Sustainable Structures and Materials, *Vol . 4, No .1, (2021) 36-47*
DOI: https://doi.org/10.26392/SSM.2021.04.01.036

DESIGN AND CONSTRUCTION OF LOW TRAFFIC VOLUME CONCRETE ROADS USING CONSTRUCTION & DEMOLITION AGGREGATES

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(Received 12 February, 2021, Revised 26 April, 2021, Accepted April 28, 2021)

ABSTRACT. *This paper presents design of low traffic volume concrete roads using C&D aggregates as recycled aggregates (RA) in base/sub-base layer and recycled concrete aggregates (RCA) in pavement quality concrete (PQC) layer. Also, in-situ blended cement with composition (50% OPC-43G cement, 30% Ground granulated blast furnace slag (GGBS) and 20% Flyash) has been used in PQC layer. The study includes testing of C&D aggregates for their suitability in base layer (as RA) and PQC layer (as RCA). It is observed that RA conform to requirements laid by IRC SP-62:2014 for base layer. RCA aggregates were tested for their physical and mechanical properties and concrete mix designs were carried out to with various replacement of natural aggregates with RCA (coarse and fine fraction) at various percentages. Experimental stretches with uniform base using recycled aggregates and PQC Layer with panel size of (1.33 m X 1.25 m) were cast using supplementary cementitious materials (GGBS and flyash with cement) and C&D aggregates (recycled concrete aggregates) at replacement of 75% and 100% to that of natural coarse and fine aggregates. A control stretch with similar base layer and PQC layer with 100% natural aggregates was cast to compare performance of the experimental stretches. The stretches were analyzed for strain and thermal stresses over a period of 28 days and results were found to be comparable with the control stretch. The study indicated that C&D aggregates can be used as 100% replacement of natural aggregates in base layer (as RA) and PQC Layer (as RCA).*

Keywords: Low Volume Traffic, Rural Roads, C&D Waste, Recycled Aggregates, Supplementary Cementitious Materials, Strain Analysis

1. INTRODUCTION

A sound road network is amongst the most important ingredients for the development of a country. As much as highways are important facilitating the commerce and trade amongst various states, rural roads and other low-traffic facilities are equally integral for proper functioning of a society. A low-traffic volume road shall be a facility lying outside of built-up areas of cities, towns, and communities and it shall have a traffic volume of less than 450 CVPD (1). LVRs (Low Traffic Volume Roads) provide the primary links to the highway transportation system. They provide links from homes and farms to markets and for raw materials from forests and mines to mills, and they provide public access to essential health, education, civic, and outdoor recreational facilities. The LVR link between raw materials and markets is critical to economies locally and nationally in all countries around the world. Many factors in addition to funding further complicate LVR engineering (2):

- Whereas they carry only 20 percent of the traffic, LVRs include 80 percent of the transportation system mileage.
- Vehicle loads may be high.
- Traditional high-volume highway engineering standards may not be appropriate.
- LVRs often mix unconventional traffic (e.g., farm machinery, bicycles, and oxcarts) with highway passenger cars, buses, and trucks.
- Few data concerning LVR performance, cost, use, and so forth are available.

One of the fundamental principles behind the recent pavement research output has been the requirement for locally orientated solutions based on available local resources and the local road environment. This approach is seen as crucial in the development of affordable and sustainable rural road infrastructure. Also, from the sustainability point of view use of virgin aggregates is discouraged consider the limited availability of resources and pollution associated with their extraction. Thus a paradigm shift has been observed in the recent decades where more emphasis has been laid over the use of waste based alternative aggregates as a replacement of virgin/natural aggregates and use of supplementary cementitious materials to further reduce the consumption of cement, one of the major component of concrete. Leite et al. (3) and Zhang et al. (4) promoted C&D wastes as recycled aggregate (RA) in road engineering. They suggested that C&D wastes may be reused for the construction of granular base and subgrade in urban (low-volume) pavements since geotechnical properties of C&D aggregates are lower than the natural stone. It has a great potential to further transform C&D wastes into high-performance RA for solving the problem of C&D waste disposal while reducing the exploitation of natural sand and stone (5). Sobhan et al. (6) analyzed the fatigue performance of recycled aggregate concrete under both wet-dry cycles and repeated loads and confirmed the possibility of RA application in the pavement structure. Barbudo et al. (7) studied the mechanical properties of 27 RAs produced from C&D wastes and found that most of them have different composition and performance. Pasandín et al. (8, 9) used coarse RA prepared from C&D wastes and mixed it into hot-mix asphalt mixture in different proportions and studied the performance of the recycled mixture. The result showed that the mixture has poor durability but good resistance to permanent deformation.

