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Replacement of recycled coarse aggregates with natural coarse aggregates in concrete

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Abstract

In this study we replaced natural aggregates with recycled aggregates in concrete cubes. This is the first part of the study we have to do. Here we are trying to see a pattern of how the strength decrease once we replace natural coarse aggregate (NCA) with recycled coarse aggregates (RCA). The percentages of replacement will be 0%, 50% and 100%. The test and design is as per Indian standard codes. The concrete cubes are designed for M30 as per Indian standard codes.

Keywords: *recycle coarsed aggregates, cube testing, NCA, concrete strength.*

1. Introduction

Conservation of resource is always the need of human kind. In the starting of era/civilization, we have used the resources but soon after we have started over exploitation. This result in the scarcity of resources. Later on we have known the fact that we need to conserve the resources. Thus human have decided that we have to use resources efficiently and wisely. This phenomenon is discussed by using the principle of 3R i.e. reduce reuse and recycle. Our study primarily focuses on these "3R". We have used the already made cubes from the laboratory. This will reduce the amount of concrete from the society. Then we will break that concrete into various sizes (This is done by crusher and the mechanism we have made) primarily into 40mm, 20mm and other. After this we recycle them into new cube for the study. _Recycled aggregate is produced by crushing concrete, and sometimes asphalt, to reclaim the aggregate. Recycled aggregate can be used for many purposes. The primary market is road base. They can be used in building, dam, canal, tunnel construction etc. Recycled Aggregate consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder, Inert solid waste is concrete, asphalt, dirt, brick and other rubble.

1.1 Classification of R.C.A.

1. Crushed construction debris (mixed crushed concrete and brick that has been screened and sorted to remove excessive contamination)
2. Clean graded mixed debris (crushed and graded concrete and brick with little or no contamination)
3. Clean graded brick (crushed and graded brick containing less than 5% concrete or stones)
4. Clean graded concrete (crushed and graded concrete containing less than 5% brick or stones)

1.2 How to obtained RCA from normal concrete

The AC and PCC generally arrive at the processor in chunks.
Heavy crushing equipment is required to break up the chunks into aggregate.
Some equipment is portable and can be set up on site for immediate use of product.

1. A crushing plant may include a **hopper** to receive the material,
2. A **jaw** to break it into more manageable pieces,
3. A **cone** or **impact crusher** to further reduce its size,
4. A vibrating **screen** to sort to the required specification,
5. A **conveyor belt** with a rotating **magnet** to remove metal contamination such as rebar.

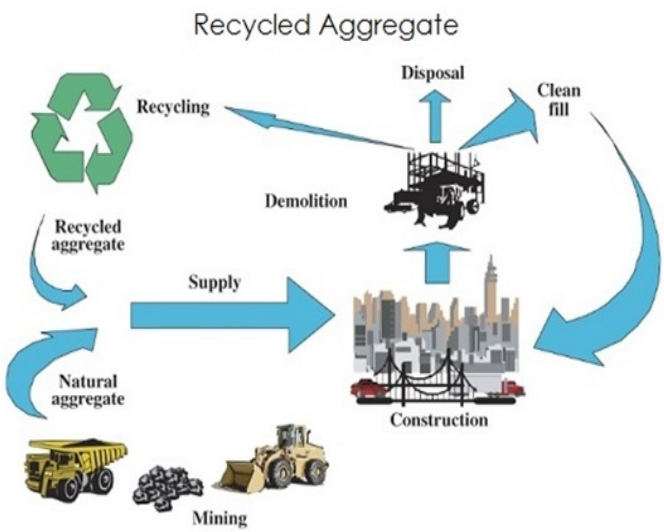


Fig. 1.1 Recycled Aggregate Process

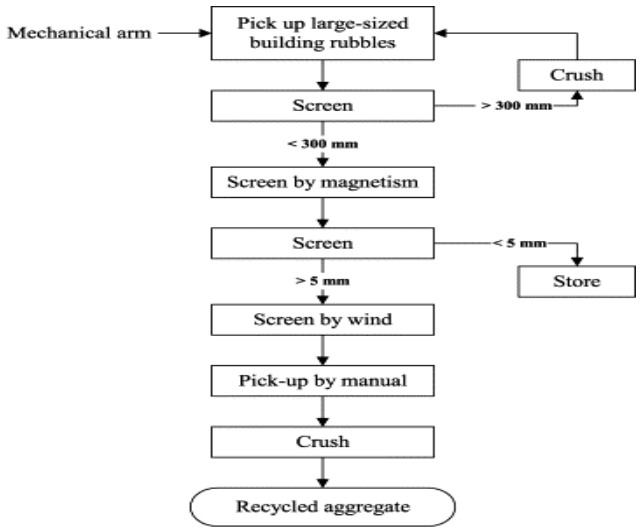


Fig.2 Structure of Recycled aggregate.

