Performance of Cement Treated Base Course in Composite Pavement

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Abstract

The importance of highway in modern transportation systems cannot be overstated. Pavement are one of the major subsystem of the highway system. Today, pavement management system has been increasingly employed by many state agencies to assist in highway pavement management. One of the key component of the management system, which is also the most challenging part, is the pavement deterioration prediction models. The development of any country depends upon the transportation system. In Islamabad when precipitation occurs and proper drainage system is not available then water precipitates into the pavement layers and finally reach to the sub grade. Due to that settlement of sub grade take place that fails the pavement. The base course of asphalt pavement effects the durability of wearing surface. The variation in thickness of base course change the strength of pavement. The use of CTB (Cement Treated Base) under the wearing surface protects the asphalt pavement better than normal base course. But one issue arises when CTB is used that is the cracks produced in CTB. The main focus of our research is to reduce these cracks by introducing the layer of chip stones or open graded asphalt or crushed aggregates between CTB and wearing surface and choose best suitable option for future recommendations. The CTB provides best design of composite pavement for HTV. This design will enhance the durability and design life of pavement structure. It is more resistant against the heavy traffic loads. This composite pavement design is best suitable where subgrade soil strata have insufficient capability to bear the traffic loads.

Keywords:

Design & analysis, Composite pavement, Cement treated base course

1. INTRODUCTION:

Composite pavements are comprising of different kinds of layers. Usually, asphaltic layer on the upper of a concrete pavement or a concrete layer on concrete pavement is used. For second type, commonly the lower layers contain aggregates or recycled concrete while the upper porous layer comprises high-quality smaller size aggregates (Rajib B. Mallick, 2013). The Major drawback is that the reflective cracks in the asphalt is produced by movement in the joints of concrete layers. To reduce these cracks, further one layer among these; chip-seal stones, open-graded asphalt & crush aggregates will added (Moghadas Nejad, Noory, Toolabi, & Fallah, 2014).

The main focus of this research is to find the solution of that problem by introducing the (CTB). CTB stands for cement treated base course that is provided in pavement as a base course. Some problems generated when we use CTB because CTB is made of concrete and concrete is a brittle material when load comes on CTB some cracks develop in the CTB. To overcome that crack problem, we use CTB with three different combinations of materials such as open graded asphalt, crushed aggregates and chip seal stones as an additional layer between CTB and wearing course. This central layer cannot reflect the cracks into the wearing surface. The main advantage of CTB is that, if water penetrates into the pavement then CTB acts as an insulator it does not allow water to move into the sub grade. So, finally subgrade protects from water and main cause of failure of pavement reduces.

Islamabad is currently facing problems with regards to the management and deterioration of pavement on arterial roads. The major problem in Islamabad is climate variation that effects drainage system of arterial roads. As the major portion of Islamabad consists of sloping areas and when precipitation occurs in different forms then water does not drain out properly from lower areas. So, water penetrates into asphalt pavement and finally reaches to sub grade. Water changes the favorable soil properties and reduces the bearing capacity of sub grade that leads to settlement. As sub grade of pavement fails the other layers such as sub base, base and wearing surface are also badly affected. At the end the wearing surface of pavement deteriorates. Cement treated base course was used because this provides stiffer and stronger base than an unbound granular base. A stiffer base reduces deflections due to traffic loads. CTB thicknesses are less than those required for granular bases carrying the same traffic because the loads are distributed over a large area. Cement stabilized bases resist consolidation and movement, thus eliminating rutting in all surface but the asphaltic layer.

2. EXPERIMENTAL PROCEDURES:

CTB is cement treated base course which is a modern technique used by NHA in the pavement to prevent rutting phenomenon and settlement of pavement under heavy traffic. Similar to concrete, CTB continues to gain strength with age. This is especially important when considering that many pavements experience greater traffic loads and volume throughout their service life.

Three main part of CTB;

1. First part is the base slab of concrete,

2. Second part is the intermediate layer and it is of three materials; Open grade asphalt, chip seal stones and crushed aggregates
3. Third part is the wearing surface of pavement.

The following different conventional as well as advanced testing techniques were chosen for design and analysis of cement treated basecourse (CTB). These include conventional tests i.e. Softening point, Flash and fire point, Penetration, Ductility and Specific gravity and advanced tests. Following tests were performed to check the performance of CTB.

Table 1: Conventional Testing Outcomes of Asphalt

STANDARD	TEST NAME	RESULT	REMARKS
ASTM D36 **AASHTO T53**	Softening point	71ºC	Standard range for softening point is 40 to 80º C , our result is close to standard value.
ASTM D92 **AASHTO T48**	Flash and fire point	Flash pt. = 260ºC Fire pt. = 268ºC	Standard range for flash and fire point is 232ºC to 400ºC, our result is close to standard value.
ASTM D3142 **AASHTT166**	Specific gravity	1.19	Standard range for specific gravity lies between 0.97 to 1.02, our specimen S.G is 1.19.
ASTM D5 **AASHTO T49**	Penetration test	46	Standard value of penetration at standard conditions is 0 to 49mm. Our value is in between this range.
ASTM D113 **AASHTO T51**	Ductility	6.0 cm	The ductility value ranges from 5cm-100cm. Our value is within the range.

