Design of Pervious Concrete & Enhancement of its Strength with Different Water-Cement Ratio & Admixtures

Rukman Patel[1] Nancy Soni[2]
[1]M. Tech. Student [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]RKDF College of Engineering, Bhopal, M.P. India

Abstract— The Strength of pervious concrete is as important as its permeability characteristics. Studies indicate that pervious concrete has lower compressive strength capabilities than conventional concrete and will only support light traffic loadings. This thesis investigated prior studies on the compressive strength of pervious concrete as it relates to water- cement ratio, aggregate-cement ratio, aggregate size, quantity of admixture and compaction and compares those results with results obtained in laboratory experiments conducted on samples of pervious concrete cube casted for this purpose. Since voids are supposed to reduce the strength of concrete 1% for every 5% voids (Klieger, 2003), the goal is to find a balance between water, aggregate, and cement in order to increase strength and permeability, two characteristics which tend to counteract one another. The end result of this research will be a recommendation as to the water-cement ratio, the aggregate-cement ratio, aggregate size, quantity of admixture and compaction necessary to maximize compressive strength without having detrimental effects on the permeability of the pervious concrete system. This research confirms that pervious concrete does in fact provide a lower compressive strength than that of conventional concrete. Researches indicate that the minimum compressive strengths of acceptable mixtures reached in to 2.8Mpa and maximum compressive strength reached to 28Mpa (Tennis et al, 2004, Yang, J. and G. Jiang, Nguyen, 2002, V.C., 2008). Extremely high permeability rates were achieved in most all mixtures regardless of the compressive strength.

Key words: Permeability, Pervious Concrete, Water-Cement Ratio, Admixtures

I. INTRODUCTION

Pervious concrete is a composite material consisting of binding material, coarse aggregate, admixture and water. It is different from conventional concrete in that it contains no fine aggregate in the mixture. The aggregate usually consists of a single size and is bonded together at its points of contact by a paste formed by the cement, admixture and water. This mix when hardens results in a concrete with a high percentage of interconnected voids that, allows the rapid percolation of water. Unlike conventional concrete, which has a void ratio approximately 3-5%, pervious concrete can have void ratio from 15-35%.The characteristics of Pervious concrete differ from conventional concrete in several other ways. If we compare Pervious concrete with conventional concrete, it has a lower compressive strength, higher permeability, and a lower unit weight, approximately 70% of conventional concrete.

A. Uses

1) The use of Pervious concrete is limited in areas subjected to low traffic volumes and loads.
2) Pervious concrete is useful in the construction of parking lots, driveways, sidewalks, residential streets, tennis courts, and swimming pool decks.
3) We can construct the pavement for Zoo areas & Sub-base for conventional concrete pavements with the help of pervious concrete.
4) We can also construct the low-volume pavements residential roads with the help of pervious concrete.
5) Sewage treatment plant sludge beds, beach structures and seawalls can be constructed by pervious concrete.
6) Bridge embankments & solar energy storage systems can be constructed by pervious concrete.

B. Advantages

Recharging of ground water table: Pervious concrete can filter the impurities those are present in storm water runoff that would penetrate into the ground. As pervious concrete absorbs runoff water, it conserves this natural resource (NRMCA, 2004). Pervious concrete helps to direct would-be runoff into the soil for use by plants and for ground water recharge. This helps to conserve this precious natural resource.

1) Sound Absorption

Pervious concrete has the ability to decrease the noise produced by vehicles on concrete pavements due to reduction of interaction noise between the tire and pavement surface. Pervious concrete pavement absorbs the sound (Olek et al., 2003). Due to the characteristics the pervious concrete minimizes air pumping between the tire and pavement surface (ACI 522 Pervious Concrete, 2006) [11]. Therefore, pervious concrete has the potential to reduce the noise generated by vehicles (Sandberg and Ejsmont, 2002). Constructing the road by pervious concrete should reduce the noise as well as the expense (Nelson and Philips, 1994, Descornet, 2000). The thickness of the pervious concrete pavement layer is closely related to the noise reduction (Beeldens et al., 2004).

