

INVESTIGATION ON ENHANCEMENT OF SUB GRADE BY USING PULVERIZED CRUSHED AGGREGATES

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ABSTRACT

Recycled aggregates consist of pulverized and crushed, graded inorganic particles processed from the material that has been used in the constructions and demolition debris. The target of the present paper work is to determine the strength characteristic of recycled aggregates for the application in concrete pavement construction. The scope of the paper is to determine and compare the compressive strength, flexural strength and sulphate resistance of concrete by using different percentages of recycled aggregates. The investigation was carried out by using workability test, compressive strength test, flexural strength test and sulphate resistance test. A total of five mixes with replacement of coarse aggregates with 0 %, 10 %, 20 %, 30 % and 40 % recycled coarse aggregates were studied. The water cement ratio was kept constant at 0.38. It was observed that workability of concrete was decreased with the increase in recycled aggregates in concrete. For the strength characteristics, the results showed that the strengths of recycled aggregate concrete was comparable to the strengths of natural aggregates concrete

Keywords: compressive strength, flexural strength, sulphate Resistance Concrete

1.0 INTRODUCTION

General

During the construction period, concrete has been the primary building material since its discovery and was deemed suitable for future use due to its durability, ease of maintenance, wide variety of applications, and ability to take on any shape and size. Concrete is a composite mixture of cement, aggregates, sand, and water. When water is mixed with cement and aggregates, concrete solidifies like rock. Concrete consists of two types of components: active and inactive. The active component includes water and cement, while the inactive component comprises sand and coarse aggregates. Concrete has high compressive strength but low tensile strength.

Concrete structures designed for a service life of at least 50 years often need to be demolished after 20 or 30 years due to deterioration caused by various factors. Preserving old structures could lead to better and more advanced economic gains. The rate of destruction has increased, creating a shortage of dumping space and driving up disposal costs. Instead of dumping pulverized crushed concrete, recycling it as pulverized crushed recycled concrete can not only reduce costs but also conserve non-renewable energy sources. The use of pulverized crushed concrete would also reduce the need for natural resources. The extraction of natural resources is causing damage to the environment, leading to an imbalance in the ecosystem. Recycled materials consist of pulverized crushed, graded inorganic materials obtained from structures, roads, and areas that have been demolished due to completion of their life cycle, wars, and earthquakes.

2.0 METHODOLOGY & MATERIAL USED

Material Properties

All ingredients had their mechanical and physical characteristics assessed in accordance with IS: 2386-1963.

CEMENT

In accordance with IS: 8112-1989, OPC of grade 43 was utilized. Cement was tested in accordance with IS: 4031. Cement's physical characteristics are listed in below.

No.	Properties	Apparatus	Observed Values	Values by IS:8112-1989
1.	Finenes Percentage	90 micron I.S Sieve	4	Not more than 10
2.	Soundness(mm)	Le Chatelier Method	1.0	Not more than 10
3.	Normal consistency	Vicat apparatus	30
4.	Specific gravity	Le Chaterlier's flask	3.76

NATURAL FINE AGGREGATES

Natural sand was used as fine aggregate. properties are given in table 2.1

Aggregates Weight of sample =1000gm

IS Sieve Size(mm)	Weight Retained(gm)	Cumulative Weight Retained(gm)	Cumulative %Age of Weight Retained(gm)	Percentage Passing
4.75	156	156	15.6	84.4
2.36	57	213	21.3	78.7
1.18	113	326	32.6	67.4
0.6	111	437	43.7	56.3
0.3	376	813	81.3	18.7
0.15	145	958	95.8	4.2
0.075	30	988	98.8	1.2

$\Sigma F=389.3$

Fineness Modulus (F.M) = 3.89 Sand conforming grading zone II of I.S 383-1970.

NATURAL COARSE AGGREGATES

Properties of coarse aggregates are given in table 2.2

Table 2.2 Physical properties of Coarse aggregates

S. No.	Property	Observed Values (10mm Aggregates)	Observed Values (20mm Aggregates)
1.	Bulk Density (Loose),kg/m ³	1311	1480
2.	Bulk Density (compacted), kg/m ³	1480	1560
3.	Specific gravity	2.74	2.8
4.	Free moisture (%)	0%	0
5.	Water absorption (%)	0.8%	0.48

COARSE AGGREGATES FROM PULVERIZED CRUSHED CONCRETE

As indicated in figure 2.3, the pulverized crushed concrete used in this investigation was obtained from the waste concrete kept in the concrete lab at B.G. SHIRKE Construction Pvt. Ltd.

Table 2.3 Physical Properties of Recycled Aggregates

Property	Observed Values
Bulk Density (Loose),(kg/m ³)	1132
Bulk Density(compactd) (kg/m ³)	1328
Specific gravity	2.52
Water absorption (%)	1.9

WATER

The water's properties were in accordance with IS 456. It contained no harmful materials. Concrete was mixed and allowed to cure using water. Concrete is typically mixed and cured using portable water.

