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CONSTRUTION OF POROUS DRAIN ASPHALT PAVEMENT

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Abstract

Porous asphalt pavements offer an alternative technology for stormwater management. A porous asphalt pavement differs from traditional asphalt pavement designs in that the structure permits fluids to pass freely through it, reducing or controlling the amount of runoff from the surrounding area. By allowing precipitation and runoff to flow through the structure, this pavement type functions as an additional stormwater management technique. The overall benefits of porous asphalt pavements may include both environmental and safety benefits including improved storm water management, improved skid resistance, reduction of spray to drivers and pedestrians, as well as a potential for noise reduction. With increasing environmental awareness and an evolving paradigm shift in storm water management techniques, this research aims to provide guidance for engineers, contractors, and government agencies on the design of porous asphalt pavement structures. One of the keys to the success of this pavement type is in the design of the asphalt mix. The air void percentage, which is ultimately related to the effectiveness of the pavement to adequately control the runoff, is a critical component of the mix. However, special consideration is required in order to obtain higher air void percentages while maintaining strength and durability for any climatic conditions. The objectives of this study were to evaluate several laboratory porous asphalt mix designed for durability,strength and flow for any climatic conditions. The porous asphalt mixes are made using Marshall mix design method whereby the asphalt binder type was varied along with replacing some amount of bitumen with polymer. Performance testing of the porous asphalt including drain down susceptibility, moisture-induced damage susceptibility. Based on the preliminary laboratory results, an optimal porous asphalt mix was recommended for use in any climate. Initial design guidelines for porous asphalt will be provided based on preliminary findings and the strength of the Dense Bituminous Macadam layer is found using different binders with different grades of bitumen along with replacing some percentage of bitumen with polymer.

1. INTRODUCTION

1.1: Objective

The objectives of this project were to study the pavement performance, durability, maintenance requirements, hydrologic benefits, and environmental considerations of a full-depth porous asphalt pavement in any climate. In order to meet this objective, two porous asphalt test cells were constructed on the Main road low-volume road (LVR) test loop. One porous asphalt cell was constructed over a sand sub grade and one over a clay sub grade In addition, a sealed/impervious, dense graded hot mix asphalt (DGHMA) control section was constructed directly adjacent to the porous sections, for comparison of water runoff, pavement performance and pavement durability.

1.2: Scope

Porous pavement is a general term used to describe a variety of materials that provide a hardened surface yet facilitate water percolation. Examples of such materials include porous

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asphalt, porous concrete, and several types of pavers. Porous asphalt pavement is mainly considered for parking lots. This type of pavement can drain runoff storm water. Laying process is very easy when compare to asphalt pavement.

1.3: Porous Asphalt Information

Porous Asphalt Background Porous asphalt is an emerging pavement technology first developed in the United States out of experimentation with seal coats. It has been researched, improved, and installed in numerous locations worldwide. Porous friction courses (PFC) are a form of porous asphalt pavement surfacing that has become well established in the United States. However, full-depth porous pavements are primarily installed for parking lot use domestically. Full-depth Porous Asphalt roadways are common in Europe, and interest is increasing worldwide due to the significant potential benefits. The need to reduce water runoff is becoming increasing important in Minnesota (and other wet climates) to mitigate the runoff associated with impervious surfaces. Porous Asphalt has been shown to reduce runoff, and the water quality degradation that can be associated with it The potential safety and noise benefits are equally compelling. Although porous asphalt mix design, construction methods, and maintenance have improved with experience, there is a need for additional research – particularly in cold climate applications. This synthesis was adapted to compile current information about PA roadway mix design, construction methods, pavement performance and maintenance practices. A summary of observed advantages and disadvantages of Porous Asphalt is also included. It was also written to inform and guide this research as to current state of the practice of PA, with an emphasis on cold-weather applications. The problems associated with traditional chip seals, including windshield damage, led to experimentation with plant-mix seal coats The special mixes evolved into thinly placed plant produced mixes, with gap-graded 0.5-inch size aggregates, and relatively high asphalt content. =

2. Method of Road Laying

2: Pavement Structure and Instrumentation Design

2.1: Pavement Structural Design Considerations

The Porous Asphalt Pavement thickness selection was based on its intended installation on a test cell of the Main road low-volume test road. The PA project was initially intended to last 2 years – from 2008 to 2010. The project was extended one year (to fall 2011) to capture data for a second winter period. During the study period both pavement performance and environmental aspects were monitored. It was important that the pavement last the duration of the study and at the end of the study be minimally serviceable. Although valuable data is gathered as a pavement deteriorates, premature failure would have also negatively impacted the environmental research. Therefore, the design was not performed strictly based on minimizing the pavement thickness or the cost of the materials.