The waste generated during construction, demolition or re-modeling of any civil structure, such as buildings, bridges, flyovers, roads, drainage and laying of services etc. or associated activities for infrastructure provision such as, site preparation by way of digging, leveling, laying of pipelines, cables etc. Construction and demolition waste includes but not limited to concrete, bricks, tiles, stone, soil, rubber, plaster, drywall/gypsum board, wood, plumbing fixtures, non- hazardous insulating material, plastics, wallpaper, glass, metals (such as steel, aluminum), asphalt etc. (10). However, C&D waste shall not include any hazardous waste as defined under "Hazardous Waste (Management & Handling) rules, 1989" (4). C&D waste shall not include any waste which may have any chance of getting contaminated with nuclear waste or exposed to nuclear radiation. C&D waste so formed can be reduced to aggregates that can be used again for various civil activities with the help of crushers. Broadly, the C&D aggregates are classified as Recycled Concrete Aggregates and Recycled Aggregates (11-13). Recycled Concrete Aggregates are crushed, and size graded concrete material produced from discarded or demolished concrete. RCA comprises of stone aggregates (coarse aggregate) which were used for preparing demolished or discarded cement concrete (source concrete) and it is usually found to be having some amount of cement mortar sticking to stone aggregate particles. It doesn't contain brickbats, tile pieces, glass etc. Recycled Aggregates denotes materials generated through crushing and sieving to yield a mixture of stone aggregates, brickbats, tile pieces, mortar pieces, etc. having a particular size range i.e., passing and retained sieve sizes, in other words, size graded material conforming to specification limits. RCA aggregates are generally a bit inferior to virgin aggregates in terms of mechanical strength and high-water absorption. Use of impact crushes can further improve the quality of aggregates to support its use in concrete (14). The C&D waste was taken from a plant situated in Delhi, India (Figure-1). In the processing facility, IL&FS Environmental Infrastructure & Services Ltd (IEISL) collected 500 tonne per day (TPD) of C&D waste from three designated zones of the Delhi. The waste collected consists of 65 -70 percent soil. Containers and skips were placed at the designated collection points for enabling private and public waste generators to store C&D waste.

With increase in demand of cement and concern towards the environment, use of supplementary cementitious materials along with cement clinker is being considered a good practice (15-17). Apart from reducing the carbon footprint, use of supplementary cementitious also reduces the cost significantly. In this work, waste-based materials fly ash and GGGBS are used as a replacement of 20% and 30% of cement content, respectively.

Figure-1 C&D Waste Plant at Delhi, India

2. EXPERIMENTAL WORK

A typical low volume concrete road consists of subgrade, sub-base and pavement layer. In present study, authors used recycled aggregates (RA) in base layer as Granular Sub Base (GSB) and Wet Mix Macadam (WMM). In the pavement layer, Recycled Concrete Aggregates (RCA) were used as full and partial replacement of natural aggregates (both coarse and fine aggregates) for making Pavement Quality Concrete (PQC). Panel dimensions were reduced to lower the thickness of pavement. The design of low volume concrete road has been performed as SP-62:2014.

Following are the design parameters for preparation of low-traffic volume road as per SP 62:2014
Minimum soaked CBR value of subgrade = 4
Dual Wheel load = 50 KN
Design traffic volume = 50-150 CVPD
Sub- Base Requirements = 75mm WMM layer over 100 mm GSB
Minimum Compressive strength of concrete at 28 days = 30 Mpa
Minimum Flexure Strength at 28 days = 3.8 Mpa
Panel size selected = 1.33m X 1.25 m
The requirements of Granular Sub-base and WMM are as per M.O.R.D. 2014 (9).

