IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 4, April 2018

Energy Efficient Cement Concrete with Partial Replacement of Ordinary Portland Cement by Fly Ash

Mr. Rikesh Bharatkar[1], Mrs. Arti Bharatkar[2]

Lecturer, Civil Engineering Department, Acharya Shrimannarayan Polytechnic, Wardha, India[1]

Lecturer, Civil Engineering Department, Agnihotri College Engineering, Wardha, India[2]

Abstract: Energy is one of the most important factors in economic growth and social development in all countries. Construction works consume energy at different levels in every stage of the life-cycle. Construction materials occupy a great share of this consumption. Therefore, the amount of energy consumed by materials used in structures during their lifecycle is an important parameter in determining the energy efficiency of the Structure. In this experimental study, the importance of energy efficient material selection in designing "Energy Efficient Cement Concrete" is considered and discussed. It presents the feasibility of the usage of by product waste materials like fly ash, query dust, marble powder/ granules, plastic waste and recycled concrete and masonry as aggregates in concrete. The use of fly ash in concrete contributes the reduction of greenhouse emissions with negative impacts on the economy and reduction of quantity of cement in concrete, hence energy required for production also reduced. It has been observed that 0.9 tonne of CO_2 is produced per ton of cement production. The concrete is made with wastes materials which are eco-friendly so called as Green concrete. Thus, by the use of green concrete it is possible to reduce the CO_2 emission in atmosphere towards eco-friendly construction technique and also reduce energy required for production of Ordinary Portland Cement.

Keywords: Energy Efficient Cement Concrete, Green Concrete, Fly Ash, Lifecycle, Greenhouse Emission.

I. INTRODUCTION

Cement concrete most widely used construction material in the world over, commonly consists of cement, aggregates (fine and coarse) and water. It is the material, which is used more than any other man made material on the earth for construction works. In the cement concrete, cement chemical reaction with water and then generates bonding gel that binds other ingredients together and creates stone type of material.

Use of fly ash in concrete imparts several environmental benefits and thus it is ecofriendly. Fly ash spares the cement required for the same strength thus saving of required raw materials such as limestone, coal for manufacture of cement. Manufacture of cement is high energy intensive industry. In the manufacturing of one tonne of cement, about 0.9 tonne of CO_2 is emitted and goes to atmosphere. Less requirement of cement means less emission of result in reduction in greenhouse gas emission. Due to low calorific value and high ash content in Indian Coal, thermal power plants in India, are producing huge quantity of fly ash. This huge quantity is being stored / disposed of in ash pond areas. The ash ponds acquire large areas of agricultural land. Use of fly ash reduces area requirement for pond, thus saving of good agricultural land.

II. LITERATURE REVIEW

A. Swapnil Samrit[1], Piyush Shrikhande[2] and M.V.Mohod[3] (2016).

In this research paper Fly ash is difficult to decompose, so using fly ash is a major step towards sustainable development. Also, Cement industry is one of the major contributors to pollution by releasing carbon dioxide. So by partially replacing cement with pozzolanic material such as fly ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time providing a green and clean environment. This can not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs. This research work is to investigate the behavior of concrete pavement while replacing fly ash in different proportions. The cement has been replaced accordingly in the range of 0%, 10%, 15%, & 20% by weight of M_{30} grade concrete. Concrete mixtures were produced, tested and compared in terms of compressive strength, flexural strength and split tensile strength as an alternative to traditional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 & 28 days.

B. Vinod Goud[1] and Niraj Soni[2] (2016).

In this research paper Fly ash a waste generated by thermal power plants is as such a big environmental concern. In modern decades, the industrialization and urbanization are the two phenomena that are spreading all over the world. Apart from the requirement of these phenomena, there should also be investigation into their negative impacts on the worldwide environment and common life. Most important poor effect of these international processes has been the production of large quantities of industrial wastes. Therefore, the problems related with their safe management and dumping has turned into a major test to environmentalists and scientists. Another problem is the stress on land, materials and resources to sustain the developmental activities, including infrastructure. The thermal power plants produce considerably large quantities of solid by product namely fly ash.