- The benefits of recycled aggregate:

1. It can save money for local governments and other purchasers,
2. It create additional business opportunities,
3. It save energy when recycling is done on site,
4. It conserve diminishing resources of urban aggregate

Recycled aggregate can be used:

1. In paved roads as aggregate base, aggregate sub base, and shoulders.
2. In gravel roads as surfacing.
3. As base for building foundations.
4. As fill for utility trenches.
5. At this time, the primary market is aggregate base and sub base in road projects

Why Concrete:

Concrete is a mixture/compound of cement, water, fine aggregate and course aggregate. The making of concrete is a one way process i.e. once it is made it is difficult to get the previous form back. Also it is the one of those things which has negative scrap value. So concrete's recycle is a very important step for the environment.

2. Literature review

2.1 M. Etxeberria , E. Vázquez, A. Marí, M. Barra(spain, 2007)

Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete

Cement and Concrete Research 37 (2007) 735–742

1. In their study, they use recycled coarse aggregates obtained by crushed concrete for concrete production.
2. Four different recycled aggregate concretes were produced; made with 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively.
3. The mix proportions of the four concretes were designed in order to achieve the same compressive strengths.
4. Recycled aggregates were used in wet condition, but not saturated, to control their fresh concrete properties, effective w/c ratio and lower strength variability

2.2 L. Evangelista a, J. de Brito b(purtagal 2009)

Durability performance of concrete made with fine recycled concrete aggregates

Cement & Concrete Composites 32 (2010) 9–14

1. The most important characteristics of concrete are compressive and tensile strength; modulus of elasticity; water absorption; shrinkage; carbonation and chloride penetration.
2. These two last characteristics are fundamental in terms of the long-term durability of reinforced or pre stressed concrete.
3. In the experimental research carried out at IST, part of which has already been published, different concrete mixes (with increasing rates of substitution of fine natural aggregates – sand – with fine recycled aggregates from crushed concrete) were prepared and tested.
4. The results were then compared with those for a reference concrete with exactly the same composition and grading curve, but with no recycled aggregates

I.S codes used in the study of this study:

- IS 383-1970 (REAFFIRMED 2002) : SPECIFICATION FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE
- IS 456:2000 (REAFFIRMED 2005) : PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE
- IS 516-1959(REAFFIRMED 2004) : METHODS OF TESTS FOR CONCRETE
- IS 2386 :Methods of test for aggregates for concrete:

1. (Part 1)-I963 :Particle size and shape
2. (Part 2)-1963 :Estimation of deleterious materials and organic impurities
3. (Part 3)-1963 :Specific gravity,density, voids, absorption and bulking
4. (Part 4)-1963 :Mechanical properties
5. (Part 5)-I963 :Soundness

- IS 9013 -1978 (reaffirmed 2008) : method of making, curing and determining compressive strength of accelerated-cured concrete test specimens
- IS 10262-2009 :concrete mix proportioning - guidelines
- ACI 555: *Removal and Reuse of Hardened Concrete*
- ACI 318: Building Code Requirements for Structural Concrete

3. Methodology

The cubes are already made in the lab. They are broken by manual means. Then they are taken from the chunks in the sizes of 20 mm. then various tests are performed like impact test, abrasion test compressive test on 100% recycled coarse aggregates, 100% natural aggregates and 50% natural aggregates+50% recycled coarse aggregates. This is done to see and verify the various patterns. After getting sufficient values a mix design is prepared for 0% 50% and 100% recycled coarse aggregates. Mix design is done as per I s 10262

The aggregate are placed as per volume in the cubes but the specific gravity of N.C.A. & R.C.A. are different. Thus we can't replace recycled coarse aggregate (R.C.A.) directly with the same amount of natural coarse aggregate (N.C.A.).

