

**Study on structural characteristics of assembled pre-stressed concrete
pavement of airport**

Jianbo Zheng^a

Binzhou University, Binzhou, 256600, China

^azjb2006@163.com

Abstract: The structural characteristics and application advantages of assembled composite pavement are described. According to the structural characteristics, stress characteristics and mechanical distribution of the section steel pre-stressed concrete fast pavement structure, the boundary condition and the pre-stressed reinforcement model are simplified. Based on the theory of Kerr elastic foundation and the theory of small deflection plate, a theoretical analysis model of composite structure is established, which lays a theoretical foundation for subsequent numerical analysis and experimental research.

Keywords: pre-stressed concrete, section steel, airport pavement, mechanical model.

1. INTRODUCTION

The assembled pavement is a special pavement structure. There are extensive applications in the temporary traffic demand, emergency rescue and emergency relief, airport expansion and military field airport. There are also many kinds of materials and structural forms. Composite structure is the combination of all kinds of heterosexual materials to form a regular overall structure, which improves the mechanical properties of single material or gets the properties that a single material does not own, thus forming a combined form that can bear external force and meet the needs of use. [1].

The steel reinforced concrete composite structure system is a structural system gradually developed under the premise of making full use of the mechanical superiority of the steel structure and the material characteristics of the concrete material. Section steel has higher flexural strength, good toughness and connectedness, making composite structure able to withstand high bending load and vibration load, and has convenient construction connection performance. [2] For its high bending stiffness and good environmental performance, pre-stressed concrete structure can maintain strong structural stability and get better durability. With the combination of the above two kinds of materials or structures, we can give full play to the performance advantages of two kinds of materials and structures of steel and pre-stressed concrete, so as to get better comprehensive technical and economic effects.

2. CHARACTERISTICS OF COMPOSITE STRUCTURE OF STEEL REINFORCED CONCRETE

Steel reinforced concrete composite structure has high bearing capacity, small section size, high utilization of space, the larger the ductility of the structure and other advantages; compared with the steel structure, steel also has less stability and strong integrity, high durability, low cost and economic advantages.

Type of steel pre-stressed concrete composite pavement has the advantages of simple structure, fast refers to the outer steel frame for permanent formwork with pre-stressed tendons inside, steel frame is welded with cement concrete slab joints, the same type, mass, pre-production and shipped to the construction site, and the connecting piece by assembling the rigid plate unit four, rapid paving after simple natural subgrade compaction or through a simple processing base, forming a temporary road for vehicles or for aircraft surface. The combination of steel and pre-stressed concrete rapid pavement structure is applied to airport expansion and reconstruction, navigation airport construction, emergency rescue operation and construction of military field airports, which has the following advantages:

The economic cost is low, the technical difficulty is small, the bearing capacity is high, the environmental adaptability is strong and so on.

It can be quickly installed, installed in different places, used repeatedly, and can be reused in airport expansion or emergency rescue operation.

The load carrying capacity of the plate element is strong, the overall performance of the pavement slab is good, and the bearing capacity and the anti-deformation ability of the structure are improved.

The application of pre-stress can make the material form a whole, greatly improve the bearing capacity of the composite pavement structure and enhance the durability of the pavement structure.

The requirement of the pavement structure to the base condition is not high, which is suitable for the weak foundation condition.

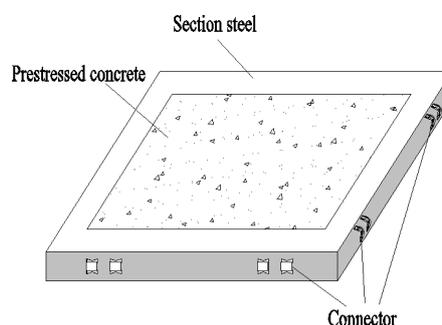


Figure 1. Type of steel prestressed track panel unit structure

The small size pre-stressed pavement structure and the steel frame structure combination have the mechanical characteristics of independent plates and multiple plates implicated in each other, and the mechanical process and stress-strain state are quite complex. [3].

3. STRUCTURAL FORM OF COMPOSITE PAVEMENT OF TYPE STEEL AND PRE-STRESSED CONCRETE

3.1 Pre-stressed precast concrete plate

The prefabricated concrete pavement slab structure of the airport is pre-manufactured by the factory according to the specifications, sizes and actual requirements, and is directly spliced on the grass roots to form the airport concrete pavement.

