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Laboratory Analysis of Recycled Cement Stabilized Concrete Aggregates as Subbase Materials

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KEYWORD

Recycled concrete aggregates;
Ordinary portland cement;
Granular sub-base layer;
California bearing ratio;
Highway Capacity;
Unconfined compressive strength;
Permeability.

ABSTRACT:

Rigid Pavement rehabilitation and reconstruction of concrete structures generate large quantities of Recycled Concrete Aggregate (RCA). These recycled aggregates could be used as material for subbase courses in pavement construction. The strength characteristics of RCA materials usually limit their application in road subbases. The high volume usage of RCA in subbase applications is better ensured by meeting the minimum standards set by the specification for material performance. When used as a substitute for natural aggregates in subbase applications, most RCA materials do not often meet the minimum requirements set by the specification. In such cases, stabilization with different stabilizers allows the use of these RCA's materials with the minimum required strength characteristics.

In the present study, an attempt is made to evaluate the suitability of RCA as a subbase material using Ordinary Portland Cement (OPC) as a binding material. Concrete waste was pulverized and sieved to obtain the required gradation for the granular subbase (Gradation-II) as per MORT&H-V revision. RCA is treated with different dosages of cement and samples were prepared. The prepared samples were cured for 3, 7 & 28 days, and were tested. Compaction, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), and permeability tests were conducted. From the laboratory studies conducted, it is observed that the Portland cement stabilized RCA mix exhibits an increase in strength, with an increase in the dosage of stabilizer and curing period.

1 Introduction

The country has been witnessing a sudden upsurge in road infrastructure with the implementation of important and major centrally sponsored schemes like NHDP (National Highway Development Project) and PMGSY (Pradhana Manthri Grama Sadak Yojana) besides many other externally funded state road projects. While these road development projects help in adding considerable infrastructure assets, their construction and subsequent maintenance of the road and its sources are depleted very fast. The focus on conservation of aggregate is based on the possibility of using waste and milled material in place of fresh aggregates. Construction and demolition waste is generated whenever any construction/demolition activity occurs, such as construction or demolition of buildings, roads, bridges, flyovers, subways, remodeling, etc. [1] It consists mostly of inert and non-biodegradable materials such as concrete, plaster, metal, wood, plastics, etc. A part of this waste comes from the municipal stream.

These wastes are heavy, have high density, are often bulky, and occupy considerable storage space either on the road or in communal waste bins/containers. It is not uncommon to see large piles of such waste, which is heavy as well stacked on roads, especially in large projects, resulting in traffic congestion and disruption. Waste from small generators like individual house construction or demolition, finds its way into the nearby municipal waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it

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finds its way into surface drains, choking them. It constitutes about 10-20% of the municipal solid waste (excluding large construction projects). It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building material requirements of the housing sector indicate a shortage of aggregates to the extent about 55,000 million cu.m. and an additional 750 million cu.m. Aggregates would be required for achieving the targets of the road sector. Recycling of aggregate materials from construction and demolition waste may reduce the demand-supply gap in both these sectors. While retrievable items such as bricks, wood, metals, and tiles are recycled, concrete and masonry wastes accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India. Recycling of concrete and masonry waste is however being done in abroad like U.K., USA, France, Denmark, Germany, Japan and China [2-3].

However, studies on physical properties, mechanical behavior, and durability of RCA materials are quite recent [4-5]. Reclaimed Portland cement concrete is the most abundant and available as a potential substitute for natural aggregate in urban areas. Recycling of demolition debris from new construction offers a way to reduce waste disposal loads sent to the area of landfills to extend the life of natural resources. Many federal and state highway contracts specify the use of recycled materials in highway construction, where the rate of this usage is influenced by the availability, engineering performance, and by financial and other marketplace incentives that encourage the use of crushed concrete as recycled aggregate. Recently, numerous laboratory studies and field trials have shown that recycled aggregate can totally or partially replace natural aggregates in road construction. Potential savings in cost and time of recycling of construction and demolition debris have made the use of RCA an attractive alternative to the highway engineer as it contributes to more sustainability in the construction [6].

Although many authors have studied the possibility of using RCA in applications, there are a few researches on the properties and mechanical behavior of mixtures treated with cement when used as road subbases or base in paving, roads because of these reasons: improving the workability of road materials, increasing the strength of the mixture, enhancing the durability, increasing the load spreading capacity. Cement-treated aggregate is described as a mixture in which a relatively small amount of cement is used as a binder of coarse aggregates, and which needs proper water content for both compaction and cement hydration. Generally, cement-treated aggregate as a road base material is produced by using coarse, natural or crushed aggregates and designed as a heavy traffic base or a heavy traffic wearing course. Recently, to protect the natural resource and reduce the environmental pollution of solid waste, recycling aggregate has been considered to use as road bases [7].

