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REDUCING THE ENVIRONMENTAL IMPACT OF CONCRETE BY USING OF HIGH AMOUNT OF CALCIUM FLY ASH

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ABSTRACT

This paper presents study on the concrete and cement industries are facing the environmental impact of the cement factories by the emission of carbon dioxide. Partial replacement of cement has been tried by high, medium and low volume with pozzolanic waste materials that include bottom fly ash, silica fume, rice husk ash, blast furnace slag having silica and cementitious materials. Total replacement of cement is also of current interest by the emerging new material called geo polymer concrete. All the replacement materials for cement, fly-ash has been identified which is being produced in vast quantities comparatively is recommended for use in concrete. A vast quantity of research has been made on bottom fly-ash using including the development of concrete geo polymer but, most of them are confined to the utilization of normal calcium fly-ash called class C fly-ash. Only limited research has been done and reported about the utilization of high volume content calcium fly-ash called class C fly-ash which is the waste, based on lignite burning in thermal power stations. Class C ash being more cementitious in nature compared to class F ash, the high calcium content is a problem for the corrosion and concrete deterioration etc.. However, it is believed that if the microstructure is suitably modified with the incorporation of silica based additives to fly-ash based concrete it could be materialized with the development of bulk utilization of high calcium fly-ash concrete .Dr Narla Tata Rao Thermal Power Plant or Vijayawada Thermal Power Plant is located at Vijayawada in Andhra Pradesh very nearer to Lakireddy Balireddy college of engineering Mylavaram, a large amount of high calcium fly-ash is annually produced which is a nuisance to the public and environment. VTPP is producing 169 million tons of class C fly-ash per annum. The engineers and other employs have try to utilize the waste bottom fly-ash as storing has environmental issues. This type of fly-ash is using in various non-structural elements like flooring and filling partial replacement of cement etc. Conventional concrete grade of M30 is designed by Indian method of mix design and based on the seventh day strength of trial mixes; an optimum trial mix proportion is arrived and validated for its workability characteristics and twenty eighth day compressive strength. Partial replacement of cement with class C fly-ash is aimed up to 30%. Concrete mixes having 5%, 10%, 20%, 25% and 30% cement replacement by weight of fly-ash are considered. Including the reference concrete without fly-ash and in parallel, with and without plasticizers totally, twelve types of concrete mixes are tried initially for experimental study. As the compressive strength results of 70%, 80% and 90% cement replacement with fly-ash are not encouraging, only the 50% and 60% cement replacement levels with fly-ash are considered for further study. In addition fly-ash replacement by silica fume is also planned by 10% and 20% respectively for both the replacement levels and without and with plasticizers. Therefore from the adequately decided total mix of twenty, only fourteen different concretes are considered for further thorough studies. The workability characteristics by slump measurement are carried out for all the fourteen types of concrete. Strength in various aspects that include compressive strength based on cube and cylinder specimens, split tensile strength based on cylinder and flexural strength based on prisms are carried out. The strength characteristics up to 360 days have been obtained. Apart from strength characteristics and durability related properties are better for high volume high calcium fly ash. In a nut shell, Cement replacement up to 60% by weight of class C fly ash is recommended for VTPP fly-ash. Further, characterization of VTPP fly ash is a must before using in concrete applications for making decision on the level of cement replacement. For more than 60% utilization of fly-ash for replacing cement, substance like rice husk ash or Nano-silica may be added in conjunction with silica fume. Incorporation of admixtures like super plasticizers and additives like silica fume is also a must in utilizing the VTPP ash that too in bulk volumes in structural concrete.

Keywords- *fly ash, silica fume, compressive strength, tensile strength.*

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I. INTRODUCTION

Mine wastes are now finding better use, given the focus on innovation in cement and concrete industries that is taking shape. Concrete industry is currently in a fix to find sustainable growth for itself. Although this is certainly possible but demands a lot of effort with accelerating the construction as a key.

1.1. Objective

This work aims to develop structural concrete with high volume of high calcium fly ash and also to find the possibility of fly ash being a substitute of cement. Vijayawada Thermal power plant has boatload of class c fly ash whose structural utilization was not focused up on. Main objectives are broadly discussed in further chapters.

Fly ash as a cement replacement material

Concrete constituents are depleted as a resource every passing day. Substituting fly ash for Portland cement is considered for its advantages like containing greenhouse gas emissions and also paving a way for sustainable development. Basically Pozzolans are siliceous content material and aluminous material also, there is no content of cementitious bonding property, in the form of finely divided particles to react with water, and produces compounds possessing cementitious properties.

