ISSN (Online) : 2455 - 3662
SJIF Impact Factor :5.148

EPRA International Journal of
Multidisciplinary Research

Monthly Peer Reviewed & Indexed
International Online Journal

Volume: 5 Issue: 5 May 2019

Published By :EPRA Publishing

Volume: 5 | Issue: 5 | May 2019 || SJIF Impact Factor: 5.148 ISSN (Online): 2455-3662

EPRA International Journal of
Multidisciplinary Research (IJMR) *Peer Reviewed Journal*

BLENDING OF RECYCLED CONCRETE AGGREGATES FOR USE IN BASE COURSE CONSTRUCTION

Nakul Hans
M.Tech. Scholar- 4th Semester,
Department of Civil Engineering ,Arni University,
Kathgarh, (Indora)-176401
H.P. India,

Er. Dalvir Singh
Assistant Professor ,
Civil Engineering Arni University,
Kathgarh, (Indora)-176401
H.P. India,

Dr. Arvind Dewangan
Professor
Civil Engineering Department,
Jodhpur Institute of Engineering & Technology Jodhpur -JIET (Raj.),

ABSTRACT

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. 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 coarse over the base coarse, only surface coarse will be sufficient. 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 coarse over the base coarse, only surface coarse will be sufficient.

KEY WORDS : *RCA, Dry lean concrete(DLC), C&D (construction & demolition), blended Recycled Concrete*
Sub Area : *Transportation Engineering*
Broad Area :*Civil Engineering*

INTRODUCTION

The properties of RCA has been established and demonstrated through several experimental and field projects successfully. It has been concluded that RCA can be readily used in construction of low rise buildings, concrete paving blocks & tiles, flooring, retaining walls, approach lanes, sewerage structures, sub base course of pavement, drainage layer in highways, dry lean concrete(DLC) etc. in Indian scenario. Use of RCA will further ensure the sustainable development of society with savings in natural resources, materials and energy.

Concrete aggregate collected from demolition sites is put through a crushing machine, often along with asphalt, bricks, dirt, and rocks. Smaller pieces of concrete are used as gravel for new construction projects. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. This reduces the need for other rocks to be dug up, which in turn saves trees and habitats.

C&D (construction & demolition) wastes are normally composed of concrete rubble, brick, tile, sand and dust, timber, plastic, cardboard, paper, and metal. Concrete rubbles usually constitute the largest proportion of C&D waste. It has been shown that crushed concrete rubble, after separated from other C&D wastes and sieved, can be used as a substitute for natural coarse aggregates in concrete or as a sub-base or base layer in pavements. But the fine fraction is not commonly used due to its higher contamination and waste absorption levels. Aggregate base is typically composed of crushed rock capable of passing through a 3/4 in (19.05 mm) rock screen. The component particles will vary in size from 3/4 inch down to dust. The material can be made of virgin (newly mined) rock, or of recycled asphalt and concrete.

Recycling timber has become popular due to its image as an environmentally friendly product, with consumers commonly believing that by purchasing recycled wood the demand for green timber will fall and ultimately benefit the environment. The arrival of recycled timber as a construction product has been important in both raising industry and consumer awareness towards deforestation and promoting timber mills to adopt more environmentally friendly practices. Wood recycling is a subject which has in recent years taken an ever greater role in our lives. The problem, however, is that although many local authorities like the idea of recycling, they do not fully support it. One of the countless examples, which have been in the news, is the concept of actually recycling wood which is growing in the cities i.e. recycling timber, trees and other sources.

OBJECTIVE AND SCOPE

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 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.

LITERATURE REVIEW

Vivian W.Y. Tama, K. Wangb, C.M. Tamb (2007) studied recycled demolished concrete (DC) as recycled aggregate (RA) and recycled aggregate concrete (RAC) is generally suitable for most construction applications. Low-grade applications, including sub-base and roadwork, have been implemented in many countries; however, higher-grade activities are rarely considered. This paper examines relationships among DC characteristics, properties of their RA and strength of their RAC using regression analysis. Ten samples collected from demolition sites are examined. The results show strong correlation among the DC samples, properties of RA and RAC. It should be highlighted that inferior quality of DC will lower the quality of RA and thus their RAC. Prediction of RAC strength is also formulated from the DC characteristics and the RA properties. From that, the RAC performance from DC and RA can be estimated. In addition, RAC design requirements can also be developed at the initial stage of concrete demolition. Recommendations are also given to improve the future concreting practice.