For preparation of subgrade, soil present at the site location was compacted to achieve required CBR value. The sub-base layer consisted of WMM over GSB. Recycled Aggregates were used for preparation of both the layers. The recycled aggregates were tested for different physical parameters in lab and at site to test their suitability for use in sub-base layer. Further, both GSB and WMM layers were checked for their grading requirements as per specifications. For making pavement quality concrete, Recycled Concrete Aggregates were used as partial and full replacement of natural aggregates. Concrete prepared with recycled aggregates as replacement of natural aggregates was evaluated for various parameters to compare its performance with the concrete prepared with natural aggregates. Strain gauges and Thermocouples were inserted in different locations of PQC layer to measure the variation of strain and temperature. The readings using strain gauges were taken for a period of 28 days after casting at 1-hour interval.

3. SUBGRADE

The natural soil present at the site location was compacted adequately to use it as subgrade (as shown in Figure 2) for the test stretches.

Figure 2: Compacted natural soil used as subgrade

The California Bearing Ratio (CBR) value requirement for subgrade is 4 as per IRC SP 62:2014. The CBR value achieved at site after compaction of natural soil was found to be greater than the required value. Apart from CBR value, subgrade was evaluated for several other parameters. The test results of those parameters along with requirements as per SP-62:2014 are given in Table 1.

Table 1: Physical parameters for sub-grade layer

Parameters	Results	Requirements as per SP- 62:2014
Optimum Moisture Content (%)	11.50	-
Max. Dry density(g/cm3)	1.97	-
CBR value(at 5.0 mm penetration) soaked	7.0	4
Liquid Limit	27.0	-
Plastic Limit	17.0	-
Plasticity Index	10.0	-

4. SUB-BASE LAYER

The sub-base layer was made up of 75 mm Wet Mix Macadam (WMM) layer over 100 mm Granular Sub Base (GSB) layer (as shown in Figure 3).

Figure 3: Sub-base layer

Recycled Aggregates were used in both the layers. In GSB layer, the maximum aggregate size was 26.5 mm. While in WMM layer, maximum aggregate size was kept as 53 mm. The coarse and fine recycled aggregates were tested for various physical parameters in lab and at site to test their suitability to be used in sub-base layer. The test results of various physical properties of Recycled Aggregates (RA) have been tabulated in Table 2 and Table 3. These test results were compared with the specifications laid down by Ministry of Rural Development (M.O.R.D) 2014.

Table 2: Physical Test Results of Coarse Aggregates (RA) used in sub-base layer

Sl. No.	Test Carried out	Result Obtained	Requirements for sub-base layer as per M.O.R.D 2014
1	Specific gravity	2.18	-
2	Water absorption (%)	5.78	-
3	Abrasion Value %	38	Less than 50
4	Crushing value %	34	-
5	Impact value %	32	-
6	Flakiness index %	6.0	Less than 50
7	Elongation index%	13.0	-
8	Soundness (Na_2SO_4) %	0.08	Less than 12%
9	Total deleterious materials % (except coal & lignite)	0.09	-

The test results of physical parameters for recycled coarse aggregates confirmed to all the specifications of Ministry of Rural Development (M.O.R.D) 2014 and thus were found suitable for use in preparation of sub base layer.

Table 3: Physical Test Results of Fine Aggregates (RA) used in sub-base layer

S. No.	Test Carried out	Result Obtained
1	Specific gravity	2.31
2	Water absorption, %	4.26
3	Material finer than 75-micron, %	5.57
4	Soundness, $MgSO_4$ %	1.65
5	Organic impurities	Nil
6	Clay Lumps, %	Nil

After evaluation of aggregates, the GSB and WMM layers were prepared and were evaluated for their grading requirements as per Ministry of Rural Development (M.O.R.D) 2014. Test results of sieve analysis and grading requirements for GSB layer and WMM layer as per M.O.R.D. have been tabulated in Table 4 and Table 5.