Materials like silica, alumina and iron, fly ash is a pozzolanic, which a substance containing aluminous and siliceous material to produce cementitious compounds when reacts with water. These material similar to general OPC, when reacts with lime and water. The recent development of geo polymer concrete technology involves the 100 percent replacement of cement with ash materials. An activating solution is used to have polymerisation process, finally resulting in a hard concrete with other conventional ingredients.

Parameters	Slump mm	Compaction Factor	Flow percentage
Without plasticizer	42	0.80	10.10
With plasticizer	44	0.86	11.30

The materials involved in this study are cement (OPC), river sand (fine aggregate), granite jelly (coarse aggregate), mixing water, admixtures (super plasticizer), fly ash and silica fume. The properties of all the materials used in this study are presented here.

Cement

Ordinary Portland cement of 53 grade conforming to IS: 8112-2009 is used for the present investigation. Its specific gravity is 3.12. The cement was tested as per the procedure given in Indian standards IS 4031:1988. The physical properties and chemical composition of cement are given in Tables.

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II. RELATED WORK

S.No	Silica Fume	
	Properties	Results by supplier
1	Loss on Ignition	Max. 3%
2	Moisture content	Max. 1.50 %
3	Specific Gravity	2.20
4	Bulk density	1.96 kN/m^3
5	SiO_2	Min. 90% and Max. 95%
6	Specific surface area	22000 m^2/kg

Chemical properties

No	Parameters	Experimental Values (%)	Limits as per IS 3812-1981(%)
1	Silicon dioxide (SiO_2)	48.20	35.00(min.)
2	Aluminum oxide (Al_2O_3)	22.20	-
3	Ferric oxide (Fe_2O_3)	7.85	-
4	Calcium oxide (CaO)	13.81	10 – 30
5	Magnesium oxide (MgO)	1.49	5.00(max.)
6	Sulphur trioxide (SO_3)	2.73	3.00(max.)
7	Sodium Oxide (Na_20)	0.88	1.50(max.)
8	Loss on Ignition	3.29	12.00(max.)

Mix proportioning of conventional M-30 grade concrete with the identify properties of the concrete constituents, concrete grade of M30 is designed by is method as detailed in table based on the trial mixes a correct proportion is arrived..initially maintained w/c ratio of 0.42 is and then is reduced to 0.3% and the dosage of sp is adjusted. Concrete specimens like 100 x 200 cylinders and 150mm cubes are cast to determine the tensile strength, compressive strength. Weigh batching, machine mixing and casting on table vibrators are adopted for specimen fabrication. The strength on 7^{th} and 28^{th} day of curing are obtained and reported.

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No	Property	Experimen-tal Value	Limits as per IS 3812-1981
1	Normal Consis-tency	42%	-
2	Initial Setting Time (min)	20 min	24 min(max)
3	Specific Gravity	2.46	-
4	Percentage on 45	37%	34%(max)
5	Soundness for fly ash	0.50 mm	-
6	Specific Surface area cm^2/gm	2977	2500-3200

Strength characteristics of fresh concrete

The details of total number of specimens for M30 grade with and without fly ash, silica fume and super plasticizer are given in the Table to test for various strength and durability characteristics.

No	Properties(specimen type)	Age of Testing (Days)	No. of Specimens
1	Compressive Strength(Cube)	7,14, 28,	9
2	Compressive Strength and Split Tensile Strength(Cylinder)	7,14, 28	9
3	Saturated Water Absorption and Porosity	28	3
Total specimens cast			**21**

Work$ability characteristics

A concrete is said to have a high nature of workability, if the compacting factor is over 0.92, or the slump is in range of 75 to125mm (IS 456-2000). For control concrete, the workability property was measured by conducting slump cone test, compacting factor test and flow test. For other concrete mixes, workability is determined by slump cone test only. It is observed that, while increasing the fly ash content, there is a reduction in slump values, and for silica fume based concrete mixes workability is in the increasing

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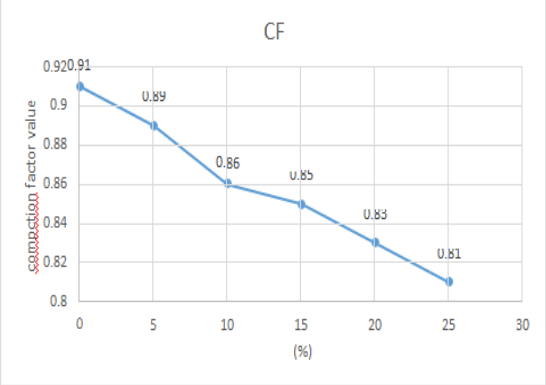
Cube specimens 100mm size and 100×200mm cylindrical specimens are tested for compressive strength in the respect to the age of curing in a standard manner as per as per IS: 516 – 1959. We considered three identical specimens to conduct tests at the agea of 3, 7 and 28 days. Results is presented in Tables As the compressive strength for cement replacement more than 60% is not satisfactory, the cement replacement of 50% and 60% are considered for further study.

