

# A Review of Interlayer Contact Studies on Pavement Structures

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## Abstract

With the rapid development of China's economy, the transportation industry is also developing rapidly, people's requirements for road construction are gradually rising, the research of pavement interlayer contact has an important impact on the pavement structure design, so in order to design a higher pavement structural performance, the research of pavement interlayer contact is essential. In this paper, through consulting the relevant literature at home and abroad, the research on the pavement interlayer contact is reviewed, mainly from four aspects: firstly, the development process of the research on the pavement interlayer contact at home and abroad is introduced; Then, from the relevant literature, it summarizes and classifies the relevant research methods, and analyzes the characteristics, advantages and disadvantages of each research method; Then, it introduces the practical application analysis of pavement interlayer contact in pavement structure; Finally, it summarizes the research content of pavement interlayer contact, analyzes the research significance of pavement interlayer contact and the current situation of practical application research. It provides some reference and corresponding inspiration for the future research of pavement interlayer contact.

## Keywords

Pavement; Interlayer Contact; Research Method; Pavement Structure.

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## 1. Introduction

With the rapid development of China's economy, the transportation industry is also developing rapidly, people's requirements for road construction are gradually rising, and pavement structure design is an important part of road construction, so there are higher requirements for pavement structure design. There are many factors that affect the performance of pavement structure, in addition to the properties and strength of many surface materials that have been studied, in fact, the contact state between the layers also has a very important impact on the design of pavement structure. According to relevant studies, the degree of bonding between each structural layer affects the stress distribution and shear stress distribution of each structural layer, as well as the fatigue performance and service life of the road surface. It can be seen that the contact between layers of pavement has an important influence on the design of pavement structure, and is an important technical parameter of pavement structure design. China's current asphalt pavement design specification standards mostly use the elastic layered mechanical system model, the basic assumption is that the object is continuous, first elastic, uniform and isotropic, that is, the contact between the layers is continuous, obviously, in actual life, the contact between the layers is complex and changeable, which is very different from the actual project. In order to solve this phenomenon, the research is mainly through a variety of mechanical and mathematical knowledge, as far as possible to establish a realistic pavement structure model, interlayer contact and pavement structural performance research for the accurate establishment of various pavement structure has an important relationship.

However, with the continuous deepening of the research on interlayer contact of asphalt pavement, we can find that there are still many problems that have not been effectively solved, first of all, the

reasons for the change in the contact state between layers cannot be accurately determined; when the evolution and characterization of the contact state between layers are carried out, it is impossible to quantify and represent them with accurate indicators.

## 2. Interlayer Contact Development Studies

The topic of interlayer contact has been mentioned a long time ago, this concept was first proposed at the first international pavement structure design conference held in 1962, M. R [1] et al. in this process, proposed changes in the contact state between layers, can change the stress distribution in the pavement structural layer, viscosity reduction will affect the ability of the pavement structural layer to withstand loads, interlayer bonding has a greater impact on the asphalt pavement structural layer, and since then countries have a strong interest in the study of the contact state between the pavement layers. Began to study the interaction relationship between road structures in contact states between different pavement layers. After consulting the relevant research literature, the research process of contact between road layers can be divided into three stages: identification stage, research stage and application stage, which should be noted that from the 60s to the 70s, scientists have conducted a preliminary conceptual understanding and analysis of the contact state between the layers of the pavement structure, and implemented the scientific research stage; after the 70s, various research methods began to emerge, the first research method was experimental research methods, followed by the rapid development of science and technology. There are also more and more research based on computer software; due to the continuous research and development of software, in recent years, scientists have combined hierarchical contact with application, using different coefficients to determine the state of hierarchical contact and began to conduct practical application research on the interaction of different levels.

In foreign countries, the first study on the interlayer viscosity problem is to analyze the effect of interlayer deformation on the change of interlayer cutting resistance mode [2], which is based on BISAR software, which shows that in the process of interlayer bonding state from complete continuous to complete sliding, different degrees of bonding have a great impact on the stress strain of the pavement structure. In order to simulate and analyze the interaction between the road surface structure and the contact between the pavement layers, F.A. HASSAN[3] and others used BASAR and finite element programs to simulate and analyze the interlayer contact of the pavement structure: poor adhesion between the base layer and the subgrade will reduce the service life of the pavement by about 80%; When the base layer and subgrade are well bonded, poor adhesion between any other layers will lead to a 40% reduction in the service life of the pavement, and the horizontal force will have a greater impact on the strength between the layers.

