

Experimental Investigation Of Abrasion Resistance Of Concrete Modified With Plastic

Sandeep Rathod¹, Prof. Sharankumar S Gobbur²

¹M.Tech Student, Department of Highway Technology, VTU PG Centre, Kalaburgi.
sandeepathod1200@gmail.com

²Professor, Department of Highway Technology, VTU PG Centre, Kalaburgi. sharangobbur61@gmail.com

ABSTRACT

Waste plastic presents a persistent disposal problem and the thesis investigates its reuse through plastic-coated coarse aggregate in pavement concrete. Waste plastic bottles were shredded to 2.5-4.36 mm, the aggregates were heated to about 140°C, and the molten plastic was used to form a coating on the aggregate surface. The study compared raw and plastic-coated aggregates through impact, crushing, and Los Angeles abrasion tests, and evaluated M40 concrete prepared at a reported mix proportion of 1:1.3:2.6 with a water-cement ratio of 0.36. Compressive strength was measured on 150 mm concrete cubes at 7, 14, and 28 days, while abrasion resistance of concrete cylinders was assessed by the Cantabro test in a Los Angeles abrasion machine without steel balls. The reported average compressive strengths of conventional concrete were 28.11, 34.94, and 38.57 N/mm² at 7, 14, and 28 days, respectively; corresponding values for concrete with plastic-coated aggregate were 13.06, 23.978, and 39.03 N/mm². The Cantabro tables report abrasion values of 99.52% and 98.14% for raw-aggregate cylinders and 99.44% and 98.47% for plastic-coated-aggregate cylinders. The thesis concludes that plastic-coated aggregates provided improved abrasion resistance and satisfactory compressive performance while supporting reuse of waste plastic in pavement concrete.

Keywords: Plastic-coated aggregate; Waste plastic; M40 concrete; Abrasion resistance; Cantabro test; Compressive strength

I. INTRODUCTION

Pavement layers are required to distribute wheel loads to the subgrade while providing a durable riding surface. The thesis focuses on rigid pavement concrete and on the role of aggregate quality in resisting wear, crushing, and traffic-related deterioration. At the same time, disposal of waste plastic bottles creates an environmental burden because plastic persists for long periods and may accumulate in landfills, open dumping areas, and water bodies.

The project adopts a plastic-coating technique in which shredded waste plastic is melted onto heated aggregate. The thesis describes this approach as a means of reusing waste plastic and modifying the aggregate surface before incorporation into pavement concrete. Earlier studies reviewed in the thesis examined plastic-coated aggregates in bituminous mixtures and pavement applications, reporting changes in aggregate and mixture performance [1]-[7].

The identified research gap is the need for alternative construction materials as natural aggregate resources are depleted and pavement concrete remains vulnerable to cracking, deformation, and aggregate wear. The thesis therefore investigates whether a thin plastic coating on aggregate can improve the reported mechanical and abrasion-related performance of the aggregate and of concrete prepared with it.

II. OBJECTIVES

- To compare the mechanical properties of raw aggregates.
- To evaluate the abrasion resistance of concrete cylinders with plastic-coated aggregate.
- To determine the maximum compressive strength of concrete.

III. LITERATURE SURVEY

Kumar and Berwal and co-authors examined crumb rubber and plastic-coated aggregates in modified bituminous asphalt and identified plastic-coated aggregate as a useful material within the modified road mixture [1]. Alave and co-authors compared raw and plastic-coated aggregates using crushing, impact, abrasion, stripping-value, and specific-gravity tests at several plastic percentages [2].

Sreedevi and Salini reported pavement performance observations for bituminous mixtures prepared with waste-plastic-coated aggregate [3]. Chandu, Anil, and Hanitha investigated waste plastic as a modifier in rigid pavement concrete [4], while Lulseged, Mehantharaja, and Prasad examined plastic-coated aggregate in a flexible pavement bituminous mix [5]. Patel and co-authors [6] and Rajput and Yadav [7] likewise addressed

reuse of plastic waste in road construction. These studies form the background for the present thesis comparison of raw and plastic-coated aggregates and the subsequent concrete tests.