Some of the researchers found that the incorporation of RCA increases the Optimum Moisture Content (OMC) and decreases the Maximum Dry Density (MDD) of the mixes, which is due to higher water absorption of RCA [8]. One of the significant design characteristics regularly used to evaluate the strength of cement-stabilized pavements is UCS [9] therby it motivates us to looking after these issues in our current research.

2 Literature Review

The authors [10] described the result of an experimental research on the physical and mechanical properties of cement stabilized recycled concrete and brick produced from construction and demolition waste materials. They concluded that the optimum moisture content, maximum dry density, bending, tensile, and unconfined compressive strength of all mixtures increase with increasing cement content. When compared with the recycled concrete aggregate with brick mixture, the brick mixture required more water for optimum moisture content than recycled concrete aggregate. Considering the strength parameter, the recycled concrete aggregate gives higher strength than brick mixture. All mixtures which satisfy the strength requirements for using as base and subbase layers, satisfy the durability requirements as well. In one of the investigations [11] concluded that the maximum density and CBR values of untreated mixtures decrease and the optimum moisture content increase and the soaked CBR values of recycled aggregate satisfy the requirement. Moreover, this shows that the UCS has a linear relationship with the cement content and dry density or the degree of compaction, where the UCS of concrete recycled aggregate is clearly higher than it for limestone aggregate, especially with increasing cement content. There exists a threshold moisture content (9%) that critically influences the UCS development of CTRA. A strong regression equation is achieved between dry

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density and UCS up to this moisture content. Beyond this level, a big scatter for the regression equation is obtained. On the other hand, the UCS approximately increases linearly with the curing time for both treated recycled and natural aggregates. The cement treatment leads to a valuable improvement in the resilient modulus reaching to35% at MixRA75 and in plastic deformation reaching to 60% at MixRA100. In of the research [12] it is concluded that there is significant potential for the growth of recycled and secondary aggregates as an appropriate and "green" solution for the anticipated increased worldwide construction activity and with it the demand for RSA. Significant steps are being taken to improve the quality of RA and new standards are easing its use in higher value higher-value. Nonetheless, this is very much limited to a few countries and the message has to travel worldwide to make a meaningful difference to the sustainable use of RSA in concrete. Practice has yet to catch up with the knowledge, and/or it could be argued that the knowledge needs to be sufficiently sound and capable of being packaged in a manner an easily workable. This will help to share information for real use and allow confidence to be gained.

Authors made an attempts to utilize Recycled Concrete Aggregates (RCA) obtained from construction and demolition (C&D) waste in the Cement Treated Bases (CTB). The efficiency of RCA was checked at various replacement levels ranging from 0 to 100% with cement stabilization of 3%, 5%, and 7%. The research yielded the highest potential RCA of up to 50% with a cement content of 5%, meeting the Indian Road Congress (IRC) criteria for CTB [13].

3 Objectives of the study

The main objectives of this study are:

1) To design RCA mixes for subbase courses.
2) To determine the basic properties of subbase materials as per MORT&H (V revision).
3) To study the Compaction characteristics of RCA material stabilized by varying dosages of 0%, 1%, 3%, 4%, and 5% of Portland cement by weight of RCA mix.
4) To study the Unconfined Compressive Strength characteristics of RCA material stabilized with 3%, 4%, and 5% dosage of Portland cement by weight of RCA mix cured for 3, 7, and 28 days.
5) To study the CBR characteristics of RCA material stabilized by varying the dosages of 3%, 4%, and 5% Portland cement by weight of RCA mix.
6) To study the Permeability of RCA mix stabilized with 3%, 4%, and 5% dosage of Portland cement by weight of RCA mix cured for 3 and 7days.

4 Experimental Investigations

In order to characterize the material to be used in the RCA mix, the laboratory investigations were carried out on the RCA material and Portland cement (Grade 43, Penna cement). In this study an attempt is made to fully replace the granular sub base with RCA material, for that purpose GSB(Grade-II) as per MORT&H-V revision [14] specification is adopted for RCA material and varying dosages of cement is used as a binder material. Optimum moisture content (OMC) and Maximum dry density (MDD) of RCA material with varying dosages of portland cement were determined by modified proctor compaction test as per IS 2720 Part 8 [15], California bearing ratio (CBR) test as per IS 2720 Part 16 [16], Unconfined compressive strength (UCS) test as per IS 2720 Part 10 [17] and Permeability tests as per IS 2720 Part 36 [18] were conducted on RCA material with varying dosages of Portland cement.

4.1 Materials used

4.1.1 Recycled Concrete Aggregates

In the present study, the RCA material is obtained from Bangalore university campus. This is pulverised, processed and used for laboratory studies.

4.2.2 Water

Potable water is used for mixing and curing of samples which is clean and free from injurious deleterious matter.

4.3.3 Ordinary Portland Cement

In this study Ordinary portland cement (Grade-43) is used as stabilizer to the RCA material.

