DESIGN AND CONSTRUCTION OF PERMEABLE CONCRETE USING DEMOLISHED AGGREGATES: A REVIEW STUDY

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Abstract: This study investigates the reuse of demolished aggregate in the design of permeable concrete. By resolving environmental issues related to the disposal of building waste and improving the performance of permeable concrete, the goal is to support sustainable construction practices. It reduces runoff from the site and permits groundwater recharge by enabling water from precipitation and other sources to pass through directly. In place of natural aggregates (NA), recycled aggregates (RA) from construction and demolition waste (CDW) were examined during the production process to create new environmentally friendly concrete. The workability, water absorption, dry density, compressive strength, tensile strength, and flexural strength of HPC produced with RA as documented in other studies are summarized in this paper. In pervious concrete without fine aggregate, the addition of recycled coarse aggregate decreased the tensile and compressive strengths by 57% and 36%, respectively. By substituting 11.7% of the recycled coarse aggregate with natural sand and incorporating date palm leaf fibers at a volumetric content of 0.64%, the concrete's compressive and tensile strengths were found to be 16.2% and 3.2% higher, respectively, than those of the control mix.

***Keywords*- RA- recycled aggregates, compressive strengths, tensile strength, HPC – high-performance computing, construction and demolition waste (CDW)**

1. INTRODUCTION

Permeable concrete (PC), sometimes referred to as porous or pervious concrete, is a kind of structural concrete with a high void content (between 15 and 35%) that permits gasses and liquids to travel through it, preventing surface ponding. Fibers can be added to PC to improve its mechanical qualities, which are slightly harmed by its high permeability. Parking lots, sidewalks, and road pavements are the best places to use PCs. Because of these uses, the material is environmentally beneficial and sustainable since it speeds up groundwater regeneration and reduces stormwater runoff. PCs typically have very little slump and may be made with moderately sized coarse aggregate (9.5–12.5 mm) and very little fine aggregate. The water-to-cement ratios used to create PCs are typically between 0.30 and 0.40. With a typical mass density of 1400–2000 kg/m3, PC has a substantially lower mass density than regular concrete.

While using coarse recycled concrete aggregate (RCA) from demolition waste in PC mixes reduces the amount of waste that is disposed of in landfills and preserves natural resources, it can negatively impact the density and permeability of the concrete as well as its strength. Specifically, whether the recycled aggregate has a mild effect on the quality of concrete while it's new or hardened depends largely on the source and quality of the recycled aggregate. Increasing the permeability of pervious concrete while maintaining a relatively high compressive strength is the main design goal. Given that the kind and size of coarse aggregate, the water-cement ratio, and the cement-to-aggregate ratio all affect the compressive strength of permeable concrete.

In many countries, waste materials are dumped illegally or sent to landfills, and a large amount of demolition waste is produced every year. Demolition disposal is a major environmental and social issue. The issue of trash dumps can be reduced by recycling these wastes. Concrete building parts and components that are dismantled and rebuilt make up recycled concrete aggregates.

The recycling and re-use of non-degradable construction wastes as recycled concrete aggregate is trending due to its potential to reduce landfill volume and pollution. The use of recycled aggregate helps in reducing the consumption of natural aggregates.

An eco-friendly option for new high-performance concrete (HPC) could be to use recycled aggregate (RA). A high-range water reducer, fine aggregate, water, Portland cement, and other admixtures are the ingredients of HPC, a cementitious composite material. Modern concrete such as high-performance concrete (HPC) and self-consolidating concrete (SCC) have previously been developed with the use of mineral admixtures including fly ash, granulated slag from blast grounds, silica fume, metakaolin, rose husk ash, and other newly discovered ones. The authors made an effort to confirm that the recently created HPC with RA. Researchers have researched HPC in great detail, and they have theorized that RA could enhance the mechanical qualities of the cement matrix. Furthermore, RA has already been used as a coarse aggregate in laboratory tests.

2. PROPERTIES OF PERMEABLE CONCRETE

2.1 Constituents

The three basic ingredients of pervious concrete are water, coarse particles, and cement. Admixtures are occasionally added as well. The coarse aggregates should be between 10 and 20 mm in size. To boost strength, fine aggregates might be omitted entirely or added in small amounts. Concrete typically has an aggregate-to-cement ratio of 6:1 to 10:1. Sharp-edged aggregates should also be avoided since loading them could cause local crushing.

2.2 Density

The aggregate grade of pervious concrete is the primary determinant of its density. The density of concrete with one-size particles is approximately ten times lower than that of concrete with well-graded aggregates when the aggregates have the same specific gravity. It is also possible to make concrete with a density of roughly 640 kg/m3 by employing low-weight particles. On the other hand, concrete with normal-weight aggregate has a density of between 1600 and 2000 kg/m3.

2.3 Flow Rate

The components used in the mixing and pouring processes of concrete determine its permeability or flow rate. Water flows through pervious concrete at a rate of typically 288 to 770 inches per hour.

2.4 Void ratio

The void ratio rises as a result of the removal of fine particles. About 15–25% of previous concrete has it. Entrapped air can also result from large spaces. The Rapid Air System can be used to measure the amount of trapped air. In this test, a slice of the concrete is examined under a microscope after being tinted black.