3.0 EXPERIMENTAL PROGRAMME

Concrete Mix Proportion

According to the cement, fine aggregate, and coarse aggregate ratios, which were taken to be 1:1.23:2.52, respectively.

Number of Samples Casted

Type of Mix	For Compressive Strength	For Flexural Strength	For Sulphate Resistance	Total
M 0	12	9	6	27
M 1	12	9	6	27
M 2	12	9	6	27
M 3	12	9	6	27
M 4	12	9	6	27
Total	60	45	30	135

The percentages of recycled and natural aggregates in each batch

Mix Type	Re-cycled Aggregate (%)	Natural Aggregate (%)
Mix 0	0	100
Mix 1	10	90
Mix 2	20	80
Mix 3	30	70
Mix 4	40	60

Properties of Fresh Concrete (Slump values and Compactor Factor value)

S.No.	Mix	W/C	Super Plasticizer	%RCA	Slump Value(mm)	Compaction Factor Value
1.	M 0	0.38	0.6% of cement	0	42	0.842
2.	M 1	0.38	0.6% of cement	10	43	0.865
3.	M 2	0.38	0.6% of cement	20	40	0.843
4.	M 3	0.38	0.6% of cement	30	38	0.828
5.	M 4	0.38	0.6% of cement	40	40	0.826

4.0 RESULTS AND DISCUSSION OF RESULTS

General

The sample was tested for compressive strength at 7, 28, 56, and 90 days. Samples underwent flexural strength testing at 7, 28, and 90 days. Sulfur defiance was tested for at 7, 28, and 56 days. The outcomes of these tests are scattered throughout this chapter along with the plasticity

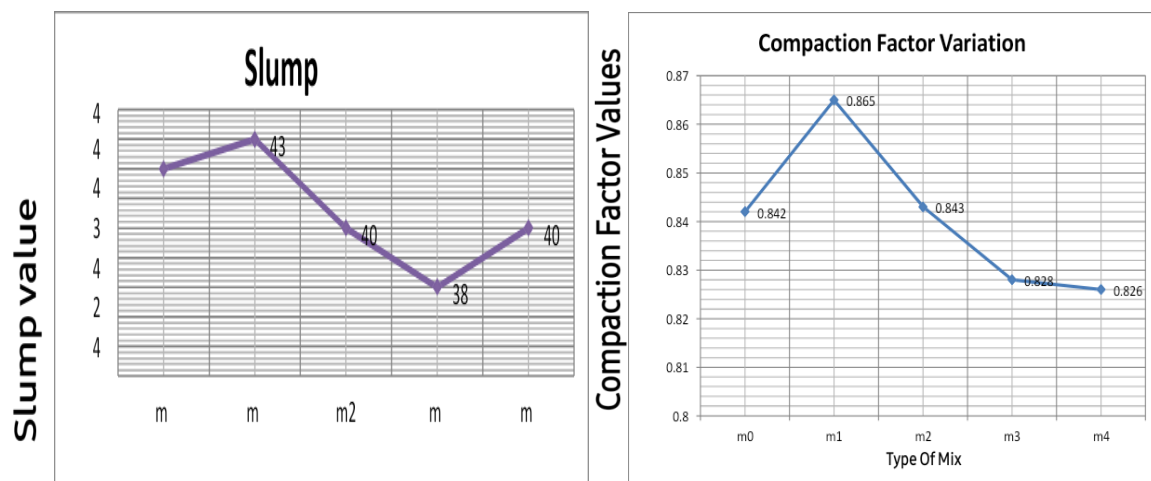
Workability

Plasticity changed as the ratio of pulverized crushed summations changed, as mentioned in chapter 3. Because there was some variation in the chance of pulverized crushed summations, the depression values and contraction factor values did not exhibit an invariant pattern. Due to the presence of pulverized crushed concrete summations, the water cement portion (W/C) was kept constant (0.38), requiring the use of super plasticizer to maintain the plasticity as water immersion increased. The variation of depression values versus composite type is shown in Figure 5.1. The variation of contraction factor versus composite type is shown in Figure 5.2.

Variation of Compressive Strength with Age

Fig.4.1 presents the compressive strength test results at 7, 28, 56, and 90 days.

