

The Optimization of Pavement Performance of the Semi-rigid Base

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Abstract: In recent years, the early damage phenomenon of semi-rigid base asphalt pavement has aroused our great attention for it, and all kinds of disputes are also our hot topics of mutual interest. This article based on the implementation of the Highway asphalt pavement design specification, from the design angle, analysis and further discusses the optimal design of the semi-rigid base, to make it play a bigger role in the construction of highway in our country.

Keywords: Semi-rigid base; Aggregate grading type; Interlayer combination design; Under-sealed layer

1. Introduction

Since the 80s, China's highway mileage increasing, with the rapid development of economy, and heavy traffic, overloading also puts forward higher requirements on high grade highway, therefore, Stable inorganic binder materials for base, asphalt concrete road surface of the semi-rigid base asphalt pavement is widely used in high grade highway pavement. Semi-rigid base, that is, in adding appropriate amount of pavement materials or other industry waste residues such as cement, lime and fly ash binder, adding water mixing to form mixture, after laying compaction and curing the formation of pavement base, also gradually become the main structure form of the base of high-grade highways. Viewing of the situation of high-grade highways' pavement in our country now, it is mainly composed of semi-rigid base asphalt pavement structure. At present in our country more than 90% of the high-grade highways' asphalt pavement base and subbase uses the semi-rigid materials.

From the road performance, the inorganic binder stabilized soil materials which is mainly composed of cement, lime has its unique advantages, such as compared with flexible base material with high intensity, large bearing capacity, good water stability, strong plate body; Inorganic binder stabilized soil materials are accessible, and can fully use of local sand materials; What's more, we can accumulated a lot of design and experience of construction using inorganic binder stabilized soil base in many years of use it. Therefore, semi-rigid base materials at present even a long period of time future will still dominate in road base materials in our country.

Compared with the previous base materials, although the semi-rigid base material has many advantages and broad prospects for the use of it, but it still appears some problems in the process of actual use of it, such as cracks, erosion, and the semi-rigid base asphalt pavement cracking phenomenon is very common, crack problem is very

serious. But the cement stability, stability of lime-ash semi-rigid base materials, can be very good to adapt to the current traffic conditions, natural conditions and economic conditions in China, which is an ideal choice. So through the system research of mechanical properties of semi-rigid base material and shrinkage characteristics, we can put forward effective measures of prevention and control, further improve its shortage, which is of great significance to highway construction in China.

2. The Problems of the Design of the Semi-rigid Base

2.1. The structure of aggregate is too single

Semi-rigid base is for the binder such as cement, lime and fly ash combined loose sand consolidation for whole construct of grassroots, in order to make it has the very good board and higher bearing capacity, in the past the design specification of either base or subbase material composition design have only a form of structure, namely the suspension - compact structure[1]. Because this structure is designed according to the principle of maximum density, belong to the continuous gradation, therefore, in the aggregate 2. 36 mm and below 0. 075 mm the fines is more, the structure of the permeability is very poor, if the material is still using this kind of structure form, when the generation between asphalt layer and semi-rigid base perched water, the tight coupling of semi-rigid base surface fine material under dynamic water pressure pump suction is susceptible to pumping slurry. At the same time under the repeated compaction, impact of vehicle load, it may be easy to loose, crush and lose stability as a whole[2].

2.2. Interlayer combination design was not enough

Semi-rigid base asphalt pavement is paved with different nature of the material, its strength and rigidity of layers,

drying shrinkage and other aspects of performance have very big difference. The design of the traditional method often only pay attention to the thickness of each layer, and ignore its interlayer combination design, leading to the integrity of the road is very poor, mutual slippage between layers, stagnant water, even reflection crack.

2.3. High cement dosage

In our country all previous specification, the deflection overall stiffness is done with design of the asphalt as control index. In the design of people in order to increase the strength and stiffness of grassroots, cement dosage is generally on the high side, mistakenly believe that the strength of the semi-rigid base, the higher the stiffness is larger, the road surface deflection will be small, and the actual situation is the opposite. This is because when the cement dosage increased, the modulus of resilience at the grassroots level also increased, modulus of resilience and asphalt layer generally less than the modulus of resilience of semi-rigid base materials, when the asphalt surface and semi-rigid base materials are continuous systems, most asphalt layers are under pressure or smaller tensile stress, and semi-rigid base are mainly subject to tensile stress. When the modulus ratio between the layers decreases, with the increase of asphalt layer shear stress, tensile stress at the grass-roots level also will increase, making the semi-rigid base easy to crack, this also is the reason that the strength and the stiffness of the semi-rigid base become greater, but the speed of road damage is fast in recent years.

