PERMEABLE CONCRETE AS A ROAD PAVEMENT

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Abstract – *At many projects water logging at highway and parking is the major issue especially during monsoon as pavements and floors are normally impermeable. This results in considerable amount of investment in repairs and providing storm water drain systems, which may get clogged during peak over flow. Besides this there are many other problems that arise due to the above. In such situations it is very important to think about an economical solution which helps in getting rid of all above problems. The best solution to above problem is permeable concrete. These papers summarize the various studies which have been carried out to fulfill the requirement of permeable concrete.*

Key Words: **Permeable concrete as a road pavement**

1. INTRODUCTION

India is a developing country and safety of roads is still in a Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. By capturing storm water and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the ability to lower overall project costs on a first-cost basis.

In pervious concrete, carefully controlled amounts of water and cement materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drain quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete

Permeable concrete pavements are use mostly in rural area. This concept of pervious concrete is relatively new for rural road pavement. Pervious concrete has ability to flow water through it and this property help to recharge the ground water. Pervious concrete pavement is unique and effective technique to meet the future demand. Strength of the pervious concrete is low as compared to conventional concrete it is all due to high porosity.

This dissertation analyses the effectiveness of Permeable concrete in pavement. This was achieved by analyzing the properties and characteristics of Permeable concrete. The performance of Permeable concrete was compared with a concrete sample that is comparable to the material used for the construction of conventional concrete road pavements.

Permeable concrete is mostly used in non-pavements applications, limited use in pavements applications. This is to assess the suitability for Permeable concrete to be used for the construction of road pavement.

The tests conducted to determine the fresh concrete properties were the slump test and compacting factor tests. These were complimented by hardened concrete tests including the following: compressive strength, indirect tensile strength. After that there is a comparisons are made between the both type of concrete.

It was found that Permeable concrete pavements possess some positive features like increased skid resistance and high permeability but lacks the high strength required for highly traffic areas. Permeable concrete has proven to have properties suitable for use in low volume traffic areas. The properties found may change depending on the aggregate particle chosen, however this aspect requires further investigation. Nonetheless, if Permeable concrete pavements can be implemented, it will have numerous positive effects on the environment.

2. LITERATURE REVIEW

Malhotra (1976), found that the density of permeable concrete is generally about 70 percent of conventional concrete when made with similar constituents. The density of permeable concrete using conventional aggregates varies from 1602 to 1922 kg/m^3.

Adequate vibration is imperative for strength of conventional concrete. The use of permeable concrete is different and is a self-packing product. Malhotra (1976) suggests that the use of mechanical vibrators and ramming is not recommended with permeable concrete. A light rodding should be adequate and used to ensure that the concrete reaches all sections of the formwork. This is not a problem with conventional concrete since it has greater flow ability than permeable concrete. The light rodding ensures that the concrete has penetrated all the areas impeded by reinforcing steel.

Malhotra stresses that in situations where normal conditions are not achieved during placement and curing, the formwork should not be removed after 24 hours as with conventional concrete. Permeable concrete has very low cohesiveness and formwork should remain until the cement paste has hardened sufficiently to hold the aggregate particles together. However, this is more of a consideration in low temperature conditions and when used in non-pavement applications where the concrete is not sufficiently supported by the ground or other means.

Ghafoori et al (1995), undertook a considerable amount of laboratory investigation to determine the effectiveness of permeable concrete as a paving material. The curing types were investigated to determine if there was any difference between wet and sealed curing. There appeared to be only a negligible difference in strength between the different curing methods. It was clear from the test results that the strength development of permeable concrete was not dependent upon the curing conditions.

The indirect tensile test conducted by Ghafoori et al found that the sample tests varied between 1.22 and 2.83 MPa. The greater tensile strength was achieved with a lower aggregate-cement ratio. Ghafoori et al (1995) explained the more favorable properties obtained by the lower aggregate-cement ratio by an improved mechanical interlocking behavior between the aggregate particles.

Ghafoori et al produced permeable concrete with a compressive strength in excess of 20 MPa when using an aggregate-cement ratio of 4:1.

Abadjieva et al (1997), determined that the compressive strength of permeable concrete increases with age at a similar rate to conventional concrete. The permeable concrete specimens tested had aggregate-cement ratios varying from 6:1 to 10:1. The 28 day compressive strength obtained by these mixes ranged from 1.1 and 8.2 MPa, with the aggregate-cement ratio of 6:1 being the strongest. He concluded the most plausible explanation for the reduced strength was caused by the increased porosity of the concrete samples. This strength is sufficient for structural load bearing walls and associate applications.

3. OBJECTIVES OF THE PROPOSED WORK

The objectives of the work would be:

(i) To determine the durability, properties of permeable concrete.

(ii) To determine the impact resistant of permeable concrete pavement.

(iii) To compare the properties of permeable concrete with the existing concrete pavement.

4. MIX DESIGN

The mix design in this case was the determination of the ratio of aggregate, cement and water that possessed the most favorable properties. For this particular situation trial mixes were designed. The mixes were determined from previous literature and particular mixes used by some companies. There are only three constituents of Permeable concrete that can be considered and varied: aggregate, cement and water content.

4.1 Conventional Concrete

There was no mix design undertaken for conventional concrete, since the strength of certain mixes is readily known. This meant that no trials were required to be carried out. When conducting the tests to determine the properties of a conventional concrete.

4.2 Permeable Concrete

The mix designs for Permeable concrete were obtained from printed articles. There were a large number of different mixes that are currently being used for a whole range of applications.

