INVESTIGATION ON HIGH PERFORMANCE PERMEABLE PAVER BLOCK

T.Ananth, Assistant Professor, Department of Civil Engineering, Jerusalem College of Engineering, Chennai, Tamilnadu. India.
Pallavi HJ, Assistant Professor, Department of Civil Engineering, ACS College Of Engineering, Bengaluru, Karnataka, India.
Dr. A.Hemalatha, Professor & Head, NPR College of Engineering and technology, Dindigul, Tamil Nadu, India.
Mr.C.Vijayakumar, Assistant Professor, NPR College of Engineering and Technology, Natham, Tamil Nadu, India.
P.Thangamuthu ,Assistant Professor , Department of Civil Engineering, Er.Perumal Manimekalai College of Engineering, Hosur, Tamil Nadu , India.

Abstract
A solid unreinforced precast member laid over a bedding material is an interlocking concrete pavement block. It is a load-bearing element of the pavement. However, due to numerous operational and environmental constraints, conventional pavement blocks have become brittle. Cracks are stopped using polypropylene fibre. Polypropylene Fibre was added in amounts of 0%, 0.5%, 1%, and 1.5%. The test results are then compared to those of a standard pavement block.
Keywords: Pavement, Polypropylene fibers, Concrete, block, Urban Road, Un-reinforcement

Introduction
Due to rapid urbanization most of the places are covered with impermeable surfaces like cement concrete. This has a major impact on the ground water table. Pervious Concrete pavement is an effective ways to minimize this issue. Pervious concrete is an open graded structure with interconnected voids through which rain and storm water is permitted to percolate into the aquifer. Pervious concrete is an environmental friendly building material and EPA (Environmental Protection agency) has identified it as a Best Management Practice (BMP) for storm water Management. It can be used for lower traffic roads, shoulders, sidewalks and parking lots. This will add points to a project with a sustainable material managing storm water, reducing ground water pollution.
Cement paste in permeable concrete is very thin layer which binds coarse aggregate. Permeable pavements are alternative paving surfaces that allow storm water runoff to filter through voids into an underlying stone reservoir. It has emerged as a widely used technology for on-site storm water control. It allows storm water to both infiltrate into an underground storage basin or ex filtrate to the soil and ultimately recharge the ground water. The type of pavers used in this study is permeable interlocking concrete pavers. In this study permeable pavement is designed to capture some or part of the rainfall and runoff from storms, and conveying water to conventional storm water drainage systems The use of filtered water from the pavement drains for agriculture productions is one of the alternate ways for irrigation.
It is best method for preservation and reuse of storm or rain water by storing underground by making proper drainage system. It is alternative process in approach towards paving surface that capture and temporarily stored pavement surface into the surface underlying stone reservoir by filtering runoff through voids. The nature of the concrete is very good in compression but weak in tension and also it is characterized by brittle in nature. It consist material of cement , coarse aggregate, water and polypropylene fibre. The infiltration rate of pervious concrete will fall into the range of 2 to 18 gallons per minute per square foot (80 to 720 litres per minute per square meter). Typically, pervious concrete has little or no fine aggregate and has just enough cementitious paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids.

Polypropylene Fiber
Polypropylene is the first stereo regular polymer to have achieved industrial importance. The fibres from Polypropylene were introduced to the textile arena in the 1970s and have become an important

member of the rapidly growing family of synthetic fibres. Today Polypropylene enjoys fourth spot behind the "big three" fibre classes, i.e. polyester, nylon and acrylic. However, as opposed to other commodity fibres, its use as apparel and household textiles has been rather limited; the bulk of the fibre produced is used for industrial applications.

Fig1:Polypropylene Fiber

Properties of Polypropylene Fiber

Polypropylene fibres are composed of crystalline and noncrystalline regions. The spherulites developed from a nucleus can range in size from fractions of a micrometre to centimetres in diameter. Each crystal is surrounded by non- crystalline material. Fibre spinning and drawing may cause the orientation of both crystalline and amorphous regions.

If the extension is less than 0.5%, the spherulite deformation is elastic and no disruption of the structure occurs, otherwise spherulites are highly oriented in the direction of the force and finally are converted to micro fibrils. These highly anisotropic micro fibrillar structures lead to anisotropic fibre properties.

