Performance Review of Bituminous Pavements with Cement Treated Base

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Recently significant investment is being made in India on construction of road infrastructure. Ensuring long lasting roads is one of the key requirements for sustainable development. There are many challenges associated with construction of roads in India including high rainfall and heavy traffic load. Furthermore, scarcity of natural aggregate resources is a serious challenge these days, in fact, at many of the project locations, the lead distance for aggregates can be as high as 200-300 km, which increases cost of construction and overall delay in completion of the project.

Highway engineers have been adopting many innovative techniques to construct strong and durable roads, and to utilize marginal materials. One of such technologies is application of cement treated base (CTB) layer in pavements. The CTB layer has been used successfully worldwide for many decades, particularly in country like, South Africa, Europe, Australia, and US. Many of the states in US (particularly, Texas), have constructed miles of roads with CTB layer. Stabilization of subgrade soil or aggregate base can provide significant benefits in terms of utilization of marginal materials or improving strength of layer. Traffic volumes and loads are increasing significantly in India, which demands stronger pavements and durable materials. The stabilized base and sub-base can accomplish this objective to provide a stronger foundation to pavements along with economic benefits.

Recently there is momentum to use CTB base or sub-base layers for many Indian highways. Highway community in India is motivated to use this technique to ensure long lasting pavement with minimal maintenance cost. The flexible pavements with CTB are constructed in two ways, Type 1: laying bituminous layer directly on top of CTB, and Type 2: laying aggregate interlayer above CTB before placing bituminous layer. Type 2 pavements (with aggregate inlayer) is called inverted pavement. Both types of pavements have satisfactory for many years as reported in literature. While, Type 1 pavements are suitable for low volume traffic, Type 2 are more appropriate for heavy loaded road. The thin layer of bituminous mix acts as a membrane, which will be under compression under wheel load, and thus can survive for a long period. Such type of pavements is very popular in South Africa. The stronger base to bituminous layer is preferred to minimize tensile strain at bottom of this layer. However, a thin layer on a very stiff CTB can exhibit high shear stress in bituminous layer, and hence may cause top down cracking or rutting.

Application of CTB has numerous benefits (i) reduced bituminous layer thickness (ii) better performance under heavy traffic road (iii) better moisture resistant (iv) cost saving (v) utilization of marginal materials. Since CTB mix is composed of cementitious additives, it exhibits shrinkage and behavioural change with temperature and moisture variation. Usually shrinkage cracks in CTB layer may propagate above to top bituminous surface layers (called reflective cracking). Therefore, usually aggregate interlayer, geofabric or stress absorbing membrane interlayer (SAMI)
are used, most widely aggregate interlayer to delay reflective cracking. There are certain challenges associated with pavement having CTB layer. The strength of CTB changes over time. Presence of wider shrinkage cracks and fatigue damage may reduce modulus of CTB layer with time. Usually heavy damage to CTB can reduce this layer equivalent to granular layer, which may cause substantial fatigue damage and failure to pavements. Some of the challenges associated with CTB layer can be listed as:

- Methodology for mix design and strength parameter
- Selection of appropriate dosage of additive
- Type of additives, suitability for aggregates
- Consideration of strength parameters for pavement design
- Construction practice, machinery and curing
- Premature failure due to shrinkage and fatigue cracking, and long term durability
- Crack relief layer, design and performance
- Traffic movement over CTB
- Selection of modulus value for design

Design of a pavement with CTB layer is based on fatigue consideration. CTB mix with minimum unconfined compressive strength (UCS) of 4.5 to 7 MPa (7/28 days) is selected, while keeping durability requirements also a check. CTB with high value of UCS should not be targeted as it may create shrinkage crack. Usually shrinkage crack below 3 mm width may be allowed without any serious performance issue. The modulus of CTB layer is taken in range of 4000-5000 MPa for design of pavements, which is on conservative side considering reduction in strength of CTB due to hairline cracks or damage. The following common distresses are being reported on pavements with CTB layer.

- Bottom up cracking (reflection cracking) – failure of CTB
- Top down compressive fatigue (with stiff base) and thin bituminous
- Transverse cracking due to shrinkage of CTB
- Rutting in bituminous layer due to stiffer CTB
- Double or single ladder cracking in wheel path of CTB

Micro-cracking or pre-cracking technique is being used to control shrinkage cracking in CTB layer. Usually 2-4 passes of vibratory roller (at speed 5 km/h) are applied on CTB layer after 2-3 days of curing. This technique induces micro-cracks in CTB layer. These micro-cracks help to control wider shrinkage crack. Studies showed that initially micro-cracking technique may reduce modulus of CTB layer to 40%, however, with time, this layer gains strength, and can perform well without any performance issue. This technique is being validated in Texas and in some of European countries, and found to be successful. Sometimes delay in top surfacing can help to minimize reflection cracking. Also, a
proper curing of CTB layer is essential to minimize shrinkage crack. At least 7 days of curing is advised before placing other layers on top of CTB. Curing using emulsion tack coat is being considered effective for CTB layer. Further, compaction of CTB layer should be targeted below optimum moisture content (OMC). The CTB layer compacted above OMC, may exhibits more shrinkage cracks. Further, maximum size of aggregates is important. Larger size of aggregates will not only cause segregation issues but will also increases cracking potential of CTB layer. Further, aggregate interlayer should be compacted well to avoid any failure to bituminous layers. The CTB layer should be compacted in one layer. In case, two layers are recommended, then cement slurry be used to bond two layers. Further, second layer should not be stabilized using in-site technique, even if first layer was in-situ, to avoid damage. Also, minimum thickness of first layer should be 150 mm to support the construction vehicle.

Overall the presentation will summarize review of performance of CTB pavements constructed in different part of the world. In Texas, usually a thick bituminous layer is constructed directly on top of CTB. Though they have not seen major issues with such type of pavements, however, some of the pavement sections failed prematurely due to several reasons. This paper will throw lights on experience reported by researchers to ensure good performance of CTB pavements. The performance review of CTB pavement with and without interlayer will be presented. Many researchers suggested to use new test methods such as falling weight deflectometer (FWD), tube suction test (TST), ground penetrating radar (GPR), and wheel tracking to evaluate long term performance and durability of CTB mix. Further, recommendation will be made to strengthen current design or construction practise of CTB layer followed in India for durable and long lasting pavements.