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Flexural Behavior of Beam made by Partial Replacement of Natural Aggregates with Coarse Aggregates from Old Concrete

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Abstract

Increasing demand of accommodation in urban areas, posed serious problems everywhere. Lesser available space in most of region of the world has led the planners to plan for skyscrapers in place of single or short height multistory buildings. This leads to huge quantum of demolished concrete waste. On other hand new construction need raw material thus natural resources of the aggregate goes on decreasing every day. Both of these problems are interrelated. Reusing demolished waste not only saves the natural resources of the aggregates but also provide a good measure of reducing waste management.

Therefore in this experimental work evaluation of flexural strength and cracking pattern of RC beam made with coarse aggregates from demolished concrete waste as partial replacement of natural aggregates is carried out. Demolished concrete is collected from the Nawabshah city and processed to maximum of 1" size. Basic properties of these aggregates (water absorption and specific gravity) are evaluated and compared with those of natural aggregates to have good insight of the aggregates.

30 RC beams in five batches with # 4 bars as main bars and #2 bars as stirrups are prepared with 0%, 50%, 60%, 70% and 80% replacement of the natural coarse aggregates. The dimensions of all beams is kept 36"x6"x6" with 1:2:4 concrete mix and 0.45 - 0.55 water cement ratio. After curing for 28 days, beams are tested using central point load for flexural strength and cracking behavior.

The test result of this research work shows that minimum and maximum reduction in flexural strength in 12% and 26.6% respectively in comparison to beams made with 100% natural aggregates. Although the first crack appeared at lesser load than reference concrete but the behavior and position of crack is same in both cases.

Based on the result of this research work it is concluded that 88% strength can be achieved with 50% replacement of natural aggregates with demolished waste concrete aggregates. Therefore can effectively be used in the areas of moderate or low load.

Keywords: Reinforced Concrete Beams, Old Concrete Aggregates, Demolished Waste.

Introduction

In construction industry concrete is a product of basic central importance. It is believed that concrete is second most widely consumed material after water. This is because with satisfactory design concrete provide required properties and confirm durability of structures. Around the world yearly production of concrete is in billion tons, based on the fast growing population construction industry have increased new construction and it is growing exponentially every year.

With passage of time structures deteriorate and other factors such as growing population and space problem in city centers have compelled construction industry to construct high rise buildings in place of short height buildings. This results in potential quantum of the construction waste. To deal with such a problem a good waste management is necessary. This is top priority and challenge for the world. It is reported that two third construction and demolition waste in developed countries consist masonry and concrete. This material provides an opportunity of reusing it in concrete construction which not only will reduce the waste management but also saves landfills where it is dumped and natural aggregates. Thus reuse of demolishing waste will reduce adverse impact on environment, economy

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and provide attractive material particularly for coarse aggregates.

Although demolishing waste provide an alternate of coarse aggregates yet there are certain issues which need to be properly addressed before making use of it. These issues include crushing bulky pieces into required size, removal of contamination and knowledge of properties of these aggregates with reference to properties of natural aggregates, social awareness to improve confidence and behavior of RC members cast with coarse aggregates from demolished concrete waste.

Therefore in this experimental work is conducted to evaluate the flexural behavior and cracking pattern of reinforced concrete beams made by partial replacement of natural coarse aggregates with coarse aggregates from demolished concrete waste. Four percentages of replacement are considered i.e. 50%, 60%, 70% and 80%. One batch of beams with 100% natural aggregates is prepared to compare the obtained results and is termed as reference concrete.

Old demolished concrete is collected from Nawabshah region. Large blocks of demolished concrete are processed by hammering and sieving to maximum of 1" size. Basic properties of these aggregates are evaluated and compared with those of natural aggregates. Total of 30 reinforced concrete beams are prepared. Size of all beams is kept 36"x6"x6". Concrete mix used is 1:2:4 with 0.45 – 0.55 water cement ratio. #4 bars are used as main bars and #2 bars are used as stirrups. After curing for 28 days all beams are tested for flexural strength and cracking pattern with central point load arrangement. The results obtained are presented and compared with reference concrete.

The outcome of this research work will improve the understanding of behavior of reinforced concrete beams in flexural with demolished concrete as coarse aggregated with partial replacement of natural aggregates. It will provide an option for better utilization of concrete waste and an option to preserve natural aggregates.

