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Experimental Study on Fal-G Binder as a Replacement of Cement in Pervious Concrete

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***Abstract* - The main objective of this paper is to expand the applications of pervious concrete by using FaL-G binder as a replacement of cement. To study the physical properties of the FaL-G binder pervious concrete by using different sizes of coarse aggregates. The scope of this paper is to provide a most economical concrete by recycling the waste materials in useful manner for sustainable development. It helps in reducing the cost of the construction. Since FaL-G binder is used as a binder instead of cement it helps in minimizing the demand for cement.**

Keywords- Pervious concrete, Fal-G, binder, replacement of cement

I. INTRODUCTION

Pervious concrete is an open graded structure with interconnected voids through which rain and storm water is permitted to percolate into the aquifer. It consists of cement, coarse aggregate, some percentage of fine aggregate and water. Pervious concrete is an environmental friendly building material and EPA (Environmental Protection agency) has identified it as a Best Management Practice for storm water Management. Pervious concrete, also commonly known as porous concrete or permeable concrete created with a high volume of interconnected voids. A pervious concrete mixture contains little or no sand, creating a substantial void content. Carefully controlled amounts of water and Cementations materials are used to create a paste that forms a thick coating around aggregate particles and densely packed to make pervious concrete which has more interconnected voids that allows the water to drains quickly. Typical pervious concrete mixtures can develop compressive strengths in range of 3.5 MPa to 28 Mpa. The process of water passing through the porous concrete actually aids in water filtration, removing some harsh chemicals and pollutants before the water returns the ecosystem. In addition to its filtration qualities, porous concrete is also used as lightweight building material that can be inexpensive to use.

Fig.1 Pervious concrete

1.1 FaL-G

FaL-G is a technological renaissance of the age -old pozzolanic chemistry proven for its strength and durability. FaL-G is a ground blend of fly ash (Fa) lime (L) and gypsum (G). The use of FaL-G binder in pervious concrete involves a lesser amount of greenhouse gas and more environmental friendly binding material compared to cement. The proportions of lime and gypsum are dependent upon the chemical constituents and the behavior of fly ash. The Technology is thus custom built with the process parameters to yield a product of superior technical virtues. Whenever the lime is short supply, Portland cement can be used as the source of lime. Thus, this technology can be practiced both in 'lime route' and 'cement route' without disturbing the ultimate technical parameters and economics.

II. LITERATURE REVIEW

Ajamu, et al., (2012) concludes that smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate.

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Sanket Sharma, et al., (2012) concluded that flexural strength will increase with adding the fine aggregate as compared with ordinary pervious concrete.

Qiao Dong, et al., (2013) investigated that that loaded wheel abrasion test had the best sensitivity and sufficient repeatability among the three tests. The studded steel wheels and high wheel load were effective in improving the level of abrasion for this test. The surface abrasion test was effective in differentiating the control mix from other mixtures. This is because the specimen damage was caused by impact instead of abrasion in this test. It is recommended that fewer revolutions be used for this test as a potential way to improve its capability.

Patil, et al, (2013) concluded that different pervious concrete mixes considering each level of cement content with addition steel fiber was used to increase the strength parameter. The effects of such variation on the properties of pervious concrete mixes were studied.

Uma Maheswari and her associate, (2013 and 2014) was noticed that increasing in variation of cement content in the mixes results in increase in compressive strength, Flexural strength and split tensile strength. Similar trend is followed for flexural strength and split tensile strength. Coefficient of permeability decreases with increasing in cement content. Coefficient of permeability increases with increase in angularity number of aggregates.

Nataraja and his associate, (2014) concluded that it is possible to produce porous concrete of any compressive strength by controlling the w/c ratio and giving additional compaction. With additional compaction, strength of porous concrete increases and the internal voids deceases. Use of supplementary cementing materials is a must to control the properties of porous concrete and to save cement from the point of view of economy and sustainability.

Huang, et al, (2014), noticed that the compressive strength and indirect tensile strength of pervious concrete with larger size aggregate was larger, which can be attributed to the smaller air void and the more cement paste between aggregates if considering the aspect ratio.

III. MATERIALS USED AND ITS SOURCES

- Fly ash of class ‘C’ which contains a higher concentration of carbon content is collected from Neyveli Lignite Corporation (NLC), Neyveli.
- Lime which is availed locally from rotary kiln is collected and used in this paper.
- Gypsum (by product of fertilizer factory) is collected from Cuddalore District.
- Locally available aggregate of size 6mm, 8 mm, 10 mm and 12 mm are taken respectively for the casting of the specimens.