Farid Debieb, Said Kenai (2006) studied Recycling and reuse of building rubble present interesting possibilities for economy on waste disposal sites and conservation of natural resources. This paper examines the possibility of using crushed brick as coarse and fine aggregate for a new concrete. Either natural sand, coarse aggregates or both were partially replaced (25, 50, 75 and 100%) with crushed brick aggregates. Compressive and flexural strengths up to 90 days of age were compared with those of concrete made with natural aggregates. Porosity, water absorption, water permeability and shrinkage were also measured. The test results indicate that it is possible to manufacture concrete containing crushed bricks (course and fine) with characteristics similar to those of natural aggregates concrete provided that the percentage of recycled aggregates is limited to 25% and 50% for the coarse and fine aggregates, respectively.

Hu¨ seyin Akbulut, Cahit Gu¨ rer (2007) investigated recycled aggregates produced from homogeneous marble and site quarry wastes in Afyonkarahisar–Iscehisar region were compared to two other aggregate specimens currently used in Afyonkarahisar city asphalt pavements. Los Angeles abrasion, aggregate impact value (AIV), freezing and thawing, flakiness index and Marshall Stability flow tests were carried out on the aggregate specimens.

Bachir Melbouci (2009) studied the mechanical response of recycled aggregate and determines their mechanical characteristics the proctor test, the CBR test and the shearing test have been carried out. The result obtained showed that their characteristics are lower than those of the natural aggregates.

*Chi Sun Poon *, Dixon Chan(2014)* studied the possibility of using recycled concrete aggregates and crushed clay brick as aggregates in unbound sub base materials. The results showed that the use of 100% recycled concrete aggregates increased the optimum moisture content and decreased the maximum dry density of the sub base materials compared to those of natural sub base materials. Moreover, the replacement of recycled concrete aggregates by crushed clay brick further increased the optimum moisture content and decreased the maximum dry density. This was mainly attributed to the lower particle density and higher water absorption of crushed clay brick compared to those of recycled concrete aggregates.

METHODOLOGY

TEST PROGRAMME

The following test programme was planned to achieve the objectives:

1. To study the compaction characteristics of blended material.
2. To study the California bearing ratio (CBR) of blended material.

MATERIALS USED

The test specimens were cast using cement, fine aggregate, recycled concrete aggregates and water. The materials, in general, conformed to the specifications laid down in the relevant Indian Standard Codes. The materials used for making specimens were having the following characteristics:

Cement

Pozzolana Portland cement from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 1489-1991 are listed in Table 3.1. Cement was carefully stored in tight silos to prevent deterioration in its properties due to contact with the ambient conditions.

TABLE 3.1 Physical properties of cement.

Sr. No.	Properties	Observation
1	Fineness (90 micron IS Sieve)	4 percent
2	Initial setting time	58 minutes
3	Final setting time	280 minutes
4	Standard consistency	31 percent
5	28-days compressive strength	42.65 MPa

Fine Aggregate

River sand was used as fine aggregate. The particle size distribution and other physical properties of the fine aggregate are listed in Table 3.2 respectively. Clumps of clay and other foreign matter were separated out from the sand by sieving it through a 150 micron sieve.

The particle size distribution curve, also known as a gradation curve, represents the distribution of particles of different sizes in the soil mass. The percentage finer by weight is plotted as ordinate and the particle size as abscissa (on log scale) as shown in Figure. 3.1

TABLE 3.2: Sieve analysis of fine aggregates

IS Sieve designation	Percentage weight retained	Cumulative percentage weight retained	Percent finer by weight (%)
4.75 mm	0.3	0.3	99.7
2 mm	0.5	0.8	99.2
1 mm	0.5	1.3	98.7
425 m	4.0	5.3	94.7
300 m	20	25.3	74.7
150 m	62.5	87.8	12.2
75 m	10.2	98	2
Pan	2.0	100	0

