Porous Pavement: Design and Cost Evaluation

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Abstract

This study is a representation of the survey and experimental works carried out for the design of Porous Pavement as a Flexible Pavement. Porous Pavement is a new concept and does not find its application much in developing countries like India so the researchers are seeking opportunities to work on this new concept. Application of porous pavement will allow storm water to infiltrate into the ground thus reducing the problem of water accumulation in the areas. For this study, Siddharth Bungalows at Sama-Savli road of Vadodara has been selected for the Traffic Volume study and Road Inventory survey. The above residential road experiences a great threat of storm water accumulation during every monsoon. For this, rainfall data of different day, month is collected. Another important part is the traffic volume count which will help determining the low traffic volume load. The thickness of each component layers can be determined by collecting the soil of the location and determining its CBR value. The material selected is single sized aggregates of sizes 20mm, 10mm and 6mm and various laboratory tests are performed on these to determine their engineering properties. Here, Bitumen is replaced by low viscous and locally available material Tar.

Keywords

Porous Pavement, Traffic Volume, Flexible Pavement, single sized aggregate, Drainage

Introduction

Porous pavement involves use of materials which have voids inside it and will help in infiltration of water thus allowing it store in the storage layer beneath and finding its use for irrigation purpose or for rain water harvesting. It's application in the areas where there is a problem of storm water accumulation will help environment by reducing the storm water volume, storing the water for other uses and lowering the temperature of road especially in summers. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are around 480 in./hr (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher. Due to the increased void

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ratio, water is conveyed through the surface and allowed to infiltrate, and evaporate, whereas conventional surfaces will not do so. A porous pavement surface therefore plays an active part in the hydrological cycle as rainfall is conveyed back to ground in the form of infiltrating water and run-off.

Study Area

Vadodara, also known as cultural capital of Gujarat, is the third largest city in western Indian states. The area selected for the study is Siddharth Bungalows near Sama-Savli road, Vadodara. It is one of the waterlogged areas in Vadodara. The rainfall data are collected from the Vadodara Irrigation Department. The Road inventory survey and Traffic volume survey are carried out here.[4]

Drainage Considerations

Drainage under the component layers of pavement can be provided to pass the storm water which has been infiltrated from the surface. These drains can help the storm water to flow directly into the rivers or streams or it can be used in the fields too.

Material Selection

For the selection of Porous material, single sized aggregate of size 6mm, 10mm and 20mm are selected. A mould is made from the single sized aggregate and locally available Tar by using 6mm, 10 mm and 2 mm aggregate with 5% tar and mixing it thoroughly with the aggregate sample. It is observed that 10mm and 20mm size aggregate mould is collapsed while in 6mm sized aggregates, it remains stable and does not collapsed and 6mm single sized aggregate with 5% tar is selected as a porous material for the study.

Data Collection and Analysis

For designing the Porous Pavement, the data collection part includes soaked CBR of soil sub grade, Road inventory survey, Traffic volume survey various laboratory tests conducted on single-sized aggregates and some important tests of Bitumen which are conducted on Tar.[7]

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Standard Proctor Test		CBR value(Soak) %
MDD	OMC	
1.858	11.9	10.8

Table 1: CBR value of soil sub-grade

Test	Test Method	Result		
		6 mm	10 mm	20 mm
Aggregate Impact Value	IS: 2386 (Part-4)	6.06	9.375	3.55
Aggregate Crushing Value	IS:2386 (Part-4)	10.16	8.25	6.11
Specific Gravity	IS: 2386 (Part-3)	2.83	2.5	0.34
Water Absoption	IS: 2386 (Part-3)	3.37	0	94

