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Blending Of Recycled Concrete Aggregates with Special Reference to Base Course Construction

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Abstract— **The objective of this study is to develop the best economic solution by blending of recycled concrete aggregates for use in base coarse construction. Therefore, the objective of this project is to investigate the properties of blended Recycled Concrete Aggregate including optimum moisture content, maximum dry density, and bearing strength.. For determining the above properties, the blending of the recycled aggregate has been done in different proportions of 100 %, 90%, 80%, 70%, 60%, and 50% recycled concrete aggregate with the varying percentage of sand. Laboratory trails were conducted to investigate the possibility of using percentage of recycled concrete aggregate (100%, 90%, 80%, 70%, 60%, and 50%) with 3% and 5% of cement to replace the part of sand in mix. The heavy compaction tests were conducted to determine the optimum moisture content and dry density of the recycled aggregates. California bearing ratio (CBR) tests were conducted at optimum moisture content.**

Key Words : Blending , Base Course, Recycled concrete aggregates
Sub Area : Construction Technology & Management
Broad Area :Civil Engineering

PROCESS

Optimum moisture content (OMC)

The proctor tests show that there is great change of the granular structure according to the number of blows and presence of water. The addition of the sand, recycled concrete aggregate and cement varies considerably the behavior of the recycled concrete aggregates at compaction. OMC decreases with increasing the percentage of recycled concrete aggregates (RCA) as shown in Figure 4.1

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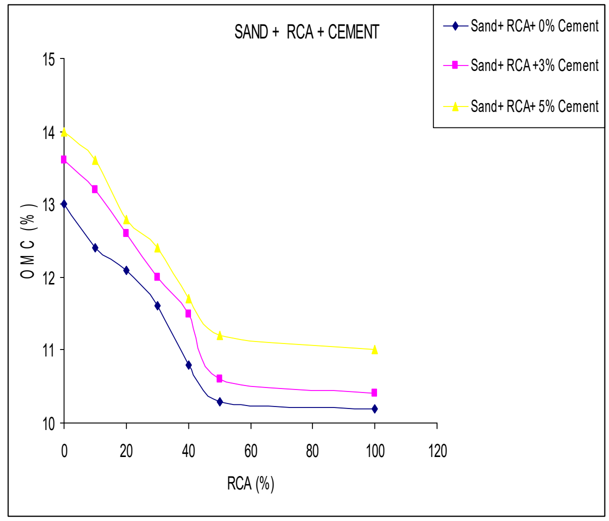

Figure 1: OMC vs RCA at different proportions of cement

When we added RCA in sand, surface area is reduced due to larger particle size, so the less water is required to lubricate them. Figure 4.1 depicts that 100% sand has highest OMC i.e 13% because of larger surface area and smaller particle size. For 100% RCA, OMC is 10.2.As the particle size increases, the surface area reduces and it requires less water to lubricate the particles.

Maximum Dry Density (MDD)

MDD of blended material increases with increasing percentage of RCA and cement as shown in Figure 4.2.This is because of the dense packing of blended material due to compaction and higher specific gravity of cement and RCA as compared to sand.

The highest value of maximum dry density is achieved with a combination of 95% RCA and 5% cement. With the addition of 5% of cement, the maximum dry density of the recycled concrete aggregates reaches a value of 2.06 g/cc (Fig. 4.2). Indeed, the mixture is strongly influenced by the small quantity of cement which surrounds the aggregates of concrete and created a strong adherence between the grains. For a combination of 45% of sand, 50% of RCA and 5% of cement, MDD is 1.99 g/cc. This phenomenon is explained by the fact that the sand particles act by slipping between the coarse grains, which confers to the materials a good compactness and low water content.