We know the fact that volume of both aggregates should be equal.

Reason: we had found that the small pieces of hydrated cement which remain on the R.C.A. contain some voids. This voids decrease the gravity of R.C.A. Their weight to be replaced by NCA comes to be lesser value then the replace NCA.

Overall 9 cubes were made with composition:

Cement	= 358.18 kg/m^3
Water	= 157.6 kg/m^3
Fine aggregate	= 709.55 kg /m^3

Coarse aggregates = 1351.93 kg /m^3
Water cement ratio = 0.44
Chemical admixture super plasticizer (0.5% weight of cement) = 0.005 x 358.18= 1.79kg/ m^3

4. RESULTS

Specific gravity test: This test is done using pycon meter test. For determining the specific gravity of cement specific gravity flask was used in the laboratory and was found to be 3.15 g/cc according to IS: 2720-1980 (part 3)

$\mathbf{W_1}$ = wt. of empty flask
$\mathbf{W_2}$ = wt. of flask + wt. of aggregate
$\mathbf{W_3}$ = wt. of flask + wt. of aggregate + water
$\mathbf{W_4}$ = wt. of flask + water

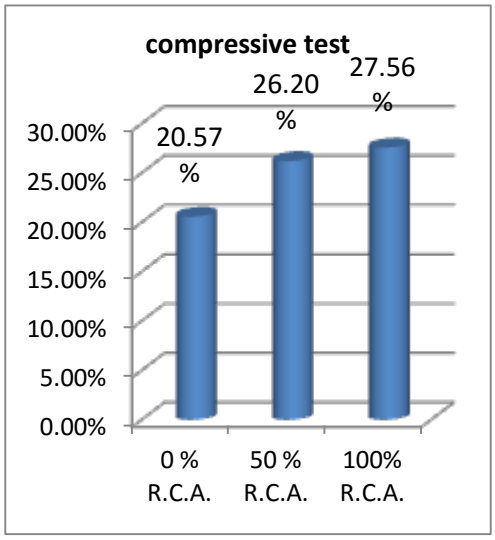
Specific gravity = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

	W1	W2	W3	W4	SP G ={(w_2–w_1)/[(w_2-w_1)-(w_3-w_4)]}
NCA	233	734	1540	1209	2.94
RCA	233	733	1523	1206	2.73
Sand	236	736	1521	1210	2.64
cement	-	-	-	-	3.15(standard value)
admixt	40	146		138	1.1

Test performed on aggregate: the aggregates are taken in the percentage of 0%, 50% and 100% of replacement of natural aggregates. That means that in the first case we have taken 100% natural aggregates. In second case we have taken 50% natural and 50% recycled aggregates. In third case we have taken 100% of recycled aggregates. And thus we have performed the various tests on these 3 sets

a) compressive test

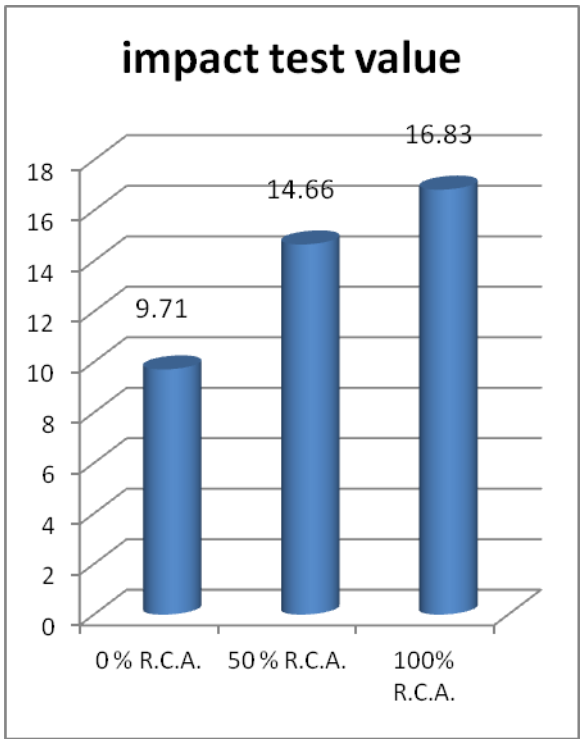
s. no.	% of rca	W_1 Kg	W_2	W_3	Percentage of wt passed = { (W_1 –W_2)/ W_1 } x 100
1	0 % R.C.A.	3.5	2.78	0.72	20.57%
2	50 % R.C.A.	3.5	2.583	0.917	26.2 %
3	100% R.C.A.	3.250	2.354	0.896	27.56 %



