

**STUDIES ON DIFFERENT WASTE CONCRETE
AGGREGATES BASED CONCRETE**

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Abstract

This work was aimed at evaluating both mechanical and physical behavior of recycled concretes with two different kinds of recycled aggregate: one is made of waste concrete test cylinders concrete having 25 MPa compression strength, the other one is based on waste frame concretes having 10 MPa compression strength. The percentages of recycled concrete aggregates were varied for all mixtures and all concrete mixtures produced with same dosage and water/cement ratio for each set.

Key words: recycled aggregate, waste concrete, compression strength.

1. INTRODUCTION

Solid waste generated during construction activity, which involves construction and demolition is a major environmental problem. This problem becomes a major concern for planners, engineers and environmentalists. Solid waste includes sand, gravel, concrete, stone, bricks, wood, metal, glass, plastic, paper, etc. is generated because of structural deterioration; demolition of structures for better economic gains (through new construction) and waste material generated by natural disasters and war-inflicted damage [1], [2], [3].

The recycling of structural concrete wastes forming the majority of solid wastes on the world reduces the environmental damages besides the labor and time losses due to transportation of aggregates obtained from aggregates resources so far away from large cities. Recycling of this waste by reusing in concrete as aggregate not only saves landfill space but also reduces the demand for extraction of natural raw material for new construction activities. Recycled aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris [3].

Recycling waste construction materials in new projects is not a new concept. The first well documented use of materials from the demolition of the buildings as aggregate in concrete was during and just after the Second World War. At this time the rubble left after the bombardment of cities,

especially after aerial bombing, was used in concrete for rebuilding particularly in Britain and Germany [1]. Today, by the supports of European Commission on Management of Construction and Demolition Waste recycling of waste construction materials is a successful research program. The estimation of European Demolition Association shows that, 200 million tons of waste produced annually in Europe, about 30% of this quantity is currently being recycled. Studies in this area, however, show large region differences in the amount of recycled material. Some early adapting countries, like the Netherlands and Belgium, achieve recycling rates of about 90%, but in other European countries, like Italy and Spain, the recycling rate is below 10% [2]

This study investigated recycled aggregates made from two sources: waste laboratory concrete frames; and laboratory-crushed specimens. Main difference of these two sources is compression strengths of each waste concrete. A series of tests was carried out to investigate the effects of concrete quality of waste recycled aggregates containing various compositions on the mechanical properties of the recycled concrete.

2. EXPERIMENTAL PROGRAMME

Physical and mechanical properties of the recycled aggregates of various sources and hardened concrete property of recycled aggregate-based concrete were identified for this study. To study the properties of recycled aggregates, two types of materials were recycled and named *set I* and *set II*.

Set I comprised material taken from the laboratory-crushed specimen having age of 28 days cube concretes. The average compression strength of the specimens was 25 MPa. However, no specimen had more than 28 MPa compression strength and less than 21 MPa. The specimens were crushed using a crusher and thereafter sieved to get the required graded material. Adhered mortar to the aggregates was not removed. In producing new concretes, in place of natural aggregates 0%, 50%, 100% of recycled aggregate were added for set I.

Set II consisted of material taken from demolished frames in the laboratory. It was obtained from a demolished beam and frame, which was constructed about 1 year earlier. The frame was broken manually, the reinforcement removed and the concrete sieved to get the required graded aggregate. The average compression strength of the frame was 12 MPa. The aggregate used in this waste concrete was angular. Also in this set adhered mortar was not removed. In producing new concretes, in place of natural aggregates 0%, 50%, 100% of recycled aggregate were added for set II. Cracked and sieved waste concrete in laboratory is shown in Figure 1.



Figure 1. Cracked and sieved waste concrete in laboratory

In all of the sets the other constituents (wood, steel) if present were removed and the material was sieved through the required sieves to make it 16 mm nominal size. Different mixes were prepared for

use in carrying out the studies by varying the proportion of recycled aggregates. In all the mixes the same cement (CEM II/B-M(P-L) 32,5 R) was used. And also the source of water, tap water, was also kept the same for all mixes.

All of recycled aggregates were tested to obtain physical characteristics and mechanical properties. Water absorption and specific gravity tests were carried out in accordance with the requirements of Turkish Standard, TS 3526 (1981) [4]. For recycled aggregate concrete the following parameters for recycled aggregate concrete the following parameters were adopted.

1. All mixes were designed with the Water/cement ratio was kept constant at 0.57 for set I and 0,64 for Set II However, depending upon amount of recycled aggregates in the mix, a correction for water absorption was made.

