Pervious Concrete pavement by using rubber aggregate

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***Abstract*— Portland Cement Pervious Concrete (PCPC) can reduce the risk of flash flood by letting the storm runoff to sip through the voids available in the PCPC hence infiltrate into the soil. This unique ability of pervious concrete offers advantages to the environment, public agencies, and building owners by controlling rainwater on site and addressing storm water runoff issues. Thus, this study was conducted to substantiate the usage of inorganic, cheap and reusable material namely Recycled and Fine Crumb Rubber (FCR) in pervious concrete. The primary objective of this study is to compare the compressive strength, density and the surface infiltration rate of pervious concrete containing waste tire rubber with pervious concrete that is made up by using natural aggregate without any enhancement. Standard pervious concrete will consist of natural coarse aggregates and cement. In this study, will be replacing the natural coarse aggregates, the same size with the previous research. The modified pervious concrete will also be mixed with a certain percentage of FCR, replacing certain percentage of the coarse aggregate. The results of this study indicate that using recycled material could achieve similar performance as using natural aggregate, hence may reduce the construction cost.**

***Index Terms*-- Portland Cement Pervious Concrete (PCPC), Fine Crumb Rubber.**

I. INTRODUCTION

Pervious concrete is known to be a concrete mixture without any fine aggregate that has the ability to let fluid such as water, to flow through the concrete and infiltrate into the soil beneath. Portland Cement Pervious Concrete (PCPC) can reduce the risk of flash flood by letting the storm runoff to sip through the voids available in the PCPC hence infiltrate into the soil. This unique ability of pervious concrete offers advantages to the environment, public agencies, and building owners by controlling rainwater on site and addressing storm water runoff issues . Based on , conventional pervious concrete has a flow rate of 3.4mm/s. With a rough calculation of 1m2 area, it can infiltrate 204mm of water in 1 minute. Other than infiltrating water from the surface into the soil, PCPC also can be used for the noise barrier because of the voids available that can reduce the sound wave. Research works done in enhancing the performances of pervious concrete using certain percentage of waste tire rubber by and properties of porous concrete from waste crushed concrete (recycled aggregate) by has set the scope and objectives of this study. Using recycled material may contribute to the economical and environmental factors positively. With the increasing number of vehicles in Malaysia, the waste tire rubber has also increased and rubber is difficult to be degradable. It is better to recycle these waste tire rubber by shredding it into small size and turn into tire chips (TC) or making smaller size into the Fine Crumb Rubber (FCR), as small as 5mm to enhance the concrete and at the same time, reduce the cost of producing pervious concrete.

In this study, inorganic, cheap and reusable material which is used to make a modified pervious concrete to compare the compressive strength, density and the surface infiltration rate with pervious concrete using natural aggregate. Considering the above factors, the primary objective of this study is to determine the compressive strength, density and surface infiltration rate for the modified pervious concrete that contain recycled asphalt pavement and waste tire rubber. Besides, the percentage amount of rubber to replace the coarse aggregate that give the best performance of the sample is another concern of this study. The performance of modified pervious concrete will then compared to natural aggregate pervious concrete.

II. LITERATURE STUDY

Jing et al. (2002) [9] used smaller sized aggregate, silica fume (SF) and super plasticizer (SP) in the previous concrete can enhance the strength of pervious concrete greatly. Using selected aggregates, fine mineral admixtures and organic intensifiers and by adjusting the concrete mix proportion, strength and abrasion resistance can improve the pervious concrete greatly. The pervious pavement materials are composed of a surface layer and a base layer. The compressive strength of the composite can reach 50 MPa and the flexural strength 6MPa. The water penetration, abrasion resistance and freezing and thawing durability of the materials are also very good. It can be applied to both the footpath and the vehicle road. It is an environment-friendly pavement material.