In China, the study of the mechanical response of pavement based on interlayer contact started late, and the early stage was mainly studied from the aspects of material properties, gradation structure, pavement structure, etc., and there was less research on the contact of each structural layer. In domestic studies, the earliest study of the contact state between layers appeared in 1989. Guan Changyu [4] et al. measured the shear strength and bond coefficient through indoor experiments, and analyzed the interlayer contact research method of the influencing factors of the bond coefficient. Subsequently, based on more and more research in this direction, Xie Liping et al. used three different pavement interlayer contact methods to study its influence on cement stabilization crushing fatigue, and their research results showed that the fatigue performance of cement stabilized crushing stone was proportional to the adhesion between layers. Luo Min [5] et al. used BISAR finite element software to study the influence of interlayer contact on its shear stress under standard design conditions and heavy-duty high-temperature working conditions, and concluded that under the high temperature of heavy load, the interlayer bonding effect has a greater impact on the shear stress of the asphalt layer, and the improper setting of interlayer bonding is improper, and it is easy to cause the degradation of road surface structural performance. Zhao Yanling et al. [6] Through abqus finite element software, the bending value, horizontal tensile stress and shear stress distribution law of asphalt pavement under different states of interlayer bonding state are analyzed, and the results show

that poor interlayer contact can easily induce vertical deformation, cracks, ruts and other diseases of pavement structure, because the pavement interlayer contact conditions are reasonably set to improve the performance of the road pavement structure.

### **3. Factors Influencing Interlayer Contact**

The contact between the pavement layers of the actual road is very complex, and the change of the contact type between the layers is affected by the different surrounding environments, and after consulting the literature on the relevant influences, the following influencing factors are analyzed.

#### **3.1 Temperature**

Effects of temperature. Temperature has a great impact on the strength of the pavement structure, not only on the stress distribution and strain distribution of the road surface layer, but also on the contact bonding of the road surface layer. According to relevant studies, under the condition of high temperature, the tensile ability of asphalt will decrease significantly, the strain will increase significantly, and it is very easy to cause damage to the pavement; under the action of temperature change, the cement concrete pavement surface layer will cause the relative displacement between the layer and the base layer and lead to the problem of contact damage between the layers.

#### **3.2 Effects of Water**

The influence of water on the contact between the layers of the road surface is very large. The main way is to cause corresponding damage by invading the pavement structure, and according to its influence mode, the main can be divided into two types: adhesion damage and cohesion damage. Moisture intrusion into pavement material leads to a decrease in material strength, causing material structure cracking and forming adhesion damage; moisture invades the structural layer and causes the bonding of pavement material and binder to decrease, making the interlayer bond unstable and forming adhesion damage.

#### **3.3 Load**

Effects of loads. Load action is the main cause of road deformation and the main cause of road rutting damage. In pavement design, the material properties of each structural layer are different, so the contact connection of each layer is the weakest place of force. Under the long-term action of vehicle load, the contact state of the structural layer will change, which will affect the force performance of the road surface structure. Luo Yaofei [7] established the coupling effect of vehicle overload and contact smooth state between the base-surface layer, and found that the evaluation index in the asphalt pavement structure changed significantly, and proved that under the condition of overload, the interlayer contact conditions will gradually deteriorate, resulting in an increase in the probability of disease on the pavement and a serious shortening of the service life.

### **4. Research Methodology**

Due to the fact that the contact state between layers is subject to external influence conditions and its characterization indicators are relatively vague, the study of the contact state between layers is mainly through experimental research, which can clearly and intuitively analyze the influence relationship between pavement structure and interlayer contact. However, with the rapid development of computer technology, computer numerical simulation analysis has gradually emerged, which is also widely used in pavement interlayer contact analysis due to its rapid calculation, small cost and convenient simulation of the contact between different pavement layers.

#### **4.1 Traditional Experimental Methods**

The traditional research method is mainly to evaluate and analyze the contact state between the layers of the pavement through the [8] straight shear, twist shear, pull and other tests. The research idea of many scholars is to carry out the corresponding test methods and testers according to their own

research needs, and then evaluate and analyze the impact of interlayer contact according to the test results.

#### 4.2 Computer Software Research Methods

Finite element software research methods have a great application in numerical simulation, its cost base, large amount of calculation, and can simulate the analysis of various pavement conditions, which is a good research method for scientific researchers, and many scientific research papers are also based on these finite element software on the basis of corresponding mechanical response analysis and impact analysis. The following is a corresponding classification and summary analysis of the principles, methods and applicability of the corresponding finite element numerical analysis according to the literature [9, 11] consulted.

