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Experimental Study on the Behavior of R.C.Beams and Columns with Treated Recycled Aggregate Concrete

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Abstract - *The paradigm of providing eco-friendly concrete is gaining impetus in the global construction industry. The dwindling resources have made the researchers to focus on sustainable development in all areas and more particularly in concrete production, due to the high rate of growth of industries and their infrastructure development, which increase the rate of consumption of concrete. The practice of recycling of demolished concrete for use in pavements and sub grades has already seen in vogue. From review of literature it is found that studies on structural element using a concrete with demolished concrete as aggregate after an effective treatment to improve its density is scarce. In this method the effective treatment has been chosen to be the one which is proved to be effective in the previous study in the same laboratory. The study is made by varying the ratios of normal (virgin) aggregate to treated recycled aggregate as 1:0 (conventional concrete), 0.5:0.5 (mixed aggregate concrete), and 0:1 (completely treated recycled aggregate concrete) for casting and testing beams and columns and testing those for their ultimate strength. Displacements are observed using dial gauges. The comparison of strength is made and it is concluded that the normal concrete produces higher strength compared to mixed and complete treated aggregate combination concrete. However, those results vary over 10-15% and hence subject experimental variation of concrete as a material, it can be concluded that both mixing of treated aggregate with normal aggregates and use of complete treated aggregates are possible solutions that can be adopted in practice.*

Keywords: *Normal aggregates, treated recycled aggregates, mixed aggregate concrete, completely treated recycled aggregate concrete.*

1. INTRODUCTION

1.2 Objective and Scope of Work

The rapid growth in population has resulted in higher demand for housing to satisfy the need of the ever increasing population. An enormous increase in construction activities has resulted in an increased rate of consumption of basic materials of concrete making. This has led to shortage of conventional building materials. Hence, recycling and reuse of wastes such as building rubbles, concrete lumps etc. generated at the construction and demolition sites is currently being tried as an economic and eco-friendly alternative.

Natural aggregate may be costlier in places which are away from source. If the recycled concrete is used as aggregate the cost of the construction will be controlled incase the concrete waste are available in the vicinity. In practical situations where the recycled material is not fully sufficient to meet the need of construction, an alternate of mixing virgin / normal aggregate with recycled aggregate may be chosen as an alternate or replacement. Quantification of such mixed aggregate's effect is a significant study towards practical use of such mixed virgin plus recycled aggregate in the preparation of concrete.

1.2 Objective and Scope of Work

The objective of present work is to evaluate the behavior of continuous beams and columns made with concrete mixture having different replacement ratios.

The scope of work is to evaluate the behavior of continuous beams and axially load columns made with concrete mixture having different replacement ratios.

2. METHODOLOGY

The methodology followed to carry out the project work is shown below. The works relating to quantification of effect of replacement of virgin or normal by recycled aggregates are scarce.

Cube tests will be done to find which replacement ratio is giving the maximum strength.