2) Skid Resistance

Pervious concrete can remove storm water more rapidly than traditional concrete (Schaefer et al., 2006) due to its higher permeability and more rapid infiltration of Storm water into the ground. By minimizing water on the pavement surface, skid resistance is dramatically improved.

3) Storm-water Runoff

Reducing storm-water runoff is one of the primary functions of pervious concrete. Pervious concrete contains no fine aggregate and contains uniformly sized coarse aggregate so that more void space exists in the matrix for holding and transporting water (Zouachi et al, 2000). Pervious concrete can substantially reduce surface runoff water in comparison to traditional concrete pavement. Thus, pervious concrete can reduce the size of necessary storm sewers (ACI 522 Pervious Concrete, 2006).

4) Heat Insulation

Pervious concrete is much cooler than bitumen and conventional concrete. First of all, the light color reflects more ultraviolet rays from sun and absorbs less heat than bitumen. Secondly, the voids in pervious concrete allow it to store less heat than conventional concrete does. This character benefits the districts in hot weather climates. For instances, the group of National Center of Excellence for Sustainable Materials and Renewable Technology at Arizona State University recommended the utilization of pervious concrete for minimizing the urban heat-island effect. Houston Advanced Research Center (HARC) published a report titled "Cool Houston A Plan for Cooling the Region," in which the benefits of reducing heat island effect in high density urban areas by using pervious concrete has been introduced. This also helps in reduction of expenses on Air Conditioners.

C. Problem Statement and Research Significance

Based on the literature review conducted (Chapter II), it was realized that previous research done on pervious concrete mixtures has focused primarily on optimizing the hydrologic properties of pervious concrete mixes. This led to the use of singled-sized aggregates such as the 10 mm and 12 mm sizes. In the event that aggregate gradations were investigated, the variations were quite limited (Ghafoori, 1995). Although permeability may be of greatest concern in one application because of high rainfall intensities, another application may place greater emphasis on strength, and another may consider smooth riding or sound absorption as the primary concern. Other porous construction materials, for instance porous asphalt, rely on a distribution of aggregate sizes for strength while providing adequate drainage properties (Kandhal, 2002). The design of each pervious concrete mixture is unique based on performance requirements. Therefore, the main objective of this study was to investigate the effects of aggregate properties and gradation on the performance of pervious concrete mixtures. The results of this study would lead to a better understanding of the manner in which aggregate gradation can be used to optimize a pervious concrete mixture depending on project or site-specific requirements.

D. Scope of the Research

A number of pervious concrete mixes was produced with single size aggregate of having size 10mm with different water-cement ratio and admixture (super-plasticizer) to study the main properties include density, porosity, compressive strength and water permeability.

Although water permeability is the most important characteristic of the pervious Concrete, there is no well-established method for its quantification. Therefore, an experimental procedure to assess the water permeability of pervious concrete is developed in this thesis work.

II. LITERATURE REVIEW

Pervious concrete is a combination of Portland cement, controlled amounts of water, coarse aggregate and little or no sand. The thick cement paste bonds the coarse aggregate together but allows adequate void formation of approximately 15% to 35%.

The rate at which the water flows through pervious concrete is "typically around 480 in./hr (0.34 cm/s which is 5 gal/ft²/min or 200 L/m²/min)" (Tennis et al, 2004).

1) Environmental Benefits

The EPA Storm Water Phase II Final Rule has regulations to manage the quantity of pollutants entering bodies of water (Tennis et al, 2004). Contaminants may include oils, grains, grease, sediment, anti-freeze, fertilizers, and pesticides. The partially filtered water is able to percolate into the soil and be further filtered by the soil structure, and in turn recharge the ground water table and readily water the surrounding plants. With pervious concrete, the need for management systems to control excess water flow is minimized. Along with these environmental benefits are safety concerns that are eliminated such as pooling, spraying and hydroplaning (Tennis et al, 2004). Pervious concrete now has the potential of being certified for construction projects by the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System, because of its environmental benefits along with the capability of lowering the heat island effect (Tennis et al, 2004). Urban areas tend to enclose large numbers of impervious pavements which add to the level of heat. The concentrated heat wave can be reduced by the open structure of pervious concrete that allows air to flow through it. Additionally, the roots of plants and trees adjacent to these pavements not only experience watering but also aeration (Tennis et al, 2004).

