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Partial Replacement of Cement, Fine Aggregates & Coarse Aggregate with Fly Ash, Steel Slag & Recycled Aggregates Respectively in Concrete

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ABSTRACT

Construction industry has a wide range of work globally. In today's world, the construction rate is progressing very faster which results in the faster consumption of naturally occurring construction materials. Millions of tons of waste is produced in the world each year and most of it is not recyclable. Furthermore, recycling waste consumes energy and produces pollution. In addition, accumulation of waste in the suburbs and the disposal of waste are very dangerous for the environment. Using waste material in concrete production is an appropriate method for achieving two --goals: eliminating waste and adding positive properties in concrete. This project presents the experimental result carried out to determine the compressive strength of concrete at different replacement of cement, fine aggregates and coarse aggregates. M-20 grade of concrete (1:1.8:3.16) at w/c of 0.5 was designed as per IS-10262-2009. Result shows that cement, fine aggregates and coarse aggregates can be replaced at 10%, 20% and 30% by fly ash, steel slag and recycled aggregates respectively without compromising compressive strength of concrete. We are replacing the materials separately to know the strength how much will be increased. At some percentage it will be increases then we are replacing all materials at a time to know the compressive strength of concrete.

Keywords: cement, fine aggregates and coarse aggregates, compressive strength of concrete, fly ash, steel slag and recycled aggregates

1. INTRODUCTION

Construction industry uses approximately 20 billion tons of raw materials annually as reported. It consumes a large amount of natural resources that cause substantial environment, energy and economic losses as it exploits 50% raw materials, 40% of total energy, as well as generates 50% of total waste. Concrete is the most widely used constructional material in the world. There is a concern to more understanding and to improve its properties. Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel, limestone or granite, plus a

fine aggregate such as sand), water and chemical admixtures. The word concrete comes from the Latin word "concretus", which means "hardened" or "hard". Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, architectural structures, foundations, and motorways/roads, bridges/overpasses, parking structures, brick/block walls and footings for gates, fences and poles.

The depletion of good quality aggregates along with the increase in aggregate requirement due to increasing infrastructure development makes the lesser availability of natural materials, over quarrying led direct impact on environment and demand-supply chain of construction material are getting affected. Natural aggregates are becoming increasingly scare and their production and shipment is becoming more difficult and cement cost also increases. Generally, millions of tons of waste are produced in the world each year and most of it is not recyclable. Furthermore, recycling waste consumes energy and produces pollution. In addition, accumulation of waste in the suburbs and the disposal of appropriate method for achieving two goals: eliminating waste and adding positive properties in concrete. Theutilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. New by-products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes the environmental and health problems. Therefore, recycling of waste materials is a great potential in concrete industry. Fly ash, steel slag and demolition waste aggregates are the waste materials. These are polluting the environment. So, we are replacing all three materials in concrete such as cement with fly ash, fine aggregates with steel slag and coarse aggregates with demolition waste aggregates (recycled aggregates) in our project to reduce the pollution

Objective Of This Study

- To compare the compressive strength of concrete to conventional concrete.
- To reduce the pressure on naturally available aggregates by waste plastic and to reduce the emission of CO_2 during the production of cement.
- To compare the physical characteristics of recycled waste with natural aggregates.
- To study the properties of fresh and hardened concrete by replacement materials.
- To find out the percentage use of feasible for construction.
- To reduce the impact of waste materials on environment.
- To find out the ways of cost saving such as transportation, excavation etc.
- To explore possibilities of improving mechanical properties of concrete using steel slag instead of fine aggregate partially.
- To evaluate the effect of using steel slag in concrete.
- To evaluate the effect of just replacing the cement by fly ash used in concrete and to study the compressive strength of concrete under varying percentage of fly ash, as well as to study, the effect of varying curing time period under different exposure condition.
- To determine the optimum level of cement in concrete elements with highest compressive strength.
- Study the effect of fly ash incorporating in concrete on permeability in normal condition and aggressive condition.

In our project, mix design is done as per the bureau of Indian standards, IS 10262-2009 for M20 grade concrete with good degree of quality control. For the mix designed, specimens are cast and investigated experimentally. The properties involve of compressive strength of M20 conventional concrete by replacing the 0%, 10%, 20% and 30% of fly ash by cement, steel slag by fine aggregates and recycled aggregates by coarse aggregates was added, test was conducted on concrete cubes to study compressive strength.

2. LITERATURE REVIEW

Partial Replacement of Cement with Fly Ash in Concrete and Its Effect" IOSR Journal of Engineering (IOSRJEN), ISSN (e): 2250-3021, ISSN (p): 2278-8719,

Vol. 06, Issue 10(Oct. 2016), ||V2|| PP 69-75, Authors: Vinod Goud and Niraj Soni.

