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Study on the Behaviour of Concrete by Partial Replacement of Fine Aggregate with Demolished Waste

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ABSTRACT

This project reports the effect on strength of concrete using recycled fine aggregate as replacement. In this project work, the concrete grade M25 is selected and IS method was used for mixing design. The properties of material for cement, fine aggregate, course aggregate and recycled fine aggregate were studied for mix design. The various tests had been studied to find the mechanical properties of concrete cube like compressive strength and split tensile strength. In this experimental work fine aggregate replaced with demolished waste in the varying percentage like 0%, 5%, 10%, 15% and 20%. The maximum strength of concrete attained at 15% replacement of fine aggregate at 7 and 28 days. The split tensile strength were also obtained higher strength at 15% replacement level at 28 days.

INTRODUCTION

Concrete is a composite material composed of water, coarse granular material (the fine and coarse aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Concrete is widely used for making architectural structures, foundations, bricks or block walls, pavements, bridges or overpasses, highways, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Concrete is used in large quantities almost everywhere mankind has a need for infrastructure.

The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastic and aluminium combined.

Concretes use in the modern world is exceeded only by that of naturally occurring water. Concrete is also the basis of a large commercial industry. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is protected to exceed $100 billion in revenue by 2017.

MATERIALS

There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cementitious and aggregate and phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties.

Coarse Aggregate

Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand.

The fine aggregate used in this study is river sand conforming to grading zone 2 table 1 of IS 383[6]. The coarse aggregate used in this study is of angular in shape and the maximum nominal size of coarse aggregate of 20mm and it is conforming to table 2 of IS 383[6].

Cement

Cement, commonly Portland cement, and other cementitious material such as fly ash and slag cement, serve as a binder for the aggregate. The cement used in this study is of OPC 53 grade conforming to IS 12269[7].

Water

Water is then mixed with this dry composite, which produces a semi-liquid that workers can shape (typically by pouring it into a form). The concrete solidifies and hardens to rock-hard strength through a chemical process called hydration. The water reacts with the cement, which bounds the other components together, creating a robust stone-like material. The good quality water is used in this study.

Fresh Fine Aggregate

The fresh fine aggregate is used in the concrete, the material passing 4.75mm sieve is used as a fine aggregate. The fine aggregate is replaced by the demolished building waste in different percentage such as 0%, 5%, 10%, 15% and 20%.

Recycled fine aggregate

The use of fine aggregate from construction demolition waste used as a partial replacement of fine natural aggregate in concrete production. The review present the initial works on this subject and an overview of the existing regulations.

It goes on to describe the production, treatment and properties of the fine recycled aggregates (FRA). The most suitable mixing techniques for concrete with this type of aggregates are then discussed. The properties of these concrete mixes are analysed in detail, after which a few examples of structures with this type of concrete are described and compared. The acquisition of fine natural aggregates and the dumping of the fine fraction of construction and demolition waste are two serious environmental problems that can be solved simultaneously by using FRA in concrete production, a subject that is lagging behind the use of corresponding coarse fraction.

Objective of this study

Many researchers had already found recycling fine aggregate possible to use as a material in concrete. In this experimental study fine aggregate is used in concrete as replacement material of fine aggregate. For this study, M25 grade of concrete is used and the test are conducted for various replacement of fine aggregate as 0%, 5%, 10%, 15%, & 20% in concrete. The obtained results are compared with fresh fine aggregate.

1. To find out the % use feasible for construction.
2. To reduce the impact of waste materials on environment.
3. To carry out different tests on recycled aggregates & natural aggregates & compare their results.
4. To find out the ways of cost saving such as transportation, excavation etc.

Experimental work

WORKABILITY:-

Workability is a measure of the ease with which a fresh mix of concrete or mortar can be handled and placed. For various mixes the concrete were prepared. In the fresh concrete, the slump cone test were carried out.

SLUMP CONE TEST:-

The slump test result is a measure of the behaviour of a compacted inverted cone of concrete under the action of gravity as per IS 1199 (13). It measures the consistency or the wetness of concrete.

