KEMENTERIAN PENGAJIAN TINGGI

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INOVASI

PAVING BLOCK USING HDPE PLASTIC

CIVIL ENGINEERING DEPARTMENT

BUILDING SERVICES ENGINEERING

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1. PROBLEM STATEMENT

Plastic wastes are increasing at an alarming rate and adversely affecting environment as they are not easily degraded. According to UN Environment, every year the world uses up to 5 trillion plastic bags. It is estimated 6.3 billion tons of plastic has been produced worldwide, of which an estimated 9% has been recycled and another 12% has been incinerated. Plastics themselves contribute to approximately 10% of discarded waste.

According to a study in Science Magazine, Malaysia is the 8th worst country worldwide for plastic waste. It is estimated that, Malaysia produced almost 1 million tonnes of mismanaged plastic waste in 2010 of which 0.14 to 0.37 million tonnes may have been washed to the oceans.

Malaysia seriously has a huge problem with plastic waste. We often see empty plastic cups, plastic straws, plastic lids, empty water bottle on the roadsides, seashore and dumpsites. Plastic waste is a serious environmental threat. It is composed of major toxic pollutants, it has the potential to cause great harm to the environment in the form of air, water and land pollution. Plastic pollution will affect us in many ways. The burning of plastic waste could emit dioxin which are the most toxic to the human organisms. They are carcinogenic and a hormone disruptor and persistent, and they accumulate in our body-fat. Moreover, the plastic waste that are dumped on the landfills will eventually seeps into underground waterways which polluted groundwater resources and river.

Plastic pollution has threatened marine and land animals. Plastic packaging and straws that have been washed out to the ocean and dump into landfills have always been a threat to marine life and land animals. The ubiquitous plastic bag is regularly eaten by numerous marine and land animals which lead to fatal consequences. According to the National Oceanographic and Atmospheric Administration, plastic debris kills an estimated 100,000 marine mammals, millions of birds and fishes annually.

1.1. Objective

I. To produce paving blocks by using collected HDPE plastic wastes (plastic bags).

II. To investigate the compression strength, water absorption and melting point of the paving block.

III. To compare the paving block with the other blocks available in the market.

1.2 Scope

A paving block is to be produced by using plastic wastes collected from landfills. These paving blocks are made from melted HDPE plastic wastes (plastic bags) and two types of sand which is fine and coarse sand. High density polyethylene (HDPE) or polyethylene high density is a poly ethylene thermo plastic made from petroleum. Known for its large strength to density ratio, HDPE is commonly used in the production of plastic bags.

This dimension of the paving block to carry out in this project is 225mm × 115mm × 60mm. This product will be recommended for the use of pedestrian walkway. There will be four paving blocks will be produced in which 2 paving blocks with ratio (50:50) and (60:40) using plastic and fine sand. Another two paving block with the same ratio of (50:50) and (60:40) using plastic and coarse sand. 60% will be sand portion and 40% will be plastic portion. Meanwhile, another ratio states half portion for plastic and sand respectively. Then, among these four paving blocks whichever is better in terms of compression strength, water absorption and melting point will be tested and compared with other paving block available in the market. This project is to cultivate Green Technology by sorting plastic waste and using it in construction will reduce waste accumulation to a great extent.

2. RESEARCH SIGNIFICANCE

The research is regarding the environmental pollution occurred by plastic waste. Lot of plastic waste is produced every day by humans because of needs. So, we cannot stop using plastic but disposal of plastics can be done by utilizing it. To reduce the pollution by plastic, plastic is utilized and used in manufacturing of plastic paver blocks. As it gives less strength when compared to concrete paver block, it can be used where low loads are applied**.** The use of plastic waste for the production of paving block is an optimal method to solve the problem of plastic pollution and to optimize the cost for the production of building materials.

2.1 MATERIALS USED

1) HDPE Plastic

HDPE (**High Density polyethylene)** is a thermoplastic polymer produced from the monomer ethylene. HDPE is known for its high strength-to-density ratio. The density of HDPE can range from 930 to 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods).

They are very slow to undergo microbial degradation and can stay intact in the environment for up to centuries. Production of HDPE and other plastics is steadily increasing year by year because of their demand in daily life activities. The packaging industry has been experiencing drastic growth over the past few years. The increased demand for packaged goods has accelerated the demand for high-density polyethylene (HDPE).

