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ALKALI ACTIVATED SLAG PERVIOUS CONCRETE FOR HIGHWAY APPLICATIONS

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Abstract: *Pervious concrete can potentially provide various environmental benefits as a storm water best management practice and is usually designed for low volume applications. It has an open void structure which allows water to infiltrate and percolate to the ground, without altering the natural hydrologic cycle. In this way, several problems related to the storm water management can be mitigated. With regard to pervious concrete pavement performance, permeability is the key functional design property. However, compressive strength, flexural strength and clogging resistance are also important properties. With regard to pervious concrete pavement performance, permeability is the key functional design property. However, compressive strength, flexural strength and clogging resistance are also important properties. Alkali activated slag based binders are being researched as definite alternatives to conventional OPC-based concrete mixes, leading to significant reduction in the use of OPC in the construction industry. Along with reduced emission of CO2 and consumption of energy in their manufacture, the alkali activated binders are also shown to exhibit superior mechanical properties than OPC binders. However, technical and economic viabilities of alkali activated slag binder systems is still a topic of recent research endeavors.*

Key Words: Alkali activated slag pervious concrete, Alkali activated slag concrete mixes; Mechanical properties, Pervious Concrete, permeability coefficient, porous concrete, Flexural performance.

1. INTRODUCTION

The cement industry of India is expected to add 30-40 million tonnes per annum (MTPA) of capacity in the next few years. The industry has a current capacity of 324 MTPA. To produce this huge quantity of cement, large quantities of naturally occurring materials like limestone, chalk, and clay are to be mined and processed every year. With the dominant use of carbon-intensive fuels like coal in clinker making, the increasing cost of fuels and raw materials in the recent years has been reflected in corresponding higher cost of cement. Thus, it is essential to find methods to increase the durability of traditional concrete by using appropriate replacements for concrete constituents; Eg. Ordinary Portland Cement (OPC) and the aggregates. Considering the crucial importance of infrastructure development for the Indian Economy, it is now believed that using more durable and less energy intensive construction materials is inevitable for the construction industry.

One possible alternative in the direction is the use of alkali activated binders using industrial by-products containing silicate materials. The most common industrial by-products used as binder materials are fly ash (FA) and ground granulated blast furnace slag (GGBFS). GGBFS has been widely used as a cement replacement material due to its latent hydraulic properties, while it cannot react directly with water, it reacts with an alkali activator, like Ca(OH)2. Fly ash is a pozzolanic material which reacts with Ca(OH)2 released during the hydration of Portland cement to form calcium silicate hydrate (C-S-H).Thus ,when used with Portland cement, GGBS or fly ash will not start to react until some Portland cement hydration has taken place. This delay causes the blended cements to develop strength relatively slowly at early ages, as compared to the normal OPC. [1, Bakharev].

Environmental issues, such as waterlogging, water pollution, atrocious climate and urban hot island phenomena, occur frequently and globally. The presence of impermeable pavement in highway and urban roads, which cuts off the moisture and heat exchange between earth and air, is one main reason for these environmental issues. Meanwhile, reported traffic accidents cause more than one million fatalities and nearly five hundred billion dollars' loss globally every year. The lack of water permeability in traditional pavement, which radically weakens the pavement's skid resistance under rain or snow, is responsible for traffic accidents. Unlike impermeable concrete pavement, pervious concrete pavement (PCP) provides better rain-drainage and snow-melting to prevent drivers' safety issues such as slippery, glare, mist and flood, under severe weather conditions. Additionally, the porous structure in pervious pavement can preliminarily purify the rain and serve as tunnels for atmosphere-pavement heat and moisture exchange, leading to positive environmental effects (maintaining water balance, relieving hot island phenomena and the protection of biodiversity, etc.) [1–4].

1.1 Alkaline Activator

The alkaline activator used in this study was a mixture of sodium silicate solution and sodium hydroxide flakes of 97% purity. Both the liquid sodium silicate and sodium hydroxide flakes were procured from a local supplier. Properties of sodium silicate are determined as per IS 14212-1995. The alkaline solution was prepared by dissolving sodium hydroxide flakes in sodium silicate solution to obtain a desired modulus (Ms) and water was then added to alkali solution.

1.2 Sodium oxide dosage and modulus on strength of ASPC mixes.

For the preparation of Alkali solution mixture of sodium silicate and sodium hydroxide, Na_2O dosage 3,4,5 and 6% Ms of 1.25 with GGBS content of 180kg and w/b of 0.3 changes in volume was observed due to change in the specific gravities of Na_2O dosage has been adjusted total aggregate content.

Solution with dosage of Na_2O 3, 4, 5, and 6% highest 28-day compressive strength with a modulus of alkali solution Ms of 1.25 (Table1.1).

1.3 Aggregates

Aggregates in permeable concrete are single-sized or narrowly graded between 9.5-19 mm (ACI, 2010). Narrow grading and larger particle size produces larger pores and improves permeability. Blending aggregates of different sizes improves mechanical properties, but this is not recommended for permeable concrete because it reduces porosity and infiltration rates (Schaeferet al., 2006). Rounded aggregates such as gravel produces lower void content and increases compressive strength. Angular aggregates tend to be oriented in one plane during compaction, adversely affecting contact area and bonding. Flaky and elongated aggregate particles are avoided. (Kevernet et al., 2010; Tennis et al., 2004). Fine aggregate is usually excluded from permeable concrete.