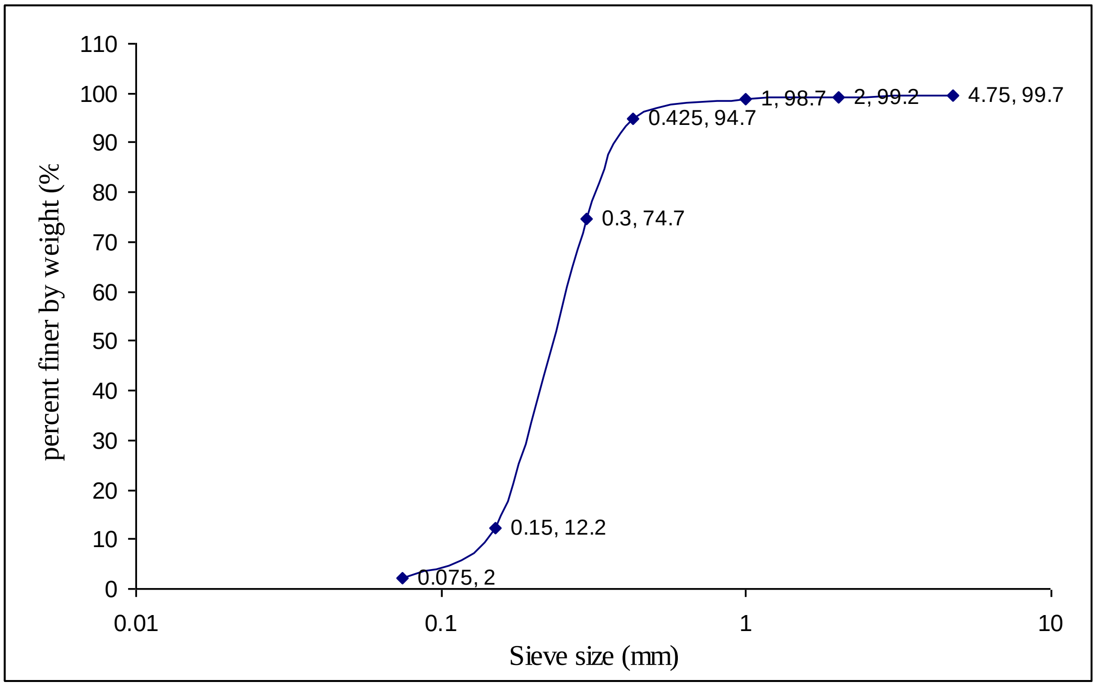

Figure: 3.1 Particle size distribution curve of sand

Table 3.3: Characteristics of sand

Uniformity coefficient, C_u	1.72
Coefficient of curvature, C_c	0.99
Specific Gravity, G	2.66
Optimum moisture content, w_{opt} %	13
Maximum dry density, γ_{dmax}	1.72

The uniformity of soil is expressed qualitatively by term known as uniformity coefficient, C_u, given by

$$C_u = D_{60}/ D_{10}$$

Where, D_{60} = particle size such that 60% of the soil is finer than this size

D_{10} = particle size such that 10% of the soil is finer than this size

The general shape of the particle size distribution curve is described by another coefficient known as coefficient of curvature (C_c).

$$C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

Where, D_{30} is particle size corresponding to 30% finer

As shown in Table 3.3, C_u value is less than 2 and C_c value is less than 1 which shows that soils used is poorly graded soils.

Coarse aggregate

Locally available recycled concrete aggregates were used as coarse aggregates. The recycled aggregates produced by the crushing of the concrete blocks resulting from the concrete cube demolition in concrete laboratory. Concrete blocks were crushed by using compressive test machine. Sieve analysis and other physical properties of aggregate are listed in Table 3.3 respectively. Coarse aggregate was sieved through a 150 micron sieve to remove dirt and other foreign material.

California Bearing Ratio Test

California Bearing Ratio (CBR) test is a type of test developed by California Division of Highways in 1929. The test is used for evaluating the suitability of sub grade and the materials used in sub-base and base coarse. The test is conducted on a prepared specimen in a mould. The laboratory test consists of a mould 150 mm diameter and 175 mm high, having a separate plate and a collar. The load is applied by a loading frame through a plunger of 50 mm diameter. Dial gauges are used for measurement of expansion of the specimen on soaking and for measurement of penetration.