Table 2: Tests on single sized Aggregates

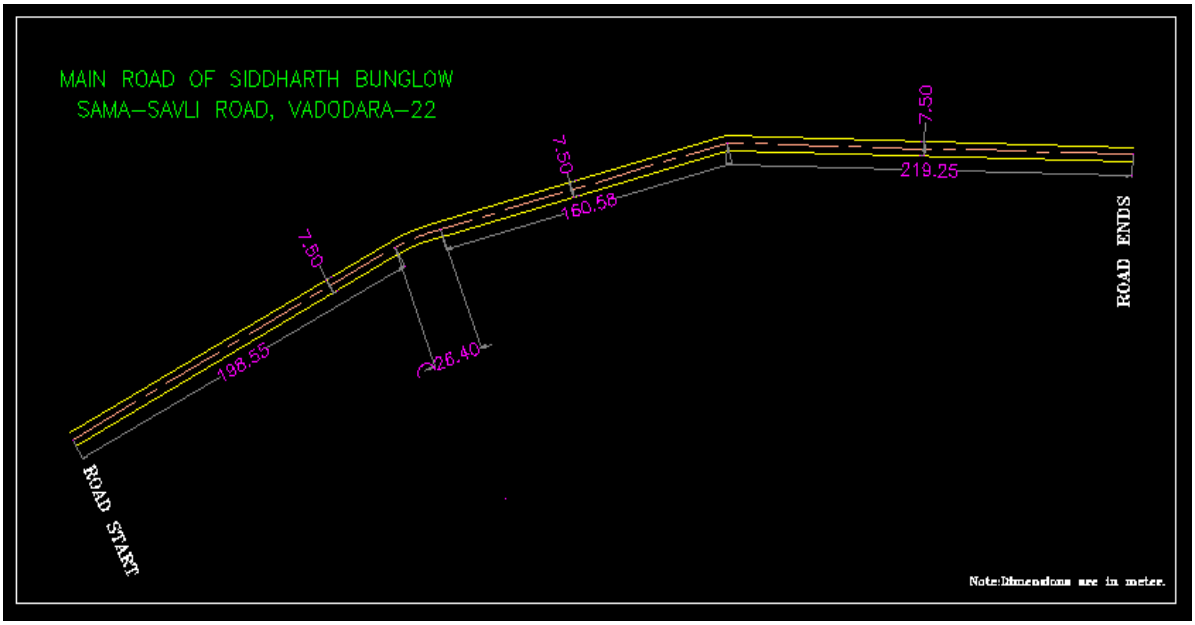

Figure 1: Road Inventory survey

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Property	Requirement	Result
Penetration 25°C	IS: 1203	8 mm
Softening Point °C	IS: 1205	95.1
Ductility	IS: 1208	2 cm
Marshall Stability	MORTH	5.41 kN
Flow Value	MORTH	5
Melting Point	-	53°C

Table 3: Tests on Tar

Week Days (IN Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	46.375	18.25	15	4.5	0.75	5.775	118
	Evening	75.75	29.25	15.5	6	0.75	6.25	114
Off-Peak Hours	Morning	70.75	31.5	20	7.5	1.5	9	35
	Evening	76.25	35	6	3	0	3.5	57

Week End (IN Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	50.75	23.75	17	5.25	7.5	5.875	129
	Evening	66.75	38.5	11.5	2.625	0.75	0.75	89
Off-Peak Hours	Morning	39.75	43	19	2.25	1.5	3.75	42
	Evening	73	38	13	1.5	0	3.25	54

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Week Days (OUT Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/ Truck	Cycle	Pedestrian
Peak Hours	Morning	79.625	47.25	9	6.375	1.5	2.75	60
	Evening	57.25	25.75	27.75	3.75	0	5.25	149
Off-Peak Hours	Morning	51.25	23.5	18	21	6.75	6.75	35
	Evening	70.5	23.5	7	4.5	2.75	2.75	42

Week End (OUT Direction)								
		2-Wheeler	4-Wheeler	3-Wheeler	LCV/ HCV	Bus/Truck	Cycle	Pedestrian
Peak Hours	Morning	74.37	42	17.5	3.75	6.75	4	76
	Evening	71.37	35.25	10	3.75	1	34.5	141
Off-Peak Hours	Morning	52.25	46	13.5	3	0	7	126
	Evening	49.75	26	14	0	0.75	6	57

Table 4: Traffic Volume Survey

Monthly Summary					
Months	2009	2010	2011	2012	2013
June	4	16	33	10	60
July	67	31	134	115	119
August	36	34	70	162	72
September	5	83	39	5	218
October	18	0	2	0	32
Total (mm)	130	164	278	292	501

Table 5: Rainfall Data

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Design of Porous Pavement using IRC 37[6]

Data:-

i. Initial traffic in the year of completion of construction=834 CV/Day
ii. Traffic growth rate per annum=7.5 per cent
iii. Design life=10 years
iv. Vehicle damage factor=3.5
v. Design CBR of sub grade soil=10%
vi. Annual growth rate of commercial vehicles=0.075

Calculations:-

(i)Distribution factor (para 3.3.5) =0.75

(ii)Cumulative number of standard axles to be catered for in the design

N= $[(365x \{(1+0.075)^{10}-1\})/0.075]x834x0.75x3.5$

=11.3 msa

(iii)Total pavement thickness for CBR 10%and traffic 11.3 msa=540mm

(From figure: 2)

