International Journal of Civil Engineering (IJCE)
Vol.1, Issue 1 Aug 2012 49-57

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

CONCRETE FOR SUSTAINABLE CONSTRUCTION

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ABSTRACT

Recycled concrete aggregate (RCA) are comprised of crushed, graded inorganic particles processed from the material that have been used in the constructions and demolition debris. The use of RCA in concrete opens a whole new range of possibilities in the reuse of materials in the construction industry. The investigation was carried out using workability test, compressive test. There were total 20 batches of concrete mixes consists of 5% increment of RCA placement from 20% to 40% incorporated with fly ash (5% to 20% increment of 5%) for M20 and M30 grade each. The workability of concrete considerably remains the same as the amount of RCA. This was evaluated through standard slump test. For compressive strength characteristics the result showed that a invariable decrease in compressive strength as the percentage of RCA used in the specimen increased. Finally the concrete made with recycled concrete aggregate incorporated with fly ash is found to be suitable for normal strength concrete and lower grade concrete.

KEYWORDS Recycled Concrete Aggregate, Recycled Aggregate Concrete, Flyash, Sustainable Construction.

INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering words, including infrastructure, low and high-rise buildings, defense installations, environment protection and domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these, aggregates, i.e. inert granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic prices and of qualities to suit all purposes. However, in recent years the wisdom of our continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection. In might of this, the availability of natural resource to future generations has also been realized. Given this background, the concept of sustainable development put forward almost a decade ago, at the 1992 Earth Summit in Rio de Janeiro, and it has now become a guiding principle for the construction industry worldwide.

Construction industry in India generates about 10-12 million tones of waste annually. A shortage of aggregate to the extent of about 5500 million m^3 for housing sector. An additional

750 million m^3 for road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sector. Research work on recycling of aggregate is being done at central building research institute, roorkee, and central road research institute, New Delhi. The advantages of Recycled Concrete Aggregate (RCA) are Environmental gain, save energy and save cost. Moreover nowadays its application is vast, i.e. for concrete kerb and gutter mix, granular base coarse, embankment fill materials, paving block and building block. The present study discusses the compressive strength of concrete made with RCA as partial substitute for natural aggregate (NA). This study also incorporates the use of fly ash, a common pozzolana as mineral admixture.

BRIEF REVIEW OF LITERATURE

Mehus and lillestol (2001) stated that in a project up to 35% percent of coarse aggregate were replaced by RCA in the foundation, half of the basement walls and columns. The results shown that the concrete with 35% percent of RCA have good freeze and thaw resistance. The use of RCA did not shown any noticeable increase in cracking strength / load. Grubl, Nealen and Schmidt (1999) evaluated the properties of freshly mixed and also hardened concrete. The result shown that the consistency controlled method for concrete with RCA is applicable. It leads to concrete of quality when compared with concrete made from NA. Studies on RCA as structural member has been done by Etxeberria, Mari, Vazquez (2005). From the observed experimental behavior, it was found that the concrete made with up to 25% of RCA is suitable for structural use and for beams without shear reinforcement the use of RCA reduces the cracking load. According to Ramamurthy and Gum aster (1998), the compressive strength of RCA was relatively lower and variation was depended on the strength of parent concrete from which the aggregate is obtained. Limbachiya and Leelawat (2000) found that RCA has 7 to 9% lower relative density and 2 times higher water absorption than NA. According to their test result, it shown that there was no effect with the replacement of 30% RCA used on the ceiling strength of concrete. It also mentioned that RCA could be used in high strength concrete mixes with RCA content in the concrete. Sagoe, Brown and Taylor (2002) found that the difference between the characteristic of fresh and hardened RCA and NA concrete is relatively narrower than reported for laboratory crush RCA mixes. Mandal (2002) stated that application of fly ash in the RCA had improved the durability of the RCA. Poon (2002) stated that the use of fly ash could improve the strength characteristic of recycled aggregate. He stated that the compressive strength of concrete paving blocks was reached 49MPa at 28days by using fly ash. Berry and Malhotra (1980) stated that in high strength concrete, fly ash functions by providing increased strength at late ages of curing (56 to 91 days) that cannot be achieved though the use of ordinary Portland cement.

