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Development of environmental friendly material- Porous concrete

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ABSTRACT

This study presents the effect of variation of cement content and the influence of fine aggregate on well graded coarse aggregate on the properties of porous concrete. Materials used are OPC Type I, fine aggregate corresponding to grading II and well graded aggregate of size 19.5mm to 16mm as 40%, 16mm to 9.5mm as 40% and 9.5mm to 4.75 as 20%. Mixes were prepared with the water cement ratio of 0.34 cement content of 400kg/m^3 300kg/m^3 and 250kg/m^3 and maintaining the aggregate cement ratio as 8.73:1, 7:1 and 4.75:1. Fine aggregate was replaced with coarse aggregate in the range of 70 - 100 % by weight. Various mechanical properties of the mixes were evaluated. Coefficient of permeability was determined by using falling head method. The relationship between the strength and permeability are discussed.

KEY WORDS Porous concrete; Permeability Compressive strength; flexural strength; split tensile Strength

I. INTRODUCTION

Development of High Rise buildings and Highways forms an impervious surface on earth leading to improper recharging of ground water. Porous concrete, also called pervious concrete, no-fine concrete, gap graded concrete, enhanced porosity concrete is a macro-porous concrete. Porous concrete is concrete with continuous voids which are intentionally incorporated into concrete, allows water from precipitation and other sources to pass through, which in turn reduces the runoff from a site and recharging ground water levels.It consists of cement, coarse aggregate, some percentage of fine aggregate and water. It belongs to a completely different category from conventional concrete and hence its physical characteristics differ greatly from those of normal concrete. Porous concrete can be used in numerous applications such as permeable concrete for pavement, base course, concrete bed for vegetation or living organism, noise absorbing concrete, thermal insulated concrete and other civil engineering and architectural applications Cement paste in permeable concrete is very thin layer which binds coarse aggregate. Porous concrete tends to fail at the binder interface between the aggregate and its results in the low compressive strength (24). Normally, the water cement ratio is one of the important factors for the compressive strength of cement concrete. However, in case of pervious concrete the above concept may have little significance.

Because, water is essential to produce the fresh cement paste with a good workability but not clog up all the pores. Optimum range of water cement ratio for both strength and permeability point of view ranges from 0.30 to 0.38(18). Porosity of the porous concrete varies from 15% to 30%, by volume, and it depends on the type of compaction and the type of the aggregates (12). High range Water reducer and thickening agent are introduced in the concrete to improve its strength and workability (3). Addition of styrene butadiene latex is found to improve the compressive strength but reduce permeability (9). Latex polymer, Styrene Butadiene rubber and sand up to 7% are introduced in concrete to improve its strength.

It reduces permeability which shows the void content is less still within an acceptable range greater than 15%. Compressive strength varies from 7 to 15 MPa (15). Efforts are being made to increase the strength characteristics by replacing the up to 40% sand with coarse aggregate and OPC was replaced with fly ash and the compressive strength was attained in the range of 65 MPa to 117 Mpa (22). Studies also focused on microstructure of pervious concrete by scanning electronic microscope and its interfacial structure (12).Attempts have also been made to improve the fatigue strength of Porous concrete and toughness of pervious concrete (2). Study also made to focus on the use of geo polymer binder for making pervious concrete using natural and recycled aggregate (1, 4).

Slipping characteristics of pervious concrete walking surfaces in icy conditions using kinetic biomechanical analysis was also carried out. Increasing cement content in a mixture does not necessarily contribute to increasing strength (17). In addition, the high cement content will cause the mixture to become sticky and may lead to increased risk of shrinkage and cracking problems. Therefore, cement content should be balanced to achieve the required performance while minimizing risk of these problems. The cement content of a mixture is commonly perceived to control concrete strength. Based on this perception, the objective of this study is to investigate the effects of variation cement content and influence of fine aggregate for the porous concrete on strength properties and durability properties.

