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Self Conducting Concrete with Fly ash Replacement Cement for High Strength Concrete

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Self-Compacting Concrete, Fly ash, GGBS, Conplast SP 430, Workability, compressive strength, split tensile strength, Flexural strength.

ABSTRACT

Self-consolidating concrete (SCC) is being used in wide ranged buildings pavements and industrial applications which may be subjected to high temperatures to support fire resistance. The proper meaning of the effects of standard temperatures on the properties of SCC is necessary. It can flow and compact under its own weight into a uniform void free mass even in areas of congested reinforcement. The mix design for SCC was arrived as per the Guidelines of European Federation of National Associations Representing for Concrete (EFNARC-2005). In this investigation, SCC was made by usual ingredients such as cement, fine aggregate, coarse aggregate, water, fly ash and GGBS at various replacement levels. The super plasticizer used was conplast SP 430. Workability of the fresh concrete is determined by using tests such as: slump flow, L-Box and U-box tests. The mixes were then tested for other mechanical properties like, cube compressive strength at 7th day, 28th day, split tensile strength, and flexural strength at 28th day. For all levels of cement replacement with admixtures concrete achieved superior performance in the fresh and mechanical tests.. In the experiment flyash was varied by 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. GGBS was kept constant at 20% for all mixes. Cement was proportioned as 75%, 70%, 65%, 60%, 55%, 50%, 45%, and 40% respectively. The mechanical properties like Compressive strength, Split Tensile Strength, and Flexural properties were examined by replacing VMA with conplast SP 430.

INTRODUCTION

The cement industry is India's second highest payer of Central Excise and a major contributor to GDP. With infrastructure development growing and the housing sector booming, the demand for cement is also bound to increase. However, the cement industry is extremely energy intensive. After aluminum and steel, the manufacturing of Portland cement is the most energy-intensive process as it consumes 4GJ per tonne of energy.

After thermal power plants and the iron and steel sector, the Indian cement industry is the third largest user of coal in the country. In 2003-04, 11,400 million kwh of power was consumed by the Indian cement industry. The cement industry comprises 130 large cement plants and more than 300 mini cement plants. The industry's capacity at the beginning of the year 2008-09 was about 198 million tonnes. The cement demand in India is expected to grow at 10% annually in the medium term buoyed by the housing, infrastructure, and corporate capital expenditures. Considering an expected production and consumption growth of 9 to 10 percent, the demand-supply position of the cement industry had improved from 2008-09 onwards. Coal-based thermal power installations in India contribute about 65% of the total installed capacity for electricity generation.

In order to meet the growing energy demand of the country, coal-based thermal power generation is expected to play a dominant role in the future as well, since coal reserves in India are expected to last for more than 100 years. The ash content of coal used by thermal power plants in India varies between 25 and 45%. However, coal with an ash content of around 40% is predominantly used in India for thermal power generation. As a consequence, a huge amount of fly ash (FA) is generated in thermal power plants, causing several disposal-related problems.

In spite of initiatives taken by the government, several non-governmental organizations and research and development organizations, the total utilization of FA is only about 50%.

India produces 130 million tonnes of FA annually which is expected to reach 175 million tonnes by 2012. Disposal of FA is a growing problem as only 15% of FA is currently used for high-valueadded applications like concrete and building blocks, the remainder being used for land filling.

Globally, less than 25% of the total annual FA produced in the world is utilized. In the USA and China, huge quantities of FA are produced (comparable to that in India) and its reported utilization levels were about 32% and 40%, respectively, during 1995.

FA has been successfully used as a mineral admixture component of Portland pozzolanic blended cement for nearly 60 years. There is effective utilization of FA in making cement concretes as it extends technical advantages as well as controls the environmental pollution. Producing one tonne of cement requires about 2 tonnes of raw materials (shale and limestone) and releases 0.87 tonne (H" 1 tonne) of CO_2, about 3 kg of Nitrogen Oxide (NO_2), an air contaminant that contributes to ground level smog and 0.4 kg of PM_{10} (particulate matter of size 10 μm), an airborne particulate matter that is harmful to the respiratory tract when inhaled. The global release of CO_2 from all sources is estimated at 23 billion tonnes a year and the Portland cement production accounts for about 7% of total CO_2 emissions.