Table 4: Grading of GSB layer along with requirements as per M.O.R.D 2014

Sieve Size (mm)	Passing (%)	Grading Requirements as per M.O.R.D. 2014
26.5	100	100
9.5	85	-
4.75	33	25-45
0.425	17	-
0.075	2	<15

Table 5: Grading of WMM layer along with requirements as per M.O.R.D 2014

Sieve Size (mm)	Passing (%) coarse fraction	Passing (%) Fine fraction	Passing (%) Combined [70% CA + 30% FA]	Grading requirement as per M.O.R.D. 2014
53	100	100	100	100
45	100	100	100	95-100
22.40	57	100	70	60-80
11.20	6	100	34	40-60
4.75	-	100	30	25-40
2.36	-	97	29	15-30
600	-	69	21	8-22
75	-	22	6	0-5

Apart from grading requirements, both WMM and GSB layers were evaluated for their individual mechanical parameters such as optimum moisture content, maximum dry density, CBR values. The test results have been tabulated in table 6 below.

Table 6: Physical parameters for sub-base layer

Parameters	Test Results (GSB Layer)	Test Results (WMM Layer)	Requirements for sub-base layer as per M.O.R.D 2014
Optimum Moisture Content (%)	13	13	
Max. Dry density(g/cm3)	1.93	1.93	
CBR value (soaked)	39.2	48	20

Liquid Limit	19.5	NA	<25
Plastic Limit	Non plastic	NA	
Plasticity Index	NA	NA	<6

From above test results in Table 4, 5 and 6, it was observed that WMM and GSB layers confirm to the confirmed to all the specifications (grading requirements and physical parameters) laid down by Ministry of Rural Development (M.O.R.D) 2014 and IRC SP 62-2014. Thus it can be concluded that Recycled Aggregates can be used as 100% replacement of natural aggregates in sub-base layer as tested through lab and cast stretch results.

5. PAVEMENT QUALITY CONCRETE (PQC)

The Pavement Quality Concrete (PQC) layer was laid in three stretches i.e. control stretch and experimental stretches RCA75/75 and RCA 100/100 (as shown in figure 4) having panel dimension of 1.33 m x 1.25 m. The three stretches had different composition of Recycled Concrete Aggregates (RCA) as replacement of natural aggregates (both coarse and fine). Natural aggregates were used for preparation of control stretch. In experimental stretch RCA 75/75, stretch Recycled Concrete Aggregates were used as 75% replacement of natural aggregates (NA) (both coarse and fine). Whereas experimental stretch RCA 100/100 contained Recycled Concrete Aggregates as 100% replacement of natural aggregates (both coarse and fine). The composition of the experimental stretches has been tabulated in Table 7.

Figure 4: Different stretches in PQC layer

While laying down the pavement quality concrete layer, strain gauges and thermocouples were inserted in the PQC layer to measure the variation of strain and temperature periodically. The details of location (Figure 5) and number of gauges embedded in control and experimental stretches of concrete are as mentioned in Table 8 below.

Table 7: Composition of experimental stretches

Experimental Stretch	Control	RCA 75/75	RCA 100/100
Nature of Aggregates(both coarse and fine aggregates)	Natural Coarse and Fine Aggregates in PQC layer	Recycled Concrete Aggregates as 75% replacement of natural aggregates in PQC layer	Recycled Concrete Aggregates as 75% replacement of natural aggregates in PQC layer
Panel Dimensions	1.33m X 1.25 m	1.33m X 1.25 m	1.33m X 1.25 m
Cementitious Mix Composition	50% Cement + 30% GGBS+20% Fly ash	50% Cement + 30% GGBS+20% Fly ash	50% Cement + 30% GGBS+20% Fly ash

Sub-Base	75 mm WMM over 100 mm GSB	75 mm WMM over 100 mm GSB	75 mm WMM over 100 mm GSB
Nature of Aggregates (both coarse and fine aggregates) in sub-base	Recycled Aggregates (RA)	Recycled Aggregates (RA)	Recycled Aggregates (RA)
Soaked CBR of Sub-Grade	7	7	7