2. The same natural basaltic rock aggregates obtained from the same source were used in all the mixes. The aggregate characterization of waste concrete aggregate for set I and set II is found due to TS 3529 (*Test Method for Determination of the Unit Weight of Aggregates for Concrete for Aggregate Unit Weight*) and TS 3526 (*Test Method for Specific Gravity and Water Absorption of Aggregates for Concrete*), [4], [5] shown in Table 1.

Table 1. Properties of coarse and fine aggregates

Property	Normal aggregate		Waste aggregate (set I)		Waste aggregate (set II)	
	Fine aggregate	Coarse aggregate	Fine aggregate	Coarse aggregate	Fine aggregate	Coarse aggregate
Water absorption (%)	1,7	1,3	9,6	4,3	17,6	6,8
Unit weight (kg/m ³)	2660	2705	2510	2600	2130	2440
Finess Modulus	2,81	5,76	2,12	5,54	1,23	5,64

3. The percentage proportions were made by weight and the ratio was applied for each sieve size to have graded aggregates of uniform size. In the concrete mix the ratio of aggregates were determined using reference curves A32 and B32 referred by TS 707 (*Method for Sampling of Aggregates for Concrete Reducing Samples to Testing Size*), and the sieve system TS 706 (*Aggregates for Concrete*) [6], [7].

4. Tap water was used in all the mixes and also the same cement was used in all mixes.

5. All the specimens were cast in cylinder moulds of required dimensions of 150 mm. diameter and 300 mm. heights, removed from the moulds after 24 h and thereafter cured in the water for 28 days. A mixture proportion of concrete containing recycled aggregates are shown in Table 2.

Table 2. Mixture proportions for concrete containing recycled aggregate

	%	Cement (kg/m ³)	Water (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse Aggregate (kg/m ³)	Waste Fine Aggregate (kg/m ³)	Waste Coarse Aggregate (kg/m ³)	W/C Ratio
Set I	0	366	209	885	898	0	0	0,57
	50	346	197	363	553	414	429	0,57
	100	323	184	0	0	853	884	0,57
Set II	0	327	209	901	914	0	0	0,64
	50	310	197	370	564	400	460	0,64
	100	289	184	0	0	882	941	0,64

6. All measurements were made by weight and mixing conditions specified in the Turkish Standards.

7. All the specimens were tested surface dry. To test the compressive strength of recycled aggregate concrete 150 mm diameter and 300 mm long cylinders, were cast. Split tensile strength was also tested using cylinders with these dimensions. The tests were conducted using a universal testing machine after 7 and 28 days. For each such test a minimum of three specimens were tested and average was taken as the mean compressive strength.

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Physical Characteristics of Recycled Concrete Aggregates

The physical characteristics of recycled aggregates for both set I and set II were water absorption, specific gravity and grading are tabulated in Table 1. The grading was taken as per requirement of nominal size 16 mm aggregates. The results of recycled aggregate concrete showed higher water absorption in comparison with conventional aggregates and the current compression strength of waste concrete due to old mortar attached to the original aggregate. The physical characteristics of recycled concrete aggregates decreases when compression strength of waste concrete decrease. As seen from the test results, the water absorption of recycled aggregates of all types that increase due to compression strength of waste concrete. In specific gravity marginally lower values were found again.

3.2. Properties of Recycled Aggregate Concrete

Increasing amount of recycled aggregates workability reduced for both 2 set. Actually waste concretes with lower compression strength had higher water absorption. The compressive strengths for Set I and Set II at 7 and 28 days for recycled aggregates with 0, 50 and 100% of recycled aggregate and split tensile strength at 28 days for recycled aggregate concrete are shown in Table 3.

Table 3. Properties of hardened recycled aggregate concrete

		7 days compression strength (MPa)	28 days compression strength (MPa)	28 days split tensile strength (MPa)
Set I	0	14,6	19,8	3,1
	50	11,4	15,3	2,6
	100	8	11,3	2,1
Set II	0	14,7	19,6	2,2
	50	11,9	16,2	1,8
	100	10,8	13,2	1,5

4. CONCLUSIONS

Concrete mix design of recycled concrete and concrete with natural aggregate was similar to each other. Higher water absorption of recycled aggregates increased when the compression strength of waste concrete decreased from 25 MPa to 12 MPa. The compressive strength decreased with decreasing concrete quality of waste concretes. This could be explained as; the increase in compression strength of waste concrete means bad quality of recycled aggregate. When recycled aggregate with less compression strength used it has more plaster on it. So, it has more voids and hence caused a loss in strength. So, more studies must be done by the researchers during production of waste concrete aggregate based concrete.

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