Literature Review

Search of alternative material to replace fully or partially one or other ingredient of concrete remained active since long. Difficulties, barriers, possibilities of using alternative material i.e. glass, jute, husk, ash, scarp etc have been studied by several scholars. Reuse of demolished material of old structures has also got good attention of the researchers. Physical and mechanical properties of such aggregates of different regions have been studied and compared with natural aggregates. Difficulties in crushing, removing contamination are also highlighted. Still there is room for lot of work to be done to understand fully the behavior of this material as aggregates. In the following literature review on subject matter is presented.

Tony[1] and Napier[2], pointed out that in recent years, utilization of demolished waste material for new construction has drawn increased attention throughout the world. According to their report about 1 billion tons of demolished waste is generated and if it is recycled and reused, can provide economic and environmental benefits. Practical and economic experiences suggest that the most important area of usage of demolished waste is road base and sub base. In such a case usage of concrete waste is maximum of 20% as replacement of aggregates i.e. sand, gravel and crash.

According to European Commission report[3], Fong et al[4] and Australian Cement, concrete and aggregate report[5] recycling and reuse of demolished concrete waste in European Union, Hong Kong and Australia is getting popular. About 28% in European Union, 22,700 m^3 in Hong Kong and 500 thousand tons is Australia is being used every year.

Mehta[6] in his paper stated that environmental legislation put emphasize on meeting present day needs by own sources without creating problem for future generations regarding their needs. Achieving sustainability is greatest challenge faced by the concrete industry in the 21st century, due to unlimited growth, high consumption of virgin aggregates and un controlled environmental pollution are main factors threatened planet earth for self-destruction.

Gilpin et all[7] in their research paper mentioned that about 2.7 billion metric tons of aggregates are being consumed in United States, of America. Out of which maximum bulk of it i.e. 60% - 70% is consumed by building construction. Therefore government has started providing incentives to promote recycling of concrete waste. As a result 14% - 50% recycled aggregates are used there.

In a study regarding recycling of concrete waste of roads/pavements, Mahta[8] with reference to American Concrete Pavement Association States that about 200 miles of such work is recycled. With average thickness one mile of road pavement provide 6000 ton of concrete waste. Relating it to total of about 1.2 million ton of recycled concrete aggregate is used. Including other sources this study mentions that about 50 million tons of concrete waste is

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recycled and used in America. This contributes hand some amount by saving natural aggregates.

Japanese government also promotes research on reuse of concrete waste since more than 25 years. Kawano[9], Development bank of Japan (2002) in their reports mentions that about 63% of total demolished concrete waste is recycled every year. Development of laws by concerned government has resulted in increased use of this recycled waste. These reports mentions that 285 million tons of such aggregate was used up to 2005.

About 60% of the total construction and demolished waste is recycled in the UK. Every year about 150 million tons construction and demolishing waste is produced in the UK. The RCA from different sources are used in pavement construction, building projects, infrastructure development. It reduces the land required for dumping waste material and reduces the need to use virgin materials in new construction. RCA was the fifth largest source of aggregate in the UK in 2001. At Terminal 5 of Heathrow Airport, almost 100,000 tons RCA was used in 2004. The Highways Agency in the UK permits the use of RCA as a secondary aggregate in most highway work and they issued modifications to "RCA Specification for Highway Works". Extensive use was made of on-site aggregates in the construction of the M6 toll road between Birmingham and Manchester, limiting the need for off-site quarrying and for lorry traffic to and from the site.

Zaharieva[10] in his research work regarding properties of demolished concrete aggregates pointed out that recycled concrete aggregates are highly heterogeneous and porous, with large amount of impurities. This makes it difficult to model and predict resulting concrete properties. He also mentioned that quantity of these aggregates with reference to particle size distribution, water absorption and abrasion etc. may also be examined to make proper use of it

Corinaldes et al[11] studied particle size distribution of recycled aggregates with reference to performance of crushers doing the job. He suggested 50 mm by primary crushing is suitable for use in concrete.

