Study of Behavior of Self-Compacting Concrete with Recycled Concrete Aggregates by Different Curing Techniques

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Abstrct: Development of Self-Compacting Concrete (SCC) with Recycled Concrete Aggregates (RCA) from demolished and disposed wastes seems to be appropriate to problems like resource exhaustion and waste management. This project gives an overview of different techniques used for curing water in concrete. The purpose of this investigation was to conduct a test program on how much different curing conditions affect the strength of the concrete. In this work two SCC mixes were developed by Nan-Su's method for target strengths of 40 and 60 MPa. Then the SCC mixtures were prepared by replacing Natural Aggregates with 25, 50, 75 and 100% of recycled coarse aggregates. The used water binder ratio for M40 is 0.35 and for M60 is 0.38. Super-plasticizers were also used to produce SCC. This study also considered the effect of different methods of curing on compressive strength of concrete. The cubes were cured using three methods (ponding, site curing, self-curing) and compressive strengths of 7 days and 28 days were determined. This project also makes us understand that the compressive strength that we will get at site curing is less than the standard curing method i.e., ponding. The usage of RCA is upto 25% replacement is seems to be good to get the targeted strength.

Keywords: Self-compacting concrete, recycled coarse aggregate, compressive strength, EFNARC, natural aggregates, self-curing.

1. INTRODUCTION

Concrete is an excellent construction material around the world. Various types of concrete have been developed to meet the current demands and requirement in the construction field. The problem occurs when more quantity of reinforcement placed in the reinforced concrete member; it is difficult to ensure that the formwork gets filled with concrete that is fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is exceptional troublesome in this circumstance. The common strategy for compaction, vibration, creates delays and extra cost in the tasks. Underwater concreting always requires fresh concrete which could be put without the need to compaction. In such conditions vibration has been basically impossible. This issue can now be solved with self-compacting concrete (SCC). SCC differs from conventional vibrated concrete by its rate of flow in fresh state.

On the other hand, our natural resources are diminishing day by day, so usage of an innovative waste material has tremendous significance. So, by using Recycled Coarse Aggregate (RCA) from waste generated in construction. This has encouraged the use of recycled concrete replaced with NA. The application of Recycled Coarse Aggregate in concrete started in US in the year 1942 by using demolished concrete pavement as recycle aggregate for stabilizing the base materials for road construction. In general, the RCA as high-water absorption due to the cement paste over the old concrete.

Curing is the name given to the procedures used for promoting the hydration of the cement and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of the cement and helps in continuous gain in the strength. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%.When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Hence curing is the one of the most important parameters of hardening the concrete.

Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. As per the Yogesh Pawar et al [17], this can be achieved by various methods like, pointing, spraying the surface, using impermeable membrane, and using chemicals as internal curing. For getting durability as well as performance of structure proper and homogeneous curing is necessary and suitable environment during the early stages of hardening also makes the difference.

2. LITERATURE REVIEW

Sherif A. Khafaga et al. [1] have produced SCC substituting 25%, 50% and 75% by weight. The effects of RCA on the key fresh properties such as filling ability, passing ability and segregation resistance of SCC were observed. The research outcome shows that the properties of the recycled aggregates SCCs have only a slight difference in their properties from the natural aggregates. Whereas C. Sumanth Reddy [3] developed SCC mixes by modification of Nan-Su's method for target strengths of 30, 50 and 70 MPa. Flowability of concrete was ensured to conform to EFNARC specifications through various fresh property tests. Compressive strength tests were conducted to include assessment of variation in curing period for durations of 28, 56 and 90 days. In addition to this resistance to H2 So4 capillary water sorption effects of use of RCA were studied.

Deepthy Varkey et al. [2] has carried out the study by replacing various percentages (10%, 20% and 30%) of natural aggregates in SCC with Recycled Coarse Aggregates and the properties of SCC were evaluated. A comparison of SCC with concrete compacted using conventional method was also included in the study. The mix design was M 30. To reduce the water binder ratio and to get sufficient flow ability for SCC a Poly carboxylic based super plasticizer was used. Mix design for SCC was carried out as per European guidelines and NanSu et-al method of mi design. This study shows compressive strength with variation in RCA in SCC decreases with increase in percentage of RCA in SCC. Split Tensile strength also reduced with increase in percentage of RCA when compared to SCC with NA. Water absorption percentage increases with increase in percentage of RCA.