In this paper, it is discussed that there is 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. The thermal power plants produce considerably large quantities of solid by-product namely fly ash. They are replaced the fly ash by cement at the percentage of 0%, 10%, 20% and 30%. Ultimate compressive strength of concrete decreasing with increase in w/c ratio of concrete. Results were shown as the 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days testing, but the 30% replacements of cement with fly ash were compressive strength of concrete decreases.

Partial Replacement of Fine Aggregates Using Steel Slag" IJEDR 2018| Volume 6, ISSN: 2321-9939, Authors: Gaurav Desai, Prem Lohakare and Akash Ugale.

The steel making industry has generated substantial solid waste. Steel slag is an industrial by product obtained from the steel manufacturing industry. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. Steel slag is currently used as aggregate in hot mix asphalt surface application, but there is a need for some additional work to determine the feasibility of utilizing this industrial by-product more wisely as a replacement for both fine and coarse aggregates in a conventional concrete mixture

Steel Slag as a Replacement of Fine Aggregate in terms of High Strength Concrete" IJESRT International Journal of Engineering Sciences & Research Technology ISSN: 2277-9655, Authors: Anurag Jain, Sandeep Gupta & Mayank Gupta.

The steel slag, as a result of steel making, is delivered amid the detachment of molten steel from polluting influences in steel making heaters. This can be utilized as sand in concrete. Steel slag sand by and large display a penchant to extend on account of the nearness of free lime and magnesium oxides that have not respond with the silicate structure.

3. MATERIALS USED AND ITS PROPERTIES

Concrete is composite material. Fresh concrete is a mixture of cement, fine aggregates, coarse aggregates, and water and chemical admixtures. But nowadays availability of these materials are very less. So we are replacing the cement with fly ash, fine aggregates with steel slag and coarse aggregates with demolition waste aggregates. The properties of concrete, whether in the fresh state or hardened state, are affected by its ingredients and their proportions. An understanding and knowledge of the workability are the most important for making a well-designed concrete mix which can be easily placed and compacted with minimum effort.

CEMENT: Ordinary Portland Cement of 53 Grade of brand name Penna Cement available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being affected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 10262-2009. The size of cement varies from 1 micron to 45 micron. The colour of the cement is grey in colour. Cement is used to bind the materials of aggregates.

FINE AGGREAGTES: River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus specific gravity and bulk density in accordance with IS: 10262-1998. The sand was surfacedried before use.

COARSE AGGREGATE: Crushed aggregates of less than 20mm size produced from local crushing plants were used. The aggregate exclusively passing through 20mm sieve size. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density.

FLY ASH: Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust

gases. Energy requirements for the developing countries are met from coal-based thermal power plants.

STEEL SLAG: Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling.

RECYCLED AGGREGATES: Many concrete structures are demolished in India and other countries. But only small quantities of demolished waste are reused. This will have serious problems creating environmental pollution and requires large amount of space for dumping the waste. When structures made of concrete are demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble.

4. RESULTS AND DISCUSSIONS

4.1 PROPERTIES OF CEMENT

Table 1: Properties of cement

TEST PARTICULARS	RESULTS OBTAINED	REQUIREMENTS
Specific Gravity	3.10	3.10-3.15
Normal Consistency (%)	30	30-35
Initial Setting Time (Minutes)	35	Above 30
Final Setting Time (Minutes)	570	Below 600
Compressive Strength (MPa)		
For 3days	16.45	8
For 7days	19.5	13
For 28days	21.85	20
Soundness of Cement (mm)	3	10
Fineness (%)	5	10

4.2 DESIGN MIX OF CONCRETE

Mix proportions for $1m^3$:

A. Cement = $372kgs/m^3$.
B. Water = $186kgs/m^3$.
C. Fine Aggregate = $671.03kgs/m^3$.
D. Coarse Aggregate = $1178.42kgs/m^3$.
E. Water-Cement Ratio = 0.5.

As per these we calculate the ratio of materials $1m^3$.

$$\frac{372}{372} : \frac{671.03}{372} : \frac{1178.42}{372}$$

$$1 : 1.8 : 3.16$$

4.3 COMPRESSIVE STRENGTH OF CONCRETE

The compressive strength of concrete cubes at various percentages as shown below

Table 2: Comparing the Compressive Strength of Concrete for ConventionalCubes with Replacement of Cement by Fly Ash

S NO	PROPORTION	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
		For 3days	For 7days	For 28days
1.	0% Replacement	16.45	19.5	21.85
2.	10% Replacement	17.15	20.45	24
3.	20% Replacement	17.5	21.65	25.7
4.	30% Replacement	15.7	18.25	19.8