Katz[12] studied that the age and strength at which concrete is crushed does not influence the amount of mortar attached or gradation of the recycled concrete aggregate. Coarse recycled concrete aggregate material contains about 6.5% adherent original mortar and the fine material contained is about 25%. He also studied specific gravity or relative density of the aggregates and pointed out that recycled aggregate has a specific gravity of 2.4 in comparison to virgin aggregates (2.7). This difference mainly is because of relative density of mortar attached to the recycled concrete aggregate. Coarse recycled concrete aggregate has a specific gravity in the range of 2.2 to 2.6 for saturated surface dry conditions. This value decrease as the particle size decreases. Fine recycled concrete aggregate possess specific gravity in the range of 2.0 and 2.3 for saturated surface dry conditions.

Water absorption of aggregates is another important aspect which should be studied properly as it affect the total quantity of water in concrete mix. ACPA[13] and Saleem[14] studied this factor and reports that coarse recycled concrete aggregate has absorption of 2 to 6% and fine recycled concrete aggregate has even higher absorption of 4 to 12%. This difference is because of higher absorption of the old mortar contained in RCA.

Abrasion resistance is an index of aggregate quality and its ability to resist weathering and loading action. According to Sagoe-crentsil[15] abrasion resistance of recycled concrete aggregate is twelve percent lower than virgin aggregate. According to ACPA[13] abrasion resistance for recycled concrete aggregate ranges between 20-45% with an upper range at 50% replacement of natural aggregates.

Shayan[16] conducted experimental evaluation of compressive strength of concrete mixes using RCA and observed decrease in compressive strength compared to virgin aggregate. Poon[17] in his study showed the compressive strength of virgin concrete was 58.6 MPa, and the RCA concrete range from 50.9 to 62.1 MPa. There were higher values for concrete made with 50% RCA compared to 100% RCA. Katz[18] reports that loss of compressive strength is in the range of 30-40% for the concrete made with RCA at 28-days. On the other hand Abou-Zeid[19] based on his research work concluded that there was a minor reduction in 28 and 56 day compressive strength when virgin aggregate was partially replaced with RCA and a much greater reduction when RCA were used in full.

According to Lin[20] most influential parameter affecting compressive strength is the water cement ratio. Other influential parameters include fine RCA content, cleanness of aggregate, interaction between fine RCA content and crushed brick content, and interaction between w/c ratio and coarse RCA content. Poon[17] used constant water cement ratio, in air-dried RCA containing concrete and observed higher compressive strength than oven-dried and saturated surface dry RCA. Chen[21] based on his research work concluded that using unwashed RCA,

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reduction in compressive strength is observed. Compressive strength of about 60% of virgin concrete at 0.38 w/c and 75% at 0.6 water cement.

Tavakoli[22] stated that there seems to be a strong interaction between maximum aggregate size and water-cement ratio when compared with compressive strength development. Saleem[14] in his research concluded that compressive strength may increase for RCA when lower w/c ratio is used.

According to ACPA[13] report majority of strength loss for RCA concrete can be attributed to material smaller than 2 mm because natural sand has greater strength than RCA fines. According to Katz[12][18] bonding between the RCA and the cement can be affected by loose particles created during the crushing process. Treating the RCA by impregnation of silica fume resulted in an increase in compressive strength of approximately 30% at 7 days and 15% at 28 days. Exposing the RCA to ultrasound resulted in a uniform increase of 7% compressive strength over time. The age of RCA containing concrete samples pay, important role in final strength of the sample. For example, crushing concrete into RCA after three days compared to one day resulted in a seven percent increase at 7 day curing. This difference even increased to higher value (13%) when samples were tested at 90 days.

Tavakoli[22] compared laboratory made RCA and field demolished RCA and observed that there was the same basic trend in all strength development. Hansen[23] proved that use of admixtures do not produce good impact on the compressive strength of the new RCA concrete. By Sagoc-crentsil[15], when slag is added to the RCA concrete, it develops strength over a longer period of time compared to normal concrete.

Research work by Rashwan[24] suggests that compressive strength is dependent on the amount of time the RCA spent in the stockpile after crushing. For example, concrete made with RCA that was in the stockpile one day had a 25% higher compressive strength than concrete made with RCA that was in the stockpile 28 days. Concrete made with RCA that was in the stockpile seven days had a seven percent lower compressive strength than concrete that was in the stockpile 28 days. In a research Zaharieva[25] showed a decrease in flexural strength between 10-20%. Another study by Poon[26] showed that flexural strength increased with the amount of RCA used. Virgin concrete had a flexural strength of 3.31 MPa, and RCA concrete ranged from 3.74 to 3.89 MPa with 100% RCA concrete having higher values than 50% RCA concrete.