II. EXPERIMENTAL PROGRAM

A. Materials and properties

Constituent used were cement, crushed gravel as coarse aggregate, fine aggregate and water. Type I Portland cement conforming to ASTM C 150 was used in all mixes, Crushed gravel was used as coarse aggregate, Well graded aggregate of size 19.5mm to 16mm as 40%,16mm to 9.5mm as 40% and9.5mm to 4.75 as 20% .Fine aggregate used in the work conform to Zone II of IS: 383- 1978. Table 1 presents the physical properties of materials.

TABLE I. PHYSICAL PROPERTIES OF MATERIALS

Properties	Value
Specific gravity (SSD)of Coarse aggregate	2.71
Specific gravity (OD)of Coarse aggregate	2.70
Specific gravity of fine aggregate	2.62
Specific gravity of cement	3.15

A. Mix proportion

Experimental work was chosen with different cement content 400kg/m^3, 300kg/m^3

, 250kg/m^3 water cement ratio of 0.34 based on an earlier study (13). ThreeControl mixes corresponding to three different cement contents are proportioned as per IS: 10262-2001 by absolute volume method. Control mixes are designed as M1F100, M2F100 and M3F100. The fine aggregate content in the above mixes was selected as one of the study parameter. Accordingly, the fine aggregate was varied between 0% and 30%. The reference mixes were re-proportioned for a constant volume. A total of 15 mixes studied. Details of these mixes are presented in

TABLE II. DESIGNATION OF THE MIXES

Fine aggregate	Cement Content Kg/m^3		
	400	300	250
100% (Control mix)	M1F100	M2F100	M3F100
30%	M1F30	M2F30	M3F30
20%	M1F20	M2F20	M3F20
10%	M1F10	M2F10	M3F10
0%	M1F0	M2F0	M3F0

Note: Designation M-Mix, 1-Cement content 400 kg/m3, 2- Cement content 300 kg/m3, 3-Cement content 250 kg/m3, F- Fine aggregate , 0-0%fine aggregate,10- 10% of fine aggregate,20-20 %of fine aggregate,30-30% of fine aggregate.

TABLE III. MIX PROPORTIONS PERVIOUS CONCRETE

Name of the Mix	Material quantity(Kg/m^3)		
	Ceme	*Fine aggrega*	*Coarse aggreg*
M1F10	400	748	116
M1F30	400	0	190
M1F20	400	75	184
M1F10	400	150	176
M1F0	400	224	169
M2F10	300	820	127
M2F30	300	628.	1466
M2F20	300	419	167
M2F10	300	209.5	1885
M2F0	300	0	209
M3F10	250	855	132
M3F30	250	654.	1527.
M3F20	250	436.4	1745.6
M3F10	250	218.2	1963.
M3F0	250	0	218

C. Preparation and Testing of Specimen

1) Strength properties

a) Compressive strength

Compressive strength test were conducted in accordance with ASTM C 39. Cubes of specimen of size 100 mm x 100 mm x 100 mm were prepared for each mix. After 24 hours the specimens were de molded and cured in water for 24ºC until testing. The strength value was reported as the average of three samples.

b) Flexural Strength

Flexural strength was obtained from three point method according to ASTM C 78 the test were carried out after 28 days of curing on the beam sample of size 100 mm x 100 mm x 500mm.

c) Split Tensile Strength

Split Tensile strength was obtained in accordance with ASTM C 496. Cylindrical specimens of 100 mm x 200 mm were cast and tested after 28 days curing.

2)Durabilitypropertie

a)Permeabiliy

Permeability of pervious mixes was determined by using falling head permeability method based on earlier study (21).Specimen of size 80 mm diameter and 150 mm length were casted and tested after 28 days of curing.