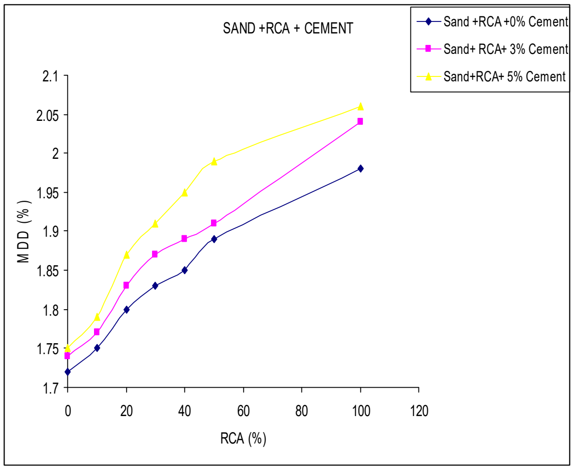

Figure .2: MDD vs RCA at different proportion of cement

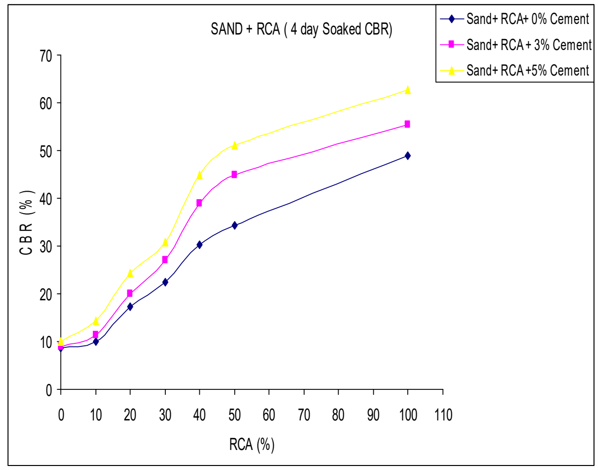

Figure 4.3: CBR vs RCA at different proportions of cement

The improvement of the dry density can be explained by the fact that the concrete aggregates have a spread out granulometry which improves with the additions of fine particles of sand and cement. As for the cement addition, the fine cement particles confer cohesion on the mixture. This improves more dry density. In term of quality, we note that optimal dry density with the mixture with 5% cement is higher than that obtained with mixture without cement or 3% cement. The quantity of sand and cement is suitable to fill the existing vacuums or voids between the recycled concrete aggregates, thus offering to the mixture of a better dry density and a better bearing pressure.

DISCUSSION ON CBR TESTS

CBR tests are of capital importance for any road project because they enable us to evaluate the bearing pressure of the compacted ground. The summary Table 4.1

CBR value obtained is higher than 80 which is the minimal value necessary for material. The results highlight an appreciable increase in CBR values after 7 days, 14 days and 28 days curing when we proceed to the addition of 3% and 5% of cement.

As for the cement addition, the percentage of cement 3% and 5% made it possible to obtain the highest value of CBR. This can be explained by the fact that cement reacts with water and makes harden the mixture of recycled aggregates to obtain a material which is concrete. The CBR value increases tremendously with addition of 45% sand and 5% cement to reach its maximum value (455) after 28 days curing. Sand without addition of RCA and cement has minimum value of CBR (8.59).

4 day soaked CBR graphs are shown in Figure. 4.3. Graphs showing that CBR percentage values increase with increasing the proportion of RCA at different proportion of cement.

As shown in Fig. 4.3, with increase in percentage of RCA, soaked CBR value of blend increases from 8.59 (100% Sand + 0% RCA + 0% Cement) to 48.9 (0% Sand +100% RCA + 0% Cement). With addition of 3% cement, soaked CBR of the blended material increase. The CBR value for (97% Sand + 0% RCA + 3% Cement) is 8.82 and that for (0% Sand + 97% RCA + 3% Cement) is 55.47. With addition of 5% cement, soaked CBR of the blended material increase. The CBR value for (95% Sand + 0% RCA + 5% Cement) is 10 and that for (0% Sand + 95% RCA + 5% Cement) is 62.8.

The increase in CBR is 16% for sand blended with 10% of RCA. It increased 5.69 times for recycled concrete aggregates without cement from 100% sand. For 80% sand+ 20% RCA, 70% sand +30% RCA, 60% sand+ 40% RCA and 50% sand + 50% RCA, the ratios of $(CBR)_b/(CBR)_s$ are 2.022, 2.59, 3.53 and 3.99 respectively. Where, CBR With the addition of 3% cement in blended material, the ratio is increased to 1.29, 2.26, 3.06, 4.42, 5.09 and 6.28 for 97% Sand +10% RCA, 87% Sand + 20% RCA, 77% Sand + 30% RCA, 67%Sand + 40% RCA, 57% Sand +50% RCA and 100% RCA. When we added 5% cement, The ratio of $(CBR)_b/(CBR)_s$ is 1.44, 24.3, 30.8, 44.9, 51.2 and 62.8 for Sand +10% RCA, Sand +20% RCA, Sand +30% RCA, Sand +40% RCA, Sand+50% RCA and 100% RCA. This can be due to the presence of RCA increased the medium aggregate fraction of the blended soil and the presence of considerable amount of fine aggregate and sand ensured that the intergranular voids were filled, thus enhancing bearing strength.

