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BEHAVIOUR OF RECYCLED AGGREGATE CONCRETE BEAMS WITH VARYING LONGITUDINAL REINFORCEMENT

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Abstract: To address sustainable issues in construction, researchers and construction firms are focusing upon utilizing recycled construction material. This present investigation is based on the use of recycled coarse aggregates in reinforced concrete beams. Recycled Coarse Aggregate was replaced by 0%, 50% and 100% of Natural Coarse Aggregates. Shear behavior of reinforced concrete beams were studied by varying longitudinal reinforcement ratios ranging from 1.0 to 4.0. Load carrying capacities of the beams were observed by plotting the load deflection curves.

Keywords: Recycled coarse aggregate, varying longitudinal reinforcement ratio, load carrying capacity.

I. INTRODUCTION

The manufacture of concrete requires the use of significant amounts of cement and aggregates. The negative environmental impact of the production of these ingredients from non-renewable sources led to a global interest in finding alternative sources. The use of recycled cementitious materials has increased considerably.

The use of recycled alternatives to the Natural Coarse Aggregate (NCA) has also been explored on a wide scale. It can lead to considerable savings in natural resources, landfills and energy. Concrete that is produced using Recycled Coarse Aggregate(RCA) is commonly referred to as recycled aggregate concrete (RAC). Research has shown that RCA generally have inferior qualities relative to NCA. It has also shown that the percentage of replacement of the NCA with RCA [7,8] and the quality and general properties of the RCA have considerable effects on the properties of the RAC [14].

II. LITERATURE REVIEW

Fernando Martinez-Abella et al **(**2006)investigated the shear behaviour of concrete made with recycled concrete aggregates. Tests have been performed on recycled aggregates and on two concrete mixes (conventional concrete and recycled concrete with 50% of recycled coarse aggregates). For every concrete, four reinforced beams with different amount of transverse reinforcement were made and were tested to failure. The results showed that whereas the deflections and the ultimate loads were little affected by the different types of concretes, in recycled concrete beams, cracking was premature. Experimental results were compared using theoretical models Modified Compression Field Theory and current codes. Both predicted the shear behaviour of the new recycled concrete well [10].

` Wei Chen et al **(**2016) have casted 36 specimens replaced NCA with RCA(0%, 50%, 100%) which are being subjected to different temperatures(20°C, 200°C, 300°C and 400°C).They have found mechanical parameters including shear strength, peak shear strain, stress-strain curves and shear modulus of the beams at different RAC proportions and different temperatures. They have observed that the temperature elevates the residual shear strength and shear modulus decline rapidly where has the peak strain increases linearly ans stress strain curves become more disperse with the increment of temperature [8].

K.N. Rahal et.al, (2017) have casted beams in two phases of total 13 beams. First phase of beams casted was partial replacement of natural aggregate to recycled aggregate of 0% ,10%,20%,35%,50%,75% and 100%, where as in second phase they used smaller grade of recycled aggregate to replace natural aggregate with 5%,10%,16%,25%, and 35%. The concrete used was M35 and longitudinal reinforcement used was 3-14ϕ in tension and 2-10ϕ in compression.

They have used four point loading test setup to test the specimens.The beam dimensions were 150mm x 420mmof length 2900mm with shear span 1162mm of effective depth 388mm with shear span to depth ratios.The researchers have concluded that first series with partial replacement of 10% to 100% cause decrease in shear strength from 13% to 18% and second series with Partial replacement of 5% to 16% didn't cause any change and replacement of 25% to 35% caused and 10 to 20% reduction in shear strength [6].

Ivan S. Ignjatovic et al (2017) have placed 95 samples and 9 full length beams were casted with different Recycled Aggregate concrete proportions(0%, 50%, 100%) and Shear reinforcement(0%, 0.14%, & 0.19%). The beams were of size 200mm x 300mm and were tested by four point loading until failure. Concrete with 50% and 100% has similar tensile and compressive strength. The failure of natural Aggregate concrete when compared to recycled aggregate concrete without shear reinforcement is just change crack angle and shape [7].

III. MATERIAL SPECIFICATIONS

IV.

