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Experimental Inspection on Shear Capacity in RCC Beams with Partial Replacement of Recycled Coarse Aggregates

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Abstract: Demolition waste increasing day by day. The old damaged building materials can be used in present buildings or other construction works. Especially the recycled aggregates are useful to the concrete structures. The experimental studies on the use of recycled coarse aggregate has been going on for many countries. This publication focuses on the relationship between the shear capacity and the flexural cracking load of reinforced recycled concrete beams with stirrups, this experimental Inspection with partial replacement of natural coarse aggregates (NAC) with recycled coarse aggregates (RAC) at different ages as 10, 20 and 30 years in various proportions as 20 per cent, 30 per cent, 40 per cent. For this, M30 grade of concrete is consider. Curing of specimens were done for 7 day and 28 days to conclude the maximum strengths. The obtained results of concrete with partial replacement of recycled aggregates of 10,20and 30 years age group conclude maximum compressive strength of 35.84 N/mm2 at 40% replacement of NCA with RCA of age group (10 years) and 34.12 N/mm2 at 30% replacement of NCA whit RCA of (20 years) age group and 36.14 N/mm2 20% replacement of NCA with RCA of age group (30 years). After the compressive strength, beam specimens were casted for 7day and 28 days.

Based on test results of 8 beams, the relationship between the cracking load that causes a beam to crack in the middle of the shear span and the beam's shear capacity is confident. All beams are reinforced in the longitudinal direction only and only tested under two-point loading conditions. The average analytical cracking load ratio is 0.60.the mid-shear span at cracking load (Vcr-a/2) in comparison with the observed shear capacity (Vexp). The analytical cracking load ratio. The analytical cracking's load was used in this exploration as it is more reliable than the observed cracking load. At mid-span, the shear capacity of most of the beams was shown to be 50%. The average shear capacity ratio to the related test crack load in the center of the shear span 0.43. The analysis showed that cracking loads are strongly related to the shear capacity of the members. This relationship can be used to develop recycled reinforced beam members ' shear design process.

Keywords: shear cracking load, shear capacity, recycled coarse aggregate, compressive strength

I. INTRODUCTION

In particular, Reinforced concrete, which is a composite material composed of concrete and steel, is very commonly used for the building of all the above structures. Sand is the fine aggregate. As water is added to the mixture between cement, sand and coarse aggregates, it forms a plastic mass, popularly known as concrete. In the present day, the studies around the world surrounding the usefulness of (R.C.A). The RCA used in concrete should be added to that found alternative materials. The experimental study presented herein, using the most studies concentrated on the mechanical characteristics of (RCA) as a test component. The beam test were carried out single reinforced concrete in order to study influence of the partial replacement of (RCA) various percentage. Many Inspections were carried out up to this point. When a beam is loaded with transverse loads, the bending moment varies from section to section. Fig (1) shows the stresses in beam, distribution in a homogeneous elastic beam of rectangular section. We know that the bending stress and the shearing stress vary across section of R.C.C beam. below the N.A., the bending stress ($\boldsymbol{\sigma}$) is tensile while the shear stress (q) is constant shows a small element, taken from the below the N.A this element is subject to a longitudinal tensile stress ($\boldsymbol{\sigma}$) and horizontal shear stress (q) along with the vertical complementary shearing stress(q). to derive the expression by Mohr's circle is the locus representing magnitude of normal and shear stress at various plane in a given stress element to considering the principal stress $\boldsymbol{\sigma}_1$ and $\boldsymbol{\sigma}_2$ can be determined as

$$\boldsymbol{\sigma}_1\boldsymbol{\sigma}_2=\frac{1}{2}f\sigma_x \pm \sqrt{\left(\frac{1}{2}\sigma_x\right)^2+q^2} \text{ and } \tan 2\Theta = \frac{2q}{\sigma_x}$$

At the supports, where bending stress ($\boldsymbol{\sigma}$) is practically zero, the value of the principal (tensile) stress is equal to the shear stress (q) and it is inclined at 45^0 to the horizontal. Hence it is known as diagonal tension. At the center of the beam, where shearing stresses are practically negligible, the principal tensile stress is equal to will be horizontal and the cracks will be vertical and flexural cracks develop in adjacent to mid-span where B.M. Vertical and flexural cracks may form in the mid-span adjacent to where B.M. it major and shear pressure is zero or bending-sheer cracks formed under the combined action of bending moment and shear, and the shear stress is maximum at N.A. and bending-shear cracks are developed along the diagonal of the component subject to shear action. Taking into account the differences M and V over the shear span of the beam supported. For a beam subjected to concentrated load, the ratio M/V at the initial section subjected to maximum V is expressed a distance (a) called shear span between the support and the load. Many tests on the shear have established that diagonal tension is function of M/V and hence on the shear span and the diagonal tension failure is function of ratio a/d provides a measure of the relative magnitudes of the flexural stress and shear stress.