Bond strength is defined as the force required to break two materials apart. According to Ajdukiewiez[27] an average RCA concrete fails with a 20% lower force than virgin concrete. Topcu[30] studied the correlation between hardness and compressive strength with surface uniformity and concluded that the Schmidt hardness values decreased from 21.3 MPa for virgin aggregate to 11.6 MPa for 100% RCA concrete. This decline in hardness usually corresponds to a decrease in compressive strength.

Chen[21] pointed out that washing the aggregate did not cause any significant variation in modulus of elasticity values. Another study by Saleem[14] showed that even with the addition of fly ash and an increase in air content, the modulus of elasticity of the RCA concrete was lower compared to the virgin concrete. The work of Katz[13] shows that actual modulus of elasticity results are approximately 25% lower than those calculated by the ACI Equation.

Gokee[31] states that reducing the amount of adherent mortar on the RCA results in a limited benefit. Hasen[23] concluded that the dry shrinkage of RCA concrete has higher values as compared to virgin concrete and ranges from 20-90%. On the other hand Katz[12] showed that RCA concrete had a dry shrinkage of 0.7 to 0.8 mm/m compared to virgin concrete with a dry shrinkage of 0.27 mm/m. Poon[26] concludes that the amount of dry shrinkage increases with the amount of RCA used in the concrete. Tavakoli[22] studied pattern of dry shrinkage and concludes that process of dry shrinkage is same for RCA and virgin aggregate.

Detail and Design of Model

Old demolished concrete is collected from Nawabshah region. Large blocks of demolished concrete are processed by hammering and sieving to maximum of 1" size. The natural aggregates of same size are also used. Basic properties (water absorption and specific gravity) of both of the aggregates are evaluated and are given in table 1. Total five batches of reinforced concrete beams are prepared with 0%, 50%, 60%, 70%, and 80% replacement of natural coarse aggregates with coarse aggregates from demolished concrete. Out of these five batches the batch with 0% replacement of natural aggregates is termed as reference concrete and results are compared with the results of this batch of concrete. In each batch six beams are prepared. The dimensions of beam are used as; length = 36 in, cross section = 6"x6" (figure 1). Grade 60 mild steel bars are used to reinforce the beams. Following the ACI design formulation four #4 bars two in each bottom and top zone are used as main bars whereas # 2 bars are used as stirrups at 6" center to center.

Table 1: Specific gravity and water absorption of aggregates

#	Aggregates	Water absorption (%)	Specific gravity
1	Natural aggregates	1.65	2.65
2	Recycled aggregate	5.54	2.34

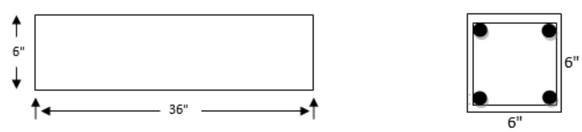

Figure 1: Beam dimensions

1:2:4 mix by weight with ordinary Portland cement, bolahri sand, crush from Jamshoro quarry and old concrete are used for all the beams. For one beam total concrete required is calculated as 0.75 cft. Quantities of all batches are given in table 2.

Table 2: Concrete mix proportion for different percentage replacement of NA

#	Material	Quantities of aggregates (Kg)				
		0% RCA	50% RCA	60% RCA	70% RCA	80% RCA
1	Cement	11	11	11	11	11
2	Fine aggregate	21	21	21	21	21
3	Coarse aggregate i. Natural aggregates ii. Recycled aggregates	43 00	21.5 21.5	17 26	13 30	8.5 34.5
4	Water	4.8	5.5	5.6	5.8	6.0

Casting and Testing of Beams

Concrete ingredients used by weight are mixed using tilt drum mixer till homogeneity is achieved. Concrete slump is evaluated to check the workability of every mix and is listed in table 3.

