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Feasible and Experimental Study on Partial Replacement of Fine Aggregate using Construction Debris

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Abstract : Concrete is the most widely used construction material today. The constituents of concrete are coarse aggregate, fine aggregate, coarse aggregate and water. Concrete plays a major role in the construction industry and a large quantum of concrete is being utilized. River sand, which isone of the constituent used in the production of conventional concrete, has become expensive and also a scarce material. In view of this,the utilization of demolished aggregate which isa waste material has been accepted as building material in many countries for the past three decades. The demand of natural sand in the construction industry has increased a lot resulting in the reduction of sources and an increase in price. Thus an increased need to identify a suitable alternative material from industrial waste in place of river sand, that is eco-friendly and inexpensive construction debris i.e fresh concrete being extensively used as an alternative to the sand in the production of concrete. There is an increase in need to find new alternative materials to replace river sand so that excess river erosion is prevented and high strength concrete is obtained at lower cost. One such material is building construction debris: a by-product obtained during construction and demolition waste. An experimental investigation is carried out on M 25 concrete containing debris during construction in the different range of 20%, 30% & 40% by weight of sand. Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube of 150×150×150 mm and beam of 700×150×150 mm for 28 days to determine the mechanical properties of concrete.

Keywords : Environment, Partial replacement, Construction Waste, Aggregate, Compressive strength, Split tensile strength, Flexural strength.

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Introduction

Today, there are critical shortages of natural resources in present scenario. Production of concrete and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregate as the largest concrete component. In the modern evaluation of buildings and technologies, people tend to move to the development through modernized building. Hence, the refreshment of the building is done either demolishing or renovating the structures for ten years once. Advance concrete technology can reduce the consumption of natural resources thereby lessen the burden of pollutants on environment. By keeping the economy cost in the mind, and also in order to avoid the wastage of materials recycled aggregate concrete is introduced. In the developing world, the number of high rise buildings also gets increase and the regular method of renovation of multi storey building is done by demolishing it.

The reuse of hardened concrete as aggregate is a proven technology. It can be crushed and reused as a partial replacement for natural aggregate in new concrete construction. The hardened concrete can be sourced either from the demolition of concrete structures at the end of their life – recycled concrete aggregate, or from leftover fresh concrete which is purposefully left to harden – leftover concrete aggregate. Recycling or recovering concrete materials has two main advantages. It conserves the use of natural aggregate and the associated environmental costs of exploitation and transportation, and it preserves the use of landfill for materials which cannot be recycled

Recycling of concrete is needed from the viewpoint of environmental preservation and effective utilization of resources. At present, utilization of recycled aggregate is limited mainly to sub bases of roads and backfill works. A large portion of concrete waste ends up at disposal sites. It is anticipated that there will be an increase in the amount of concrete waste, a shortage of disposal sites, and depletion in natural resources especially. These lead to the use of recycled aggregate in new concrete production, which is deemed to be a more effective utilization of concrete waste. However, information on concrete using recycled aggregate is still insufficient, and it will be advisable to get more detailed information about the characteristics of concrete using recycled aggregate.

Literature Survey

Ravi Patelet al,(2013) used to study availability of demolished concrete for use as recycled concrete aggregate (RCA) is increasing. Using the waste concrete as RCA conserves natural aggregate, reduces the impacton landfills, decreases energy consumption and can provide cost savings. The application of recycled aggregate has been started in many countries for construction projects. This Research Paper works on the basic properties of recycled coarse aggregate. It also compares these properties with natural aggregates. Basic changes in all aggregate properties were determined. Basic concrete properties like compressive strength, workability etc. are explained here for different combinations of recycled course aggregate with natural aggregate. Ingeneral, present status & utilization of recycled coarse aggregate in India with their future need of Indian region. Srujan Gaddam et al(2017) studied construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction, the waste glass from in and around the small shops is packed as a waste and disposed as landfill. Glass is nonbiodegradable, landfills do not provide an environment friendly solution. Hence, there is strong need to utilize waste glasses. In their study it was investigate the effect of using waste glass powder in concrete. The performance of control sample and concrete was determined by the workability test and compressive strength test. Geo synthetics are used widely a soil reinforcement, separators, drainage, filters and also used across the globe in various infrastructure projects. Vipin Agariya et al,(2017) investigated short implementation of waste management practices within the construction comes has led to the unsuccessful end in reducing environmental impacts and outlaw dumping. In this paper represent that only Govt. can take the initiate to increase the use of construction waste to use refill materials of Civil Engineering works. Tomas U and Ganiron Jr(2015)studied recycling of concrete debris can make a contribution to reduce the total environmental impact of the building sector. In this experimental study aimed to use crushed concrete debris as alternative fine aggregate in a mortar mixture. A conventional mortar mixture will be compared to concrete debris mixture of the same proportions. J Oluwafemi et al(2019) conducted an study on construction wastes are aesthetically displeasing and not of good environmental impactre. The conclude from their research results from two research works compared established 25% to 30% optimum replacement level of recycled concrete with satisfactory structural properties.