4.2 Basics tests with RCA materials

4.2.1 Sieve analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. The Grain size distribution of material determines the important properties like permeability and workability of aggregates. This is done by sieving the pulverized RCA material through different sizes of sieves as mentioned in IS: 2386 (Part I) – 1963 [19] and collecting the material.

Gradation of aggregate helps in minimize void content and maximize the density. The Gradation results of RCA

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materials are fallowing Grade-II (Table 400-1) as per MORT&H (V revision) shown in Table 1. Fig.1 represents the gradation curve of the RCA material.

Table 1: Gradation of RCA Material

IS sieve size, [mm]	Weight of soil retained, [gms]	Cumulative weight retained, [gms]	Cumulative % retained	Cumulative % passing (obtained gradation)	Requirement as per MORT&H [V revision] Table 400-1, Grade-II	
					Upper limit [% passing ; adopted gradation]	Lower limit [% passing]
53	0	0	0	100	100	100
26.5	40	40	2	98	100	70
9.5	300	340	17	83	80	50
4.75	540	880	44	56	65	40
2.36	980	1860	93	7	50	30
0.425	80	1940	97	3	15	10
0.075	60	2000	100	0	5	0

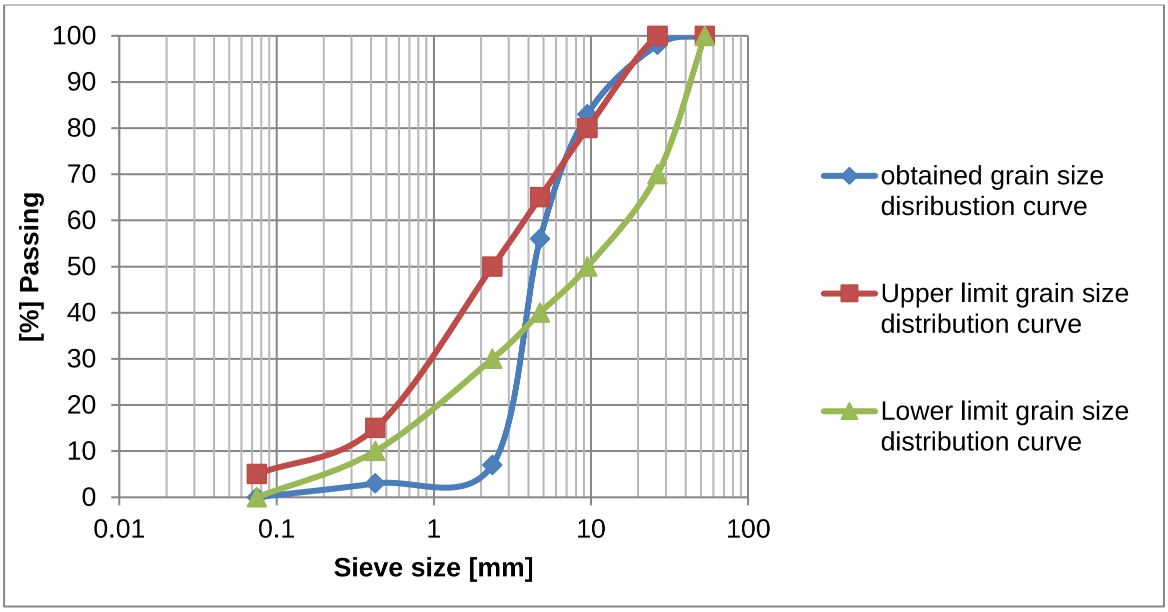

Fig.1: Grain size distribution curve of RCA material.

4.2.2 Physical properties

The Table 2 shows the other physical properties of RCA material

Table 2: Test results of RCA material

Description	Test result Obtained	Requirements as per Table 400-2 of MORT&H [V revision] Specifications
Aggregate specific Gravity		
Coarse aggregate	2.33	-
Fine aggregate	2.40	-
Water absorption [%]	2.50	-
Wet Aggregate impact value [%]	36.48	40 Max

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Ten percent fines value [KN]	71	50 Min
Liquid limit	Non plastic	25Max
Plasticity index	Non plastic	6 Max

4.3 Test on Portland cement

4.3.1 Specific gravity test

The specific gravity of a Portland cement is considered as a measure of the quality of the Portland cement and it was found to be 3.06.

4.4 Tests on stabilized RCA mix

4.4.1 Compaction test

The modified Proctor compaction test was carried out on recycled concrete aggregate as per IS: 2720 part 8. The treating RCA with portland cement at dosages 0%, 1%, 3%, 4%, and 5%. The compaction is done after mixing without much delay because the stabilized material starts setting after a certain period was determined for RCA materials treated with various dosages of stabilizers to know the amount of water to be added and to achieve the maximum density in the field for a given dosage of stabilizer optimum moisture optimum dry density relationship is shown for 0%, 1%, 3%, 4%, and 5% portland cement dosage and the test results are presented in Table 3.