Table 4.1: CBR test results of samples blended with RCA at different proportion of cement

Sample	OMC (%)	MDD g/cc	Soaked CBR values			
			4 days	7 days	14 days	28 days
100 % Sand+ 0% aggregate+ 0% cement	13	1.720	8.59			
90%Sand + 10%aggregate+ 0% cement	12.4	1.75	10			
80%Sand + 20%aggregate+ 0% cement	12.1	1.8	17.37			
70%Sand + 30% aggregate+ 0% cement	11.6	1.83	22.3			
60%Sand + 40% aggregate+ 0% cement	10.8	1.85	30.3			
50%Sand + 50% aggregate+ 0% cement	10.3	1.89	34.3			
0%Sand+ 100%Aggregate+ 0% cement	10.2	1.98	48.9			
97%Sand+ 0% aggregate + 3% cement	13.6	1.74	8.82	41.5	96	128
87%Sand + 10% aggregate + 3% cement	13.2	1.77	11.37	42.9	124	154
77%Sand + 20% aggregate + 3% cement	12.6	1.83	19.96	53	189	222
67% Sand + 30% aggregate + 3% cement	12	1.87	27	55.8	223	251
57%Sand + 40% aggregate + 3% cement	11.5	1.89	39	65.7	244	270
47%Sand + 50% aggregate + 3% cement	10.6	1.91	44.9	75.5	293	314
0%Sand+ 100%Aggregate+ 3% cement	10.4	2.04	55.47	78	345	375
95%Sand+ 0% aggregate + 5% cement	14	1.75	10	42	105	137
85%Sand + 10% aggregate + 5% cement	13.6	1.79	14.4	48.6	132.9	166
75%Sand + 20% aggregate + 5% cement	12.8	1.87	24.3	60.76	252.5	288
65%Sand + 30% aggregate + 5% cement	12.4	1.91	30.8	55.45	278.5	303
55%Sand + 40% aggregate + 5% cement	11.7	1.95	44.9	75	300	320
45%Sand + 50% aggregate + 5% cement	11.2	1.99	51.2	79	357.8	387
0%Sand+ 95%Aggregate + 5% cement	11	2.06	62.8	80	407	455

EFFECT OF CURING ON BLENDED RCA

3% and 5% cement was added to blend of sand and RCA. It has been observed that material becomes stronger after 28 day curing. Figure 4.4 showing the comparison between the graphs of 4 day, 7 day, 14 day and 28 day curing. As the curing days increased, the cement gains more strength. This can be explained by the fact that the cement reacts with water and makes harden the mixer of the recycled aggregates to obtain a material with higher bearing strength. Graphs show that with the addition of cement to blend of sand with RCA becomes semi-rigid pavement i.e the pavement changes its nature from flexible to semi-rigid pavement. Then there may be no need of construction of any pavement over the base course, and then only surface course is sufficient.