Table 8: Details of gauges embedded in the experimental stretches

Experimental Stretch	**Control**	**RCA 75/75**	**RCA 100/100**
Panel Dimensions	**1.33 m X 1.25 m**	**1.33 m X 1.25 m**	**1.33 m X 1.25 m**
Position of Strain gauges	Corner, Edge & Centre(both longitudinal and transverse direction)	Corner, Edge & Centre(both longitudinal and transverse direction)	Corner, Edge & Centre(both longitudinal and transverse direction)
Placement of strain gauges	Both top and bottom	Both top and bottom	Both top and bottom
Number of Strain gauges	8	8	8
Position of Thermocouples	Edge & Centre(both longitudinal and transverse direction)	Edge & Centre(both longitudinal and transverse direction)	Edge & Centre(both longitudinal and transverse direction)
Number of Thermocouples	4	4	4

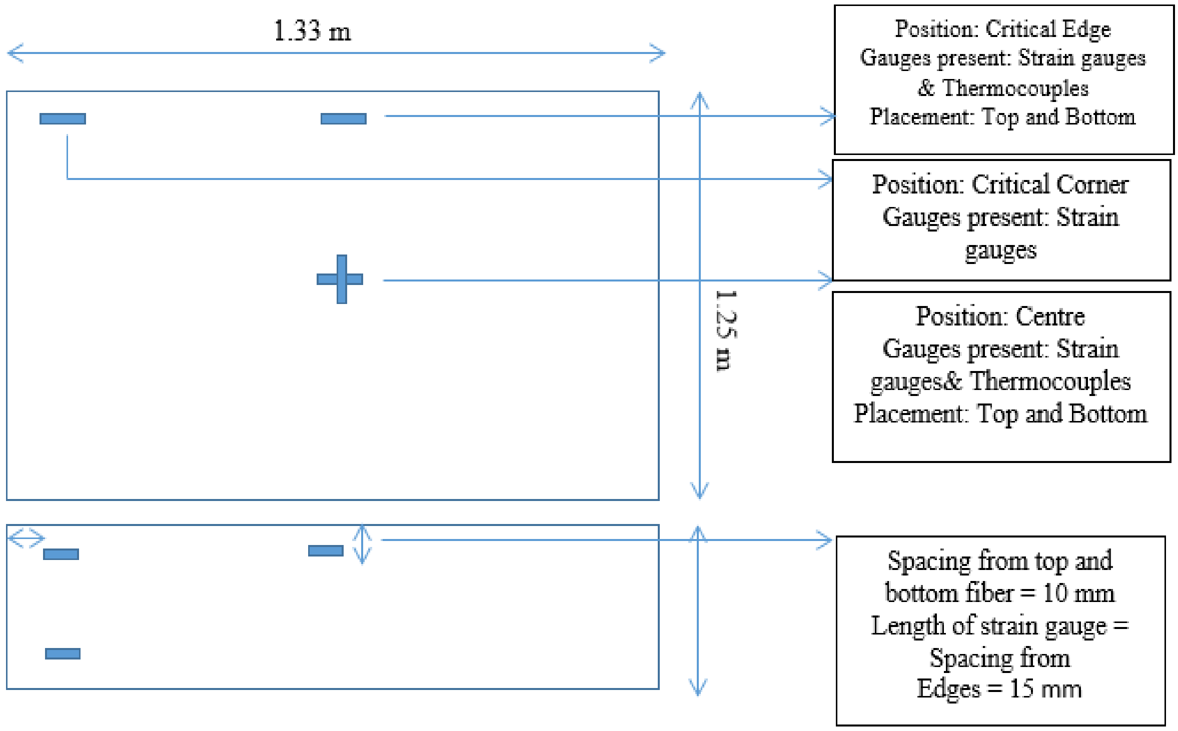

Figure 5: Location of gauges embedded in the experimental stretches

5.1 Evaluation of physical properties and grading of Recycled Concrete aggregates and natural aggregates used in PQC

As discussed above, Recycled Concrete Aggregates were used as partial and full replacement of natural aggregates (both coarse and fine) for preparation of control and experimental stretches of PQC layer. Recycled Concrete Aggregates (both coarse and fine) were evaluated for different physical properties along with sieve analysis. The test results (Table 9 to Table 12) were compared with natural coarse and fine aggregates used for preparation of control stretch.