Suleiman et al. (2011) [14] constructed a parking lot using both traditional concrete and pervious concrete systems. The traditional concrete layer was placed on natural sub grade. The pervious concrete portion was divided into two sections with two pervious concrete mixtures and aggregate base thicknesses of 300 mm and 450 mm. Falling Weight Deflectometer (FWD) tests were performed on the three pavement systems to compare their structural behaviour as well as to document the uniformity of the pavement system and support (i.e., traditional concrete or pervious concrete layer). ANN (Artificial Neural Network) back calculation models were used to better understand the response of the three pavement systems. The pervious concrete section with 450 mm thick aggregate base shows the smallest measured deflections under the FWD plate load. The magnitudes of measured deflections for the traditional concrete sections were between the two pervious pavement systems. The relationship between normalized deflections and load amplitudes is quasi-linear for all three pavement systems. The slopes of these relationships are slightly different for the three pavement systems. The back calculated pervious concrete elastic modulus and modulus of sub grade reaction for both PC-12 and PC-18 pavement systems are smaller than that of traditional concrete. Baoshan Huang et al. (2009) [2] evaluated the effects of latex, natural sand and fiber on the pervious concrete. Laboratory test such as air void test, permeability test, compressive strength test, split tensile strength test were conducted. The basic mix proportion for the control mix is cement: coarse aggregate: water = 1:4.5:0.35 by weight. When latex and/or fine aggregate were included in the mixture, the solid portion of latex was used to replace 10% cement and natural sand to replace 7% coarse aggregate by weight. The performance and properties of PMPC were compared to those of the conventional pervious concrete. Based on this study, it was found that the use of the combination of latex, natural sand and fiber could produce acceptable pervious concrete with both enough drainage and strength properties. Latex and sand could both decrease the porosity and permeability of pervious concrete and increase the compressive strength of pervious concrete. However, only the addition of latex could increase the split tensile strength of pervious concrete. Fiber did not have a significant effect on the strength properties of pervious concrete in this study. This was due to the fact that fiber was not fully dispersed and evenly distributed in the pervious concrete mixture. Special methods are recommended for good separation and dispersion of fibers in the mixtures.

Hao Wu et al. (2011) [6] evaluated the performance of latexmodified pervious concrete with a particular focus on abrasion resistance, Air voids permeability, compressive and splitting tensile strength, and two abrasion resistance tests (Cantabro and APA abrasion tests) were performed for the investigation and evaluation. The following conclusions are PCPC mixtures made with smaller grain-size aggregates had stronger mechanical properties and higher abrasion resistance than those made with larger size aggregates. Latex could efficiently improve the strength and abrasion resistance but slightly decreased the air voids and permeability of PCPC. Fiber showed little or no effect in improving the mechani cal properties or abrasion resistance of PCPC. The Cantabro and APA abrasion tests were both effective in evaluating the abrasion resistance of pervious concrete. The two parameters, weight loss and wear depth, could both be used as an indicator of abrasion resistance in the APA abrasion test. Based on the test results from this study, the potentially optimum properties of the PCPC mixtures are as follows: effective air voids of 15 to 20%, permeability of 1:02:0 mm/s and compressive strength of 2025 MPa.

Experimental Analysis on High Strength Pervious Concrete- Ch. Hari Sai Priyanka1(2017)
The author researched on experimental analysis on high strength pervious concrete. As use of pervious concrete has increased significantly in the last several years, perhaps largely because it is considered an environmentally friendly, sustainable product. This study describes the work done on determining the strength characteristics of pervious concrete, the further all the analysis was done by doing the strength tests and and comparing the characteristics of the high strength pervious concrete and conventional concrete samples. The objective was to determine the compressive strength test, split tensile strength test to determine its properties. Cubes were casted of size 150 x 150 x 150 mm for the tests. This paper also evaluates the suitability of pervious concrete for other applications such as buildings, bridges etc. the compressive strength was conducted on the compression testing machine. The tensile was determined for concrete cylinder of size 150mm dia and 300mm height.

Experimental Study on Implementation of Pervious Concrete in Pavements- Nishith M N, Gururaj Acharya, Shaik Kabeer Ahmed(2016)
The author research on the Study Experimental Study on Implementation of Pervious Concrete in Pavements. This study is based to obtain the compressive strength, flexural strength and abrasion value and porosity value of pervious concrete. The main objective of this study is to provide and improve the strength of pervious concrete. To determine the

	Propotion (kg/m3)
Cementations material	315
Aggregate	1315
Water-Cement Ratio	.027 to 0.34
Aggregate-Cement Ratio	4 to 4.5
Fine –Course Aggregate	0 to 1.1

goals that needs to achieve for porosity, permeability, and strength in porous concrete mixes. The cubes for determining the tests were casted at the age of 7, 14 and 28 days of curing.