C Sumanth Reddy et al. [3] has investigated the fresh and hardened properties of SCC using recycled concrete aggregate as both coarse and fine aggregates were evaluated. The SCC mixtures were prepared by replacing 25, 50 and 75 % ofCoarse and fine aggregates were evaluated. Silica fume and super plasticizer were also used to produce self-compacting concrete. The obtained results in all mixes indicated that the properties of the recycled aggregates SCCs have only a slight difference, in their properties from the natural aggregates. The self-compacting ability properties were evaluated directly by the diameter of flow, time that a concrete sample requires for a spread of 50 cm diameter and absorbed that there were lower slump flow values when increased percentage of RCA as replacement. The recycled concrete aggregate as both coarse and fine aggregates can successfully be used for making SCC.

Sudhir P. Patilet al. [4] in this project it is observed that the compressive strength seems to increase slightly with the addition of RCA. This could be due to the higher absorption capacity of the recycled aggregate. When the water is absorbed by aggregate, more space left by the water being absorbed can be occupied by the aggregates in a unit volume. Hence the density of recycled concrete is lower. And it also observed that the development of compressive strength of recycled concrete is better during early stage but it exhibits lower compressive strength during later stage.

Prof Nanak J pamnani et al. [6] in their project "compressive strength of SCC by different curing techniques" reported that the behavior of the design concrete mix is significantly affected by variation in humidity and temperature both in fresh and hardened state. During the concrete curing humidity and temperature plays on important role to achieve the designed strength of concrete and showed that immersion method seems to be the best method for curing giving maximum strength External curing with curing compound method gives @ 9% less compressive strength at 28 days than immersion curing. While internal curing the initial strength gain at early age is much lesser than immersion curing. However, at later age the difference is not much.

Lal Ram Sangra [7]of project named "Study of partial replacement of Natural Aggregates by Recycle aggregates on concrete" tested Physical properties of Coarse aggregate by mixing 0%, 30% and 100% Comparison of RCA concrete against natural aggregate concrete is performed and found 30%

replaced RCA concrete is same showing strength and recommended that more 30% is not performing well.

Prakash et al. [8] of project named "Experimental investigation on M30 SCC with self-curing compound with various admixtures" showed that Self-curing concrete reduces the water evaporation from the concrete and also it increasesthe water retention capacity compared to conventionally cured concrete. Self-curing methods have studied by suing polyethylene glycols and Glenium B233.

3. OBSERVATIONS FROM LITERATURE REVIEW

The slump flow results obtained for the concrete mixes with different RCA contents are within the range of 600 mm - 800mm and which is as per the recommended slump flow of minimum 600 mm by EFNARC(2002) [9]

The slump flow decreases for mixes with higher RCA due to decrease of the free water content in SCC mix which is due to high water absorption of RCA. Sudhir P Patil (2013) [4] is concerned he obtained water absorption % of RCA as 6.4% when compared to NA of 1.56%. Deepthi Varkay (2014) [2] has obtained water absorption % of RCA as3.1 % when compared to NA of 1.2%

Greater surface roughness and angularity of RCA increase friction between coarse aggregates n cement paste. These two reasons are more dominant for high percentages of RCA. More RCA percentages concrete mix becomes more viscous and provided a lower slump flow value. The super plasticizer used by C. Sumanth Reddy (2014) [3] was 1.37% of powder content.

Compressive strength of mixes decreases with increasing of the parentage of coarse RCA. The range of reduction is up to 10%. This may be due to presence of inferior mortar/cement layer on RCA. Better results will be obtained if fully processed RCA utilized in the concrete. It was also observed that age of the RCA also one factor in strength variation of the concrete.

Earlier studies show that up to 50% of the replacement of NA with RCA has considered to be optimum mix and no effect on the properties as well as strength of the fresh concrete.