III. ANALYSIS OF RESULTS

The experimental part completed through various experiments and the results are grouped in the order of conducting the test. From the twenty mix proportions, cube compressive strength is arrived by experiments and 14 mix proportions are positively selected for thorough investigation. For all the 14 mix proportions, workability, strength and durability characteristics are grouped and analyzed.



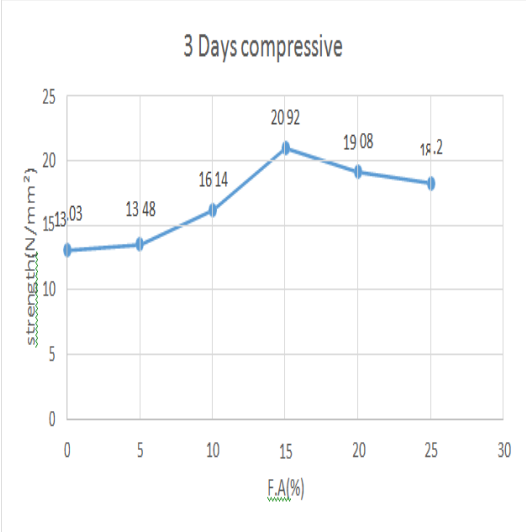
ISSN 2348 – 8034
Impact Factor- 5.070

Effect of Fly ash on Compressive Strength.

The values of compressive strength at the ages of 3, 7 and 28 days with 5, 10, 15 and 20 percentages of fly ash with and without SP are shown in figure. It is observed that there is a reduction in compressive strength at earlier ages by increasing the fly ash content. However, the strength could not be achieved satisfactorily for 70 %, 80%, and 90% replacement of cement by fly ash. The reduction in compressive strength for 50% and 60% cement replacement by fly ash are 17% and 23% without SP and 8.88% and 15.93% with SP at 28 days respectively. The gain in compressive strength Effect of Fly ash on Compressive Strength.

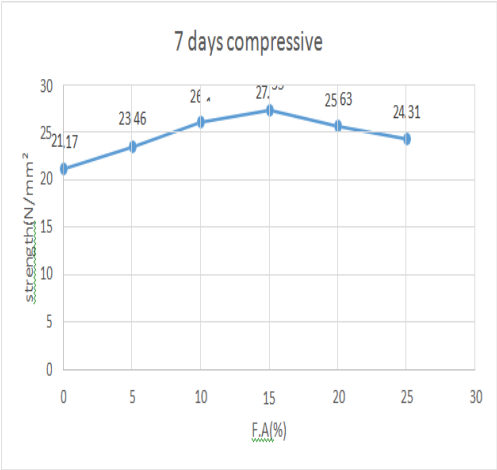
Fig: Cube placed in compressive testing machine

The rate of gain of compressive strength at the ages of 3, 7 and 28 days with 5, 10, 15 and 20 percentages of fly ash with and without SP are shown in fig.

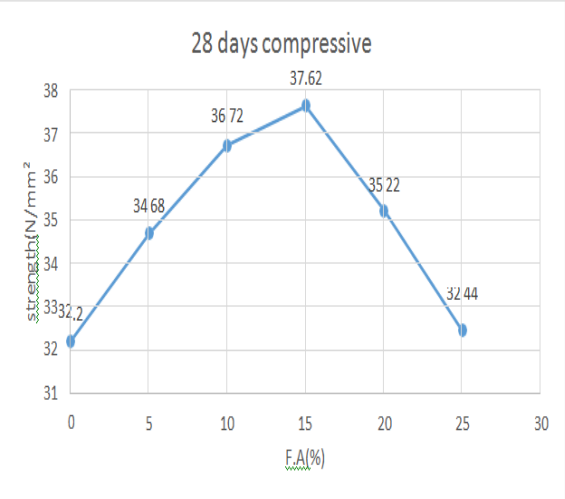


Fly ash% vs 3days compression strength values

ISSN 2348 – 8034
Impact Factor- 5.070



Fly-ash % vs 7days compression strength values



fly ash% vs 28days compression strength values

It is observed when adding flyash content in concrete we observed that, the compressive strength is reduced at the age of 3 days. However, the strength could not be achieved satisfactorily for 70 %, 80%, and 90% replacement of cement by fly ash. The reduction in compressive strength for 50% and 60% cement replacement by fly ash are 17% and 23% without SP and 8.88% and 15.93% with SP at 28 days respectively. The gain in compressive strength

Tensile strength

Tensile strength increased with addition of marble dust powder. We have observed that up to 15% replacement of cement with fly ash the concrete shows the hike in strength. Further increment of bottom fly ash in concrete shows in decrease of strength as compared to the 15% replacement.