Table 9: Physical Test Results of Coarse Aggregates (Recycled Concrete Aggregates (RCA) & Natural Aggregates (NA)) used in PQC layer

Sl. No.	Test Carried out	RCA Coarse Aggregate	Natural Coarse Aggregate
1	Specific gravity	2.34	2.76
2	Water absorption (%)	4.92	0.2
3	Abrasion Value %	28	26
4	Crushing value %	27	27
5	Impact value %	24	17
7	Soundness (Na2SO4) %	0.66	0.48

Table 10: Grading of Coarse Aggregates (Recycled Concrete Aggregates (RCA) & Natural Aggregates (NA)) used in PQC layer

Sieve Size (mm)	Sieve analysis of Coarse aggregates			
	Percentage passing (Fraction: 10-20mm)		Percentage passing (Fraction: <10mm)	
	NA Coarse Aggregate	RCA Coarse Aggregate	NA Coarse Aggregate	RCA Coarse Aggregate
40	100	100	100	--
20	97	98	100	--
12.5	--	--	100	100
10	1	6	95	82
4.75	0	1	9	5
2.36	0	0	2	0

Table 11: Physical Test Results of Fine Aggregates (RCA & NA) used in PQC layer

Sl. No.	Test Carried out	RCA Fine Aggregate	NA Fine Aggregate
1	Specific gravity	2.19	2.62
2	Water absorption, %	5.71	0.80
3	Material finer than 75-micron, %	10.97	1.57
4	Soundness ,Na_2SO_4 %	2.01	0.6

Table 12: Grading of Fine Aggregates (RCA & NA) used in PQC layer

Sieve Size	Percentage Passing		Percentage Passing for Grading Zone II of IS:383-2016 (11)
	Percentage Passing (NA Fine Aggregate)	Percentage Passing (RCA Fine Aggregate)	
10 mm	100	100	100
4.75 mm	89	100	90-100
2.36 mm	76	97	75-100

1.18 mm	66	78	55-90
600 micron	56	57	35-59
300 micron	35	35	8-30
150 micron	6	21	0-10
Zone as per IS: 383: 2016	Zone II		

On perusal of results mentioned in above tables, it was observed that physical properties of Recycled Concrete Aggregates (RCA) are comparable to Natural Aggregates except water absorption. Water absorption of both coarse and fine Recycled Concrete Aggregates is quite higher in comparison to natural coarse and fine aggregates. Grading (sieve analysis results) of both coarse and fine Recycled Concrete Aggregates (RCA) are comparable to Natural Aggregates. Fine Recycled Concrete Aggregates (RCA) was found to lie in zone II grading as per IS 383: 2016.

5.2 Design thickness and adopted thickness of PQC layer

Using the parameters obtained above, design thickness of PQC layer was evaluated for all three different stretches as per SP 62:2014. The design thickness for three test stretches in PQC layer is as mentioned in Table 13.

Table 13: Design Thickness for the three test stretches in PQC layer

Panel Dimensions	Design Thickness as per SP-62:2014		
	Control	RCA 75/75	RCA 100/100
1.33 m X 1.25 m	105	114	116

The adopted thickness for the three test stretches in PQC layer at site is as given below in Table 14.

Table 14: Adopted Thickness for the three test stretches in PQC layer

Adopted Thickness at site		
Control	RCA 75/75	RCA 100/100
120	120	120

5.3 Concrete Mix design for PQC Layer

The mix design details for three test stretches (control and experimental) in PQC layer along with workability obtained in terms of slump after 90 mins have been tabulated in Table 15.