RESEARCH SIGNIFICANCE

The available literature on RCA are to be thoroughly read and current state of art is to be fully understood to frame the main objective of the work. After the literature survey, the

recycled aggregate has to be characterized for its use in concrete as coarse aggregate. Collection and processing of RCA and Gradation of RCA are done. After which the physical and mechanical properties of RCA such has density specific gravity, water absorption, crushing value were determined. The Workability of concrete made with varying percentage of RCA and fly ash are found using slump cone test. Sufficient numbers of cubes of recycled aggregate concrete were cast for various percentage (20 to 40%) replacement of RCA incorporated with fly ash (5 to 20%) to study its effect on strength of concrete. In order to compare the strength of RCA, normal concrete cubes are also to be cast as reference mix. Finally the results are to be compiled and guidelines may be proposed for application of RCA in construction.

EXPERIMENTAL INVESTIGATION

Preliminary test such as consistency, setting time, specific gravity, gradation of aggregate, water absorption, impact and crushing value of aggregate were conducted for cement, fly ash, natural coarse aggregate, fine aggregate and recycled concrete aggregate. The workability of concrete made with varying percentage of RCA (20 to 40% at an interval of 5%) incorporated with fly ash (5 to 20% at an interval of 5%) using slump cone test was also done. The workability of concrete made with varying percentage of RCA replacement incorporated with fly ash is found by slump cone test. The workability remains to be same as for NA. The slump values are as tabulated in Table 1.Specimen cubes of concrete are casted with varying percentage of RCA and fly ash. i.e. for M20 mix and M30 mix concrete around 360 cubes are casted with varying percentage of RCA (20 to 40% at an interval of 5%) incorporated with fly ash (5 to 20% at an interval of 5%). The reference mix cubes for M20 and M30 concrete are also casted. The specimens are tested for compressive strength (7^{th} day and 28^{th} day). The results are compiled and compared with normal reference mix.

The compressive strength of concrete cubes was found out at the ages of 7 and 28 days. Three cubes were crushed to get the average at each age. The compressive strength for RAC samples produced at various percentage of RA incorporated with varying percentage of fly ash are presented in Figs. 1 to 10.

RESULTS AND DISCUSSIONS

The slump value of concrete made with partial replacement of RCA incorporated with fly ash remains nearly equal to concrete made with NA. Hence the workability remains same. However the workability is drastically reduced after 30 minutes, due to high water absorption of recycled aggregate. The compressive strength of concrete invariably decreases with increases in RCA. The results are compiled and compare with normal concrete. Finally it is found the concrete made with partial replacement of RCA incorporated with fly ash is suitable for normal structural concrete and lower grade application. However suitable measures are to be incorporated in order to raise the compressive strength of these recycled aggregate concretes. Addition of fly-ash improves the strength of recycled aggregate concrete. Hence, it is recommended to add fly ash in producing recycled aggregate concrete. The important conclusions drawn based on the limited study is summarized below.

1. The water absorption of RCA is found to be 5% which is 2 to 3 times higher than NA. This is due to presence of dry cement mortar matrix and cement adhered on the RCA.
2. The specific gravity of RCA is found to be 2.35 which are lesser than that for NA. This is due to higher water absorption of RCA.
3. The crushing value of RCA is found to be 48% which is 2 times higher than NA. This is also due to presence of dry cement mortar matrix in RCA.
4. The impact value of RCA is found to be 31% which is 1.5 times higher than NA. This is also due to presence of dry cement mortar matrix in RCA.
5. The slump value of concrete made with RCA remains 60 to 70 mm at the time of mixing and 10mm after 30 minutes.
6. The compressive strength of concrete made with RCA 20% and fly ash 5% for M_{20}, M_{30} mix is found to be 37N/mm^2 and 42N/mm^2. It invariably decreases with increase in RCA and fly ash. The compressive strength of normal mix (control) for M_{20}, M_{30} mix is found to be 38N/mm^2 and 44N/mm^2.

