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Experiment study on the use of varying percentage of silica fume with cement and natural aggregate with recycled coarse aggregate in concrete

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ABSTRACT

Natural aggregate is used in large quantities from natural resources, which accounts for, big problem in future. For less use of natural aggregate, the availability of demolished concrete for use as a recycled concrete aggregate (RCA) is increasing. Using this waste concrete as RCA conserves natural aggregate, reduces the quantities of landfills, decreases energy consumption and is available at less cost. However, there are still many questions about the beneficial use of RCA in concrete pavements. The aim of this research is to find the possibility of the structural usage of recycled aggregate concrete mixed with natural aggregates, based on a better understanding about the behavior of recycled aggregate in concrete structures experimenting fresh and hardened concrete, mixtures containing recycled aggregates. This work provides an overview of sustainability, the material properties of RCA both as an aggregate and in concrete, concrete mixture and designs with RCA, the performance of used RCA pavements, and the implementation of RCA. Use of recycled aggregate (RA) in concrete is very useful for environmental protection and economical terms. Recycled aggregates are the construction materials for the future. Recycle concrete aggregate provides a little lower strength than what is provided by natural aggregate concrete. Though, if it is used up to 20% of replacement by weight then it can give almost same strength as that of natural aggregate concrete. Hence it was very important to improve the strength of recycled aggregate concrete for higher recycled aggregate content. Therefor silica fume was used to improve the strength of the material.

Keywords*:* *Natural aggregate, Recycled Aggregate Concrete, Recycled Aggregate, Silica Fume.*

1. INTRODUCTION

Concrete is the main construction material all over the world and is most widely used in all types of civil engineering works, including infrastructure, low and high rise buildings, defense installations, environmental protection facilities etc. The use of recycled aggregates in concrete opens a whole new world of possibilities in recycled materials used in the building industry. The use of recycled aggregates in civil engineering work is a good solution to the problem of excess waste material, provided that the desired final result will fit the standards. The studies on the use of recycled aggregates have been going on for 40 years. None of the results showed that recycled aggregates are unsuitable for structural use. Recently the use of recycled concrete as a structural fill material, in lieu of natural aggregate, has recently been increasing due to high demand in construction industries. In some regions, the recycled concrete aggregate may cost 25 % to 35 % less than the natural aggregate. The construction of infrastructures related to bridges, highways, water systems, and buildings has increased in the past decades, especially in areas where population density is high. Infrastructures need to be repaired with the course of the time. In some cases, constructions need to be replaced, because their service period is reached or their original design no longer satisfies the new requirements. These facts have generated these important issues:

- Increasing production of construction material waste.
- A growing demand for construction aggregates.
- On the other hand, just the construction waste, produced from building demolition is estimated to be 125 million tons per year.
- In recent years, the most common method of managing this material has been through disposal in landfills. It is estimated that 55% of concrete debris and 25% of all asphalt pavements end up in landfills. Due to increased cost, environmental

regulations and land policies of landfill arise, the concern to seek alternative should be taken as the use of the waste material is also increasing. This situation has led the aggregate industry to begin reclaiming construction waste as an alternative aggregate especially, for pavement uses. Additionally, government entities have started promoting recycling coarse aggregate.

2. MATERIAL

2.1 CEMENT (OPC 35)

Cement is a fine grey powder which is the best binding material for construction work. It is mixed with water and materials such as sand, gravel, and crushed stone to make a strong bond. Cement and water form a paste that binds the materials together and forms hard concrete. The ordinary cement contains two basic ingredients argillaceous and calcareous. The property of the argillaceous material is that here clay predominates and in calcareous materials, calcium carbonate predominates. Portland cement is manufactured by grinding together calcareous materials (limestone, chalk, marl, etc.) and argillaceous (shale or clay) materials in approximate proportion of 2:1 and other silica, alumina or iron oxide bearing materials together OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. The grade indicates the compressive strength of cement at 28 days tested according to IS: 4031- part IV (Methods of physical tests for hydraulic cement).