Table 2: Design Mechanism Of CTB Pavement

	Base course	
Materials	**Ratio /Thickness**	**Remarks**
Sand	1:1.5:3	Pass of 19 mm sieve
Cement		Fine
Aggregates		Pass of ¾ and retained of #4 sieve
	Intermediate layers	
Crushed aggregates	2”	Retained of ¾ sieve
Open graded asphalt	2”	OK
Chips seal stones	1”	OK
	Wearing surface	
JMF	2”	Class A

3. RESULTS:

In this section we check the performance ability of sample under different condition and different temperature. Any change in the samples under different loadings will also considered. Any pavement design based on two major test that is rutting and resilience modulus. Our mission is to analysis the rutting phenomenon and resilience modulus of the samples and discuss the behaviour of samples and to select the best design of CTB pavement.

3.1 DESIGN 1:

In design (1) we use 2" thick layer of each material is used respectively (wearing surface, open graded asphalt, cement treated base course).

3.1.1 RESULTS

Modulus of resilience (AASHTO T 342)

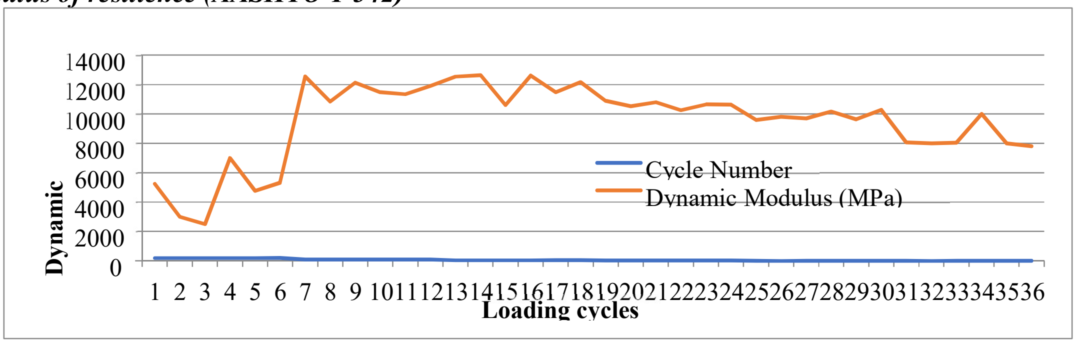

figure 1: Changing behavior of modulus resilience under different loadings

Figure shows the relation between loading cycles and dynamic modulus. The above graph shows that when No. of passes increases the value of dynamic modulus fluctuates at a certain limit and then shows a constant behavior. The maximum value of dynamic modulus is 12,500MPa.

3.1.2 RUT DEPTH (AASHTO T 324)

Rutting Depth

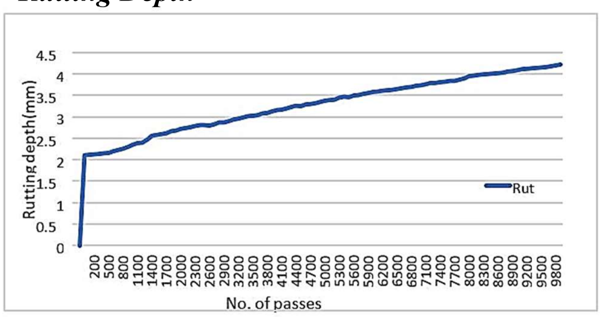

figure 2 : Analysis of rutting under different

Table 3: Comparison of Design 1

Comparison Between Modulus Of Resilience And Rut Depth		
	Modulus of resilience	**Rut depth**
Maximum	12500 MPA	4.1 mm
Minimum	8200 MPA	2.1 mm
Average	10350 MPA	3.16 mm

3.2 DESIGN 2

In design (2) we use 2" thick layer of each material is used respectively (wearing surface, crushed aggregates, cement treated base course).

3.2.1 RESULTS

Modulus of resilience (AASHTO T 342)

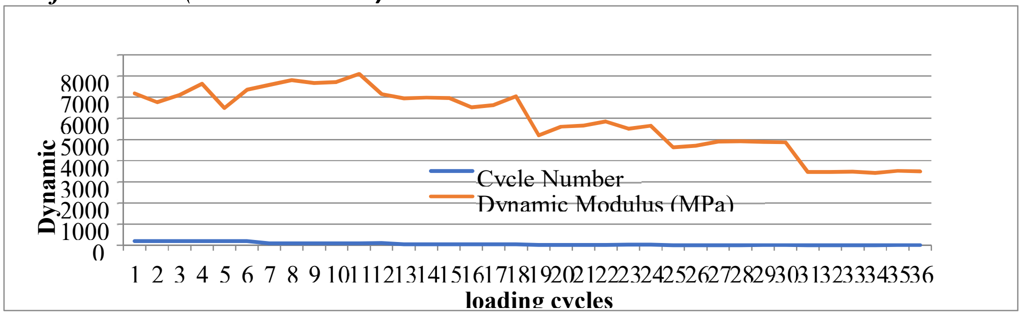

Figure 3: Changing behavior of modulus resilience under different loadings

The above graph shows that when No. of passes increases the value of dynamic modulus fluctuates at a certain limit and then shows a constant behavior. The maximum value of dynamic modulus is 8100MPa. (it is less than open graded asphalt).