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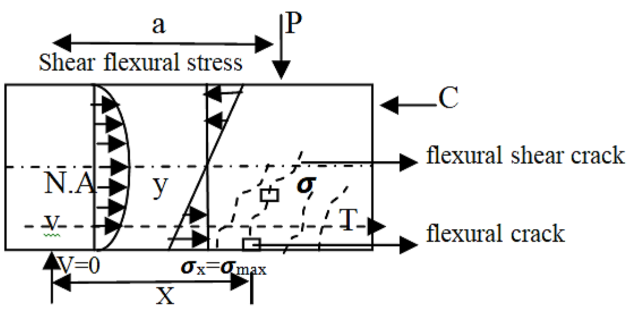


Fig.1 stresses in beam

Referring to fig.1, the shear stress, q = 0 and the flexural stress, $\sigma_x = \frac{My_t}{I_T}$ on the lower side of the beam. Therefore, Eq. (1) gives,

$$\sigma_1 = \sigma_x = \frac{My_t}{I_T} \text{ And } \sigma_2 = 0$$

Concrete cracking begins if the tensile stress reaches the tensile strength in flexure, i.e. the modulus of rupture (f_r).The main tensile stress equalizes (σ_1) to (σ_r) , Eq. (2) can be written as:

$$\sigma_r = \frac{M_{cr}\, y_t}{I_T} = \frac{V_{cr}\, a y_t}{I_T}$$

M_{cr} = cracking moment at any point from the support = V_{cr} a

V_{cr} = shear load that causes a crack in the beam

I_T = moment of inertia of the transformed

y_t = distance from the neutral axis to the extreme fibers in tension

The modulus of

f_r=0.75 $\sqrt{f_{ck}}$

f_{ck} = is the concrete compressive strength.

The first crack develops in a constant moment zone for two-point charging where M_{cr}=$V_{cr}\, a$ and (a) is the shear span substituting the values of f_r and M_{cr}

$$0.75\sqrt{f_{ck}} = \frac{V_{cr}\, a y_t}{I_T} \Rightarrow V_{cr} = 0.75\sqrt{f_{ck}}\, \frac{I_T}{a y_t}$$

Similarly, a crack develops in the middle of the shear span, should be $V_{cr-\frac{a}{2}}$ where is the shear load that causes cracking in the center of the shear span. Substitution this value in Eq. (3):