III. RESULTS AND DISCUSSION

A. Different paste content

1) Strength Characteristics

Table 4 and 5 shows the compressive strength, flexural and split tensile strength for the control mix and other mixes with different cement content at various ages. Cement content plays a vital role in concrete; mainly in case of porous concrete minimum paste content is required to coat the aggregate. Compressive strength increases with the increase of cement content in the mix as shown in Fig 1. The strength of porous concrete is marginally increased with the age, due to the improved strength of the binder paste with time. Similarly Fig 2 and Fig 3 shows the same trend as expected like the compressive strength for the flexural strength and split tensile strength.

Strength increases with the ages, while comparing the 7, 28 and 56 days it keep on increasing. When compared to 7 days and 28 days 34% is increased. When comparing the 28 and 56 days strength 10 % is increases. It shows that curing is also very important criteria for porous concrete.

TABLE IV. STRENGTH OF CONTROL MIX

Mix Details	Compressive Strength(N/mm^2)			Flexural Strength (N/mm^2)	Split Tensile Strength (N/mm^2)
	7days	28days	56 days	28 days	28 days
M1F100	24.5	39.4	42.2	4.8	4.86
M2F100	7.4	26.33	28.5	4	3.82
M3F100	14.7	18.5	20.5	3	3.37

TABLE V. COMPRESSIVE STRENGTH OF POROUS CONCRETE AT VARIOUS AGES

Mix Details	Compressive Strength (N/mm^2)		
	7 days	28 days	56 days
M1F0	8.4	14.6	15.83
M2F0	4.6	5.6	6.5
M3F0	2.8	3.7	4.1

With the increase in cement content from 250 to 300 kg/m^3 it's average increases the compressive strength from 3.7N/mm^2 to 5.6 N/mm^2. The cement content increases from 300 to 400 kg/m^3, its compressive strength also increases from 5.6N/mm^2 14.6 N/mm^2

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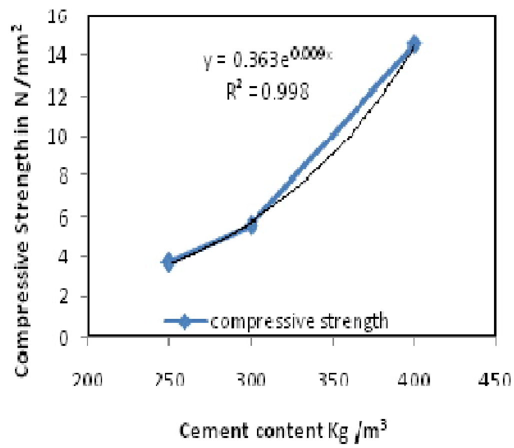

Fig. 1. Influence of Cement Content on Compressive Strength

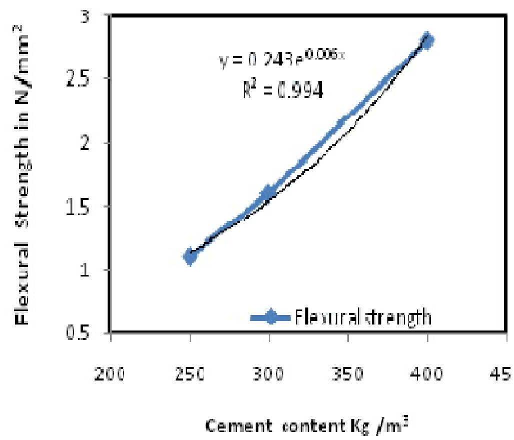

Fig. 2. Influence of Cement Content on Flexural Strength

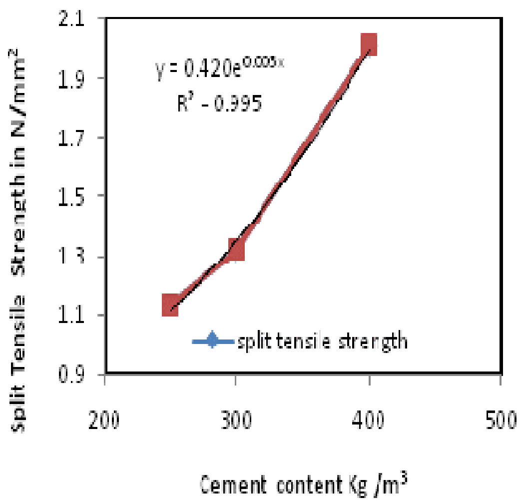

Fig. 3. Influence of Cement Content on Split Tensile Strength

B. ADDITION OF SAND

1) Strength criteria.