The water cement ratio was maintained at 0.38 for every composite. Cement made up 0.6 of the super plasticizer used. For each composite at a different number of days, Table 4.2 shows the chance reduction in compressive



It can be seen from the above figures and tables that when RCA is utilized instead of natural total, the compressive strength does not follow an invariant pattern of proliferation or reduction. In 28 days, every composite material achieved its target strength of 48.26

Table 4.1 Test Results for Compressive Strength

S.No.	Mix	W/C	Compressive strength (MPa)			
			7 Days	28Days	56 Days	90 Days
1	M 0	0.38	42.43	50.06	51.20	51.8
2	M 1	0.38	42.47	50.36	50.89	51.23
3	M 2	0.38	41.84	50.20	50.68	50.80
4	M 3	0.38	42.60	49.11	50.68	51.4

5	M 4	0.38	40.27	52.36	53.24	53.26
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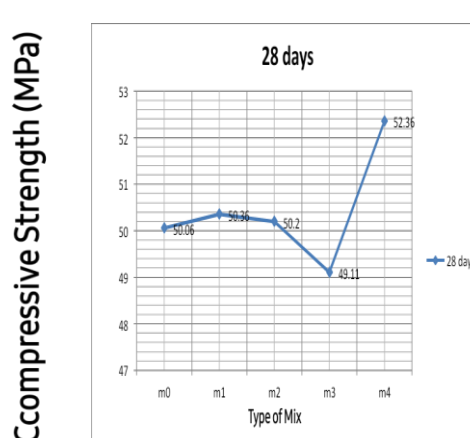
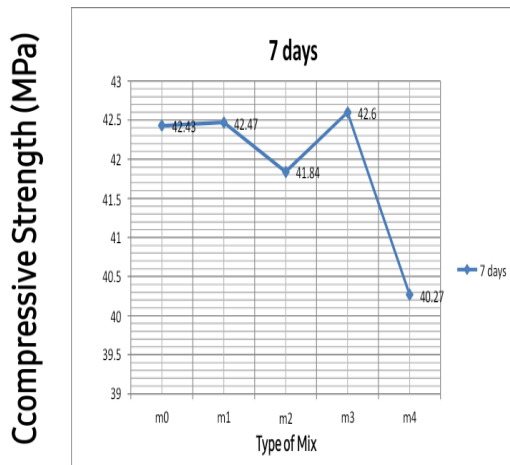
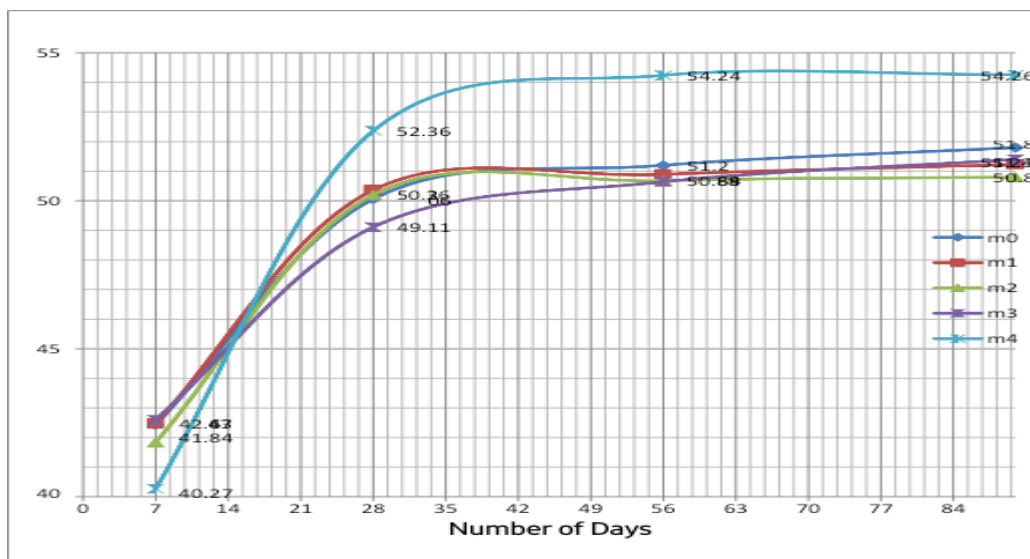
Table 4.2 Percentage Reduction in Compressive Strength at Different Ages.