C. R. D. Padhye[1] and N. S. Deo[2] (2016).

In this research paper the potential for using fly ash as a supplementary cementitious material in concrete has been known almost since the start of the last century. Historically, fly ash has been used in concrete at levels ranging from 15% to 25% by mass of the cementitious material component. There has been lot of research took place over using fly ash as additive in cement, admixture in concrete and cement replacement material in concrete. But most of the research has been limited to few percentages of cement replacement for concrete of fewer grades. Different grades of concrete mixes with varying percentage of fly ash content were prepared and the effects of fly ash on mechanical properties of fresh and hardened concrete have been investigated. The compressive strength of concrete was measured for 7, 28 and 45 days and compaction factor is taken as a measure of workability. A different comparative study is done consisting of rate and strength as parameters. Compressive strength of concrete at different proportions of cement being replaced by fly ash has been checked and results have been found effective and applicable. Hence, a comparative study is done and use of fly ash as a cement replacement in concrete can be analyzed and compared. The paper aims to study the effects of Fly ash as partial replacement of cement in concrete and ascertain the optimum proportion of fly ash for different grades of concrete which is acceptable, applicable and economical. This paper studies the variation in compressive strength of different grades of concrete at different percentages of fly ash and at different curing periods.

D. T. Subramani[1] and K. S. Ramesh[2] (2015).

In this research paper due to rapid growth in construction activity, the available sources of natural sand are getting exhausted & also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality. Therefore, it is necessary to replace natural sand in concrete by an alternate material partially, without compromising the quality of concrete. Quarry sand is one such material which can be used to replace sand as fine aggregate. The present study is aimed at utilizing Quarry sand as fine aggregate replacing natural sand and also the compressive strength of the water cured specimens is measured on the 7,14,28 Days. Split Tensile strength, Flexural Strength, Here we have conducting a test on concrete by using fly ash and m sand. By using these materials we have find out strength on a concrete by adding partial replacement on cement with fly ash and complete replacement of sand with m sand.

E. Sanghsheel Ghodeshwar[1], Mukesh Pandey[2] and Rakesh Gupta[3] (2017).

This Paper is dealing with the energy and comfort issue in residential and real estate sector without affecting the nature. Challenge is the planet facing various problems like global climate change, environmental contamination, foul air and depletion of resources, due to increasing amount of carbon element in nature which helps in reducing the resources and affects human health.

Building itself contain more than 40% of energy, 30% of natural resources, 20% of water, also 40% of CO_2 emission and produce 30% of solid waste. This paper is concerning about energy and atmosphere, sustainable sites, indoor environment quality, water efficiency, material and resources, with adopting techniques like proper designing, orientation, using energy efficient materials, proper insulation with maximize the use of renewable resources and achieves various measures to save energy, resources as well environment health.

F. Izzet Yuksek (2015).

Buildings consume energy at different levels in every stage of the life-cycle. Building materials occupy a great share of this consumption. Therefore, the amount of energy consumed by materials used in building during their life cycle is an important parameter in determining the energy efficiency of the building.

In this study, the importance of energy- efficient material selection in designing "Energy-Efficient Building" is considered and discussed.

It is possible to evaluate some building materials in Turkey in the framework of energy efficient building material criteria. This information is considered as a guide for users and employees of the building sector. As a result of the

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study, the selection of building material and energy efficient features of building materials are important parameters for the provision of energy efficiency.

III. MATERIAL USED

1) **Ordinary Portland cement:** IS: 8112-1989 conforming to 43 Grade OPC cement. The properties of the cement tested ware Normal consistency 32%, Fineness (90 Micron Sieve) 5.50%, Initial and Final Setting time 160 minute and 365 minute and after curing (28 Days) compressive strength 49.35 Mpa.
2) **Water:** Water conforming to as per IS: 456-2000 SECTION 2, Clause:5.4 was use for mixing and curing clean and free from injurious amount of oil, acid, alkalis, salt, sugar and other substance deleterious to concrete specimens.
3) **Fine Aggregate:** IS**:** 383-1970 conforming to Natural sand with maximum size of 4.75 mm was used (zone II) with specific gravity 2.53 and fineness modulus 5.13 and free from silt.
4) **Coarse Aggregate:** IS**:** 383-1970 conforming to Natural coarse aggregates with maximum size of 40 mm were used with specific gravity of 2.7 and fineness modulus 6.5
5) **Fly Ash:** IS: 3812-1981 conforming to Fly ash is complex material having wide range of chemical, physical and mineralogical composition.