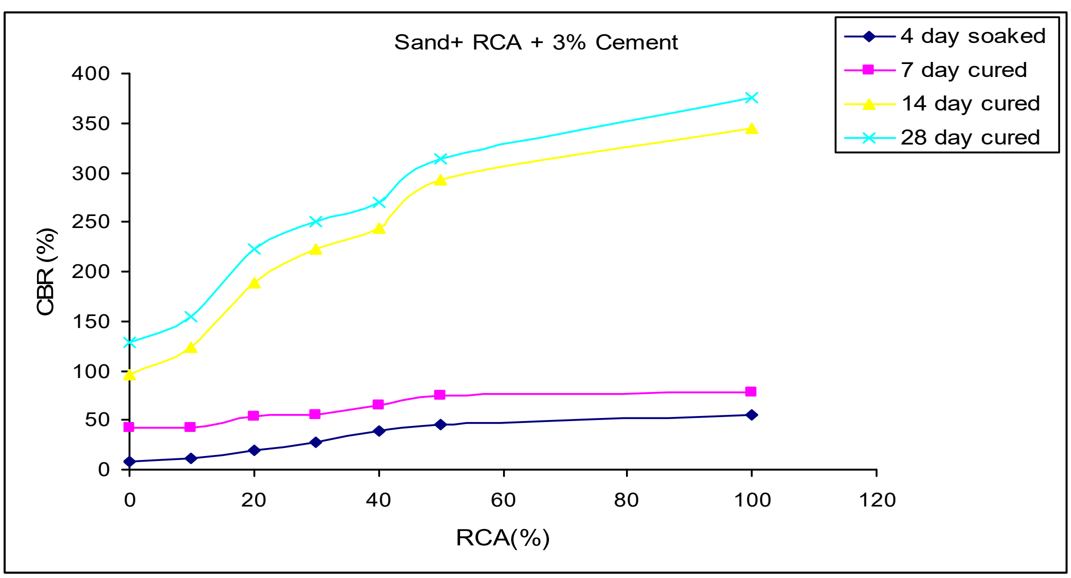

Figure 4.4: CBR vs RCA at different days of curing

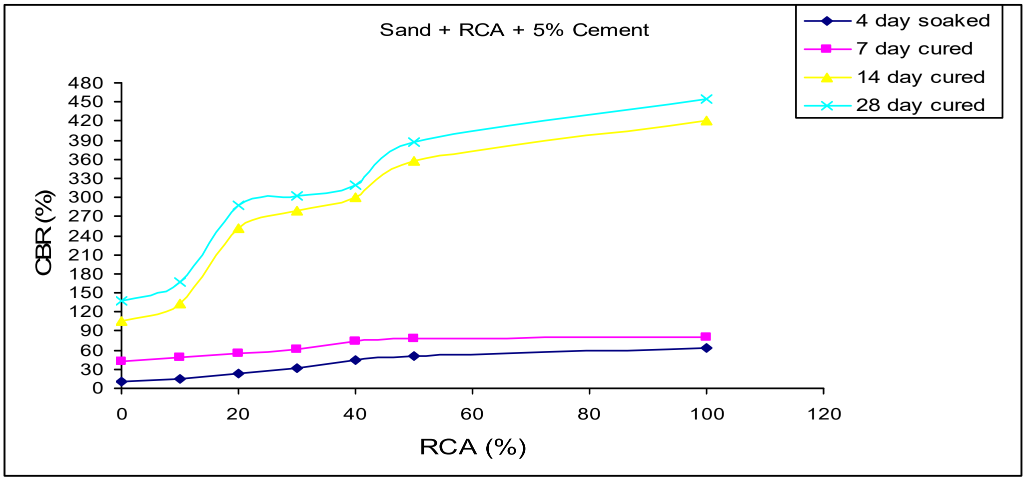

Figure 4.5: CBR vs. RCA at different curing days

CONCLUSIONS

The results obtained in this study highlighted the influence of the additions of cement and sand on the mechanical properties of RCA. From the characterization of mechanical properties, it is concluded that they cannot be regarded as inert and can influence the behaviour of roadway layers by presence of water or the additions.

In this study, the highest dry densities are for additions of 5% cement in recycled concrete aggregates. The study of bearing pressure revealed a good resistance of the granular mixture (recycled concrete aggregate + cement), which resulted in high values of CBR due to improvement of grain size distribution during the compaction. Furthermore good results obtained with the addition of cement to the proctor and CBR tests.

The proctor tests show that there is great change of the granular structure according to the number of blows and presence of water. The addition of the sand, recycled concrete aggregate and cement varies considerably the behavior of the recycled concrete aggregates at compaction. OMC decreases with increasing the percentage of recycled concrete aggregates (RCA). When we added RCA in sand, surface area is reduced due to larger particle size, so the less water is required to lubricate them. 100% sand has highest OMC of 13% because of larger surface area and smaller particle size. For 100% RCA, OMC is 10.2. As the particle size increases, the surface area reduces and it requires less water to lubricate the particles.

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It has been observed that by curing of blended RCA, it has gained very high strength which shows that with the addition of cement to blend of sand and RCA, it becomes semi- rigid pavement i.e the pavement changes its nature from flexible to semi-rigid pavement. Then there may be no need of construction of any wearing course over the base course, only surface course will be sufficient.

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