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An Evaluation of the Performance of the Macadam Road with Cement Grouted

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ABSTRACT—

Grouting macadam combines the greatest qualities of bituminous macadam and cement concrete. Cement grouted bituminous mix (CGBM) is a cross between a stiff and flexible pavement; it is essentially an open-graded bituminous mix that has cement mortar grouted into it. To make cement grouted bituminous macadam, a mixture of cement, aggregates of varied sizes, and grout are mixed. How materials for roads are constructed impact both their behaviour and the management of deterioration. Many research are being carried out over the globe to improve the performance of pavements. Experiments are conducted to determine the efficacy of different grouting materials on large void matrix asphalt macadam, which is used as a material for semi flexible pavements (SFPs). So, this research provides a systematic approach to constructing volumetrically and strength-wise cement grouted bituminous macadam, among other performance-related parameters. Cement grouted bituminous mix is gaining popularity due to its many advantages over conventional bituminous mix. This project's main lesson is that various pavement designs can benefit from the cost-effectiveness of grouted macadam due to its improved strength and serviceability.

Keywords— Grouted macadam, flexible, rigid, bitumen, concrete, grout, porous aggregate skeleton mound.

1. INTRODUCTION

The air voids in the bituminous skeleton can reach 25% to 35% in cement grouted bituminous macadam (CGBM), a high void bituminous mix, with the correct amount of stone-on-stone contact. Concrete Paved Pavement known as bituminous macadam is filled with a cementitious grout that is very flow able and does not have a bituminous surface. Cement grouted composite courses with varying grades of paving bitumen were mechanically evaluated using tests like marshal stability, compressive strength, Indirect Tensile Strength (ITS), and Resilient Modulus (ITSM). Cement Grouted Bituminous Macadam is an eco-friendly pavement building process. Pavements constructed utilizing the composite method can imitate concrete's characteristics while still utilizing asphalt concrete for rapid construction. In places like parking lots and city streets in areas where heavy vehicle traffic puts excessive strain on the pavement, cement grouted bituminous macadam, also known as semi-flexible pavement, is commonly used. One kind of semi-rigid pavement is Cement Grouted Bituminous Pavement (CGBP), which combines the flexibility of bituminous surfaces with the strength and longevity of cementitious materials. In comparison to conventional bituminous pavements, which can rut or distort when subjected to heavy traffic, this material is excellent for use in bus lanes, intersections, industrial zones, and other heavily populated places. In order to build pavements with grouted macadam more accurately, to develop roads that last longer and cost less, and to improve our understanding of the material's properties, this study aims to collect additional data. Results from the research on cementitious grout's properties are quite encouraging.

2. Literature Review

Hashem Jahangir et al. conducted an experiment to assess the compressive properties of various composites, including grouting composites, steel fiber reinforced polymer, and short square-section concrete columns restrained by SRP and SRG. The bearing capacity of these columns was then compared. The final strain was used to evaluate the confinement impact. The results showed that the core concrete and composite separated in SRG-confined concrete columns as the main failure mode, and that the overlapping surfaces of the fibers separated in SRP-confined concrete columns.

With the use of natural zeolite and waste tire rubber (WTR) powder, Haman et al. investigated the compressive strength, flexural strength, drying shrinkage, permeability, durability, and stress-strain relationship of semi flexible pavement (SFP). The results show that the ideal ratio of 5% tire rubber powder to 15% zeolite produces the best mechanical properties for SFP.

The effect of cement slurry infusing SFP mixtures of different characteristics was studied by Kiting et al. Researchers found that adding cement slurry to semi flexible materials improved its compressive strength, resilience modulus, and resistance to spalling.

3. Lab Work

A cementitious grout preparation process.

Materials for cementitious grout include sand, water, micro silica, fly ash, and cement. admixtures. Cement grout with 43 grade regular Portland cement was utilised in the studies. The initial strength of the grout was enhanced by the incorporation of micro silica. You can decrease the early-age shrinkage and temperature rise by using fly ash as well. Their purpose was to achieve the desired fluidity in cement grout at lower water contents. To facilitate grout penetration into crevices, the crushed sand utilised in cement grout should have a particle size that passes through a 2.36 mm aperture. A dry mix was prepared by carefully mixing the specified proportions of cement, fly ash, micro silica, and crush sand. The dry mix was watered down to the specified level of moisture. Between 0.25 and 0.4, the water-to-binder ratio (w/b) was adjusted. Since there was no discernible change in either the water demand or the initial setting time when using distilled water, tap water was utilised in the grouts. Use of chemical admixtures improves performance while decreasing the water requirement to make grout flow able enough to fill voids.

Composition of cementitious grout.

Table 1 displays the results of the many laboratory studies that were conducted. The following major conclusions were obtained from these trials.