Density	**930 – 970 kg/m^3**
Melting point	110 – 140 ℃
Thickness	0.4mm – 25mm
Water Absorption	< 0.05%

Table 1: Physical Properties of HDPE plastics

Waste HDPE plastic

2) Sand

Coarse sand and fine sand are part of quarry like other materials that excavated from the ground such as rock, stone, riprap, aggregate, slate or gravel. Sand is actually some grainy materials made by mineral and rock particles, much coarser than silt and finer when compared to gravel, when it is measured by size. Sand cannot be renewed and it is defined as non-renewable resources and sand is highly demanded for concrete making. Sand has the capability of improving the plastic mechanical properties such as rigidity and characteristic strength. Another study showed that clay particles; due to their large surface area, sand was found to better bind with plastics.

Coarse sand: its fineness modulus is 3.7-3.1, the average particle size is over 0.5 mm.

Fine sand: its fineness modulus is 2.2-1.6, the average particle size is 0.35—0.25 mm.

Fine sand Coarse sand

Sample	Mixing ratio (sand: plastic)	Weight of material (kg)			Percentage of each material in mixture	
		HDPE	Coarse sand	Fine sand	Sand	HDPE
1	3:2	1.2	3.0	-	60	40
2	1:1	1.5	2.48	-	50	50
3	3.2	1.2	-	3.7	60	40
4	1:1	1.5	-	3	50	50

Table 2: Plastic and sand mixing ratio

3. EXPERIMENTAL PROCEDURE

A. Plastic Composition

HDPE plastic waste was collected from dumping site. The plastic bags were clean, free from other ingredients inside the poly bags. These bags were heated till it turns to viscous form. About 150℃ to 160℃ heat was required to melt the plastic bags.

B. Mixing Procedure

Manufacturing of plastic paver blocks had to be done in open places. A metal tin with fire under it was arranged to heat the plastic. The plastic bags were heated according to the weights given in the mix design. While heating care had taken by wearing gloves to hands, a long rod used for mixing the plastic waste. When the plastic changes to viscous form fine sand added into the mixture. The both materials are mixed thoroughly. The mixing process should be done fast. The procedure repeated for coarse sand according to ratio. Oil was applied on the mould to get friction resistance when the block removed after placing. The mixture of

plastic and sand then poured into a mould and kept for drying for 24 hours. After completion of 24 hours, the block gets hardened and it is removed from the mould.

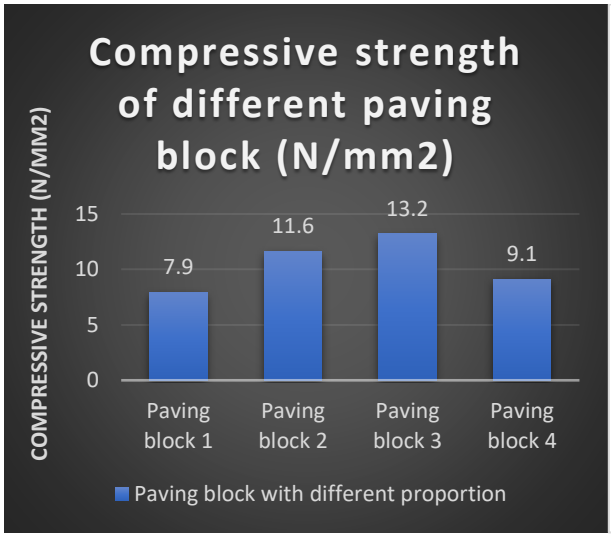
4. RESULT AND ANALYSIS

A. Compression strength

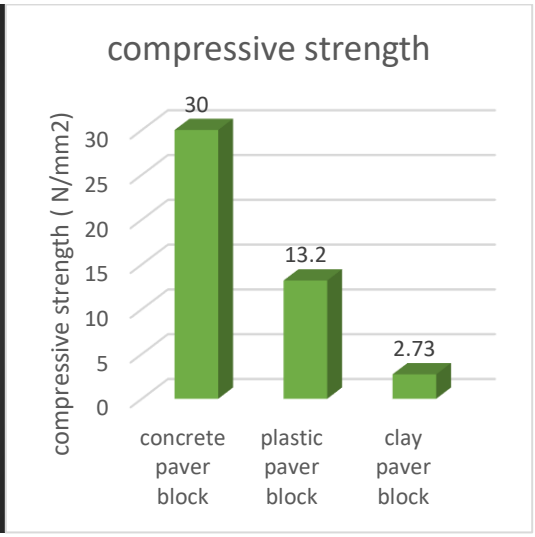
If a material is introduced in construction field, the main aspect to be considered is strength. To find the resistance of this plastic paver under compression, compressive strength test has to be done by using UTM (Universal Testing Machine). The surface of the paver block should be plane in all the sides, so that the load can distributed evenly. The importance of finding compressive strength is to measure the load bearing capacity of the block. The table below shows the compressive strength of different mix ratios.