Table: 1 Slump Value of Concrete

Duration % of RCA Replaced with NA	Slump value in mm	
	At the time of mixing	After 30 minutes
Control	60	7
RA 20% with fly ash	60	8
RA 25% with fly ash	65	8
RA 30% with fly ash	68	8
RA 35% with fly ash	67	8
RA 40% with fly ash	68	9

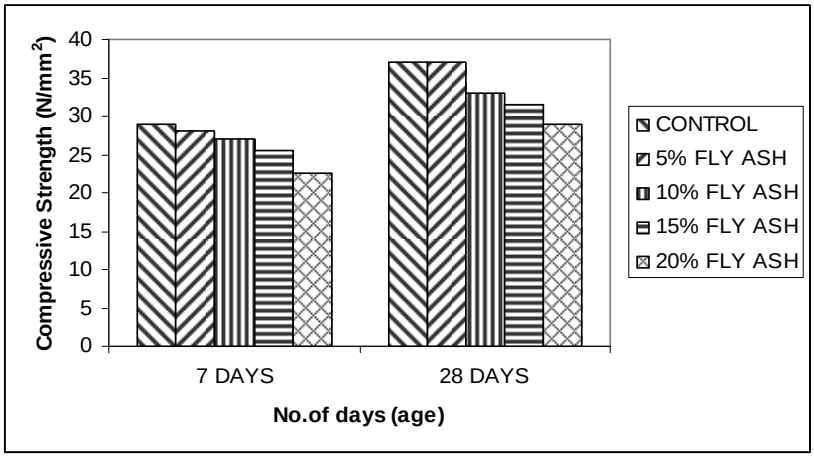

Figure 1: Compressive Strength of Specimen Replaced With RA-20% for M_{20}