III. SCOPE OF PROJECT WORK

The objectives of using pervious concrete pavement with rubber aggregate are to:

- Improve Drainage: Pervious concrete is designed to allow water to permeate through it and enter the underlying soil. This helps to improve drainage and prevent flooding.
- Increase Sustainability: Using rubber aggregate in pervious concrete pavement helps to reduce the amount of waste tires that end up in landfills, making it a more sustainable option.
- Improve Durability: Rubber aggregate in pervious concrete pavement can improve its durability by reducing the amount of cracking and damage caused by freeze-thaw cycles.
- Enhance Safety: Pervious concrete pavement with rubber aggregate provides a skid-resistant surface that improves traction and reduces the risk of accidents, making it a safer option.
- Reduce Heat Island Effect: The use of rubber aggregate in pervious concrete pavement can help to reduce the heat island effect by reflecting sunlight and reducing the surface temperature of the pavement.

Overall, the use of pervious concrete pavement with rubber aggregate can help to create a more sustainable, durable, and safe infrastructure while also addressing issues related to drainage and the heat island effect.

IV. METHODOLOG

Methodology adopted for this study includes the following steps that taken for the study are explained from sample preparation, mixing design of the pervious concrete, preparing the mould, molding and curing, and sample testing. This are the steps required to produce the pervious concrete sample and also to determine the objective.

3.1. Sample preparation

The preparation of samples for this study was done in reference to the work of as shown in Table 1.

Natural aggregates:

Natural aggregate required to be washed and dried to make sure the aggregate does not have any other materials other than natural aggregate and to make sure the aggregates is dried from any moisture. The natural aggregate is dried by leaving it in an open space where the water can evaporate naturally. If it was dried using furnace, it can give an effect to the strength of the aggregate itself. After it is dried for 1 day, the natural aggregate is sieved using sieve shaker, to obtain a single size aggregates that is between 16-10mm. Since it is used for pervious concrete, it is better to use natural aggregate that is smaller size than 20mm. Therefore; 16mm was picked as the maximum size and 10mmfor the minimum size. The reason of choosing a smaller size than 20mm is because it will give a slight effect to the strength of the concrete by the increase of the contact area between the cement pastes with the aggregate, more economical mixture since will be using less cement to achieve a high strength and producing smoother surface of the concrete. Thus it will increase the binding between cement paste and the aggregates and produce higher compressive strength.

Fine crumb rubber.

There are a few factories that could process the waste tire rubber. The waste tire rubber was collected and it is shredded into small pieces. In this study, 20kg of waste tire rubber that has shredded into a small size of 5-8mm size called as Fine Crumb Rubber. The FCR should not be less than 5mm to make sure there are sufficient voids that still available in the pervious concrete. If it is smaller, it will be act similar to fine aggregate where it will reduce the void thus affecting the main purpose of pervious concrete that is to make water flows through it. The CR was placed in a closed container to prevent for any water to enter into it. If there is water, the CR will be moist and soon reduce its ductility.

Mixing design of the pervious concrete

Based on the literature review, there is no specific method for designing the concrete mix of the pervious concrete. Therefore, according to the research by stated the specific material proportion used. The research use a ratio of 0.27:1:3.57 (Water/cement: cement: Aggregate/cement) as shown in Table 1. In given material proportion range that may found to be suitable for designing pervious concrete.

