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Compressive strength study on high strength concrete using demolished concrete as coarse aggregate

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Abstract
21st century is the age of innovation and excellence. In this age of excellence the construction industry plays a vital role in making the dream visions of beautiful and extraordinary buildings come true. For this purpose there is random demolition of buildings around the world. Due to this 33% of solid waste is being generated which is creating a lot of chaos due to lack of land for disposal. The idea born out of this chaos is the utilisation of demolished concrete as coarse aggregate. The present research aims at making high strength concrete by replacing normal aggregate with coarse aggregate with replacement levels from 10-40%. A comparative study is given and it can be concluded that recycled aggregates can be used up-to 30% replacement levels.

Keywords: Recycled aggregates, demolished concrete, compressive strength, high strength concrete

1. Introduction
Concrete waste from demolished activities is seldom used as recycled concrete aggregate. To achieve sustainability in construction, researches and companies focus on using waste concrete as a new construction material. Many researches have been done and the utilisation of recycled concrete has been done in construction of pavements and drainages, embankments, bases and sub-bases. However the number of successful incorporations in replacement of recycled aggregate with normal aggregate is very limited due to lack of suitable laws, guidelines, experience in utilisation and low quality. Moreover limited usage or no usage of this demolished concrete is an environmental hazard since it requires a large re for disposal. Hence one has to look forward for effective utilisation of demolished concrete in order to rescue the depleting natural aggregates and reduce the environmental degradation.
The construction and demolition industry fact file stated that the usage of stones from previous roads in rebuilding new set of roads is dated since Romans. Since the end of World War II, the recycling industry has been well established in Europe. In the 1970s, the United States began to reintroduce the use of RCA in non-structural uses. The main problem while incorporating the usage of demolished concrete is with the sources f demolished aggregates as demolished wastes may not be from the same source and workability. The problem with workability can be reduced by using super plasticizers and many researchers conducted reveals that source have a little effect on strength of recycled aggregate concrete(RAC) and the variation of strength RAC is not very significant and Recycled aggregates can be used for regular constructions as the strength falls in the nominal range.
The present research deals with the use of recycled aggregates in making high strength concrete. The replacement levels are 0%, 10%, 20%, 30% and 40%. The 0% is the normal aggregate concrete. The compressive strength variation of each replacement ratio is studied.

2. Materials
Materials used in this research are tested for their properties and checked that they fall within the limits prescribed by the IS codes. The materials used are: natural coarse aggregates with specific gravity 2.657, demolished concrete from the demolishing activities near our locality. The specific gravity of aggregates made from demolished concrete is 2.469.
Cement used in this study is of 43 grade cement with specific gravity 3.279 and sand is local river sand. Super plasticizer "Conplast" is used to achieve the desired workability.

3. Experimental Program
The research focuses on high strength concrete. High strength concrete of M60 grade is manufactured. The mix design is done as per Perumal's method of mix design for high strength concrete. Aggregates used in this method are mixture of natural aggregates and demolished concrete aggregates (recycled aggregates). The demolished concrete was crushed manually to obtain the aggregates with attached mortar in them. These aggregates were washed thoroughly to remove the adhered mortar to maximum possible extent. Then these recycled aggregates were dried and used as coarse aggregates in new concrete.

Fig 1: Crushing and washing of recycled aggregates

Fig 2: Recycled aggregates

Super plasticizer "Conplast" is used to enhance the workability. The mix proportions for desired replacement level of recycled aggregates (0%, 0%, 20%, 30%, 40%) are calculated by using Perumal's method. The ingredients of concrete were mixed using the mixer. Cast iron moulds of 150mm X150mm X 150mm were used the cube specimens. Once the concrete was poured in moulds, they were compacted thoroughly by placing on table vibrator. Demoulding was done 24 hours after casting and then the specimens were kept for curing in the curing tank.

Compression test was done at 3days, 7days, 14days and 28days.the cube is compressed by operating the Universal Testing Machine(UTM) at a constant rate of 14N/mm^2 and the dial gauge reading is noted when the cube yields. Then the compressive strength is calculated and variation is shown in graphs.

Fig 3: Compression test on cubes

Fig 4: Crushed specimen after compression test

4. Results and discussion

In the present research the effect of percentage of recycled aggregate on the compressive strength of concrete is studied. All the cubes are tested for compressive strength in UTM. The variation is studied at 3,7,14 and 28 days and the results are presented in the given table. The values in the table are average of three cube specimens.

Table 1: Compression test results of concrete

% replacement	3 days N/mm^2	7 days N/mm^2	14days N/mm^2	28 days N/mm^2
0%	41.52	50.24	52.88	69.2
10%	41.08	49.99	52.32	68.82
20%	40.88	49.89	53.32	68.25
30%	38.56	48.56	50.03	67.12
40%	36.88	47.12	47.28	59.26

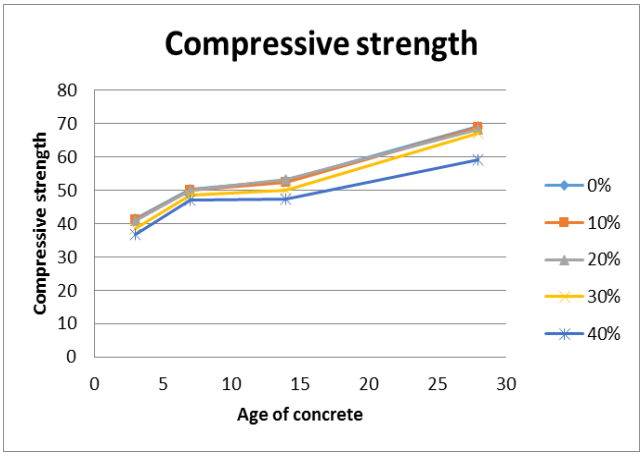

Fig 5: Variation of compressive strength with age for different percentages of recycled aggregates

The above figure gives a comparison of compressive strength developed with age for different replacement ratios of recycled aggregate concrete. It can be concluded that both

natural aggregate concrete and recycled aggregate concrete the compressive strength progressively increases with age of concrete as seen in the graph.

Also it can be seen that the strength development in recycled aggregate concrete is less than that of natural aggregate concrete at all ages and the reduction in strength increases with increase in the replacement of natural aggregates by recycled aggregate.

From the graphs and test results it can also be concluded that though with the increase in replacement of natural aggregates there is a decrease in the strength development, replacement up to 30% by recycled aggregates is found to be usable as it crosses the target strength of 67MPa at 28days.

4. Conclusion

The following conclusions can be drawn from the present experimental investigations

- Both natural and recycled concrete gained strength with age but at any instant the strength of recycled concrete is less than natural concrete
- The variation in strength between natural and recycled concrete is not significant as the variation is very less. For concrete made with 10% recycled aggregates the maximum strength variation shown from natural aggregate concrete is just 1.06% at 3 days. This may be due to high absorption of recycled aggregates
- Whereas for concrete with 40% replacement level the maximum variation is 14.36% at 28 days.
- As the proportion of recycled aggregate increased the percentage variation of strength also increased.
- The compressive strength of 40% recycled aggregate concrete is 14.36% lower than that of natural aggregate concrete while that of 10% recycled aggregate concrete is just 0.55% lower than that of natural aggregate concrete.
- Thus we can conclude that recycled concrete can be used to replace conventional concrete even for structural purposes when the replacement ratio is less than 30% thus attaining sustainability and creating way for an economic structure.

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