In respect curing process immersion curing/ponding is the only process getting higher compressive strengths. Sri Yogesh Pawar (2020) [17] has tested for compressive strength for immersion curing and wet gunny bag curing and accelerated curing. The result observed was immersion curing is giving good result when compared to others

4. OBJECTIVES OF THE PRESENT STUDY

Based on the detailed literature review (presented in the chapter 2), the objective of the present research work is identified as the investigation of properties of SCC concrete made by using recycled aggregate under different curing conditions. Following are sub-objectives to achieve the major goal:

- To determine the properties of Recycled aggregate obtained from the demolishing of old buildings RCC structures.
- To study the water conservation techniques and reduce the excess amount of water usage on construction site.
- To propose a mix design of Self compacting concrete for M40 and M60 using Nan-Su method.
- To determine the compressive strength of Self compacting concrete using Recycled aggregates replaced with different proportions by weight and curing the cubes under different curing conditions.

5. METHODOLOGY

Tests conducted for the aggregates replaced with different proportions i.e., 0% to 100% RCA

a. Water absorption test : Water absorption increases0.3% to 2.4 %

b. Specific gravity decreases from 2.65 to 2.45

c. Packing factorincreases from 1.12 to 1.14

d. Fineness modulus of coarse aggregate 5.94

Experimental programme: This experimental investigation is carried out to study the effect of using the local produced RCA as coarse aggregate on producing self compacting concrete (SCC) for M40 and M60. In this study, number of design mixes have been tried to get the targeted strength by trial and errorby adopting Nan su's method of mix design [10]. 5 series of concrete mixes with 0% 25% 50% 75% and 100% of the natural coarse aggregates replaced by recycled coarse aggregates. As the main theme of the project is to determine the difference in compressive strength of the above 5 mixes under 3 different curing techniques. So, 180 cubes have been casted

Testing of concrete: Tests conducted for the fresh concrete replaced with different proportions i.e., 0% to 100% RCA for both M40 and M60

i. Slump flow test 745 to 680mm
ii. L-box test : No variation in the results
iii. V-funnel test 7 to 9