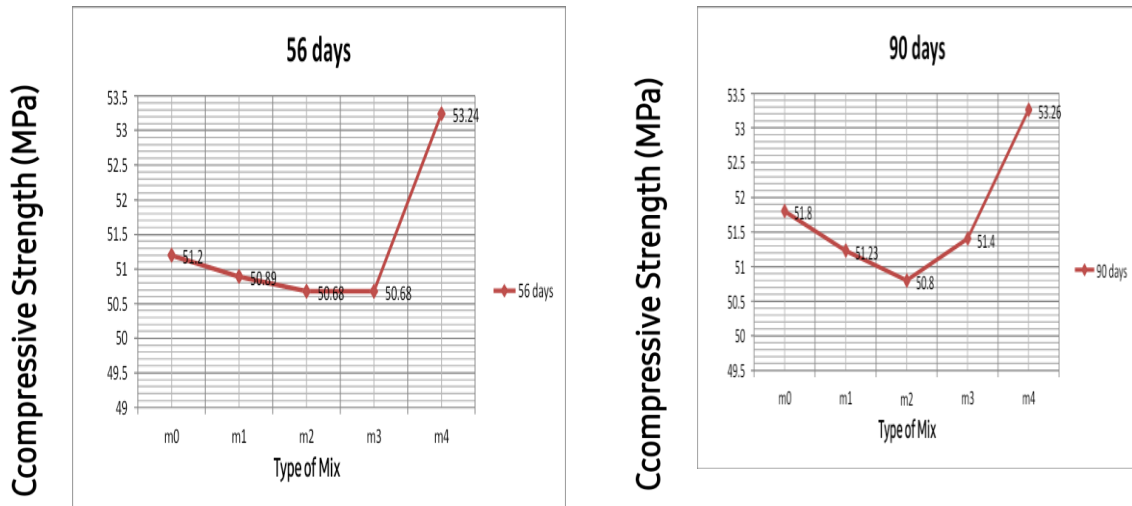
S.No.	Mix	Age (in days)	%age Reduction in Compressive Strength				
			m0	m1	m2	m3	m4
1.	1:1.23:2.52	7	-	100.1	98.6	100.4	95
2.	1:1.23:2.52	28	-	100.5	100.3	98.1	104.5
3.	1:1.23:2.52	56	-	99.4	98.8	98.9	106
4.	1:1.23:2.52	90	-	98.8	98	99.2	104

Figure 4.2 Shows the comparison of compressive strength of different mixes at 7, 28, 56 and 90 days

Figure 4.3 Comparison of Compressive Strength of all Five Mixes with Age of 7,28, 56 and 90 Days.

The variations in compressive strength at 7 days, 28 days, 56 days, and 90 days with various test mixes are displayed below.





VARIATION OF FLEXURAL STRENGTH WITH AGE

For all composites at various days, Table 5.2 shows the chance reduction in compressive strength. The aforementioned data and tables showed that when RCA is utilized in place of natural total, the compressive strength does not follow an invariant pattern of proliferation or reduction. Within 28 days, every composite material achieved its target strength of 48.26.

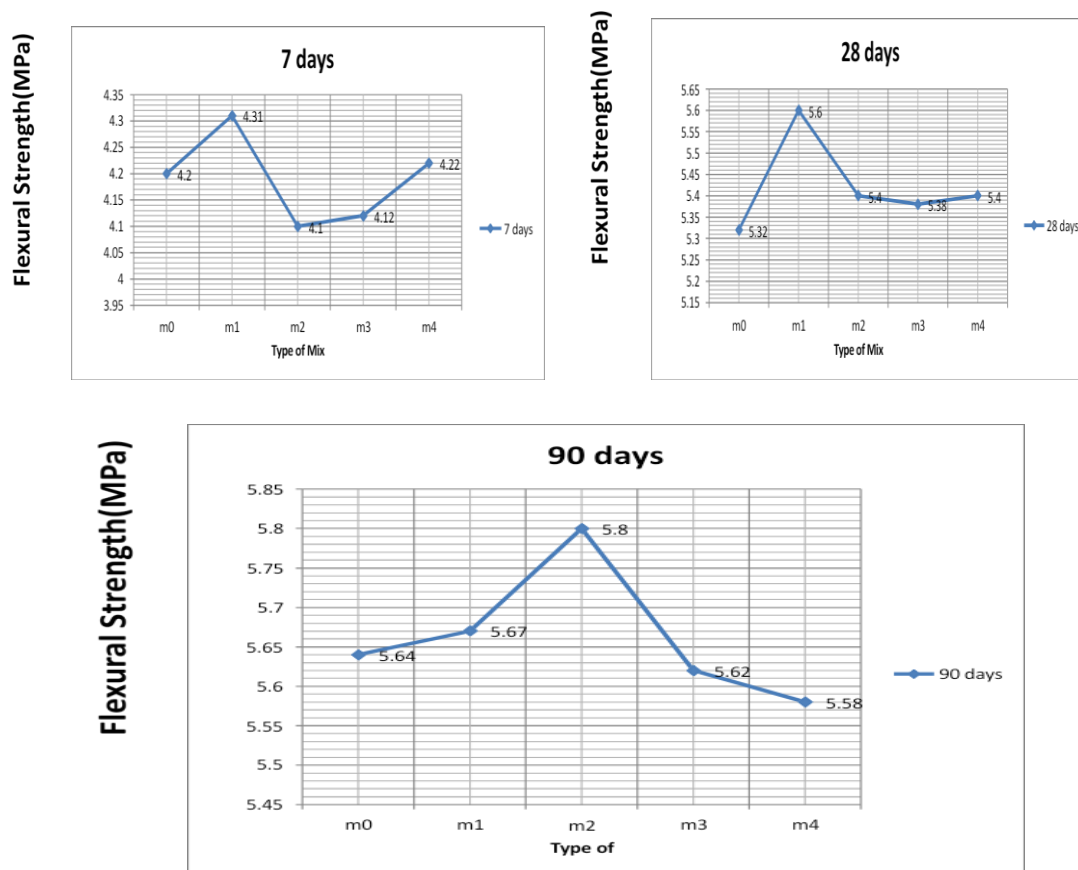
Table 4.3 Results of Flexural Strength

S.No.	Mix	W/C	Flexural strength (MPa)		
			7 Days	28Days	90 days
1.	Mix 0	0.38	4.20	5.32	5.64
2.	Mix 1	0.38	4.31	5.60	5.67
3.	Mix 2	0.38	4.10	5.40	5.8
4.	Mix 3	0.38	4.12	5.38	5.62
5.	Mix 4	0.38	4.22	5.40	5.58