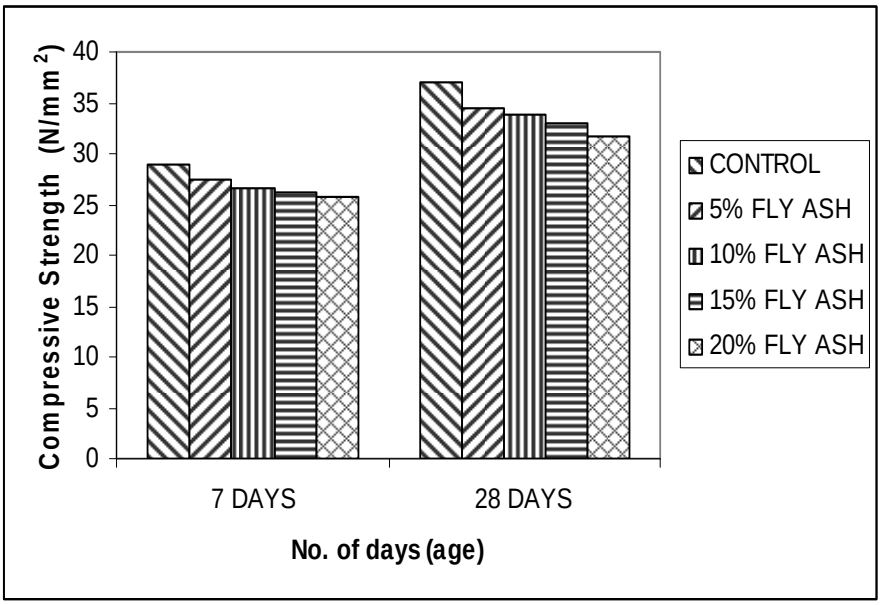

Figure 2: Compressive Strength of Specimen Replaced With RA-25% for M_{20}

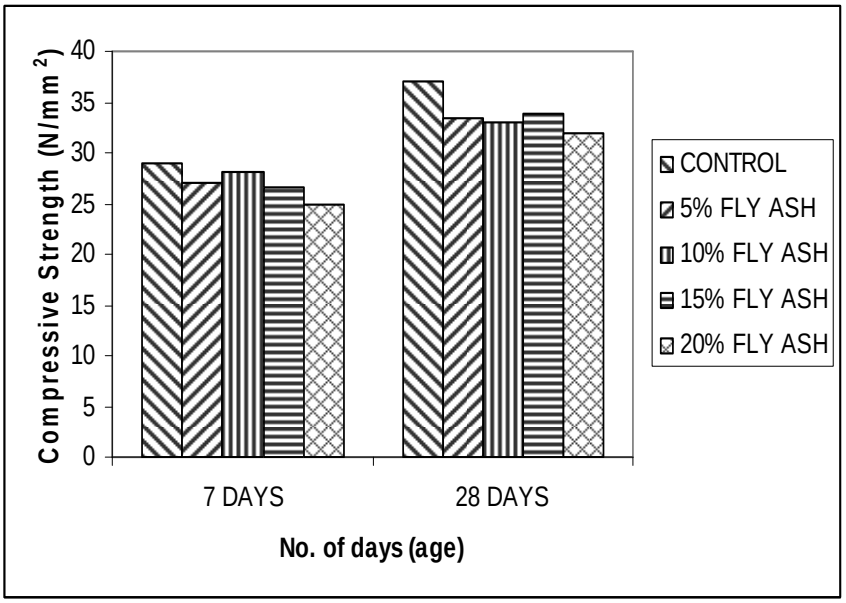

Figure 3: Compressive Strength of Specimen Replaced With RA-30% for M_{20}

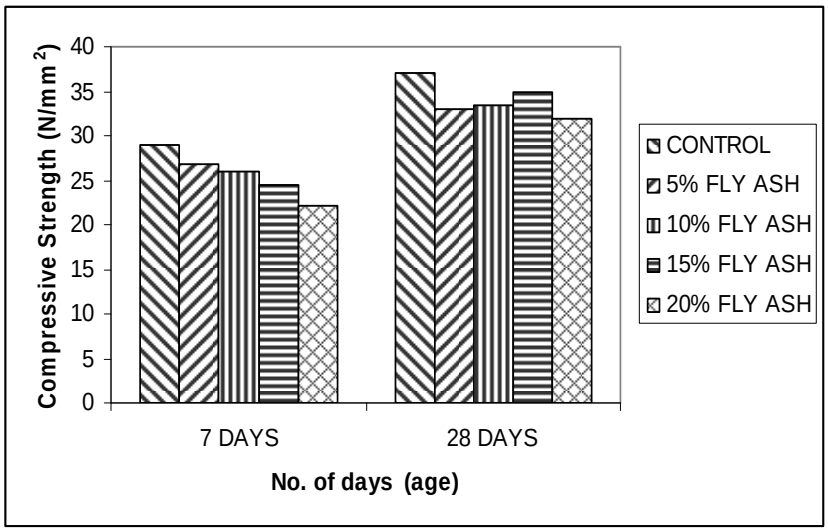

Figure 4: Compressive Strength of Specimen Replaced With RA-35% for M_{20}

