

Insight on Structural Application of Permeable Concrete

M.Balaji¹, K.Nirmalkumar²

Post Graduate Student, Department of Civil Engineering, Kongu Engineering College, Erode, India¹.

Professor, Department of Civil Engineering, Kongu Engineering College, Erode, India².

ABSTRACT: The population and urbanization creates huge demand on water, food and shelter. The demand is further critical due to the human habitat practices. One of such human misleads are in the form of conversion of the cultivatable areas and soil exposed area into impermeable concrete shielding. This causes the water to run-off without percolating inside the ground and the rain water is simply transmitted in to sea. This makes the ground water in to critical status. The permeable concrete can be a possible solution for the deprived situation. The permeable concrete is widely used in parking lots, swimming pool decks, foot paths, street roads and rural roads. Further, the permeable can be possibly used in the applications including the purposes of artificially raining roofs for recreation, abutments and shoulders of roadways. In similar ways, the permeable concrete can be used for enhanced living standards of life. This Present state of art, elaborately reviews the various works developed across the frontiers and find a suitable aspect of the pervious concrete for the structural requirements and the environmental requirements. The insight clearly identifies the methods, technologies and applications developed on the permeable concrete and also discusses about the newer structural applications which are possibly adopted for the future developments for the permeable concrete applications.

KEYWORDS: Pervious concrete, Permeability, Porosity, nature Compressive strength.

I. INTRODUCTION

In general, concrete is the constituent of cement, fine aggregate, coarse aggregate and water. The knowledge about the usage of the constituent is very much necessary based on the purpose leads us to do several research works. Cement which is in the concrete is used to bind the other ingredients which are used in concrete. The coarse aggregate is used to impart mechanical strength, abrasion resistance and Impact strength in the concrete. The Fine aggregate is used as the filler materials and also to obstruct the flow of water in the concrete after the hardened state.

India is developing at rapid phase and it results in urbanization. The urbanization has significant effects in the climatic change, water table depletion, floods and its associated problems. The roads and parking area which we create by using normal concrete acts as a barrier for the rain water to penetrate in the ground. The structural requirements of such pavers and car parking are that the concrete should be able to bear the abrasion caused by moving vehicle. If we could develop a concrete that resist abrasion and impact load and also that allow water permeability then it will be a fine development or lead in the concrete/ construction industry. The above purpose has the solution in the name of 'Pervious Concrete'.

Structurally explaining, pervious concrete are the special concrete where it is devoid of fine aggregate (filler materials), the other materials like coarse aggregate, cement and water as binding agent are present. As the filler materials are absent there are several voids between the aggregates that will allow the storm/rain water to percolate.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

II. REVIEW OF LITERATURES

A. General

To create a permeable concrete structure with optimum permeability and compressive strength, the amount of water, amount of cement, type and size of aggregate, and compaction must all be considered. A multitude of experiments have been previously conducted throughout the past few decades by a variety of researchers comparing some or all of these elements.

B. Without Special Admixtures

Porous concrete tends to fail at the binder interface between the aggregate and its results in the low compressive strength (Uma Magesvari and VL Narasimha, 2013). 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 (Zhuge Y & Lian C, 2009). Porosity of the porous concrete varies from 10% to 30%, by volume, and it depends on the type of compaction and the type of the aggregates (Narayanan Neithalath et al, 2010). The ratio between the paste volume and inter-particle voids and correlated it to the splitting tensile strength and compressive strength of pervious concrete (Yahia and Kabagire, 2014). Developed a mix to optimize the splitting tensile strength of plain and fiber reinforced pervious concrete (Alaica et al, 2010). To utilize pervious concrete for heavier loading pavements and other relevant construction or transportation fields, demand for improved performance has increased significantly. The term of Sponge City was introduced in China (2012), which reflects the consideration of water absorption, reservation, permeability, purification and release. From that time onward, building more pervious concrete pavements as well as permeable asphalt pavements became more widely encouraged and practiced. However, it is very intriguing but challenging to overcome the performance bottlenecks of traditional pervious concrete pavement, especially on its low strength (28d's compressive strength hardly exceed to 35 MPa), high likelihood of clogging and inconvenient maintenance. The general methods to improve the strength of PCP are the optimization of aggregate quality (Yuwadee Zaetang et al, 2015) gradation (Mehmet Gesoglu et al, 2014) as well as the modification of binders by blending mineral and chemical admixtures (Betiglu Eshete Jimma et al, 2015) to strengthen the bond between the aggregates.

