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Enhancing Pervious Concrete Pavement

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Abstract- When it comes to transportation, road infrastructure is essential for promoting connectivity and mobility. However, because of things like subgrade soil conditions, building materials, and construction techniques, the strength and endurance of traditional pavements have come under more and more criticism. A sustainable solution to these problems that can manage stormwater and ease the problems associated with standing water on road surfaces is the idea of pervious concrete pavement, or PCP. The goal of this proposed project is to add admixtures to PCP to increase its strength and durability. To maximize pavement performance, critical components of Portland cement pavement (PCP), such as cement, coarse aggregate, water, and additives like fly ash and ground granulated blast furnace slag (GGBS), are carefully analyzed.

Keywords- ervious concrete pavement, Ground Granulated Blast Furnace Slag (GGBS), Permeability, Admixtures.

I. INTRODUCTION

Roads carry over 60% of the country's trade and almost 85% of its passenger traffic, making them India's principal mode of transportation. But in addition to being essential for promoting economic growth and connectivity, roads also create a serious issue when it comes to urbanization and infrastructure development. The natural mechanisms of the water cycle have been significantly altered by human development and construction techniques. Naturally falling to the earth, rainwater is absorbed by plants and soil, where it stores, filters, evaporates, and then returns to the cycle.

When the earth's natural filter is obstructed, there is an increased chance of excessive runoff. This may lead to a number of problems, such as bank erosion, floods downstream, and the possibility of contaminants getting into sources of drinkable water. Many academics contend that Pervious Concrete Pavement (PCP) offers a workable solution to these problems. In the 1800s, load-bearing walls and pavement surfaces were the first applications for porous concrete in Europe. The first instance of porous concrete was used in the construction of two residential dwellings and a sea groin in the United Kingdom in 1852.

Research indicates that utilizing smaller aggregates in pervious concrete can improve its strength; nevertheless, this approach may lead to a drop in compressive strength and an increase in void ratio. Finally, adding Ground Granulated Blast Furnace Slag (GGBS) to concrete has been shown to improve pumpability and compaction of the mix, decrease concrete voids, and increase tensile strength and lifespan.The transportation infrastructure's sustainability profile is further improved by the incorporation of GGBS into PCP. GGBS produces more cementitious chemicals in the concrete matrix through its pozzolanic reaction. The aim of this study work is to investigate the planning and implementation of Pervious Concrete Pavement (PCP), with a special focus on the© 2024 Gugulothu Nagesh. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. addition of Ground Granulated Blast Furnace Slag (GGBS).

Objectives

The goals are to direct research efforts toward comprehending how the GGBS content and water-cement ratio affect the permeability and compressive strength of pervious concrete pavement.

- To improve strength and permeability, determine the ideal mix proportions for pervious concrete pavement (PCP) using ground-granulated blast furnace slag (GGBS).
- To solve the present issues with PCP, make a connection between the design of the pavement mix and the application of GGBS.
- Improve PCP's drainage properties to manage surface runoff and reduce the need for separate stormwater ponds and storm drains.
- Reduce the amount of contaminants that enter rivers, ponds, and streams by making use of pervious concrete's inherent stormwater purification capabilities.

II. METHODOLOGY

The examination of pervious concrete pavement was conducted using a rigorous approach that began with material identification. This required a meticulous process to ensure that components were chosen based on predetermined criteria. Thorough material testing was then carried out to evaluate the potency and suitability of every component in the mixture.

The complex working of the pervious concrete pavement mechanism is clearly depicted in fig 1.

1. Selection of Raw Materials

For pervious concrete pavement (PCP) to be practical and long-lasting, the materials chosen are essential.

These materials directly impact the pavement's ability to manage storm water runoff, ensuring effective drainage and reducing the risk of flooding