Material Used

Cement

Cement in concrete acts as a binding material that harden after the addition of water. It plays an important role in construction sector. In this study the Ordinary Portland Cement (OPC) of 53 grade (Sanghi Cement) is used according to IS: 1489-1991.

Table 1:Physical properties of cement

Fineness(m^2/kg)	3.20
Specific gravity	3.15
Density (kg/m^3)	3.07

Fine Aggregate

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass. It conforms to IS 383 1970 comes under zone II.

Coarse Aggregate

Construction aggregate or simply "aggregate", is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. The material which is retained on BIS test sieve number 4 (4.75mm) is termed as coarse aggregate. The broken stone is generally used as a stone aggregate. Coarse aggregate used is locally available crushed angular aggregate of size 20mm and 10mm are used for this experimental work.

Water

Normal Drinking water available in the laboratory was used in concrete. However we take the samples and tests are done to satisfactory the requirements. Water quality which can be used in mixing and curing shall comply with IS.

Construction Debris

Construction waste consists of unwanted material produced directly or incidentally by the construction or industries. This includes building materials such as insulation, nails, electrical wiring, shingle, and roofing as well as waste originating from site preparation such as dredging materials, tree stumps, and rubble. Construction waste may contain lead, asbestos, or other hazardous substances.

Demolition waste is waste debris from destruction of buildings, roads, bridges, or other structures. Debris varies in composition, but the major components, by weight include concrete, wood products, asphalt, brick and clay tile, steel, and drywall. There is the potential to recycle many elements of demolition waste.

Much building waste is made up of materials such as bricks, concrete and wood damaged or unused for various reasons during construction. Observational research has shown that this can be as high as 10 to 15% of the materials that go into a building, a much higher percentage than the 2.5-5% usually assumed by quantity surveyors and the construction industry. Since considerable variability exists between construction sites, there is much opportunity for reducing this waste.

Experimental Procedure

Batching

It is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Traditionally batching is done by volume but most specifications require that batching be done by mass rather than volume. Percentage of accuracy for measurement of concrete materials is as follows:

Cement

When the quantity of cement to be batched exceeds 30% of scale capacity, the measuring accuracy should be within 1% of required mass. If measuring quantity is less than 30% i.e. for smaller batches then the measuring accuracy should be within 4% of the required quantity. Than 30% then the measuring accuracy should be within less than 3%.

Aggregates

If the measurement is more than 30% of the scale capacity then the measuring accuracy should be within 1%.

Mixing

It is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Traditionally batching is done by volume but most specifications require that batching be done by mass rather than volume. Percentage of accuracy for measurement of concrete materials is as follows: Concrete is basically a mixture of two components:

- Paste
- Aggregates

The paste, usually comprised of Portland cement and water, binds the aggregates (sand and gravel or crushed stone) into a rocklike mass as the Paste hardness because of the chemical reaction of the cement and water.

Casting

Casting of Specimens Compressive strength and split tensile strength of the concrete measured using 150mm x150mm x 150mm cubes and150mm x150mm x 1000mm beams. All the cubes and beams were cast in three layers and each layer was fully compacted by using a needle vibrator for beam and a vibrating table for other specimen. Compressive strength of the cube was measured by compression testing machine (CTM) having a capacity of 2000KN at the age of 7 days, 14 days and 28 days.