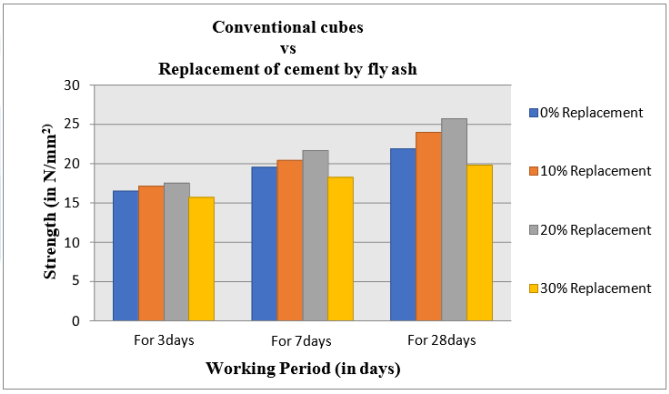
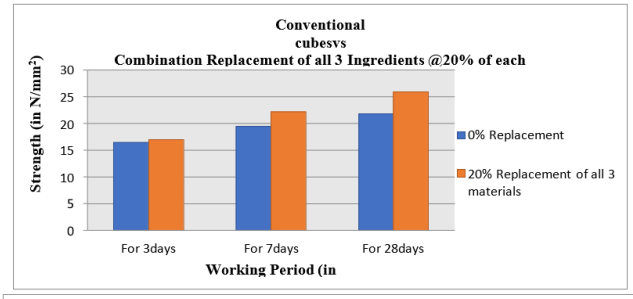


FIGURE 1: COMPRESSIVE STRENGTH OF CONCRETE

Table 3: Comparing the Compressive Strength of Concrete for Conventional Cubes with Combination Replacement of all 3 Ingredients @20% of each material

S NO	PROPORTION	AVERAGE COMPRESSIVE STRENGTH (N/mm²)		
		For 3days	For 7days	For 28days
1.	0% Replacement	16.45	19.5	21.85
2.	20% Replacement of all 3 materials	17	22.2	25.95



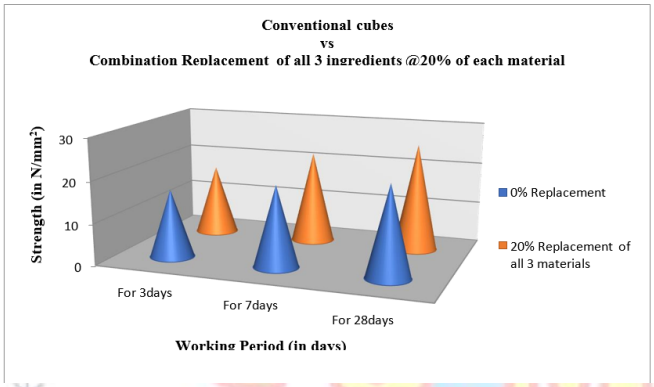


FIGURE 2: COMPRESSIVE STRENGTH OF CONCRETE IN N/MM² FOR COMPARING CONVENTIONAL CUBES WITH COMBINATION REPLACEMENT OF ALL 3 INGREDIENTS @20% OF EACH MATERIAL

4. CONCLUSIONS

This research concludes the study of the effect of replaced materials on the properties of concrete for nominal mix of M20 grade of concrete are as follows:

- The compressive strength of concrete for replaced concrete was similar to conventional concrete.
- Fly ash can be added in OPC concrete as partial replacement of OPC up to 20% without compromising compressive strength of concrete. Workability is decreased with increase inreplacement level of fly ash.
- The 10% and 20% replacement of cement with fly ash shows good compressive strength for 28days and but the 30% replacement of cement with fly ash, the compressive strength of concrete is slightly near as compare to conventional concrete cubes.
- The 10% and 20% replacement of fine aggregates with steel slag shows better compressive strength for 28days and the 30% replacement of fine aggregates with steel slag also good compressive strength as compare toconventional concrete cubes. But the 30% replacement is decreased as compared to 10% and 20% replacement.
- This work relates the use of steel slag; a waste cheap material used
- as fine aggregate in M20 grade of concrete and recommends the approval of the material for use in concrete as a replacement material for fine aggregates. The partial substitution of natural aggregates with steel slag aggregates permits a gain of compressive strength and modulus of elasticity of concrete up to an optimum value of replacement.
- The 10%, 20% and 30% replacement of coarse aggregates with recycled aggregates shows the better compressive strength for 28days as compared to conventional concrete cubes.
- When demolished waste aggregates are used in concrete, the cost ofproduction will be economical.
- At last we are prepared the combination replacement of all three materials at a time @20% of each material such as cement by fly ash, fine aggregates by steel slag and coarse aggregate by recycled aggregate, the compressive strength of concrete is increased as compared to conventional concrete cubes.

Conflict of interest statement

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

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