3. Optimal Design of Semi-rigid Base

3.1. Mineral aggregate composition design

Pavement base of all kinds of requirements. Recent research results and practical experience shows that the performance of semi-rigid base is good or bad, not only with aggregate interlock each other at the grass-roots level, occlusion of internal friction and the cohesive force of inorganic cementing material, but also with the coarse aggregate distribution in the mixture. As the mineral mixture of 4.75 mm, 2.36 mm, 0.075 mm through decreases, especially 0.075 mm by decreases of semi-rigid base not only increase the strength, stiffness, and basic performance of crack resistance, resistance to erosion will have obvious improvement. Therefore, in order to seek the best mineral aggregate composition design. Specification according to the relationship between the volume of coarse aggregate after compaction and the space of compaction trend filling effect of fine aggregate, for the first time, classifies semi-rigid base mixture gradation as suspended-dense, skeleton-dense, skeleton-gap, evenly dense[3]. As shown in Figure1,2,3 and 4. Which suspended - dense refers to the coarse aggregate ($d > 4.75$ mm, same below) in the compacted mixture in a sus-

pending state, namely the pressure of the fine physical product is greater than the formation of coarse aggregate void volume; Skeleton - dense structure refers to the coarse aggregate skeleton in compacted mixture has a certain effect, namely the fine aggregate pressure entity product is less than the formation of coarse aggregate void volume; skeleton-gap structure refers to the coarse aggregate forming skeleton after compaction, fine aggregate pressure entity of product is less than the formation of coarse aggregate void volume; evenly dense refers to the lime and fly ash stabilized fine grained soils.

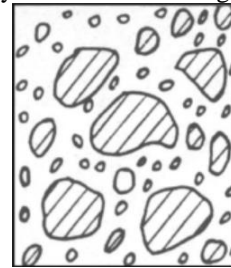


Figure 1. Suspended-dense

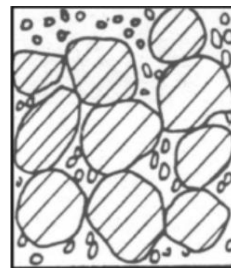


Figure 2. Skeleton-dense

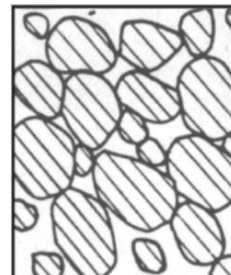


Figure 3. Skeleton-gap



Figure 4. Evenly dense

3.2. The design and the thickness of each layer design

Semi-rigid base asphalt pavement is composed of surface, base and subbase, cushion and so on, and it is the combination of multi-level structure, as shown in Figure 4. Asphalt covering only act a functional role in normal circumstances, base and subbase is the main bearing layer, and it should have enough strength, stiffness and stability, and cushion layer is the main drainage, water, antifreeze, etc. Under traffic load, the stress of asphalt pavement condition is very complex, it has have a close relationship with each structural layer of pavement structure combination, the stiffness and the type of work load and other factors, different thickness and different stiffness of pavement structure under the condition of different structure combination, can get the great stress and strain difference. Therefore, we must accord to the load and material strength and stiffness characteristics scientifically and design the combination of the pavement structure.

In terms of structure layer design, design specification is still use the pavement deflection as stiffness design index. Because the overall pavement deflection is reduce with the increase of the thickness of asphalt surface or at the grass-roots level; The stress and strain of wheel load on surface, are gradually decreasing with the increasing of the depth of the grassroots. Therefore, structural layers should be according to layer stress distribution characteristics of the various structural layers in the pavement structure, strength and stiffness characteristics of combination according to decreasing of top-down way. For the stiffness of the semi-rigid base should not be too big, the modulus ratio of the grass-roots level and the asphalt surface layer should locate in 1.5 ~ 3; Base and subbase modulus ratio should not be greater than 3.0; the modulus ratio of subbase and soil should locate in 2.5 ~ 12.5. For cement stabilized aggregate, cement dosage is 3% ~ 5% commonly, when strength can not meet the requirements, we should adjust gradation, and the maximum dose of cement should not be more than 6%.

In terms of thickness design, Specification corrected the design method of the thickness ($h < 15$ mm), 250 mm the semi-rigid base above 250 mm is divided into two layers, such can enhance the degree of compaction, but destroy the integrity of semi-rigid base, under the action of heavy truck, thin base will appear early cracking because of excessive tensile stress. Semi-rigid base, therefore, the minimum thickness of compaction is not less than 150 mm; Base and subbase layer paving compaction thickness should be 180 ~ 200 mm; Minimum highway asphalt layer thickness is 120 mm; The minimum level of road asphalt layer thickness is 100 mm.

4. The Structure Combination Design Among Layers

Semi-rigid base asphalt pavement is paved with different nature of the material, in order to enhance the continuity between the various structural layers, the following technical measures in the interlayer combination should be taken:

- (1) Set up stress absorbing membrane modified asphalt or stress absorbed layer on the semi-rigid base.
- (2) Set up under-sealed layer on the semi-rigid base layer Under-sealed layer is a single asphalt surface treatment on the surface of the semi-rigid base, or lay a layer of sand type, fine grained type dense gradation asphalt mixture, it is not only beneficial to combine, but also can protect the grass-roots construction from vehicle damage, and it is helpful for semi-rigid materials keeping in good health, and can prevent the rain infiltration to the grass-roots structure layer.
- (3) Set up gravel or grading macadam flexible base on the semi-rigid base
- (4) Through the application of penetrate-layer oil and tack coat[4].

5. Conclusion

Semi-rigid base develop with our country highway construction and development, its application and popularization not only conforms to the basic national conditions of the highway construction in our country, but also has made a tremendous contribution to the development of the asphalt surface for our country. In recent years, with the rapid development of highway construction, traditional design method of semi-rigid base has been difficult to adapt to the demands of the development of modern highway construction in the practical work, we should be in a new specification for design of highway asphalt pavement as the criterion, closely combined with the construction practice, the thorough analysis, optimization design, make the semi-rigid base in our country play a more important role in the construction of high-grade highway.

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