Strength tests: In the hardened concrete, the Semi-destructive tests like Compressive strength test, Split tensile strength test and flexural strength test were carried out as per IS 516.

Compressive strength: Compressive strength is often measured on a universal testing machine. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength (N/mm^2) is calculated by using the formula,

$$\text{Compressive Strength} = \frac{\text{Ultimate load (N)}}{\text{Area of c/s (mm}^2\text{)}}$$


SPLIT TENSILE STRENGTH:-

Ultimate tensile strength (UTS), often shortened to tensile strength or ultimate strength is the maximum stress that a material can withstand while being stretched or pulled before failing or breaking. Tensile strength is not the same as compressive strength and values can be quite different. The tensile strength (N/mm^2) is calculated by using the formula,

$$\text{Split tensile strength} = \frac{2P}{\Pi LD}$$

Where

P= Ultimate load at failure (N).

L= Length of specimen (mm).

D= Diameter of specimen (mm)


Details of specimen used in the study:-

Strength test	**Compression test**	**Split tensile strength**
Sample type	Cube	Cube
Sample size (mm)	150mm	150mm
Days of testing	7 & 28	7 & 28
Total number of sample for one series	3 & 3	3 & 3

Table 1:- Details of specimen used in the study

Result and Discussion:-

CEMENT:-

The various properties of cement are shown in the table 2 below.

Test	**Cement**
Specific gravity	3.09
Fineness modulus (%)	1.4
Standard consistency (%)	31.5
Initial setting time (minutes)	100
Final setting time (minutes)	240

Table 2:- Properties of cement

SOUNDNESS TEST:-

COARSE AGGREGATE:-

Crushing Value Of Aggregates:-

Weight of aggregate before crushing (w_1) = 2000gm

Weight of aggregate after crushing (w_2) = 548gm

Percentage (%) = $(w_{2}/W_{1})*100$

Percentage (%) = (548/2000) * 100

Percentage (%) = 27.40%

Loss Angles Abrasion Test:-

Weight of aggregates before crushing = 5000gm

Weight of aggregates after crushing = 1319gm

Percentage (%) = $(w_{2}/W_{1})*100$

Percentage (%) = (1319/5000) * 100

Percentage (%) = 26.58%

Impact Test:-

Weight of aggregates before crushing = 600gm

Weight of aggregates after crushing = 150.5gm

Percentage (%) = ($w_{2/W1)*100}$

Percentage (%) = (150.5/600) * 100

Percentage (%) = 25%

FINE AGGREGATE:-

For Fresh Fine Aggregate

Sieve Analysis:-

The **3 kilogram** of fresh fine aggregate is taken for the sieve analysis. The different types of sieves used are 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm and 0.15mm.The fine aggregate is taken and the weight retained on the different is shown in the table below

Sieve Size(mm)	Weight retained on sieve(mm)	% weight retained on sieve	Cumulative %
4.75	271	9.03	9.03
2.36	354	11.8	20.83
1.18	688	22.93	43.76
0.6	529	17.63	61.39
0.3	743	24.76	86.15
0.15	316	10.53	96.68
Pan	91	3.03	100

Table 3:- Sieve analysis of fresh fine aggregate

∑of cumulative percentage (%) = **417.55**

Fine modulus (F.M) = ∑of cumulative%/100

F.M = 417.55/100

F.M = 4.17%

For Recycled Fine Aggregate

Sieve Analysis:-

The **3 kilogram** of recycled fine aggregate is taken for the sieve analysis. The different types of sieves used are 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm and 0.15mm.The fine aggregate is taken and the weight retained on the different is shown in the table below.