The cement industry has been making significant progress in reducing CO_2 emissions through improvements in process technology and enhancements in process efficiency, but further improvements are limited because CO_2 production is inherent to the basic process of calcinations of limestone. Mining of limestone has an impact on land-use patterns, local water regimes, and ambient air quality and thus remains as one of the principal reasons for the high environmental impact of the industry.

Dust emissions during cement manufacturing have long been accepted as one of the main issues facing the industry. The industry handles millions of tonnes of dry material. Even if 0.1 percent of this is lost to the atmosphere, it can cause havoc environmentally. Fugitive emissions are therefore a huge problem, compounded by the fact that there is neither an economic incentive nor regulatory pressure to prevent emissions.

The cement industry does not fit the contemporary picture of a sustainable industry because it uses raw materials and energy that are non-renewable; extracts its raw materials by mining and manufactures a product that cannot be recycled. Through waste management, by utilizing the waste by-products from thermal power plants, fertilizer units and steel factories, energy used in the production can be considerably reduced.

This cuts energy bills, raw material costs as well as greenhouse gas emissions. In the process, it can turn abundantly available waste materials such as FA and GGBS and have a very small Greenhouse footprint when compared to traditional concretes.

For several years beginning in 1983, the problem of durability of concrete structures was a major topic of interest in Japan. The creation of durable concrete structures required adequate compaction by skilled workers. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work.one solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self compacting concrete, which can be compacted into every corner of a formwork, purely by its own weight and without the need of vibration and compaction.

II. OBJECTIVES AND SCOPE OF THE WORK

There is a necessity for the development of high strength self compacting concrete using GGBS and FLY ASH in order to stop the environmental pollutants that are liberated into the atmosphere in the making of cement, to stop the utilization of fossil fuels in manufacturing of cement in kilns and to stop the depletion of natural resources.

The utilization of the waste materials which are nothing but the by products in the manufacturing iron and in thermal industries while burning coal were used which serves as mineral admixtures. GGBS slag greatly enhances the chemical resistance particularly to chlorides and sulphates and are especially advantageous when used in marine environment. Fly ash being very small particles they can reduce the voides and densifies the structure and reduces the permeability. Compared to ordinary Portland cement, fly ash liberates very low amounts of heat during hydration process and more over the workability of the concrete will be improved

Objective 1: To obtain the Mix Design for High Strength Self Compacting Concrete of M 40 grade incorporating fly ash fillers as per Nan Su mix design procedure and satisfying with EFNARC guide lines for different combinations of mineral admixtures, chemical admixtures, and complete replacement of fine aggregate fly ash and ggbs.

Objective – II: To study the Fresh Properties of HSSCC.

Objective– III: To study the Hardened Properties of HSSCC.

Objective– IV: To analyze the flexural behavior and crack pattern for HSSCC.

With the above objectives in mind the experimental program is categorized into four phases as detailed below.

III MATERIALS

The materials generally required for producing self-compacting concrete differs from the ordinary normal concrete as self-compacting concrete uses more powder content and less coarse aggregate, in addition, to reducing water in a larger quantity. The factors which dominate the selection of materials are-

I. Amount of aggregates used for self-compacting concrete which is deviating from ideal shapes and sizes.

Ii. Type of superplasticizer used.

Iii. Types of powder used (fly ash and ggbs).

Iv. Compatibility between cement, water, aggregate, superplasticizer, flyash,andggbs.

Cement

In our work, we have used ordinary Portland cement of 53 Grade ultra tech super conforming to IS 12269:1987. The properties of the cement used are shown in TABLE 4.

IV PROPERTIES OF CEMENT

Properties of cement

Physical Properties	Results
Fineness by dry sieve % (90 micron)	5 %
Specific Gravity	3.2
Initial setting time (min)	204
Final setting time (min)	315
Normal Consistency	30%
Compressive strength at 3- days (N/mm2)	35.10
Compressive strength at 7- days (N/mm2)	47.30
Compressive strength at 28- days (N/mm2)	56

4.1 Aggregates: The shape and size of aggregates play an important role in making self-compacting concrete. Much research has been conducted in this area to produce self-compacting concrete by using locally available aggregates. However, it is possible to produce a flowable concrete by using angular aggregates by Naturally available aggregates which are used as the coarse aggregates in the concrete mixtures. Locally available aggregates of medium size 20mm were used as the coarse aggregate.

