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PERFORMANCE OF TERNARY CONCRETE WITH PARTIAL REPLACEMENT OF AGGREGATES BY STEEL SLAG AND GEOGRID REINFORCEMENT

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ABSTRACT

Concrete is a versatile material extensively used in construction applications throughout the world. Properly placed and cured concrete exhibits excellent compressive force-resisting characteristics. In the present experimental investigation M20 grade with ternary blend of metakaolin and flyash as partial replacement by weight of cement is used. Partial replacement of cement by these two elements is known as ternary concrete. Steel slag is the glass like by product left over after a desired metal has been separated from its raw ore. In India 12million tons per annum has been recorded as a waste from industries. So it has been taken as a partial replacement for course aggregates and fine aggregates in order to make by-product as one of the constituent in concrete and also to increase strength. As we know from past studies, Concrete is strong in compressive strength and week in flexural strength. In order to reduce its failure due to bending, geogrid is reinforced which increases its flexural strength. In the present experimental investigation, it is aimed to develop ternary concrete. Various materials like metakaolin, fly ash, steel slag, geogrid and super plasticizers are used in concrete to improve its strength and flowability. Tests are conducted on the strength properties of concrete. Strength properties like Flexural strength have been studied by testing beams. It was observed from the results that coarse aggregate replacement level of 20 % slag in concrete mixes was found to be the optimum level to obtain higher value of the strength and durability at the age of 28 days.

Keywords*: Metakaolin, Flyash, Steel slag, Geogrid , Flexural strength.*

I. INTRODUCTION

This study focuses on producing concrete of acceptable strength with ternary concrete and steel slag as partial replacement of fine aggregate and coarse aggregate with geogrid and determining the optimum fine aggregate and coarse aggregate mix ratio to achieve this strength. The increase in strength is due to shape, size and surface texture of steel slag aggregate, which give better adhesion between the particles and cement paste. Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress. Ternary concrete mixtures include three different cementations materials. In this project ternary concrete includes Cement, metakaolin and flyash. Metakaolin is a dehydroxylated form of clay mineral kaolinite, the particle size of Metakaolin is smaller than cement particles therefore it fills voids in the concrete and also increases the strength of concrete. Girish Sharma (2015) studied in his work "Beneficial effects of steel slag on concrete" with the aim of replacing steel slag. Their deep analysis concludes that there is constant increment when replaced with that of steel slag and can be used practically. As per the work done by Pankaj B A and Hardeep S J S S (2016), in "Effect of Steel Slag as a Replacement of Fine Aggregate in M40 Grade of Concrete", workability decreases as the percentage replacement of fine aggregate by steel slag increases.

II. MATERIALS USED

Cement:53 Grade Ordinary Portland cement confirming to IS: 1489 (part-1) was used in this study. The cement was obtained from a single consignment and of the same grade and same source. After procuring, the cement was stored properly. The specific gravity of the cement is 3.15.

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Fine aggregate: The fine aggregates conforming to Zone-2 according to IS: 383-1970 is used. The fine aggregate used was obtained from a nearby river source. The bulk density, specific gravity and fineness modulus of the sand used are 1.29g/cc, 2.67 and 2.63 respectively.

Coarse aggregate: The crushed granite aggregate ratio of 20mm -12.5mm aggregates to 10mm4.75mm aggregates in terms of percentages 60% (20mm-12.5mm): 40% (10mm4.75mm) is used as coarse aggregate. The bulk density, specific gravity and fineness modulus of the coarse aggregate has been 1.45g/cc, 2.77 and 7.18 respectively.

Fly Ash: Fly ash is a residual material of energy production using coal, which has been found to have numerous advantages for use in concrete. Some of the advantage include improved workability, reduced permeability, increased ultimate strength, reduced bleeding, and better surface and reduced heat of hydration.

Fig 1: Fly Ash

Metakaolin: Metakaolin is not a by-product. It is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 6500 C and 8500 C, followed by grinding to achieve a fineness of 700-900 m2 /kg. It is a high quality pozzolanic material, which is blended with cement in order to improve the durability of concrete.

Fig 2: Metakaolin Powder

Steel slag: Steel slag, a by-product obtained from the steel manufacturing plant, is crushed into pieces and used as a fine and coarse aggregate along with conventional fine and coarse aggregate.

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Fig 3: Steel slag as coarse aggregate

Fig 4: Steel slag as fine aggregate

Geo-grids:A geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as sub cases or subsoil below roads or structures. Geogrids are commonly made polymer materials, such as polyester, polyethylene or polypropylene.

III. METHOD

Tests conducted on fresh concrete

Slump test: The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch .The obtained slump value for fresh concrete is 75mm which is true slump used for normal reinforced concrete placed with vibration.