IV. MATERIALS AND METHODOLOGY

Experimental programme

The laboratory programme comprised material collection, physical testing of cement and aggregates, preparation of plastic-coated aggregate, M40 concrete mix design, casting of conventional and plastic-coated-aggregate concrete specimens, compressive-strength testing, and Cantabro abrasion testing. The thesis used OPC 53-grade cement, M-sand as fine aggregate, coarse aggregate selected to suit each test procedure, potable water, and waste plastic water bottles.

Preparation of plastic-coated aggregate

Waste plastic bottles were shredded to a reported size of 2.5-4.36 mm. Coarse aggregate was heated to approximately 140°C and mixed with the shredded plastic until a uniform coating formed. The coated aggregate was then allowed to cool before testing and concrete production.

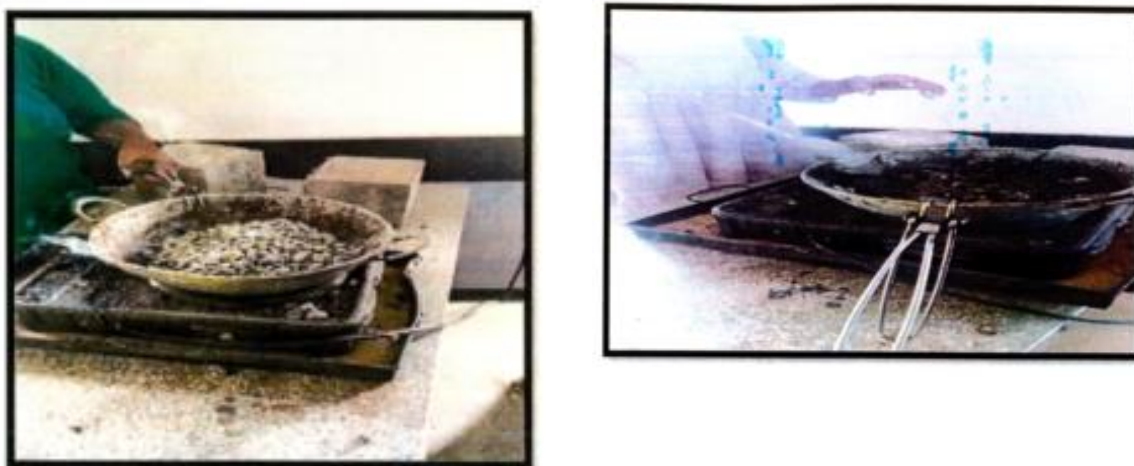


Fig. 1. Preparation of plastic-coated aggregate reported in the thesis.

Material characterization

Cement and fine aggregate were characterized through the tests reported in the thesis, while raw and plastic-coated coarse aggregates were evaluated through impact, crushing, and Los Angeles abrasion tests. The impact and crushing tests were reported with reference to IS 2386-4 [12], and the fine-aggregate tests with reference to IS 2386-3 [11].

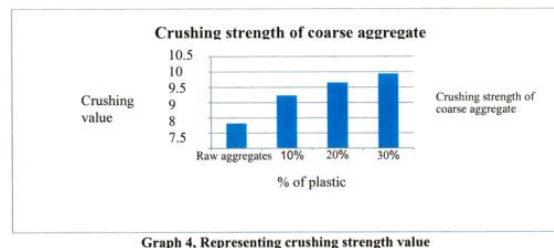
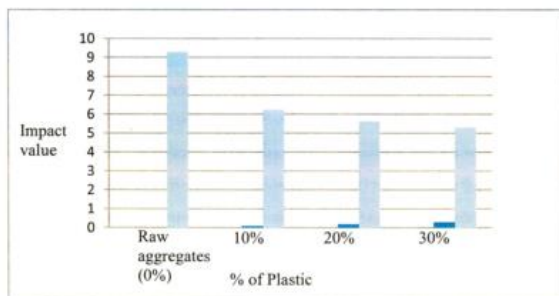
Table 1. Selected material properties reported in the thesis

