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REVIEW ON MAKING GREEN POROUS CONCRETE FOR RAIN WATER HARVESTING AND URBAN PAVEMENTS

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ABSTRACT

Pervious concrete is a special type of concrete, which consists of cement, coarse aggregates, water and if required and other cementations materials. As there are no fine aggregates used in the concrete matrix, the void content is more which allows the water to flow through its body. So the pervious concrete is also called as Permeable concrete. There is lot of research work is going in the field of pervious concrete. The compressive strength of pervious concrete is less when compared to the conventional concrete due to its porosity and voids. Hence, the usage of pervious concrete is limited even though it has lot of advantages. If the compressive strength of pervious concrete is increased, then it can be used for more number of applications. For now, the usage of pervious concrete is mostly limited to light traffic roads only. If the properties are improved, then it can also be used for medium and heavy traffic rigid pavements also. Along with that, the pervious concrete eliminates surface runoff of storm water, facilitates the ground water recharge and makes the effective usage of available land. The main aim of this project was to improve the compressive strength characteristics of pervious concrete. But it can be noted that with increase in compressive strength the void ratio decreases. Hence, the improvement of strength should not affect the porosity property because it is the property which serves its purpose.

Keywords: Pervious Concrete, Environmental problem, Flexural Strength, Ground Granulated Blast Furnace Slag, mix design, Partial replacement.

1. INTRODUCTION

1.1 GENERAL

Pervious concrete is a composite material comprising of coarse total, Portland concrete, and water. It is not quite the same as traditional cement. It contains no fine since the underlying blend, perceiving notwithstanding, that fines are presented amid the compaction procedure. The total more often than not comprises of a solitary size and is reinforced together at its purposes of contact by glue framed by the concrete and water. The outcome is a solid with a high level of interconnected voids that, when working accurately, license the fast permeation of water through the solid concrete. Pervious concrete is comprised of cement, coarse aggregate and water. As there is no fine aggregate, it can also be referred as no fines concrete (Anju Chandran 2014). In other expression, it can be named as gap graded concrete, porous concrete or permeable concrete. The pervious concrete consists of interconnected pores of size ranging from 2 mm to 8 mm with the void content varying from 15% to 25%. The compressive strength ranges from 2.8 MPa to 28 MPa and however strength of 2.8 MPa to 10 MPa are common. The penetration rate of pervious concrete pavement with the range of 81 lit/min/sq.m to 730 lit/min/ sq.m depends on the aggregate size and density of the mixture

2. REVIEW OF LITERATURE SURVEY

Kuruvila et al. (2023) This paper reviews the effect of Recycled Asphalt Pavement (RAP) addition with a detailed analysis of changes in the properties of pervious concrete. The properties such as compressive strength, flexural strength, elastic modulus, abrasion resistance, split tensile strength, water infiltration and clogging, and permeability of different mixes were analysed across various studies. The addition of RAP aggregate increases the infiltration performance of pervious concretes but there is also a significant decrease in mechanical behaviour. Although the concrete's flexural strength declined as RAP material was added, the ratio of maximum stress to flexural strength was lower than it would have been for a control mix without RAP. This suggests that utilising concrete that contains RAP might enhance the functionality of concrete pavements. In virtue of this, the tested mixtures satisfied the minimal specifications outlined in regulations for use as non-structural pervious concrete for standard bicycle lanes, sidewalks, or other uses requiring a lower level of strength. Furthermore, the inclusion of RAP aggregates can resolve the issues of its disposal space thus having a significant contribution to the environment.

Lichao Feng et al. (2023) Two pervious concrete projects (named as SR28 and SR431), with the same mixture design but different winter maintenance activities, were included in this research. Both projects are located in the Lake Tahoe area, Nevada, United States. Testing results indicated that the mechanical properties were significantly higher in SR28 cored samples than the ones in SR431. It was found that the SR28 pieces have fewer air voids, while the SR431 samples have higher water absorption and hydraulic conductivity, and the SR28 samples show fare better performance against

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repeated freezing and thawing cycles than the SR431 ones. scanning electron microscope pictures of crack surfaces in cores taken from SR28 indicate that the cement binder phase has been largely retained. However, in the coring sample of SR431, needle-shaped residues can be seen within the cement binder phase and an abundance of precipitated micro-sized crystalized particles can be observed. On a micrometer scale, the μCT examination reveals that the porosity of SR28 samples is significantly less than that of SR431. The analyzing results give a clue to demonstrate the durability of pervious concrete pavement can be attributed to the construction quality control, maintenance activity, or the weather and locations of the field sites.