I. Cement

TABLE I Properties of Cement

Tests	Results
Standard Consistency	32%
Fineness	6%
Specific Gravity	3.15
Initial Setting Time	150 minutes
Final Setting Time	220 minutes

II. Fine Aggregate

TABLE II Properties of Fine Aggregate

Tests	Results
Specific Gravity	2.45
Bulk Density	1.5gm/cm^3
Grading Zone	II
Fineness modulus	2.7
% of Voids	35%
Void Ratio	0.53

III. Natural Coarse Aggregate

TABLE III Properties of Natural Coarse Aggregate

Tests	Results
Specific Gravity	2.77
Bulk Density	1.402gm/cm^3
Void Ratio	0.9
% of Voids	49.8%
Fineness Modulus	7.89
Water absorption	2.58%

IV. Recycled Coarse Aggregate

TABLE IV
Properties of Recycled Coarse Aggregate

Tests	Results
Specific Gravity	2.53
Bulk Density	1.371gm/cm^3
% Of Voids	45.71%
Void Ratio	0.84
Water absorption	4.12%

V. EXPERIMENTAL SETUP

The support rollers are positioned at the end of the beam leaving 100mm at either end. The remaining span between those ends is divided into three partswhich are vividly demarcated on the beam. The specimen is placed in the machine and tested under two point loading. Dial gauge is placed at the center under the beam. The load was gradually applied and digital recorder was used to measure the deflection.

Fig 1.Testing of specimens in UTM

VI. RESULTS AND DISCUSSIONS

Table V load and deflection for various mix proportions

MIX	LOAD @ FIRST CRACK (KN)	DEFLECTIO N (mm)	PEAK LOAD (KN)	DEFLECTIO N (mm)	ULTIMATE LOAD (KN)	DELECTION (mm)
M11	60	1.82	124	6.15	105.4	8.67
M12	50	2.05	90	5.84	76.5	9.89
M13	45	2.21	74	4.6	62.9	6.25
M21	75	3	128	6.22	108.8	8.37
M22	50	1.59	112	4.51	95.2	4.99
M23	40	2.1	84	4.26	71.4	5.01
M31	45	1.65	144	5.5	122.4	7.45
M32	55	1.86	124	4.6	115	5.41
M33	60	2.41	95	4.23	79.9	4.95
M41	50	1.3	161	3.63	136.85	3.98
M42	60	1.82	124	6.15	105.4	6.44
M43	75	2.4	100	3.56	85	3.68

Table VI Shear parameters for various mix proportions

MIX	Ultimate load (KN)	Shear force (KN)	Average shear stress (KN/m^2)	Shear stress @ N-A (KN/m^2)
M11	105.4	52.7	4.0538462	12.161538
M12	76.5	38.25	2.9423077	8.8269231
M13	62.9	31.45	2.4192308	7.2576923
M21	108.8	54.4	4.1846154	12.553846
M22	95.2	47.6	3.6615385	10.984615
M23	71.4	35.7	2.7461538	8.2384615
M31	122.4	61.2	4.7076923	14.123077
M32	115	57.5	4.4230769	13.269231
M33	79.9	39.95	3.0730769	9.2192308
M41	136.85	68.425	5.2634615	15.790385
M42	105.4	52.7	4.0538462	12.161538
M43	85	42.5	3.2692308	9.8076923

Where, mix M11 represents 1% of longitudinal reinforcement and 100% NCA

M12 represents 1% of longitudinal reinforcement and 50% RCA

M13 represents 1% longitudinal reinforcement and 100% RCA

M21 represents 2% longitudinal reinforcement and 100% NCA

M22 represents 2% of longitudinal reinforcement and 50% RCA

M23 represents 2% of longitudinal reinforcement and 100% RCA

M31 represents 3% of longitudinal reinforcement and 100% NCA

M32 represents 3% of longitudinal reinforcement and 50% RCA

M33 represents 3% of longitudinal reinforcement and 100% RCA

M41 represents 4% of longitudinal reinforcement and 100% NCA

M42 represents 4% of longitudinal reinforcement and 50% RCA

M43 represents 4% of longitudinal reinforcement and 100% RCA

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Fig 2. Shear failure of specimen