Molding and curing

There are several ways to molding the sample. However, in this study works done by [2] were followed. Pour 3 layers of concrete paste into the mould. For each layer, tamp the concrete paste using the 1.8mm diameter tapping rod, for 25 times. After that, the vibrators is turned on and make the sample vibrate for at least 5 seconds to make sure the aggregate was well connected. Continue the same steps for the other 2 layers. After it was done, the sample is placed at a place where it is covered from rain or direct sun to prevent for any rapid hydrates or dehydrates process. If it is rapid hydrated, the samples will have more water and causes the samples to take more time to dry, However if it is rapid dehydrated, it is possible to see a visible cracks or hairline cracks on the sample after the sample is hardened,. Therefore, place the samples in a covered place and also place a piece of wet, clean cloth on top of the samples to make sure there are no rapid dehydration since Malaysia's average temperature is quite high.

The samples are left in the mould for 24 hours. Demould carefully to prevent any cracks on the samples. The samples were inspected to make sure the concrete paste was well dry, enough for curing. If it was dry, place the samples into a curing tank filled with water. Leave the samples in the curing tank according to the aging time required that is 7, 14 and 28 days.

Sample testing

In this study, 3 tests conducted namely compressive, density and surface infiltration test. The compressive test is to determine the strength of the concrete to resist the load applied. Meanwhile, for density test, it is to determine the category of the concrete's weight that is either lightweight or heavyweight concrete. Lastly the surface infiltration rate is to determine the surface infiltration rate of the sample.

Compression test.

Compressive strengths of the concrete samples were determined according to BS: Part 116: 1983 (Method for determination of compressive strength of concrete cubes). Compression Machine Test was used to obtain the maximum loads and compressive strength. The loading to the concrete samples, were applied continuously at nominal rate within the range 0.2 N/mm2.s to 0.4 N/mm2.s until no greater load can be sustained. By using the compressive Machine Test, the maximum load is obtained and is recorded. The average of the concrete cube samples was calculated and recorded. By determining the compression strength of the specimen, the maximum strength of the concrete mix to resist the load is obtained. Thus it requires in designing either structural or non-structural component to make sure it is suitable to be used.

Split Tensile strength

Split tensile strength is a measure of the tensile strength of concrete, and it is commonly used to evaluate the mechanical properties of pervious concrete pavement. In pervious concrete pavement, split tensile strength is an important parameter as it reflects the ability of the pavement to withstand tensile stresses due to traffic loads and other external forces.

Split tensile strength of pervious concrete pavement can be determined by conducting laboratory tests on cylindrical specimens. The test involves applying a compressive load to the specimen while simultaneously measuring the tensile force perpendicular to the applied load. The tensile force is then divided by the cross-sectional area of the specimen to obtain the split tensile strength.

Research has shown that the split tensile strength of pervious concrete pavement can vary depending on several factors, including the type and size of the aggregate, the cement content, the water-cement ratio, and the curing conditions. Generally, pervious concrete pavement with higher cement content and lower water-cement ratio tends to have higher split tensile strength.

V. EXPERIMENTAL INVESTIGATIONS

Compressive strength results

The compressive strength conducted in compression testing machine for the cast and cured specimens and the results are furnished in table 2.

Table2: Compressive strength of concrete replacement of coarse aggregate with waste tire rubber in pervious concrete

Cubes	7days compressive strength	14 days Compressive Strength
C1	10.6	12.2
C2	9.8	11.2
C3	11.3	13.4
C4	9.3	11.3
C5	12.6	14.6
C6	12.3	14.7

Split Tensile strength results

At the age of 7 and 28days, the cylindrical specimens (150mm diameter x 300mm height) were tested for evaluating the split tensile strength. The experiment is performed by putting a cylindrical sample horizontally between a compression testing machine loading surface and the load is applied until the cylinder fails along the vertical diameter.

Cubes	7days compressive strength	14 days Compressive Strength
C1	2.74	3.15
C2	2.59	3.12
C3	2.36	2.95
C4	2.99	3.65
C5	3.14	4.15
C6	2.48	3.89

VI. CONCLUSION

In the past due to scarcity of cement , the pervious concrete has been use extensively. The pervious concrete has lost is importance after successful production of cement in large quantity. But now a days , the uses pervious concrete has gained its popularity due to many advantages The urban areas all over the world have become CONCRETE JUNGLES. The discharge of storm water is very difficult problem in the present conditions. By using the pervious concrete we can able to recharge the ground water table and the storm water disposal can be done.

VII. REFERENCES

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