TABLE I
CHEMICAL COMPOSITION IN FLY ASH

Sr. No.	Chemical Composition in Fly Ash	Percentage (%)	Total	Remark
1	Silica (SiO_2)	53.20	82.35% > 70%	Siliceous Fly Ash (Class F Fly Ash)
2	Alumina (Al_2O_3)	22.44		
3	Ferric oxide (Fe_2O_3)	6.71		
4	Calcium oxide (CaO)	6.73	< 10%	
5	Magnesium oxide (MgO)	Nil		
6	Loss on Ignition	4.49		

IV. METHODOLOGY

In order to study the behaviour of fly ash based concrete, normal concrete testing was done to determine the material and structural properties of concrete and how will these properties differ according to a different type of mixture and its composition. Once concrete has hardened it can be subjected to a wide range of tests to prove its ability to perform as planned or to discover its characteristics. For new concrete this usually involves casting specimens from fresh concrete and testing them for various properties as the concrete matures. The concrete mix was designed for M_{20} grade and the mix design was done as per IS: 10262-1982 and IS: 456-2000. Mix design for concrete was made considering the properties of constituents of concrete. Concrete mix with varying fly ash content percentage were produced, replacing 0% (reference concrete), 10%, 30%, and 40%, cement in terms of weight. Cubic specimens of 150 mm size conforming to IS: 10086-1982 was casted for compressive strength test. The cubes were casted in steel moulds and wet cured at standard temperature until the time of test. The cubes cured for a time period of 7 and 28 days.

V. RESULT

Compressive strength tests ware conduct in accordance with IS: 516-1959 on all cubes of mixed ratio at 7 days and 28 days curing. The compressive strength test result is shown in figures.

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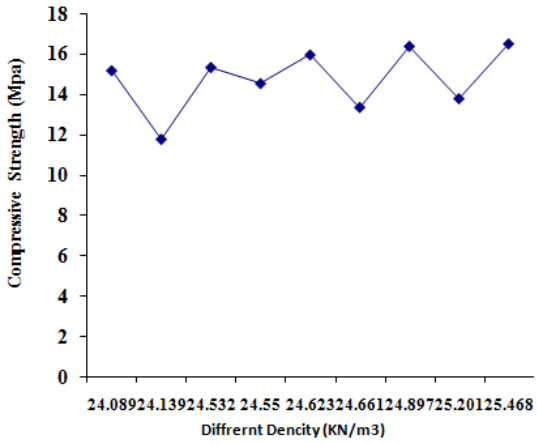

Figure 1: Compressive Strength at Different Density (For 7 Days)

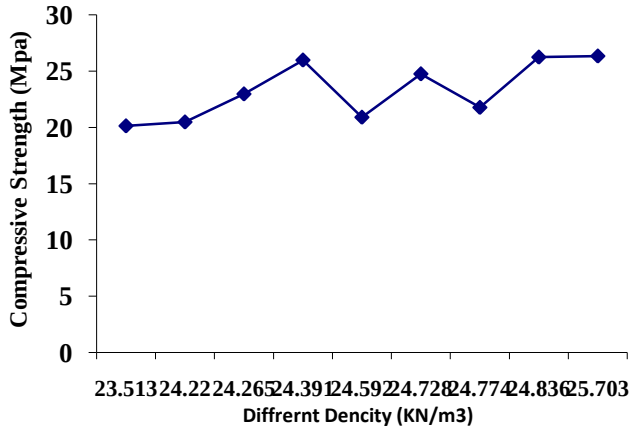

Figure 2: Compressive Strength at Different Density (For 28 Days)