Ester et al. (2023) To produce the pc, a mix proportion of 1:3 (cement: coarse aggregate) was used (taken from, contemplating a w/c ratio of 0,34 (fixed in all mixtures) to obtain a zero slump and a suitable consistency as recommended . The mix was carried out in a concrete mixer with a capacity of 450 liters and a total mixture time of five minutes. To evaluate PC performance in the laboratory and compare it with the specimens extracted from the experimental fields, cylindrical specimens (10 cm x 20 cm) were molded. As there is no standardization and/or consensus in the literature for compacting , two compaction procedures were used: steel bar with 12 blows per layer with three layers three aggregates from civil construction waste and one basalt aggregate (reference and 2,5 kg Proctor's hammer) with ten blows per layer with two layers . These procedures were chosen because they are the most common in the literature to keep the PC produced within the standard parameters (unit weight). All specimens produced were cured and immersed in water until the test age.

The mechanical performance of the evaluated PCS was more associated with the grain size than with the compaction used, where smaller sizes present smaller pores than a greater stress distribution, meaning greater resistance. Finally, the permeability loss found with the clogging simulation was associated with the type of sediment used (mix of soils). In this case, to guarantee greater hydraulic durability, it is recommended to use aggregates larger than 10 mm.

Shan Gao et al. (2023) presented a feasibility study of pervious concrete preparation with ceramsite as aggregate. First, pervious concrete specimens with different types of aggregates at various water–cement ratios were prepared, and the mechanical properties of pervious concrete specimens were evaluated based on the compressive strength test. Then, the permeability properties of the pervious concrete specimens with different types of aggregates at various water–cement ratios were characterized. Meanwhile, statistical analysis and regression fitting were conducted. Finally, the analysis of the freeze–thaw durability of pervious concrete specimens with ceramsite as aggregate according to indexes including quality loss rate and strength loss rate was performed. The results show that as the water–cement ratio increased, the compressive strength and permeability coefficient of pervious concrete generally decreased. Compressive strength and permeability coefficient showed a great correlation with the water–cement ratio; the R2 values of the models were around 0.94 and 0.9, showing good regression. Compressive strength was mainly provided by the strength of the aggregates, with high-strength clay ceramsite having the highest 28-day compressive strength value, followed by ordinary crushed-stone aggregates and lightweight ceramsite. Porosity was mainly influenced by the particle size and shape of the aggregates. Lightweight ceramsite had the highest permeability coefficient among different types of cement-bound aggregates, followed by high-strength clay ceramsite and ordinary crushed-stone aggregates. The quality and compressive strength of pervious concrete specimens decreased with the increase in freeze–thaw cycles; the quality loss was 1.52%, and the compressive strength loss rate was 6.84% after 25 freeze–thaw cycles. Quadratic polynomial regression analysis was used to quantify the relationship of durability and freeze–thaw cycles, with R2 of around 0.98. The results provide valuable insights into the potential applications and benefits of using ceramsite as an aggregate material in pervious concrete for more sustainable and durable infrastructure projects.

Yanchen et al. (2022) This research was intended to develop pervious concrete made from ground granulated blast furnace slag (GGBFS) to further decrease the environmental impact of the construction sector by reducing the content of ordinary Portland cement (OPC). The primary objective of the mix proportion was to maximize water permeability while meeting the required compressive strength. Two levels (60 and 100%) of OPC replacement by GGBFS were evaluated and compared to OPC-only concrete, and two target porosities (10 and 15%) were achieved by modifying the binder-to-aggregate ratio. CaO and CaCl2 were utilized as an activator and an accelerator, respectively, for the GGBFS only binder. Characteristics of the pervious concrete were determined with the compressive strength, porosity and water permeability test. Meanwhile, the efects of the rheological properties of binders on the water permeability and compressive strength of pervious concretes was evaluated. According to the results, the permeability of pervious concretes always exhibited a positive correlation with porosity, regardless of binder type. Although, the pervious concrete made with CaO-activated GGBFS has a lower compressive strength than the other two cases (60% GGBFS and only OPC), it still meets the minimum strength requirement. Based on the rheology studies of binder, it was found that, the adhesion force of the binder and the compressive strength of the pervious concrete decreases, as evaluated by rheology studies on binders. The CT scan revealed that when the adhesive force of the binder was weaker, the local porosity was higher (i.e., pore volume was larger) at the bottom of the specimen, which might be due to the limited consolidation and compaction of the binder between aggregate particles at the bottom due to its higher plastic viscosity.