Table 1. The ratio of flow able cementitious grout is shown

MATERIALS	**QUANTITY (%)**				
	TRIAL 1	***TRIAL 2***	***TRIAL 3***	***TRIAL 4***	***TRIAL 5***
Cement	**32.46**	**47.33**	**31.45**	**64.22**	**65.25**
Fly ash	**7.61**	**13.46**	**9.21**	**5.11**	**4.83**
Micro silica	**8.45**	**12.85**	**8.65**	**1.76**	**1.57**
Crush sand	**32.46**	**1.84**	**32.56**	**3.22**	**1.76**
Water	**12.45**	**18.48**	**13.52**	**20.45**	**21.25**
Admixture	**0.48**	**0.76**	**0.46**	**0.75**	**0.84**

The fifth and last trial has been chosen. In order to gain cost savings in the design, the crush sand composition was higher in earlier testing. The compressive strength was lower in experiments that used a higher amount of crush sand compared to trials 4 and 5. The grout separates because there is a higher percentage of crush sand. The necessary compressive strength is achieved by increasing the cement content.

Gout testing in a controlled environment.

Cementitious grout was subjected to the following tests:

i) How watery the grout is.

The goal of the fluidity test is to ensure that the grout has penetrated the aggregate. After the aggregate mix, which makes up the open graded friction course, is filled with grout, the process is complete. Two methods for gauging fluidity are the Marsh cone and flow table tests. The optimal method for determining flow capability when the efflux time exceeds 34 seconds is, as shown in Figure 1, a flow table. The reason for performing a flow table test was because, as Each of the first three trials had an efflux time longer than thirty-four seconds.

For grouts, the Marsh cone test is applicable if the efflux time is 35 seconds or shorter. The results of calculating the amount of time needed for a certain volume of paste to flow down a metal funnel, in this case 1500 ml, are shown in Figure 2 using the marsh cone. The marsh cone was calibrated using water and time.

Deflating the cone took 7.24 seconds. Because the efflux time was less than 30 seconds, trials 4 and 5 were subjected to the mars cone test. Table 3 shows the data from the marsh cone, whereas table 2 shows the results from the flow table.

Table 2. Flow table test results.

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Flow in mm	**876**	**1024**	**896**	-	-

Table 3. Marsh cone test results.

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Flow in sec	-	-	-	**32**	**18**

Fig. 1. Flow table test.

A 40 mm and 50 mm porous aggregate skeleton mould was made with aggregate that passed through 20 mm and retained on 16 mm (80%) and 10 mm (20%), respectively. The moulds were filled with the ready-made grout for testing, with a thickness of 40 and 50 mm, respectively, to maintain a void ratio of 25-30%. Following it, the permeable the penetration of grout as shown in Fig. 2.

Fig. 2. Penetration of grout of trial 5.

3.3 Compressive strength of grout.

Cast cubes of grout measuring 150x150x150 mm were used to measure its compressive strength. A compressive strength test was performed on the grout after1,7, and 28 days. Table 4 provides the data, while figures 4 and 5 show the results for compressive strength and cube failure pattern, respectively.

Table 4. Compressive strength results.

	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5
1 day(in Mpa)	31	18.24	18.45	22.68	18.45
7 day(in Mpa)	24.45	30.15	47.56	52.48	47.65
28 day(in Mpa)	44.66	38.52	49.65	71.47	56.48

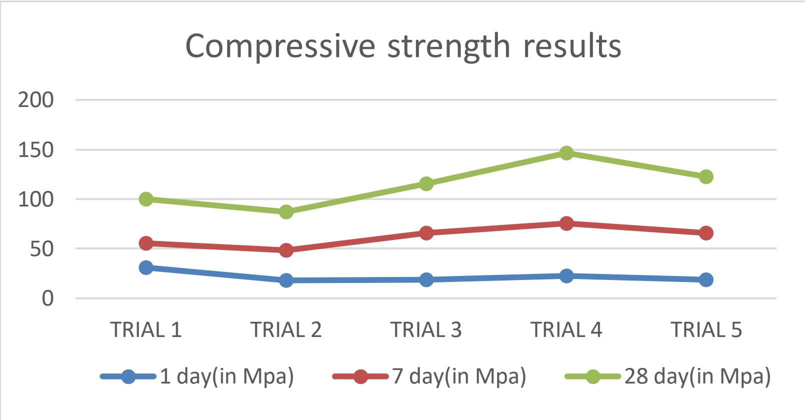

Fig. 3. Compressive strength results.

Flexural strength of grout.

A beam specimen measuring 700*150*150 mm was used to ascertain the cementitious grout's flexural strength. At the 28th day, the grout's flexural strength was measured. Table 5 displays the results.

Table 5. Flexural strength results.

	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5
28 day (in Mpa)	1.22	1.64	1.62	2.5	2.4

Fig. 6 and Fig. 7 shows flexural beam specimen and flexural strength results respectively.