Curing

The curing period depends upon the type of cement used, mixture proportions, required strength, size and shape of member, ambient weather, future exposure condition, and method of curing. Since all desirable properties are improved with curing, the period should be as long as practical. For most concrete structures, the curing period at temperature above 5°C (40°F) should be minimum of 7days or until 70% of the specified compressive or flexural strength is attained. The period can be reduced to 3days if high early strength concrete is used and the temperature is above 10°C (50°F).

Properly curing concrete leads to increased strength and lower permeability and avoids cracking where the surface dries out prematurely. Care must also be taken to avoid freezing or overheating due to the exothermic setting of cement. Improper curing can cause scaling, reduced strength, poor abrasion resistance and cracking.

Figure :1: Concrete casting, molding and Curing

Test Results and Discussion

Compressive Strength

The internal resisting force to the load applied called compressive strength. Compression testing machine is used for testing the cube strength. Concrete cubes were casted for the standard size of (150mm×150mm×150mm) for M25 grade of concrete and strength has calculated for 3, 7, 28 days .The result obtained are as follows in table 2.

Control Mix (M25)	**Compressive Strength in N/mm^{2}3 DAYS**			
	PC (0%)	CONSTRUCTION DEBRIS (20%)	CONSTRUCTIO N DEBRIS (30%)	CONSTRUCTION DEBRIS (40%)
	13.78	13.89	16.12	15.11
	Compressive Strength in N/mm^{2}7 DAYS			
	17.11	17.2	17.55	15.15
	Compressive Strength inN/mm^{2}28 DAYS			
	30.23	30.16	29.81	27.05

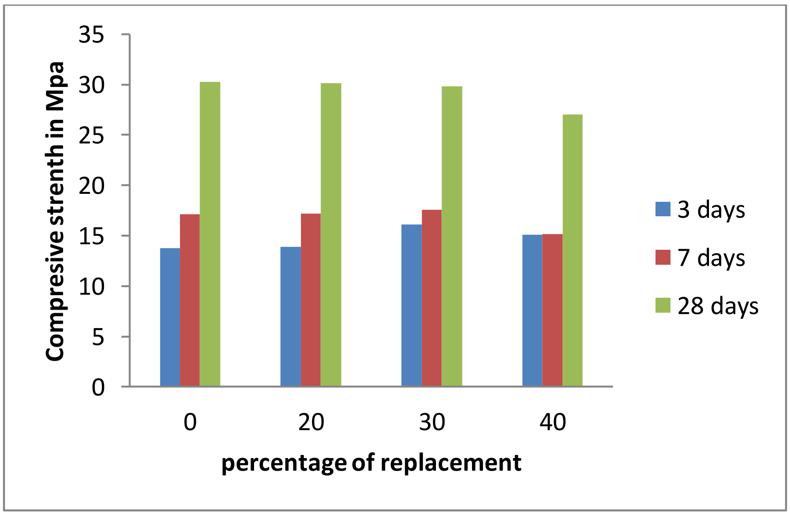

Figure 2 : Compressive strength Vs percentage of replacement

Split Tensile Strength

Split tensile strength tests were conducted on standard cylinders of dimension 150mm diameter and 300 mm depth,specimens each for plain concrete and construction debris concrete were casted at varying percentages of 0%, 20%, 30%, and 40%. For each case 7& 28days strength values were obtained by loading under a compression testing machine.

Control Mix (M25)	**Split Tensile Strength in N/mm^{2}3 DAYS**			
	PC (0%)	CONSTRUCTION DEBRIS (20%)	CONSTRUCTION DEBRIS (30%)	CONSTRUCTION DEBRIS (40%)
	2.35	2.12	2.10	2.07
	Split Tensile Strength in N/mm^{2}7 DAYS			
	3.82	3.75	3.70	3.62
	Split Tensile Strength in N/mm^{2}28 DAYS			
	4.02	4.00	3.60	3.50