It is noted that with the displacer disc inside the mould, effective height of the mould is only 125 mm. The test consists of causing the plunger to penetrate the specimen at the rate of 1.25 mm per minute. The loads required for penetration of 2.5 mm and 5.0 mm are recorded by a proving ring attached to the plunger. The load is expressed as a percentage of the standard load at the respective deformation level, and is known as the CBR value. The CBR value is determined corresponding to both 2.5 mm and 5.0 mm penetration, and the greater value is used for the design of flexible pavement. California bearing ration test apparatus is shown in Figure 3.4

CBR value = Test load x 100 Standard load
CBR (2.5 mm) = Corrected load at 2.5 mm x 100
13.44
CBR (5.0 mm) = Corrected load at 5.0 mm x 100
20.16

Detail of tests performed

Table 3.5: Various combinations for tests performed for compaction

Serial no.	Combination for tests performed for compaction
1	100 % Sand+ 0% aggregate+ 0% cement
2	90%Sand + 10%aggregate+ 0% cement
3	80%Sand + 20%aggregate+ 0% cement
4	70%Sand + 30% aggregate+ 0% cement
5	60%Sand + 40% aggregate+ 0% cement
6	50%Sand + 50% aggregate+ 0% cement
7	0%Sand+ 100%Aggregate+ 0% cement
8	97%Sand+ 0% aggregate + 3% cement
9	87%Sand + 10% aggregate + 3% cement
10	77%Sand + 20% aggregate + 3% cement
11	67%Sand + 30% aggregate + 3% cement
12	57%Sand + 40% aggregate + 3% cement
13	47%Sand + 50% aggregate + 3% cement
14	0%Sand+ 100%Aggregate+ 3% cement
15	95%Sand+ 0% aggregate + 5% cement
16	85%Sand + 10% aggregate + 5% cement
17	75%Sand + 20% aggregate + 5% cement
18	65%Sand + 30% aggregate + 5% cement
19	55%Sand + 40% aggregate + 5% cement
20	45%Sand + 50% aggregate + 5% cement
21	0%Sand+ 95%Aggregate + 5% cement

In case of CBR tests, soaked CBR tests were performed for the above combinations and wherever the percentage of cement is added, tests were performed after 7, 14 and 28 days curing also.