2.5 Compaction

To improve the compressive strength of concrete, compaction is necessary. Even though strength is increased, over-compaction should be avoided as it may decrease permeability. Thus, vibration is applied to permeable concrete for a relatively brief period.

2.6 Compressive Strength

Compared to regular concrete, this concrete has a relatively low compressive strength. It is adequate, nevertheless, for use in applications and buildings up to a particular number of stories. Pervious concrete has a compressive strength ranging from 14 N/mm^2 to 140 N/mm^2. This kind of concrete is typically unreinforced. However, if necessary, a 3mm thick layer of cement paste is applied to the reinforcement. This not only stops corrosion but also strengthens the relationship. Concreting is the main method used to apply the coating.

2.7 Flexural Strength

The flexural strength of the permeable concrete is between 10 N/mm2 to 38 N/mm^2.

3. MATERIALS

3.1 Cement

As in traditional concreting, portland cement (ASTM C 150, C 1157) and blended cement (ASTM C 595, C 1157) may be used in pervious concrete. Furthermore, fly ash, pozzolans (ASTM C 618), and ground-granulated blast furnace slag (ASTM C 989) are examples of supplemental cementitious materials (SCMs) that can be utilized.

3.2 Aggregates (Coarse aggregate)

Pervious concrete has a restricted amount of fine aggregate and a narrow gradation of coarse aggregate. An important quality is a narrow grading. A rougher surface is produced by larger particles. Pervious concrete has recently been utilized mostly for pedestrian walkways, parking lots, and low-traffic pavements. For aesthetic purposes, the lowest possible aggregate is chosen in these applications. For parking lot applications, coarse

aggregate size 89 (9.5 mm or ⅜ in. top size) has been widely employed. Similar to regular concrete, pervious concrete demands that the aggregates be almost surface-dry and saturated, or that the moisture content of the aggregates be closely monitored to account for any free moisture present. It should be mentioned that water management is crucial for pervious concrete mixtures. Too-dry aggregates absorbing water from the mixture might result in dry mixtures that are difficult to put or compact.

3.3 Recycled Coarse Aggregates

Concrete that has been removed when old buildings and roadways are demolished is frequently seen as useless and disposed of as demolition debris. Recycled coarse aggregate (RCA) is produced by gathering and fragmenting leftover concrete. RCA is the original concrete's coarse aggregate, which is left over after the mortar and recycled rock are removed.

3.4 Water

When chemical admixtures are properly added, water-to-cement ratios of 0.27 to 0.36 are frequently employed; values as high as 0.40 have also been used with success. Since the total paste content of pervious concrete is lower than that of conventional concrete due to the voids between the aggregates, the relationship between strength and the water-to-cement ratio is not evident. Consequently, increasing the paste's strength might not always result in a stronger paste overall. Water content needs to be strictly regulated. It has been said that the combination has a sheen when the water concentration is right, but it doesn't flow off the aggregate. When the paste fills in the gaps between the particles, a handful of pervious concrete shaped into a ball won't crumble or lose its void structure.

3.5 Admixture

As with ordinary concrete, chemical admixtures are utilized to give pervious concrete specific qualities. Retarders or hydration-stabilizing admixtures are frequently employed with pervious concrete because of its quick setting time. Admixtures that promote air movement can lessen the effects of freeze-thaw on pervious concrete.

4. LITERATURE REVIEW

- A study conducted by Babu Ram Bhandari, Sagar Chhetric, and the Department of Civil and Geomatics Engineering at the Institute of Engineering, Tribhuvan University of Nepal, on the physical properties of smart shale (pervious concrete). A uniform mixture of cement, fine aggregate, and coarse aggregate combined with water is called concrete. It is a substance that resembles hardened stone and is widely employed in modern construction. A unique kind of concrete called pervious concrete (PC) is made with either very little or no fine aggregate.
- Pervious Recycled Aggregate Concrete Mix Design (Received August 29, 2012, Accepted November 6, 2012, Published online November 27, 2012) Rasiah Sriravindrarajah1),, Neo Derek Huai Wang2), and Lai Jian Wen Ervin2) With its high water permeability and customized properties, pervious concrete facilitates easy water flow through the massive pore structure that already exists. The

compressive strength at 7 and 28 days, void content, and water permeability under falling head were used to assess the pervious concrete's qualities.