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Figur-1 Cement (OPC 35)

2.2 FINE AGGREGATES

The material which passes through 4.75 mm sieve is termed as a fine aggregate (IS 383-1970).

2.3 COARSE AGGREGATE

Normally, aggregates occupy 70% to 80% of the volume of concrete and have an important role in its properties. They are granular materials, derived for the most part from natural rock, crushed stone, or natural gravels and sands. In order to obtain the best concrete quality, aggregates should be hard and strong, free from impurities, and chemically stable. Broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20 mm was used in the present work

2.4 RECYCLED COARSE AGGREGATE

Recycled aggregates comprise of crushed, graded inorganic particles processed from the materials that have been used in the construction and waste concrete debris. The maximum size of coarse aggregate 20 mm was used in the present work. These materials were obtained from a building which was 25-30 years old. The density of RA is found lower than the NA because of the porous and less dense residual mortar lumps that adhere to its surfaces. The aggregates were properly graded according to the Indian standard codes and then mixed with the respective natural aggregate with in percentages. The fine recycled aggregate below 2 mm is uncommon in recycled aggregate usage because of the high water demand of the fine material smaller than 150 μm, which lowers the strength and increases the shrinkage in concrete.

2.5 SILICA FUME

Yamuna Nagar, Haryana, Rock fit Corporation manufacture's Silica Fume. It is very fine no crystalline silica manufactured by electric arc furnaces as a by-product of the production of ferrosilicon alloys. The raw materials are coal, woodchips, and quartz. The smoke that is produced from furnace process is stored and sold as silica fume, as it is better than land filling. The silica fume powder particles are produced, which is hundred times finer than ordinary Portland cement when dealing with silica fumes, various problems arise, such as use, transportation, and storage, all of which are needed to be taken into account. To reduce the difficulties, the material is commercially divided in various forms. The main difference is the size of the particle which does not significantly affect the chemical reaction of material. Thus, it is very important that before using the silica fume, a careful consideration must be made for choosing a type of silica fume for a specific application.

Figur-2 Silica Fume

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3. MIX DESIGN

Experimental investigations on the utilization of silica fume with replacement cement mixed with silica fume and Natural aggregate with recycled aggregate for M45mix design.

4. EXPERIMENTAL PROCESS

4.1 SLUMP TEST

The slump test was conducted in order to determine the workability obtained for RAC in comparison with the conventional concrete. The slump value was used as an indication of mix water/cement ratio and all the mixes were designed for 80-100mm slump value.

Figur-3: Slump test

Table-1: Slump test values

MIX	0% SF	10% SF	15% SF
NA	96 mm	86 mm	76 mm
RCA 20	85 mm	71 mm	61 mm
RCA 40	56 mm	31 mm	21 mm
RCA 50	41 mm	11 mm	11 mm

4.2 COMPRESSIVE STRENGTH RESULTS

The compressive strength test results including some correction between yearly strength increases and the addition of silica fume. The compressive strength is affected by both the aggregate properties. The potential strength of concrete is related to mix proportioning such as cement content, water/cement ratio and choice of suitable aggregate, and proper curing when chemical bonding develops. The w/c ratio and curing give proper compaction, affect the development of concrete microstructure, and also affects the amount, distribution and size of pores. The bond that is developed in concrete becomes hard due to aggregate-paste bond, which is both physical and chemical. The main important parameter is that recycled aggregate concrete develops a weaker chemical bond with cement paste, and the chemical composition of the aggregate is different from commonly used natural aggregates. The re-bonding of some elements in cement paste residue can take place. The main important parameter of the aggregate affecting compressive strength is its shape, texture, maximum size and the strength of coarse aggregate.

The decrease of compressive strength due to an increase of recycled aggregate percentage (%) can be explained as follows:

- The recycled aggregate is covered with cement paste, which is a very weak layer, so the compressive strength of recycled aggregate is weak.
- The cement paste on recycled aggregate has high water absorption, therefore, no enough water is present to complete chemical reaction. This leads to poor compaction in concrete.
- Due to some impurities in the recycled aggregate like wood, glass, bricks, etc. which could not be removed completely which affected the bonds.