Table 3: Compaction test results of stabilized RCA mix.

Portland cement [%]	Optimum Moisture Content [OMC,%]	Maximum Dry Density [MDD,gms/cc]
0	13.30	1.898
1	14.68	1.915
3	15.81	2.048
4	16.48	2.081
5	17.86	2.103
0	13.30	1.898

4.4.2 Unconfined compression test

The Unconfined Compressive Strength (UCS) test is carried out as per IS: 2720 Part 10. The prepared UCS specimen with 10cm diameter and 20cm height of RCA mix was treated with 3%, 4%, and 5% of Portland cement and cured specimen in a water tank for respective periods 3, 7, and 28 days. Moreover tried for 0 and 1% of cement for RCA mix stabilization but the specimens are collapsed immediately after demoulded due to lack of cohesion between particles.

The test results of stress and strain of RCA mix stabilized with 3%, 4%, and 5% cement and cured for 3, 7, and 28days are shown in Table 4. Fig. 2, 3, and 4 are the results of UCS test (stress and strain of RCA mix stabilized with 3%, 4%, and 5% cement and cured for 3, 7, and 28days). In this case, the stabilized RCA mix tested specimens showing strength is increasing with increasing curing period and increasing the dosage of cement.

Table 4: The results of UCS Test (stress and strain of RCA mix stabilized with 3%, 4%, and 5% cement)

Strain	3 days			7 days			28 days		
	Normal stress=P/A, [kg/cm^2]			Normal stress=P/A, [kg/cm^2]			Normal stress=P/A, [kg/cm^2]		
	3 days	7 days	28 days	3 days	7 days	28 days	3 days	7 days	28 Days
0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0010	0.24	0.29	0.48	0.47	0.16	0.85	0.14	0.23	0.14
0.0020	0.41	0.71	1.40	0.91	0.76	1.99	0.38	0.76	0.29
0.0030	0.81	1.01	2.45	1.78	1.46	3.29	0.58	1.22	0.65
0.0041	1.54	1.44	3.54	3.06	2.40	4.67	1.10	1.72	1.26
0.0051	2.27	2.22	5.06	4.25	4.01	6.04	1.77	2.37	1.91

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0.0061	3.00	2.95	6.87	5.41	5.65	7.29	2.96	3.06	2.67
0.0071	3.56	3.70	9.27	6.12	7.08	8.66	4.21	3.83	4.25
0.0081	4.12	4.49	12.87	6.82	8.43	10.22	5.43	4.68	5.90
0.0091	4.84	5.14	15.89	7.49	8.99	11.91	6.51	5.49	7.85
0.0102	5.32	6.01	17.02	8.07	9.57	13.63	7.78	6.41	10.18
0.0112	5.72	6.66	17.60	8.23	9.88	15.43	8.70	7.61	12.42
0.0122	6.03	7.23	17.42	8.44	10.24	17.18	9.40	8.97	14.65
0.0132	6.19	7.59	17.38	8.65	10.09	18.24	9.91	10.32	17.65
0.0142	6.26	7.26	17.35	8.89	9.86	18.84	9.79	11.47	20.04
0.0152	6.17	7.10	17.30	9.05	9.52	18.63	9.71	12.57	22.32
0.0162	6.11	7.03	17.26	9.21	9.48	18.58	9.68	13.25	22.18
0.0173	6.08	6.80	17.18	9.27	9.38	18.5	9.61	13.16	22.11
0.0183	6.03	6.73	17.1	9.32	9.13	18.42	9.52	13.08	22.02

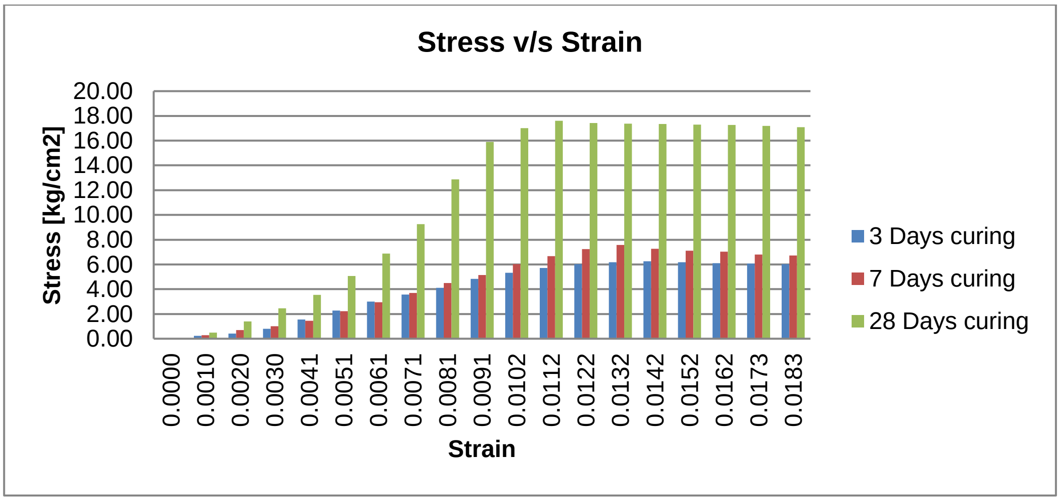

Fig.2: The results of UCS test (stress and strain of RCA mix stabilized with 3% cement).