(iv)Pavement composition interpolated from Plate-2, CBR 10%

(a) Bituminous surfacing = 40 mm BC +50 mm DBM

(b)Road base =250 mm

(c)Sub-base =200 mm

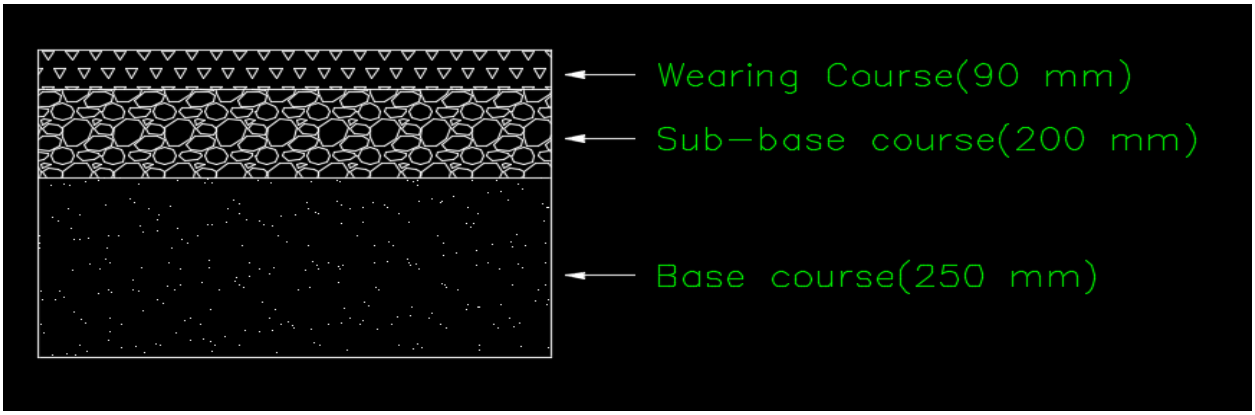

Figure 2: Pavement Thickness

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Cost Evaluation

Items	Dimensions			Rates	Result
	L (m)	B (m)	H (m)		
Base course	1	7.5	0.25	107 Rs/m^2	201 Rs/m^2
Granular Sub-base course	1	7.5	0.20	700 Rs/m^3	1050 Rs/m^3
Wearing Course	1	7.5	0.09	2661 Rs/m^3	1796 Rs/m^3
Total Rate per km					3047175 Rs.

Table6: Cost Evaluation of Porous Pavement

Items	Dimensions			Rates	Result
	L (m)	B (m)	H (m)		
Base course	1	7.5	0.25	107 Rs/m^2	201 Rs/m^2
Granular Sub-base course	1	7.5	0.20	700 Rs/m^3	1050 Rs/m^3
Wearing Course	1	7.5	0.09	1456 Rs/m^3	982.20Rs/m^3
Total Rate per km					2233000 Rs.

Table 7: Cost Evaluation of Flexible Pavement

Conclusion

From the survey and laboratory work carried out, it can be concluded that the rainfall data obtained shows the area receives heavy rainfall during every monsoon. The width of the road obtained after Road Inventory survey is 7.5 m. The result of the Traffic volume survey shows PCU/hr which is low and can be preferred for constructing porous pavement on it. The focus of the research was to design Porous Pavement as Flexible Pavement. For that, the wearing course material Bitumen was replaced by Tar which is low viscous and locally and easily available. Single-sized aggregates of sizes 20mm, 10mm and 6mm were used and various laboratory tests were conducted to determine their engineering properties. Then major tests of

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Bitumen were conducted on Tar. Marshall Stability test was conducted on the combination of aggregates and Tar and their feasibility as a wearing course was determined. As per IS, 6mm sized aggregates satisfies most of the test value range. From the Bitumen tests to be conducted on Tar, the values does not satisfies the IS range but it was observed that Softening point of Tar is more than Bitumen.

Future Scope

As observed from the laboratory tests and design, it is suggested that the samples should be tested for Stripping Value for further knowledge of their behavior. The samples should also be tested with the use of stone dust and other sizes of aggregates for accurate results. The economic benefits attained by using Porous Pavement design can also be determined

Acknowledgement

We would like to express our gratitude towards our guide Ms. Vaidehi Jain who gave us opportunity to focus on the project in one of the wide field by guiding us in various scenario during project and gave numerous consultations. We are thankful to our Head of the Department, Navrachana University, Dr. Bhairav Thakkar for encouraging and sharing great knowledge. We are grateful to Mr. Nitin Darji who helped us during the project span, overcoming some difficulties and helping us in many ways. In addition, we would like to thank Mr. Pradip Chauhan (Geo-test House, Vadodara), Mr. Amit Rana (Geo-test House, Vadodara) and Mr. Santosh Zunjar (Independent Consultants and Technocrates, Vadodara) for allowing and helping us to perform laboratory tests in their premises. Lastly, we would like to show the deepest gratefulness towards our Parents for believing in us and greatly motivating us in their best possible ways.

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