Paving Block	*Mix Design*	*Ratio*	*Ultimate strength (N/mm^2)*
1	Fine sand + plastic	3:2	7.9
2	Fine sand + plastic	1:1	11.6
3	Coarse sand + plastic	3:2	13.2
4	Coarse sand + plastic	1:1	9.1

Table 3 : Compressive strength of different mix ratio paving block



Bar chart 1



Bar chart 2

From the above bar chart, it clearly shows that the mix design ratio between plastic and coarse sand (3: 2) gives more compressive strength 13.2 N/mm^2 rather than other different ratios. In compliance with Malaysia Standard (MS 1380:1995) for 60 mm thick concrete paver block min compressive strength is 30 N/mm^2. Based on bar chart 2, plastic paver block is having high compressive strength than clay paver block but low compared to concrete paver block.

B. Water absorption test

In this test, paving block are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion, those are taken out from water and wipe out with cloth. Then, block is weighed in wet condition. The difference between weights is the water absorbed by paver block. The percentage of water absorption is then calculated.

Procedure of water absorption test

The block was cooled to room temperature and its weight (M1) obtained. The block was completely immersed in clean water at a temperature of 27+2℃ for 24 hours. After 24 hours, the block was removed and wiped out with damp cloth and the block weight (W2) obtained after it removed from water. Water absorption % by mass, after 24 hours immersion in cold water as shown in equation 1.

$$W = \frac{M2 - M1}{M1} \times 100$$

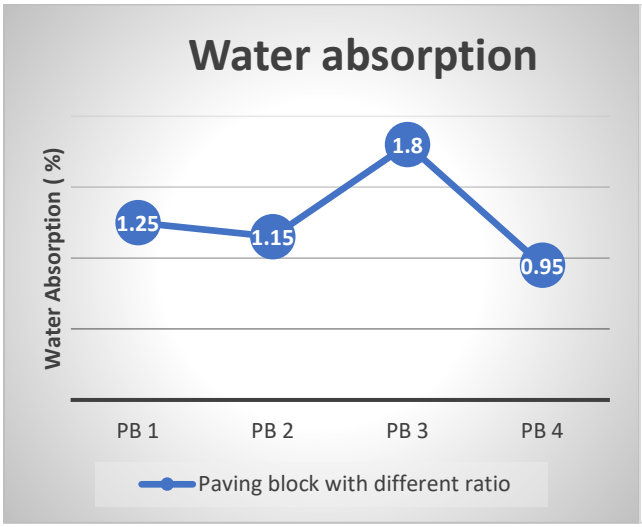


Table 4: Water absorption of paving block with different ratio

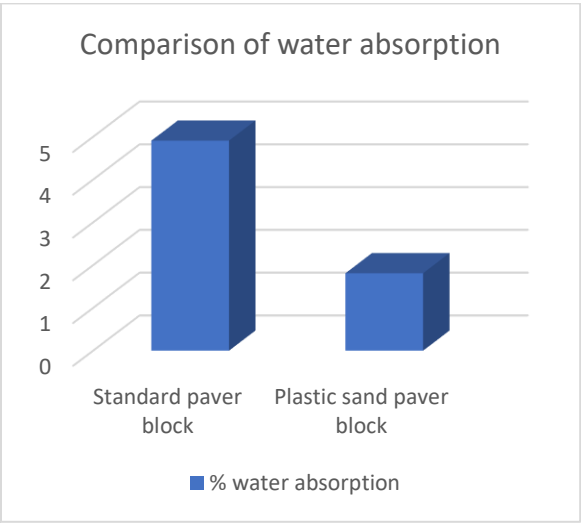


Table 5: Comparison between standard paving block and plastic paving block

From the above table 5, it shows that the standard pavement has 4.91% of water absorption whereas Plastic paver block has 1.8% of water absorption. As per the test result, plastic paver blocks good in resisting water absorption as compared to standard paver block.

C. Melting point test

As plastic can melt for heat, so melting point test is conducted to the plastic bricks to check at what temperature the brick will melt. The produced paver block will be kept in an oven for 2 hours and after 2 hours it's condition will be verified.