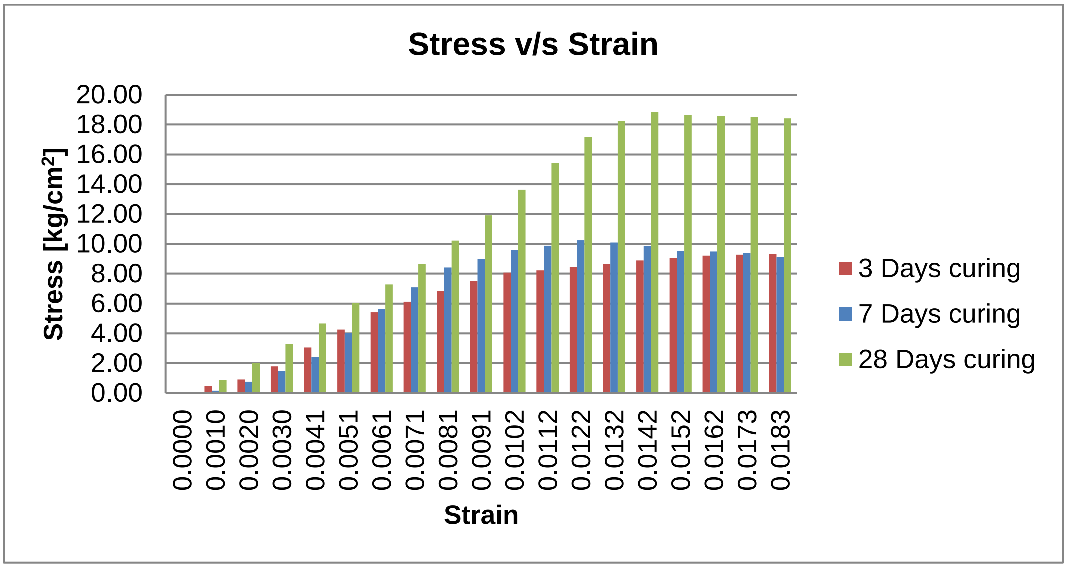

Fig.3: The Results of UCS Test (stress and strain of RCA mix stabilized with 4% cement).

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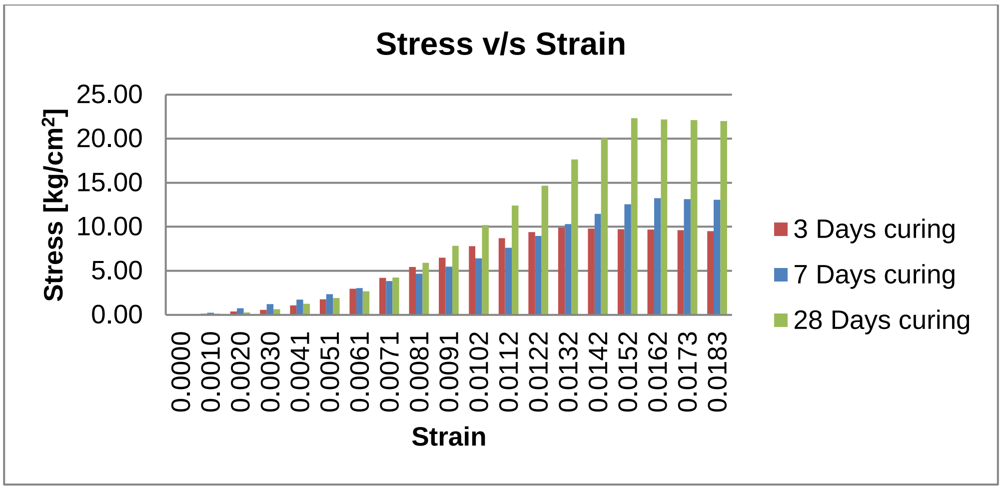

Fig.4: The Results of UCS Test (stress and strain of RCA mix stabilized with 5% cement).

4.4.3 Comparison of UCS values of RCA mix stabilized with 3% dosage of cement, 4% dosage of cement, wand 5% dosage of cement at common days of curing

Fig. 5, 6, 7, and Table 5 show the results of UCS test (stress-strain values of RCA mix stabilized with 3%, 4%, and 5% dosage of cement at 3,7 and 28 days curing). The 5% of cement dosage showed improvement in strength compared to the 3% and 4% cement dosage.