6. RESULT AND DISCUSSION

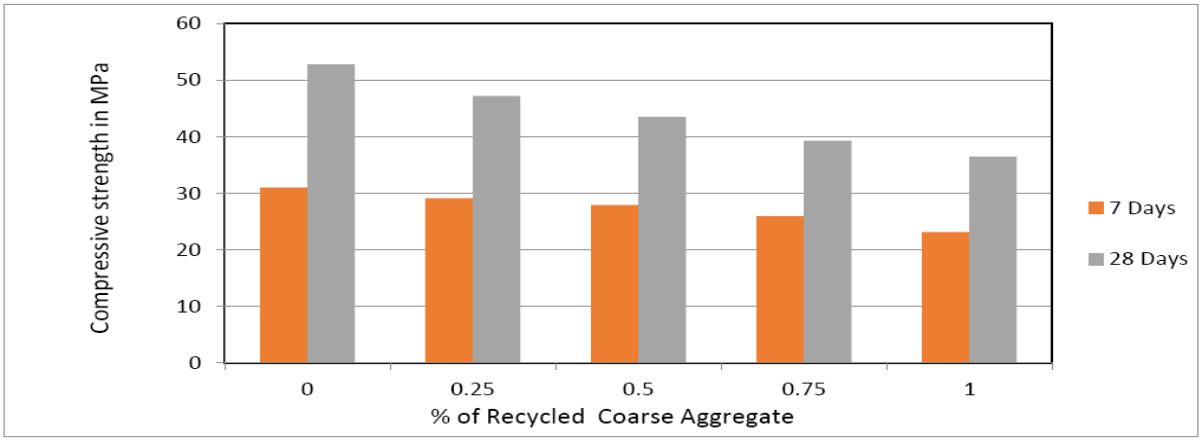

Chart1 Bar diagram showing compressive strengths of M40 mix with normal-curing

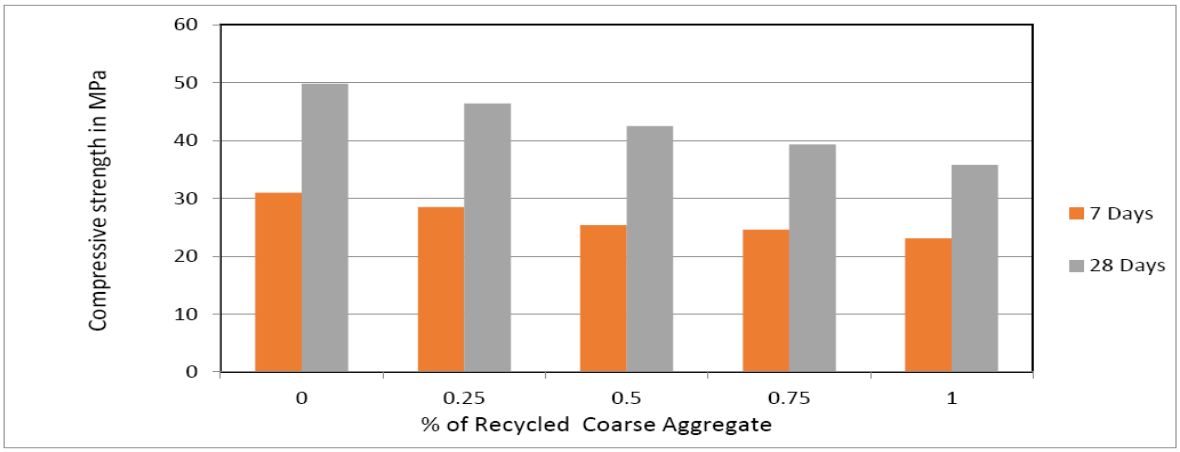

Chart2 Bar diagram showing compressive strengths of M40 mix with site-curing

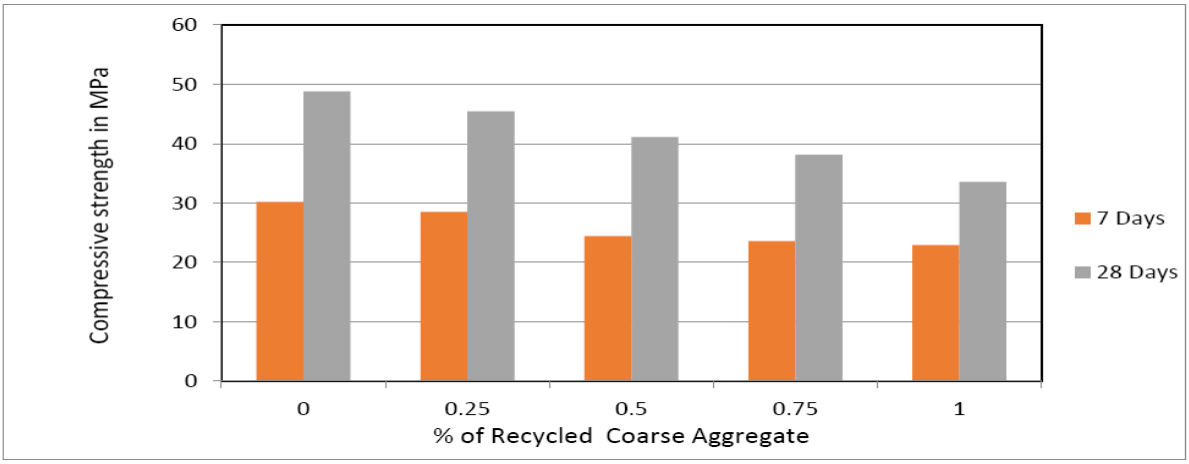

Chart3 Bar diagram showing compressive strengths of M40 mix with self-curing

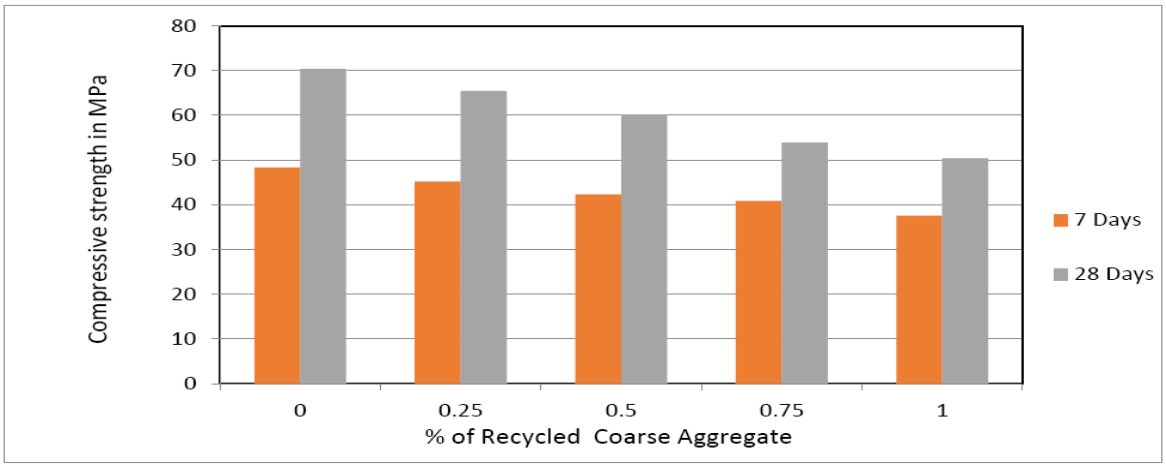

Chart4 Bar diagram showing compressive strengths of M60 mix with normal –curing