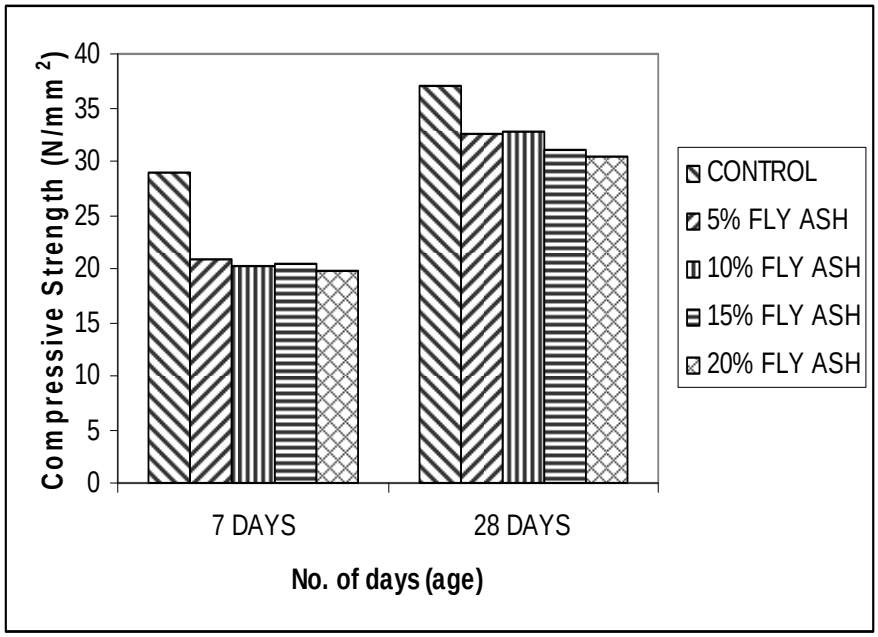

Figure 5: Compressive Strength of Specimen Replaced With RA-40% for M_{20}

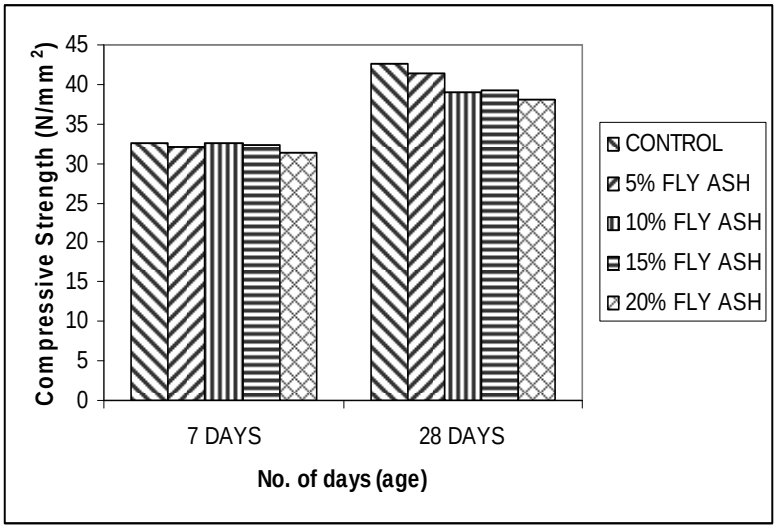

Figure 6: Compressive Strength of Specimen Replaced With RA-20% for M_{30}

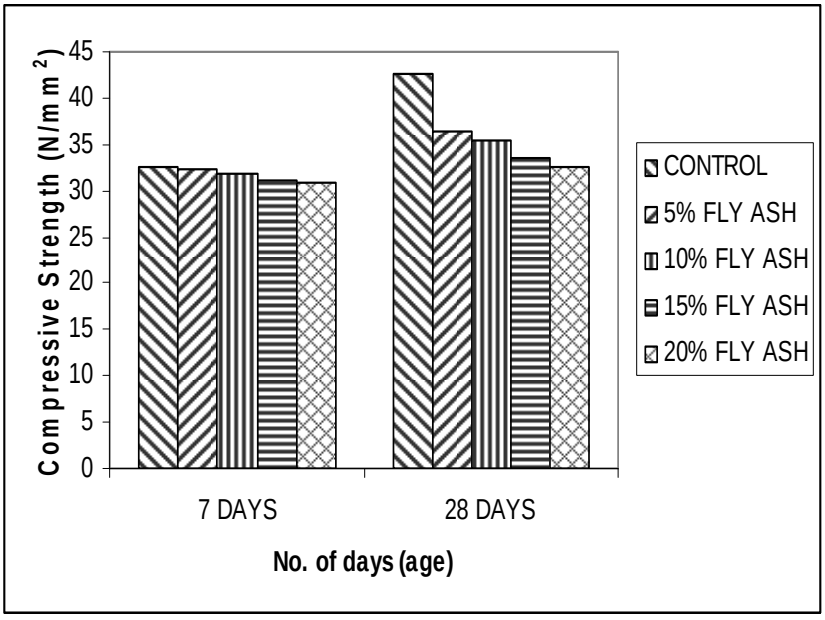

Figure 7: Compressive Strength of Specimen Replaced With RA-25% for M_{30}