Material / test	Reported result	Reported comparison / code
Cement specific gravity	2.78	3.1-3.16; IS 2720-1980 Part 3
Cement initial setting time	35 min	30 min; IS 5513-1976 Part 3
Cement final setting time	570 min	600 min; IS 5513-1976 Part 3
Cement consistency test	34% water; 8 mm penetration	Initial reading 41; final reading 33
Fine aggregate specific gravity	2.36	2.65-2.67; IS 2386-3 (1963)
Fine aggregate water absorption	1.5%	Not greater than 3%; IS 2386-3 (1963)

Table 2. Mechanical-test values for raw and plastic-coated coarse aggregate

Test	Raw	PCA 10%	PCA 20%	PCA 30%	Reported criterion / code
Impact test (%)	9.3	6.25	5.625	5.312	<20%; IS 2386-4
Crushing strength (%)	8.32	9.23	9.65	9.94	<30%; IS 2386-4

Abrasion resistance (%)	1.95	14.95	16.46	18.59	IS 2386:1964
-------------------------	------	-------	-------	-------	--------------



Graph 4, Representing crushing strength value

Fig. 2. Impact-test and crushing-test graphs retained from the thesis.

Mix design and specimen preparation

The concrete grade was M40 and the thesis states that mix design was carried out using IS 10262:2009 [14]. The adopted mix proportion was 1:1.3:2.6 with a water-cement ratio of 0.36. The final material table in the report gives the quantities shown in Table 3. For the plastic-coated-aggregate concrete calculation, the report used 20% plastic: 12.894 kg of coarse aggregate for three cubes corresponded to 2.5788 kg (2578.8 g) of plastic. **Table 3. Reported M40 mix quantities for 1 m³ of concrete**

Material	Reported quantity
Coarse aggregate	1273.48 kg/m ³
Fine aggregate	636.74 kg/m ³
Cement	489.77 kg/m ³
Water-cement ratio	0.36
Mix proportion	1 : 1.3 : 2.6

Compression-test cubes measured 150 × 150 × 150 mm. The methodology states that three specimens were prepared for each curing age of 7, 14, and 28 days for both conventional concrete and concrete with plastic-coated aggregate. The specimens were compacted in layers, demoulded after 24 hours, water-cured, and tested in compression in accordance with the procedure reported in the thesis and IS 516:1959 [13].

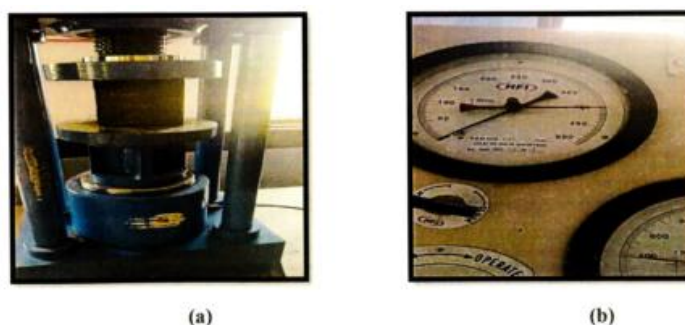


Fig. 3. Compressive-strength test arrangement retained from the thesis.

Cantabro abrasion test

The Cantabro test was used to evaluate abrasion resistance of the concrete cylinders. The thesis describes testing in the Los Angeles abrasion machine without steel-ball charges. Each cylindrical specimen had a reported diameter of 10 cm and height of 10 cm. The initial weight was recorded and the specimen was rotated for 500 revolutions at 50 rpm; the final weight was then measured and the thesis reported an abrasion value in percent. The source methodology states curing at 7, 14, and 28 days, but the two-cylinder result tables do not identify a curing age for the individual Cantabro values.