C. With Special Admixtures

I) Fly-ash

Pervious concrete mix for the maximum compressive strength and the desired permeability at 7 mm/s with varying percentages of water-to-binder (W/B), fly ash-to-binder (FA/B), nano-iron oxide-to-binder (NI/B) and water reducer to-binder (WR/B). The mass ratio of coarse aggregates in sizes of 4.7 to 9.5 mm to the binder was fixed at 4:1 (Linoshka Soto-Perez et al, 2016).

II) Titanium Dioxide

Partial replacement of cement by TiO₂ and they have laid pervious concrete trial mixes with the different size of aggregates with and without fine aggregates and tests for compression strength, water permeability, porosity and density. Trial mixes for their investigation was selected with optimum compression strength along with sufficient permeability. They come to conclusion that addition of TiO₂ replacement to cement increased compression strength and split tensile strength and had no adverse effect on permeability of pervious concrete (Ketan et al, 2013).

III) Electric arc furnace slag (EAFS) and alkali activated slag cement (AASC)

The important and notable property of the EAFS is the porosity of the material. The electric arc furnace slag (EAFS) has the porosity of 40.75%. From the basic of physics and engineering we are aware of that, the porous material is able to

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

absorb the sound and that porosity nature can be helpful to create sound insulating or sound absorbing material (Chang J.J et al, 2016)

IV) Recycled concrete block and Recycled concrete aggregate

The use of the recycled aggregate tends to lower the strength parameter value but this case was a slight different due to the fact that the aggregate created a good bonding with the recycled block aggregate and the cement paste (Yuwadee Zaetang et al, 2016). Regarding the Surface abrasion value the recycled concrete aggregate showed good result for all the replacement. In the split tensile test and in flexural test the influence of the recycled aggregate was considered to be really less and the strength parameter in this aspect is same. The properties of pervious concrete with recycled aggregate and geopolymer concrete. The recycled aggregate used in the project are crushed concrete member and crushed clay brick (Vanchai Sata et al, 2013).

V) Palm oil clinkers

The pervious concrete with palm oil clinkers as a replacement of coarse aggregate. The Palm oil aggregate is the waste material, the reason behind choosing the material was reuse of the waste, its light weight nature and the physical properties. The aggregate is of 10 mm size and the water cement ratio fixed is 0.3. The replacement was done with the varied percentages of 0% to 100% (Hussein Adebayo Ibrahim et al, 2016). The reducing of about 65% in the weight is observed for full replacement so it could be used in the areas where the dead load has to be very low.

VI) Polymer modified pervious concrete

The ingredient used in the concrete is cement, coarse aggregate, water and polymer. The aim was to develop the concrete to bear high stress and develop high strength to bear the load at base course of the infrastructure development. The behavior of the polymer modified pervious concrete specimen under flexural was studied. The aggregate used is of three sizes 27.5mm, 32.5 mm, and 37.5 mm (Juanlan Zhou et al, 2016).

VII) Bamboo bioretension basin

To remove the toxic chemicals that is mostly found in the storm water in the Urbanized cities or places. The study focused on the water quality and its enhancement with pervious concrete pavers with bamboo bioretension basin (BBB) and with *Dracaena sanderiana* (Vincent Hwang et al, 2017).

VIII) Carbon fiber composite

To impart mechanical strength into the pervious concrete element by providing additional reinforcing fibers into the concrete as the normal pervious concrete does not provide long term stability against the heavy loads at the areas like parking lot, as like in the case of normal Portland cement concrete. The carbon fiber composite material (CCFCM) was incorporated in the pervious concrete wet mixture. The conventional mix of regular pervious concrete is cast for the comparison of physical and mechanical properties of the element with the pervious concrete with CCFCM. The mix proportions were derived with varied CCFCM volume size and varied Particles size too (Milena Rangelov et al, 2016). The workability varied positively accordance with the addition of the CCFCM but the permeability varied negatively (Decreased) due to the addition of the CCFCM.