The design approach initially took into account limiting factors. First, the porous asphalt cells would be built in an "urban design"; two 12-foot lanes with curb and gutter edges. They would also be constructed in conjunction with the pervious concrete project (LRRB INV879). The confined construction area greatly encouraged designing overall thickness of pavement + base to be identical in each of the five test sub cells involved. Secondly, the bottom of the crushed stone base (depth of excavation) was set approximately 2 feet from the surface due to site constrictions. Lastly, the stone base thickness and porosity was designed for storage of a five inch rain event (the largest single rain event recorded at Main road in recent history).

2.2: Aggregate Base and Pavement Thickness Design

The minimum base thickness was determined simply by applying an estimated in place aggregate porosity of 0.4 (based on previous experience with local CA-15 sources), and allowing for a storage capacity of a five-inch rainfall event. Therefore, 5 inches/0.4 required

Approximately 12.5 inches of base; twelve inches was determined to be adequate for the pervious concrete cells. This thickness allows the minimum base, pervious concrete thickness, and curb thickness, within a total depth of two feet. As all cells 85 through 89 would be constructed to identical total thickness, the porous asphalt cells would then have (a slightly more than necessary) 14 inches of aggregate base. The pavement surfaces and the bottom of the base then both matched for all cells 85 through 89. The total depth of the pavement/base system was intentionally designed to not extend below the frost depths regularly recorded at the site, in order to induce some measurable freezing for analysis

3. Process of Porous Asphalt Road Laying

3.1: Construction of Main Porous Road Test Sections

This section details the process employed and the timeline to construct the porous asphalt test cells and the impervious control cell on the Main road LVR. Cells 86 and 88 were constructed with porous asphalt; control Cell 87 with dense-graded Super pave. All are constructed using open-graded (high porosity) CA-15 aggregate base material to collect infiltrated water. All sections included a Type V geotextile fabric (to separate the base and subgrade layers), vertical plastic barriers (to prevent water from flowing into or out of the pavement from the sides), curbing and transverse drains for surface runoff. The only difference between Cells 86 and 88 is that Cell 86 was constructed above a sand subgrade and Cell 88 above a clay subgrade. Cell 87 was constructed with the same base material, but above the transition area between subgrade types - the east end has sand subgrade, the west end has clay, and the DGHMA layer is only 4 inches thick.

3.2: Placement of Porous Asphalt

Paving of Cells 86-88 was performed on October 15th, 2008. Installation of the standard HMA control Cell 87 went well. However, the contractor experienced difficulties both at the plant and the paver while paving the porous asphalt cells. The aggregates for the mix came to the HMA plant directly off the wash plant from the quarry. Due to the high moisture content, the material would not veil in the mixing drum and almost started the baghouse on fire. The plant operator decided to run each of the aggregate materials through the plant separately to dry them before mixing. By the time that was finished the asphalt binder line had cooled excessively and became plugged. The contractor waited about five hours until the surface temperature of the mix was below 100°F before starting the rolling. Then the pavement mat was rolled once or twice to make it smooth, but no more so as to retain the desired surface porosity. After rolling the pavement appeared to have acceptable smoothness and porosity. This was a learning experience for MnDOT and contractor personnel alike.

Final Porous Pavement

4. Tests on Bitumen

4.1: Tests of Bitumen-Plastic Results

1. DUCTILITY TEST
2. PENETRAIOM TEST

4.2: Ductility Test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation.

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Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square. The bitumen sample is heated and poured in the mould assembly placed on a plate. These samples with moulds are cooled in the air and then in water bath at 27 °C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm. The ductility value gets affected by factors such as pouring temperature, test temperature, rate of pulling etc. A minimum ductility value of 75 cm has been specified by the BIS. Shows ductility moulds to be filled with bitumen.