Table 4.4 Percentage Variation of Flexural Strength at Different Ages.

S.No.	Mix	Age (in Days)	% age Reduction in Flexural Strength				
			m0	m1	m2	m3	m4
1	1:1.23:2.52	7	-	102.6	97.6	98.06	100.47
2.	1:1.23:2.52	28	-	105.26	101.5	101	101.5
3.	1:1.23:2.52	90	-	100.5	102.8	99.64	98.9

Comparison of Flexural Strength of all Mixes at 7, 28 and 90 days.



Gaphs illustrate the variation in flexural strength after seven, twenty-eight, and ninety days, using various mixes while maintaining a water cement ratio of 0.38. From mix to mix, the results revealed variations.

SULPHATE RESISTANCE OF RCA CONCRETE

This study section examined the impact of the sulphate result on the compressive strength of RCA concrete. Within MgSO₄ (magnesium sulfate) results, concrete cells were stored for 7, 28, and 56 days following a standard 28-day curing period. Using CTM, the compressive strength of the cells was evaluated. The test results at a given age of days are shown in Table 5.5. Table 5.6 provides information on the probability of a decrease in compressive strength at a given age in days.

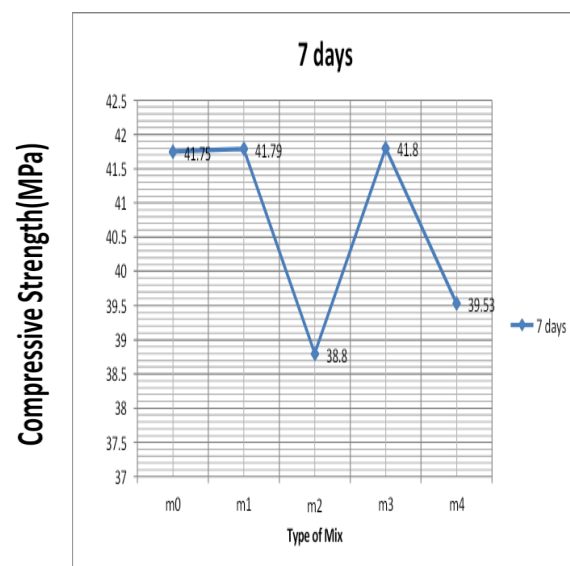
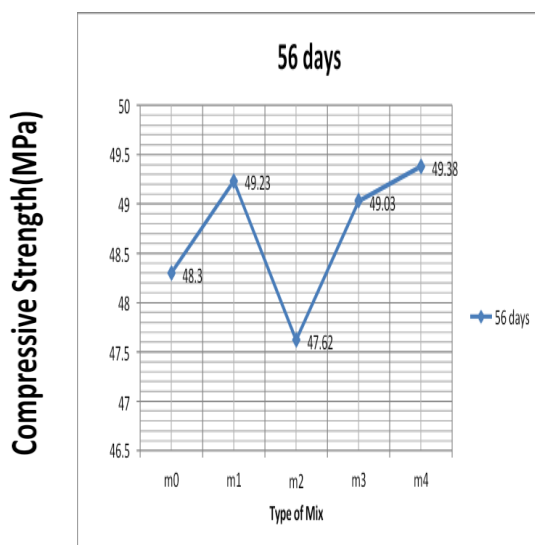
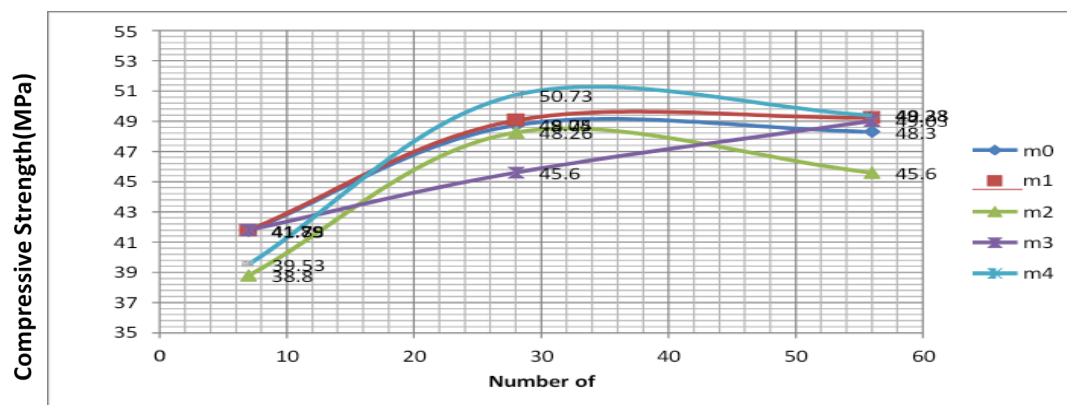
Table 4.5 Test Results for Sulphate Resistance