V. RESULTS AND DISCUSSION

Aggregate mechanical properties

The raw and plastic-coated aggregate values are reproduced unchanged in Table 2. The impact value decreased from 9.3% for raw aggregate to 6.25%, 5.625%, and 5.312% at 10%, 20%, and 30% plastic coating,

respectively. The crushing values reported were 8.32%, 9.23%, 9.65%, and 9.94%, while the corresponding abrasion-resistance values were 1.95%, 14.95%, 16.46%, and 18.59%. The thesis conclusion states that the comparison of raw and plastic-coated aggregates provided better results in impact, crushing, and abrasion testing.

Compressive strength

Table 4. Compression-test results for conventional concrete

Specimen	7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
1	28.08	34.84	38.67
2	28.22	34.93	38.65
3	28.04	35.06	38.40
Average	28.11	34.94	38.57

Table 5. Compression-test results for concrete with plastic-coated aggregate

Specimen	7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
1	13.156	24.223	39.11
2	12.44	22.834	39.33
3	13.6	24.877	38.667
Average (reported in summary table)	13.06	23.978	39.03

Table 6. Average compressive-strength comparison

Concrete type	7 days	14 days	28 days
Conventional concrete	28.11	34.94	38.57
Plastic-coated aggregate concrete	13.06	23.978	39.03

The conventional concrete had the higher reported average strength at 7 and 14 days. At 28 days, the average reported strength of concrete with plastic-coated aggregate was 39.03 N/mm² compared with 38.57 N/mm² for conventional concrete. The thesis therefore identifies the plastic-coated-aggregate concrete as having gained good compressive strength at the later curing age.

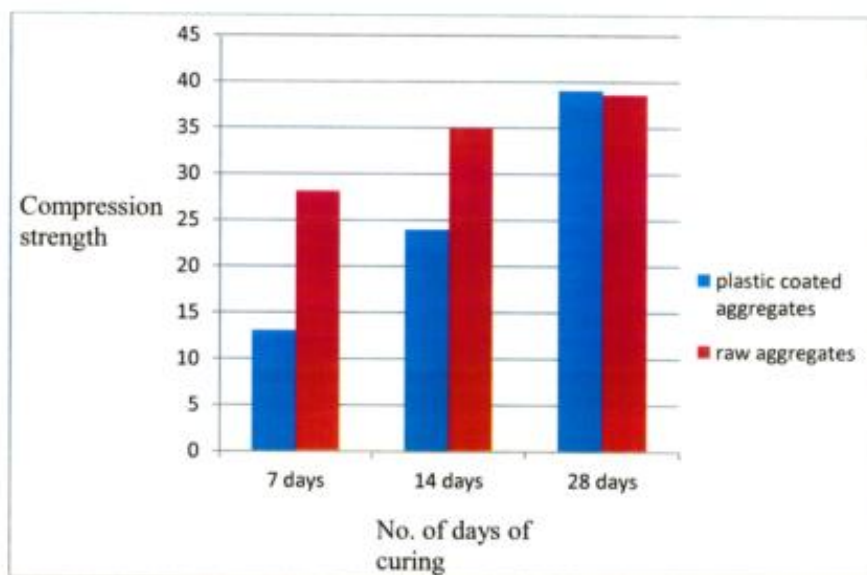


Fig. 4. Compression-strength comparison for raw-aggregate and plastic-coated-aggregate concrete.

Cantabro abrasion resistance

Table 7. Cantabro results reported for raw and plastic-coated-aggregate cylinders

Aggregate condition	Cylinder	Initial weight (kg)	Final weight (kg)	Reported abrasion value (%)
Raw aggregate	1	2.10	2.09	99.52
Raw aggregate	2	2.15	2.11	98.14
Plastic-coated aggregate	1	1.79	1.80	99.44
Plastic-coated aggregate	2	1.94	1.97	98.47

Note: The source tables label these quantities as “Abrasion value (%)”; the values are reproduced without recalculation.