Tests conducted on hardened concrete

Flexural Strength Test: The 750 x 150 x 150mm beam specimens of ternary concrete were tested, as per to IS: 516-1969, on a digital flexural testing machine of 3000KN capacity after 14 and 28 days of conventional water curing. The bearing surface of the machine was wiped off clean and any loose sand or other material was removed from the surface of the specimen. The specimen was placed in the machine in such a manner that the load was applied to opposite sides of the beams as cast that is, not top and bottom. The axis of the specimen was carefully aligned at the center of the loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and could no longer sustain

Table 1: MIX PROPORSIONS

MIX	CEMENT %	METAKAOLIN %	FLYASH %	FINE AGG %	STEEL SLAG (F.A) %	COARSE AGG %	STEEL SLAG (C.A) %
M-1	100	0	0	100	0	100	0
WITHOUT GEOGRID							
M-2a	88	2	10	90	10	90	10
M-3a	87	3	10	80	20	80	20
M-4a	88	2	10	90	10	90	10
M-5a	87	3	10	80	20	80	20
GEOGRID							
M-6b	88	2	10	90	10	90	10

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M-7b	87	3	10	80	20	80	20
M-8b	88	2	10	90	10	90	10
M-9b	87	3	10	80	20	80	20

IV. RESULT & DISCUSSION

The results of experimental investigation of flexural strength for concrete mix of M20 grade are presented in the Tables.

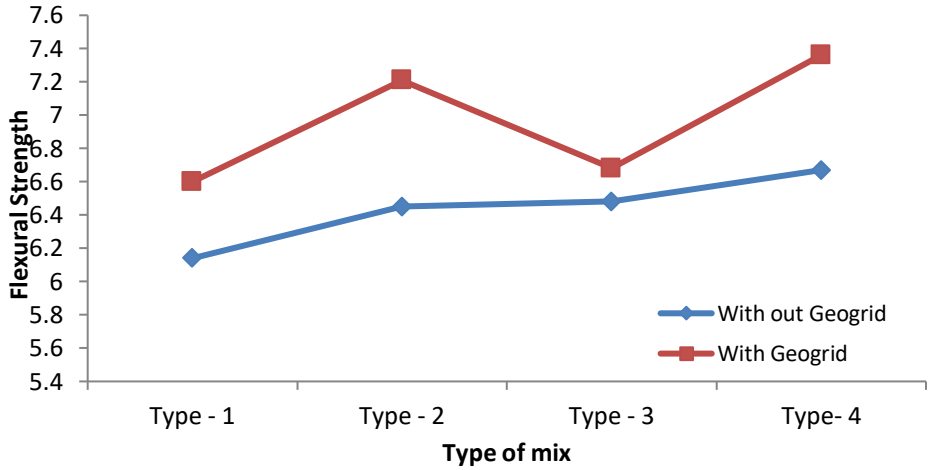

Fig 4: Comparison of flexural strength of concrete for 14 days

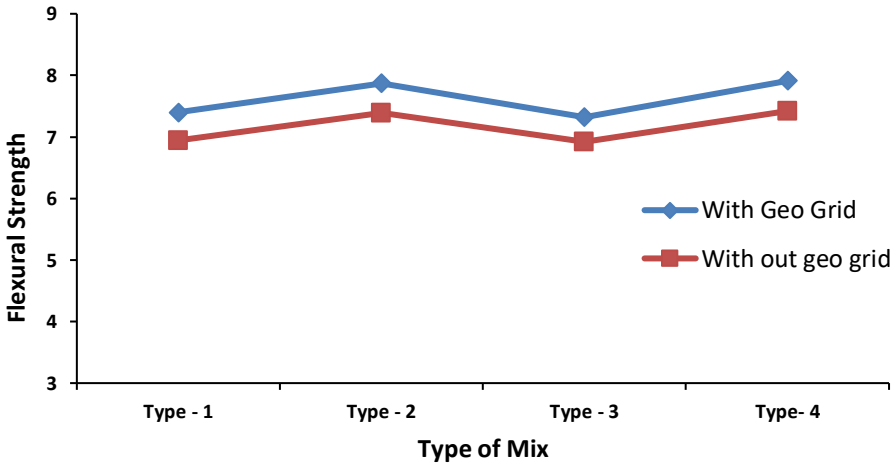

Fig 5: Comparison of flexural strength of concrete for 28 days

Where
Type – 1 = Mix-2a&2b
Type – 2 = Mix-3a& 3b
Type – 3 = Mix-4a& 4b
Type – 4 = Mix-5a& 5b

a – Without Geogrid
b – With Geogrid

Discussion of test results for 28days comparison of with and without geogrid in ternary concrete:
Flexural strength of ternary concrete with geogrid is more than without geogrid because; concrete is weak in tension and by introducing geogrid as reinforcement material it results in high flexural strength than conventional concrete. M-5a and M-5b are the mixes which has same mix proportions but differ by geogrid reinforcement where M-5a is the mix with geogrid reinforcement has more flexural strength than M-5 mix which has no geogrid reinforcement

V. CONCLUSION

Hence, after performing all the tests and analyzing the results, the following conclusions can be derived:
It was observed that Flexural strength of concrete has been increased to around 100% by replacing aggregates with steel slag in ternary concrete.

Further to improve its performance geogrid is used as the reinforcement. Its strength has been improved around 7%. Overall performance of concrete has been improved from 3.53N/mm^2 to 7.91N/mm^2 by replacing 20% of steel slag and using geogrid in ternary concrete.

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