2) Economic Benefits

Economic concerns and regulations have rekindled an interest in pervious concrete. Regulations such as storm water impact fees are increasing the cost of developing real estate because of the size and cost of required drainage systems (Tennis et al, 2004). The labor, construction, and maintenance cost of implementing storm water management systems, such as retention ponds, pumps, swales, and storm sewers can be substantially reduced or even eliminated with the proper construction of pervious concrete pavements. Land developers who have installed these pavements have been rewarded with more available building area. Another economical benefit of pervious concrete presents itself to local concrete companies. Because of the low slump property of pervious concrete, the delivery time is relatively short and would create issues for contractors and owners, but for companies that operate close to the construction site, they would have the advantage over their competitors who are further away. Finally, pervious concrete has a lower maintenance cost over its life- cycle due to its durability and strength in comparison to asphalt pavements (Tennis et al, 2004).

3) Physical Benefits of Pervious Concrete

The surface of pervious concrete possesses a peculiar texture, because its mix is comprised of gravel or crushed stone and little or no fines. The coarse aggregate texture of the pervious pavement surface improves skid resistance by removing excess precipitation during rainy days and causes snow to melt faster (Schaefer et al, 2006).

The surface of pervious concrete pavements experiences some raveling which only last during the early weeks after placement (Tennis et al, 2004). Proper compaction and curing methods greatly reduce this defect. The possibility of drying shrinkage of the hardened concrete is lower than conventional concrete since there is less water

in the fresh mix (Offenberg, 2005). Because cracking is not as prevalent in pervious concrete pavements, control joints are spaced further apart (i.e., around 20 feet from each other) (Tennis et al, 2004).

4) Applications and Performance

The quality and performance of pervious concrete depends on the quality of the sub-grade, and the constructor's ability to correctly proportion, mix, place, finish and cure the mixture (Crouch et al, 2003). A vibrating screed is used to maximize the density and strength and a steel pipe roller is used for compaction. The pavement is immediately sealed with plastic sheeting which remains on the pavement for at least a week and the cured pervious concrete has the appearance of Rice Krispies treats (Tennis et al, 2004). The gradations of pervious concrete mixes can be adjusted to meet the desired performance requirements for a given application whether for pedestrians, vehicles, or sound absorption. The unique abilities of pervious concrete offer solutions to environmental issues, public agencies, and building owners, which allow for diverse applications in which it can be used successfully. Some of the applications for pervious concrete involve residential roads and driveways, sidewalks, parking lots, low water crossings, sub-base for conventional concrete pavements, patios, artificial reefs, slope stabilization, hydraulic structures, well linings, noise barriers and many other applications exist (Tennis et al, 2004).

5) Properties of Fresh Pervious Concrete

Fresh pervious concrete is characterized as having a very low slump of about ¾ inches; therefore, it cannot be pumped. Generally, the coated aggregates maintain a molded shape since the mix is quite sticky. With regards to achieving some level of quality control and quality assurance, unit weight measurements are the best means of doing so. A unit weight range of 100 to 125 lb/ft3 is typical with a tolerance of ± 5% or 5 lb/ft3. The mixing and placement time for pervious concrete is usually one hour, but it can be increased to one and one-half hours when retarders or hydration stabilizers are added (Tennis et al, 2004). Modifications to the mixing process of allowing the aggregate to rotate for 1 minute with 5% of the total cement has increased the 7-day strength of the specimens tested (Schaefer et al, 2006).

III. OBJECTIVE OF STUDY

The main objectives of this study are to:

1) Investigate the properties of pervious concrete with different mixes of aggregate & cement.
2) Establish an experimental procedure to determine water permeability of pervious Concrete.
3) The purpose of this thesis is to provide tools to evaluate and improve the durability and strength of pervious concrete with sufficient permeability such that it may be more confidently employed in urban roadways, driveways, and parking lots.