	Temperature (℃)	State
Plastic paver block (PB)	50	No change
	100	No change
	150	Melts

Table 6: Melting point of plastic paver block

Table 6 shows that melting point of PB is 150℃. The plastic paver block can resist high temperature when it is in use. It may not affect any structure or life when fire accidents occur.

5. DISCUSSION

As we know the main theme of this project is to reduce the environmental pollution produced by the plastic waste. Environmental factors depend upon how the blocks are used. Heating of plastic is a different matter where harmful gases will raise while heating plastic. Toxic gases are emitted which are harmful to the human life. So, the process of heating should be taken very far away from the city, where no life is present. When the plastic is heated, the week bonds between the polymer chains will be melted first and when the temperature exceeds the melting point, the organized bonds starts melting. Apart from that, acetone is the chemical which will helps to melt the plastic which will not harm environment. Acetone is an organic compound and a small ketone

with the formula $(CH_3)_2$O. Acetone doesn't affect the environment because it occurs naturally in plants, trees, volcanic gases and as a product of the breakdown of body fat. Plastic contains some chemicals which present after melting. So, when the plastic paver block is laid at footpaths and walk way in gardens, there is a chance of some chemicals leak into soil which pollutes the soil and sometimes ground water. Nano coating is best choice for block which controls the block from water ingress, salt ingress which disintegrate the block slowly, cracks in the block, edges flaking away. Actual life span of plastic block is 60 plus years. If we want to recycle the plastic blocks, the plastic blocks can be converted into fuel. This also reduces the extraction of fossil fuels from the earth. By this there will be no chance of throwing the waste plastic blocks and pollute the environment. As we are producing the fuel from the recycled plastic, the fuel price gets low. Furthermore, when the plastic blocks are laid at any garden areas, the aesthetic sense of the block may disturb the peacefulness of the person and odd atmosphere may be raised. When we use some coatings for block the odor of the paint may bring the aesthetic sense of the block to normal state. In addition, plastic paver block has smooth and even edges (were it not shrinking). In the case of concrete paving blocks that have uneven and rough edges. These characteristics of the paving block can be highly useful in preventing or lowering possibility of surface rutting occurrence. As the smooth edges creates capillary forces that prevent water molecules from percolating in between the blocks, their evenness ensures closer and tighter packing thus resulting into lesser water percolation.

6. ADVANTAGES OF PLASTIC PAVER BLOCK

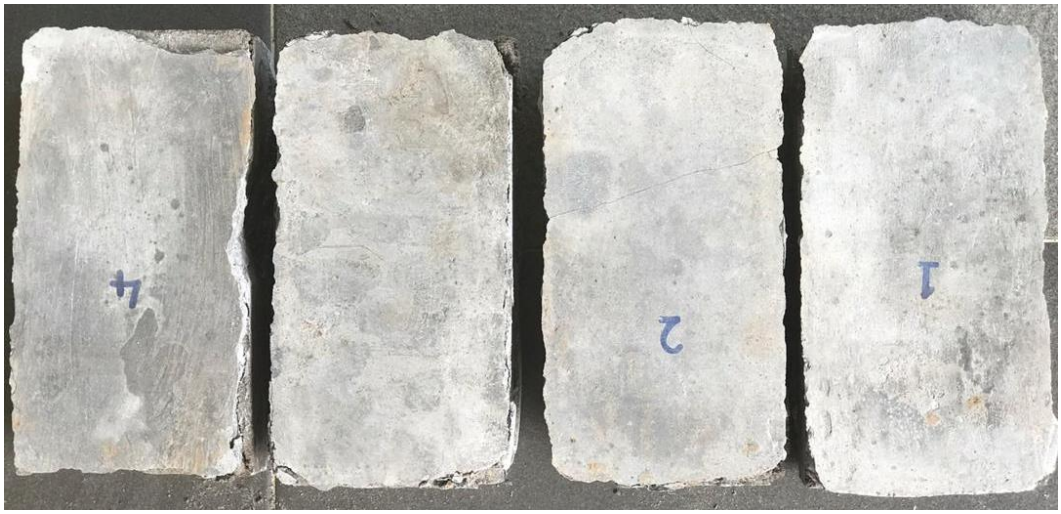
The cost of plastic paver block is low compared to other block available in the market which is economical. The costing for plastic paver block is approximately RM 0.40 per piece whereas the conventional block is about RM 0.80 to RM 1.00. The production of plastic paver block by using only waste plastic and sand is an innovative attempt to reduce the pollution occurred by plastic bags. The utilization of waste plastic in production of paving block has productive way of disposal plastic waste. It also reduces greenhouse emissions and the consumption of raw materials. It also minimizes the health risk and also help the economy. Safer and clean environment will be

created. On top of that, plastic paver block is good in terms of water absorption as it absorbs 1.8 % which is lower than concrete paver block (4.91%). Plastic paver block is lightweight (2.4 kg) compared to conventional block (3.3 kg) for 60mm block. These blocks made by only waste HDPE plastic and sand leads to total replacement of cement in designed ratios.