Table 15: Concrete Mix proportions used in three cast stretches

Mix Constituents (kg/one cubic meter)	Control	RCA 75/75	RCA 100/100
Cement (OPC-43 grade)	200	200	205
GGBS	120	120	123
Fly Ash	80	80	82
Water	180	180	180
Fine Aggregate (RCA) Fine Aggregate (NA)	0 656	347 133	414 0

Coarse Aggregate Fraction –I) 20mm (60%) RCA 20mm (60%) NA Fraction –II) 10mm (40%)RCA 10mm (40%)NA	0 706 0 469	492 196 324 130	681 0 448 0
Water – Cementitious Ratio	0.45	0.45	0.44
Workability obtained in terms of slump (after 90 mins of retention period)	50 mm	45 mm	40 mm

5.4 Fresh and Hardened Concrete Properties

Concrete mix designs were conducted using recycled concrete aggregates both as coarse and fine aggregate at 0%, 75% and 100% replacements of natural aggregates. The mixes were tested for various mechanical properties of concrete such as compressive strength, flexural strength, abrasion test, Modulus of elasticity, Poisson's ratio and drying shrinkage at different ages to compare the performance of concrete cast with recycled aggregates at 75% and 100% replacement of natural aggregates with the concrete cast with natural aggregates. The test results for individual tests have been tabulated in Table 16.

Table 16: Fresh and Hardened Concrete Properties of Mixes to be used in PQC layer

Blend description: Cement -50%, GGBS-30%, Flyash-20%,Water/cementitious -0.45			
Parameters	**Mix-1**	**Mix-2**	**Mix-3**
RCA coarse/RCA Fine (% replacement)	0/0	75/75	100/100
Compressive Strength 7 days	31.04	25.43	22.04
Compressive Strength 28 days (12)	39.24	34.36	31.07
Compressive Strength 56 days	39.01	37.88	34.66
Flexural Strength 7days	4.65	3.3	3.2
Flexural Strength 28days	5.8	4.6	4.4
Abrasion test (30 mins)	0.5	0.49	0.48
Abrasion test (120 mins) (13)	1.15	1.15	1.11
MOE (14)	34450	22630	20325
Poisson's ratio (14)	0.187	0.089	0.155
Drying Shrinkage (15)	0.0168	0.0177	0.0168
Sand (%)	37	33	33

The compressive strength required at 28 days for low volume concrete roads as per SP: 622014 is 30 MPa and flexural strength is 3.2 MPa. All the mixes above were found to conform both the requirements. The abrasion value of concrete was further evaluated at 2 hours and compared with control sample (Mix 1). The two hours' abrasion value were quite similar and low. However, the modulus of elasticity was found to be considerably lower than the control sample. The trials for Mix 3 were conducted keeping water cement ratio as 0.45 and sand as 33% of total aggregate volume. However, the water cement ratio was reduced to 0.44 and sand as 27% of total aggregate volume after conducting confirmatory trials. The behavior of mixes was quite similar in drying shrinkage and abrasion value. From the test results it can be concluded that recycled concrete aggregates can be used as 100% replacement of natural aggregates in PQC in low volume concrete roads.

5.5 Strain Data Analysis

The active strain gauges were analyzed for a period of 28 days after casting. The reading was measured at 1-hour interval. The micro strain corresponding to maximum and minimum temperature for each day is plotted against age of concrete for 28 days for three stretches. Test results have been plotted in Figure 6 & 7 as shown below.