Ductility Test Report:

Observations:			
Room Temperature	^{0}C	:	
Pouring Temperature	^{0}C	:	
Period of cooling in atmosphere	(minutes)	:	(Spc: 30min to 40min)
Period of cooling in water bath before trimming	(minutes)	:	(Spc: minimum 30min)
Period of cooling in water bath after trimming	(minutes)		(Spc: 85min to 95min)
Actual test Temperature	^{0}C	:	(Spc: 50± 2.5mm/min))

Description	**Briquette Number**			Average
	1	**2**	**3**	
(a) Initial reading (cm)	0	0	0	79.3
(b) final reading (cm)	79	78	81	
Ductility = b-a (cm)	79	78	81	

4.3: PENETRATION TEST

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25o C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred.

Observations:

Room Temperature	^{0}C	**27**	
Pouring Temperature	^{0}C	**100**	Not more than 90^{0}C
Period of cooling in atmosphere	(minutes)	**90**	60-90min. For 35mm depth
Period of cooling at 25+0.1^{0}C water bath	(minutes)	**90**	
Actual test Temperature	^{0}C	**25**	

S. No.	PENETROMETER DIAL READING (1/10th of mm)		
	Initial Reading in mm	**Final Reading in mm**	**Penetration value in mm**
1	80	145	65.00
2	82	148	66.00
3	84	150	66.00

5. DESIGN OF DENSE BOUND MACADAM (DBM)

DESIGN PROCEDURE FOR DBM (DENSE BITUMEN MECADAM) [BASE COARSE]

- Design mix proportion for 150 mm diameter of DBM mould
- According to **MORT & H** 5th edition 2013 Method

Is Sieve Size (mm)	Weight Retained (gms)	Percentage of Retained	Cumulative Wt Retained(gms)	Percentage of Passing
45	0	0	0	100
37.5	2.5	100	100	97.5
26.5	22	780	880	78
13.5	35	520	1400	65
4.75	54	760	2160	46
2.36	65	440	2600	35
	Total Weight	2600		

- PERCENTAGE OF AGGREGATE ARE TAKING FOR **DBM**
- According to Mort & h 5^{th} Eddition-2013.

Size of Aggregates & ingredients	Percentage of mix proportions (%)
40 mm	20
20	22
10	18
Bitumen	4

- Here we are considering 4% of Bitumen
- So we are eliminating the Bitumen percentage (4%) in total percentage of Mix.
- **Bitumen** $= \frac{4*4000}{100}$=160 gms

Size of Aggregate & Ingredients	Calculations	Percentage Passed	Percentage of Ingredients	Wt. of Ingredients (gms)
40 mm	$\frac{20*96}{100}$	19.2	0.192*4000	768
20 mm	$\frac{22*96}{100}$	21.12	0.2112*4000	844.8
10 mm	$\frac{18*96}{100}$	17.28	0.1728*4000	691.2

- Total weight of Ingredients =2600 gms + 104 gms of Bitumen-Plastic.
- Now considering the addition of plastic to the **MIX.**
- Here showing the weight of Plastic and Bitumen.

Percentage of plastic	Plastic Wt. (gms)	Bitumen Wt. (gms)
10	16.7	150.3
15	25.05	141.95
20	33.4	133.60

- Mixing the total ingredients at 160°C and then adding of plastic.
- Then we are adding reduced percentage of Bitumen (160°C) to the mixed ingredients before we mix.
- After completing of mixing compaction done to the mould by Manual compacter.

6.2: Marshal Stability Test

This test procedure is used in designing and evaluating bituminous paving mixes and is extensively used in routine test programs for the paving jobs. There are two major features of the Marshall method of designing mixes namely, density – voids analysis and stability – flow test. Strength is measured in terms of the 'Marshall's Stability' of the mix following the specification ASTM D 1559 (2004), which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60°C.