Where W_1 = weight of aggregate filled in the mould passed by 12.5 mm and retained on 10 mm
W_2 = weight retained on 2.36 mm sieve of W_1
W_3 = weight pass from 2.36 mm sieve of W_1

b) Impact test

s. no.	% of rca	W_1 Gram	W_2	W_3	Impact value = $\{(W_1 - W_2)/W_1\} \times 100$
1	0 % R.C.A.	499.5	451	49.5	9.71
2	50 % R.C.A.	498	425	73	14.66
3	100% R.C.A.	499	415	85	16.83



Where
W_1 = weight of aggregate filled in the mould passed by 12.5 mm and retained on 10 mm
W_2 = weight retained on 2.36 mm sieve of W_1
W_3 = weight pass from 2.36 mm sieve of W_1

Los Angeles abrasion test

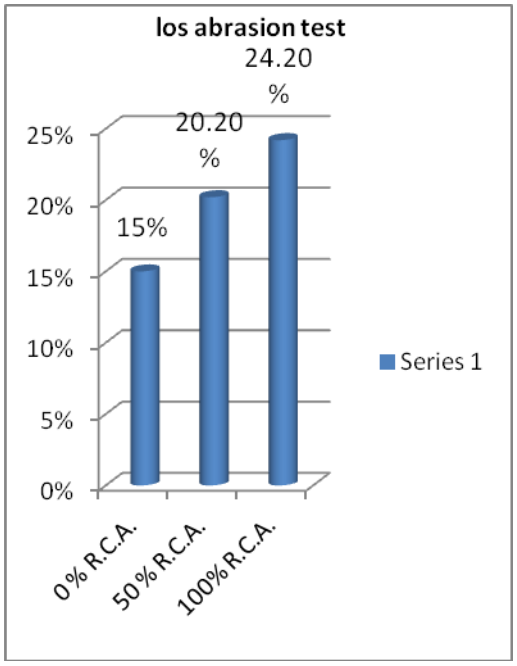
s. no.	% of rca	W_1 gram	W_2	W_3	Abrasion value = $\{(W_1 - W_2)/W_1\} \times 100$
1	0 % R.C.A.	500	425	75	15%
2	50 % R.C.A.	500	399	101	20.2%
3	100% R.C.A.	500	379	121	24.2%

Where,

W_1 = weight of aggregate filled in the mould passed by 12.5 mm and retained on 10 mm

W_2 = weight retained on 2.36 mm sieve of W_1

W_3 = weight pass from 2.36 mm sieve of W_1



CUBE STRENGTH:

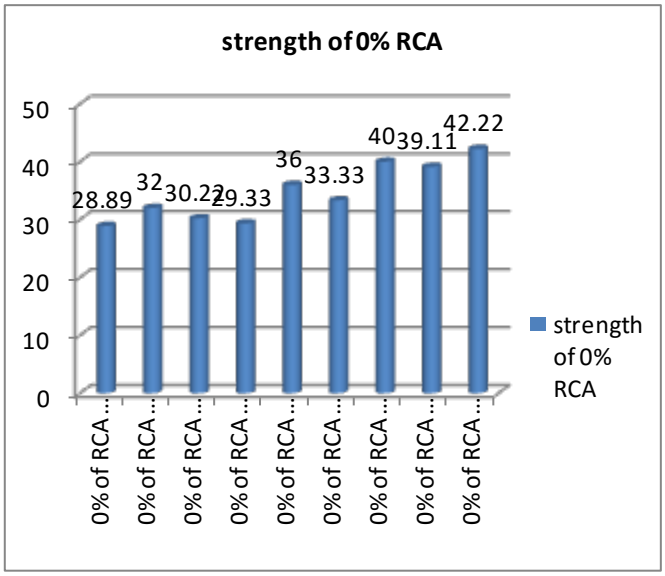
After the test we have made concrete cubes. The cubes are made in the percentage of 0%, 50% and 100% of replacement of natural aggregates. That means that in the first case we have taken 100% natural aggregates. In second case we have taken 50% natural and 50% recycled aggregates. In third case we have taken 100% of recycled aggregates. And thus we have performed the various tests on these 3 sets. The replacement is done as per volume.