Table 5: The results of UCS test (stress-strain values of RCA mix stabilized with 3%, 4%, and 5% dosage of cement at 3, 7, and 28days curing)

Strain	3days curing, Normal Stress [kg/cm^2]			7days curing, Normal Stress [kg/cm^2]			28days curing, Normal stress [kg/cm^2]		
	3% cement	4% cement	5% cement	3% cement	4% cement	5% cement	3% cement	4% cement	5% cement
0	0	0	0	0	0	0	0	0	0
0.001	0.24	0.47	0.14	0.29	0.16	0.23	0.48	0.85	0.14
0.002	0.41	0.91	0.38	0.71	0.76	0.76	1.4	1.99	0.29
0.003	0.81	1.78	0.58	1.01	1.46	1.22	2.45	3.29	0.65
0.0041	1.54	3.06	1.1	1.44	2.4	1.72	3.54	4.67	1.26
0.0051	2.27	4.25	1.77	2.22	4.01	2.37	5.06	6.04	1.91
0.0061	3	5.41	2.96	2.95	5.65	3.06	6.87	7.29	2.67
0.0071	3.56	6.12	4.21	3.7	7.08	3.83	9.27	8.66	4.25
0.0081	4.12	6.82	5.43	4.49	8.43	4.68	12.87	10.22	5.9
0.0091	4.84	7.49	6.51	5.14	8.99	5.49	15.89	11.91	7.85
0.0102	5.32	8.07	7.78	6.01	9.57	6.41	17.02	13.63	10.18
0.0112	5.72	8.23	8.7	6.66	9.88	7.61	17.6	15.43	12.42
0.0122	6.03	8.44	9.4	7.23	10.24	8.97	17.42	17.18	14.65
0.0132	6.19	8.65	9.91	7.59	10.09	10.32	17.38	18.24	17.65
0.0142	6.26	8.89	9.79	7.26	9.86	11.47	17.35	18.84	20.04
0.0152	6.17	9.05	9.71	7.1	9.52	12.57	17.3	18.63	22.32
0.0162	6.11	9.21	9.68	7.03	9.48	13.25	17.26	18.58	22.18
0.0173	6.08	9.27	9.61	6.8	9.38	13.16	17.18	18.5	22.11
0.0183	6.03	9.32	9.52	6.73	9.13	13.08	17.1	18.42	22.02

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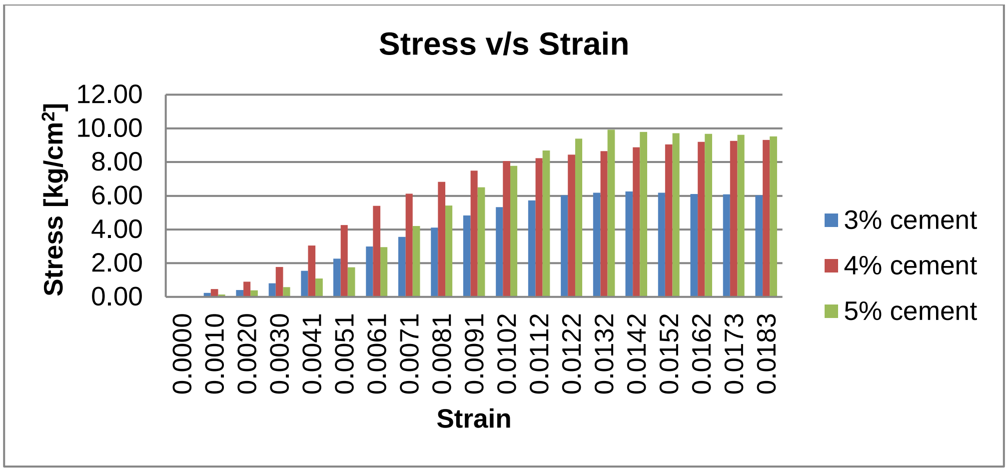

Fig.5: The results of UCS test (stress-strain values of RCA mix stabilized with 3%, 4%, and 5% dosage of cement 3 day says curing).