Fine aggregate increases in mix resulted in increase of compressive strength as shown in Fig 4. More importantly, the cohesive agent, namely sand, and the cement hydration products co-mingle and create two interpenetrating matrices which work together, resulting in improved strength (15).The average increase in compressive strength from 250 kg/m^3 to 300 kg/m^3 were $6N/mm^2$ to $11N/mm^2$. Similarly there is an increase in compressive strength from 300 kg/m^3 to 400 kg/m^3

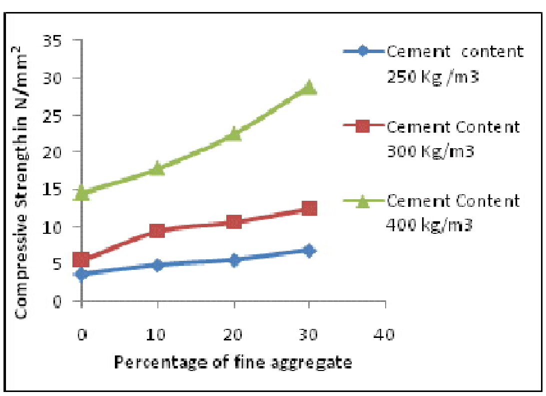

Fig. 4. Influence of fine aggregate on Compressive strength

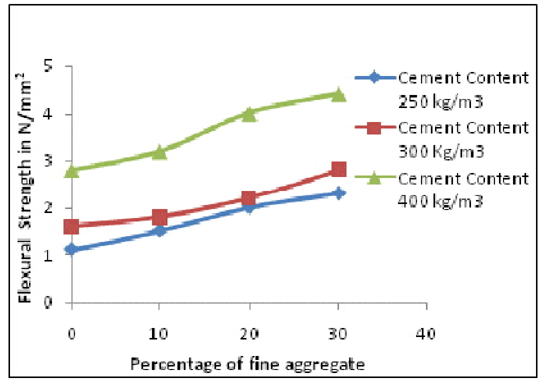

Fig. 5. Influence of fine aggregate on flexural strength

Fig 5 and 6 presents the static flexural strength and split tensile strength test results for various mixes with different proportion of fine aggregate addition. The test result shows that same tendency as compressive strength.

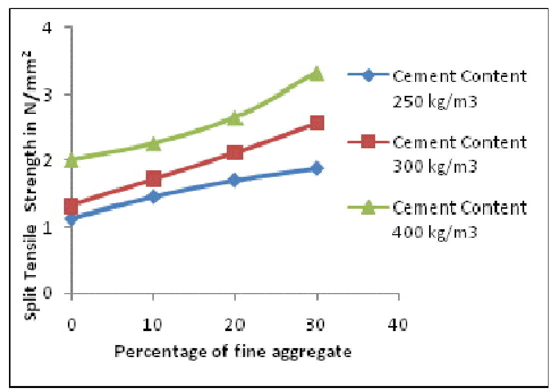

Fig. 6. Influence of fine aggregate on Split tensile strength

C. Permeability

The most distinguished feature of pervious concrete is its high permeability, which is a measure of the ease by which fluid may flow through the material under a pressure gradient. Results of permeability of the pervious concrete mixtures are shown in Fig 7. Permeability mainly depends upon the size of interconnected pores, which present in pervious concrete. It shows that decrease in permeability occurs with the increase in cement content in the mix. Comparing M2F0 to M1F0 percentage reduction in permeability it is 14%, M3F0 and M2F0 percentage reduction it is 11.57%

