Development of Lightweight Paving Block Using Plastic Bottles and SW-PU200

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Abstract:
Paving block is versatile, aesthetically attractive, functional, and cost effective and requires little or no maintenance if correctly manufactured and laid. But there are few problems that occur whenever it comes to paving block. Nowadays, the paving block is too heavy due to their high density and have durability which are not strong for long periods of usage and causes of cracking. Thus, in order to modify conventional paving block, plastic bottles and PU200 will be used to reduce the weight of the concrete block paving. The main purpose of the use of plastic bottles is to reduce the current pollution of the environment. Testing has been carried out to determine the density of lightweight paving block with the conventional paving block. The result of the test for lightweight paving block should be less than conventional paving block. To determine the skid resistance the value of the road pavement surface dry and wet, we are using skid resistance test on the paving block. Normal density for paving block nowadays is between 2240 to 2400 kg/m³. This research to produce an innovative lightweight paving block with density between 1440 to 1840 kg/m³ but still maintaining its strength. Furthermore, bottles that been added into paving block are very important for the effectiveness in this project, also from the paving block that produced can less the labour to install the paving block at the site work and reduce the time of installation. The size for the lightweight paving block that we created is 140mm x 80mm x 330mm. This lightweight paving is focused on pedestrian, home areas and pool areas.

Keywords: lightweight paving block, plastic bottles, PU-200 chemicals

1.0 Introduction

In Malaysia, 24% of the domestic waste that is sent into landfill are plastic waste. As plastic is not biodegradable, it is creating a critical environmental concern in our society by Bhutta (2013). Thus, the main purpose of this study is to reduce the current pollution of the environment by using plastic bottles and SW-PU200 (Polyurethane 200) as the main materials.

During our past Corporate Social Responsibility (CSR) programme, the paving blocks that were installed in polytechnics were heavy and difficult to operate as well as having low strength where the brick was easily cracked. Thereby generating ideas for today's innovative paving block to lightweight block. The natural aggregate and crush sand was replaced by polystyrene at the level of 40% and 10% by volume respectively by (Kothari & Chaudhari, 2017).

The main problem statement that define is the paving block nowadays is too heavy due to their high density. Furthermore, paving blocks nowadays have durability which are not strong for long periods of use and causes of cracking.

The environment is filled with toxic plastic waste, posing a serious health risk to every living thing on our planet. Plastic waste including plastic bottles is the most accumulated on waste landfills in the country with a rate of 70 per cent compared with other waste materials (Peter Nansian, 2011).

Plastic bottles take hundreds of years to biodegrade in landfills. Every year people are dumped into water way and landfills causing pollution and health problem. The amount of waste or solid waste disposed to landfill is of 2,122 tons per day and an average of 20 percentage is plastic waste. (Peter Nansian, 2011).

Hence, a research on the construction of paving brick using lightweight block was conducted in this study with the objectives were to produce lightweight paving block using plastic bottles. Besides, it is also to determine the density of lightweight paving block using plastic bottles. Also, to compare compressive strength between lightweight paving block and control sample.

2.0 Methodology

In the initial stage, all the materials and equipment needed are gathered and checked for availability. Then the creating 330 mm x 140 mm x 80 mm paving block (MS1380:1995). The flow chart of methodology of this project is indicated in Figure 1.