IV. SAMPLE PREPARATION

A. Cube Moulds- (As per IS: 516:1959)

The mould shall be of metal, preferably steel or cast iron, stout enough to prevent distortion. It shall be constructed in such a manner as to facilitate the removal of the moulded specimen without damage, and shall be so machined that, when it is assembled ready for, the dimensions and internal faces shall be accurate within the following limits.

Fig. 1: Cube mould filled with pervious concrete

The height of the mould and the distance between opposite faces shall be the specified size + 0.2mm. The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould shall be 90 0 - 0.5 0 C the interior faces of the mould shall be plane surface with a permissible variation of 0.03mm. Each mould shall be provided with a metal base plate having a plane surface. The base plate shall be such dimensions as to support the mould during the filling without leakage and it shall be preferably attached to the mould by spring or screws. The part of the mould when assembled shall be positively and rigidly held together, and suitable methods of insuring this, both during the filling and on subsequent handling of the field mould, shall be provided.

In assembling the mould for use, the joints between the sections of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escape during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete.

B. Casting of test specimens (Cube) (As per IS: 516:1959)

All materials shall be brought to room temperature, preferably 27 0 C+ 3 0 C before commencing the result.

The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry other by hand or in a suitable mixer in such a manner as to insure the greatest possible blending and uniformity in the material, care is being taken to avoid intrusion of the foreign matter. The cement shall than be stored in a dry place, preferably in air tight metal containers.

Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air dried condition. In general, the aggregate shall be separated in to fine and coarse fraction and recombined for each concrete batch in such a manner as to produce the desired grading. Is sieve 480 shall be normally used for separating the fine and coarse fractions, but where special grading are being investigated, both fire and coarse fractions shall be further separated in to different sizes.

C. Proportioning

The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work. Where the proportions of the ingredients of the concrete as used on the site are to be specified by volume, they shall be calculated from the proportions by weight used in the test cubes and the unit weights of the materials.

D. Workability

Even though a few researchers have reported slump values for pervious concrete, the standard slump test is not suitable for pervious concrete to assess its workability because of lightweight nature of pervious concrete was too small [2, 7, 9, 10, 13], Tennis et. al. [2] recommended that workability for pervious concrete should be assessed by forming a ball with the hand to established mouldability of pervious concrete (Figure 3.6, 3.7, 3.8). Mouldability of pervious concrete is quite sensitive to water content; hence the amount of water should be strictly controlled. Strength and permeability of pervious concrete are found to be affected by several factors including binder types, aggregate type, aggregate grading, mix combination and compaction [2, 7, 10, 13, 17, 18]. By the help of this test we select the water cement ratio between in the range 0.34-0.38.

Fig. 2: Less water/cement ratio

Fig. 3: Sufficient amount of water

Fig. 4: Excess amount of water

Sample No.	W/C Ratio	A/C Ratio	Weight of Aggregate / m3 (kg)	Weight of cement /m3 (kg)	Weight of Water /m3 (kg)	Quantity of Admixture (ml)
I II III	0.38	5	1612	323	123	1615
I II III	0.36	5	1612	323	117	3230
I II III	0.34	5	1612	323	110	4845
I II III	0.38	4.5	1638	364	139	1820
I II III	0.36	4.5	1638	364	131	3640
I II III	0.34	4.5	1638	364	124	5460

Table 2: Different mixtures those were used in this thesis work

V. RESULT

S. No.	W/C Ratio	Aggregate Cement Ratio	Quantity of admixture (ml/kg of cement)	Weight of concrete (kg)	Density (kg/m^3)
1	0.38	5	5	4.288	1905
2	0.36	5	10	4.280	1902
3	0.34	5	15	4.254	1890
4	0.38	4.5	5	4.236	1882
5	0.36	4.5	10	4.231	1880
6	0.34	4.5	15	4.220	1875
7	0.38	4	5	4.168	1852
8	0.36	4	10	4.159	1848
9	0.34	4	15	4.150	1844