$$V_{cr-\frac{a}{2}} = 1.5\sqrt{f_{ck}}\, \frac{I_T}{a y_t} = 2V_{cr}$$

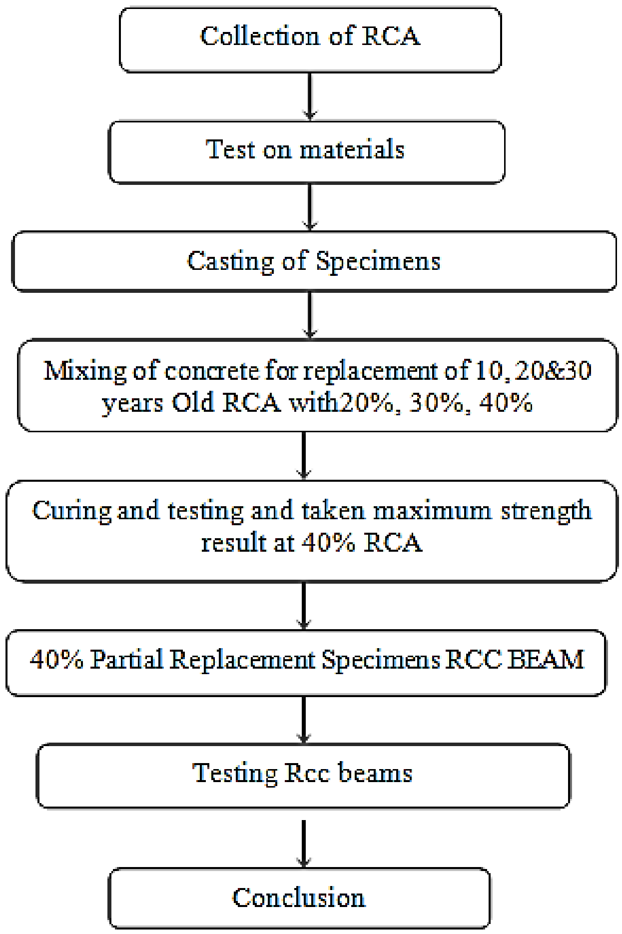
II. LITERATURE REVIEW

[1]**Robert Grygo et .al** The application of concrete waste for recycled aggregate concrete (R.A.C) used in structural member is associated with an increased risk for the structure due to, e.g. pollutions in the old crushed concrete and random variable strength. A new concept of RC flexural members like beams and slabs made of (R.A.C) with strengthening inclusion was elaborated and presented in the paper based on application of precast concrete inserts made of HSC, located in the compression zone of the members. The paper present the results of experimental and numerical (FEM) analysis carried out on such composite beam. The results of experimental research on the behavior of such beam and numerical simulations using Diana computer program reveal some positive effects, such as higher stiffness and flexural capacity of the innovative beams compared to the reference beams made fully of RAC.

[2]**Rajan vinayak et.al** In the era of latest science and technology, the fossil fuels are used gradually. So this paper deals with the relationship between the Flexural strength of plane natural aggregate concrete (PNAC) and plane recycled concrete aggregate (PRAC). By find out the flexural strength of M20 & M30 grade with different percentage of recycled material for the usage of further concrete works. With the usage of plane recycled concrete aggregate the cost of the project will be decreased. The result shows that with the increase of recycled aggregates in concrete the flexural strength decreased.

[3]**Roumiana Zaharieva et.al** the research presented in this paper deals with concrete containing building waste recycled as aggregates. The frost resistance is used as a durability indicator, the characteristics of recycled aggregates (RA) and their impact on the characteristics of RA concrete are presented. Some basic factors concerning the frost resistance of RA concrete as RA content and degree of water saturation are considered. The RA concrete is compared with a control concrete made with natural aggregates. The pertinence of different criteria for the assessment of the frost resistance is also discussed

III. MATHODOLOGY



IV. MATERIALS

A. Cement

Portland Pozzolana cement is produced either by inter-grinding Portland cement and Pozzolana or by intimately and evenly blending Portland cement and fine Pozzolana. While intergrading does not present any difficulties, it tends to result in a non-uniform product and Indian standard.IS 3812:1981

Table-1: Properties of cement

S.No	Test Particulars	Results	Remarks
1	Specific gravity of cement	2.91	2-3 IS Suitable as per is code
2	Normal consistency of cement	34%	25%-30%
3	Initial setting time	38 mints	30 min
4	Final setting time	532 mints	600 mix
5	Fineness of cement	2.55%	Should not be most than 10% and 90 micron sieve

B. Natural coarse aggregate (NCA) and recycled coarse aggregate (RCA).

Used from nearby (NCA) by a quarries and The concrete was demolished from various sources, which we collected by cutting i.e. collected three various demolished concrete samples of the 10-year-old, 20-year-old and 30-year-old age groups.

Table-2: properties of Natural course aggregate and recycled aggregate

S. No	Property	Obtained results for NCA 20 mm	Obtained results for 10 years 20 mm	Obtained results for 20 years 20 mm	Obtained results for 30 years 20 mm
1.	Impact test	17.22%	20.5%	20.9%	21.2%
2.	Crushing test	20.67%	14.65%	18.5%	17.1%
3.	Specific gravity	2.82	2.37	2.55	2.64

C. Fine aggregate

Locally accessible Vamsadhara and nagavali rivers and is employed as fine aggregates that square measure passing through four.75mm IS sieve. Natural sands are generally used as fine aggregates. The sand can be obtained from the river and the lake.

Table-3: Properties of Fine Aggregate

S.No	Property	Obtained values for fine aggregate
1.	Specific gravity	2.72
2.	Bulking	44%
3.	Sieve analysis	4.9

V. TEST RESULTS

A. Compressive strength test

Specimen compressive strength for partial replacement of a coarse aggregate with recycled aggregate for 10 years, 20 years and 30 years.