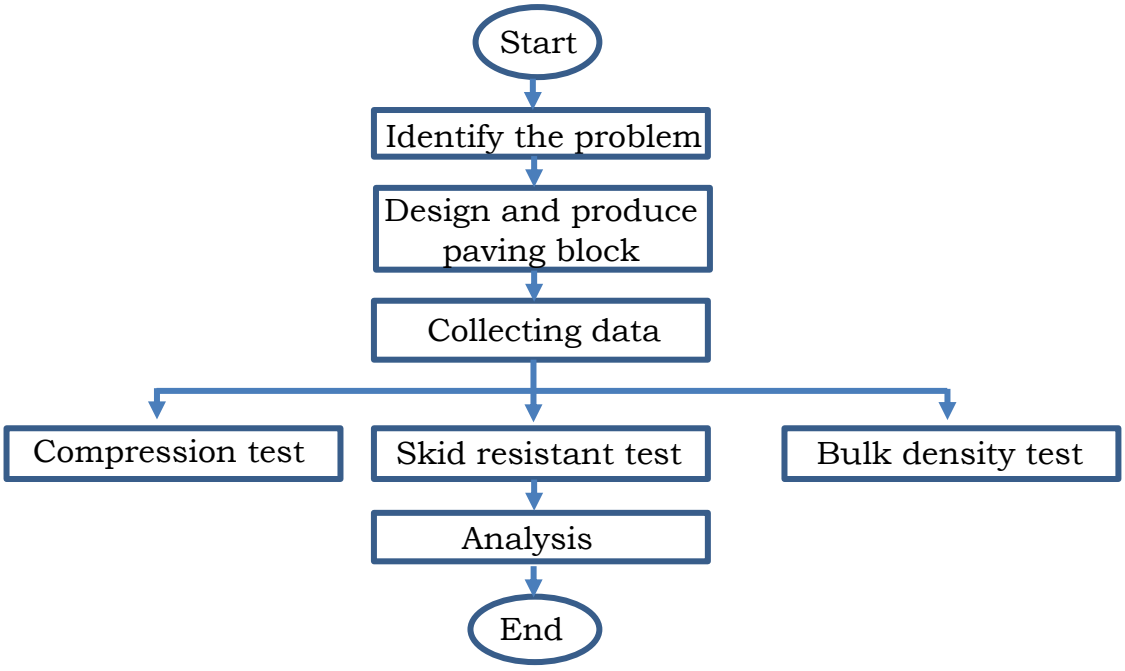

Figure 1: Flowchart of methodology

2.1 Material properties

The material used in this study were plastic bottle and foam (SW-PU200). The description of each of the material is described in the following sections.

2.2 Plastic bottles

The plastic bottles in this study were PET/PETE (Polyethylene Terephthalate), HDPE (High Density Polyethylene), LDPE (Low Density Polyethylene) and Other (Including Polycarbonate, Nylon & Acrylic). The types and description of plastic bottles are listed in Table 1.

Table 1: Types of plastic bottles and description

Types of plastic bottles	Description
 PET/PET (Polyethylene Terephthalate)	Commonly use in mineral water and drinking water and cannot be used, refilled or heated
 HDPE (High Density Polyethylene)	This bottle is thicker than PET, it is safe to refill and reuse also commonly use as shampoo, bottle, detergent bottle and etc.
 LDPE (Low Density Polyethylene)	LDPE bottle has its toughness, flexibility and relative transparency that make it good for packaging applications requiring heat- sealing. This bottle is used to make many thin, flexible products like plastic bags for dry-cleaning and fresh produce.
 OTHERS (Including Polycarbonate, Nylon & Acrylic)	This bottle commonly uses as baby bottles, sport bottle and 5-gallon of water and this bottle sometime can be recyclable and sometimes cannot.

2.3 SW-PU200

SW-PU200 is one liquid type radius firing urethane having strong hydrophobic type through injecting and putting leakage part of concrete and reacting with water, it is the product forming water firing stage of closed cell

structure closing off from Influx water. As free-flux type having no stimulating offensive smell, it is a product that having quick response, no shrinking change and excellent permeable. Physical Properties of SW-PU200:

a. Viscosity (450 – 600mPa.s)
b. Specific Gravity (1.12–1.2)
c. Foaming Time (300–400s)

2.4 Creating the paving block

The procedure as follows:

a. Find a wooden board.
b. Cart the board using a wooden saw according to the size (330mmx140mmx80mm).
c. Nail the board to make it into square shape.
d. Found and dry empty bottles and chemical SW-PU200.
e. Put a little SW-PU200 in the bottle and fill it with water.
f. Shake the bottle until the water and SW-PU200 mixed.
g. After a few minutes, the mixtures in the bottle will be hard.
h. Place the bottle brick vertically in the wire mesh.
i. Tied the bottle brick inside wire mesh.
j. Put it inside the formwork and fill it with concrete.

2.5 Compression test

One of the important properties of concrete is its strength is compression. Compression test will be applied on four lightweight paving blocks, two blocks for control variable and two blocks of existing lightweight paving blocks. Compression test is very significant to determine the compressive strength for products which receive vertical loading. The compressive strength of the lightweight paving blocks samples was determined after the samples have been cast and cured for 7 and 28 days. The weight of the lightweight paving blocks samples was taken before conducting the compressive strength test. Samples were crushed with the cast faces touch with the testing machine at 7 and 28 days using the Compression Testing Machine. Compressive Strength = Maximum Load (N)/Load Area (mm^2) (Kassim & Rohim, 2017).