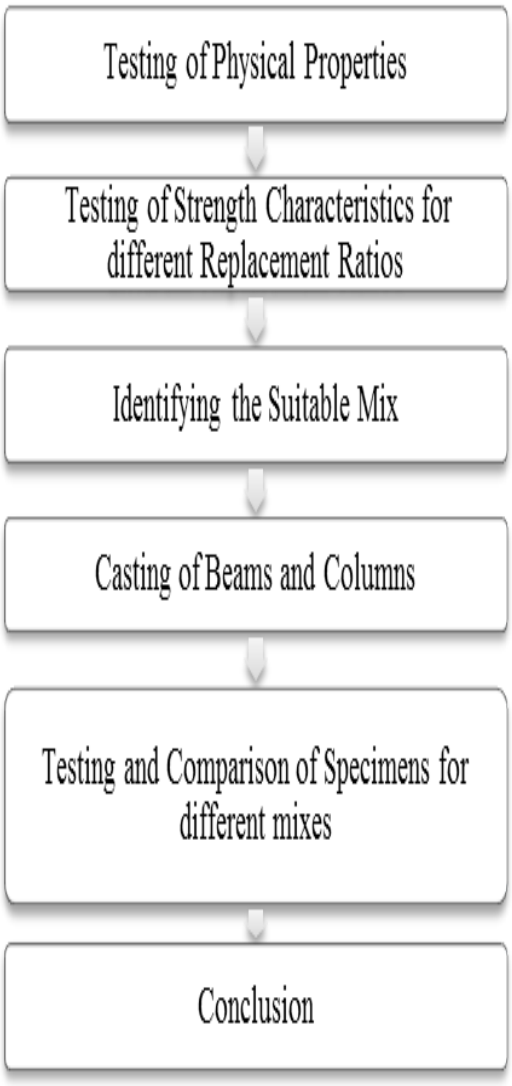


Fig -1: Methodology

3. EXPERIMENTAL INVESTIGATIONS

3.1Properties of Materials Used

Experimental investigations have been carried as per IS code standards. The materials used for the present experimental work is discussed in the subsequent sections.

3.1.1 Cement

Ordinary Portland Cement (OPC) of 53 grade conforming to IS 12269 :(1987) is used and its properties are given in Table 1.

Table -1: Properties of Cement

S.No	Property	Observed Value	Limiting Value
1.	Fineness (Air permeability)	8.1%	Not greater than 10%
2.	Specific gravity	3.12	3.10 – 3.25
3.	Standard Consistency	33%	26 % - 35%
4.	Initial Setting time Minutes	48 Minutes	Not less than 30 minutes
5.	Compressive Strength at 28 days (N/mm^2)	55	Not less than 53 N/mm^2

3.1.2 Fine aggregate

Clean sand conforming to IS 383 :(1970) is used. The results are shown in Table 2.

Table -2: Properties of Fine Aggregate

S.No	Property	Observed Value	Limiting Value
1.	Specific Gravity	2.74	2.6 – 2.85
2.	Fineness Modulus	2.71	2.0 – 4.0

3.1.3 Natural Coarse Aggregate (NCA)

Natural angular aggregate of 20mm (maximum) size conforming to IS 383: (19790) and its properties are given in Table 3.

Table -3: Properties of Coarse Aggregate

S.No	Property	Observed Value	Limiting Value
1.	Specific gravity	2.72	2.5 – 3.0
2.	Abrasion value (%)	5.33	4% - 30%
3.	Fineness Modulus	7.11	6.5 – 10
4.	Crushing value (%)	20.3	20% - 45%
5.	Water Absorption (%)	0.64	0%-2.5%

3.1.4 Recycled Aggregate (RCA)

The aggregates are prepared by breaking already tested concrete cubes available at Structural Laboratory and are properly sieved and brought to size of 20mm (Maximum) conforming to IS 383 : (1970) and IS 2386 (PT1): 1963 and their properties are given in Table 4.

Table -4: Properties of Recycled Aggregate

S.No.	Property	Observed Value	Limiting Value
1.	Specific gravity	2.50	2.5 – 3.0
2.	Abrasion value (%)	6	4% - 30%
3.	Fineness Modulus	7.63	6.5 – 10
4.	Crushing value (%)	22.5	20% - 45%
5.	Water absorption (%)	2.40	0%-2.5%

3.1.5 Fly-Ash

Fly ash used for this project is class-F fly ash available from Puzhal in Chennai.

3.1.6 Treated Recycled Aggregate (TRA)

The treatment process adopted is the one that is adopted by Rajprasad (2006) [6] as the most efficient method. As per the guide lines a mixture solution of Cement: Fly ash of 1:2 is mixed with 30 percent of water and recycled aggregate are soaked in the solution for 24 hours after which they are taken out and dried in air. Fly ash used is from Puzhal in Chennai. The properties of treated recycled aggregate are given in Table 5.

Table-5:Properties of Treated Recycled Aggregate

S.No	Property	Observed Value	Limiting Value
1.	Specific gravity	2.84	2.5 – 3.0
2.	Abrasion value (%)	5.67	4% - 30%
3.	Fineness Modulus	7.2	6.5 – 10
4.	Crushing value (%)	21	20% - 45%
5.	Water absorption (%)	1.05	0%-2.5%

3.1.7 Water

Potable water available at college campus is used for mixing and curing.