Table 3: Density of fresh pervious concrete

Sample No.	W/C Ratio	A/C Ratio	Load taken by sample after 7 days (kg)	Load taken by sample after 28 days (kg)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28 days (kg/cm2)
I II III	0.38	5	8000 8000 9000	14000 13000 14000	35.56 35.56 40.00	62.22 57.78 62.22
I II III	0.36	5	10000 9000 9000	15000 14000 15000	44.44 40.00 40.00	66.67 62.22 66.67
I II III	0.34	5	11000 10000 11000	17000 16000 16000	48.89 44.44 48.89	75.56 71.11 71.11
I II III	0.38	4.5	11000 12000 12000	18000 17000 17000	48.89 53.33 53.33	80.00 75.56 75.56

I II III	0.36	4.5	12000 12000 13000	18000 19000 19000	53.33 53.33 57.78	80.00 84.44 80.00
I II III	0.34	4.5	12000 13000 13000	18000 20000 19000	53.33 57.78 57.78	80.00 88.88 84.44
I II III	0.38	4	14000 13000 13000	20000 21000 21000	62.22 53.33 53.33	88.88 93.33 93.33
I II III	0.36	4	14000 14000 13000	23000 21000 22000	62.22 62.22 53.33	102.22 93.33 97.78
I II III	0.34	4	14000 15000 14000	23000 22000 23000	62.22 66.67 62.22	102.22 97.78 102.22

Table 4: Compressive strength of pervious concrete

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	5	5	35.56	62.22
2	0.38	5	5	35.56	57.78
3	0.38	5	5	40.00	62.22

Table 5: Compressive strength of pervious concrete (Mix-I)

Average compressive strength of these specimen after 7 days curing = 37.04 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 60.74 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.36	5	10	44.44	66.67
2	0.36	5	10	40.00	62.22
3	0.36	5	10	40.00	66.67

Table 6 Compressive strength of pervious concrete (Mix-II)

Average compressive strength of these specimen after 7 days curing = 41.48 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 65.19 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.34	5	15	48.89	75.56
2	0.34	5	15	44.44	71.11
3	0.34	5	15	48.89	71.11

Table 7: Compressive strength of pervious concrete (Mix-III)

Average compressive strength of these specimen after 7 days curing = 47.41 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 72.59 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	5	5	37.04	60.74
2	0.36	5	10	41.48	65.19
3	0.34	5	15	47.41	72.59

Table 8. Combine table for compressive strength of pervious concrete

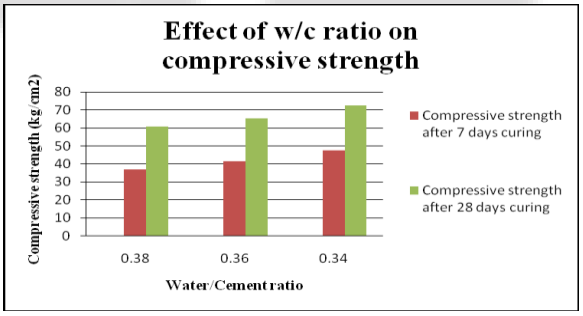

Fig. 5: Compressive strength v/s water cement ratio

By these observations we found that we can improve the compressive strength upto 16 % with the increase of quantity of super-plasticizer in mix.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	4.5	5	48.89	80.00
2	0.38	4.5	5	53.33	75.56
3	0.38	4.5	5	53.33	75.56

Table 9: Compressive strength of pervious concrete (Mix-IV)

Average compressive strength of these specimen after 7 days curing = 51.85 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 77.04 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.36	4.5	10	53.33	80.00
2	0.36	4.5	10	53.33	84.44
3	0.36	4.5	10	57.78	80.00

Table 10: Compressive strength of pervious concrete (Mix-V)

Average compressive strength of these specimen after 7 days curing = 54.81 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 81.48 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.34	4.5	15	53.33	80.00
2	0.34	4.5	15	57.78	88.88
3	0.34	4.5	15	57.78	84.44