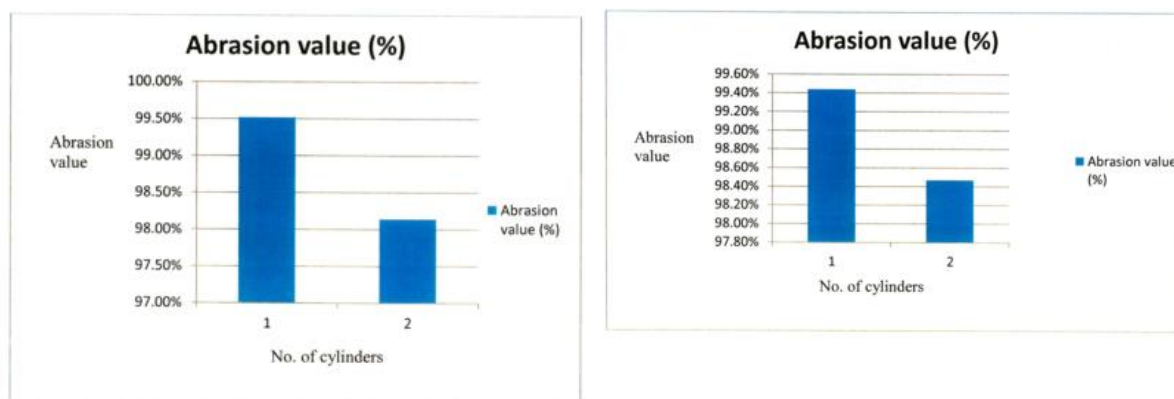


Fig. 5. Cantabro abrasion-value graphs for raw-aggregate and plastic-coated-aggregate cylinders.

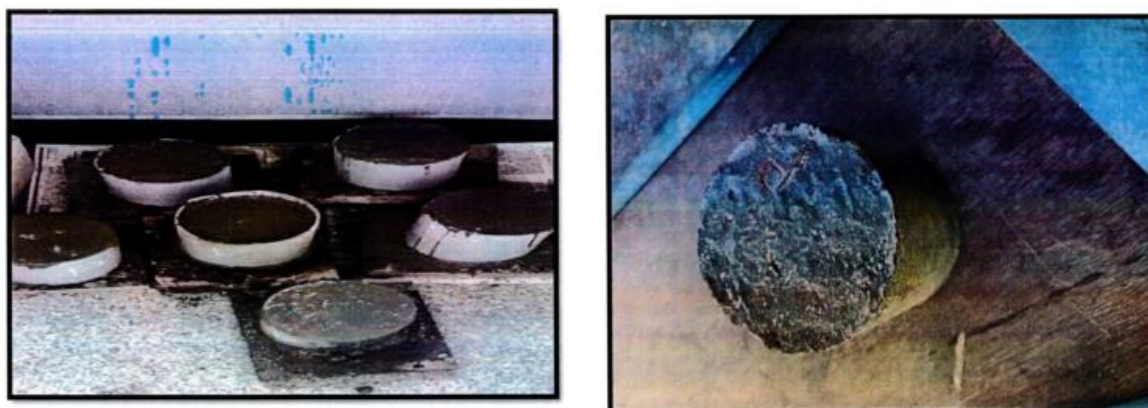


Fig. 6. Cylinder preparation and Cantabro-test specimen photographs retained from the thesis.

For raw-aggregate cylinders, the thesis reports abrasion values of 99.52% and 98.14%; the plastic-coated-aggregate cylinders are reported as 99.44% and 98.47%. The project conclusion states that the concrete cylinders containing plastic-coated aggregate acquired better abrasion resistance than the cylinders made with raw aggregate. Because the source result tables do not state the curing age for these four measurements, no age-specific interpretation is added here.