3.1.8 Comparison of Properties of Aggregates

The comparisons of the recycled and natural aggregates are mentioned in Table 6.

S. No.	Mix Used	Specimen	Compressive Strength in N/mm² for days		
			7	14	28
1	Natural Aggregate Concrete (NAC)	1	18.67	21.77	31.64
		2	19.11	22.17	31.25
		3	19.20	22.27	30.90
		Avg	18.99	22.07	31.27
2	Treated Recycled Aggregate Concrete (TRAC)	1	17.20	20.53	31.15
		2	15.55	20.40	30.22
		3	16.88	20.31	30.49
		Avg	16.99	20.41	30.62
3	25% NAC + 75% TRAC	1	17.95	19.55	29.69
		2	18.13	19.64	29.87
		3	18.22	19.73	28.17
		Avg	18.10	19.64	29.24
4	50%NAC + 50% TRAC	1	19.55	20.80	32.00
		2	18.66	21.33	30.31
		3	19.09	21.60	30.13
		Avg	19.08	21.24	30.81
5	75%NAC + 25% TRAC	1	17.33	18.67	28.13
		2	15.55	18.97	28.00
		3	17.82	19.91	28.22
		Avg	16.58	19.30	28.09

Table-6: Comparisons of Properties of Aggregates

S.No	Property	NCA	TRA	Percentage Difference
1.	Specific gravity	2.72	2.84	4.41%
2.	Abrasion value (%)	5.33	5.67	6.38%
3.	Fineness Modulus	7.11	7.2	1.26%
4.	Crushing value (%)	20.3	21	3.45%
5.	Water absorption (%)	0.64	1.05	64%

4. COMPRESSIVE STRENGTH

4.1 General

Cubes of size 150mm x 150mm x 150 mm was used and tested. The results of compressive strength at the end of 7 days, 14 days and 28 days are taken. Various mix proportions are taken for recycled aggregates are

- 100% NCA
- 100% TRA
- 25% NCA + 75% TRA
- 50% NCA + 50% TRA
- 75% NCA + 25% TRA

Table-7:Compressive Strength for Different Mixes

5. EXPERIMENTAL INVESTIGATIONS ON BEAMS

5.1 General

The main objective of the work is to quantify the effect of replacement of Natural Aggregate (NA) by Treated Recycled Aggregate (TRA) by 50%. For this purpose structural element i.e. beam is chosen. Since the previous work by Rajprasad (2006) [9] was on testing on simply supported beams, the behaviour of two span continuous beams are taken up here.

5.2 Designation of Beams

The beams tested are designated as follows:

NAB - Beams with mix NA: TRA = 1:0

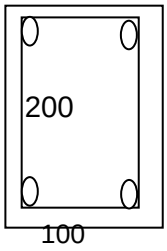
TRAB - Beam with mix NA: TRA = 0:1

MAB - Beam with mix NA: TRA = 0.5:0.5

5.3 Details of Beams

The beams tested have a constant cross section as given in the Table 8.

Table -8: Cross Sectional Details of Beam

Description	Size	Remarks
Cross section	100mm (width)x200mm (depth) main : 4 nos. of 12mm ϕ bars stirrups : 6mm ϕ @ 75mm center to center	
Clear cover	20mm	
Overall length	3000mm	

6. EXPERIMENTAL INVESTIGATIONS ON COLUMNS

6.1 General

In order to study the effect of use of treated aggregate, columns have been tested by applying axial load.

6.2 Designation of Columns

The beams tested are designated as follows.

NAC - Column with mix NA: TRA = 1:0

TRAC - Column with mix NA: TRA = 0:1

MAC - Column with mix NA: TRA = 0.5:0.5

6.3 Details of Columns

The cross sectional details of the columns tested are given in Table 1.9. The aspect ratio (l/*b*) of the column is 700/110 = 6.363. Hence it is treated as a short column.