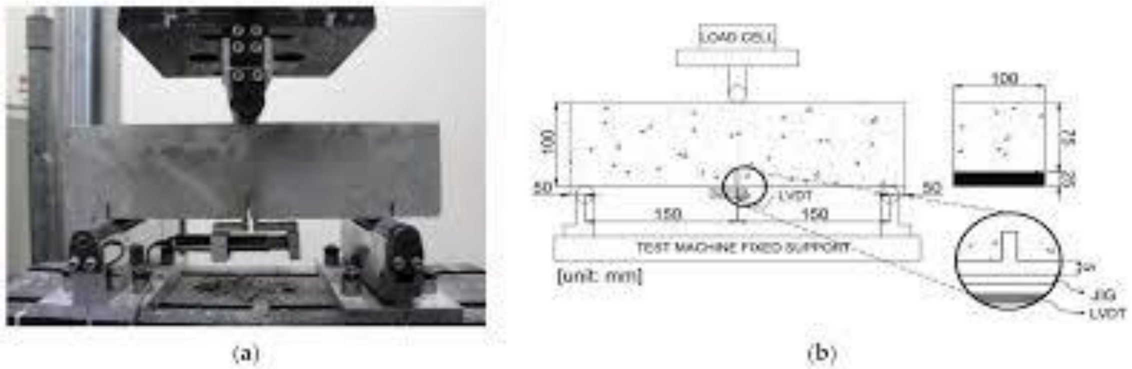

Fig. 4. Flexural beam specimen

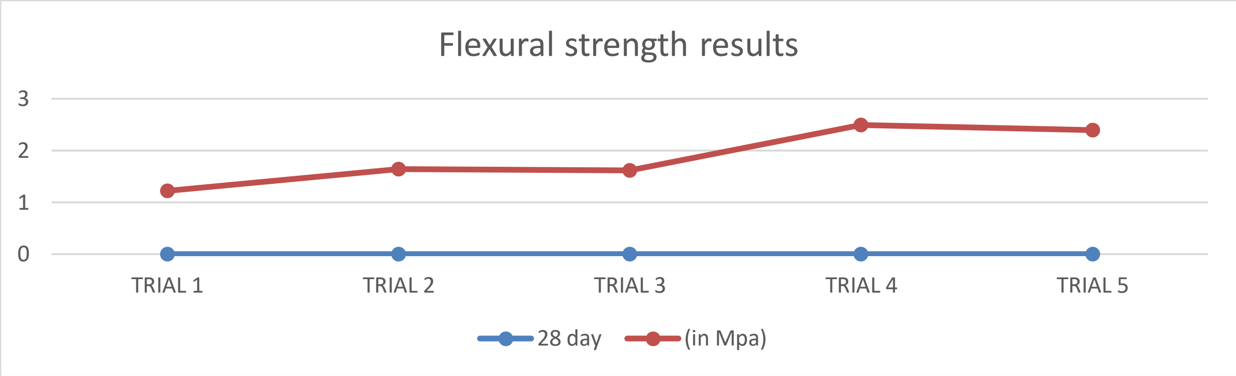

Fig. 5. Flexural strength results.

Testing of Aggregate.

Using coarse aggregate, a laboratory model of a porous aggregate skeleton was constructed. Data from a number of tests, including bulk density, specific gravity, aggregate crushing value, aggregate impact value, elongation index, flakiness index, and loss angle abrasion value as per is code, were recorded for both 10mm and 20mm aggregate in Table 6.

Table 6. Test results on aggregate.

Test Particular	**10mm aggregate**	**20mm aggregate**
Specific Gravity	**2.94**	**2.94**
Density of Bulk	**1.52 Kg/lit**	**1.54 Kg/lit**
Flukiness Scale	**3.65%**	**3.98%**
Length Measure	**2.45%**	**3.44%**
Crushing Value of Aggregate	**14.6%**	**15.4%**
Total Value of Impact	**10.54%**	**9.65%**
Angle of Attack Abrasion Threshold	**16.98%**	**17.64%**

4. Conclusions

Bituminous pavements are known for their flexibility and load-distribution properties, while cementitious materials are known for their strength and rigidity; these qualities are combined in cement grouted macadam roads. The various experiments conducted on the cementitious grout were detailed in the research paper. In conclusion, Cement Grouted Macadam provides a sustainable, long-term, and budget-friendly substitute for conventional pavement systems, guaranteeing dependable performance with low maintenance requirements. In this article, we look at the various tests and aggregate grading. According to trial 5, the flexural strength is 2.4 Mpa and the compressive strength is 56.48 Mpa after 28 days. For heavy-duty uses like industrial roads, airports, and village roads, cement grouted macadam is an affordable option for road building. With cement grouted bituminous roads, you get: • Superior structural stability thanks to high compressive and flexural strengths. Even when subjected to repeated, heavy loads, it exhibits exceptional resistance to rutting and fatigue.

- More traction and less risk of falling, especially when wet.
- Water intrusion and the resulting damage are prevented by the extremely low permeability.
- Less maintenance needed and reduced total cost of ownership.

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