Table 11: Compressive strength of pervious concrete (Mix-VI)

Average compressive strength of these specimen after 7 days curing = 56.30 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 84.44 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	4.5	5	48.89	80.00
2	0.36	4.5	5	53.33	75.56
3	0.34	4.5	5	53.33	75.56

Table 12: Combine table for compressive strength of pervious concrete

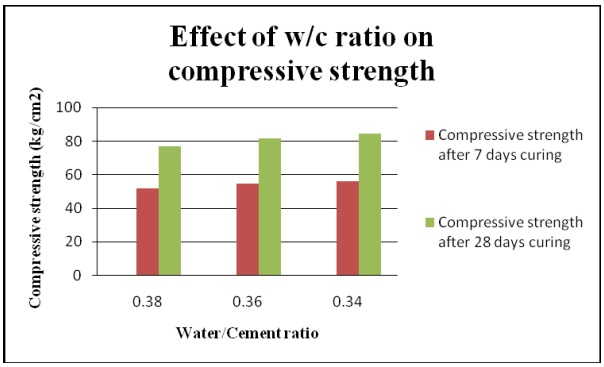

Fig. 6: Compressive strength v/s water cement ratio

By these observations we found that we can improve the compressive strength upto 9 % with the increase of quantity of superplasticizer in mix.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	4	5	62.22	88.88
2	0.38	4	5	53.33	93.33
3	0.38	4	5	53.33	93.33

Table 13: Compressive strength of pervious concrete (Mix-VII)

Average compressive strength of these specimen after 7 days curing = 56.30 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 91.85 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.36	4	10	62.22	102.22
2	0.36	4	10	62.22	93.33
3	0.36	4	10	53.33	97.78

Table 14: Compressive strength of pervious concrete (Mix-VIII)

Average compressive strength of these specimen after 7 days curing = 59.26 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 97.78 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.34	4	15	62.22	102.22
2	0.34	4	15	66.67	97.78

3	0.34	4	15	62.22	102.22

Table 15: Compressive strength of pervious concrete (Mix-IX)

Average compressive strength of these specimen after 7 days curing = 63.70 kg/cm2.

Average compressive strength of these specimen after 28 days curing = 100.74 kg/cm2.

Specimen No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Compressive Strength after 7 days (kg/cm2)	Compressive Strength after 28th days (kg/cm2)
1	0.38	4	5	56.30	91.85
2	0.36	4	10	59.26	97.78
3	0.34	4	15	63.70	100.74

Table 16: Combine table for compressive strength of pervious concrete

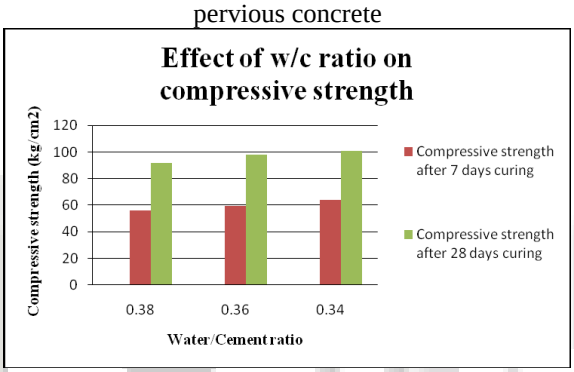

Fig. 7: Compressive strength v/s water cement ratio

S. No.	A/C Ratio	Msd (kg)	Mbm (kg)	Mod (kg)	Porosity (%)
1	5	7.018	6.987	6.925	33.33
	5	7.012	6.979	6.912	33.00
	5	7.010	6.976	6.910	34.00
2	4.5	6.995	6.967	6.897	28.57
	4.5	6.988	6.962	6.895	27.95
	4.5	6.980	6.954	6.886	27.66
3	4	6.970	6.945	6.858	22.32
	4	6.964	6.940	6.852	21.43
	4	6.958	6.932	6.832	20.63