Table 1 Physical properties of Coarse Aggregate

S.No.	Tests	Results
1	Specific Gravity Test	2.762
2	Water Absorption Test	0.6%
3	Impact value Test	15.2%(Very strong)
4	Crushing Test	14.63%
5	Los Angles Abrasion Test	17%

Table 2 Chemical Analysis of Lime IV. CHEMICAL ANALYSIS OF FaL-G

The chemical properties of lime, gypsum are analyzed and the results are shown below:

S.No.	Parameter	Experimental Value
1	Sand and Silica	12.36%
2	Calcium Oxide (CaO)	45.36%
3	Magnesium Oxide (MgO)	4.68%

Table 3 Chemical Analysis of Gypsum

S.No.	Parameters	Experimental Value
1	Sand and Silica	10.36%
2	Calcium Sulphate(CaSO4)	82.69%

V. EXPERIMENTAL PROGRAM

Cube Size of 100 mm x 100 mm x 100 mm was used to study the compressive strength properties of FaL-G binder pervious concrete at the age of 7 and 28 days. Cylinder of size 150 mm diameter and 300 mm height was used to find split tensile strength of at the age of 7 and 28 days.

Cube size of 70 mm x 70 mm was used to find the tile abrasion value and further cube size of 100 mm x 100 mm was used to find thermal expansion/ contraction properties FaL-G pervious concrete at the age of 7 days.

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Fig.2 Batching of Materials

Fig.3 Dry Mixing Process

4.1 Mixing of FaL-G Concrete

Thorough mixing of material is essential for production of uniform course. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency.

Fig.4 Mixing Process

4.2 Curing

Since FaL-G is used as a binder instead of cement. Curing method varies from conventional concrete. Moist curing method was carried out for curing of specimens by covering with wet gunny bags which casted to determine the physical properties.

4.3 Testing of specimen

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete work. Systematic testing of raw materials and hardened concrete are inseparable part of any quality program for concrete, which helps to achieve higher efficient of the material use and great assurance of the performance of the concrete with regard to both strength and durability.

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Table 4 Compressive Strength of FaL-G Binder Pervious Concrete

Aggregate size in mm	Compressive Strength in N/mm^2	
	7 Days	28 Days
6 mm	3.56	5.54
8 mm	2.92	4.36
10 mm	2.82	4.02
12 mm	2.75	3.85

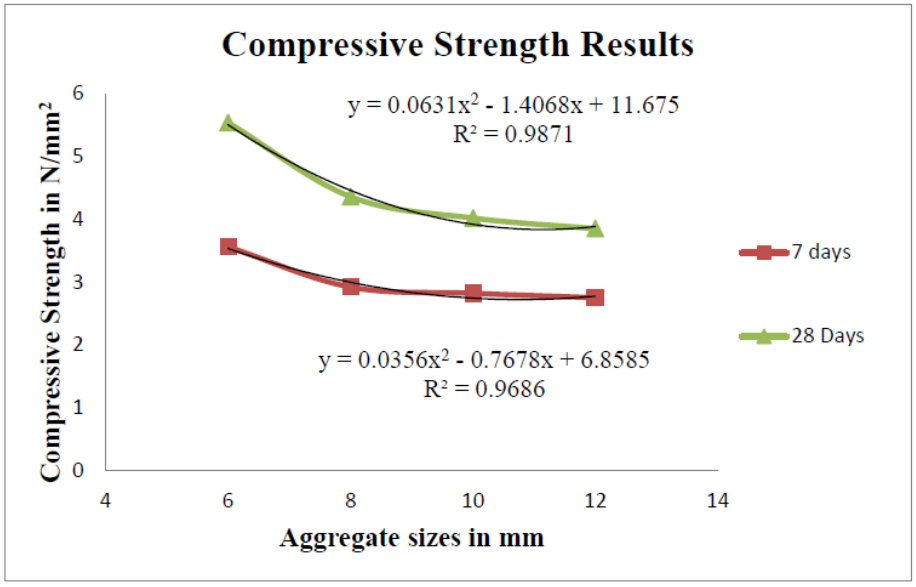

Fig. 5 Aggregate size vs Compressive Strength

Table 5 Split Tensile Strength of FaL-G Binder Pervious Concrete

Aggregate size in mm	Split Tensile Strength in N/mm^2	
	7 Days	28 Days
6 mm	0.29	0.44
8 mm	0.27	0.41
10 mm	0.19	0.35
12 mm	0.16	0.30