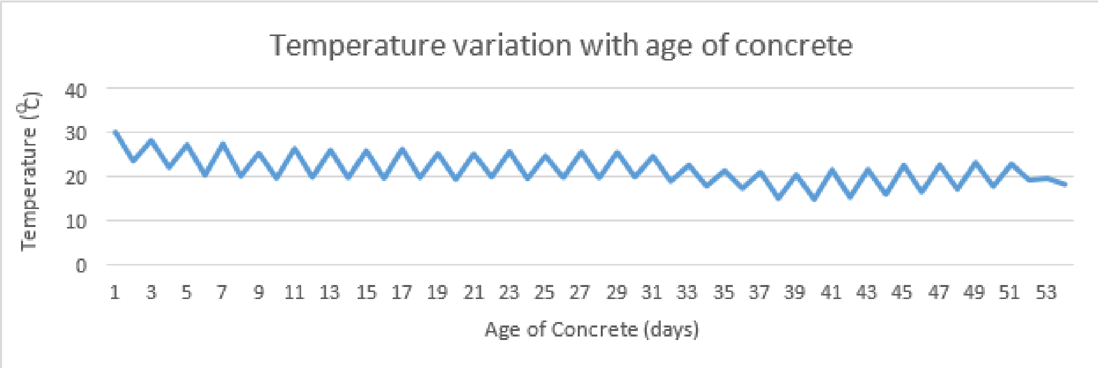

Figure 6: Variation of maximum and minimum temperature in three stretches versus age of concrete

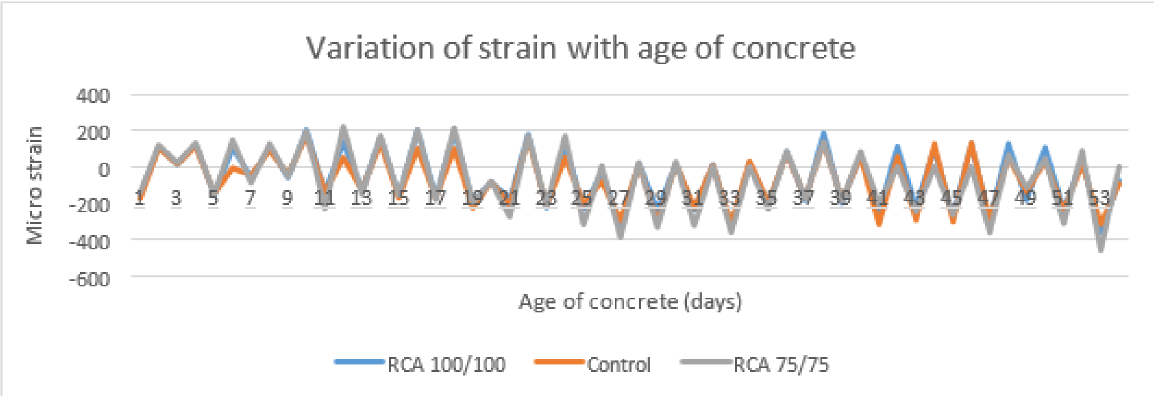

Figure 7: Micro strain data of test stretches with age of concrete

Following are the observations of strain data analysis for first 28 days:

1. The strain at different positions i.e. corner, edge and center was found to be similar in each stretch.
2. The micro strain values observed corresponding to maximum and minimum temperature achieved every day, nearly coincides with each other. As evident from the graph, the strain values are similar in terms of value and nature. Also, no significant temperature gradient was observed between the top and bottom layer of PQC in all the experimental stretches.
3. As tested in hardened concrete properties, the value of drying shrinkage is similar in all the three mixes. The same is evident from the graph, as all the three curves progress towards similar negative strain values over the age of pavement.
4. The response behavior of the three stretches thus can be concluded as similar.

6. CONCLUSIONS

Based on the above study and literature survey done, it can be concluded that:

1. Compressive Strength and Flexural Strength results were conforming to the requirements of IRC SP: 62-2014 even at 75% and 100% replacement of natural aggregates with recycled concrete aggregates for low volume concrete roads.
2. Theoretical design of thickness of PQC layer using the parameters as evaluated during testing was found to be higher (marginally) when compared to PQC with natural aggregates. However, the increase in thickness is justified as the cost of C&D aggregates is significantly lower than that of natural aggregates.
3. Three stretches were cast to compare the performance of pavements. The strain and temperature data was found to be similar in all three stretches. The drying shrinkage value was observed to be similar in test results and was validated with the strain value data measured.
4. Recycled aggregates can be used as 100% replacement of natural aggregates in sub-base layer as tested through lab and cast stretch results. Thus, recycled concrete aggregates can be used as 100% replacement of natural aggregates in PQC in low volume concrete roads.

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