2.6 Skid resistance test

Skid resistance is important for road safety. With skid resistance it allows for better 'grip' between users and road surface. Most road surfaces have adequate skid resistance in the dry as compared during wet condition.

2.7 Bulk density test

The soil bulk density (BD), also known as dry bulk density, is the weight of dry soil (Msolids) divided by the total soil volume (Vsoil). The total soil volume is the combined volume of solids and pores which may contain air (Vair) or water (Vwater), or both. The bulk density is calculated as mass per unit volume;

Bulk Density = Mass (M) / Volume (V)

Where; M is the weight of the specimen after dried in a ventilated oven at a temperature of 105 -115°C, while V is the volume (length x width x height) of the block.

3.0 Results and discussion

The data gained are skid resistance test, compression test and density test based on the research objective.

3.1 Compressive strength of lightweight paving block

Table 2: Result and data of compression test

Type of bottles	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
PET	10.40	10.40
LDPE	9.00	9.00
HDPE	5.00	5.00
OTHER	3.70	3.70

From the data obtained, this research to compare the strength of PET bottle 10.4 N/mm^2 with the HDPE bottle 5.0 N/mm^2. Followed by LDPE with 9.0 N/mm^2 and for other is 3.7 N/mm^2. It proves the PET bottle is the strongest compare to HDPE, LDPE and OTHER.

3.2 Density of lightweight paving block

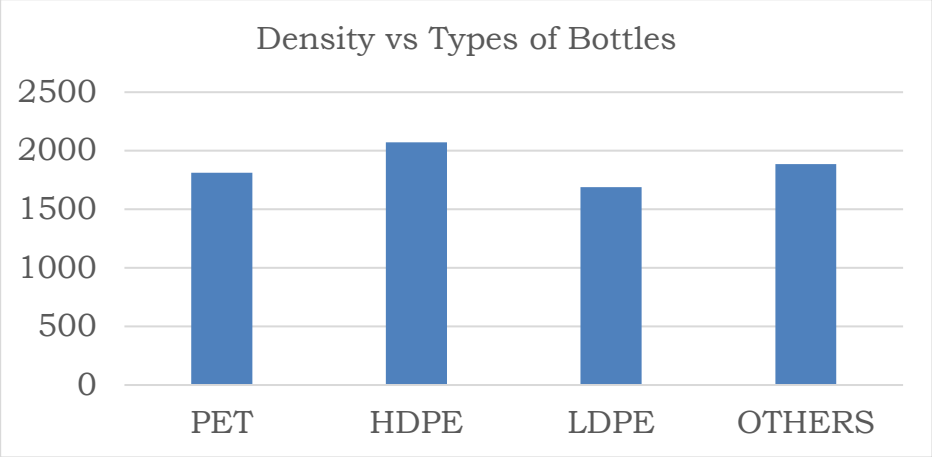

Figure 2: Data and result of bulk density test

From graph shows that the reading of LDPE is the lowest followed by PET, OTHER and HDPE. The LDPE weight is density = $1688.31\frac{kg}{m^3}$ meanwhile density of PET is $1812.77\frac{kg}{m^3}$, OTHERS density is = $1885.82\frac{kg}{m^3}$ and HDPE density is $2072.51\frac{kg}{m^3}$. This proof that LDPE paving block is much lighter compared to PET, OTHER and HDPE.

3.3 Skid resistance of lightweight paving block

Table 3.2: Data and result of skid

Types of surface	Temperature	Skid Resistance Coefficient C value					Average of C value	A corrected value of C_t
		1	2	3	4	5		
Dry Surface	30	25	27	25	28	30	27	29.25
Wet Surface	29	26	29	30	25	24	26.7	28.7

From the data obtained, this research to compare the skid resistance of dry surface 29.25 and wet surface 28.7.

4.0 Conclusion

Based on the discussions above, we can conclude that the suggested type of plastic bottles such as PET/PET (Polyethylene Terephthalate) has shown that it can produce a lighter paving block than control sample. Moreover, the outcomes of this study has produce greater success when it has lighter density and higher compressive strength.

Thus, the objectives of this study which was to produce lightweight paving block using plastic bottles along with to determine the density of lightweight paving block using plastic bottles and to compare compressive strength between lightweight paving block and control sample have been achieved according to the final results.

We recommended to future research panel to use different types of plastics in order to achieve a lighter paving block with lower density and higher number of compressive strength than this study.

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