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Optimization of Fly Ash in Concrete for Grade M15, M20, M25, M30, M35, M40

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Abstract: In today's scenario, we always think for the optimization in each field to get the maximum potential with lower cost. And so our engineering persists, we engineers got the respect. On the other hand, to save our environment is the prime concern, obviously, the concern of this research paper is. This research paper desires to obtain the optimized quantity of fly ash in concrete of grade M15, M20, M25,M30,M35,M40.Optimization of fly ash in concrete is varying the amount of fly ash as replacement of the cement which acts as a binder material. The replacement of larger proportions of cement by fly ash will reduce the cost of concrete, improves the intrinsic property like durability of the structure also the consumption of by product waste material fly ash from the coal based power plant as a resource material.

Portland slag cement confirming IS: 455-1989 and high lime fly ash which is categorised as class C fly ash by ASTM, because of its high calcium content ,is used for the each trial mixes of concrete .High lime fly ash will act as binder material along with cement, also it's pozzolanic nature improves the durability of the concrete The physical and chemical properties most importantly, its fineness and carbon content imparts vital role in water cement ratio and strength parameters in concrete.

Several design mixes will be prepared, cured and tested for their compressive strength. Each compressive strength sample will be tested at 7and 28 days. The results will be analysed and compared with standard concrete and conclusions made on how best the fly ash can be utilized to give optimum results.

Earlier attempts for optimizing the fly ash content in cement concrete is with the Ordinary Portland cement. It is exciting to optimize the fly ash content with the Portland Slag Cement, a huge cost relieves for concrete production .

Keywords: Concrete, Compressive strength, Class C fly ash, ASTM, Pozzolanic

I. INTRODUCTION

In last four decades, cement concrete technologies have shown drastic and the innovative changes. Apart from the strength consideration, durability and economy have become important factors for deciding the concrete quality. Earlier, the concept of higher cement content means greater strength and thus durability has not marked in true sense for the structures, exposed to different climatic conditions. To make cement concrete strong and durable at lower cost, use of supplementary cementitious material i.e. fly ash started in practice and is now established technology in all over the world. Today cement concrete has 4 essential ingredients- cement, aggregates (coarse & fine), water and fly ash in place of traditionally 3 ingredients cement, aggregate and water. Although various Indian Standards published by Bureau of Indian Standard (BIS) specifies use of fly ash as part of replacement of cement in concrete, in actual practice, our journey is in initial stage.ash is a residual material of energy production using coal, which has been found to have numerous advantages for use in the concrete industry. Some of the advantages include improved workability, reduced permeability, increased ultimate strength, reduced bleeding ,better surface finish and reduced heat of hydration. Fly ash produced in modern power stations of India is of good quality as it contains low sulphur& very low unburnt carbon i.e. less loss on ignition For several years it has been used in varying proportions and compositions in concrete. Research indicates that there are still additional benefits to be gained if the concrete industry can further optimize its use in concrete. Several types of fly ash are produced depending on the type of coal and the coal combustion process. It is a pozzolanic material and has been classified into two classes, F and C, based on the chemical composition of the fly ash. The fly ash being used for this research contains significant amounts of lime and would be categorized as a Class C fly ash. Portland cement is composed of free lime and siliceous and aluminous materials (pozzolans), which in the presence of water, will chemically react with the calcium hydroxide released by the hydration process to form a cementitious paste that binds the inert materials in the concrete . Fly ash is also a pozzolanic material but with different amounts of the constituents. The fly ash being used for this study contains significant amounts of lime, which reacts with the pozzolans within itself forming (hydrated) calcium silicate gel or calcium aluminate gel (cementious material) which bind the inert material together, making it self-cementing. All fly ashes have a particle size ranging less than 0.075 mm . The fineness and lime content properties of the fly ash are of great concern since they will affect the air content and water demand of the concrete;

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parameters that greatly affect the durability and strength of concrete respectively.

A. Methodology

A series of tests will be carried out, analyzed and compared to concrete manufactured with only Portland Slag cement as a binder. The tests to be done will focus on the workable and cohesive mix in fresh concrete and the compressive strength at 7 days and at the 28 days of the different mixes of concrete.