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Table-2 Compressive strength value of 7 and 28days

MIX	CURING PERIOD	0% SF	10%SF	15%SF
NA	7 DAYS	24.12	24.5	25.4
	28 DAYS	35.1	35.2	35.5
RCA 20	7 DAYS	22.8	23.7	24
	28 DAYS	33.8	34.3	35.5
RCA 40	7 DAYS	21.8	23.8	23.4
	28 DAYS	31.5	34.6	33.9
RCA 50	7 DAYS	23.2	23.1	23.5
	28 DAYS	26.1	27.3	27.7

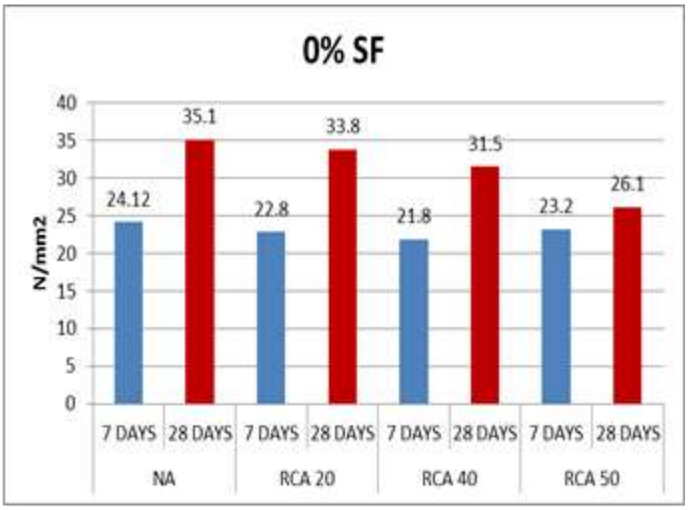

Figure 4: Compressive strength value of 7 and 28days of 0% silica fume

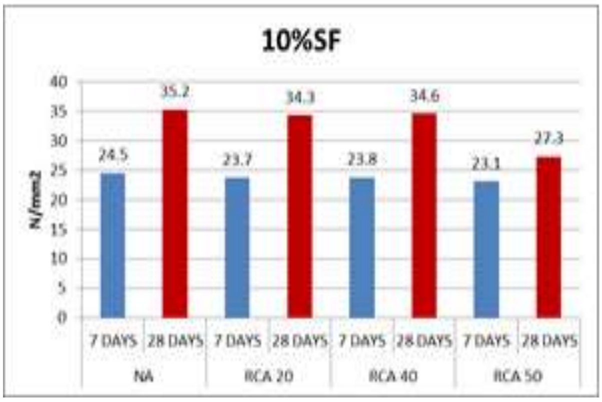

Figure 5: Compressive strength value of 7 and 28days of 10% silica fume

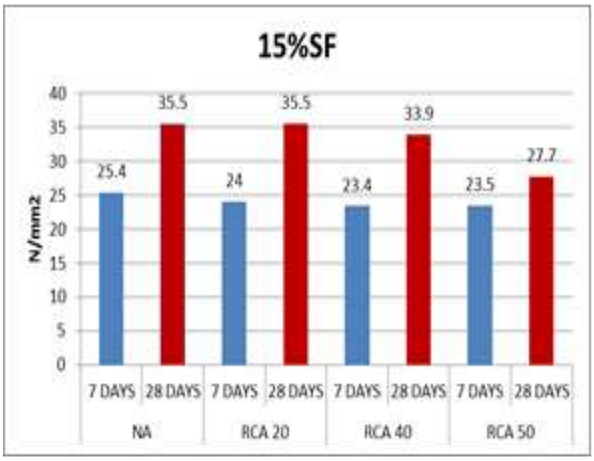

Figure 6: Compressive strength value of 7 and 28days of 15% silica fume

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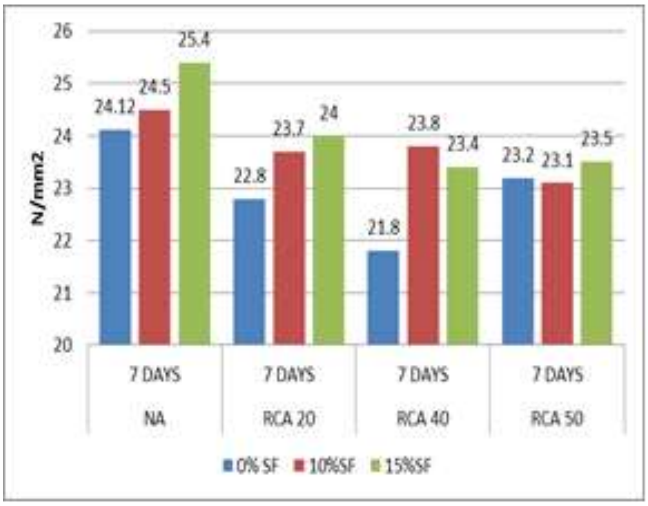

Figure 7: 7 days compressive strength for mix with different % of SF and RCA