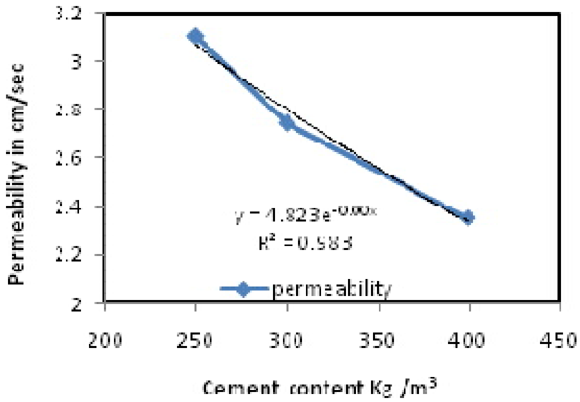

Fig. 7. Influence of Cement Content on permeability

D. Permeability with the influence of sand:

Permeability decreases with increase in sand content. It is evident from the Table 8 that permeability values for all the mixes range between 1.43 cm/sec to 3.1 cm/sec which is sufficient enough for a drainage layer for pavement.

Permeability reductions of various mixes with the corresponding sizes are presented in Table 8. Comparing M2 to M1 percentage reduction in permeability it is 16%, M2 and M3 percentage reduction it is 17%.

TABLE VI. PERMEABILITY OF POROUS CONCRETE

Mix Details	Permeability of concrete (Cm/Sec)
M1F0	2.354286
M1F10	1.831111
M1F20	2.00243
M1F30	2.478
M2F0	2.746667
M2F10	1.498182
M2F20	2
M2F30	1.831111
M3F0	3.109434
M3F10	1.373333
M3F20	1.436792
M3F30	1.648

E. Relation between compressive strength and permeability

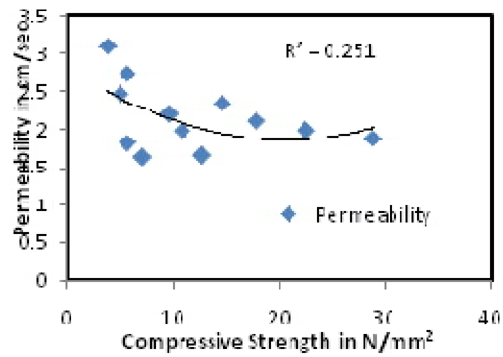

Fig. 8. Compressive strength Vs Permeability

Fig.8 shows the relationship between the compressive strength and permeability of porous concrete with and without addition of sand, also with the variation of cement content in the mixes. It shows that increases in compressive strength causes decreases in permeability of porous concrete. Influence of fine aggregate and increase in cement content in the mixes increases in the compressive strength of porous concrete but decreases the permeability of porous concrete, but both the parameter are very important, balancing the compressive strength and permeability optimization of the porous concrete is determined .Compressive strength found to be lying between 4N/mm^2 to 28.9 N/mm^2 and permeability between 1.43 cm/sec and 3.1 cm/sec.

IV. CONCLUSION:

This study presents the effect of variation of cement content and the influence of fine aggregate on well graded coarse aggregate on the properties of porous concrete. The laboratory tests were conducted to detect the strength and permeability of porous concrete. Increasing in variation of cement content in the mixes results in increase in compressive strength, Flexural strength and split tensile strength. The percentage of addition of fine aggregate in the porous concrete causes increase of compressive strength. Similar trend is followed for flexural strength and split tensile strength. The range of Compressive strength Varies between 4N/mm^2 to 28.9N/mm^2. Coefficient of permeability decreases with Increasing in variation of cement content and influence of fine aggregate addition. Its range varies from 1.43 cm/sec and 3.1 cm/sec.

