INVERTED PAVEMENTS: AN OVERVIEW

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ABSTRACT

The goal in any pavement design and construction project is to produce a pavement that is durable and performs satisfactorily throughout its expected design life. Pavement design involves a procedure for choosing a pragmatic along with economical collaboration of substances of familiar power as well sufficient thickness to help the foreseen traffic beneath awaited environmental states. Pavements were coated structures of changing thickness along with features resting on subgrade soil. Engineering model of a pavement was relied on a presumption where every coat in the pavement had a less mentioned structural standard to aid as well as issue the superimposed loads. Inverted pavement structures were a creative pavement method evolved in South Africa in the 1970s. Inverted pavements constitutes of the same material components as those utilized in a traditional adaptable pavement however, the substance coats were rearranged [Shane Buchanan]. Unlike in a flexible pavement where the unbound aggregate base (UAB) layer was positioned on subgrade and thicker hot mix asphalt (HMA) layers were put on top, in an inverted pavement, a cement treated base (CTB) layer was put on the developed subgrade with the UAB coat put on top accompanied through HMA layers. The motivation behind increasing use of inverted pavement system is its ability to allow maximum use of the structural elements of UAB layers in association with a thin HMA coat as well as a CTB coat which gives an outstanding technique of attaining performance, economic savings as well as sustainability.

KEYWORDS: *Cement Treated Base, Inverted pavements, Reflective Cracking & Unbound Aggregate Base*

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INTRODUCTION

World-over transportation agencies and the road building sector were conventionally modelled as well as developed two pavement kinds, adaptable also firm. The selection of pavement was frequently relied upon a pavement type selection (PTS) procedure to decide the finest pavement alternative for a specific project. This procedure supports pavement engineers to determine the less expensive pavement type capable of supporting anticipated traffic beneath prevailing environmental states while providing safety along with driving ease. Depleting natural resources and large lead distance for transporting good quality aggregates to the site, pose a problem for large-scale highway construction projects. Local aggregates may not always conform to the material specification requirements. Thus, locally available weak/ marginal aggregates cannot be directly used for road construction purpose. However, there is a possibility that these marginal aggregates, in cemented form, may find its use as base/ sub-base layer of bituminous pavement. Suitably designed cemented base/ sub-base layer, may result in certain economy to the pavement design. Considering increasing scarcity of naturally available material, there is a strong need to encourage such technology. Since these bituminous pavements contain cemented layer as base/ sub-base layer, they may also be considered as one variety of composite pavements.

SCOPE

The scope of this paper is to highlight the possibility of inverted pavements as a definitive and more economical substitute to traditional pavements. Inverted pavements may effectively decrease the reliance of pavement building on good quality aggregates which are fast depleting natural resource and on thick bituminous layers while simultaneously providing a good standard pavement alternative for all traffic levels by utilizing the granular base as a key structural component. The various components of an inverted pavement, its utility, performance and advantages over the conventional flexible systems are discussed in this paper.

WHY INVERTED PAVEMENTS?

The requirement for enhanced road function, maximum utilization of resources, budget limitations, and energy effectiveness motivates the use and examination of substitute pavement systems. The adoption of a mixture pavement design, inclusive of cement treated sub-base/cement treated base course covered with a thinner bituminous layer of wearing course, reduces the overall quantity of material required and permits the use of lower quality aggregates. However, an inherent weakness in pavements of this design has been the development of cracks in the surface materials as reflections of transverse cracks in the stabilized base. In order to overcome this weakness, an “inverted” pavement design was introduced which includes a cushion of unbound granular substance among the stabilized base and the bituminous surfacing. This design was termed “inverted” because it reversed the traditional positions of the stabilized and unbound layers. Inverted base pavements include a well-compacted granular total base construct among thin hot mix asphalt coat as well as a cement-treated base. World over, inverted base pavements had been utilized as inexpensive and structurally competent pavement structures since the 1970's. Its design methodology highlights the significance of a better base, also involving novel establishment techniques along with attentive substance option to attain dense unbound total coats that show a capability to help the massive traffic loads beneath both dry and wet conditions. Optimal utilization of an unbound aggregate base in association with a thin hot mix asphalt coat as well as a cement treated base coat gives an outstanding technique of attaining performance, economic savings and sustainability [Shane Buchanan]. The optimally designed layer arrangement gives a good overall stiffness to the pavement structure while decreasing the chances of reflective cracking initiating from the cement treated base and propagating through the hot mix asphalt surfacing which was a most distressing aspect in semi-rigid pavement structures [Wang et al]. Inverted pavement affords following advantages [Sharma, Bhardwaj et al]:

- Blending of small and well-designed amount of cement content in granular layers greatly enhances their strength while decreasing the overall pavement thickness; including reduction in thickness of bituminous layer.
- The stress/ strain at the bottom of the bituminous layer decreases because of high stiffness value of the cemented layer. Thus, the fatigue life of the pavement is more as compared to conventional bituminous pavements.
- Due to reduction of vertical strain caused by relatively higher stiffness of the cemented layer, the permanent deformation (rutting) is reduced. High vertical strains are generally linked with increased possibility of rutting.
- The deflection of the pavement is reduced because of the presence of higher stiffness of cemented layer. Cement treated granular layers act like a slab structure resulting in uniform load distribution thereby making a strong layer in comparison to an untreated layer.
- Resilient modulus of the cement treated granular layer is higher as compared to the untreated granular layer and

gives stronger support.

- Cement treated base in an inverted pavement structure facilitates better compaction of the unbound aggregate base which prevents propagation of reflective cracking.
- Unlike in case of an untreated granular layer, cement treated base continues to gain strength with age even under traffic thereby maintaining the integrity of the specifications.
- Benefit of the base course layer is best utilized when it is placed near the surface where stresses are the highest. Inverted pavement moves the base to the top and improves its performance efficiency.
- The material cost of inverted pavements is lower than the conventional bituminous pavements. Use of local material reduces transportation cost of bringing good quality aggregates from far distances. However, use of binding material involves additional cost.

DISCUSSIONS

Inverted pavement formation was an optimistic substitute for attaining finest standards roads at significantly less expensive than traditional pavements. It consists of an unbound total foundation restricted by a firm cement-treated coat as well as a thin bituminous wearing coat. The thin bituminous layer shield and the closeness of the unbound total coat to the surface create the granular coat an evaluative structural component. The design of inverted pavement has developed in South Africa in the early 1970s and has been given different names including G1-Base, inverted base, Sandwich pavement, and upside-Down pavement [Douglas D. Cortes Arellaneda]. The substances utilized in an inverted pavement were identical to traditional adaptable pavements with the substance coats being rearranged [Shane Buchanan]. Unlike in a Flexible pavement system, where Unbound Aggregate Base (UAB) layer is placed on the subgrade and thicker Hot Mix Asphalt (HMA) coats were repositioned on top, in an inverted pavement a Cement Treated Base (CTB) layer is placed on the prepared subgrade with the UAB coat positioned on top accompanied through the HMA layers (Figure 1). The elements of the structure comprise of the succeeding [Shane Buchanan]:

- Thin HMA coat of about 2 inches.
- UAB layer of 6-8 inches, compacted to a least of 100 percent altered Proctor density.
- CTB layer of 6-12 inches with cement loading of nearly 4 percent.

Figure 1: Inverted Pavement Section.

Inverted pavement structures attain their working by pursuing benefit of the engineering elements of the different pavement coat substances. Every coat was positioned in its maximum place to function as well as attain good outcomes. A CTB coat positioned over a created subgrade gives a power, firm base on which the UAB coat is compacted. UAB is a very distinctive paving substance which becomes softer with raised loading. Since, UAB is a non-linear strain dependent layer its firmness or resilient modulus is higher when utilized in an inverted pavement in comparison with a traditional adaptable pavement structure as the foundation is nearer to the pavement surface where the strains were superior. In an inverted pavement the entire strain condition within the UAB can be 3 to 5 times greater than in a traditional adaptable system. In response to this raised strain condition, the UAB becomes harder.