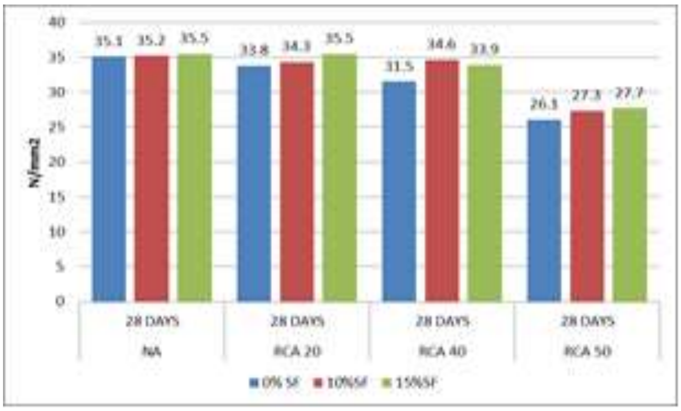

Figure 8: 28 day's compressive strength for mix with different % of SF and RCA

4.3 SPLIT TENSILE STRENGTH

The result of split tensile strength was same as the results as that of the compressive strength shown in the graph. The tensile strength of the concrete is 10% to 15% of compressive strength. The results of tensile strength are shown in the graph for mix with different % of SF and RCA, respectively.

Table-3 Split tensile strength of 7and 28days

MIX	CURING PERIOD	0% SF	10%SF	15%SF
NA	7 DAYS	4.1	4.7	4.7
	28 DAYS	5.7	6.5	6.3
RCA 20	7 DAYS	4	4.2	4.4
	28 DAYS	5.1	6.2	5.5
RCA 40	7 DAYS	3.2	4.3	4.2
	28 DAYS	5.4	5	5.2
RCA 50	7 DAYS	3	3.2	3.3
	28 DAYS	4	5.9	5.3

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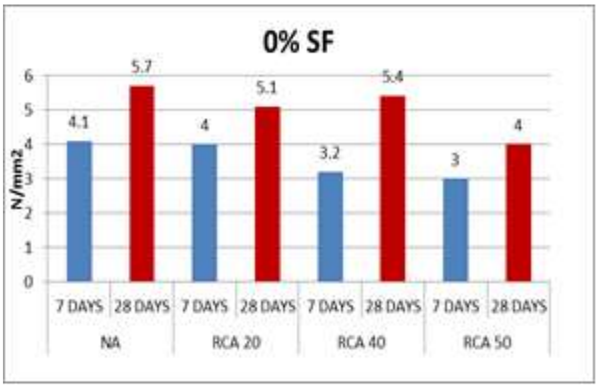