Aggregate	Cement	Water
8	1	0.4
6	1	0.4
4.5	1	0.4
4.8	1	0.36

Table 1 – Mix Proportions used for Permeable Trial Mixes

4.3 Trial mix Result and Analysis

Half the specimens were tested for compressive strength and indirect tensile strength at 14 days. The remaining small and large specimens were tested for 28 day compressive strength. The results of those tests can be found in the table below.

	14 Day Strength		28 Day Strength	
Aggregate-Cement-Water ratio	Compressive Strength (MPa)	Indirect Tensile Strength (MPa)	Compressive Strength (MPa)	Compressive strength of large cylinders (MPa)
8:1:0.4	4.23	1.05	3.06	5.97
	4.23		3.72	
6:1:0.4	5.60	1.62	7.41	5.44
	8.02		7.62	
4.5:1:0.4	7.64	2.25	11.18	7.60
	7.78		12.85	
4.8:1:0.36	7.78	1.05	6.35	5.22
	7.32		6.25	

Table 2 – The data collected from the trial mixes

From the 14 day testing, the aggregate-cement-water ratio of 4.5:1:0.4 was chosen as the most suitable mix since it produced the highest average compressive strength and possessed the greatest indirect tensile strength. The rest of the analysis will be completed using this mix design.

5. RESULTS AND ANALYSIS

5.1 Compacting Factor Test

Types	Partially compacted (m1) kilograms	Fully compacted (m2) kilograms	Compacting Factor
No-Fine concrete	10.815	11.332	0.90
Conventional concrete	13.035	13.440	0.96

Table 3 – Shows the Compacting Factor for all the samples of concrete used

5.2 Compressive Strength Test

Test No.	Specimen No.	Force P(KN)	Cross Sectional Area (mm^2)	Compressive Strength (Mpa)	Average Compressive Strength (Mpa)
1	Permeable	116.3	7854	14.8	
2	Permeable	164.5	7854	20.9	
3	Permeable	141	7854	17.95	17.045
4	Permeable	114.7	7854	14.60	
5	Permeable	123.8	7854	15.76	
6	Permeable	143.4	7854	18.26	
7	Conventional	318	7854	40.5	
8	Conventional	300	7854	38.2	39.8
9	Conventional	311	7854	39.6	
10	Conventional	318	7854	40.5	

Table 4 – Shows the force determined from the testing machine and the cylinder compressive strength of the test specimen

Figure 1 – Shows the shear failure mechanism of the Permeable concrete (left) and conventional concrete (right) after compressive strength testing

5.3 Indirect Tensile Strength Test

Test No.	Specimen No.	Force P(KN)	Length L(mm)	Diameter (mm)	Indirect Tensile Test (Mpa)	Average Indirect Tensile Test(Mpa)
1	Permeable	116	300	150	1.64	
2	Permeable	150	300	150	2.12	
3	Permeable	188	300	150	2.66	2.21
4	Permeable	111	300	150	1.57	
5	Permeable	182	300	150	2.57	
6	Permeable	190	300	150	2.69	
7	Conventional	253	300	150	3.58	
8	Conventional	226	300	150	3.20	3.39
9	Conventional	232	300	150	3.28	
10	Conventional	248	300	150	3.51	

Table 5 – Shows the results from the indirect tensile test

The conventional concrete exhibited reasonably similar tensile strength ranging from 3.20 to 3.58 MPa. The Permeable concrete varied more, with tensile strength between 1.57 and 2.69. The Permeable concrete did not have as much tensile strength as the conventional concrete, due to the bonding mechanisms within the concrete samples.

Figure 3 – The failure of the Permeable concrete after an Indirect Tensile Test

6. CONCLUSION

There was a considerable difference in the compressive strength between the concrete samples but this does not affect the outcome as it was the relationships between the characteristics that were assessed. The relationships showed that Permeable concrete acts in a manner similar to what was found in the conventional concrete sample.

A major difference found was that the Permeable concrete deformed more than the conventional sample before failure. This shows that a Permeable pavement has the ability to deform under the loading of traffic. The deformation should not affect the performance of the pavement providing its capacity is not exceeded.

7. FUTURE SCOPE

We can use 25 mm aggregate size for future study or analysis. Pervious concrete is a special type of concrete with a high porosity used for concrete pavement applications that allows water from precipitation and other sources to pass directly through it, thereby reducing the runoff from a site and allowing groundwater recharge.

REFERENCES

1. Malhotra, V. M. 1976. "Permeable Concrete – Its Properties and Applications", Journal of the American Concrete Institute. Vol 73. No. 11. pp 628 – 644.

2. Abadjieva, T & Sephiri, P. "Investigations on Some Properties of Permeable Concrete".

3. Department of Civil Engineering University of Botswana.

4. Australia Standard, As 1012.2 – 1994. "Method 2: Preparation of concrete mixes in the laboratory", Standard Australia Committee. Australia standard, AS 1012.3.1 – 1998. "Method 3.1;7: Determination of properties related to the consistency of concrete – Slump Test", Standard Australia Committee. .

5. Ayers, R 2004. "Transport Engineering – Study book. University of Southern Queensland".

6. Basavararajaiah, B. S. & Krishna Raju, N. 1975. "Experimental Investigations on Permeable Concrete", Journal of the Institution of Engineers (India. Part CV: Civil Engineering Division. Vol 55. No. Pt. CI 4. March. pp 137-140.

7. Sharma Devinder, Sharma Sanjay, Goyal Ajay, 2016, Utilization of Waste Foundry Slag and Alccofine in Developing High Strength Concrete, International Journal of Electrochemical Science, 11 (2016).

8. Er. Neeraj Kumar Garg, 2016, "Self Compacted Concrete", International Journal of Recent Research Aspects, Vol. 3, Issue 2 June 2016.