III. STRENGTH PRAMETERS

Compressive strength and Permeability test

One optimum pervious concrete (Opt A) targeting high volume FA utilization had a 28-day compressive strength of 22.8 MPa and a permeability of 5.6 mm/s with a mix design at 36% W/B, 35% FA/B, 6% NI/B and 1.2% WR/B. The

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

other (Opt B) targeting a less use of admixtures had a 28-day compressive strength and a permeability of 21.4 MPa and 7.6 mm/s, respectively, at 32% W/B, 10% FA/B, 0.5% NI/B and 0.8% WR/B. During 10 loads at a 2-h contact time each, the Opt A and Opt B achieved the average fecal coliform removals of 72.4% and 77.9% and phosphorus removals of 49.8% and 40.5%, respectively (Linoshka Soto-Perez et al, 2016). The 40% replacement of the recycled block aggregate showed the maximum of all the replacement, compressive strength was observed to be 17.0 MPa compared to the pervious concrete containing normal angular aggregate strength as 13.4 MPa (Ketan et al, 2013). The mix with EAFS and AASC with 90% void filled ratio (10 % vacuum) showed the higher compressive strength of 35 MPa and the permeability of 0.49cm/s with the additional property of sound absorption coefficient at 125 Hz was around 0.94. (Chang J.J et al, 2016). The 40% replacement of the recycled block aggregate showed the maximum of all the replacement, compressive strength was observed to be 17.0 MPa compared to the pervious concrete containing normal angular aggregate strength as 13.4 MPa (Yuwadee Zaetang et al, 2016). The recycled aggregate specimens show a considerable decrease in the strength yet that is a mild variation. The compressive strength of 10.3 MPa could be achieved. The voids ratio varies not with the variation in the aggregate but varies due the sodium hydroxide concentration (NaOH). The increase in the sodium hydroxide concentration (NaOH) results in the increase in the strength properties of the specimen but subsequent reduction in the voids ratio and permeability. The final conclusion is that for the optimum loading conditions the recycled aggregates geopolymer concrete could be used practically (Vanchai Sata et al, 2013). The surface abrasion value increased upto the value of 20% replacement, beyond that there observed considerable reduction in the abrasion value due to the use of the weak recycled aggregate (Yuwadee Zaetang et al, 2016). In the split tensile test and in flexural test the influence of the recycled aggregate was considered to be really less and the strength parameter in this aspect is same. Two pervious concrete pavement (PCP) having a permeability of 4.5 mm/s was cast (nPCP, tPCP) and it is compared with the impervious concrete pavers (just as screeding concrete) (Hussein Adebayo Ibrahim et al, 2016). The better/ good load distribution ensures the specimen to bear high stresses. The Polymer modified concrete (PPC) showed strength as $PPC 37.5 < PPC32.5 < PPC27.5$. For the polymer modified concrete the probabilistic distribution with the fatigue life and strength was formulated (Juanlan Zhou et al, 2016). Two pervious concrete pavement (PCP) having a permeability of 4.5 mm/s was cast (nPCP, tPCP) and it is compared with the impervious concrete pavers (just as screeding concrete). The results show that the pollutants removal especially in the nature of phosphate, fecal coliform was successful. It also shows good permeability rate when practically implemented and checked (Vincent Hwang et al, 2017). To improve the mechanical strength of the pervious concrete which accounted of 4% to 11% increase in the 28 days compression strength, 11 % to 46% increase in the tensile strength (This sudden increase is due to the fact that the fiber added resist the tension in the specimen), the corresponding modulus of elasticity increased to 6% to 45%. (Milena Rangelov et al, 2016).