In this test compressive loading was applied on the specimen at the rate of 50.8 mm/min till it was broken. The temperature 60°C represents the weakest condition for a bituminous pavement. The flexibility is measured in terms of the 'flow value' which is measured by the change in diameter of the sample in the direction of load application between the start of loading and at the time of maximum load. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The associated plastic flow of specimen at material failure is called flow value. The density- voids analysis is done using the volumetric properties of the mix, which will be described in the following sub sections.

MARSHAL TEST REPORT FOR DBM

S.NO	SPECIMENS	STABILITY (KN)	TEST (Kgs)	FLOW
1	10%	230	2346	3
2	10%	250	2550	3.6
3	10%	250	2550	3.4
4	15%	255	2601	2.8
5	15%	255	2601	3.2
6	15%	255	2601	3.2
7	20%	255	2601	4
8	20%	255	2601	3.3
9	20%	255	2601	3.2

Result:

For 10%: Average Marshal Stability result is **2482 kgs** and Flow value is **3.33**

For 15%: Average Marshal Stability result is **2601 kgs** and Flow value is **3.07**

For 20%: Average Marshal Stability result is **2601 kgs** and Flow value is **3.5**

7.ADVANTAGES AND DISADVANTAGES

7.1: ADVANTAGES OF POROUS ROADS

A well-constructed porous road will result in the following advantages

- Rapid drainage of surface water
- Reduction of traffic noise
- Reduction of spray and the improvement of skid resistance in wet weather
- Reduction of road surface glare from oncoming headlights
- Improved fuel consumption due to the smooth ride qualities of the negatively
- Textured surface
- Reduction in tire wear due to reduced rolling resistance.

7.2: DISADVANTAGES OF POROUS ROADS

- Reduced pavement strength. This leads to having to provide more support in the Structural layers of the pavement. The reduced strength can also limit the Application of the material to areas not susceptible to high stresses which could Lead to aggregate fretting
- reduced pavement life in comparison with other materials due to the increased Likelihood of binder oxidation caused by the voided nature of the material
- possible clogging of pores and drainage paths while under construction and also During the service life of the road

- the need for more salting during winter as snow and frost linger longer on pa
- increased construction costs due to the increased sensitivity of the material to Temperature and adverse weather conditions
- increased maintenance costs incurred by many of the above factors and the fact that Methods of repairing the pavement would be more complex than with other more

These disadvantages most probably contributed to the caution displayed in the early stages of development. They also highlight the major problem encountered when designing pa - the necessity to achieve a balance between the two essential qualities required. These qualities are permeability and durability. The material must exhibit a degree of permeability allowing the free flow of water whilst retaining a durability that permits an acceptable pavement life. This is where laboratory assessment can help in predicting the performance of pavement

8. RESULT AND CONCLUSION

RESULT:

Preliminary studies on the use of plastic-waste as a blending material with bitumen, suggest that the blends behave similar to Polymer Modified Bitumen, thus having improved properties compared to plain bitumen. It is also observed that this process of blending has limitation. At high percentage of blending there is separation of polymer. Hence, process modification was needed and a new product namely plastic waste coated aggregate was developed. This product is not only easy to prepare but also helps to use higher percentage of plastic-waste for coating without much of difficulty.

The coating of molten-polymer over the aggregate will reduce water absorption. This shows that the voids at the surface were reduced. Lesser the voids better the quality of the aggregate. Otherwise, the air entrapped in the voids would cause oxidation of bitumen resulting in stripping, pothole formation etc. Moreover, the presence of water in the voids is detrimental to adhesion between aggregate and the binder namely bitumen. Hence the aggregate with lesser voids is considered to be good for better road construction. These observations help to conclude that plastic-waste coated aggregate can be considered as more suitable material for flexible pavement construction.

CONCLUSION:

Polymers will increase the melting point of the bitumen. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income.

Porous roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste. Polymer Modified Bitumen is used due to its better performance. But in the case of higher percentage of polymer bitumen blend, the blend is a more polymer dispersion in bitumen, which get separated on cooling. This may affect the properties and quality of the blend and also the road laid using such blend.

In the modified process (dry process) plastics-waste is coated over aggregate. This helps to have better binding of bitumen with the plastic-waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reduced rutting, raveling, and there is not pothole formation. The road can withstand heavy traffic and show better durability.