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Performance of Precast Bituminous Pavement

Akash Kakde[1], Ronak Gandhi[1], Deepali Tondare[1], Dipti More[1], Siddharth Gaikwad[2]

[1](*Student, Department of Civil Engineering, Pimpri Chinchwad College of Engineering, India)*
[2](*Assistant Professor, Department of Civil Engineering, Pimpri Chinchwad College of Engineering, India)*
*Corresponding Author: * Akash Kakde*

Abstract: *India has one of the largest road networks across the world, spanning over a total of 5.5 million km, the major problem long-term traffic restriction is a key disadvantage of conventional cast-in-place pavements. Therefore, development of such structures with short construction time as well maintaining the quality is important. Precast system is the prime solution to overcome such conditions. Precast pavements can be cast in factory, under controlled conditions and can be used immediately after installation. Precast systems are primarily used for rapid repair, rehabilitation and rapid construction of cement concrete pavements. The benefits of precast concrete pavements can also be realized in precast bituminous pavements as bitumen is a major material in pavements. This study explains the application of precast technology to bituminous pavements in surface course and to explore alternatives in precast pavement technology. The materials required, deformations observed while lifting and placing of pavement by use of ANSYS is explained. To strengthen and overcome the drawbacks of conventional bituminous concrete, addition of polymer (Styrene Butadiene Styrene) to bitumen has been considered. The results obtained show addition of polymer to bituminous concrete improved the elasticity compared to conventional bituminous concrete thereby decreasing the deformations.*

Keywords: *ANSYS, Deformation, Materials, PMB, Precast.*

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I. Introduction

Cast-in-place pavements have been the most extensively used technology but the drawbacks such as time hindrance, traffic congestion, inability to work in extreme weather condition lead to adopt the new technology i.e. Precast. Precast pavement technology is a new and innovative construction method that can be used to meet the need for rapid pavement repair and construction. Precast pavement systems are fabricated or assembled off-site, transported to the project site, and installed on a prepared foundation. The system components require minimal field curing, setting, cooling time to achieve strength before opening to traffic. Precast pavements are an easier and faster solution to the tedious and time-consuming conventional method of road construction. Although cement concrete pavements are widely used yet major important highways are still constructed with bitumen because of its ease of maintenance and better protection from skidding and slipping rain and snow. Thus, precast bituminous pavements can be an effective technology [1]. The aspects to be studied for precast bituminous pavements are material, stresses during lifting, stresses during placing and service, joints, aging and economics.

II. Materials and Methods

The materials to be used in this study include

1) Coarse aggregate
2) Fine aggregate
3) VG 30 grade bitumen
4) Styrene Butadiene Styrene (SBS) polymer
5) Various tests were performed to determine the physical properties of bitumen as well as polymer modified bitumen. The bitumen tested was VG 30 grade. Gradation for bituminous concrete mix was adopted from Specifications for Roads & Bridge Works.5% of SBS (SOL T-166) was mixed with bitumen by wet process and stirred continuously for 2 hours at 200°C -250°C until homogeneous mix was achieved[2]. The length and breadth of the models were varied from 0.3m to 2.0m and 0.4m to 2m respectively. The thickness of the models was varied from 0.01m to 0.25m. Furthermore, the composition of mixture model of panel size 0.4m x 0.3m x 0.05m was finalized according to ANSYS and compacted to obtain the sample. By obtaining the density and volume of sample, total weight of bituminous mix and weight of aggregate was calculated as follows

- Volume = 6 x 10^{-3} m^3
- Assumed density = 2353.33 kg/m^3
- Therefore, weight = 14120 kg.

8% PMB of total weight of bituminous mix was assumed and weight of aggregate was calculatedGradation of aggregate
The gradation adopted was as per specification for road and bridge works (5^{th} revision) by Ministry of Road Transport and Highway (MoRTH) in TABLE 1

Table 1: Adopted gradation for bituminous concrete mix

IS Sieve sizes (mm)	Grade 2	Cumulative % retaining	% Retaining	Weight retained (grams)
19	100	0	0	0
13.2	89.5	10.5	10.5	1397
9.5	79	21	10.5	1397
4.75	62	38	17	2261
2.36	50	50	12	1596
1.18	41	59	9	1197
0.6	32	68	9	1197
0.3	23	77	9	1197
0.15	16	84	7	931
0.075	7	93	9	1197
Pan	-	-	-	930
			Total	13300

2.1 Preparation of sample
The graded aggregates were heated in the oven to a temperature of 175°C to 190°C.
The polymer modified bitumen was heated at 120°C - 165°C. The material was mixed in vessel by continuous heating with a mixing tool until proper coating for all aggregates was achieved. After thorough mixing the mixture was poured and spread throughout the greased mould [3]. Filter paper was placed under the sample and on the top of the sample followed by placing the plate on it. Compaction with 90 blows to sample was done with the help of two rammers each. The compacted sample was kept at rest for 24hrs before demoulding.