IV. INFERENCE FROM LITERATURES

From all the above literatures, it is evident that mechanical properties and permeability are inversely proportional to each other. The choice of the pervious nature concrete has to be determined according to the place where the concrete going to be laid (like passage ways or car parking or traffic roads), the loads that the pervious concrete has to resist without any damage, the surface which are present underneath the pervious concrete and the most important one is rainfall intensity of the region. Based on all these criteria effective pavers have to be used.

V. CONCLUSIONS AND FUTURE WORK

The Plan of this project is to arrive at the relationship between the compressive strength of the permeable concrete and the permeability of water/storm water into the permeable concrete. For the mix to be more site oriented the admixtures or chemicals are planned to be avoided inside the pervious concrete and a standard mix of 1:3 is chosen. The variable parameter in this project is the coarse aggregate. The Natural coarse aggregate which are readily available is chosen to be

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

used. The coarse aggregate is of size 6mm, 10mm, 16mm, and 20mm. The strength and permeability is compared with constant water cement ratio, cement aggregate ratio with the variation at size of the aggregate. The optimum strength to permeability value will be summarized at the end of this project.

REFERENCES

- [1] A.L.Alaica, M.H. Dolatabadi, A. Susic, M. Shehata, "Optimizing the strength and permeability of pervious concrete", Annual Conference of the Transportation Association of Canada, 2010.
- [2] A.M.Amde, S. Rogge, "Development of high quality pervious concrete specifications for Maryland conditions", Journal of State Highway Administration, 2013.
- [3] Betiglu Eshete Jimma, Prasada Rao Rangaraju, "Chemical admixtures dose optimization in pervious concrete paste selection-A statistical approach", Journal of Construction and Building Materials, Vol.101, pp.1047– 1058, 2015.
- [4] Chang,J.J, W. Yeih, T.J. Chung, R. Huang, "Properties of pervious concrete made with electric arc furnace slag and alkali-activated slag cement", Journal of Construction and Building Materials, Vol. 109, pp. 34–40, 2016.
- [5] Hussein Adebayo Ibrahim, Hashim Abdul Razak,"Effect of palm oil clinker incorporation on properties of pervious concrete", Journal of Construction and Building Materials, Vol.115, pp.70–77, 2016.
- [6] Juanlan Zhou, Mulian Zheng, Qi Wang, Jiangang Yang, Tianfa Lin, "Flexural fatigue behavior of polymermodified pervious concrete with single sized aggregates", Journal of Construction and Building Materials, Vol.124, pp.897–905, 2016.
- [7] Linoshka Soto-Perez, Sangchul Hwang, "Mix design and pollution control potential of pervious concrete with non-compliant waste fly ash", Journal of Environmental Management, Vol.176, pp.112-118, 2016.
- [8] Milena Rangelov, Somayeh Nassiri, Liv Haselbach, Karl Englund,"Using carbon fiber composites for reinforcing pervious concrete", Journal of Construction and Building Materials, Vol.26, pp.875–885, 2016.
- [9] Uma Magesvari, V.L. Narasimha,"Development of environmental friendly material- Porous concrete", Singaporean Journal of Scientific Research,Vol.6, pp. 36-42, 2013.
- [10] Vanchai Sata, Ampol Wongs, Prinya Chindaprasit, "Properties of pervious geopolymer concrete using recycled aggregates ", Construction and Building Materials , Vol-42, pp.33–39, 2013.
- [11] Vincent Hwang, Amber Masters, Marleisa Arocho, Sangchul Hwang, "Fly ash-amended pervious concrete pavement followed by bamboo bioretention basin with *Dracaena sanderiana* for urban stormwater runoff control", Journal of Construction and Building Materials Vol.132, pp.161–169, 2017.
- [12] Yuwadee Zaetang, Vanchai Sata, Ampol Wongs, Prinya Chindaprasit, "Properties of pervious concrete containing recycled concrete block aggregate and recycled concrete aggregate", Journal of Construction and Building Materials,Vol.111, pp.15–21, 2016.
- [13] Zhuge.Y and Lian.C, "Development ofenvironmentally friendly and structural enhanced permeable concrete pavement material," Southern Engineering conference, 2009.