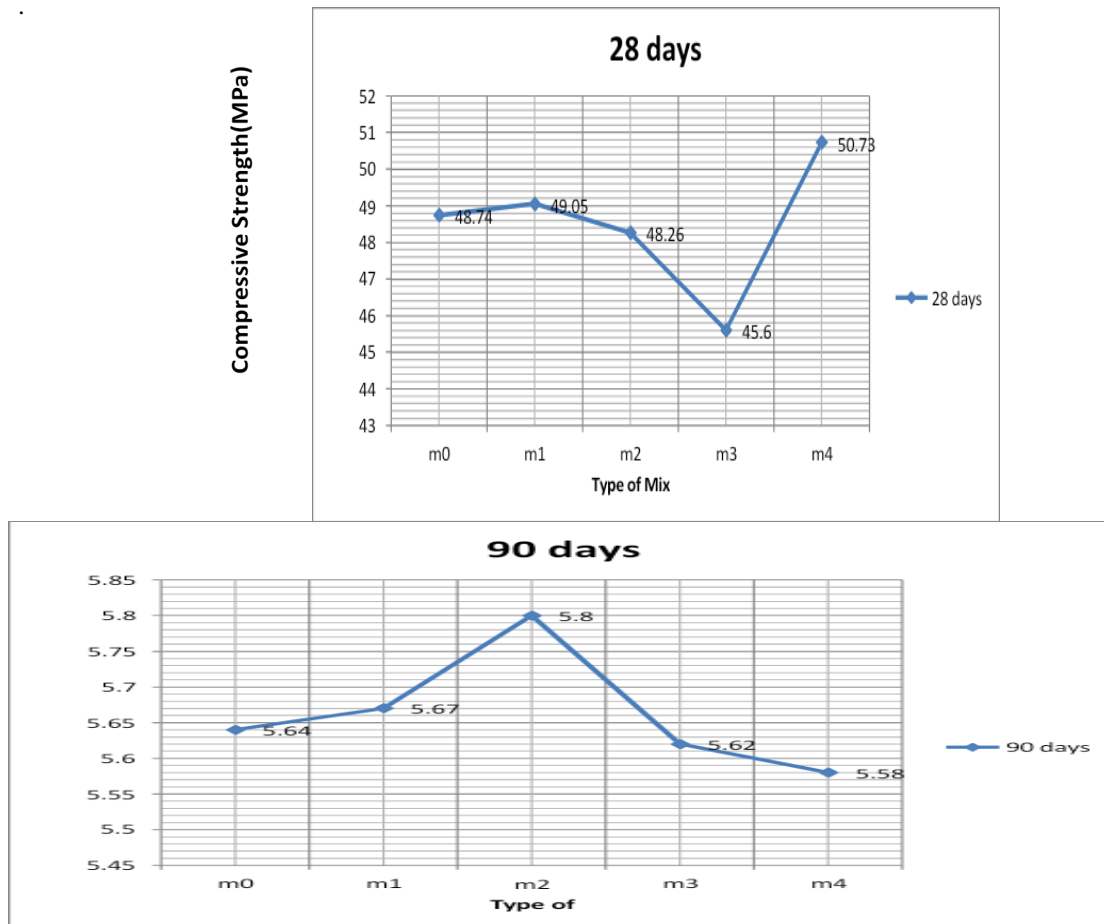
S.No.	Mix	Type Of Solution	Compressive Strength(MPa)		
			7 Days	28 Days	56 Days
1.	M 0	5% of MgSO ₄	41.75	48.74	48.3
2.	M 1	5% of MgSO ₄	41.79	49.05	49.23
3.	M 2	5% of MgSO ₄	38.8	48.26	47.62
4.	M 3	5% of MgSO ₄	41.8	45.6	49.03
5.	M 4	5% of MgSO ₄	39.53	50.73	49.38

Table 4.6 Percentage Reduction of Compressive Strength Due To Sulphate Attack

S.No	Mix	Type of solution	% age reduction in compressive strength		
			7 Days	28 Days	56 Days
1	M 0	5% of MgSO4	98.42	97.38	94.3
2	M 1	5% of MgSO4	98.4	97.4	96.08
3	M 2	5% of MgSO4	92.73	96.13	93.96
4	M 3	5% of MgSO4	98.2	92.85	95.4
5	M 4	5% of MgSO4	98.17	96.9	92.75