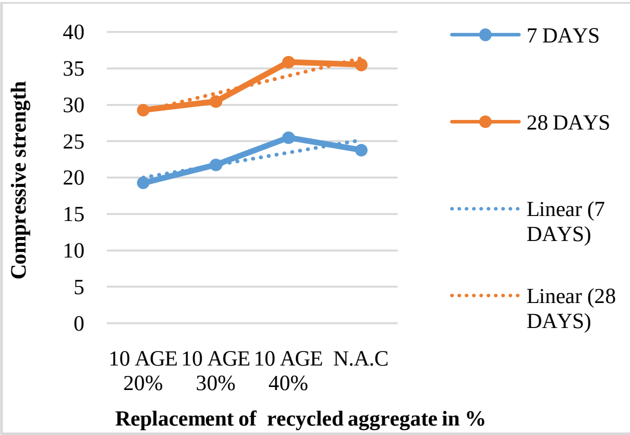
Better cubes in the dimensions 150mm × 150mm were cast in place of natural aggregates in 20%,30% and 40% over 10,20 and 30 years of recycled aggregate substitution. The compression strength is tested for 7, 28 days of treatment for the M30, and the outcomes are shown and displayed below.it is mixed into mold and correctly tempered, so that there is no void. The molds are removed after 24 hours and tested to mater for curing. These samples should be equal and smooth

On the top surface. This is achieved by smoothly spreading cement paste on the full sample region.

After 7 days and 28 days of treatment, these samples are analyzed by a compression test machine. A load of 140kg/cm^2 per minute should be applied gradually until the samples fail

Table-4 Effect of partial replacement of 10 years of RCA the compressive strength

S.No	%of RECYCLED AGGREGATE (COARSE AGGREGATE)	Avg 7 Days Compressive Strength (N/MM2)	Avg 28 Days Compressive Strength (N/MM2)
1.	**0%**	**23.76**	**35.48**
2.	**20%**	**19.24**	**29.26**
3.	**30%**	**21.74**	**30.44**
4.	**40%**	**25.47**	**35.84**

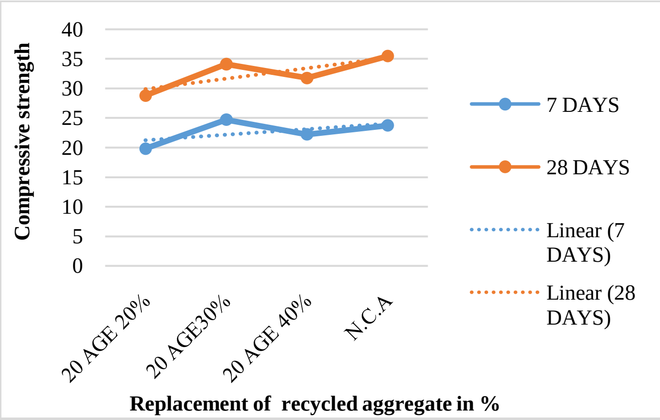


Graph 1 Effect of partial replacement of 10 years of RCA at the compressive strength

Explanation of results: Due to increase in the percentage of RCA from 20% to 40%, results the maximum average compression strength value for 7 days and 28 days in 40% rather than 20%and 30%.

Table-5 Effect of partial replacement of 20 years of RCA at the compressive strength

S.No	%of RECYCLED AGGREGATE (COARSE AGGREGATE)	Avg 7 Days Compressive Strength (N/MM^2)	Avg 28 Days Compressive Strength (N/MM^2)
1.	0%	23.76	35.48
2.	20%	19.84	28.78
3.	30%	24.72	34.10
4.	40%	22.24	31.75

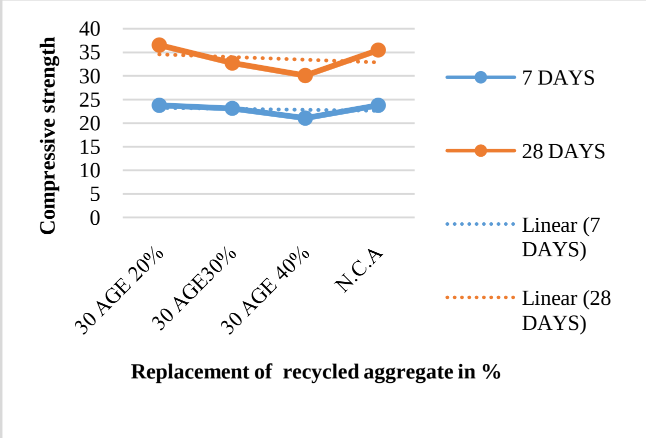


Graph 2 Effect of partial replacement of 20 years of RCA at the compressive strength

Explanation of results: Due to increase in the percentage of RCA from 20% to 40%, results the maximum average compression strength value for 7 days and 28 days in 30% rather than 20%and 40%.