Table 3: Slump test values

Batch No.	RCA (%)	Slump (mm)
1	0	75
2	50	65
3	60	45
4	70	35
5	80	30

Table 4: Compressive strength of cylinders

Batch No.	Type of aggregate	Cylinder No.	Strength (N/mm^2)	Mean strength (N/mm^2)
1	Natural (0% RA)	1	19.99	25.26
		2	32.70	
		3	25.20	
		4	24.00	
		5	26.40	
		6	23.30	
2	50% RA	1	24.20	22.25
		2	21.40	
		3	19.80	
		4	26.48	
		5	22.19	
		6	19.42	
3	60% RA	1	18.20	19.40
		2	16.80	
		3	24.10	
		4	19.32	
		5	19.61	
		6	18.60	
4	70% RA	1	19.70	18.73
		2	22.40	
		3	21.50	
		4	16.81	
		5	15.41	
		6	16.61	
5	80% RA	1	19.20	17.78
		2	17.69	
		3	16.20	
		4	20.31	
		5	15.83	
		6	17.43	

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Beam molds are then prepared in standard manner. Steel bars are positioned as per details mentioned in previous section then concrete is filled in standard fashion and is compacted using rotating vibrator. After 24 hours molds are opened and beams are water cured for 28 days. In addition to beams six cylinders of standard size are also cast from each batch (total 30 cylinders) to check the compressive strength of concrete with recycled aggregates and compare results with reference concrete. The results of compressive strength of cylinders is given in table 4.

All beams are then tested using universal load testing machine equipped with automatic control and point load assembly. Displacement is measured using dial gauges. Both load and displacement are recorded by taking 18 readings of each beam. Average of maximum load and deflection for all batches of beams tested are given in table 5.

Load versus deflection history of all five batches of beams by using average values for both parameters are plotted in figures 2 to 6.

Table 5: Load and deflection in all batches of beams

Batch No.	Percentage replacement of natural aggregates (%)	Load (KN)	Deflection (mm)
1	0	84.32	9
2	50	71.74	9
3	60	66.44	9
4	70	63.17	9
5	80	60.48	9

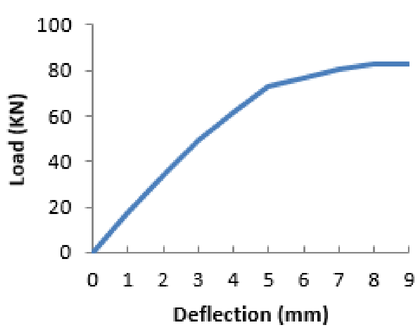

Figure 2: Load vs deflection curve (0% RA)

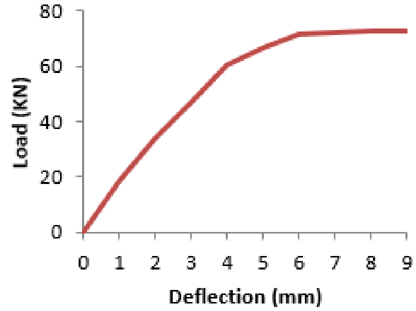

Figure 3: Load vs deflection curve (50% RA)

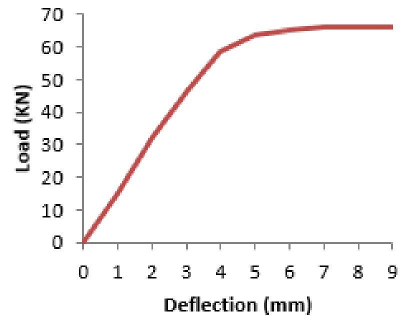

Figure 4: Load vs deflection curve (60% RA)

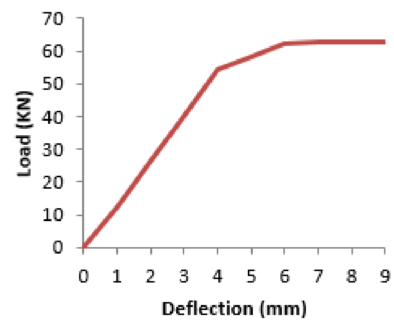

Figure 5: Load vs deflection curve (70% RA)

