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Activated FA Blended With Black Cotton Soil – an Ecological Substitute of Binder in Roadway

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ABSTRACT: *Owing to its low initial cost, flexible pavements have been preferred in compare with rigid pavement. In the recent era, the insufficiency of raw materials and growing rates of bitumen are become a great problem. Now the benefits of rigid pavement is well recognized. But only disadvantage for concrete rigid pavement is the initial cost which is around 30% more than flexible pavement. For rigid pavement LCC (lifecycle cost) is much lesser than flexible pavement. Our industry is seeking for a true substitute which is sustainable and economic. In this study a typical non- conventional composite is developed by presenting Class C Flyash and Black cotton soil in alkaline medium. Flyash is an alumino-silicate material whether Black cotton soil is argillaceous and relatively reach in calcium carbonate (Kankar Nodules). The alkaline atmosphere insists the development of polymeric structure (Si-O-Al-O, tetrahedral structure) under hot steam curing. Cloth-jacketing has been used in the curing method of steam curing. Water glass sodium silicate solution has been used as alkali activator medium. Scanning Electron Microscopy, Compressive strength test, Ultrasonic Pulse velocity were conducted to evaluate its mechanical and microstructural characteristics.*
KEYWORDS: *Dark Cotton Soil, Class C Flyash, Kankar Nodules, Polymer, steam curing*

I. INTRODUCTION

For the last half decades scientists are working for alternative concrete. The second alternative is very well known to the industry named geopolymer.A geopolymer is a kind of alkali aluminosilicatecementitious material which has superior mechanical, chemical and thermal properties as compared to Portland-based cements, and with significantly lower CO_2 production [1]. Mechanism of geopolymers involves the polycondensation reaction of geopolymeric precursors i.e. alumino-silicate oxide with alkali polysiliates yielding polymeric Si–O–Al bond [2,3,4,5]. $M_n[-(Si - O_2)_z - Al – O]_n$can be expressed as the basic polymeric formula. wH_2O where M is the alkaline element, z is 1, 2, or 3 and n is the degree of polycondensation [5].In this research we have focused to build a polymeric binder by means of readily available raw material like black cotton soil and fly ash.Again this alkali activated raw materials were tested, mechanically and microscopically.

II. TEST PROGRAM

A.Material Properties

Flyash to ASTM C 618, class F was supplied by NTPC, Farrakka,West Bengal.Glass Sodium Silicate solution) of silicate modulus 2.89 and bulk density 1265 kg/m^3 was used in this study. The detail of the base materials have been tabulated in Table-1.The black cotton soil of average grain size less than 75 micron was collected from Maharashtra, India.

Table-1. The Detail of Base Material Compositions

Chemical Composition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	MnO	K_2O	Na_2O	P_2O_5	LOI
Fly ash	53.25	32.8	4.12	0.26	1.89	0.05	Nil	0.69	0.91	0.54	0.55
Black Cotton Soil	52.23	16.85	0.47	Nil	20.07	6.95	0.32	0.78	0.51	Nil	0.04

B.Test Setup

a.Strength Test: Compressive strength of specimens were tested by digital compression testing machine of model no. EM500 supplied by ENKAY Enterprise. The least count was 0.001 KN. The compressive strength of cube specimens was as per ASTM C109.

b.Scanning Electron Microscopy: QUANTA 2000 with a capacity of 2.4 nm at 30kv at high vacuum condition was used to perform Scanning Electron Microscopy. Sample was collected as a small scrap form to perform Scanning Electron Microscopy. Scraps were collected at the stint of crushing.

c.Ultrasonic pulse velocity: Ultrasonic pulse velocity was determined as a nondestructive test in CSET laboratory, Kolkata. Ultrasonic pulse velocity is a measure of time required for a sound propagation. UPV can reveal the density or compactness of any material.

d.Specimen Preparation: In a power mixer, Flyash, Black cotton were properly mixed in complete dry condition. Then preset quantity of sodium silicate solution was added into the dry mix. Mixing was carried out for 5 minutes. The mix was molded and exposed to a table vibration for 2 minutes to expel entrapped air. After 24 hours of rest period in 27^o C, the specimens were subjected in a steam jacket curing. The detail of mixed composition is given at Table-2.

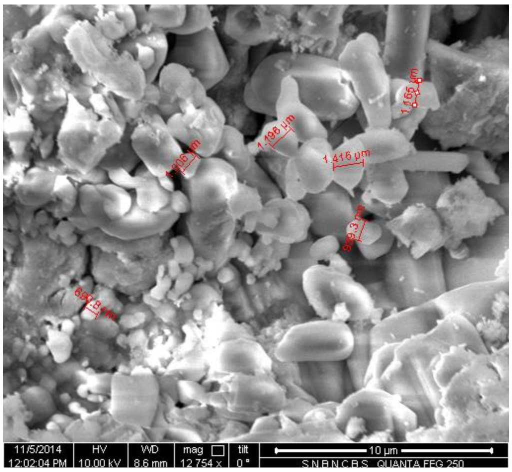
Table-2. Mixing details of different mix proportion