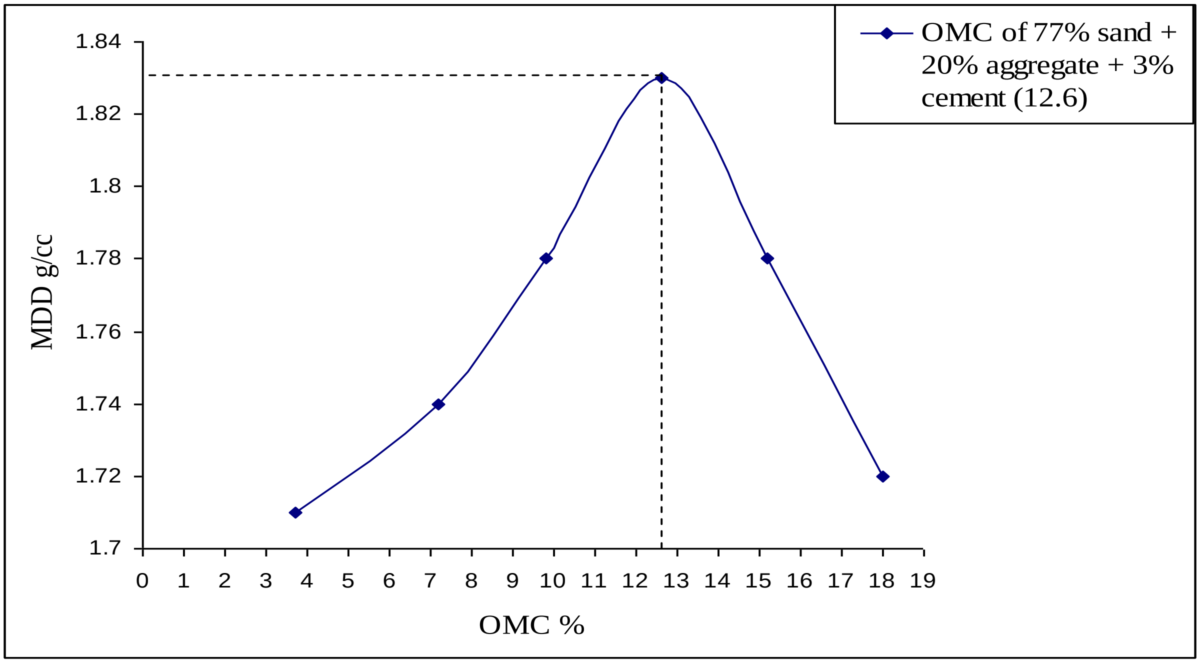

Figure 3.14: MDD vs OMC of 77% sand + 20% aggregate + 3% cement

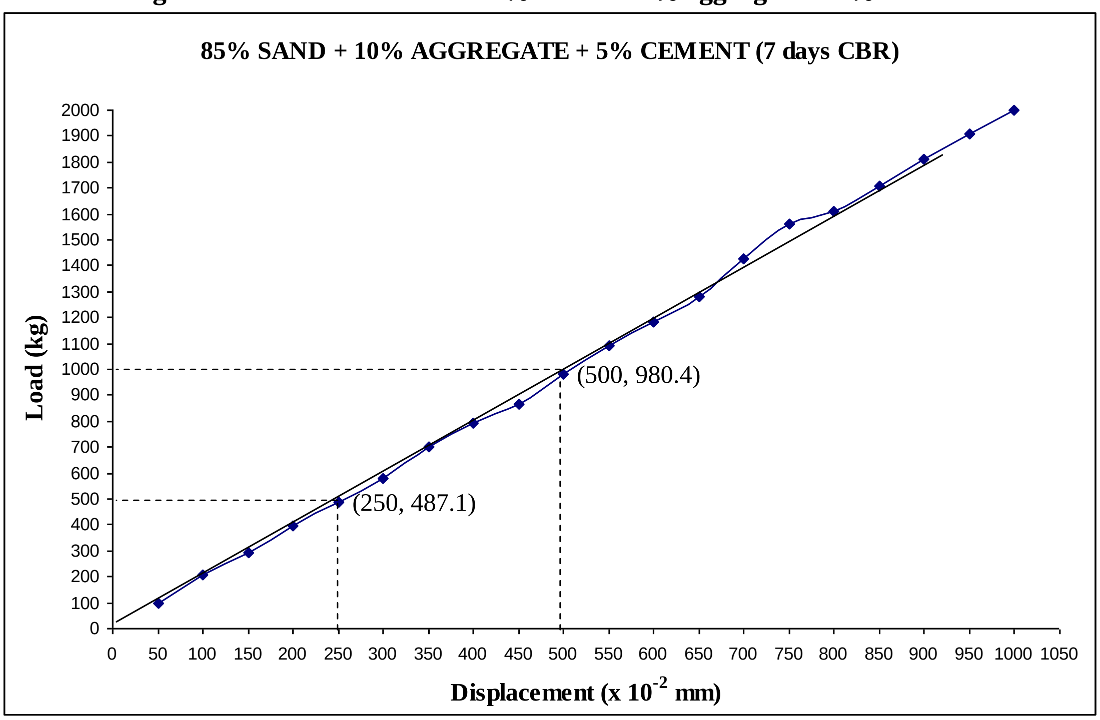

Figure 3.55: Load vs Displacement of 85% sand + 10% aggregate + 5% cement

DISCUSSION OF RESULTS

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

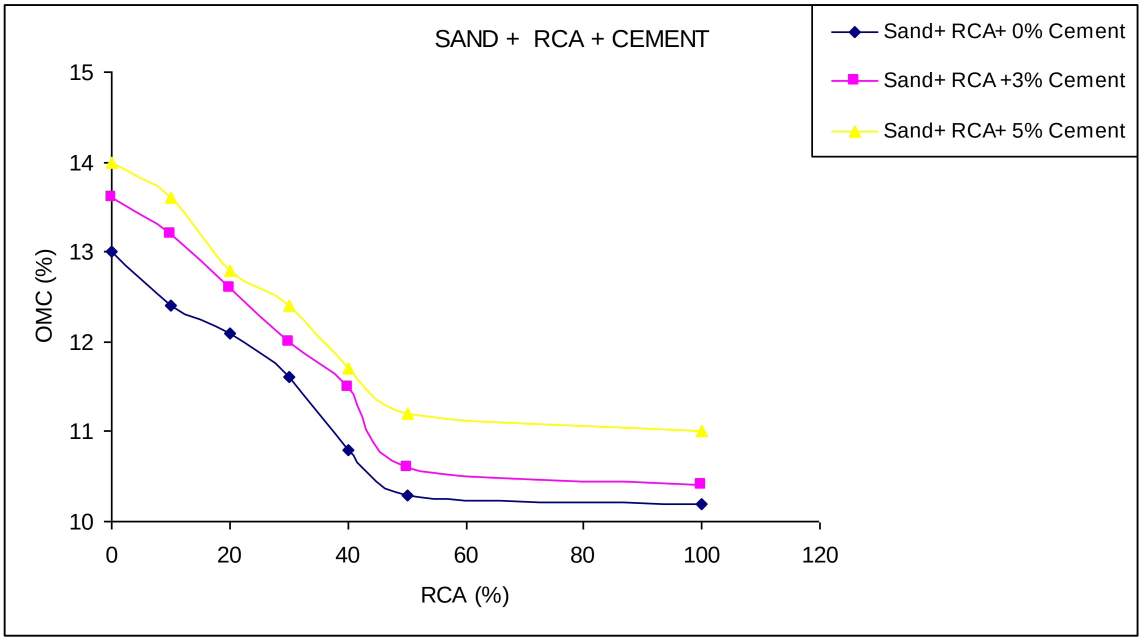

Figure 4.1: OMC vs RCA at different proportions of cement

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.

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.

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.

CONCLUSION

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.

MDD of blended material increases with increasing percentage of RCA and cement. .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. 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