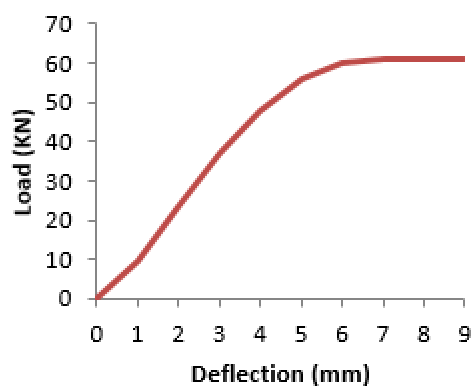

Figure 6: Load vs deflection curve (80% RA)

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Results & Discussions

Flexural Strength

Test results of beams made by using natural/virgin aggregates showed usual pattern in flexure, whereas beams made by partial replacement of recycled aggregates showed similar behavior in general but with different failure load. In some beams horizontal cracks at reinforcement level are traced which shows possibility of bond failure between steel and concrete.

Flexural cracks in vertical direction are also observed. Failure of beams due to crushing of concrete with significant deflection compared to beams made from virgin aggregates is recorded. The individual results given in earlier section for all batches of beams are plotted in figure 7 together with results of beams of reference concrete for comparison. Up to deflection of 5 mm 50% and 60% RCA beams remained in close vicinity of reference concrete then observed wider deviation. Whereas beams made with 70% and 80% RCA observed deviation much earlier than 50% and 60% RCA beams at about 1.5 mm deflection. The load bearing pattern of all RCA beams remained similar to that of the reference concrete. It is also observed that load – deflection curves of all beams shows fairly linear relationship up to cracking. With onset of flexural cracks slope of load-deflection curve changes.

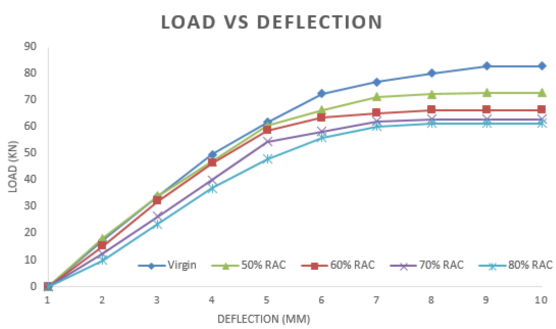

Figure 7: Comparison between virgin & various percentages of recycled aggregates

Compressive Strength

All cylinders are tested for compressive strength using UTM. Test results shows decreasing trend for cylinders with partial replacement of recycled aggregates than cylinder with 0% replacement of natural aggregates (table 6). Characteristic cylindrical compressive strength at 28 days for natural aggregate cylinders is 25.26 N/mm^2 whereas results of 22.25 N/mm^2, 19.40 N/mm^2, 18.73 N/mm^2 and 17.78 N/mm^2 are obtained for cylinders with 50%, 60%, 70% and 80% replacement of natural aggregates with recycled aggregates. This indicates a 12%, 23.2%, 25.8% and 29.6% reduction in compressive strength in comparison to cylinders with 0% replacement of natural aggregates. Observation also reveals that with increasing replacement of natural aggregates reduction in strength is more and for this research work it is maximum of 29.6% when 80% natural aggregates are replaced with recycled concrete aggregates.

Table 6: Mean compressive strength of cylinders

No.	Percentage replacement of Natural aggregate	w/c ratio	Mean Strength (N/mm^2)	% Reduction
1	0%	0.45	25.26	-
2	50 % RA	0.50	22.25	12.0
3	60 % RA	0.51	19.40	23.2
4	70 % RA	0.53	18.73	25.8
5	80 % RA	0.55	17.78	29.6

Cracking Behavior of Beams

Cracks were observed at every load interval and crack formation points were marked on each beam. Only first three cracks of virgin and each percentage of RCA are given in table 7. It is observed that crack formation pattern and style of beams made with partial replacement of natural aggregates with recycled aggregates is same to that of beams made with only natural aggregates. However cracking load of former beams remained lower than later beams.

Based on the results of compressive strength, flexural load, cracking pattern it is observed that 50% replacement of natural aggregates with recycled aggregates is suitable and gives better / comparable results. Therefore 50% replacement of natural aggregates can be used without much loss of properties.