The pre-stressed pavement design can effectively reduce the thickness, reduce the cost and weight, increase pavement durability, because of its special tectonic plate so that it can be directly in the soil or soil surface area on the flight area directly paved in airport construction, not only increase the bearing capacity of pavement, and the rapid construction of small environmental impact. [4]

For the fabricated pavement structure can be quickly assembled and installed in different places, it can achieve rapid construction of pavement structure, reduce interference to airport prototype and environmental pollution, and is very conducive to the safe operation of airports. Environmental improvement;

In addition, the plate assembled pre-stressed concrete pavement structure can achieve rapid replacement, and is more convenient for timely maintenance, so that the integrity of pavement structure is more easily guaranteed.

Considering the wide application prospects of small-size pre-stressed precast pavement in airport engineering, it is necessary to further study its mechanical behavior, especially to further improve its structure and structure, so as to get better technical and economic effects. [5]

3.2 Composite structure of steel frame

The composite structure of steel frame is to use the advantages of steel structure and its components, such as high strength, strong bearing capacity, various shapes and good stability, to make the structural form needed to enhance the bearing capacity and durability of the structure.

A steel frame structure is used to enhance the stability of the plate body, the plate body part to play their respective advantages, to complete the requirements of structure; on the other hand can make the steel frame structure unit as a whole, so that Each unit can play a synergistic effect, a joint bearing, and a common force. The steel frame structure has high flexural strength and toughness, and excellent connectivity, which makes the composite structure have better structural stability. [6]

The mechanical transfer between plates depends mainly on the force effect of the connector. It is difficult to obtain uniform and coordinated deformation effect if the former pull rod or shear bar is used. It is necessary to study the joint structure that can transmit the load evenly between the plates and have good resilient resilience. Because the connection mode plays a key role in the overall stability of the structure, it is necessary to study the stress state and deformation behavior of the connector.

3.3 Fast loading and dismantling surface of steel pre-stressed concrete

The fast loading and disassembling surface of steel and pre-stressed concrete is a structural form composed of pre-stressed concrete structure and steel concrete structure. The stress and strain behavior of the outsourced steel structure is easier to be analyzed and calculated. The existence of pre-stressed concrete and its internal reinforcement significantly improves the bearing capacity and stiffness of the pavement structure, and the mechanical properties are complex.

Prefabricated pre-stress force panel advantage is that before the plate subjected to loads, most of the concrete structure is pre-pressed state, deformation and reverse force under the pre-deformation, can use phase offset part of the force deformation of the pre deformation, the tensile stress decreases from the load. [7] These effects make the road panel can in order to meet the requirements of the bearing capacity and stiffness, can significantly reduce the thickness of pavement structure.

The existence of the steel frame and its surrounding connections enables the prefabricated single board structural units to be effectively connected to a whole. When load is applied, the stress of the pavement slab is not only a single plate to bear the load independently, but also transfers the partial load effect to other surrounding plates by connecting parts, so as to achieve better effect of multi plate joint load bearing and coordinated deformation. This can not only improve the bearing capacity of the plate significantly, but also avoid the bad phenomena such as the dislocation of the joint at the joint of the single plate. The existence of pre-stressed technology can largely delay the occurrence of cracks in pavement structure, and even do not appear cracks, thus improving the bearing capacity and stiffness requirements of steel reinforced pre-stressed concrete fast combined pavement panels.

The single plate structure with the same thickness and the same plane characteristic size is assembled into the whole plate through the connection piece. The pavement panel can maintain continuity and smoothness of the plate body and form the effect of fast pavement. [8].

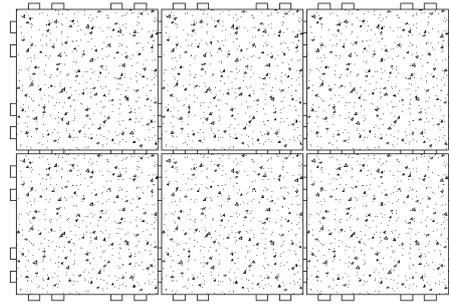


Figure 2. Six plate composite pavement structure

4. MECHANICAL MODEL OF ASSEMBLED PAVEMENT SURFACE

The type steel pre-stressed concrete composite pavement panel unit is made up of the combination of the steel, the pre-stressed reinforcement and the concrete. Considering the influence of the surrounding steel border, it is regarded as a single plate structure, that is, the rigid pavement slab structure. The bending problem of a rectangular plate on four sides of the Winkler elastic foundation is analyzed.