Table-6: Effect of partial replacement of 30 years of RCA at the compressive strength

S.No	%of RECYCLED AGGREGATE (COARSE AGGREGATE)	Avg 7 Days Compressive Strength (N/MM^2)	Avg 28 Days Compressive Strength (N/MM^2)
1.	0%	23.76	35.48
2.	20%	23.69	36.54
3.	30%	23.11	32.71
4.	40%	21.04	30.08



Graph 2 Effect of partial replacement of 30 years of RCA at the compressive strength

Explanation of results: Due to increase in the percentage of RCA from 20% to 40%, results the maximum average compression strength value for 7 days and 28 days in 20% rather than 30%and 40%.

B. Experimental Inspection

- From the above compressive strength results , R.C.A for 10 years age group the maximum value obtained in 40% partial replacement of concrete. By considering the 40% of average strength value the beams are casted.
- From the above compressive strength results , R.C.A for 20 years age group the maximum value obtained in 40% partial replacement of concrete. By considering the 40% of average strength value the beams are casted.
- From the above compressive strength results , R.C.A for 30 years age group the maximum value obtained in 40% partial replacement of concrete. By considering the 40% of average strength value the beams are casted.
- The reinforced concrete beam is casted and is cured for 7days and 28 days. The cured beam is then placed in the tested machine where a two-point loaning is subjected to the top surface of the beam.
- RCC beam containing the longitudinal reinforcement of 4 of 10mm dia bars. The beam is subjected two point loading crates a first crack at the center of the shear span within the moment zone.

Table- 7: Specimen details

Speci men	Da ys	Height (h) (mm)	Width (b) (mm)	Effective depth (d)(mm)	Span Length (L)(mm)	Shear-Span (a) (mm)	Shear Slenderness (a/d)	*fc* Mpa (cube)	Reinforc ement *(Pt%)*	# of bars
N.A	7	150	150	125	700	166	1.32	21.4	1.67	4#10@
N.A	28	150	150	125	700	166	1.32	33.7	1.67	4#10@
R.C.A-10	7	150	150	125	700	166	1.32	22.2	1.67	4#10@
R.C.A-10	28	150	150	125	700	166	1.32	34.2	1.67	4#10@
R.C.A-20	7	150	150	125	700	166	1.32	20.6	1.67	4#10@
R.C.A-20	28	150	150	125	700	166	1.32	32.	1.67	4#10@
R.C.A-30	7	150	150	125	700	166	1.32	22.7	1.67	4#10@
R.C.A-30	28	150	150	125	700	166	1.32	34	1.67	4#10@

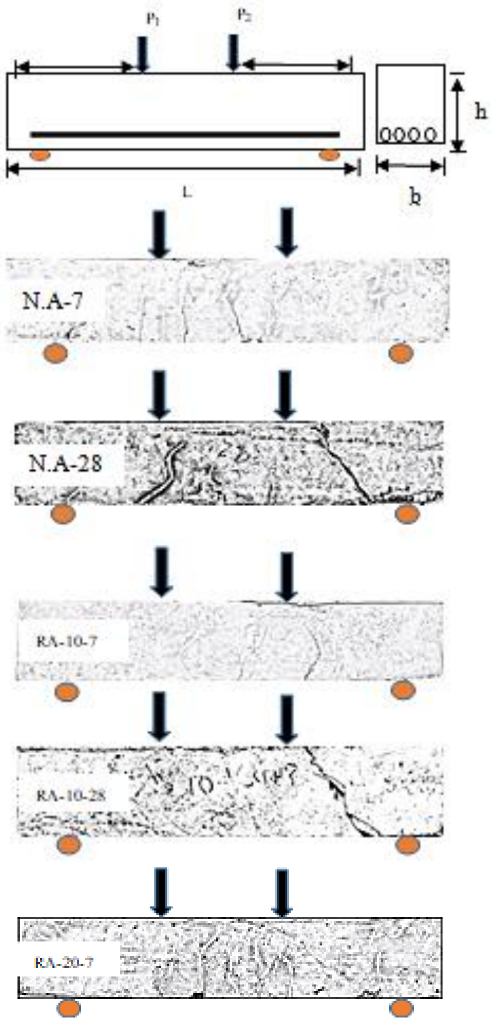
A) Observed cracking load

Displays analytical cracking load (V_{cr}) values of the observed cracking load (first flexural cracking and beam shear capability (V_{exp}).The universal testing machine read about half the failure load.