2. METHODS

The process of pervious concrete preparation can be described as follows.

a) Materials preparation: In this step, the raw materials were prepared and weighted.

b) Casting after mixing concrete ingredients, the materials were caste.

c) The pervious cube then was removed to check the pore quality .The removed porous concrete cube samples were continuously cured in laboratory condition till the testing age.

To prepare performance satisfied matrix material, single factor and orthogonal experiments and analysis were implemented with the index of mechanical properties. Other properties were also tested for better understanding of the material and the process of ASPC preparation.

Pervious concrete is prepared by using 20mm and down size aggregate and ordinary Portland Ms 1.24 with water cement ratio of 0.25. The cube of 150x150x150mm sizes is prepared and they are cured for 28 days.

Table -1.1: Details of Mix design of ASPC mixes.

GGBS	Coarse Aggregate	LSS	NaOH	Water	Total water	HP
180	1570	88.7	6.5	79.3	134	7

3. RESULTS AND DISCUSSION

Table 1.2: Details of compressive strength at 3, 7 and 28 days

Na_2O Dosage	Modulus Ms	Porosity (%)	Compressive Strength (MPa)		
			3 Days	7 Days	28 Days
3	1.25	18.80%	5.1	6.4	7.7
4	1.25	18.20%	9.6	12.2	14.8
5	1.25	19.00%	13.4	17.0	20.1
6	1.25	19.50%	15.7	20.5	24.3

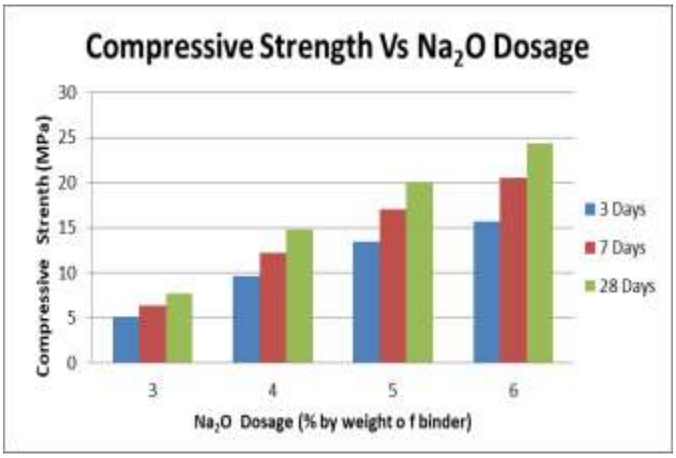

Chart -1: Compressive strength vs % of Na2O Dosage

Compressive strength of cubes Were tested in 200T capacity compression testing machine. The cubes were tested for 3, 7 and 28 Days. Cubes with 6% of Na_2O dosage and Ms 1.25 showed highest strength compared to others. There was not much variation in the porosity compared to cubes with Na_2O dosage.

Fig -1: Cubes after De-moulding

3.1 Permeability

In present study Co-efficient of permeability is determined by Falling Head Method. It can be seen that when the Na_2O dosage is replaced there was not much variation in the permeability. Normal pervious concrete with 3% Na_2O dosage has 18.8% of porosity whereas dosage Na_2O of 6%. Since there is only 0.5% increase in porosity there was no considerable variation in permeability.

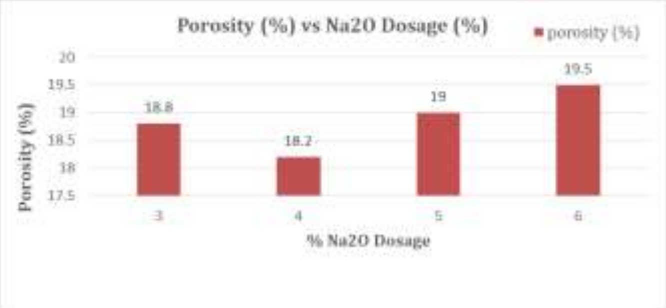

Chart -2: Porosity (%) vs Na_2O Dosage (%).

Table 1.3: Details of Porosity (%), (%) Na_2O Dosage and Permeability (cm/sec).

Na_2O Dosage (%)	Porosity (%)	Permeability (cm/sec)
3	18.8	0.45
4	18.2	0.43
5	19.0	0.41
6	19.5	0.39

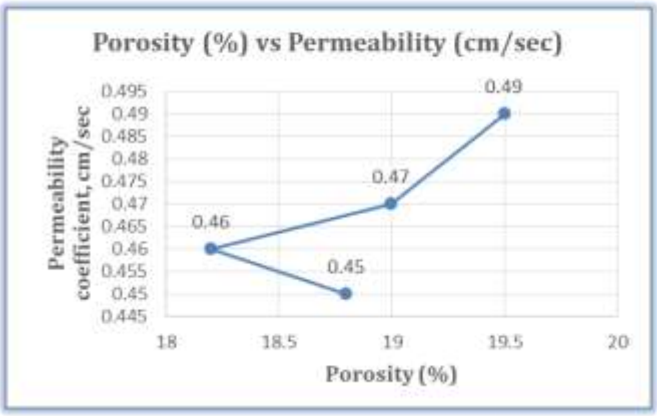

Chart -3 Porosity (%) vs Permeability coefficient (cm/sec)

4. CONCLUSION

Compressive strength was found to be highest when Na_2O dosage 6% with Ms 1.25. Compressive strength of concrete with OPC was better compared to previous pervious concrete with ASC mix. There was no much variation in the permeability since the porosity percentage was not much changing. This allows water to infiltrate and percolate to the ground, without altering the natural hydrologic cycle. In this way, several problems related to the storm water management can be mitigated. With regard to pervious concrete pavement performance, permeability is the key functional design property.

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