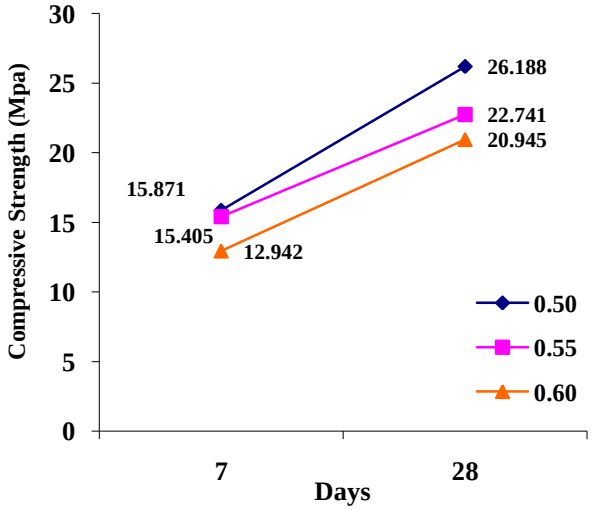

Figure 3: Compressive Strength at Different Water Cement Ratio

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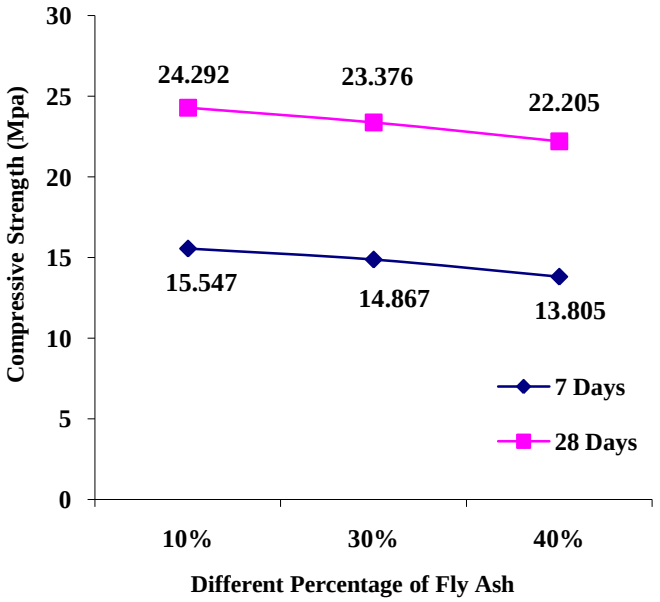

Figure 4: Compressive Strength at Different Percentage of Fly Ash

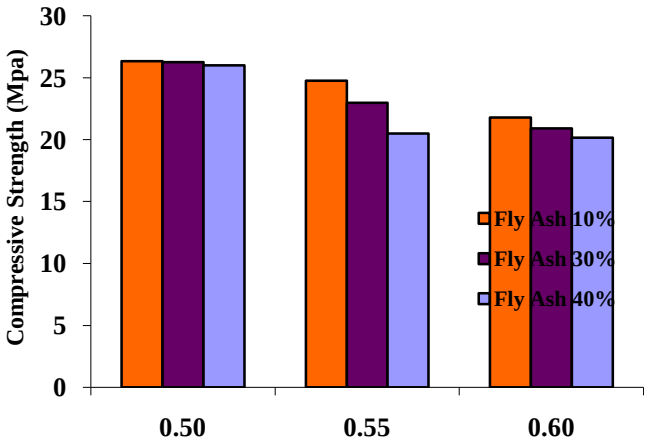

Figure 5: Compressive Strength at Different Water Cement Ratio and Different Fly Ash Percentage

VI. CONCLUSION

This study investigated the effect of Fly Ash on compressive strength of concrete. The results showed that the compressive strength, Density, water cement ratio and percentage of fly ash partial replacement of cement. The following conclusions could be drawn:

1) Ultimate compressive strength of concrete decreasing with increase in water cement ratio without affecting the target strength of concrete (Refer Figure: 3).
2) The 10% and 30% replacement of Ordinary Portland Cement with fly ash obtained required compressive strength for 7 days and 28 days (Refer Figure: 4) cannot effect on design mix strength, hence due to fly ash impact on environment is also reduced. Use of fly ash in concrete can save the coal and thermal industry disposal costs and produce a 'Green Concrete' for construction.
3) The fly ash can be replaced up to maximum of 40% and replacements above 40% may not be safe for different concrete mixes.

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