Sample Id	Shape & Size of the specimen	Alkali solution /Base Material	Black Cotton Soil % of (Fly Ash plus Soil) in wt.	Type of Specimen
FB1	Cubical 50mm × 50mm × 50mm	0.3	25	Paste
FB2		0.3	50	Paste

III. RESULTS & DISCUSSION

A.Scanning Electron Microscopy

Scraps of the activated samples, collected from the inner part of the specimens were subjected to scanning electron microscopy. For FB1 samples in common cases, partial amorphous structure was observed. The presence of crystal in between a wholesome amorphous build indicates non –reacted alkali portion. Whereas more compact structure is obvious for FB2 samples.In this program the SiO_2 and Al_2O_3 (Silicon Oxide and Aluminium Oxide) presence within flyash,were activated by alkaline activator (Sodium Silicate).Here the Calcium compound presence in Black Cotton soil (Ca^{++}) acts as charge compensator of Aluminium ions.The SiO_2 presence in Black cotton soil and Sodium Silicate is the primary source of forming monomer and dimer, the initiator of tetrahedral polymer.



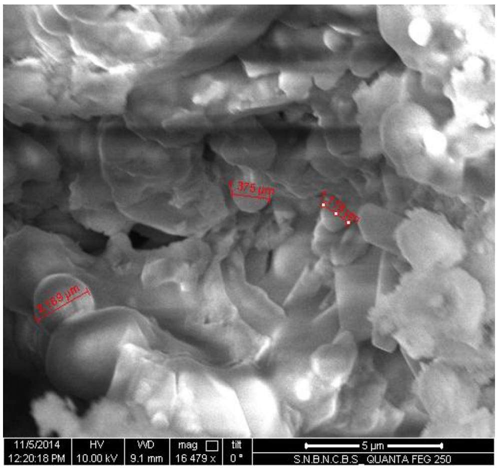


Fig. 1: Scanning Electron Microscopy of typical samples of FB1&FB2 under resolution of 12754x &16479xzoom respectively

B.Compressive strength

Compressive strength is considered as the prime characteristic of material assessment. Fig. 2 presents mean compressive strength of the twenty samples .Fly ash activation in the presence of black cotton soil yield to better polymerization. Outcome displays successive increment in compressive strength with the incorporation more percentage of black cotton soil in the composition. Maximum compressive strength was obtained for FB2 (21.14 MPa) after 3 days.The compressive strength was tested right after 3 days and 7 days from casting. AgainFig. 2 depicts the rate of strength change with time being, is quite low for FB2 specimens in compare to FB1.

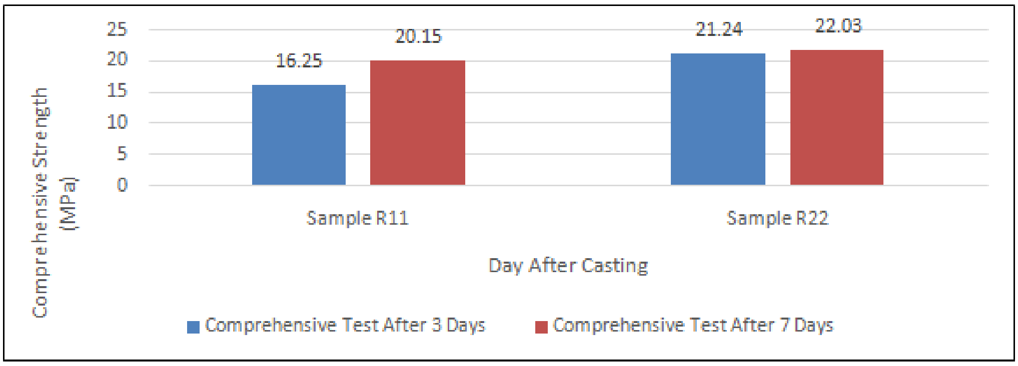


Fig. 2: Compressive strength of FB1&FB2 samples with time

C.Ultrasonic pulse velocity

Around twenty samples of each sets were subjected to UPV test.In every cases it was limited within a range of 2.78-3.58 which is supposed to be perfect for paste. Actually sound can run through solid well. This value supports the compactness of the material. Whatever porous character may somehow make the value ordinary. But polymeric structure is porous but not permeable. That is why UPV is not all-time a good indicator of measuring perviousness.

IV. CONCLUSION

Maximum compressive strength was observed for sample FB2.More precise result may be obtained with vast future study. 21.14 MPa after 3 days from activated solid waste may contribute significantly.
Scanning electron microscopy shows almost compact and dense integrity in high resolution.This is very important parameter in connection with fluid percolation when used as road material.This in fact affects greatly on durability.

Though absolute UPV data is available for concrete mainly. This study is rather focused on only binder.The UPV result,obtained within a range of (2.78-3.58) is considered right enough.
The basic performance of a construction material is depends on strength, stability and durability.The result shows a new way of developing a pioneer material with elegant feature like strength and durability considering economic facet as road material.

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