Unlike traditional pavement segments that based on the upper firm coats to carry as well as spread the traffic loads, the unbound total inter-coat in an inverted base pavement acts as an important part in the mechanical response of the pavement system [Douglas D. Cortes and J Carlos Santamarina]. The unbound total substance elements are not the identical in an inverted pavement from that in traditional adaptable pavement systems. The total foundation in an inverted pavement may attain much greater density due to the help given through hard cement-treated foundation throughout compaction. Thus, the unbound total foundation in an inverted pavement structure shows greater firmness as well as lesser long-term firmness degradation than the total foundation in a traditional pavement [Douglas D Cortes and J Carlos Santamarina]. The thin bituminous concrete layer acts as a seal to prevent water ingress and provides a better riding surface whereas the unbound aggregate base acts as the main load distribution course and protects the cement-treated foundation and the subgrade. The cement-treated foundation serves as a rigid substrate for improved compaction of the unbound total base also provides stability for the unbound aggregate base layer [J Carlos Santamarina and Efthymios Papadopoulos].

While stabilized layer improves the structural capacity of the pavement by providing high overall pavement stiffness they also increase the possibility of reflective cracking resulting in accelerated pavement deterioration. Figure 2 shows the establishment of reflective splitting on the HMA due to cracks in the lower layer propagating into it while traffic load progress over these cracks and because of temperature difference. The strain concentration in the cover just above the prevailing splits was accountable for the aspect of split propagation during the cover. Cracks within cement treated base course are extended and tend to get reflected in the HMA surface layer because of traffic as well as temperature consequences, relying upon the measure of the strain applications at the edge of the split, defiance of the over substance to split propagation along with the features of the interface among the cover as well as the prevailing pavement [Jorge Pais]. Reflective cracks, when they become wide enough (greater than 6 mm width), may cause raised strain in the pavement in less load transport also thereby adversely affecting pavement performance. Factors contributing to the cracking and crack spacing in a cement treated base are material characterization which includes kind of soil, cement content, level of compaction and healing, construction procedure along with methodology adopted, nature also intensity of traffic loading as well as limitation inflicted on the foundation through subgrade. Methods of controlling reflective cracking include proper construction technique, compaction and adequate curing of the stabilised base, proper material selection, optimizing the mix design reduction of crack size by using "pre-cracking" and by providing stress relief layers within the pavement crust. A stone inter-coat may stop the propagation of reflective splits via stress dissipation within the unbound total coat [Rasoulia et al]. Maximum employment of the system elements of the UAB in association with a thin HMA coat and a CTB layer helps controlling reflective cracking while providing an outstanding technique of attaining function, economic savings (both initial and life cycle), and sustainability. Figure 3.

Figure 2: Reflective Cracking in Flexible Pavement with CTB Layer

Figure 3: Providing UAB Layer over CTB Layer to Prevent Reflection Cracking

CONCLUSIONS

Considering the recent trend of depleting natural resources, employ of innovative technologies need to be encouraged further. However, complete evaluation of such material in terms of engineering properties, performance and construction issues are important considerations. An innovative pavement design such as an inverted pavement has turned out to be economical, much stronger than the conventional bituminous pavements and useful in terms of employment of domestically accessible marginal totals.

The “inverted” pavement design was conceived as a possible method that would reduce or eliminate the transverse cracking in flexible pavement surfaces that develops as a reflection of transverse cracks in the underlying stabilized aggregate base. In the inverted design, an unbound layer of granular material, often used as a sub-base beneath the stabilized base, is placed between the bituminous surfacing and the stabilized base material to serve as a “cushion course” separating the surfacing and the stabilized base. This reverses or “inverts” the normal positions of these layers. Inverted pavement systems offer tremendous opportunities to finest use the inherent elements of the foundation substance to increase functioning at reduced cost by optimizing resources.

The entire end employ energy need of unbound “granular materials” or aggregates is nearly 80 percent lower than HMA or concrete. In comparison with adaptable systems, the entire energy requirement of an inverted pavement is lesser as an outcome of decreased HMA thickness and by employing foundation as well as CTB. When compared to a concrete pavement, the possible energy savings would be obtained by removing of the concrete pavement coat as well as substitution with an inverted structure.

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