Comparison of compressive strength of all mixes kept in MgSO4 Sol at the age of 07, 28, 56, days





CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- At the age of 28 days, all composites surpassed in terms of compressive strength. The control blend's (m0) compressive strength is 50.05 MPa, which is less than the 48.25 MPa target strength for M40 concrete. The compressive strength of m1 has been marginally elevated to 50.36. Thus, there is a 0.5 increase in compressive strength. Moreover, it demonstrated a 0.3 increase in compressive strength for m2, increasing it to 50.20 MPa. The compressive strength of m3 decreased to 49.11 MPa, indicating a 1.9 decrease in compressive strength. However, in the instance of m4, an unanticipated rise in compressive strength causes the value to increase to 52.36 MPa. The increase in compressive strength is 4.5. Accordingly, test results indicate that there is no consistent trend in compressive strength from m0 to m4. However, the findings also indicate that, over the course of 28 days, compressive strength never fell below the target strength. This suggests that RCAs for compressive strength can be utilized as relief summations.
- The relationship between compressive and flexural strengths was similar. When the blend is 28 days old, its flexural strength is 5.32 MPa. Blend m1 experienced an increase in flexural strength to 5.60 MPa. According to this, m1 has a flexural strength increase of 5. At the age of 28 days, the flexural strength for m2 is 5.40 MPa, indicating a 1.5 increase in stress. Blend M3 has a flexural strength of 5.38, with a 1.5% increase. Blend M4 has a flexural strength of 5.40 MPa. By the time the animal was 28 days old, the flexural strength had grown by 1.5. Positively, it can be inferred from the results and discussion of the results that the flexural strength of RCA concrete is comparable to that of natural concrete as a whole. In light of this, the W/C rate of the RCA concrete can be adjusted for flexural strength.
- Compressive strength was decreased by using 5 of the MgSO₄ result. With an increase in the total volume of pulverized crushed concrete, the effect of the sulphate result increased. Therefore, the compressive strength of concrete decreased as sulphate levels increased.

4. It was established that, in comparison to natural concrete, RCA concrete had a comparatively lower bulk viscosity, specific gravity, and high water immersion. The reason for this was that the recycled coarse summations contained mortar.
5. Trial castings were used in this study to determine the plasticity and water content. Therefore, it made sense to conduct trial castings using the entire amount of pulverized crushed concrete that was intended to be used in order to determine the water content and its proportion to suit the strengths conditions and plasticity situations separately.
6. This study revealed that the persecuted concrete was just a workable source for concrete pavement construction. The benefits of RCA concrete are justified as being essential to natural concrete due to providential and environmental pressures. When natural total from fresh jewels is unavailable, RCA can be a good or practical alternative to provide natural coarse total when building pavement.
7. Based on the aforementioned findings, it is eco-friendly and innovative to utilize persecuted concrete when building concrete pavements.

REFERENCES

1. Abou-Zeid, M.N., Shenouda, M.N., McCabe, S.L., and El-Tawil, F.A. (2005). "Reincarnation of Concrete," *Concrete International*, V. 27, No.2, February 2005, pp. 53-59.
2. Ajdukiewicz, A., and Kliszczewica, A. (2002). "Influence of Recycled Aggregates on Mechanical Properties of HS/HPS," *Cement and Concrete Composites*, V. 24, No. 2, 2002, pp. 269-279.
3. Bairagi, N. K., Vidyadhara, H. S., and Ravande, K. (1990). "Mix Design Procedure for Recycled Aggregate Concrete," *Construction and Building Materials*, V. 4, No. 4, December 1990, pp. 188-193.
4. Buyle-Bodin, F., "Influence of industrially produced recycled aggregates on flow of properties of concrete." *Materials and structures/ Mate'riaux et. Construction*, Vol. no. 35, September-October 2002, pp 504-509.
5. Chen, H.J., Yen, T., and Chen, K.H. (2003). "Use of Building Rubbles as Recycled Aggregate," *Cement and Concrete Research*, V.33, No.1, pp. 125-132.
6. FHWA. (2004). "Transportation Applications Of Recycled Concrete Aggregate: FHWA State of the Practice National Review September 2004," U.S. Department of Transportation, Federal Highways Administration, Washington, DC.
7. GTAA. (2007). "Reducing, Reusing and Recycling Terminal 2," *Toronto Pearson Today: Terminal 2, Terminal 2 Commemorative Issue*, Greater Toronto Airports Authority, Toronto, ON. Hansen, T.C., and Hedegard, S.E. (1984). "Properties of Recycled Aggregate Concretes as Affected by Admixtures in Original Concretes," *ACI Journal*, January-February 1984, pp. 21-26.
8. Harrington, J. (2004). "States Achieve Recycling Success," *Roads and Bridges*, V.42, No.7.
9. Hendricks, Ch. F., "Use of Recycled materials in constructions", *Materials and structures/ Mate'riaux et. Construction*, Vol. no. 36, November 2003, pp 604-608.
10. IS: 456-2000, "Indian Standard Code of practice for plain and reinforced concrete", (second revision), Bureau of Indian Standard, New Delhi.
11. IS: 383-1963, "Indian Standard Specifications for Coarse and Fine Aggregate from Natural Sources for Concrete", Bureau of Indian Standard, New Delhi.
12. IS: 516-1959, "Methods of Tests for Strength of Concrete", Bureau of Indian Standard, New Delhi.
13. IS: 10262-1982, "Recommended Guidelines for Concrete Mix design", Bureau of Indian Standard, New Delhi.
14. IS: 2386(Part-1)-1963, "Methods of Test for Aggregate for Concrete (Part-I Particle Size and Shape)", Bureau of Indian Standard, New Delhi.
15. IS: 8112-1989, "Specification for 43 Grade Ordinary Portland Cement", Bureau of Indian Standard, New Delhi.