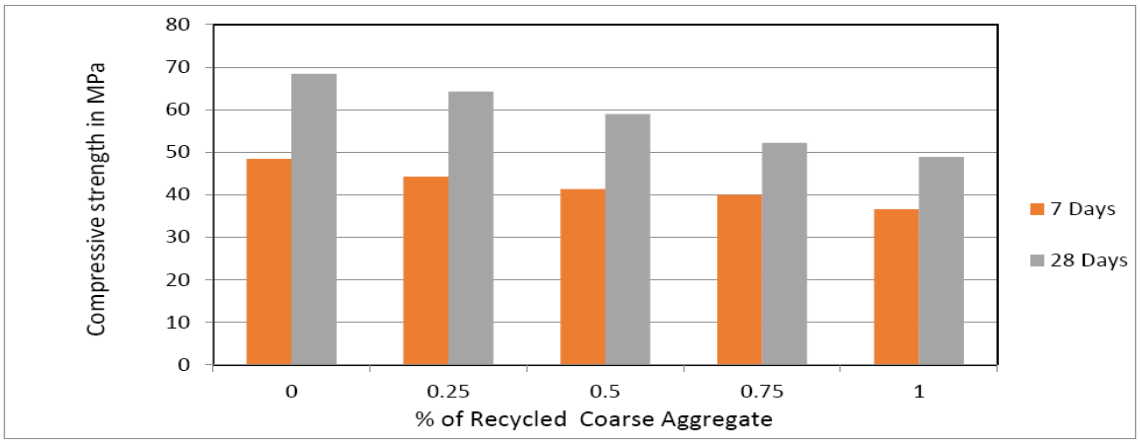

Chart5 Bar diagram showing compressive strengths of M60 mix with site-curing

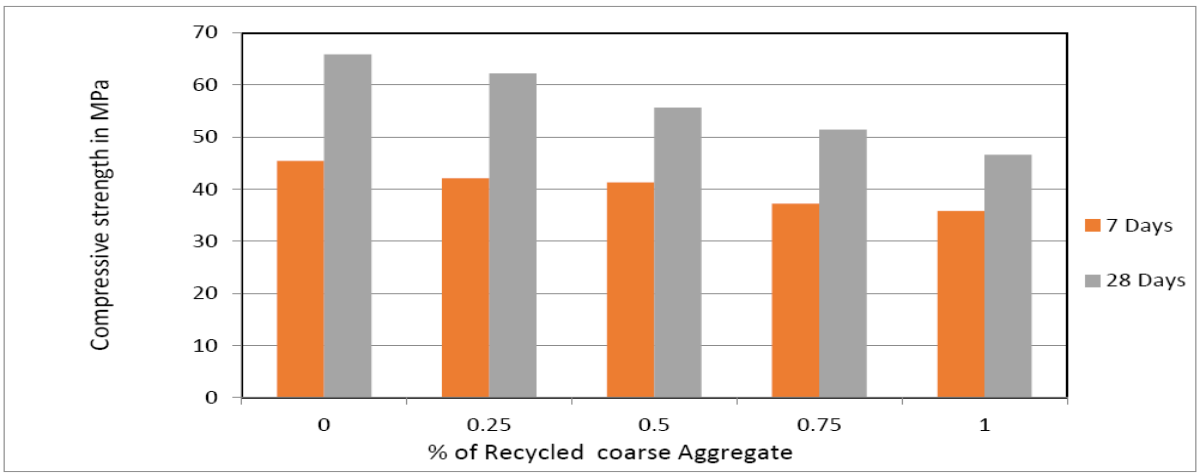

Chart6 Bar diagram showing compressive strengths of M60 mix with self-curing

7. CONCLUSIONS

1. There was increase in the water absorption for recycled coarse aggregate it was noticed that water absorption for recycled coarse aggregate was 2.4% and for natural aggregate was 0.3%.