Table -9: Details of Column Tested

Description	Value in mm
Width	110mm
Depth	110mm
Length	700mm
Overall length	1300mm
Reinforcement details : Main Lateral ties	 4 # 8mm Ø 6mm @ 100mm c/c

7. RESULTS AND DISCUSSIONS

7.1 Results on Tests of Beams

7.1.1 Load vs. Deflection curve

The load vs. deflection curve for the mid span of the beam NAB, TRAB, MAB is plotted and shown in Figure 2, 3 and 4.

7.1.2 Initial and Ultimate Cracking Load

The initial cracking load values of the beams are tabulated in Table 10 and Table 11.

Table -10: Initial Cracking Load

S.No	Type of beam	Load at Initial Crack (KN)
1	NAB	31.85
2.	TRAB	29.4
3.	MAB	24.5

Table -11: Ultimate Load at Failure

S.No	Type of beam	Ultimate Load at Failure (KN)
1	NAB	122.5
2.	TRAB	98
3.	MAB	110.25

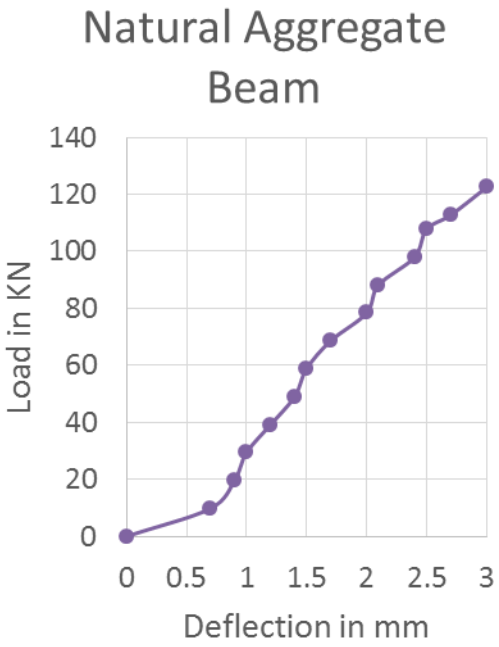


Fig-2:Load Deflection Curve For Natural Aggregate Beam

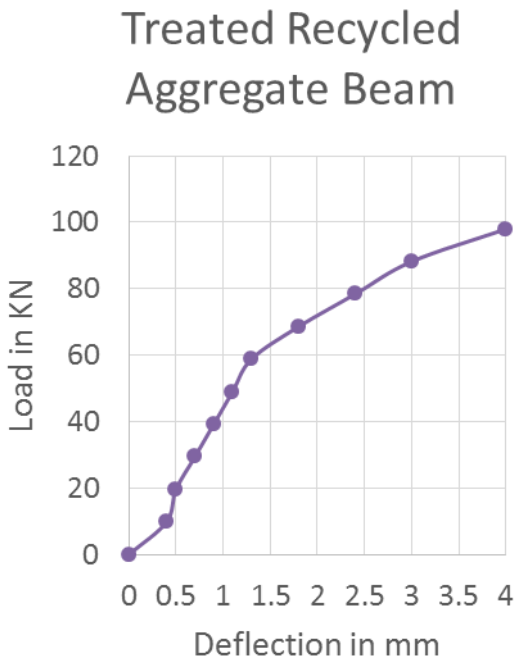


Fig -3:Load Deflection Curve for Treated Recycled Aggregate Beam

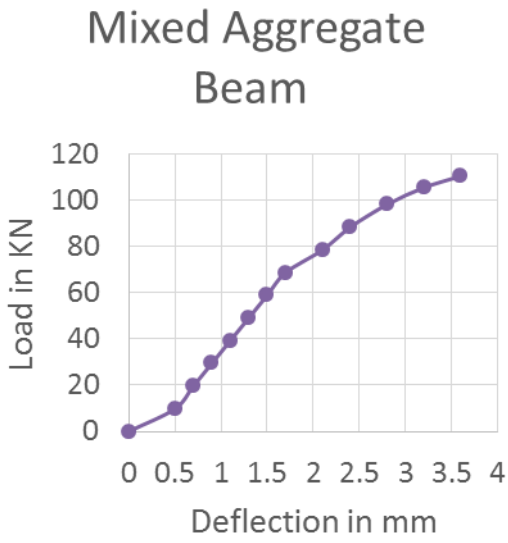


Fig -4:Load Deflection Curve For Mixed Aggregate Beam

7.2. Results of Tests on Columns

7.2.1 Load vs. Deflection curve

The Load vs. Deflection Curve for the column is plotted and shown in figure5, 6 and 7.