3.2.2 RUT DEPTH (AASHTO T 324)

Rutting Depth

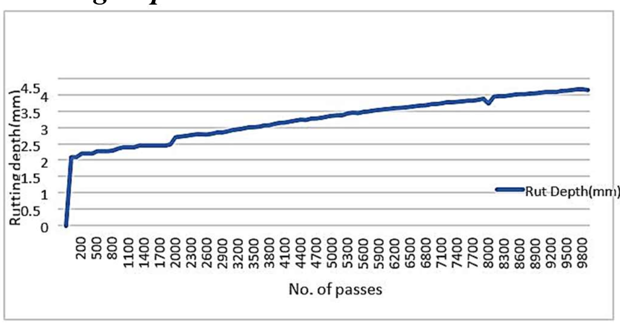

figure 4: Analysis of rutting under different passes

Table 4: Comparison of Design 2

Comparison Between Modulus Of Resilience And Rut Depth		
	Modulus of resilience	**Rut depth**
Maximum	8100 MPA	4.18 mm
Minimum	3800 MPA	2.2 mm
Average	5950 MPA	3.19 mm

3.3 DESIGN 3

In design (3) we use 2” thick layer of wearing surface, 1” thick layer of chip seal stones and 3” thick layer of cement treated base course respectively.

3.3.1 RESULTS

Modulus of resilience (AASHTO T 342

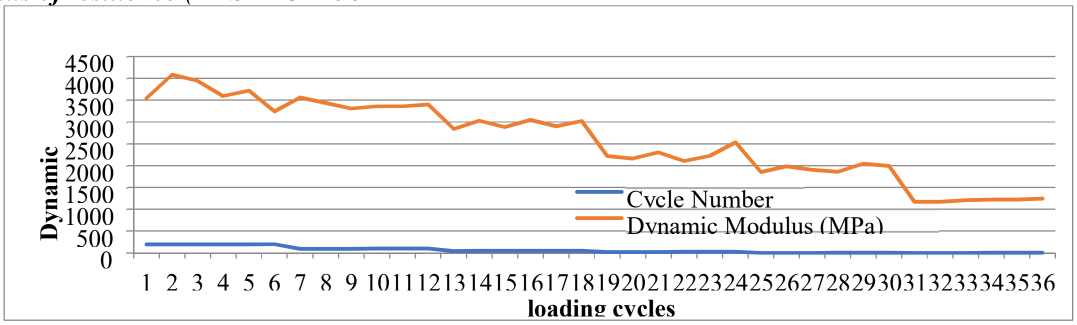

figure 5: Changing behaviour of modulus resilience under different loadings

The above graph shows that when No. of passes increases the value of dynamic modulus fluctuates at a certain limit and then shows a constant behavior. The graph shows that maximum value of dynamic modulus is 4100MPa. (it is less than open graded asphalt and crushed aggregate).

3.3.2 RUT Depth (AASHTO T 324)

Rutting Depth

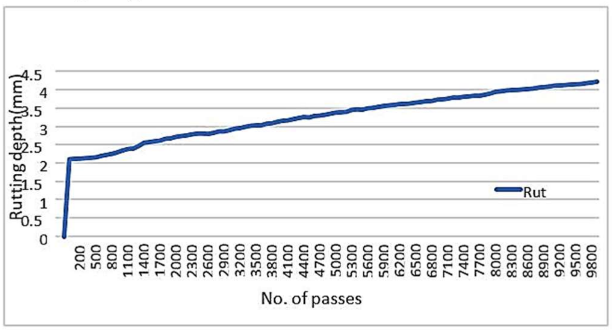

figure 6 :Analysis of rutting under different

Table 5: Comparison of Design 3

Comparison Between Modulus Of Resilience And Rut Depth		
	Modulus of resilience	**Rut depth**
Maximum	4100 MPA	4.22 mm
Minimum	1800 MPA	2.2 mm
Average	2950 MPA	3.21 mm

4. CONCLUSIONS:

Following conclusions can be drawn from the conducted study:

- According to upper discussion the design (1) has maximum value of M_R is almost 12,500 MPa & minimum value of M_R is 8,200 MPa. The maximum rut depth occurs in the design (1) is 4.1 mm & minimum rut depth is 2.1 mm. Hence the design (1) is best suitable among these three designs for CTB pavements as per AASHTO T 342.
- It is best suitable for those areas where fluctuations of ground water table occur because CTB pavement prevents the water to penetrate into the pavement as base course acts as barrier between subbase and wearing surface. Base course prevents the capillary movement of ground water table into wearing surface. Hence pavement remains safe from deteoration problems.
- This CTB design has resistance against heavy traffic loads as it has greater strength of M_R and low value of rutting, so this design can applicable for HTV.
- CTB pavement has several cost saving advantages over rigid pavement as it is long lasting life span.

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