Overall interpretation

The evidence chain in the thesis connects the material modification to aggregate testing, M40 concrete production, compressive-strength measurements, and Cantabro abrasion measurements. The 28-day compressive-strength comparison gives a slightly higher reported average for the plastic-coated-aggregate concrete, while the Cantabro values are close between the two conditions and are interpreted in the thesis as supporting improved abrasion resistance. The study therefore supports further use of waste-plastic-coated aggregate in pavement concrete within the limits of the reported laboratory data.

VI. CONCLUSION

- The mechanical properties of raw and plastic-coated aggregates were compared through impact, crushing, and abrasion tests; the thesis concludes that plastic-coated aggregates imparted better results in these tests.
- The Cantabro test values reported for plastic-coated-aggregate concrete were 99.44% and 98.47%, compared with 99.52% and 98.14% for raw-aggregate concrete; the thesis concludes that plastic-coated aggregate provided better abrasion resistance.
- The reported 28-day average compressive strength was 39.03 N/mm² for concrete with plastic-coated aggregate and 38.57 N/mm² for conventional concrete. The thesis therefore concludes that concrete with plastic-coated aggregate gained good compressive strength.

SUPPLEMENTARY MATERIAL CHARACTERIZATION

The following supporting grading data are retained from the thesis because they document the fine aggregate used in the experimental programme.

Table A1. Fine-aggregate sieve-analysis data reported in the thesis

Sieve size	Weight retained (g)	% retained	Cumulative % retained	Cumulative % passed
4.75 mm	71	7.1	7.1	92.9
2.36 mm	58	5.8	12.9	87.1
1.18 mm	245	24.5	37.4	62.6
600 micron	250	25	62.4	37.6
425 micron	125	12.5	74.9	25.1
250 micron	86	8.6	83.5	16.5
150 micron	108	10.8	94.3	5.7
75 micron	35	3.5	97.8	2.2
Pan	12	2.2	100	0

REFERENCES

- [1] Kumar, A., Berwal, P., Al-Mansour, A.I., Khan, M.A., Alam, S., Lee, S.ssM., Malik, A. and Iqbal, A., 2022. Impact of Crumb Rubber Concentration and Plastic Coated Aggregates on the Rheological Performance of Modified Bitumen Asphalt. *Sustainability*, 14(7), p.3907.
- [2] Alave, Y.B., Mahimkar, S.S., Patil, K.S., Gupta, J.J. and Kazi, A., Experimental Investigation of Plastic Coated Aggregate.
- [3] Sreedevi, B.G. and Salini, P.N., 2013. Pavement performance studies on roads surfaced using bituminous mix with plastic coated aggregates. *International Journal of Engineering Research and Technology (IJERT)*, 2(9), pp.149-156.
- [4] Chandu, M., Anil, N.C. and Hanitha, P., 2016. An Experimental Investigation on Utilization of Waste Plastic as a Modifier in Rigid Pavements for Improving Strength. *International Journal of Engineering Research and Application*, 6(12), pp.59-63.
- [5] Lulseged, A., Mehantharaja, K. and Prasad, C.V.S.R., 2016. A study on using plastic coated aggregate in bituminous mix for flexible pavement. *International Journal of Scientific Engineering and Technology Research*, 5(05), pp.2319-888.
- [6] Patel, V., Popli, S. and Bhatt, D., 2014. Utilization of plastic waste in construction of roads. *International Journal of Scientific Research*, 3(4), pp.161-163.
- [7] Rajput, P.S. and Yadav, R.K., 2016. Use of plastic waste in bituminous road construction. *International Journal of Science and Technology & Engineering*, 2(10), pp.509-513.
- [8] IS: 383 - Specifications for fine and coarse aggregate from natural sources for concrete.
- [9] IS: 2720-1980: Part 3 - Specific gravity of cement.
- [10] IS: 5513-1976: Part 3 - Initial and final setting time of cement.
- [11] IS: 2386-3-1963 - Fine aggregates.
- [12] IS: 2386-4 - Coarse aggregates (impact test and crushing test).
- [13] IS 516-1959 - Compression test.
- [14] IS: 10262:2009 - Mix design.