7.2.2 Initial and Ultimate Cracking Load

The initial and final cracking load values of the beams are tabulated in Table 12 and Table 13.

Table -12: Initial Cracking Load

S.No	Type of beam	Load at Initial Crack (KN)
1	NAB	88.2
2.	TRAB	68.6
3.	MAB	78.4

Table -13: Ultimate Load at Failure for Column

S.No	Type of column	Ultimate Load in KN
1	NAC	352.8
2.	TRAC	294
3.	MAC	313.6

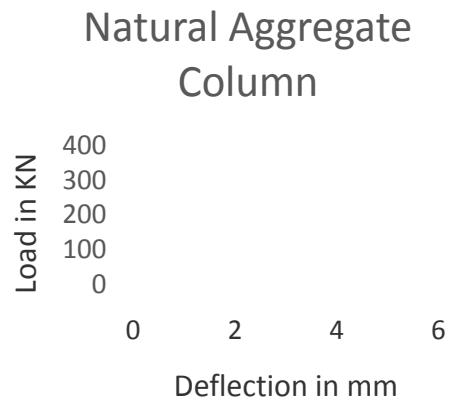


Fig-5:Load Deflection Curve For Natural Aggregate Column

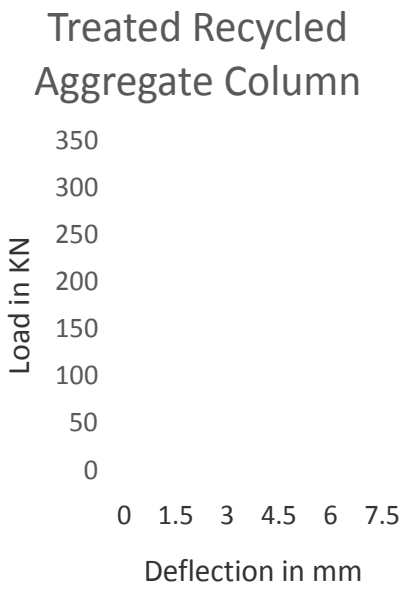


Fig -6:Load Deflection Curve For Treated Recycled Aggregate Column

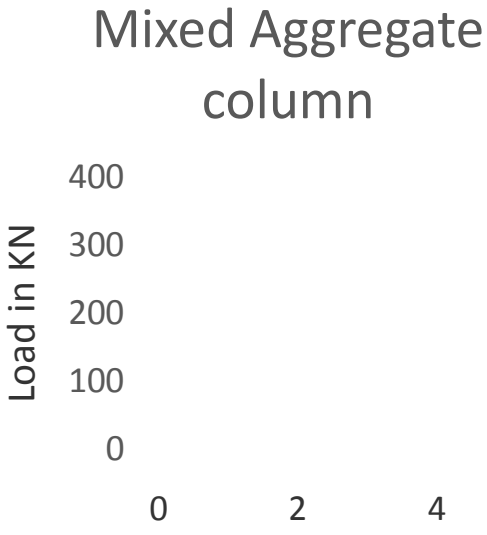


Fig -7:Load Deflection Curve For Mixed Aggregate Column

8. CONCLUSIONS

8.1 General

The maximum values of strength of beams do not vary more than 10-15% which can be accepted for concrete as a material and hence the replacement of virgin aggregates by treated aggregates can be adopted in practice.

8.1 Effect of Replacement on Strength

Based on Ultimate Load, the descending order of series for beam is

NAB > MAB > TRAB

For column, ranking in the descending order is NAC > MAC > TRAC

9. SCOPE FOR FUTURE WORK

Replacement ratios can be made closer and effect may be tried.

10. REFERENCES

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11. BIOGRAPHIES

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