Crystallinity of Polypropylene Fiber

The degree of crystallinity of Polypropylene fibre is generally between 50-65%, depending on processing conditions. Crystallization occurs between glass transition temperature (Tg) and the equilibrium melting point (Tm). The crystallization rate of PP is fast at low temperature. It is reported that the crystallization rate decreases with increasing crystallization temperatures and also decreases with the increase of molecular weight. A paracrystalline structure with only 45% crystallinity resulting from immediate quenching after extrusion was observed. A significantly higher crystallinity of 62% was achieved when quenching further downstream of the die. Although the drawing orients the crystallites, it also might decrease the crystallinity.

Thermal Properties

Polypropylene fibres have a softening point in the region of 140°C and a melting point at 165°C. At temperatures of -70°C or lower, PP fibres retain their excellent flexibility. At higher temperature (but below 120°C) PP fibres nearly remain their normal mechanical properties. PP fibres have the lowest thermal conductivity of all commercial fibres. In this respect, it is the warmest fibre of all. The thermal conductivity of common textile fibres.

Table1- Properties of Polypropylene Fibre

Tensile strength (MPa)	350 to 550
Elongation (%)	40 to 100
Abrasion resistance	Good
Moisture absorption (%)	0 to 0.05
Softening point (ºC)	140
Melting point (ºC)	165
Chemical resistance	Generally excellent
Relative density	0.91
Thermal conductivity	6.0 (with air as 1.0)
Electric insulation	Excellent

Constituents of Concrete

Cement

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. Cement used in construction are sometimes named after their commonly reported place of origin, such as Roman cement, or for their resemblance to other materials, such as Portland cement, which produces a concrete resembling the Portland stone used for building in Britain. The term cement is derived from the Latin word Cementum, which is meant stone chippings such as used in Roman mortar notthe binding material itself.

Fig2:OPC cement

Cement, in the general sense of the word, described as a material with adhesive and cohesive properties, which make it capable of bonding mineral fragments in to a compact whole. 14 The first step of reintroduction of cement after decline of the Roman Empire was in about 1790, when an Englishman, J. Smeaton, found that when lime containing a certain amount of clay was burnt, it would set under water. This cement resembled that which had been made by the Romans. Further investigations by J. Parker in the same decade led to the commercial production of natural hydraulic cement.

Chemical Compounds of Cement

The raw material used in the manufactures of Portland cement comprises four principal compounds. These compounds are usually regarded as the major constituents of cement and tabulated with their symbols

Table 2 - Chemical Composition Of Cement

Name of the compound	Oxide Composition	Abbreviation
Tricalcium Silicate	3CaO.SiO2	C3S
Dicalcium Silicate	2CaO.SiO2	C2S
Tricalcium aluminate	3CaO.Al2 O3	C3A
Tetracalcium Aluminoferrite	4CaO.Al2O3.Fe2O3	C4AF

Dicalcium Silicate, C2S hardens slowly and contributes largely to strength increase at ages beyond one week. Tricalcium aluminate, C3A liberates a large amount of heat during the first days of hardening. It also contributes slightly for early strength development Cements with low percentages of this compound are especially resistant to soils and waters containing sulphates. Concrete made of Portland cement with C3A contents as high as 10.0%, and sometimes greater, hasshown satisfactory durability, provided the permeability of the concrete is low. Tetracalcium aluminoferrite, C4AF reduces the clinkering temperature. It will act as a flux in burning the clinker. It hydrates rather rapidly but contributes very little to strength development.

Aggregates

The shape and particle size distribution of the aggregate is very important as if affects the packing and voids content, water absorption, grading and variation in fines content of all aggregate should be closely and continuously monitored order to produce constant quality. Coarse aggregate of maximum size 20mm was used in this experimental study.

Fig3: Fine and coarse aggregates

Experimental results indicated that above the 38.1mm maximum size the gain in strength due to the reduced water requirement is offset by the detrimental effects of lower bond area (so that volume changes in the paste cause larger stresses at interfaces) and of discontinuities introduced by the very large particles. In structural concrete of usual proportions, there is no advantage in using aggregate with a maximum size greater than about 25 or 40mm when compressive strength is a criterion.