Mulu et al. (2022) aimed to study the impact of clogging on pervious concrete mixes and explore a simple method to calculate permeability and clogging using the falling head method in a fabricated unit. materials used are cementitious materials and aggregates, along with superplasticizers. cementitious materials used are OPC Grade 53 cement and micro Ground Granulated Blast Furnace Slag (μGGBS). Two separate narrow aggregate gradations are used: 2.36–4.75 mm and 4.75–6.30 mm. The water-binder ratio is taken as 0.25, and the aggregate-binder ratio is taken as 3.33. The compressive strength, permeability, and clogging potential of pervious concrete are calculated. The average permeability for 2.36–4.75 mm and 4.75–6.3 mm is 4.78 mm/s and 8.16 m/s, respectively. The clogging materials used are clay and sand with a concentration of 5 g/l. The introduction of clay slurry reduces the permeability by 69.8% and 74.9%, respectively, and with sand, it decreases by 74.7% and 71.7%, respectively, in its cycle. The permeability response for such small aggregates is different from the standard coarse aggregates. The paper compares the study's compressive strength, porosity, and permeability with the existing literature. It concludes that the maximum clogging occurs when the clogging material is introduced to the specimen for the time. The degradation of permeability depends on the clogging particle's particulate size and the concrete matrix's pore size. The smaller aggregates in pervious concrete are not recommended in areas of high siltation.

Carlos et al. (2021) The work presented includes a review of the state of art of porous concrete. Its purpose is to evaluate the potential use of porous concrete in constructions where the level of surface runoff justifies it. A review of the literature presented here has been necessary where parameters of special consideration have been defined in the dosage of permeable mixtures.

The study includes the definition of porous concrete in terms of its main components: cement, coarse aggregate, water, additives, and sand, in little or no quantity, to cause the generation of an effective content of interconnected voids that allow rapid storm drainage. Given the reports of variables of high incidence in the mechanical behavior of porous concrete (resistance/permeability relationship), an investigation is warranted to synthesize the effects of the variables in the preparation of the mixture: water– cement ratio, granulometry, and morphology of the aggregates, compaction pressure, and curing techniques, among others. Likewise, the protocols for the characterization of porous concrete and additional aspects relevant to support the experimental phase are exposed, constituting a reference or anchor point for developing technologies associated with the manufacture of this material and the possibilities of its implementation in constructions.

T Ahmed and S Hoque (2020) provided an overview on pervious concrete mix designs and their effect on strength and permeability. Materials of pervious concrete include those used in conventional concrete, however eliminating the fine aggregate content. Different mix designs have been prepared and tested to understand the behavior of Pervious Concrete and recommend an ideal mix. The findings from the Compressive Strength Test and Standard Test Method for Infiltration Rate of in place Pervious Concrete, investigate the gradually varying properties of pervious concrete with changes in the mix which are reported and discussed. Results indicate that a fine balance between compressive strength and permeability is not possible however pervious concrete pavements can be an acceptable alternative when used in low volume and low impact areas.

3. CONCLUSION

Pervious concrete mix made with 12.5 mm larger size aggregate exhibited higher coefficient of permeability and porosity than smaller size aggregate. It is worth noting that larger size aggregate creates more number of interconnected voids between the aggregate particles and those voids cannot be entirely occupied by the binder paste. This fact allows more amount of water to penetrate. • For GGBFS mix it ranges from 3.21 MPa to 1.83 MPa with increasing aggregate to cement ratio from 3:1 to 6:1. And for FA mix it ranges from 3.11 MPa to 1.35 MPa with increasing aggregate to cement ratio from 3:1 to 6:1 The variation in flexural strength between small S1 and medium size S2 aggregate mix is up to 7.75 % and between S1 and bigger size S3 aggregate mix is up to 10.91%. Increase in flexural strength of different mix was observed by decreasing aggregate to cement ratio from 3:1 to 6:1.

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