**Table 1.** Comparative Analysis of various finite element software

Numble	Name	Research principles	Conditions apply
1	BISAR	Based on the theory of elastic layered system	The pavement structure is set to be completely continuous or partially continuous between layers
2	MICHPAVE	Axisymmetric finite element method	Directly view the complete continuity between the structural layers
3	EverStressFEV	Three-dimensional finite element method	The contact between the layers of the pavement is completely continuous, or partially continuous

### 5. Practical Application of Interlayer Contact

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#### 5.1 Practical Application of Interlayer Contact

In asphalt paving studies, due to differences in material properties or surface layering between different structural layers, the situation from complete contact to complete slip may be different, and it is often difficult to achieve complete continuous contact between the layers, indicating that the interaction between these layers has a very strong impact on the pavement structure. Due to differences in materials and buildings, as well as due to advances in technology, it is difficult to achieve the ideal continuous state of layering, and it is difficult to achieve the ideal state between the asphalt layer and the old asphalt layer, and it is not clear how the interaction between the layers affects the structure of the asphalt and coating.

There is also a lot of research on this issue in China. BISAR developed by Zhu Jun [12] et al. for computational purposes: Under the condition that the contact state between layers of the road surface is missing, such as road surface bending, tension and surface displacement, there will be unfavorable stress states, and it is also explained that the shear stress between layers should become a benchmark or control index in the road surface design. Zhang Jiupeng [13] et al. used shear elastic flexibility in BISAR to characterize the contact state between layers to represent the shear elasticity between the ground layers and the interaction between them, and concluded that when the asphalt between the base layers is continuous, the asphalt stress is mainly pressure, when the interlayer conditions become slip, the road structure state is the tensile state, and the actual tensile stress between the basic layers has a great mutation, Zhao Xiaohui [14] and others used ANSYS to conduct numerical simulations of the asphalt pavement in contact with each layer. The comparison of the contact model and the continuous model with the mechanical response of the asphalt pavement shows that the role of the model is closer to the actual pavement force. By simulating the mechanical response of the asphalt pavement structure contact model under different interlayer contact states, it is obtained that poor

contact will significantly improve the bending and sinking of the pavement, the maximum principal stress at the bottom of the layer and the maximum shear stress, which has a greater impact on all indicators of the asphalt pavement.

In summary, the following [15] analysis can be obtained: when the contact between the layers of the pavement is completely smooth, the vertical deformation of the pavement is an unfavorable force state, and the contact state between the layers has a significant impact on the use life of the pavement; in the case of poor contact between the layers, the tensile stress of the pavement will be mutated compared with the tensile stress state of the actual old pavement, resulting in an unfavorable stress state of the pavement structure; when the interlayer contact is poor, the horizontal force coefficient becomes larger, which will significantly increase the shear stress of the pavement. It is very easy to cause lateral cracks in the paved road.

## 6. Conclusion

Most of today's pavement structure design specifications still apply the theory of layered elastic systems, which basically assumes that the object is continuous, linear elastic, uniform and isotropic, and the deformation is small, but this is very different from the actual situation of the road. In the actual pavement structure design, the contact state between the layers of the structure is very complex, and there is an important relationship between the pavement structure materials and the surrounding road environment. The quality of the contact between the layers of the road surface directly affects the performance of the pavement structure: if the bonding strength between the pavement layers is not enough, it will lead to the slip and deformation of the various structures of the road surface, affecting the strength of the structural layers and causing damage to the pavement structure. Therefore, the study of the influencing factors and mechanical response of the interlayer contact of the pavement structure can provide reliable reference significance for the design of the road pavement structural layer, and some ideas for the improvement of the interlayer contact between the pavement structural layers of the construction.

In this paper, through the review of relevant literature, the following three aspects are mainly reviewed for the contact between pavement layers:

- 1) Introduced the literature research at home and abroad on the contact between the pavement layers, from the origin and development process of foreign interlayer contact, the development state of the interlayer contact of the pavement was classified into 3 stages: the understanding stage, the research stage, and the application stage, and the corresponding review and analysis were carried out; the relevant research literature on the interlayer contact of the pavement was studied in China, and then a simple analysis was made of the development trend of such research in China: from the experimental research - computer finite element research - computer and experimental combined research.
- 2) The relevant research literature was consulted, and the research methods of the literature were classified and analyzed from the two aspects of traditional experiments and computer finite element simulation. In the traditional test, the relevant contents of the instruments, research principles and conditions of use of straight shear, pulling and two test methods are introduced, and the application of the four software of the computer finite element software is introduced, and the corresponding exposition and analysis are made from the research theoretical basis, the applicable conditions of the structural layer, and the advantages and disadvantages of the software.

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