The cracking and ultimate force in the R.C beam as first, the mid-span, flexural cracks developed. As a result of shear stress, the primary cause of 45 degree crack is diagonal tension. The failure process come differently is shout beam. Two significant diagonal cracks developed symmetrical in the beam's two opposite support zones when the load reached 55 percent and did not develop from the flexural crack.at failure, two significant diagonal cracks formed symmetrically in the opposite areas of the beam when the load extended into the applied load and the support and its length increased substantially to 0.7 m.

Several shear studies have shown that in a function of diagonal tension and therefore on the shear span a. This also depends on both the effective depth d, the ratio of the diagonal voltage failure.it is also interesting to note that the dimension provides measure of the relative magnitudes of the flexural stress and shear stress. The shear failure occurs in applying the total load of the beam. Due to the shear stress, we got the shear failures occur and developed in upon the value of ratio. The design of failure moment is taken by the observing cracking at the P1 and P2

B) Shear capacity in NCA and RCA beam



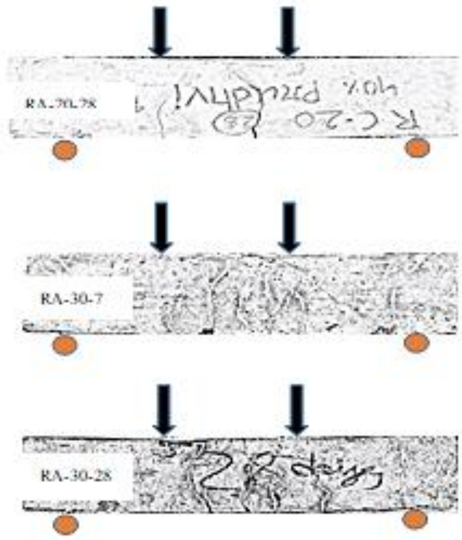


Fig.2. types of crack pattern in NCA and RCA beams

C) Comparing of cracking load with shear capacity

We confirmed from the results of the experiment that the shear capacity of the beam is manually affected by the shear span-of-depth ratio. Since the beam has a standard effective length, the cross-section is the same. It was an observer without increasing the size of the beam, the length of the initial force is increasing and the shear strength, but also the extent of the failure of the investigated beams, is more affected.

Table- 8: Comparing of cracking load with shear capacity

Specimens	Calculated cracking load V_{cr} (KN)	Calculated cracking middle of the shear span $V_{cr-a/2}$ (KN)	Observed cracking load (v/a) (KN)	Shear capacity V_{exp} (KN)	$\frac{V_{cr}}{(V/a)}$	$\frac{V_{exp}}{V_{cr-a/2}}$
NA-7 D	12.05	24.1	17.3	10.5	0.69	0.43
NA-28 D	12.05	24.1	23.9	14.5	0.50	0.60
RA-10 - 7D	12.05	24.1	18.9	11.5	0.63	0.47
RA-10 -28D	12.05	24.1	23.5	14.3	0.51	0.59
RA-20 - 7D	12.05	24.1	16.83	10.2	0.75	0.42
RA-20 -28D	12.05	24.1	21.78	13.2	0.55	0.54
RA-30 - 7D	12.05	24.1	16.9	10.3	0.71	0.47
RA-30 -28D	12.05	24.1	22.7	13.8	0.53	0.57
Average =					0.60	0.43

The table 3 shows the investigative value of the calculated cracking load by looking at the cracking load at the first flexural cracking and the shear capacity of the beams. By determining the investigative cracking loads and comparing them to the cracking load staring and the excellent finding shown in Table 3. The average ratio of the analysis cracking load to the control cracking load is a simple deviation. The required cracking load at the mid-shear interval was estimated to almost twice the cracking load at the mid-span. The cracking load in a shear span was connected to the shear capacity. On this comparison, given its so much greater reliability than the observed cracking load, the investigative cracking load was used. A shear capacity for a maximum of the beams in cracking load on the center of the shear span. The typical shear capacity ratios to the relative cracking load testing in the middle of the shear span are with a primary deviation. The table 3 shows that only the shear capacity matches well with loads in cracking.

VI. CONCLUSION

1. The shear capacity of 10 years age RCA-RCC beams is more than the shear capacity of NCA-RCC beams.
2. The cracking load of the middle of the shear span is RCA of 10, 20, 30, year's age group in on increase and also cracking load of NCA-RCC beams is 0.43.
3. The diagonal tension cracks began to form at the top of the flexural cracks and projections of these cracks intersected the reinforcement at approximately the center of the shear span.

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