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## Utilization of polystyrene waste for wall panel to produce green construction materials

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### Abstract

The wall structure separating floor areas significantly contribute the weight of the building that put it into a greater risk to earthquake event. The use of lighter wall materials is more desirable to reduce the potential risk of damage due to earthquake treat. This development of polystyrene wall panel is an effort to achieve two objectives, namely development light wall material and promoting green construction materials by utilizing polystyrene waste. The paper present the study on the development of polystyrene waste wall panel by pre-compacted method. In this research, the shredded polystyrene was blended with cement Portland and water at various certain proportion. When the mixed already properly blended, it was poured into the steel mold of 30x80cm. The mixed within the mold was subjected to compaction stress for up to 2 MPa that reduce the thickness of the mixed into about 1 cm. The polystyrene panel was kept in the humid zone for curing for about 28 days. They were 12 wall panel specimens made for this purpose. Result of test show that at the same compaction stress, higher cement content produces stronger polystyrene concrete. The average compressive strength of specimens with 250 kg/m<sup>3</sup> and 300 kg/m<sup>3</sup> cement content are 4.9 MPa and 5.3 MPa, respectively, and for flexural strength are 2.4 MPa and 3.3 MPa, respectively. The result show that the compressive strength of concrete matrix and flexural strength panel are significantly high. However, under repeated loading of about 10% of maximum load, the panels experience decrease in stiffness in each load cycles suggesting the low tensile capacity of the concrete matrix. These results indicate the potential use of polystyrene wall panel for construction materials purposes with further attention on improvement the tensile characteristic of the concrete matrix.

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## 1. Introduction

Wall is one component of building structure that is generally made of bricks, concrete blocks, concrete panels, wood boards, plywood and gypsum. The use of brick, concrete brick and concrete walls will produce large self-weight of wall resulting in large building's dead weight. The use of lighter wall materials is more desirable to reduce the potential risk of damage due to earthquake treat. To reduce the dead load of building, lighter weight wall has been widely used, such partition walls from plywood or gypsum. This study is attempted to take advantage the nearly weightless polystyrene waste into light weight wall panels. Polystyrene waste is well known as waste material that is hardly decomposed by nature. In a view of nature conservation, this situation is alarming since the volume of this waste is increasing by time. It is expected that this research will be able to bring a hope of the potential utilization of waste polystyrene as environmentally friendly building materials to support nature conservation efforts. This study has been started for quite a while but has not been able to produce some potential finding worth to be developed. The potential use of polystyrene waste began to appear with the application of pre-compaction processes in the manufacturing process of wall panel specimens. The polystyrene used in this study is limited to polystyrene from the pack of electronic goods.

## 2. Research objectives

The long term objectives of the research is the utilization of polystyrene waste as construction material thereby developing a green concept in construction program. This paper presents the extent of research result. The more detail of the objective of study presented in this paper are as follows:

- Developing procedures for processing polystyrene waste into a lightweight concrete based construction materials.
- Studying the mechanical characteristics of polystyrene wall panel, such as compressive strength, flexural strength, density, water absorption,
- Studying the behavior of polystyrene wall panel under repeated load to simulate the action of forces on wall.

## 3. Literature review

Lightweight concrete is defined in the literature as concrete with bulk density of less than  $1800 \text{ kg/m}^3$  [1]. Research on the development of lightweight concrete has been widely carried out, and one of an attempt to achieve a lightweight concrete is to replace aggregate with nearly weightless polystyrene [2-7]. There are several studies of lightweight concrete using polystyrene waste. Musana (2006) carried out research where the polystyrene was cut into small cube shape of less than 1 cm to replace the coarse aggregate [2]. Various PCC cement proportion of  $250 \text{ kg/m}^3$ ,  $300 \text{ kg/m}^3$  and  $350 \text{ kg/m}^3$  was used. The test results showed that compressive strength of polystyrene concrete is very low ( $<1 \text{ MPa}$ ). Ndale (2010) conducted study on the use of polystyrene into wall panel of concrete with various thickness of 6 cm and 8 cm [3]. The concrete polystyrene panel was reinforced with wire mesh of 4 mm diameter. The result of study showed that the flexural strength of panel is too low (flexural strength  $<1 \text{ MPa}$ ). Atmoko (2012), Aidil (2012) and Siregar (2012) conducted similar study and they introduced pre-compacting process in casting panel specimens [8,9]. Unfortunately, the wooden mold used for casting was capable only to withstand limited pre-compaction forces and hence the result of specimens were also unsatisfactory.

### 3.1. Wall panel

The idea of utilization of polystyrene waste for wall panel come from the availability of light wall panel products that basically consists of super foam sandwiched between steel wire mesh and concrete. One of factory product of polystyrene wall panels is M-System, originally developed in Italy ([www.M-Systemindonesia.com](http://www.M-Systemindonesia.com)) [10]. M-System wall panels consists of thick super foam core reinforced with wire mesh and concrete at both surfaces than for residential house, high rise buildings and special applications such as swimming pools, tribunes and others. The M-system panel is bearing wall that can be used for up to four floors of building structure. The panel wall size of  $15 \text{ cm} \times 270 \text{ cm} \times 112 \text{ cm}$  is capable to sustain load up to 1,700 KN. Another product of lightweight wall concrete panels is

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