REFERENCES

1. *Tavakoli M. "Strengths of Recycled Aggregate Concrete Made Using Field-Demolished Concrete as Aggregate" ACI Materials Journal Vol. 93 No. 2,March- April 1996; page no.182-190.*
2. *Dhir et al "Use of recycled concrete aggregate in high-strength concrete" Materials and Structures, Volume 33, Number 9 / November, 2000*
3. *Papp, W.J., Maher, M.H., Bennert, T.A., and Gucunski, N. (1998) "Behaviour of*
1. *Construction and demolition debris in base and subbase applications" Geotechnical Special Publication, CSA.*
4. *Xu and Chung (1999) "Improving the workability and strength of silica fume concrete by using silane treated silica fume" Cement and Concrete Research, p.451-453*
5. *Taerwe, L., De Pauw, P., and Desmyter. J (1999) "Concrete with Recycled materials as Coarse Aggregates: Shrinkage and Creep Behaviour" Materials and Construction, CSA, page no.720-727.*
6. *Ravande Kishore, Bairagi,N.K., and Kumar.P "Strength characteristics of concrete made with recycled fine aggregate and crushed stone fines" International Conference on Solid Waste Technology and Management, The Journal of Solid Waste Technology and Management, Philadelphia, U.S.A, December1999, pp – 4C*
7. *E.M. Fremponga, K.E.N. Tsidzib(1999) "Blending of marginally suitable tropical sub-base materials for use in base course construction" Construction and Building MaterialsVolume 13, Issue 3, 1 April 1999, Pages 129-141*
8. *Taha, R., Ali, G., Basma, A., and Al-Turk, O(1999) ''Evaluation of reclaimed asphalt pavement aggregate in road bases and subbases.'' Transportation Research Record 1652, 1, 7th Int. Conf. on Low- Volume Roads, Transportation Research Board, National Research Council, Washington, D.C., 264–269.*
9. *Sanchez de Juan et al. (2000) "Influence of recycled aggregate quality on concrete properties" International RILEM Conference on the Use of Recycled Materials in Buildings and Structures, vol.1, January*
10. *Ramzi Taha, A.M.ASCE, Ali Al-Harthy, Khalid Al-Shamsi3, and Muamer Al-Zubeidi "Cement Stabilization of Reclaimed Asphalt Pavement Aggregate for Road Bases and Subbases" Journal of material in civil engineering ,June 2002 , page no. 239-245*
11. *Mandal , Chakarborty, Gupta "Some studies on durability of recycled aggregate concrete" Indian Concrete Journal ,Volume 76, Issue 6, June 2002, Pages 385-388*
12. *C. S. Poon, et al. (2002) "Use of recycled aggregates in moulded concrete bricks and blocks" Construction and Building Materials, Volume 16, Issue 5, July 2002, Pages 281-289*
13. *Fumoto, T., and Yamada, M. (2002) "Influence of Quality of Recycled Fine Aggregate on Properties of Concrete" Osaka City University, Volume 43*
14. *Taesoon Park "Application of Construction and Building Debris as Base and Subbase Materials in Rigid Pavement" Journal of Transportation Engineering © ASCE, volume 129, Issue 5, September-October 2003*
15. *P. Paige-Green "Strength and Behavior of Materials for Low-Volume Roads as Affected by Moisture and Density" Journal of Transportation Research Board, Volume 1819/2003*
16. *Katz (2004) "Treatments for the improvement of recycled aggregate" Journal of materials in civil engineering, American Society of Civil Engineers, Vol. 16, Issue No. 6, November-December, 2004, page no. 597-603*
17. *Limbachiya (2004) "Construction and Demolition Waste Recycling Reuse as Aggregate in Concrete Production" School of Engineering, Kingston University<http://engineering.kingston.ac.uk/strc/documents/Interim%20Report1.pdf>*
18. *Chi Sun Poon , Dixon Chan "Feasible use of recycled concrete aggregates and crushed clay brick as unbound road sub-base" Construction and Building MaterialsVolume 20, Issue 8, October 2006, Pages 578-585*
19. *Vivian W.Y. Tama, K. Wangb, C.M. Tamb(2007) "Assessing relationships among properties of demolished concrete, recycled aggregate and recycled aggregate concrete using regression analysis"*
20. *Farid Debieb , Said Kenai(2006) "The use of coarse and fine crushed bricks as aggregate in concrete" Construction and Building Materials 22 (2008) 886–893*
21. *Gilpin R. Robinson Jr., W. David Menzie , Helen Hyun(2004) "Recycling of construction debris as aggregate" Resources, Conservation and Recycling Volume 42, Issue 3, October 2004, Pages 275-294 ,Recycled Materials in Highway Infrastructure*
22. *Hu¨ seyin Akbulut, Cahit Gurer (2007) "Use of aggregates produced from marble quarry waste in asphalt pavements" Building and Environment, vol. 42 (2007) 1921–1930*
23. *Eshmaiel Ganjian "Scrap-tyre-rubber replacement for aggregate and filler in concrete" Construction and Building Materials, May 2009, Pages 1828-1836*
24. *Bachir Melbouci (2009) "Compaction and shearing behaviour study of recycled aggregates" Construction and Building Materials, vol. 23 (2009) 2723–2730*

BIOGRAPHY

Corresponding Author Nakul Hans is M.Tech. Scholar- 4th Semester (Transportation Engineering), Department of Civil Engineering ,ARNI UNIVERSITY, KATHGARH, (INDORA)-176401 H.P.

Co-Author Er. Dalvir Singh is working as an Assistant Professor in Department of Civil Engineering ,ARNI UNIVERSITY, KATHGARH, (INDORA)-176401 H.P. He has published research papers in different Seminars and Journals.

Co-Author Dr. Arvind Dewangan, Working as a (Professor in Department of Civil Engineering, **Jodhpur Institute of Engineering & Technology Jodhpur –JIET, Jodhpur** (Raj.)-**India**. He has 18-years of experience in teaching and research. He has published 130 papers in International and National journals and **won more than 25-times National level Essay Competition.** He has published various articles about Technical & Higher education in national level competition magazine like – Competition Success Review, i-SUCCEED, Civil Services Chronicle, Pratiyogita Sahitya, Pratiyogita Vikas, and Pratiyogita Darpan also.