Sieve Size(mm)	Weight retained on sieve(mm)	% weight retained on sieve	Cumulative %
4.75	4	0.13	0.13
2.36	453	15.8	15.93
1.18	1074	35.8	51.73
0.6	425	14.16	65.89
0.3	584	19.46	85.35
0.15	266	8.86	94.21
Pan	167	5.56	100

Table 4:- Sieve analysis of recycled fine aggregate

∑of cumulative percentage (%) = **413.24**

Fine modulus (F.M) = ∑of cumulative%/100

F.M = 413.24/100

F.M = 4.13%

Slump value:-From figure 5 it was noted that the slump value increased with the percentage of copper slag increases in concrete. The measured slump was 26 mm for the control mixture whereas 36 mm with 100% replacement of fine aggregate using copper slag. This considerable increase is due to the low water absorption characteristics of copper slag and its glassy surface compared with sand which caused surplus quantity of free water to remain after the absorption.

Hydration: processes have completed. It should be noted that mixes with high contents of copper slag showed signs have bleeding and segregation which can have detrimental on concrete performance.

Replacement of fine aggregate (%)	Slump Value (mm)	Degree of Workability
0	17	Low
5	21	Low
10	23	Low
15	24	Low
20	26	Low

Table 5:- Slump value and workability

Compressive strength: From the figure 7 it was found that the weight of the cube showed lowest value in control concrete at before curing, 7 days curing and 28 days curing were 8.037 kg, 8.309 kg and 8.494 kg respectively whereas in concrete with 100% fine aggregate replacement using copper slag, the weight of the concrete value found the highest at before curing, 7 days curing and 28 days curing were 9.631 kg, 9.725 kg and 9.918 kg. The weight of specimen increased with the addition of copper slag into concrete. This is because of higher density if copper slag which was 2197 Kg/m^3 compared with density of sand which was 1700.67 Kg/m^3.

Figure 8 showed that the compressive strength of cube was found to be 29.88 N/mm^2 at 0% fine aggregate replacement and of 38.88 N/mm^2 at 100% fine aggregate replacement of 7 days. And the compressive strength of cube at 28 days was found to be 26.87 N/mm^2 at 0% fine aggregate replacement and of 27.66 N/mm^2 at 100% fine aggregate replacement. The maximum compressive strength was found to be at 40% fine aggregate replacement of about 38.37 N/mm^2 at 7 days and of 42.97 N/mm^2 at 28 days. The compressive strength of concrete 7 and 28 days increases gradually up to 40% fine aggregate replacement and then decreased with increase in percentage of replacement.

Replacement of fine aggregate (%)	7th day Compressive strength (N/mm^2)	28th day Compressive strength (N/mm^2)
0	19.92	27.20
5	22.96	30.38
10	22.59	30.60
15	23.70	29.18
20	25	30.83

Table 6:-Compressive Strength tesr results

Split tensile strength: Figure 9 showed that the split tensile strength of cylinder was found to be 2.45 N/mm^2 at 0% fine aggregate replacement and of 1.85 N/mm^2 at 100% fine aggregate replacement. The maximum split tensile strength was found to be at 40% fine aggregate replacement of about 3.09 N/mm^2. The split tensile strength of copper slag added concrete was gradually increased up to 40% replacement and then decreased with further fine aggregate replacement. The split tensile strength of cylinder showed a similar behaviour to the compressive strength of the cube for all mixtures.

Replacement of fine aggregate (%)	7th day split tensile strength (N/mm^2)	28th day split tensile strength (N/mm^2)
0	4.74	8.60
5	6.0	7.93
10	6.45	7.70
15	5.56	5.56
20	7.26	8.86

Table 7:-Split tensile strength results

Conclusion

From the results and discussions, the following conclusions were made

- The replacement of fine aggregate using demolished waste in concrete increases the density of concrete there by increases the self-weight of the concrete.
- The workability of concrete increased with the increase in demolished waste content of fine aggregate replacements at same water-cement ratio.
- From the results of compressive strength and split tensile strength, the concrete shown higher value at 20% replacement of fine aggregate using demolished waste. So it is recommended that 20% of fine aggregate can be replaced by recycled fine aggregate.
- To find out the percentage (%) use feasible for construction.

- To reduce the impact of waste materials on environment.
- To carry out different tests on recycled aggregates & natural aggregates & compare their results.
- To find out the ways of cost saving such as transportation, excavation etc.
- The construction industry is the only area for safe use of waste materials, which reduces the environmental problems, space problems and cost of construction.

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