Water

Water is a key ingredient in the manufacture of concrete. the first is to react chemically with the cement, which will finally set and harden, and the second function is to lubricate all other materials and make the concrete workable . Although it is an important ingredient of concrete, it has little to do with the quality of concrete. One of the most common causes of poor-quality concrete is the use of too much mixing.

Test on Paver Block

Compressive Test on Paver Block

For compression test for paver block, zigzag paver block mould size of 20cm x 10cm x 7.6cm are used. Iron oxide pigment was filled inside the mould at 1mm thickness. Then the concrete of different proportions of silica fume 10%, 20%, 30%, 40% and polypropylene fibre of 2% was added & nominal mix was prepared. Each mix was poured into a separate mould and tempered properly so as not to have any voids. After 24 hours these moulds were removed and test specimens were put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing, 14days curing and 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

The compressive strength of the paver blocks is calculated as follows:

Fig4: Compressive Test on Paver Block

Table 3 - Compressive Strength Of Paver Block In 7 Days

Sl.no	silica fume content	polypropylene fibre content (%)	load (kn)	area	compressive strength
1	(Nominal Mix %)	-	485	20000	24.25
2	10,20,30,40	2	460, 540, 595, 525	20000	23, 27, 29.75, 26.25

Table 4- Compressive Strength of Paver Block In 28 Days

Sl.no	silica fume content	polypropylene fibre content (%)	load (kn)	area	compressive strength
1	(Nominal Mix %)	-	610	20000	30.5
2	10,20,30,40	2	960, 995, 1065, 970	20000	48, 49.75, 53.25, 48.5

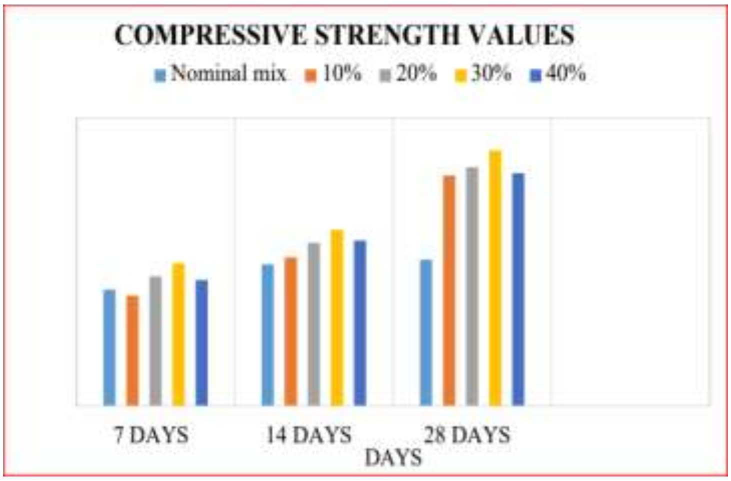

Fig6: Compressive Strength of Paver Block

Water Absorption Test on Paver Block

The test specimen shall be completely immersed in water at room temperature for 24±2 h. The specimen then shall be removed from the water and allowed to drain for 1min by placing them on a 10mm or coarser wire - mesh. „Visible water on the specimens shall be removed with a damp cloth. The specimen shall be immediately weighed and the weight for each specimen noted in Kg. This test are conducted for different proportion specimens.

The percent water absorption shall be calculated as follows:

Water Absorption = Ww-Wd/ Wd

Table 5 - Water Absorption On Paver Block In 7 Days

Sl.no	Mix ratio in %	Wet weight (Ww) in kg	Dry weight (wd) in kg	Weight in %
1	Nominal mix	6.30	6.1	1.20
2	10,20,30,40	6.0,6.0,6.2,6.16	5.9,5.92,6.02,6.1	0.84,1.05,2.24,1.12

Table 6 - Water Absorption On Paver Block In 28 Days

Sl.no	Mix ratio in %	Wet weight (ww) in kg	Dry weight (wd) in kg	Weight in %
1	Nominal mix	7.16	7.05	1.35
2	10,20,30,40	7.35,7.42,7.35, 7.33	7.15,7.315,7.2,7.21	1.25,1.51,2.15,1.63

Abrasion Test

Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (IS:2386 part-IV). The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge. The abrasive wear of the specimen after 16 cycles of testing shall be calculated as the mean loss in specimen volume ΔV.