7. CONCLUSION

From the obtained data from the testing, our objective that has been stated earlier was achieved. The usage of HDPE plastic in paving block does provide some advantage to the construction industry and to the earth's one of the leading pollutions which is plastic pollution. From the compression test results plastic paver brick is having high strength (13.2 N/mm^2) compared to clay brick (2.73 N/mm^2) and low when compared to concrete paver block (30 N/mm^2). So, it can be used for limited applications in construction industry such as pedestrian walkways, slab finishes, garden, cycle way and swimming pool. Next, by the data from melting point test, we can conclude that the paving blocks has high melting point which is 150℃ however it is not recommended for used in building construction or wall finishes as it is exposed to heat and if in any cases fire occurs then the paving block could fail due to the lazing heat and high temperature. Plastic paver block also good in water resistance compared to concrete paver block. Plastic paver block gives us hope and a way to work on innovative things related to the plastic and to try to invent some new civil engineering materials which shows some remarkable response in future industry. As an engineer and a citizen of our country we have the responsibility of educating people about the recycling and reusing of our resources because of the scarcity of resources and their effects. This attempt of utilizing plastic waste into a paving block has been made so as to reduce the degradation of plastic waste into an "Eco-Friendly "paving block, it can also help improve human life for plastic wastes management in the future.

ATTACHMENTS



PLASTIC PAVER BLOCK

WATER ABSORPTION TEST

MELTING POITING TEST

COMPRESSIVE STRENGTH TEST

News related to plastic pollution in Malaysia

Human Writes: Malaysia rated one of the world's worst for plastic pollution

ENVIRONMENT

Sunday, 27 Jan 2019

8:00 AM MYT

By MANGAI BALASEGARAM

Human Writes: Malaysia is 8th worst in the world for plastic waste

ENVIRONMENT

Sunday, 25 Mar 2018

8:00 AM MYT

By MANGAI BALASEGARAM

Plastic and glass waste lies on the ground after an event in San Sebastian, Spain. There is a global crisis in plastic waste and Malaysia is the eighth worst country worldwide for plastic waste. Photo: Reuters

source: The STAR

MATERIALS TESTING LABORATORY SDN. BHD.

(118063-P)

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Tel: 603-7982 8757, 603-7982 7325 Fax: 603-7981 3625

TEST REPORT NO. : MO20/09/2020
DATE OF REPORT : 11/09/2020

1. Test Requested By Client :	Determination of Compressive Strength on Sand Bricks.
2. Project :	Paving Block using HDPE Plastic.
3. Tested For :	**YUVASHALINI MATHIALAGAN**
4. Method of Testing :	BS 3921: 1985
5. Date Tested :	9 September, 2020.
6. Results :	Please refer to the following page.

MATERIALS TESTING LABORATORY SDN. BHD. (118063P)

CLIENT : **YUVASHALINI MATHIALAGAN**
PROJECTS : Paving Block using HDPE Plastic

MATERIAL : Sand Bricks
DATE TESTED : 09 September, 2020

COMPRESSIVE STRENGTH OF SAND BRICKS

TEST METHOD : BS 3921 : 1985

REFERENCE	DIMENSION, mm * L * W * H	Gross Area mm^2	DENSITY kg / m^3	LOAD kN	COMPRESSIVE STRENGTH N/mm^2
Sand Bricks coarse sand : 3 plastic : 2	221 x 115 x 50	25,415	1,960	336	13.2
coarse sand : 1 plastic : 1	224 x 114 x 48	25,536	2,120	233	9.1
fine sand : 3 plastic : 2	222 x 115 x 57	25,530	1,770	202	7.9
fine sand : 1 plastic : 1	223 x 115 x 55	25,645	1,800	297	11.6

Note : * These values are recorded before capping.

for **MATERIALS TESTING LABORATORY SDN. BHD.**

RAUL T. FRANCISCO
Test Engineer

MATERIALS TESTING LABORATORY SDN. BHD. (118063-P)