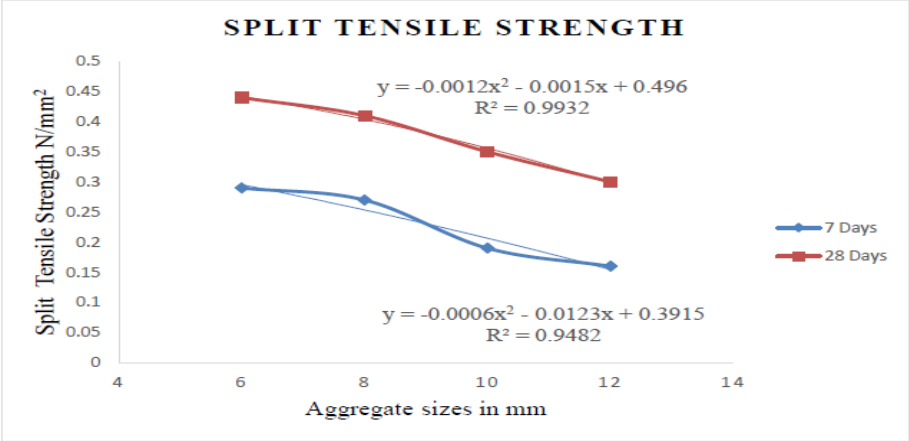

Fig. 6 Aggregate size vs Compressive Strength

Table 6 Tile Abrasion Properties

Aggregate size in mm	Average loss in thickness (t) in mm
6 mm	0.70
8 mm	1.05
10 mm	1.55
12 mm	2.60

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Table 7 Thermal Expansion/ Contraction Properties

Aggregate size in mm	Initial Reading (mm)	Final Reading (mm)
6 mm	40	39
8 mm	40	38
10 mm	40	37.5
12 mm	40	36

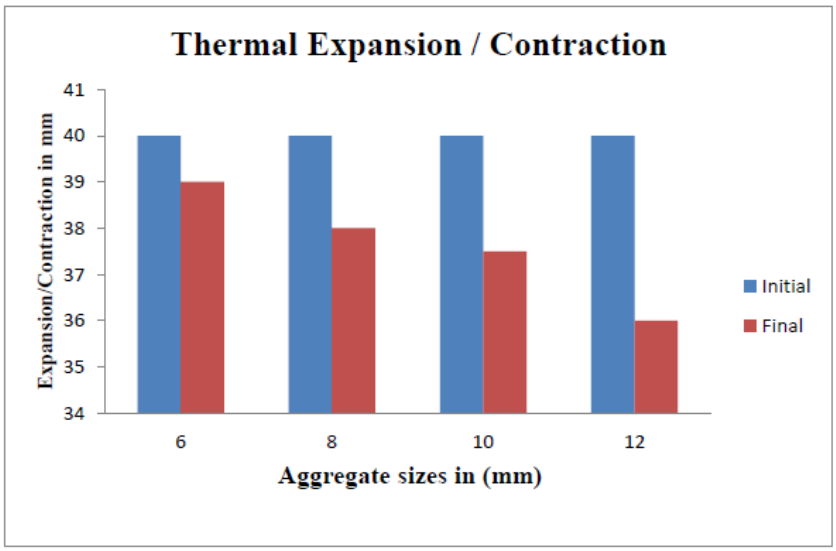

Fig.7 Aggregate size vs Expansion/Contraction

V. CONCLUSION

[1] FaL-G binder with aggregate size 6 mm has higher compressive strength and split tensile strength than other size aggregates.

[2] It was noticed that increase in aggregate size leads to decrease in compressive strength and split tensile properties of FaL-G binder pervious concrete and it has significant effect on size of aggregate.

[3] In view of tile abrasion properties when aggregate size increases the average loss in thickness increases.

[4] There was a contraction in concrete nearly of about 4 mm for 12 mm aggregate size when compared with 6 mm size aggregate.

[5] FaL-G binder pervious concrete made with aggregate sizes ranging from 6 mm to 12 mm satisfied the requirements and it can be used for sustainable pavement construction.

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