That means the volume of RCA is matched with the volume of NCA

$$\frac{weight\ of\ RCA}{specific\ gravith\ of\ RCA} = \frac{weight\ of\ NCA}{specific\ gravity\ of\ NCA}$$

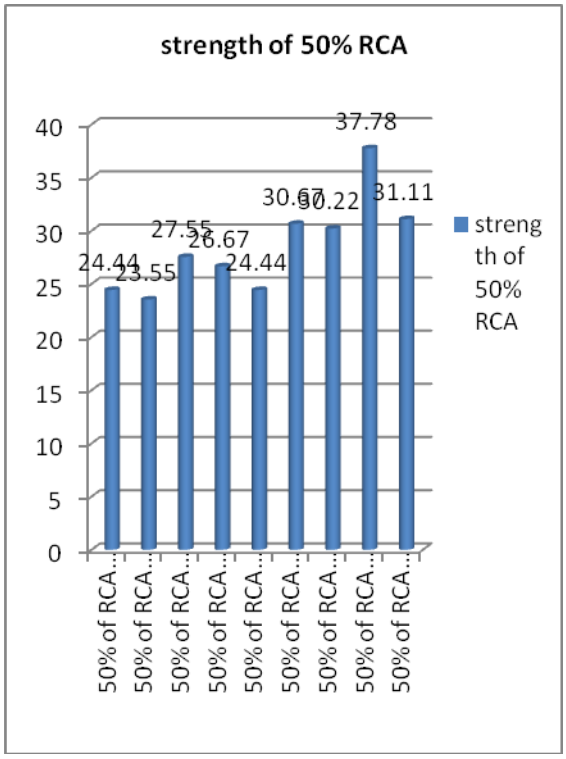
Sheet of cube testing for 00% replacement of RCA

s. no.	% of RCA	Sample no	07 day strength	14 day strength	28 day strength	f_{ck} in n/mm^2 = strength/22500
1	0% of RCA	1	650			28.89
2	0% of RCA	2	720			32.00
3	0% of RCA	3	680			30.22
4	0% of RCA	4		660		29.33
5	0% of RCA	5		810		36.00
6	0% of RCA	6		750		33.33
7	0% of RCA	7			900	40.00
8	0% of RCA	8			880	39.11
9	0% of RCA	9			950	42.22



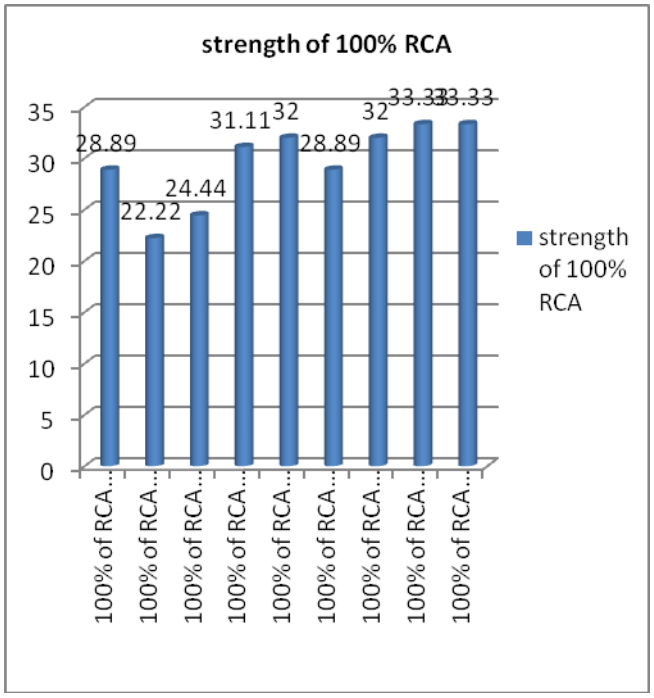
Sheet of cube testing for 50% replacement of RCA