16. IS: 4031-1968, "Indian Standard Definitions And Terminology Relating To Hydraulic Cement", Bureau of Indian Standard, New Delhi.
17. Katz, A. (2003). "Properties of Concrete Made with Recycled Aggregate from Partially Hydrated Old Concrete," Cement and Concrete Research, V. 34 No. 5, pp. 703-711.
18. Katz A. (2004). "Treatments for the Improvement of Recycled Aggregate," Journal of Materials in Civil Engineering, V. 16 No. 6, November/December 2004 pp. 597- 603.
19. Kumar, Satish(2002), " Design of concrete mix using aggregate from Pulverized crushed Concrete", M.Tech Thesis.
20. Lin, Y.H., Tyan, Y.Y., Chang, T.P., and Chang, C.Y. (2004). "An Assessment of Optimal Mixture for Concrete Made With Recycled Concrete Aggregates," Cement and Concrete Research, V. 34, No. 8, pp. 1373-1380.
21. Mehta, P.K. (2001). "Reducing the Environmental Impact of Concrete," Concrete International, V. 23, No.10, October 2001, pp. 61-66.
22. Meyer, C. (2008). "The Greening of the Concrete Industry," 2nd Canadian Conference on Effective Design of Structures, paper #97, McMaster University, Hamilton, ON, 2008.
23. Naik, T.R., and Moriconi, G. (2005). "Environmental-Friendly Durable Concrete Made with Recycled Materials for Sustainable Concrete Construction," International Symposium on Sustainable Development of Cement, Concrete and Concrete Structures, Toronto, Ontario, October 5-7, pp. 277-298.
24. Oikonomou, N.D. (2005). "Recycled Concrete Aggregates," Cement and Concrete Composites, V. 25, No. 2, pp. 315-318
25. Olorunsogo, F.T., and Padayachee, N. (2002). "Performance of Recycled Aggregate Concrete Monitored by Durability Indexes," Cement and Concrete Research, V. 32, No. 2, 2002, pp. 179-185.
26. Poon, C.S.(2007), "Influence of recycled aggregate on slump and bleeding of fresh concrete," Material and Structure, v.40, pp. 981-988.
27. Poon, C.S., Shui, Z.H., Lam, L., Fok, H., and Kou, S.C. (2003). "Influence of Moisture States of Natural and Recycled Aggregates on the Slump and Compressive Strength of Concrete," Cement and Concrete Research, V.34, No.1, 2004, pp. 31-36.
28. Poon, C.S., Kou, S.C., and Lam, L. (2002). "Use of Recycled Aggregates in Molded Concrete Bricks and Blocks," Construction and Building Materials, V. 16, No. 5, pp. 281-289.
29. Rao, Aakash(2007), " Use of aggregates from recycled construction and demolition waste in concrete", Resources, Conservation and Recycling, V. 50, Issue 1, pp. 71- 81.
30. Rashwan, M.S., and AbouRizk, S. (1997). "The Properties of Recycled Concrete," Concrete International, V. 18, No.7, July 1997, pp. 56-60.
31. Sagoe-Crentsil, K.K., Brown, T., and Taylor, A.H. (2001). "Performance of Concrete Made with Commercially Produced Coarse Recycle Concrete Aggregate," Cement and Concrete Research, V. 31, No. 5, pp. 707-712.
32. Salem, R.M., Burdette, E.G., and Jackson, N.M. (2003). "Resistance to Freezing and Thawing of Recycled Aggregate Concrete," ACI Materials Journal, V. 100, No. 3, May-June 2003, pp. 216-221.
33. Seow, K. (2005). "Old Terminal 1 Decommissioning and Demolition," Annual Conference of the Transportation Association of Canada, Calgary, AB, 2005.