Conclusion

In this experimental work flexural behavior of reinforced concrete beams using demolished concrete as partial replacement of natural course aggregates is studied. Old demolished concrete is collected from Nawabshah city. Large pieces of concrete are manually processed to maximum of 1" size. Basic properties of aggregates i.e. water absorption and specific gravity are evaluated and compared with natural aggregates. Four batches of six beams are prepared by replacing natural aggregates with recycled aggregates. Replacement of 50%, 60%, 70% and 80% is used. Also six beams with 100% natural aggregates are prepared to compare the results. Therefore total of 30 beams are prepared. In all beams #4 bars are used as main bars along with #2 bars as stirrups @ 6" c/c.

From each batch of concrete 6 cylinders are also prepared to check and compare the compressive strength. All beams are then tested for flexural strength. Based on the observations and results following points are concluded.

1. Recycled concrete aggregates possess higher water absorption (5.54%) than virgin aggregates (1.65%).
2. Visible differences between beams made with recycled aggregates and natural aggregates are observed.
3. Reduction in flexural strength is observed in comparison to beams made with recycled aggregates.
4. Maximum reduction in strength recorded is 29.6% for 80% replacement of natural aggregates.
5. Minimum reduction in strength is recorded as 12% for 50% replacement of natural aggregates.
6. Initial crack in beams made with recycled aggregates appeared in early loading stage and showed more deflection as compared to beams made with 100% natural aggregates.
7. All beams showed ductile behavior.
8. Mean compressive strength of concrete cylinders with RCA is 17.22 N/mm^2 less compared to mean compressive strength of cylinders with natural aggregates (25 N/mm^2).
9. After 5 to 10 minutes of mixing, concrete made with recycled aggregates becomes stiff and loose workability at faster rate. It is mainly due to absorption of water by old mortar attached to recycled aggregates. Hence concrete mix with recycled aggregates needs higher water-cement ratio compared to concrete mix with natural aggregates.
10. Concrete mixes with recycled aggregate, has lower slump (45mm) as compared to concrete mix with natural aggregates (75mm).
11. Based on experimental evaluation it is concluded that percentage of recycled aggregate has significant influence on the crushing load, pattern and crack width. First crack observed is about at mid of beam on load nearly 1/3 of ultimate load.
12. Based on the obtained results it is observed that 88% strength can be achieved with 50% replacement of natural aggregates with recycled aggregates. Hence can be used effectively without much loss of properties.

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Table. 7: Cracking load and displacement in all batches of beams

Beam No.	Crack	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
		0% RCA		**50% RCA**		**60% RCA**		**70% RCA**		**80% RCA**	
1	I	69.736	4.5	56.818	3.5	51.230	3.3	53.448	3.8	47.960	4.0
	II	74.350	5.0	67.787	4.5	58.930	3.9	56.380	4.2	53.360	4.5
	III	78.400	6.0	70.187	5.0	62.850	5.0	61.572	5.0	58.140	5.5
2	I	59.799	4.0	47.062	3.0	54.289	3.5	52.752	4.0	46.820	4.0
	II	72.080	5.0	56.005	4.0	59.077	4.0	569.30	4.5	52.680	4.5
	III	74.890	5.8	62.420	4.5	65.129	5.0	60.876	5.5	57.120	5.0
3	I	56.488	3.5	56.248	3.7	57.182	3.7	51.360	4.0	48.412	4.1
	II	66.484	4.5	62.182	4.5	60.540	4.5	57.338	4.5	52.248	4.4
	III	73.192	5.7	64.440	5.0	63.472	5.0	60.298	5.0	57.226	5.50
4	I	60.886	4.0	52.934	3.0	58.732	4.0	50.698	3.9	51.870	4.5
	II	71.280	4.8	57.456	3.5	62.348	4.5	56.838	4.5	57.146	5.0
	III	72.536	5.3	63.684	4.0	64.480	4.8	59.248	5.0	59.146	6.0
5	I	68.620	4.5	49.878	3.0	51.290	3.5	53.618	4.0	46.952	4.0
	II	73.980	5.0	60.456	4.0	58.644	4.0	57.247	4.5	56.248	5.0
	III	80.474	6.0	68.538	5.0	62.216	5.0	61.204	5.5	57.620	5.5
6	I	69.192	4.5	56.276	3.5	58.927	4.0	58.133	4.5	47.268	4.0
	II	74.232	5.0	61.218	4.0	62.028	4.5	60.072	5.0	57.660	5.0
	III	81.134	6.0	69.148	5.0	64.233	5.5	62.248	5.5	59.832	6.50