As we compared to the conventional concrete ,we got around 16.84% increase in compressive strength.

ISSN 2348 – 8034
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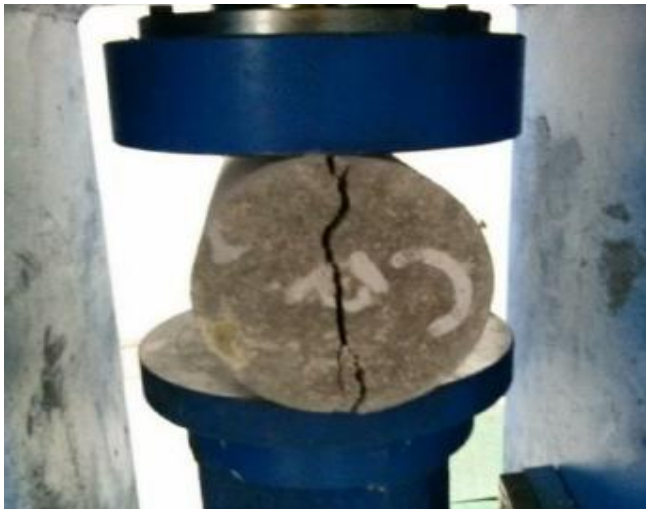

Tensile test

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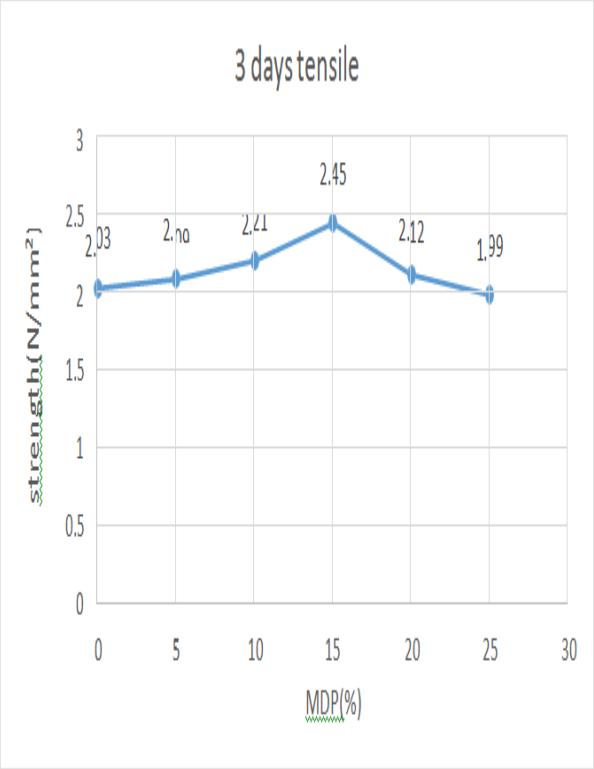

fly-ash% vs 3days tensile strength values

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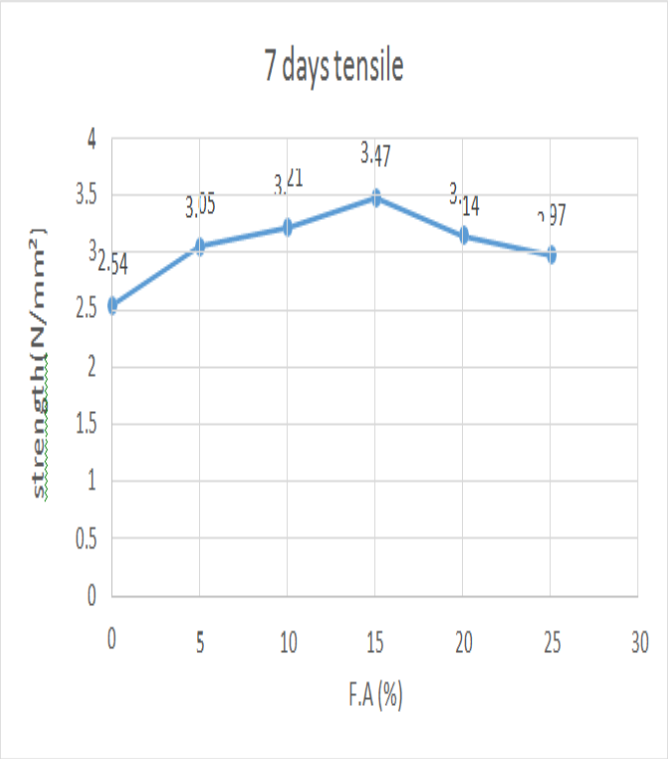