B. Materials and Testing

1) *Fly Ash:* High Lime fly ash obtained from a local power plant was used in this project. The specific gravity of the fly ash used was 2.71 g/cc. This fly ash had a significant amount of lime at 21.35% and a sulfur trioxide content of 5.19 %, which exceeds the ASTM C618 limits for Class C fly ashes for use in concrete. At the initial stages, this project has focused more on the positive utility of the high lime and very little concern has been given to the high sulfur content.
2) *Portland Slag Cement (PSC):* PSC is blended cement. It is the most suitable cement for Infrastructure Projects because of its high flexural strength. Maximum strength, low risk of cracking, improved workability, and superior finish are the advantages of PSC. Portland Slag Cement (PSC) is manufactured by either inter-grinding in the Portland cement clinker, Gypsum & Granulated Slag or blending the Ground Granulated Blast Furnace Slag (GGBS) with Ordinary Portland Cement by means of mechanical blenders. It confirms the IS: 12089 standards for producing PSC. It is created with a combination of 45-60% slag, 35% – 50% clinker, and 3-5% gypsum. PSC has been voted as the most suitable cement for concrete pavements, mass concrete applications, high performance or high strength concrete, structures and foundations, pre-cast concrete such as pipe & block, concrete exposed to sea water and marine application.
3) *Aggregate:* As coarse aggregate 20mm size and 10 mm size aggregate is being used. It is crushed stone. River sand is used as fine aggregate.It's source is Mahanadi River. All aggregates confirming the criteria of IS 383, along with requirements of IS 2386.
4) *Admixture:* To maintain the required workability of the green concrete upto the pouring point of the structure, super plasticizer is used.

C. Compressive Strength

The concrete was designed using the recommended guidelines as per IS 10262. Design strength at 28 days is target strength, for grade 15 MPa and 30MPa is with a target strength of 19.95MPa and 38.25MPa respectively. Workability in terms of slump is maintained at 80-120 mm after 1hour. Water/cementitious ratio for each trials of particular Grade will be maintained, following the criteria of IS 456:2000.The concrete mixes would be made using PSC Cement and maximum size of aggregate is 20mm.They were prepared and batched by weight with varying percentages of fly ash added to replace varying percentages of the cement. The Concrete cubes casted for 7days and for 28 days will be tested to know the Compressive strength of each trials, following the criteria of IS 516.

II. LITERATURE REVIEW

Many researchers had worked and published the papers on optimization of fly ash in concrete. After studying these papers, the methods, approach and further study of research motivates for this research. Summary of some research papers are mentioned here.

A. Literature on Optimizing the use of Fly Ash in Concrete - Portland Cement

Thomas used fly ash as a supplementary cementitious material (SCM) in the production of portland cement concrete.A supplementary cementitious material,when used in conjunction with portland cement,contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity,or both.As such,SCM's include both pozzolans and hydraulic materials.A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value,but that will,in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties.Pozzolans that are commonly used in concrete include fly ash,silica fume and a variety of natural pozzolans such as calcined clay and shale,and volcanic ash. SCM's that are hydraulic in behaviour include ground granulated blast furnace slag and fly ashes with high calcium contents (such fly ashes display both pozzolanic and hydraulic behaviour).

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For any given situation there will be an optimum amount of fly ash that can be used in a concrete mixture which will maximize the technical, environmental,and economic benefits of fly ash use without significantly impacting the rate of construction or impairing the long term performance of the finished product. The optimum amount of fly ash will be a function of wide range of parameters and must be determined on a case-by-case basis.

B. Literature on Specifying Fly Ash for use in Concrete

Karthik H. Obla, used fly ash in concrete has had a successful track record. The performance benefits fly ash provides to mechanical and durability properties of concrete have been well researched and documented in actual structures.Currently, fly ash is used in more than 50% of all ready mixed concrete placed in the United States, yet many design professionals continue to remain overly restrictive when it comes to using fly ash in concrete.Th is article addresses some optimal ways of specifying fl y ash for use in concrete while ensuring that the desired concrete performance is achieved. Most of these recommendations form part of a larger NRMCA publication that should be released later in 2008. Project specifications for most commercial work in the United States are typically written as per American Institute of Architects Master Spec format.

C. Literature on Development of Statistical Models for Mixture Design of High-Volume Fly Ash Self-Consolidating Concrete

R. Patel, K. M. A. Hossain, M. Shehata, N. Bouzoubaa, and M. Lachemi worked on Self-consolidating concrete (SCC) in the fresh state is known for its excellent deformability, high resistance to segregation, and use, without applying vibration, in congested reinforced concrete structures characterized by difficult casting conditions. Such concrete can be obtained by incorporating either mineral admixtures such as fly ash (FA) or viscosity-modifying admixtures (VMA). The use of VMA has proved very effective in stabilizing the rheology of SCC, and recent researches are focused on the development of new, cheaper VMAs compared with currently available, costly commercial ones. Research to produce an economical SCC with desired properties was conducted over the last few years with the use of FA. In the present study, 21 statistically balanced concrete mixtures were investigated to minimize the use of high-range water-reducing admixtures (HRWRA) and to optimize the use of fly ash in SCC. The minimum use of HRWRA and optimum use of FA were desired in this study. Four independent variables such as total binder content (350 to 450 kg/m3), percentage of FA as cement replacement (30 to 60% by mass), percentage of HRWRA (0.1 to 0.6% by solid mass), and water-binder ratio w/b (0.33 to 0.45) were used for the design of SCC mixtures. The fresh concrete properties were determined from slump flow, V-funnel flow, filling capacity, bleeding, air content, and segregation tests. The mechanical properties and durability characteristics of SCC such as compressive strength, freezing-and-thawing resistance, rapid chloride permeability, surface scaling resistance, and drying shrinkage were determined to evaluate the performance of SCC. Four statistical models to predict the slump flow, 1-day and 28-day compressive strength, and the rapid chloride permeability of SCC were developed and their performances were validated. The models can be used as economical tools for the optimized design of FA SCC mixtures with desired properties in practical applications.