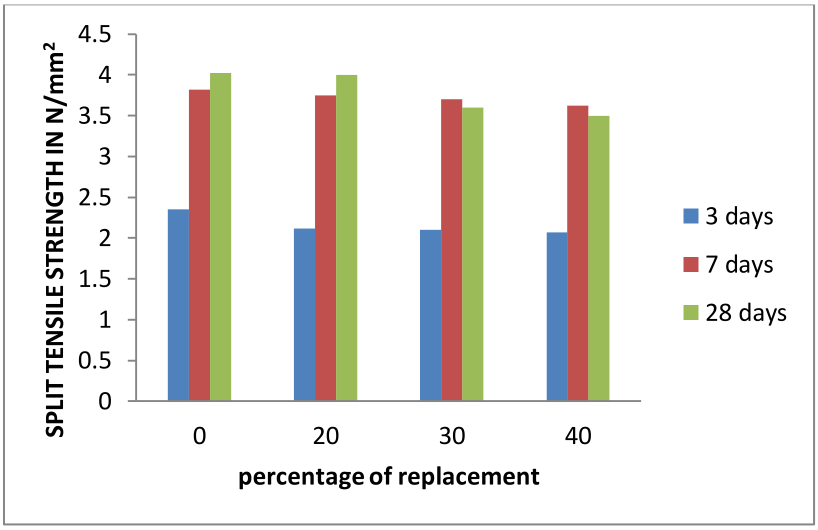

Figure 3 : Split Tensile strength Vs percentage of replacement

Flexural Strength

To investigate the capacity of the concrete it's important to test reinforced beam. The beam will fail after reach its maximum load. This can be observed by testing the beam with two point loading and its corresponding deflection can be measured by placing deflectometer at the bottom of the beam. The size of the beam is 1500mm×150mm×1500mm are used for the casting of the beams .10mm bars are used for the reinforcement and 6mm bars used as stirrups with a spacing of 150 mm c/c.

S.NO	Replacement of concrete	Breaking load (kN)	Max. Deflection (mm)
1	0% replacement	150	6.15
2	20% replacement	145	6.08
3	30% replacement	135	5.95
4	40% replacement	125	5.83

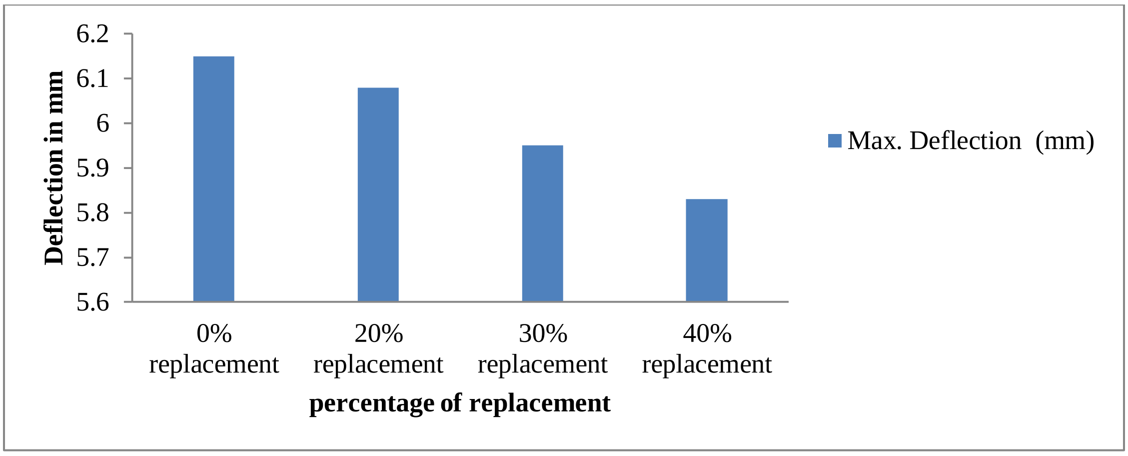

Figure 4:Deflection Vs percentage of replacement

Conclusion

Based on the practical evaluation on concrete with cement partially replaced by construction debris of 20%, 30% & 40% the following conclusions were made:

1. Compressive strength of concrete increases with the amount of construction debris by 20% and 30% respectively. Optimum compressive strength is obtained for replacement of construction debris up to 30% replacement levels. After that strength gradually slips while increasing the percentage of construction debris.
2. The replacement of fine aggregate with construction debris upto 30% is desirable, as it is cost effective.
3. At present there are lack of sand availability so this research of alternative method is very useful and urgent need to seek an alternative for construction materials and protect the environment , made eco-friendly way of concrete.
4. From this study concludes that more than 30% of construction debris is not a suitable material for cement replacement in concrete.

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