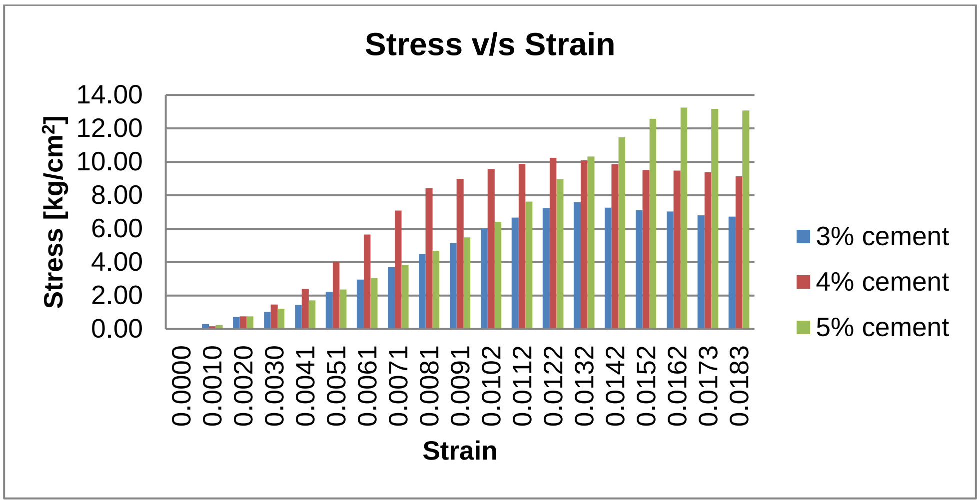

Fig.6: The results of UCS test (stress-strain values of RCA mix stabilized with 3%, 4%, and 5% dosage of cement at 7 days curing).

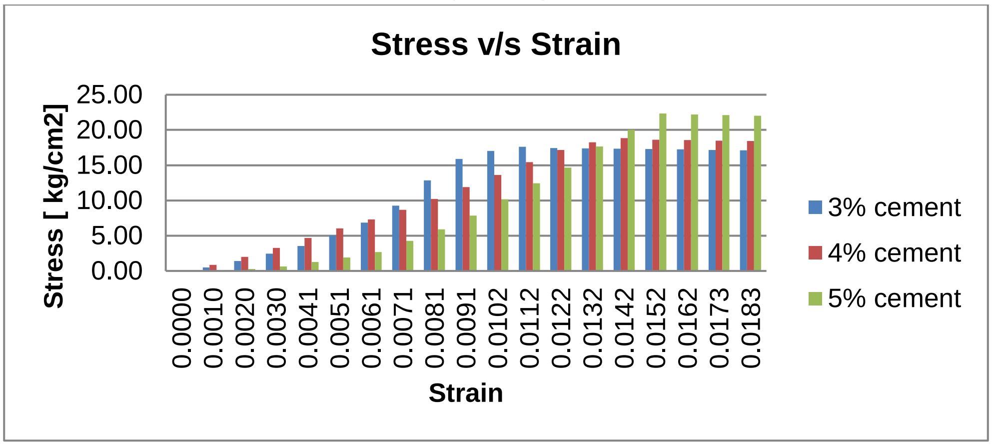

Fig.7: The results of UCS test (stress-strain values of RCA mix stabilized with 3%, 4%, and 5% dosage of cement at 28days curing).

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4.4.4 UCS results of stabilized RCA mix cured for different curing periods

Fig.8 shows the improvement of unconfined compressive strength with increase in curing Period for stabilized RCA mix treated with 3%, 4% and 5% dosage of Portland cement. The results are presented in Table 6.

Table 6: UCS test results on stabilized RCA mix

Cement Dosage [%]	Curing Period [days]	Unconfined Compressive Strength [kg/cm^2]
3	3	6.26
	7	7.59
	28	17.6
4	3	9.32
	7	10.24
	28	18.85
5	3	9.91
	7	13.25
	28	22.32

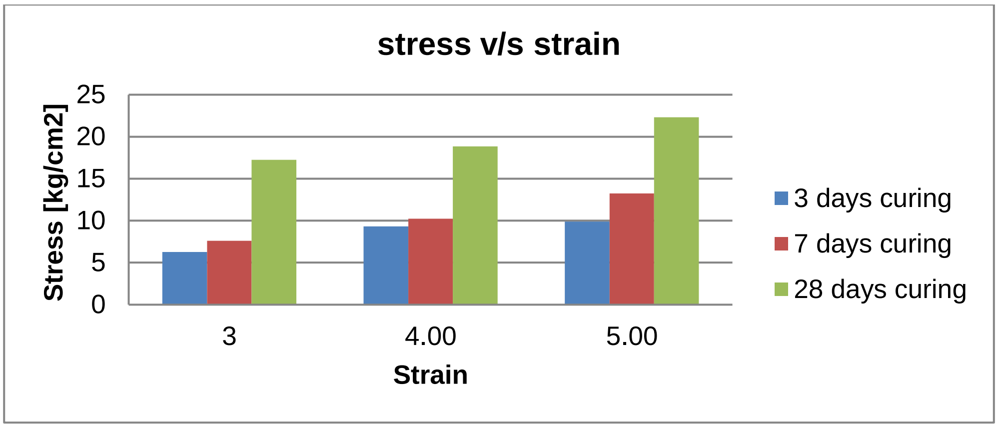

Fig.8: Curing period v/s UCS of stabilized RCA Mix permeability test on RCA.