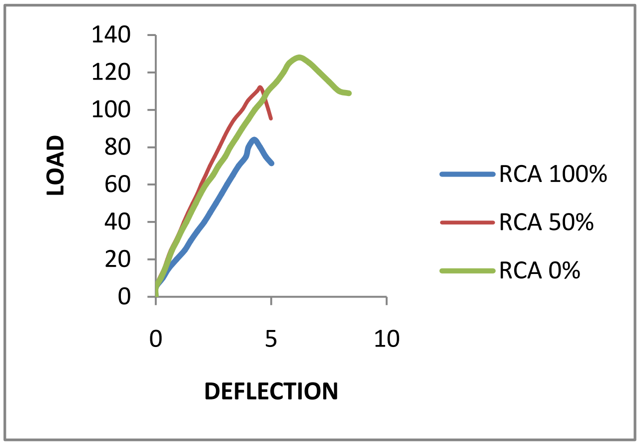

Fig3.load vs deflection curve for 1% longitudinal reinforcement

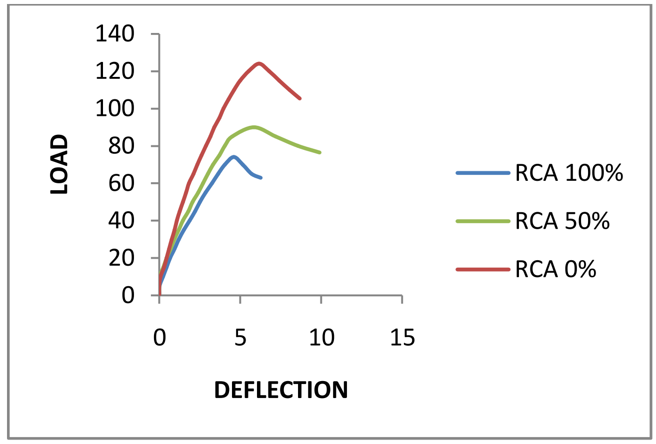

Fig4.load vs deflection curve for 2% longitudinal reinforcement

For 1% longitudinal reinforcement - Maximum peak load and maximum deflection is obtained when 0% of RCA is used.

For 2% longitudinal reinforcement – Maximum peak load and maximum deflection is obtained for 0% of RCA and 50% of RCA respectively

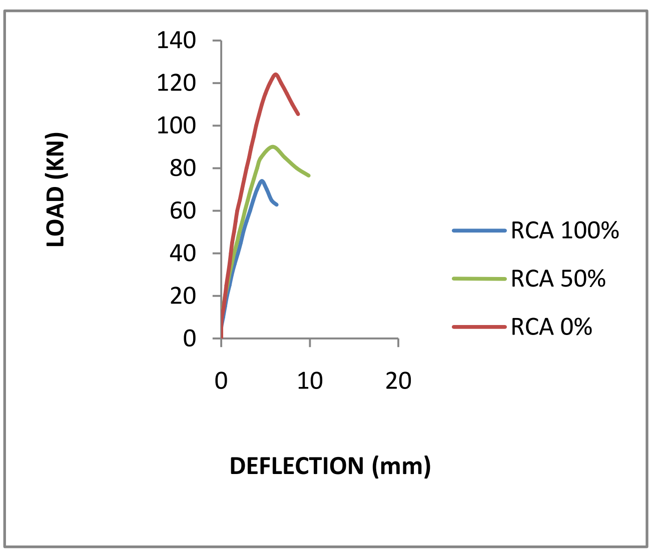

Fig5.load vs deflection curve for 3% longitudinal reinforcement

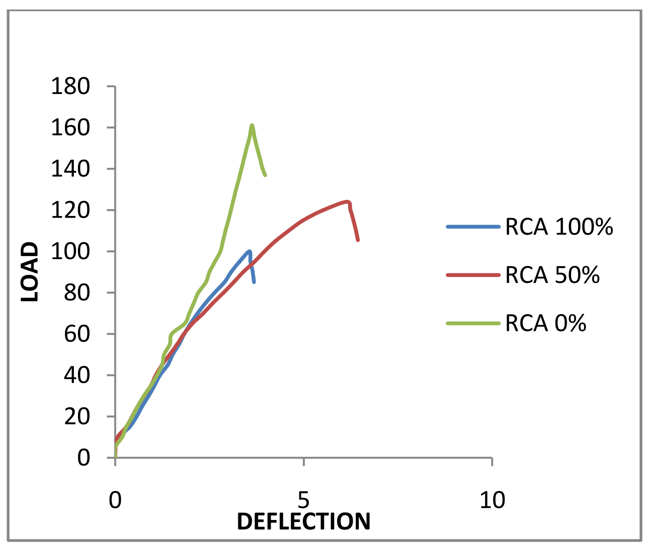

Fig6.load vs deflection curve for 3% longitudinal reinforcement

For 3% longitudinal reinforcement - maximum peak load and maximum deflection is obtained for 0% of RCA and 50 % of RCA respectively.

For 4% longitudinal reinforcement – maximum peak load and maximum deflection is obtained for 0% of RCA and 50% of RCA respectively.

VII. CONCLUSIONS

1. We observed that increase in longitudinal reinforcement led to the decrease of deflection.
2. Average shear capacity of beam increased with decrease in percentage of RCA and increased with increase in longitudinal reinforcement.
3. Shear stress at neutral axis decreased with increase in percentage replacement of RCA.
4. Test results indicated that failure loads and shear stress induced in beams got formidably influenced by the change in percentage of longitudinal reinforcement.
5. Failure of beam became brittle in nature with increase in percentage of RCA.
6. Maximum Peak load is obtained for 4% longitudinal reinforcement and 100% NCA, where as maximum deflection is obtained for 1% longitudinal reinforcement and 50% RCA.

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