Figure 9: Split tensile strength value of 7 and 28days of 0% silica fume

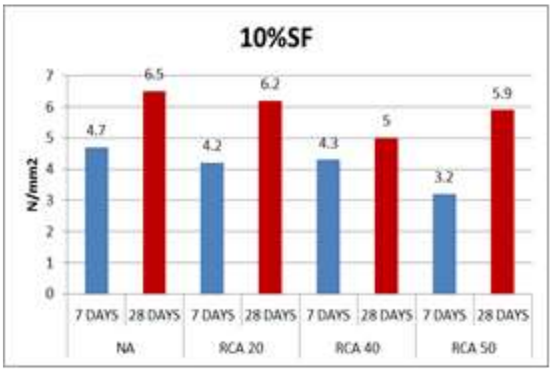

Figure 10: Split tensile strength 10%of silica Fume

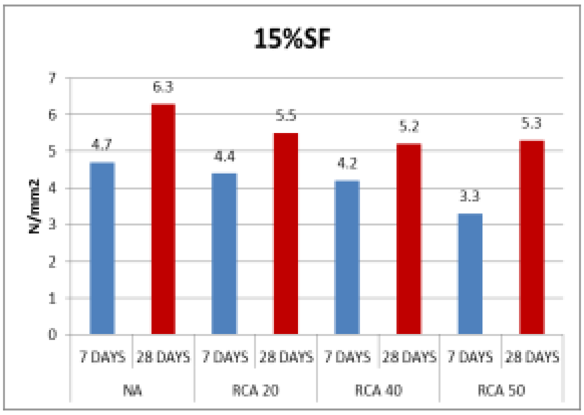

Figure 11: Split tensile strength 15%of silica fumes

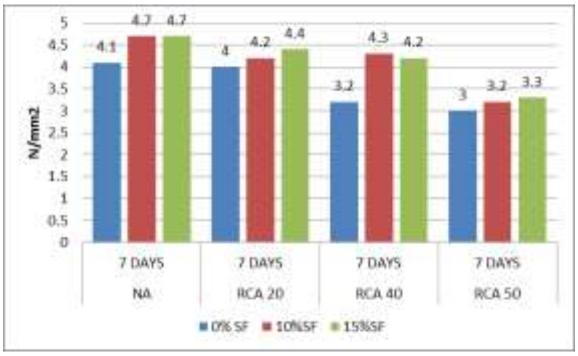

Figure 12: 7 days split tensile strength for mix with different % of SF and RCA

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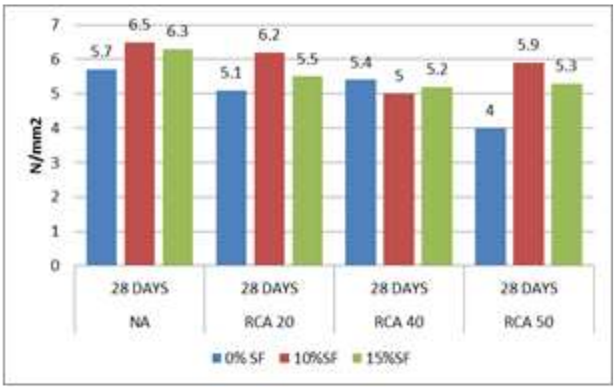

Figure 13: 28 days split tensile strength for mix with different % of SF and RCA

5. CONCLUSION

- Water absorption of RCA was 5 to 9 times higher than NCA, therefore, resulting in a weak chemical reaction.
- The specific gravity is 15% to 20% lower than the NCA. Attached cement mortar and voids in that are the basic reason behind these behaviors.
- The workability of the recycled aggregate concrete mix is lower than natural aggregate concrete.
- The strength of concrete decrease with increase in the percentage (%) of recycled aggregate'.
- RCA based concrete with 10% silica fume gives higher compressive strength than normal RCA. This may be due to bonding between the old mortar and Silica Fume.
- RCA based concrete with 15% silica fume gives lower result than required as the strength should have increased but it decreases.

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