4.1 Simplification of mechanical model of steel bar

The mechanical analysis of pre-stressed pavement, considering only the size of the bearing capacity of reinforced slab with reinforced; model can be used to form the overall model of steel and concrete is considered as a composite material, equivalent elastic matrix analysis of pavement mechanics. [9] D refers to the equivalent elastic matrix of the channel panel.

$$[D] = [D_c] + [D_s] \quad (1)$$

Where, $[D_c]$ is the stress and strain matrix of concrete, which does not consider the cracking of concrete, and is calculated as the general homogeneous body.

$$[D_c] = \begin{pmatrix} D_1 & D_2 & D_2 & 0 & 0 & 0 \\ & D_1 & D_2 & 0 & 0 & 0 \\ & & D_1 & 0 & 0 & 0 \\ & & & D_3 & 0 & 0 \\ & & & & D_3 & 0 \\ & & & & & D_3 \end{pmatrix} \quad (2)$$

In which, $D_1 = \frac{E_c(1-\mu)}{(1+\mu)(1-2\mu)}$, $D_2 = \frac{\mu \cdot E_c}{(1+\mu)(1-2\mu)}$, $D_3 = \frac{E_c}{2(1+\mu)}$; E_c is elastic modulus of concrete, μ is concrete Poisson ratio.

For the equivalent steel bar, the stress strain matrix D_s can be calculated by the press formula:

$$[D_s] = E_s \begin{pmatrix} \rho_x & D_2 & D_2 & 0 & 0 & 0 \\ & \rho_y & D_2 & 0 & 0 & 0 \\ & & \rho_z & 0 & 0 & 0 \\ & & & 0 & 0 & 0 \\ & & & & 0 & 0 \\ & & & & & 0 \end{pmatrix} \quad (3)$$

In which, E_s is elastic modulus of steel; ρ_x , ρ_y , ρ_z are the rate of reinforcement in the direction of X, Y, and Z respectively.

4.2 Simplification and assumption of plate boundary conditions

The composite pavement structure of steel pre-stressed concrete is composed of multiple blocks, and there is a complex linkage effect between different blocks. For the existence of rigid connecting structures between plates, the plates are constrained and integrated into each other.

In the initial stage of the channel loading, the single plate structure can be considered as a four-side free road surface structure in a short and small deformation range. Plate elements are displaced under load. Because of the rotation of surrounding structures, there is almost no constraint on unit plates. It can be regarded as the first stage of boundary conditions of plate units, that is, the free boundary stage.

After a certain displacement of the slab element, a certain stress action will be produced between the plates. The joints between the plates are in the stage of no free deformation. At this point, the boundary condition of the plate will change, and it is no longer the stage of free deformation. The stress and deformation around the plate are constrained by the surrounding connections, which are considered as a constraint state of the simple support of the four sides. Under such constraints, the stress around the edge of the plate is in stress state, and the pavement structure has also changed. Therefore, it is necessary to reconsider the mechanical model of the pavement structure, which is the second stage of the boundary condition of the plate element. It is defined as a simply supported boundary. [10].

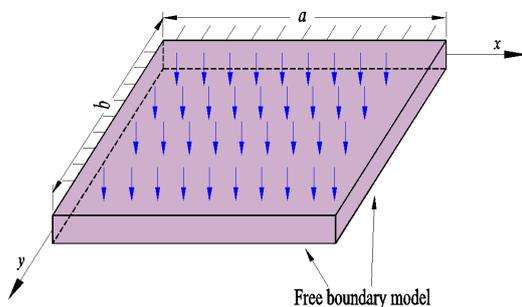


Figure 3. Free boundary model

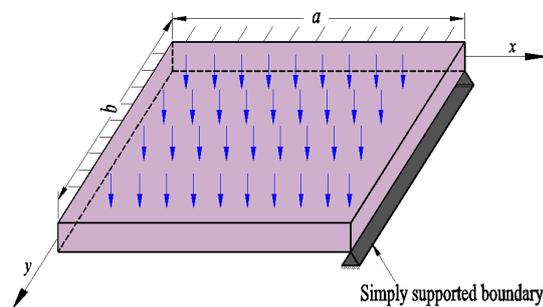


Figure 4. Simply supported boundary

The mechanical properties and displacement changes of the boundary conditions are similar to that of the articulated boundary. Although the two boundary conditions are different from

the actual state of the pavement plate, it can also simulate the mechanical behavior state of the fast combination pavement structure under load.

5. CONCLUSION

According to the structural characteristics, stress characteristics and mechanical distribution of the section steel pre-stressed concrete fast pavement structure, the boundary condition and the pre-stressed reinforcement model are simplified. Based on the theory of Kerr elastic foundation and the theory of small deflection plate, a theoretical analysis model of composite structure is established, which lays a theoretical foundation for subsequent numerical analysis and experimental research.

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