Table 7 - Abrasion Value in 28 Days

Sl.no	Mix ratio in %	Loss in volume (ΔV) in mm3	Permissible value in g/mm3
1	Nominal mix	770	1125
2	10	720	1125
3	20	751.67	1125
4	30	715	1125
5	40	758	1125

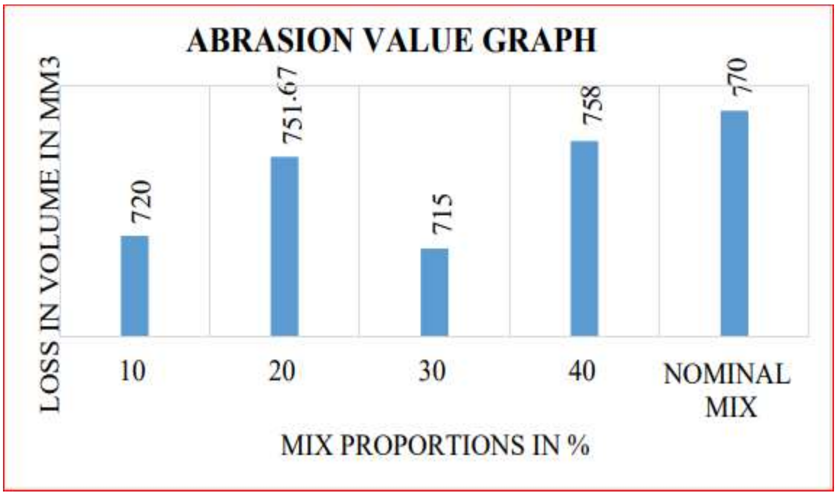

Fig 7: Abrasion value for coarse aggregates

Conclusion

Based on experimental observations, the following conclusions are drawn Higher compressive strength was achieved when 30% cement was replaced by equal proportion of water 68% and 2% polypropylene fiber. The abrasion resistance seems to be satisfactory. Water absorption is well below the permissible limit. Concrete paving blocks to be used in heavy traffic areas. The percentage of saving is highly beneficial for mass production of paving blocks.

References

1.Shackel.B ,"The Design of Interlocking Concrete Block Pavements for Road Traffic" Proceedings of 1st International conference on Concrete Blocks Paving, London, pp. 23-32, 1980

2.Dr. S.D. Sharma, " An Easy Approach For Road Constructioninterlocking Concrete Paver Blocks", New Delhi , NBMCW, September 2009

3.Baruah, P., and Talukdar, S. A comparative study of compressive, flexural, tensile and shear strength of concrete with fibers of different origins. Indian Concrete Journal, 81, 7:17-24(2007).

4.Sudhir S. Kapgate and S.R.Satone, "Effect of Quarry Dust as Partial Replacement of Sand in Concrete, Indian Streams Research Journal, Volume 3,Issue 5,June 2013, pp.2230-7850.

5.Dhanaraj Mohan Patil1, Dr. Keshav K. Sangle, "Experimental investigation of waste glass powder as partial replacement of cement concrete", International Journal of Advance Technology in Civil Engineering, Volume- 2, Issue-1, 2013, pp112-117.

6.Radhikesh P. Nanda , Amiya K.Das , Moharana N. C.,"Stone Crusher dust as a fine aggregate in concrete for paving blocks" International Journal Of Civil & Structural Engineering, Volume 1, No. 3, 2010.

7.Gudbjartoon,& Iversen.k.k ., "High–Quality Wear Resistant Paving Blocks In ICELAND", Seventh International Conference on Concrete Block Paving (PAVE AFRICA 2003).

8.J.Brozovsky,O.Matejka, "Application of Contemporary Non-Distructive Testing in Engineering",Eighth International Conference of the Solvenian Society for Non-Destructive Testing, September 1-3,2005.

9.Kent.R. Hansen, "Current and Future Use of Nonbituminous Components of Bituminous Paving Mixtures", Committee on Charactristics of Nonbituminous Components of Bituminous Paving Mixtures. Page 1-11 © MANTECH PUBLICATIONS 2017. All Rights Reserved Advances in Civil & Structural Engineering Volume 2 Issue 3

10.J.Brozovsky,O.Matejka, Eighth International Conferenceof the Solvenian Society for Non-Destructive Testing"Application of Contemporary Non-Distructive Testing in Engineering" September 1-3, 2005,protoroz,Slovenia,pp.91-97 .