2. For M40 mix there was considerable change in the strength of the concrete. Loss of the strength up to 24% when natural aggregate was fully replaced with Recycled Coarse aggregate in normal curing had been observed.

Target Compressive strength is: 48.25 N/mm2 (40 + (1.65 x 5))

Table 1: comparison of Normal curing with target compressive strength (M40)

% of Recycled aggregate used in SCC	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Variation in % with respect to target compressive strength
0%	31	52.8	Plus 9.4%
25%	29.1	47.2	Less 2.18%
50%	27.9	43.5	Less 9.85%
75%	25.9	39.3	Less 18.55%
100%	23.1	36.5	Less 24.35%

3. For site-cured (periodical curing) M40 mix : a) The loss of compressive strength was by 5.68% with NCA and loss was 1.7 % to 1.9% with recycled aggregate when compared with normally cured recycled aggregate mix with periodical curing method. The reduction in loss in RCA may be due to high absorption of water.

Table: 2 Normal with periodical curing comparison (M40)

% of Recycled aggregate used in SCC	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Variation in % with respect to target compressive strength
0%	31	49.8	Plus 3.2%
25%	28.5	46.4	Less 3.83%
50%	25.4	42.5	Less 11.92%
75%	24.6	39.3	Less 18.55%
100%	23.1	35.8	Less 25.8%

4. For self-cured M40 mix with recycled aggregate there was loss of strength by 7.5% with NCA and loss was 3.8% to 4.4% with recycled aggregate when compared with normally cured recycled aggregate mix with self cured method.

Table: 3 Normal with self curing comparison (M40)

% of Recycled aggregate used in SCC	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Variation in % with respect to target compressive strength
0%	30.2	48.8	Plus 1.14%
25%	28.5	45.4	Less 5.90%
50%	24.4	41.1	Less 14.82%
75%	23.6	38.1	Less 21.0%
100%	22.9	33.5	Less 30.57%

5. For M60 mix there was considerable change in the strength of the concrete. Loss of the strength up to 26% when natural aggregate was fully replaced with Recycled Coarse aggregate in normal curing had been observed.

Table: 4 Normal curing with targeted strength comparison (M60)

% of Recycled aggregate used in SCC	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Variation in % with respect to target compressive strength
0%	48.36	70.36	Plus 3.09%
25%	45.2	65.4	Less 4.18%
50%	42.3	60.2	Less 11.79%
75%	40.9	53.9	Less 21%
100%	37.6	50.4	Less 26.15%

6. For site-cured (periodical curing) M60 mix : a) The loss of compressive strength was by 2.84% with NCA and loss was 1.8 % to 3% with recycled aggregate when compared with normally cured recycled aggregate mix with periodical curing method.

Table: 5 Normal with Periodical curing comparison (M60)

% of Recycled aggregate used in SCC	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Variation in % with respect to target compressive strength
0%	48.36	68.36	Plus 0.16%
25%	44.2	64.2	Less 5.93%
50%	41.3	58.9	Less 13.7%
75%	39.9	52.1	Less 23.66%
100%	36.5	48.8	Less 28.5%

7. For self-cured M60 mix with recycled aggregate there was loss of strength by 6.48%with 100% NCA and loss was 4.5 % to 7.5% when compared with normally cured recycled aggregate mix concrete with self cured concrete

Table: 6 Normal with Self curing comparison (M60)

% of Recycled aggregate used in SCC	7days compressive strength	28 days compressive strength	Variation in % with respect to target compressive strength
0%	45.40	65.8	Less 2.45%
25%	42.1	62.2	Less 8.86%
50%	41.3	55.6	Less 18.53%
75%0	37.2	51.4	Less 24.69%
100%	35.8	46.6	Less 31.72%

8. Therefore, based on overall results it shows that Mix design upto 25% replacement of natural aggregates has satisfactory results in respect of achieving targeted compressive strength. As far as curing methods is concerned there is a loss in compressive strength by increasing the percentage of Recycled Aggregate (RAC) and there is a loss of compressive strength in both periodical and self-curing methods when compared to normal curing method.

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