4.4.5 California Bearing Ratio test

The recycled concrete aggregate is compacted in laboratory as per IS 2720 part-4 [20]. California Bearing Ratio (CBR) test was carried out as per IS: 2720 part-15 [21] for RCA mix stabilized with 3%, 4% and 5% of Portland cement. Two set of CBR specimens were prepared and tests were conducted on stabilized RCA mix. The first set of specimens were subjected to CBR test immediately after preparing the specimen and second set of specimens were soaked in water tank for a period of 4 days to check the adverse drainage condition and pozzolonic action likely to take place during soaking period and then the CBR test is conducted. The test results are tabulated in Table 7.

Table 7: CBR value of stabilized RCA mix at 2.5mm penetration

Portland cement [%]	California Bearing Ratio [%]	
	Un-soaked condition	soaked condition [4 days]
3	93	131
4	98	145
5	126	168

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4.4.6 Constant Head Permeameter test

The permeability test is conducted on RCA material stabilized with portland cement, as per IS 2720-1987(part 36). The Granular sub-base act as a drainage layer so it required a minimum permeability co-efficient is 30 m/day, as per IRC-15-2011 [22]. The test is conducted by varying dosage with number of curing day such as 3, 4, 5% of cement and 3 and 7 days respectively as tabulated in Table 8. We know that water or moisture is very devastating as far as our pavements and paved structures are concerned. Water within the base and sub-base causes a lot of troubles which may ultimately cause failure of the pavement structure. The amount of water flowing through a certain area can be represented by coefficient of permeability represented by 'K' the unit of K is meter / seconds.

Coefficient of Permeability is calculated as follows:

$$K=\frac{Q}{Ai} \quad (1)$$

Where

K= Coefficient of permeability (m/day)

Q= Discharge (cc/s)

A= Cross sectional area of specimen (cm^2)

i= Hydraulic gradient

Table 8: Permeability test results on stabilized RCA mix

Cement Content [%]	Coefficient of Permeability [m/day]	
	3days curing	**7days curing**
3	31.10	30.24
4	30.90	30.12
5	28.51	27.64

5 Results and Discussions

5.1 Compaction Characteristics

Optimum moister content of untreated RCA mix and treated RCA with 1%, 3%, 4% and 5% of portland cement were found to be 13.30%, 14.68%, 15.81%, 16.48% and 17.86% and maximum dry density were found to be 1.898, 1.915, 2.048, 2.081 and 2.103 g/cc respectively. The increases in optimum moister content and maximum dry density with increase in cement content may be due to the increase in surface area.

5.2 Unconfined Compression test

5.2.1 Effect of curing period on Unconfined Compressive Strength Value

The UCS of RCA mix treated with 3% portland cement and cured for 28 days is increased by 64.44% as compared to 3 days curing period.

The UCS of RCA mix treated with 4% portland cement and cured for 28 days is increased by 50.55% as compared to 3 days curing period.

The UCS of RCA mix treated with 5% portland cement and cured for 28 days is increased by 55.60% as compared to 3 days curing period.

This increase may be attributed to chemical bond that develops due to increase in curing period. The hydration process starts when contact with water, due to hydration process gradually bond together the individual fine and coarse particles, components of the stabilized RCA mix, to form a solid mass.

5.2.2 Effect of cement content on UCS Value

Unconfined compressive strength of RCA mix treated with 5% Portland cement and cured for 3 days is increased by about 36.83% and 5.95% as compared to RCA mix treated with 3% and 4% cement.

UCS of RCA mix treated with 5% Portland cement and cured for 7 days is increased by about 42.71% and 22.71% as compared to RCA mix treated with 3% and 4% cement.

UCS of RCA mix treated with 5% Portland cement and cured for 28 days is increased by about 21.14% and 15.54% as compared to RCA mix treated with 3% and 4% cement.

This increase is attributed to pozzolanic reaction in RCA mix due to increase in cement dosage. The pozzalonic reactions cause presence of fine particle in stabilized RCA mix, increasing strength with increasing cement content.

5.3 California Bearing Ratio test

The un-soaked CBR value of stabilized RCA mix treated with 3%, 4% and 5% dosage of Portland cement was found to be 93%, 98% and 126% respectively.

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The 4 days soaked CBR value of stabilized RCA mix treated with 3%, 4% and 5% dosage of Portland cement was found to be 131%, 145% and 168% respectively.

Higher CBR indicates that the RCA mix has a good interlocking property due to the presence of cement. The increase in bearing strength of soaked sample may be due pozzalonic action of Portland cement, which increases the bonding action in stabilized RCA mix.

6 Conclusions

The test results of RCA are satisfying the requirements of GSB as per table 400-2 of MORT&H (V revision) specification.

Increase in dosage of stabilizer, increases the optimum moisture content and dry density.

The CBR of stabilized RCA mix treated with Portland cement and soaked for 4 days is higher than the mix tested after treating with Portland cement.

Unconfined compressive strength of stabilized RCA mix increases with increase in percentage of Portland cement and curing period.

Permeability of stabilized RCA mix decreases with increasing in percentage of Portland cement and number of curing days.

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