III. CONCLUSION

There are lots of works relating the optimization but in each cases binder material cement, Portland cement like OPC cement is being used. The literature on the optimization of fly ash with Portland cement, greatly helps to understand the behaviour of fly ash in concrete. A 25-35% of fly ash gives the optimal results. The uses of 30-60% fly ash by mass of cementitious material is being used for high volume fly ash self- consolidating concrete .It is good opportunity to work out the project, to optimize the fly ash in concrete with Portland slag cement.

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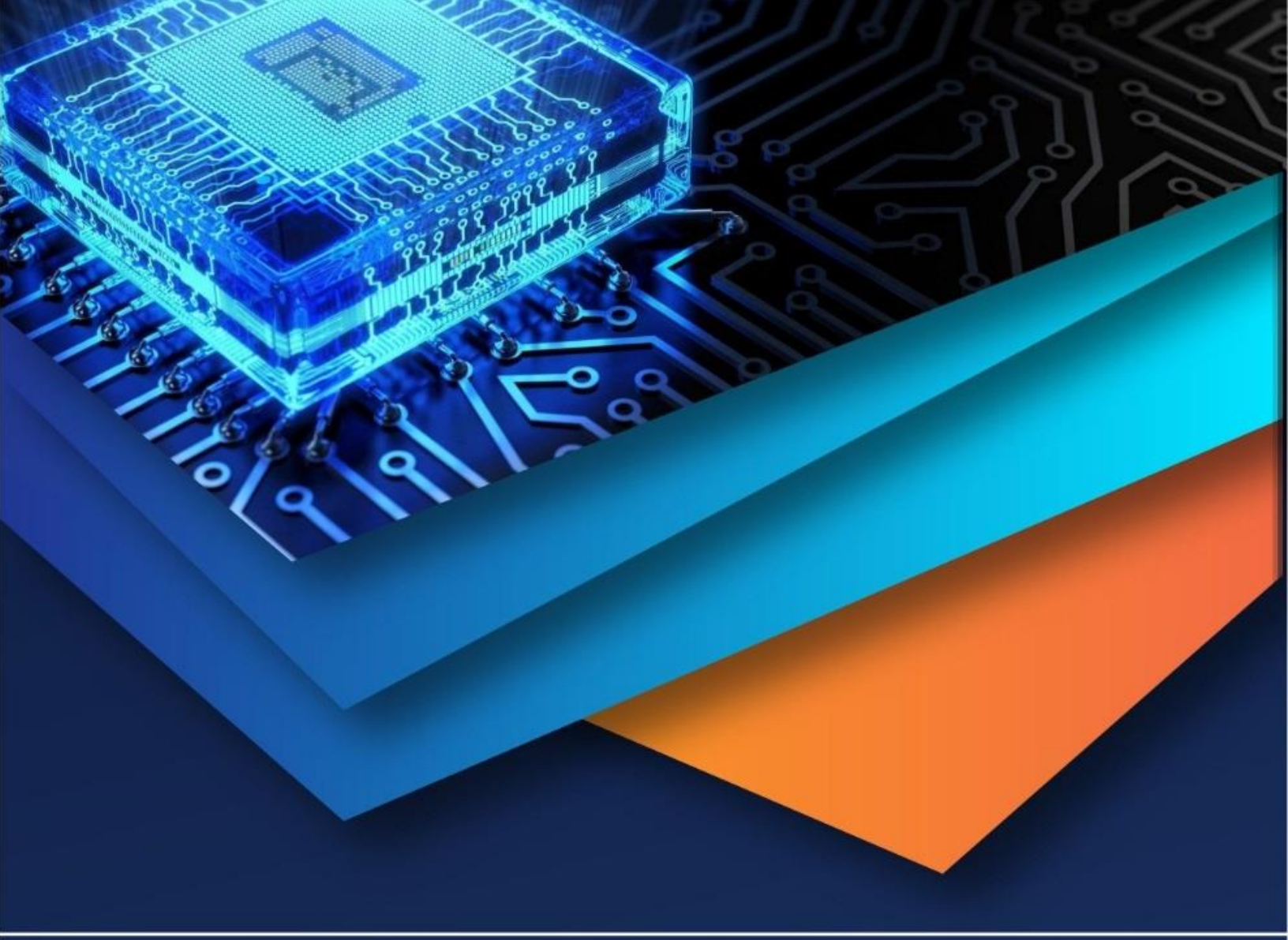

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