F.A% vs 7days tensile strength values

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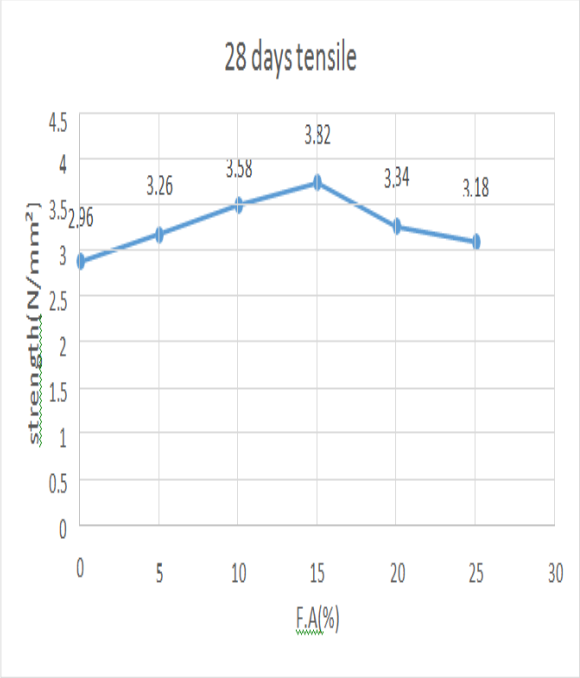

F.A % vs 28days tensile strength values

Saturated water absorption

Saturated water absorption (SWA) test of concrete is one of the basic permeability tests conducted on hardened concrete specimens which denote the quantity of water, which can be removed on drying a saturated specimen

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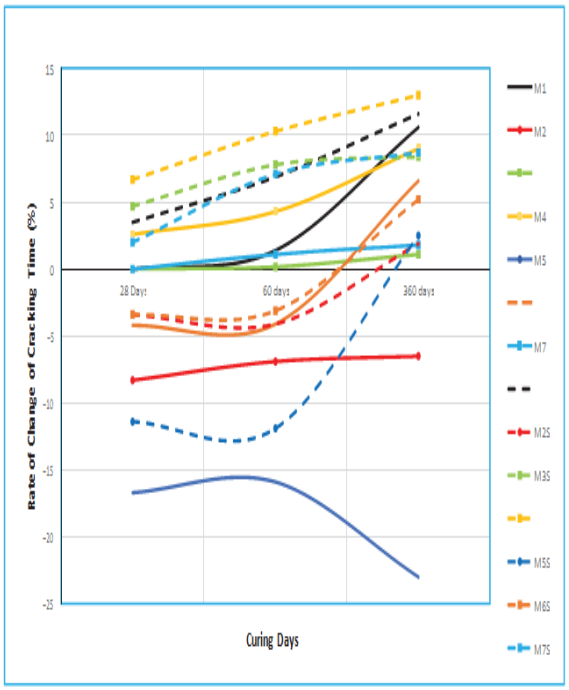

Fig. Comparison of Rate of Change of Cracking Time

IV. CONCLUSION

Compared with conventional cement concrete, the fly ash based concrete is more workable and still more with the additions of silica fume. However, slump value is slightly reduced (0 to 20mm) with the intention of improving the strength which is indirectly proportional to the water-cement ratio. For M30 grade concrete even though studies are made for concrete with and without SP, the concrete with SP showed better overall performance in workability, strength and durability characteristics in general. Compressive strength of concrete for 50% and 60% cement replacement with fly ash is satisfactory and other replacement levels are not so even with the addition of silica fume with the normal conditions. Alkaline resistance is better than the sulphate attack and the sulpahte attack is better than the acid resistance in general for all cases. Compared with cement concrete w.r.to durability characteristics particularly through rapid chloride permeability test, the performance is not good (less by 29%) for fly ash added concrete. But the addition of silica fume has improved the performance considerably(less by 59%). However, the improvement in performance after 28 days of curing is more significant (64%).

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