- Properties, Applications, and Mix Design of Pervious Concrete Ammar Yahiaca School of Natural and Building Environment, Mohammed Sonebia*, Mohamed Bassuonib, Queen's University Belfast, BT9 5AG, UK University of Manitoba, Department of Civil Engineering, R3T 5V6, Winnipeg, Canada University of Sherbrooke, Department of Civil Engineering, Sherbrooke, Quebec, Canada Numerous human and industrial activities are to blame for the current changes in the climate. Particularly, it's probable that more precipitation is occurring in numerous geographic areas due to the consequences of urbanization and the growing threat of global warming. Portland cement pervious concrete (PCPC) has been contributing significantly for a long time. Utilizing PCPC to lessen stormwater issues has several advantages.
- A study on the performance of pervious concrete built using regular and recycled aggregate was carried out by P.C. Baal Murugan et al. in 2019. A 1:3 concrete mix ratio and a 0.35 water-to-cement ratio are used. In this inquiry, construction and pre-used specimen wastes are used. Tests for slump and compaction factor are conducted for varying ratios of cement to water:0.35,0.4, and 0.5. It is discovered that pervious concrete created with recycled aggregate has lower compressive and split tensile strengths than pervious concrete made with regular aggregate. In recycled coarse aggregate mixes, inadequate aggregate-cement paste bonding may be the cause of this strength loss. Cement paste is used less when glued mortar is present on recycled coarse aggregate because it absorbs mixing water.
- Soon Poh Yap et al. (2018) studied the permeability and mechanical characteristics of pervious concrete composed of RCA and blended typical granite aggregates. The following RCA replacement levels were used: 20%, 40%, 60%, 80%, and 100%. The RCA mixes produced inferior mechanical qualities, according to the experimental data. The mix's compressive strengths for RCA 20 with 20% RCA replacement and that NA mix were extremely similar. However, when the RCA replacement was greater than20%, the RCA mix's compressive strengths decreased as the RCA content increased. A possible cause of this strength decrease in RCA mixtures could be inadequate aggregate-cement paste bonding. Cement paste is used less when adhering mortar is present on RCA because it absorbs mixing water. Eventually, this leads to inadequate cement bonding.
- The purpose of this part is to examine the keywords of a large number of publications produced between 2018 and 2023 from the scientific databases of Science Direct and Google Scholar. We will be able to determine the relationships between each study topic, research possibilities, and new research directions by looking over and analyzing these terms. We can also decide which specific subjects study will focus on, which can be quite helpful when starting.
- M. Anjaneyulu naik1, a. Ramakrishnaiah, PhD student, Department of Civil (Structural Engineering and Construction Management), Golden Valley Integrated Campus, Kaanapali, Chittoor, Andhra Pradesh, India, conducted an experimental study on the use of demolished concrete waste for new construction. Associate professor at Golden Valley Integrated Campus's civil engineering department at Kaanapali, Chittoor, Andhra Pradesh.

5. OBJECTIVES OF STUDY

- When porous concrete is substituted for standard concrete, it reduces the overall volume and velocity of runoff that leaves a site, encourages runoff to seep into the earth, and lessens the quantity of pollutants that are delivered to storm drains or waterways.
- To reduce the size and number of storm sewers.
- To prevent the pollution of groundwater by aiding in the filtration of water before infiltration.
- To recharge the groundwater.
- To reduce the cost of construction.

6. PROBLEM STATEMENT

- One proposed remedy for reducing stormwater runoff is permeable concrete.
- Effectively connected macroporosity at a high level in pervious concrete.
- Reduces drainage from the pavement. Pervious concrete also offers additional benefits.
- For instance, permeable concrete is quieter to drive on than ordinary pavement.
- Porous pavement absorbs sound Pervious concrete can remove stormwater more quickly than traditional concrete which results in improved skid resistance.

7. METHODOLOGY

At four distinct replacement levels—10, 20, 30, and 40%—recycled concrete aggregate (RCA) will take the place of natural coarse aggregate (NCA). The water-to-cement ratios will also be changed to 0.25 and 0.30. The following characteristics decrease: water permeability, splitting tensile strength, abrasion resistance, effective void content, and cubic compressive strength. The results show that as the w/c ratio or replacement ratio of RCA increases, the void content and permeability coefficient of pervious concrete increase to some amount, but the cubic compressive strength, splitting tensile strength, and abrasion resistance decrease. Strong correlations exist between the relevant performance metrics, according to an analysis of the data. Portland cement, water, little to no fine particles, and coarse aggregate in a single size or non-continuous grading. Green and extremely porous is pervious concrete. Examining the impact of coarse aggregate, cement.

In this study, instead of using crushed stone to create permeable paving blocks, coarse aggregate made from leftover brick, tile, and concrete debris is used. The building waste is first sorted, crushed, and sifted in order to be used as recycled aggregate later on. Researchers have made an effort to investigate the mechanical and physical properties of recycled pervious concrete. Using RCA after learning that the damage pathway of pervious concrete is always along the transition zone between the particles.

8. CONCLUSION

Permeable concrete is among the most promising sustainable materials. Its purpose is to have more interconnected spaces so that water can permeate the material. via making use of recycled aggregate. It was shown that the permeability coefficient rose when recycled materials were included in place of natural aggregates. The strength qualities are reduced when recycled aggregate is used. This might be as a result of mortar that has been bonded to the recycled coarse aggregate, which absorbs mixing water and requires less cement paste. Consequently, there is a poor bond between the coarse aggregates and the cement paste. The addition of more cementitious materials improves the metrics used to gauge the strength of pervious concrete. The use of recycled aggregates in the manufacturing of concrete paving blocks was examined. Therefore, it is important to keep in mind the compositional diversity, reduced density, and increased water absorption of Concrete demolition waste (CDW).

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