TABLE 4.1 [COARSE AGGREGATE PROPERTIES]

Properties Of Coarse Aggregates

Property	Value
Size	20mm
Shape	Irregular
Specific gravity	2.8
Abrasion	28.58%
Water Absorption	0.60%
Crushing value	14.23%

Because of unavailability of sand in present days due to the environmental impact of mining river sand in India, an alternative to fine aggregates or artificial sand is being used much as a filler to produce self-compacting concrete.

4.2 FLYASH AND GGBS

FLY ASH

Fly ashis residue attained after combustion of coal. Fly ash used in the study from ASTM Class F and it is sourced from RDC CC plant near Bachupally in Hyderabad. The specific gravity of fly ash used was 1.79. Class F fly ashes are produced from bituminous and sub-bituminous coals and contain alumina and silicate as active components. In this experimental work,flyash is taken as a binder.

Ground Granulated Blast Furnace Slag (GGBS)

Blast furnace slag is a by-product obtained in the manufacture of iron. It is a product formed by the combination of the earthy constituents of iron-ore with the limestone flux at high temperature in

The blast furnace (about 1500 0c). The molten slag is rapidly quenched by a hose of water to yield a glassy granular non-metallic material consisting essentially from silicates and aluminates of calcium and other products called ground granulated blast furnace slag. The specific gravity of GGBS is 2.58. In this experimental work, GGBS was assumed as a binder.

TABLE 4.2 [FLY ASH AND GGBS PROPERTIES]

Properties of Fly Ash and GGBS

Property	**Fly-ash**	**GGBS**
Specific gravity	1.72	2.56
Bulk density (Kg/m^3)	500-800	1100
Appearance	Grey	White
Particle size	30 microns	25 microns
Fineness (m^2/kg)	345	375

4.3 Super Plasticiser (conplastsp 430)

High range water reducing admixture plays an important role in the desired flow at low water contents. In this experiment, we have used conplastsp 430 as superplasticizer it is an admixture of a new generation based on polycarboxylic ether. The product has been developed for application of High-strength concrete where highest durability and performance is required. Conplast 430 is free of chlorine and low alkali. It is compatible with all types of cement. The product complies with ASTM C494 Type F.

TABLE 4.3 [CONPLAST 430 PROPERTIES]

Properties of conplast 430

Aspect	Brownishfree-flowing liquid
Relative Density	1.09, 0.01 at 25°C
PH 7	± 1
Chlorine iron content	< 0.2%

Water

Potable water was used for mixing and curing.

V EXPERIMENTAL INVESTIGATION

The main objective of the present experimental investigations is to produce a standard grade of HIGH STRENGTH SELF COMPACTING CONCRETE (HSSCC) of strength 100 mpa and above, with addition of mineral and chemical admixtures and to study their rheological and hardened properties.

Total experimental programme was taken up in four phases. They are

To obtain the Mix Design for High Strength Self Compacting Concrete M100 grade using Nan Su mix design, optimizing materials, replacement of cement withggbs and flyash.

I. To analyse the mix design of HSSCC.

II. To study the Fresh Properties of HSSCC.

III. To study the Hardened Properties of HSSCC.

IV. To analyze the flexural behaviour and crack pattern for HSSCC.

VI EXPERIMENTAL CALCULATIONS RESULTS AND DISCUSSIONS

This chapter illustrates the mix designs and the experimental results that we have arrived at after several tests and the analysis of the test results was done and the mixes were optimized by based on the test results obtained as per the guidelines given by EFNARC for self –compacting concrete mixes. As explained in the previous chapter the fresh properties were determined through flow table test and L-Box test. The fresh properties were analysed to get an optimized mix satisfying the guidelines given by EFNARC. All the details of the tests that are performed on the fresh and hardened concrete were given in this chapter

CONCLUSION

The following Conclusions arrived based on this study:

1) In this project we worked on the development of highstrength self compactingconcrete.