s. no.	% of RCA	Sample no	07 day strength	14 day strength	28 day strength	f_{ck} in n/mm^2= strength/22500
1	50% of RCA	1	550			24.44
2	50% of RCA	2	530			23.55
3	50% of RCA	3	620			27.55
4	50% of RCA	4		600		26.67
5	50% of RCA	5		550		24.44
6	50% of RCA	6		690		30.67
7	50% of RCA	7			680	30.22
8	50% of RCA	8			850	37.78
9	50% of RCA	9			700	31.11



sheet of cube testing for 100% replacement of RCA

s. no.	% of RCA	Sample no	07 day strength	14 day strength	28 day strength	f_{ck} in n/mm^2= strength/2 2500
1	100% of RCA	1	650			28.89
2	100% of RCA	2	500			22.22
3	100% of RCA	3	550			24.44
4	100% of RCA	4		700		31.11
5	100% of RCA	5		720		32
6	100% of RCA	6		650		28.89
7	100% of RCA	7			720	32
8	100% of RCA	8			750	33.33
9	100% of RCA	9			750	33.33



5. Conclusion

1. the strength of cubes decrease from 0% to 50% and then to 100%
2. The cubes of 50% replaced RCA could not achieve the targeted mean strength
3. The optimum value should lie in between 0% and 50% RCA used
4. For this we should perform more replacement like 10%, 20%, 30% and 40% replacement of natural coarse aggregates(NCA) with recycled coarse aggregates(RCA)
5. Although all replacement percentages of RCA satisfied for impact and los angels abrasions test.

References

1) M. Etxeberria , E. Vázquez, A. Marí, M. Barra "Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete" Cement and Concrete Research 37 (2007) 735–742

2) A.M. Neville, Properties of Concrete, Longman 981-4053-56-2, 2000 by
   a. Pearson Education Asia.

3) Comité Euro-International du Beton and Federation Internationale de la
   a. Precontrate, Paris, 1978.

4) R. Sri Ravindrarajah, Y.H. Loo, C.T. Tam, Recycled concrete as fine and
   a. coarse aggregates in concrete, Magazine of Concrete Research 39 (141)
   b. (Dec. 1987) 214–220.

5) M. Kakizaki, M. Harada, T. Soshiroda, S. Kubota.,T. Ikeda, Y. Kasai,
   a. Strength and Elastic Modulus of Recycled Aggregate Concrete; Demolition
   b. and Reuse of Concrete and Masonry, vol. 2. Reuse of Demolition
   c. Waste, Proceedings of the Second International RILEM Symposium on
   d. Demolition and Reuse of Concrete and Masonry, November 1988, Japan;
   e. Ed. Y. Kasai, pp. 565–574.

6) Ramesh T, Prakash R, Shukla KK. Life cycle energy analysis of buildings: An overview. Energy and Buildings 2010;42:1592–600.

7) T.C. Hansen, H. Narud, Strength of recycled concrete made from crushed

8) concrete coarse aggregate, Concrete International—Design and Construction
9) 5 (1) (January 1983) 79–83.

10) R.S. Ravidrarajah, T.C. Tam, Properties of concrete made with crushed
    a. concrete as coarse aggregate, Magazine of Concrete Research 37 (O. 130) (March 1985)
11) V.M. Malhotra, Use of recycled concrete as a new aggregate, Proc. of

12) Symposium on Energy Ad Resource Conservation in the Cement and
13) Concrete Industry, Report, vol. 76-8, CANMET, Ottawa, 1978

14) T. Mukai, H. Koizumi,
    a. Study on reuse of waste concrete for aggregate of
    b. concrete, Paper Presented at a Seminar on "Energy and Resources Conservation in Concrete Technology", Japan–US Co-operative Science Programme, San Francisco, 1979.
15) A.D. Buck, Recycled concrete, Highway Research Record 430 (1973).

16) S. Frondistou-Yannas, Waste Concrete as aggregate for New Concrete,
    a. ACI Journal (August 1977) 373–376.

17) M. Kikuchi, T. Mukai, H. Koizumi,

    a. Properties of concrete products containing recycled aggregate, Demolition and Reuse of Concrete and Masonry: Reuse of Demolition Waste, Chapman and Hall, London, 1988, pp. 595–604.

18) S. Nagataki, "Properties of Recycled Aggregate and Recycled Aggregate Concrete,

19) International Workshop on Recycled Concrete, 2000.