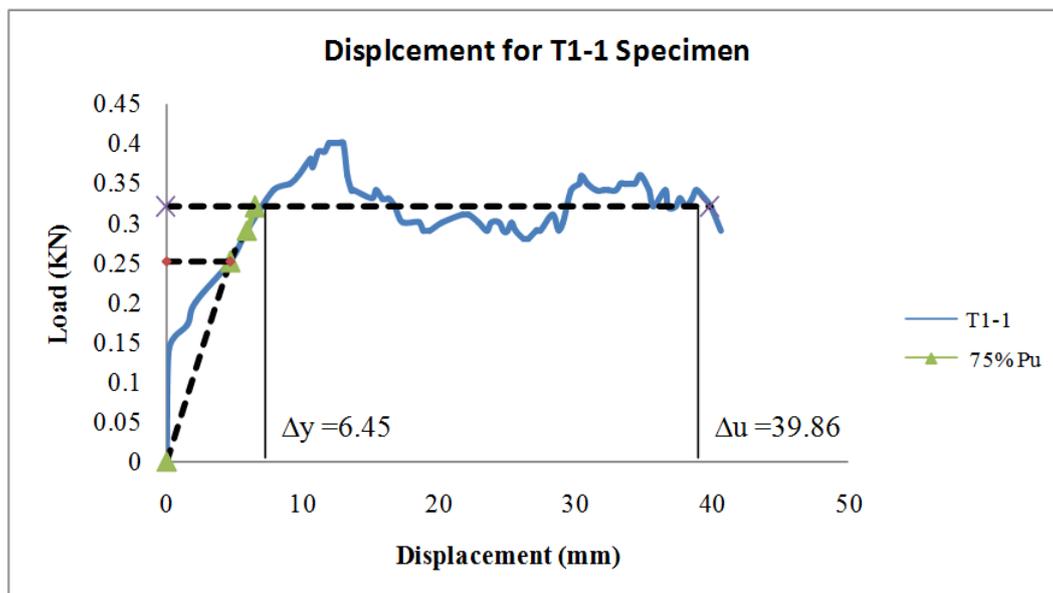


Figure 6. Load and displacement T1-1specimen

Displacement ductility index for T1-1 specimen as shown in Figure 6, according to [5] the ultimate load is 0.8 maximum load, it is the same as 0.32 KN. Therefore from the figure 6, the result of the displacement (Δu) is 39.86 mm. The yield load is 75% ultimate load, it is the same as 0.24 KN. The result of the displacement (Δy) is 6.45 mm. Therefore, the displacement ductility index (μ) for T1-1 is 6.179. The deflection ductility index, (μ), for all panels tested in this study experimentally is presented in Table 4 and Figure 7.

Table 4. The result of deflection ductility index polystyrene waste panels

Specimen	Δu [mm]	Δy [mm]	Ductility Index
T0.5-1	80.04	48.33	1.656
T0.5-2	73.86	59.00	1.252
T0.5-3	71.28	32.89	2.167
Average			1.692
T1-1	39.86	6.45	6.179
T1-2	27.24	6.44	4.239
T1-3	14.58	8.24	1.711
Average			4.043

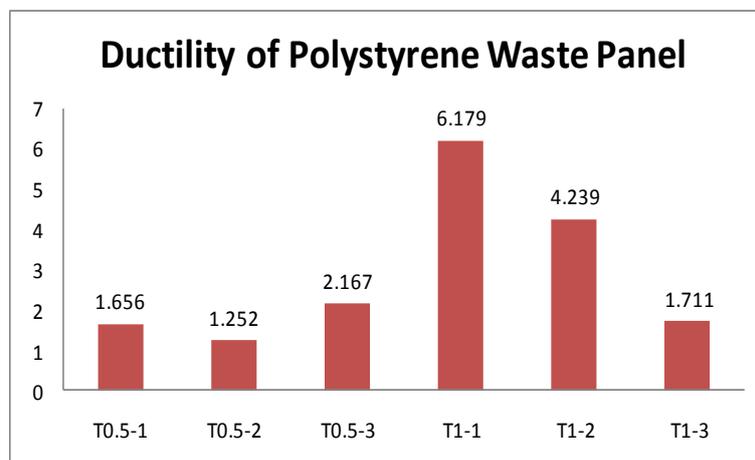


Figure 7. Ductility of Polystyrene waste Panel

A high ductility index indicates that a structural member is capable of undergoing large deformations prior to failure. Panel with ductility index in the range of 3 to 5 is considered imperative for adequate ductility especially in the areas of seismic design and redistribution of moments [7]. Panels with ductility index only up 1.99 lacked adequate ductility and cannot redistribute moment.

Based on the test result, the average of displacement ductility index of panel with 0.5 cm thickness planned is under 1.99 and the panel with 1 cm thickness planned is upper 3, therefore, it is considered imperative for adequate ductility.

4. Conclusion

Based on the test, the following conclusions can be drawn :

- (1). The polystyrene waste panel with 0.5 cm thickness planned, the results are more stable than 1 cm thickness planned but the variation of the thickness is not comparable to the variation of the maximum load. So in this experiment, the wire mesh is the main role in restraining the load.
- (2). Displacement Ductility Index of the polystyrene waste panel with 1 cm thickness planned upper 3 indicates that the panel is capable of undergoing large deformation.
- (3). In general polystyrene waste has the potential to be used as non structural panels and it is expected to reduce polystyrene waste.

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