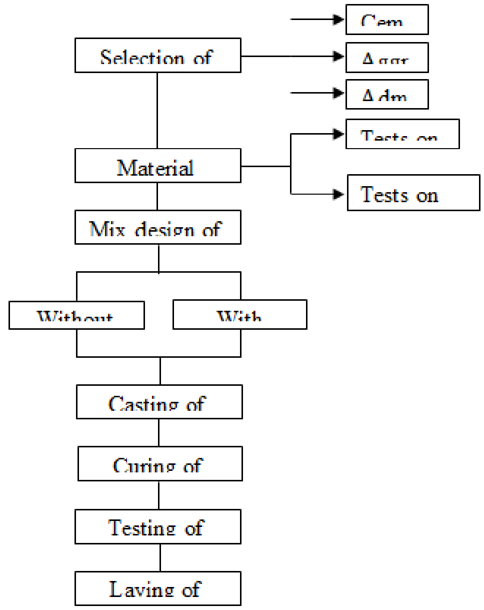

Fig 1: Process of Implementation of PCP

Cement

Portland Pozzolana Cement (PPC) contains pozzolanic elements such as fly ash or silica fume, which improves its characteristics for a variety of applications, including pervious concrete pavements. Compressive strength, permeability, durability, and workability are all important features for this type of pavement.

Aggregates

Most concrete mixtures contain aggregates, including crushed stone or gravel, which are necessary to create a porous structure in pervious concrete pavement (PCP) that permits drainage and water penetration. For PCP, the selection of aggregates is crucial, especially those with diameters of 10 and 20 mm. The smaller 10 mm aggregates fill in spaces, ensuring stability and compatibility, while the larger 20mm aggregates define wider voids and provide structural support.

Water Content

The water content plays a crucial role in maintaining the aggregates bond. When the water-to-cement ratio is higher than ideal, the aggregate and cement paste will not form a suitable bond, causing the cement paste to flow off the particles. The cement paste will not be sufficiently sticky to attach the aggregate if the water-cement ratio is below optimal. The design mixes need to take the aggregate's rate of absorption into account, as it also affects the water content.

Admixture

A byproduct of the iron and steel industries, ground granulated blast furnace slag (GGBS) is frequently utilized as an additional cementitious ingredient in pervious concrete pavement (PCP). By aiding in the hydration process, GGBS increases PCP's strength and produces denser, more durable concrete. Because of the fine particles it contains, aggregate spaces are filled, creating a more cohesive and compact structure that strengthens the pavement as a whole.

Table 1: Properties of GGBS

Property	Value
Bulk density (kg/m3)	1200
Specific gravity	2.9

2. Material Testing

(a)Portland Pozzolana Cement (b)20mm coarse aggregates (c)10mm coarse aggregates (d) GGBS

Fig 2 (a,b,c,d): Selection of Raw materials

strength of the aggregate, which is essential for withstanding high traffic volumes.

- Aggregate porosity and permeability are determined by specific gravity and water absorption tests, which are crucial for effective water drainage through the pavement surface.
- Appropriate bonding and hydration of the concrete mix are guaranteed by cement consistency and setting time tests.
- Porosity and permeability are impacted by compactness, which is indicated by bulk density testing.

By analyzing these factors, PCP system designs are enhanced to effectively control runoff from storms, withstand high traffic volumes, and guarantee long-term resilience. This has a major impact on the creation of sustainable infrastructure.

3. Mix Design of Cubes

Standardized mix designs and codebooks are not present in pervious concrete pavements, making it difficult to achieve the best possible blend while building. Rather, they rely on a synthesis of earlier research and experimental studies carried out by different industrial specialists.

Table 2: Typical ranges of the materials used in cubes

S. No	Materials	Proportions (kg/m)
1.	Coarse Aggregate (CA)	270 to 415
2.	Fine Aggregate: Coarse Aggregate	0 to 1:1
3.	Water/Cement(W/C) ratio (by mass)	0.26 to 0.40
4.	Aggregate/Cement (by mass)	4 to 4.5:1
5.	Cementitious Material (Cement + GGBS)	1190 to 148

This collection of collective work has yielded ranges of diverse proportions for the materials used in PCP building. The reference materials we have evaluated corroborate the veracity of these claims.

Mix Design of Cubes without GGBS

Using a trial-and-error method, we have determined the following proportions for the mix design of cubes (GGBS excluded) based on the previously specified ranges of materials used in pervious concrete pavement construction.

Volume of the cube = 0.0034 m3 For 1 m3

Table 3: Mix proportions for 1 m3.

Materials	Quantities
Cement	330 kg/m3
Coarse aggregates (combination of 20mm and 10mm)	1650 kg/m3
Water cement ratio	0.3, 0.35, 0.4

For 1 cube,

Table 4: Mix proportions for one cube

Materials	Quantities
Cement	1.1220 kgs
Coarse Aggregates (combination of 20mm and 10mm)	5.610 kgs
Water cement ratio	0.3,0.35, 0.4

Therefore, for one cube including 5% excess as wastage,

Cement content (including wastage) = 1.1781 kgs
Coarse aggregates (including wastage) = 5.8905 kgs

Table 5: Percentage of 10 mm and 20 mm coarse aggregate.