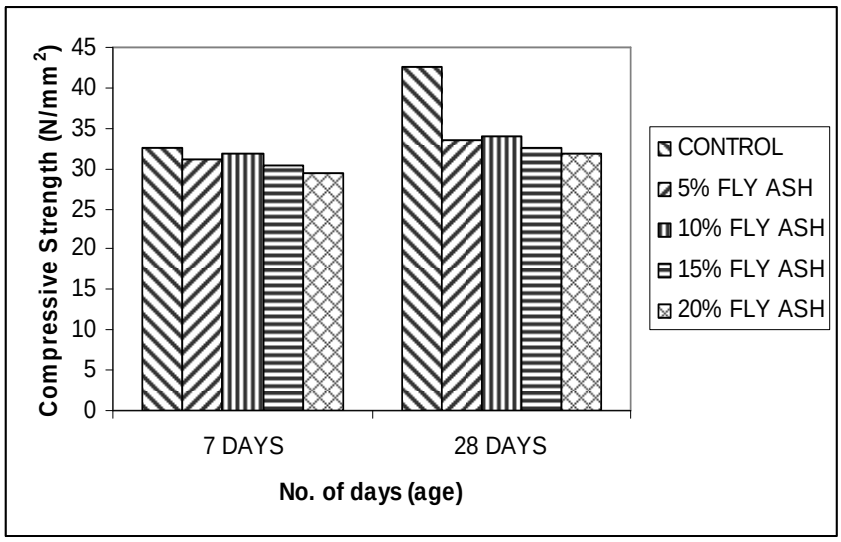

Figure 8: Compressive Strength of Specimen Replaced With RA-30% for M_{30}

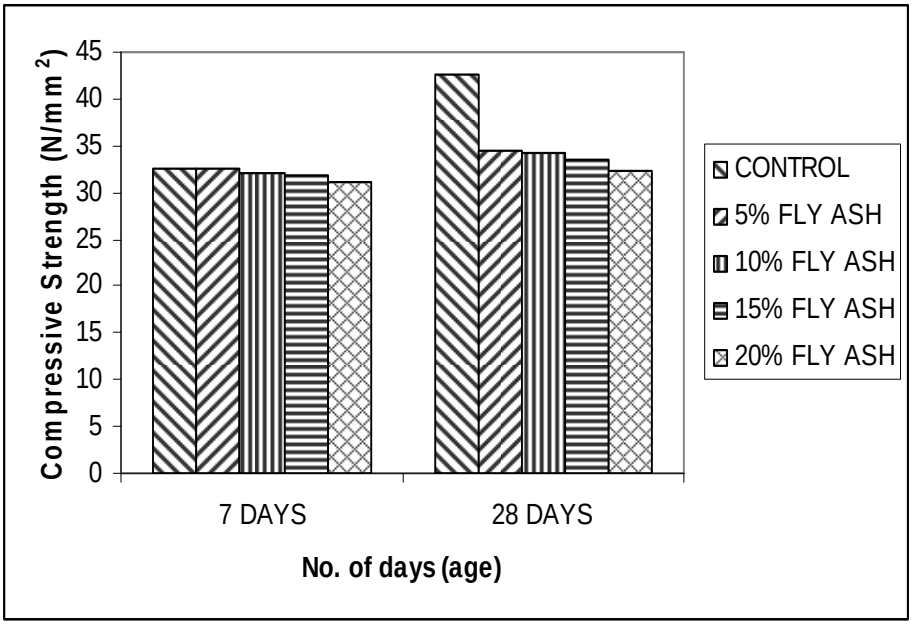

Figure 9: Compressive Strength of Specimen Replaced With RA-35% for M_{30}

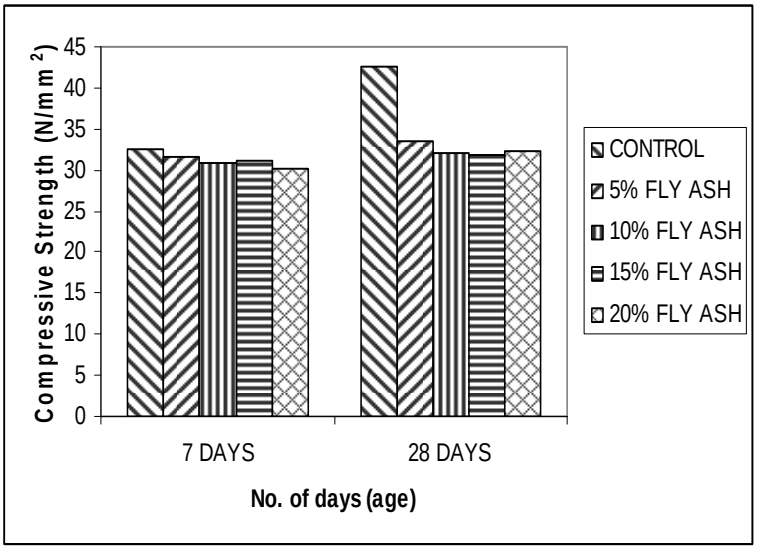

Figure 10: Compressive Strength of Specimen Replaced With RA-40% for M_{30}