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Potential of South African road technology for application in China

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HIGHLIGHTS

- The paper proposes adapting the South African approach for pavement design to China to overcome limitations and early distress.
- The design method incorporates a deep pavement which can support overloading, and a thin surfacing which has the required life and is easy to repair.
- The approach caters for the local environment as well as overloading.

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ABSTRACT

One of the main problems with roads and highways in China is the reflection cracking caused by the cement stabilized subbase layers passing through the overlying asphaltic layers. The cracks permit the ingress of moisture which softens the layers below the subbase resulting in loss of support and accelerated breakdown of the subbase layer and reduction in the riding quality. The aim of this paper is to present the use of South African pavement design approach of deep structure and thin surfacing to overcome the existing problems. The deep pavement structure provides good long-term support and avoids the influence of moisture ingress, which means that only surfacing damage needs to be repaired. An unbound crushed stone base layer which is an integral component of the pavement structure limits reflection cracking.

The paper first deals with the South African pavement design procedure and contrast this with the Chinese pavement design method. The inherent weaknesses of these methods are discussed and flowing from this discussion proposals for adapting the South African approach to China is presented. The resultant proposals have a high likelihood of success and will counteract the influences of extreme climate and rampant overloading that occurs on the Chinese roads.

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1. Introduction

One of the main problems with roads and highways in China is the reflection cracking caused by the cement stabilized subbase layers passing through the overlying asphaltic layers, as shown in Fig. 1. Shrinkage cracks are natural phenomenon when cemented materials hydrate and harden. The amount of cement defines the shrinkage; the more cement the more the shrinkage. Under the action of diurnal temperature cycles the cemented layers, even when covered by 20 cm of asphalt, will expand and contract. The resultant strains and stress concentration at the cracks together with heavy axle loading result in the transverse cracks reflecting through the asphalt. The cracks permit the ingress of moisture which softens the layers below the subbase resulting in loss of support and accelerated breakdown of the subbase layer and reduction in the riding quality.

The aim of this paper is to present the use of South African pavement design approach of deep structure and thin surfacing to overcome the existing problems. The deep pavement structure provides good long-term support and avoids the influence of moisture ingress, which means that only surfacing damage needs to be repaired. An unbound crushed stone base layer which is an integral component of the pavement structure limits reflection cracking. The paper first deals with the South African pavement design procedure and contrast this with the Chinese pavement design method. The inherent weaknesses of these methods are discussed and flowing from this discussion proposals for adapting the South African approach to China is presented.

2. The South African pavement design method

The South African pavement design guidelines are contained in a catalogue denoted as TRH4:1996 (Committee of State Road Authorities, 1996). This catalogue provides guidance for a range of traffic, base types and climatic zones. The catalogue is designed for equivalent 80 kN standard axles (E80) although the legal axle load is 9 tons. The traffic stream axle loads are converted to E80s by using a load equivalency exponent of 4.

Fig. 1 – Typical transverse reflection crack.

Fig. 2 shows the catalogue of pavement designs for crushed stone bases. Three designs are shown for 10 million, 30 million and 100 million E80s, as designs are in multiples of traffic of 3. The 100 million E80s design life is hardly found even on the heaviest trafficked South African roads.

It is interesting to note that the asphalt surfacing in all three cases are similar, ranging from 4 to 5 cm for the three designs. A SMA type grading with a modified binder is typically used. It has been found that bitumen rubber with more than 20% crumb rubber has high flexibility and long life. The SMA grading is a stone skeleton mix where the stone to stone contact limits rutting. The crushed stone base has a dense grading approximating the Fuller maximum density curve with less than 12% passing the 0.075 mm sieve and a maximum size of 37.5 mm. The crushed stone is obtained from unweathered rock. The only difference between the bases is that a higher density is required for the higher traffic loading. Density is measured in terms of the bulk density which relates to the solid density of the crushed material, and not in terms of a laboratory compaction test. The high density specification results in a material with 12%–16% voids which does not rut and has a high strength and a stiffness of about 500 MPa. The crushed stone has minimal tensile strength and for this reason reflection cracks do not pass through the base layer to the surfacing.

The subbase layer is cement stabilized with a maximum of 3% cement. The stabilized layer has a 7-day unconfined compressive strength of 1500 kPa. The cement is limited to reduce shrinkage and also for economic reasons. A suitable material that provides the strength has to be used. There is no merit in using a poor quality gravel and then try to obtain the strength by increasing the cement content. The cemented subbase is constructed in two layers, as it is difficult to compact 25 cm of material without breaking down the particles. The cemented layer provides a sound anvil on which the crushed stone can be compacted to achieve the high density.

Below the subbase the materials are checked to a depth of 100 cm from the surface, and if the subgrade material has a poor support with a CBR of less than 3 the pavement will receive at least 3 layers of 15 cm of selected material so that pavement has a deep support. The overall pavement depth is

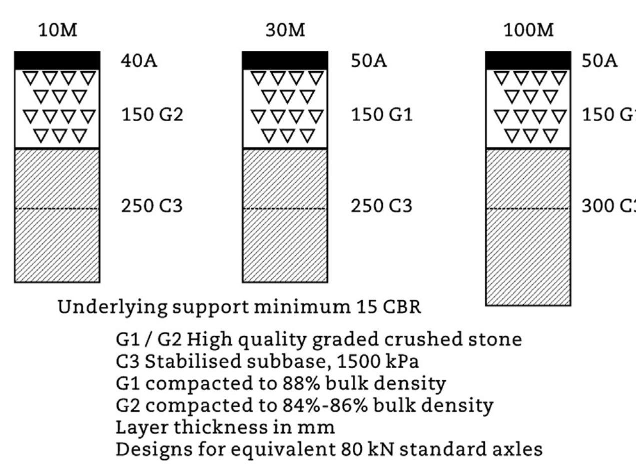

Fig. 2 – Pavement design according to South African TRH4:1996.