S. No	10mm(Coarse Aggregate)	20mm(Coarse Aggregate)
1.	3.5343 kgs (60%)	2.3562kgs (40%)
2.	3.8285kgs (65%)	2.0617kgs (35%)
3.	4.1234kgs (70%)	1.7672kgs (30%)

Water content (including wastage):

Table 6: Water content (including wastage)

S. No	Water Cement Ratio	Water content
1.	0.3	384.3 ml
2.	0.35	448.3 ml
3.	0.4	512.4 ml

Mix Design of Cubes with the Inclusion of GGBS The mix proportion having the highest permeability and compressive strength among all of these proportions is thought to be the ideal mix proportion. However, because PCP has a lower compressive strength than ordinary pavements, GGBS (an additive) is added in different percentages (10, 20, 30, and 50%) to achieve the ideal mix proportions of PCP at the end.

From the above mix proportions, high compressive strength and high permeability is obtained for the following mix proportion.

Table 7: Optimal mix proportion of cubes casted without GGBS

1.	Cement content	1.1220 kgs
2.	Coarse aggregates	5.610 kgs
	a) 65% of 10mm	3.6465 kgs
	b) 35% of 20mm	1.9635 kgs
3.	Water Cement Ratio	0.4
4.	Water Content	448.8 ml

GGBS is used in the varying percentages of 10%, 20%, 30% and 50%,

Table 8: Varying percentages of GGBS

S. No	GGBS (%)	GGBS (kgs)	Cement (kgs)
1.	10%	0.1122	1.0098
2.	20%	0.2244	0.8976
3.	30%	0.3366	0.7854
4.	50%	0.5610	0.5610

For one cube including 14% excess as wastage,

Table 9: Mix proportions for one cube including 14% excess as wastage.

1.	Coarse aggregates			
	i) 10 mm Aggregate		4.157 kgs	
	ii) 20 mm Aggregate		2.238 kgs	
2.	Water Content		515 ml	
3.	Percentage of GGBS		GGBS (kgs)	Cement (kgs)
	i)	10%	0.1279	1.1512
	ii)	20%	0.2558	1.0200
	iii)	30%	0.3837	0.8953
	iv)	50%	0.6395	0.6395

4. Casting of Cubes

Cubes are formed into molds to begin the process of figuring out the ideal mix proportion for constructing pavement. Usually measuring 15 cm x 15 cm x 15 cm, these cubes are put through a series of tests which provide essential data for evaluating elements critical to pavement performance, like strength, durability, and permeability.

The appropriate mix proportion that satisfies the specifications for the pavement can be found by analyzing the test data. To ensure consistency and accuracy in the specimens, great care is taken during the casting process. The information gained from testing these cubes is essential for adjusting the mix design and creating long-lasting, high-performing pavement constructions.

5. Curing of Cubes

Cube curing is essential to the strength and longevity of concrete. Cubes are fully hydrated in a controlled atmosphere after casting, which encourages ideal structure creation and minimizes cracking. Proper curing, which usually takes 28 days, improves concrete's endurance to environmental variables and ensures long-term performance.

6. Testing of Cubes

Testing the cubes permeability and compressive strength after curing is necessary to determine the ideal mix proportion for pervious concrete pavement (PCP). By evaluating the blocks' resistance to water penetration and maximum load capacity, these tests provide valuable information into the performance and durability of the blocks.

III. CONCLUSION

In conclusion, GGBS (ground granulated blast furnace slag) added to pervious concrete pavements (PCP) improves permeability rates and compression strength, making PCP an excellent option for strong and sustainable pavement solutions. The ideal mix proportions have been determined by rigorous research and experimentation, utilizing the special qualities of GGBS to provide higher compressive strength while preserving acceptable permeability rates. In addition to guaranteeing the durability and endurance of pavement constructions, this combination of increased strength and permeability also makes it easier to regulate storm water runoff and restore groundwater, all of which support environmental sustainability. Thus, GGBS-enabled pervious concrete pavements represent a significant innovation in pavement engineering, providing unmatched environmental advantages and performance for a broad spectrum of uses.

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