REFERENCES

[1] Vanchai Sata , Ampol Wongsa, Prinya Chindaprasirt, "Properties of pervious geopolymer concrete using recycled aggregates," Construction and Building Materials, 42, pp 33–39, 2013
.

[2] Yu Chen,Kejin Wang,Xuhao Wang &Wenfang Zhou," Strength, fracture and fatigue of pervious concrete," Construction and Building Materials, 42, 97-104, 2013.

[3] M. Aamer Rafique Bhutta , K. Tsuruta & J. Mirza, " Evaluation of high-performance porous concrete properties," Construction and Building Materials, 31, 67 – 73, 2012.

[4] Tawatchai Tho-in ,Vanchai Sata , Prinya Chindaprasirt a, Chai Jaturapitakkul, "Previous high-calcium fly ash geopolymer concrete," Construction and Building Materials ,30 ,pp 366–371,

[5] G.Girish&R.Manjunath Rao, "A step towards mix proportioning guidelines for pervious concrete,".International Journal of Earth Sciences and Engineering, 4, pp768 -771, 2011.

[6] Milani S. Sumanasooriya & Narayanan Neithalath, "Pore structure features of pervious concretes proportioned for desired porosities and their performance prediction, "Cement & Concrete Composites, 33, pp778-787, 2011.

[7] Xiang Shu , Baoshan Huang, Hao Wu, Qiao Dong & Edwin G. Burdette, "Performance comparison of laboratory and field produced perviousconcrete mixtures," Construction and Building Materials, 25 ,pp3187–3192 ,2011.

[8] C. Lian, Y. Zhuge & S. Beecham, "The relationship between porosity and strength for porous concrete," Construction and Building Materials, 25, pp4294–4298, 2011.

[9] An Cheng, Hui-Mi Hsu, Sao-Jeng Chao & Kae-Long Lin, "Experimental Study on Properties of Pervious Concrete Made with Recycled Aggregate. Internal Journal of Pavement Research and Technology, 4 ,N0.2, pp104-110,2011.

[10] Bradley J. Putman & Andrew I. Neptune, "Comparison of test specimen preparation techniques for pervious concrete pavements," Construction and Building Materials, 25, pp3480 –2011

[11] H.K. Kim & H.K. Lee, "Influence of cement flow and aggregate type on the mechanical and acoustic," Applied Acoustics ,71, pp 607–615,2010
.

[12] Narayanan Neithalath, Milani S. Sumanasooriya & Omkar Deo, "Characterizing pore volume, sizes, and connectivity in pervious concretes for permeabilityprediction,"Materials Characterization , 61, pp 802 – 813, 2010.

[13] C. Lian & Y. Zhuge, "Optimum mix design of enhanced permeable concrete –An" Construction and Building Materials, 24 , pp 2664–2671, 2010. Experimental investigation,

[14] Omkar Deo & Narayanan Neithalath, " Compressive behavior of pervious concretes and a quantification of the influence of random pore structure features,"*Materials Science and Engineering* ,528 , pp 402–412, 2010.

[15] Baoshan Huang, Hao Wu, Xiang Shu & Edwin G. Burdette, "Laboratory evaluation of permeability and strength of polymer- modified pervious concrete," Construction and Building Materials , 24, pp 818-823, 2010.

[16] P. Chindaprasirt, S. Hatanaka, N. Mishima, Y. Yuasa & T. Chareerat, " Effects of binder strength and aggregate size on the compressive strength and void ratio of porous concrete,"International Journal of Minerals, Metallurgy and Materials , 16, N0. 6,pp 714-719,2009.

[17] Wassermann, R., Katz, A., and Bentur, A, " Minimum cement content requirements: a must or a myth?," Materials and Structures, No. 42, pp973–982,2009.

[18] Zhuge.Y & Lian.C, "Development of environmentally friendly and structural enhanced permeable concrete pavement material," Southern Engineering conference. ,2009.