Table 17: Test observation for porosity

S. No.	Sample No.	W/C Ratio	A/C Ratio	Quantity of admixture (ml/kg of cement)	Quantity of water (ml)	Time (S)
1	I	0.38	5	5	1450	33
	II					34
	III					32
2	I	0.36	5	10	1450	33
	II					34
	III					36
3	I	0.34	5	15	1450	33
	II					32
	III					34
4	I	0.38	4.5	5	1450	36
	II					34
	III					38
5	I	0.36	4.5	10	1450	35
	II					34
	III					36
6	I	0.34	4.5	15	1450	35
	II					36
	III					34
7	I	0.38	4	5	1450	38
	II					37
	III					39
8	I	0.36	4	10	1450	37
	II					36
	III					36
9	I	0.34	4	15	1450	38
	II					37
	III					38

Table 18: Hydraulic conductivity of pervious concrete mixes

S. No.	Water Cement Ratio	Aggregate Cement Ratio	Time (Sec)	Permeability (mm/sec)
1	0.38	5	33	25.45
2	0.36	5	34	24.70
3	0.34	5	33	25.45
4	0.38	4.5	36	23.33
5	0.36	4.5	35	24.00
6	0.34	4.5	35	24.00
7	0.38	4	38	22.11
8	0.36	4	36	23.33
9	0.34	4	38	22.11

Table 19: Results of hydraulic conductivity of pervious concrete mixes

VI. CONCLUSION

Pervious concrete has high water permeability due the presence of interconnected air voids in its matrix. The presence of high porosity with respect to conventional concrete makes the pervious concrete to become light weight concrete with limited compressive strength. However, now a days pervious concrete has been becoming more popular for a few decades due to its potential to reduce the incidence of flooding, and to assist in recharging the groundwater table.

In this thesis we use an admixture (Conplast sp430) i.e. a super-plasticizer to reduce the water cement ratio in the mix, by this we achieved higher compressive strength with same mix. In this research work we observed that we can achieve the compressive strength of pervious concrete with 10 mm single size aggregate around 100 kg/cm2.

On the basis of our observations on pervious concrete the following conclusion were made:

1) We can improve the compressive strength of pervious concrete around 9%-15 % with use of superplasticizer.
2) The porosity of pervious concrete was between 20%-34% as compare with conventional concrete's 3%-5%.
3) The compressive strength of pervious concrete was around 100 kg/cm2.
4) The permeability of pervious concrete was 22.11 mm/sec- 25.45 mm/sec.
5) The density of pervious concrete was 1844 kg/m3 -1905 kg/m3 which was 20%-25% lower than that of conventional concrete.

6) The hydraulic conductivity decreased as the decrement takes place in the percentage of aggregate in mix.

ACKNOWLEDGEMENT

The author are Grateful to the Department of Civil Engineering, RKDF College of Engineering, Bhopal, M.P., India for extending the facilities and support during study, and also very thankful to the Co-ordinator of M-Tech, Dr. R. Gupta and project guide Prof. Nancy Soni (HOD), lecturers for their guidance and support.

REFERENCES

[1] ASTM C1602 / C1602M - 12 Standard Specifications for Mixing Water Used inthe Production of Hydraulic Cement Concrete.
[2] Tennis, P.D., M.L. Leming, and D.J. Akers, Pervious concrete pavements. PortlandCement Association, Skokie, Illinois, & National Ready Mixed Concrete Association, Silver SpringSS, Maryland, 2004.
[3] Cement and Concrete Research, 2006: 36(11): p. 2074-2085.
[4] Neithalath, N., J. Weiss, and J. Olek, Characterizing enhanced porosity concrete using electrical impedance to predict acoustic and hydraulic performance.
[5] Malhotra, V.M., No-Fines Concrete – Its Properties and Applications, ACI Journal, November 1976, Vol. 73, Issue 11, pp 628-644.
[6] Cube Moulds- (As per IS: 516:1959)
[7] Zhuge, Y., Comparing the performance of recycled and quarry aggregate and their effect on the strength of permeable concrete. In Future in Mechanics of Structures and Materials. Toowoomba, Australia, 2008: p. 343-349.

