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Experimental study on strength and durability of sustainable concrete

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Abstract: The increase in concrete consumption increases the utilization of large quantities of energy and decreases the natural resources available. Ordinary Portland Cement (OPC) which is used in the production of concrete produces large amount of green house gases. Hence the conventional concrete is not sustainable. On the other hand industrialization leads to pollution and disposal of its waste has become a great problem. The possible solution for both of these problems is to replace all the ingredients of concrete with industrial by-products. Sustainable concrete is the only solution to make environmental friendly concrete. Sustainable concrete is manufactured by using industrial by-products like copper slag, Fly ash, silica fume etc.In this study ceramic waste+ Silica fume are used as alternatives to cement. Copper slag is used as alternative to sand (FA) and Ferro chrome slag is used as an alternative to coarse aggregate. Various trail mixes are conducted by using mortar mixes with different percentages of ceramic waste, Silica fume and fly ash with varying percentages of alkaline solution to binder ratio. Of all the mixes ceramic waste (60%) + Silica fume (40%) with 0.6 alkaline solution to binder ratios is finalized. the ratio of NaOH to Na_2SiO_3 is taken as 2.5.The concentration of solution was fixed as 10M NaOH solution and 50% Na_2SiO_3 solution. 1% of SP 430 is used as a super plasticizer. Alkaline solution is prepared 1 hour prior to preparation of sample. Various specimens like cubes, cylinders and prisms are casted as per IS specifications and studied for various properties like Compressive strength of cube , Split tensile strength, Flexural strength, Rebound hammer, Water absorption, density and durability properties like Rapid chloride penetration value and Temperature resistance were determined. It is observed from these tests that it can be used as an alternative to normal concrete for structural purposes.

Keywords: Sustainable Concrete, Durability

Introduction

In the present scenario, no construction activity can be imagined without using concrete. The consumption of concrete is increasing yearly. Ordinary Portland cement which is being traditionally been used as binder material in concrete is responsible for emission of huge amount of green house gases. Each ton of Portland cement manufactured produces one ton of CO_2. Besides this loss, since all its ingredients are natural resources, there is a threat for their extinction. Hence the conventional concrete is not sustainable. On the other hand industrialization leads to pollution and disposal of its waste has become a great problem. This is a threat to sustainability of environment. The possible solution is to replace all the ingredients of concrete with industrial byproducts. This project is an attempt to study the mechanical and durability properties of a sustainable concrete mix made by replacing all its ingredients with industrial byproducts.

With the increase in the number of industries the amount and type of wastes generated are also increased. Many wastes produced today will remain in the environment for thousands of years. The creation of non-decaying waste materials, combined with a growing consumer population has resulted in a waste disposal crisis. One solution to this crisis lies in recycling wastes into useful products for making the constructions economical and eco-friendly. If waste materials are used in concrete then it can be considered as Sustainable concrete.

Sustainability means “meeting the needs of the present without compromising the ability of the future generations to meet their own needs”. One of the biggest threats to the sustainability of the cement industry is the dwindling amount of limestone in some geographical regions. Limestone is essential for the production of Portland cement. As limestone becomes a limited resource, employment and construction associated with the concrete industry will decline. Therefore, those involved with these industries must develop new techniques for creating concrete with minimal use of limestone. Not only is concrete production a valuable source of societal development, but it is also a significant source of employment. Concrete is the world’s most consumed man-made material.

Some geographical regions are running out of limestone resources to produce cement. And major metropolitan areas are running out of materials to use as aggregates for making concrete. Sustainability requires those in the construction industry to consider the entire life cycle including construction, maintenance, demolition and recycling of buildings.

Cement plays a major role in production of concrete. A high amount of CO_2 is emitted during manufacture of Ordinary Portland Cement. Cement production contributes to 7% of global CO_2 emission. The key causes of high CO_2 emissions arising from OPC manufacture have been attributed to calcination of limestone and high energy consumption during manufacturing, including heating raw materials within a rotating kiln at temperatures greater than 1400 $^{\circ}$C.

Conclusion

Based on the results of the experimental program the following results were developed:

The appropriate percentage of ceramic waste and silica fume are finalized as 60% and 40% by conducting various trail mortar mixes using ceramic waste, Silica fume and fly ash.As the workability and setting time of geopolymer concrete are less, 0.6 alkaline liquid to binder ratio is finalized with respect to strength and workability.Compressive strength of GPC decreases with increase or decrease in silica fumes beyond 40%.After studying 14 types of mortar trail mixes it is concluded that combination of ceramic waste (60%) + silica fume (40%) gives the maximum compressive strength and good workability with alkaline binder ratio 0.6. Compressive strength of geopolymer concrete is comparatively higher than ordinary concrete for the same grade of concrete. It is also observed that the 7days compressive strength is almost equal to two third of 28 days strength which supports the application of this concrete as an alternative to normal concrete.The rapid chloride penetration test, chloride ion permeability values fall below 1000 for ambient curing specimens and in the range of 1000 to 2000 for the oven curing specimens. The low chloride ion permeability indicates that concrete reduces the steel corrosion and hence can be recommended for RCC.

LITERATURE CITED

Ashfi and Harjinder (2015), studied the Effect of supplementary cementitious materials on Characteristics of High Strength Concrete. It was concluded that the replacement material.

Harald Mullera et al. (2014), studied on the methods to assess and reduce the environmental impact of concrete and means to increase its performance. The presented concept is applied to the concrete type with the greatest potential in sustainability i.e., green concrete.

Mohamed Elchalakani et al. (2014), investigated the experimental test results of 13 types of concrete mixes made with high volume of ground granulated blast furnace slag (GGBFS) cement with 50%, 60%, 70% and 80% replacement of ordinary Portland cement (OPC) to reduce the carbon emissions.

Parthiban et al. (2013), studied the effect of various proportions of GGBS on fly ash based geopolymer. They also studied the effect of alkaline activated solution on the development of strength.