Fig. 1 Fabricated box

Fig. 2 Casted sample

III. Analysis Sing ANSYS

The software used is ANSYS workbench version 16.0. It is finite element software in which analysis of flexible pavement model is carried out. The finite element method is a numerical analysis technique to obtain various structural parameters such as stress, strain and deformation of pavement layers and to check products durability. Total deformation is the vectors sum all directional displacements of the systems. Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. It enables to simulate test in virtual environment before manufacturing prototypes of products. Vertical surface deflections in flexible pavement have always been a major concern and are used as a criterion for pavement design. It helps in determining and improving weak points. In this work different model were designed and its structural parameters were studied. [4]

3.1 Inputs

1. Type of bituminous mix - Bituminous Concrete
2. Density - 2322.67 kg/m^3
3. Modulus of elasticity - 10350 MPa
4. Poisson's ratio - 0.35
5. Resilient modulus - 1700 MPa

- Support Conditions Fixed support at four corners of eccentricity 100 mm from edges

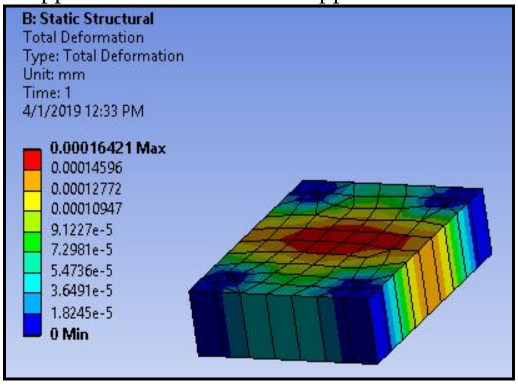

Fig. 3 Total deformation

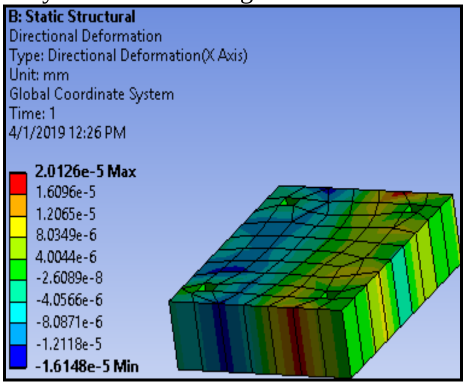

Fig. 4 Directional deformation

IV. Result and Discussion

Table 2 Comparison of results with IS

Sr. No	Properties	Conventional bitumen	IS standard (Bitumen)	PMB (5%)	IS 15462: 2004 (PMB 40)
1.	Penetration (mm)	64	50 to 70	23	30-50
2.	Softening point (°C)	51	47	55	60
3.	Ductility (cm)	55	-	84	-
4.	Specific gravity	1.01	0.99 to 1.02		-

The ductility value obtained from TABLE 2 for PMB is 84cm which is higher and ensures proper coating of bitumen with aggregates. On the contrary, penetration for PMB is lower than the specified standards. The softening point of PMB sample is 55°C which is as specified in IS 15462:2004. The specific gravity of conventional bitumen is 1.01 which indicates that the bitumen is free from impurities [3].

Table 3 Comparison of different ANSYS models

Model No.	Model Size (m)	Directional Deformation (in 10^{-5})		Total Deformation (10^{-4})	
		Max (mm)	Min (mm)	Max (mm)	Min (mm)
1	0.3 x 0.4 x 0.01	2.0126	-1.6148	1.6421	0
	0.3 x 0.4 x 0.05	2.0126	-1.6148	1.6421	0
	0.3 x 0.4 x 0.1	2.0126	-1.6148	1.6421	0
	0.3 x 0.4 x 0.25	2.0126	-1.6148	1.6421	0
2	0.5 x 0.5 x 0.01	2.4991	-2.4565	1.8661	0
	0.5 x 0.5 x 0.05	2.4991	-2.4565	1.8661	0
	0.5 x 0.5 x 0.1	2.4991	-2.4565	1.8661	0
	0.5 x 0.5 x 0.25	2.4991	-2.4565	1.8661	0
3	1 x 1 x 0.01	71.196	-66.468	70.268	0
	1 x 1 x 0.05	358.93	-343.88	465.34	0
	1 x 1 x 0.1	71.196	-66.468	70.268	0
	1 x 1 x 0.25	71.196	-66.468	70.268	0
4	1.5 x 1.5 x 0.01	358.93	-343.88	465.34	0
	1.5 x 1.5 x 0.05	358.93	-343.88	465.34	0
	1.5 x 1.5 x 0.1	358.93	-343.88	465.34	0
	1.5 x 1.5 x 0.25	358.93	-343.88	465.34	0
5	2 x 2 x 0.01	2202.7	-2208.5	5191	0
	2 x 2 x 0.05	202.7	-2208.5	5191	0
	2 x 2 x 0.1	2202.7	-2208.5	5191	0
	2 x 2 x 0.25	2202.7	-2208.5	5191	0

According to general field practice, the thickness of surface course is between 25mm to 50mm and that of binder course is 50mm to 100mm. So model size of 0.3m x 0.4m x 0.05m is selected as seen in TABLE 3. The maximum and minimum directional deformation is 2.0126 x 10^{-5} mm and -1.6148 x 10^{-5} mm respectively. The maximum and minimum total deformation is 1.6421 x 10^{-4} mm and 0 mm respectively [5]. Total deformation and directional deformation for this panel size is also less as compared to deformations of other models.

V. Conclusion

1. Quality of the pavements is uniformly maintained and fast repairing of patch work as compared to conventional method
2. The empirical tests carried out like softening point, ductility conclude that addition of SBS polymer increases the stiffness of bituminous pavements as well as improves the binding property of bitumen
3. Model size of 0.3m x 0.4m x 0.05m is selected by analysis using ANSYS as total deformation and directional deformation for this panel size is less as compared to deformations of other models.
4. The PMB was blended by addition of 5% SBS polymer by weight to the conventional bitumen. The tests performed on PMB yield satisfactory results and are confining to IS 15462:2004
5. SBS (SOL T-166) required 2 hours for complete blending whereas SBS (KRATON D1101 A) required 6 hours for partial blending, thus SBS (SOL T-166) is suitable.

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