2) We also discussed about the literature reviews and there referels.

3) We have work on the material properties and mixing and placing of concrete mix into moulds and after that curing for the time period.

4) In this project we have replaced cement with flyash partially and compared results of compressive strength, flexural strength, split tensile strength.

5) We have used GGBS 20% for whole mixes the GGBS % was constant.

6) Flyash was varied from 5% to 40% by replacing cement for every mix to develop high strength concrete.

7) Conplastsp 430 was used as the super plasticizer and viscosity modifying agent was not used in the pan mix.

8) We conclude that replacement of flyash for cement improved the fresh and hardened properties confirming the use of this sustainable material in concrete. All the mixes (HSSCC1 – HSSCC8) could satisfy the SCC properties laid by EFNARC guidelines.

9) It is absorbed that Increase of 40% in 28 days compressive strength when compared with 7 days compressive strength of nominal mix (mix 1).

10) It is observed that Increase of 25% in 28 days compressive strength when compared with 7 days compressive strength of optimum mix (mix 4).

11) It is observed that Increase of 15% is observed in 28 days compressive strength when compared with 7 days split tensile strength of optimum mix (mix 4).

12) It is observed that Increase of 20% in 28 days compressive strength when compared with 7 days flexural strength of optimum mix (mix 4)

13) Mix 4 is considered as optimum mix with maximum mechanical properties and maximum increase of their parameters.

14) Optimum mix is also satisfies all rheological properties under EFNRC guidelines.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Christelle Didier, Engineering ethics at the Catholic University of Lille (France): research and teaching in a European context, Eur. J. Eng. Educ. 25 (February) (2000) 325–335, https://doi.org/10.1080/03043790050200368.

[2] Michiel Brumsen, Ethics in engineering in The Netherlands: the role of professional associations, universities, and law, Int. J. Eng. Educ. 21 (3) (2005) 391–401.

[3] Hengli Zhang, Michael Davis, Engineering ethics in China, Bus. Prof. Ethics J. 37 (1) (2018) 105–135, https://doi.org/10.5840/bpej201821967.

[4] Geoffrey M. Hodgson, What are institutions? J. Econ. Issues 40 (1) (2006) 1–25, https://doi.org/10.1080/00213624.2006.11506879.

[5] Douglass C. North, Institutions, institutional change and economic performance. Political Economy of Institutions and Decisions, Cambridge University Press, Cambridge, 1990. https://books.google.com/books?id=oFnWbTqgNPYC.

[6] E. Ostrom, R. Gardner, A. Agrawal, J. Walker, J.M. Walker, J. Walker, Rules, Games, and Common-Pool Resources. ACLS Humanities E-Book, University of Michigan Press, 1994. https://books.google.com/books?id=DgmLa8gPo4gC.

[7] Clifford Geertz, What is a country if it is not a nation? Brown J. World Aff. 4 (2) (1997) 235–247. [8] Sara R. Jordan, Phillip W. Gray, Responsible conduct of research training for engineers: adopting research ethics training for engineering graduate students, in: Engineering Ethics for a Globalized World, Springer, 2015, pp. 213–228.

[9] Gary Lee Downey, Juan C. Lucena, Carl Mitcham, Engineering ethics and identity: emerging initiatives in comparative perspective, Sci. Eng. Ethics 13 (4) (2007) 463–487, https://doi.org/10.1007/s11948-007-9040-7.

[10] Brock E. Barry, Joseph R. Herkert, Overcoming the challenges of teaching engineering ethics in an international context: a us perspective, in: Engineering Ethics for a Globalized World, Springer, 2015, pp. 167–187.

[11] Abdi O. Shuriye, Mohammad H. Hassan, Waleed F. Faris, Islamic engineering ethics: foundation, integration and practice, Future Text Publication (2006) 67–73.

[12] E. Ostrom, Understanding Institutional Diversity, Princeton University Press, Princeton, 2005.

[13] Michael D. McGinnis, An introduction to IAD and the language of the Ostrom workshop: a simple guide to a complex framework, Pol. Stud. J. 39 (1) (2011) 169–183, https://doi.org/10.1111/j.1541-0072.2010.00401.x.