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Study on Mechanical Properties of Airport Fast Assembly Pavement Structure Adapted to Soft Foundation

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Abstract

Fast assembly pavement structure has the characteristics of factory prefabrication, on-site fast assembly and demolition, which can meet the needs of airport reconstruction and expansion or emergency relief.In order to ensure the function and reliability of pavement, the bearing capacity of pavement under different foundation conditions and service load conditions with different plate structures and scales is discussed.Based on the finite element analysis software ABAQUS, the physical and mechanical behaviors of pavement under different soft foundation conditions and service load conditions are discussed, and the main influence parameters and specific influence rules of the load effect of the fast composite pavement are obtained.

Keywords

Airport assembly pavement, Mechanical properties, ABAQUS, Soft foundation.

1. Introduction

Due to the influence of various environmental factors, a large number of runway, taxiway, linkway, apron and other pavement facilities in the airfield runway project are suffering from more and more serious diseases, and their bearing capacity is also declining, resulting in the pavement structure operating with diseases, which has become a major threat to the safe operation of the airport.It is necessary to seek airport pavement operation during airport reconstruction and expansion by building temporary alternative pavement structure under the condition of airport construction without suspension of navigation, and the temporary pavement structure must be removed after use for a period of time and restored to bare soil, lawn and other non pavement structures.In order to meet the above requirements, it is necessary to research and develop airport pavement structures that can be quickly paved and demolished.In order to meet the requirements of construction convenience and reliability of mechanical properties of pavement structure, the fast assembling pavement structure of section steel and prestressed concrete and its implementation technology are studied. The physical and mechanical properties of different slab thickness composite pavement under the condition of soft foundation are analyzed based on ABAQUS [1]. Obtain the physical and mechanical properties meeting the technical requirements of airport pavement. The physical and mechanical properties which can meet the technical requirements of airport pavement can be obtained [2].

2. Design Theory of Fast Assembly Pavement

Under the action of aircraft load, the steel prestressed concrete pavement slab deflects downward, the upper concrete is compressed, and the lower concrete is tensioned.The prestressed reinforcement makes the prestressed precast concrete pavement deflect upward, and the stress effect produced by the concrete is just opposite to the stress effect produced by the aircraft load.The stress of the concrete

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in the steel prestressed composite pavement can be obtained by superposition of the above two states. The influence of prestressed steel bar and encased channel steel frame on the load effect of fast composite pavement slab is not considered temporarily [3].When the aircraft load acts on the center of prestressed precast pavement slab, the stress equation of pavement slab is shown in Formula 1.

$$\sigma_1 = 1.1(1+\mu_c)\left(\lg\frac{l}{R}+0.2673\right)\frac{P}{h^2} \tag{1}$$

In the above formula, P is the aircraft tire load, h is the pavement thickness, l is the relative stiffness radius of the pavement, R is the equivalent action radius of the aircraft tire load.

3. Stress Analysis of Fast Assembly Pavement Based on ABAQUS

3.1 Construction of Finite Element Model for Fast Assembly Pavement

Considering the convenience of construction, the self weight of quick assembly road panel should not be too big.The plane size of precast pavement slab is 1 m × 1 m, the thickness range is 8 cm ~ 12 cm, the strength grade of concrete is C35, the elastic modulus is 32 500 MPa, and the Poisson's ratio is 0.15.The aircraft load adopts single wheel load on B737-800 main landing gear, which is 184KN [4]. Using elastic foundation element in ABAQUS to represent winkler foundation model to simulate supporting effect of foundation.The height of the outer steel frame changes with the thickness of the slab, and the prestressed reinforcement adopts the heat-treated ribbed reinforcement [5].Under the action of aircraft load, the stress and deformation of pavement are shown in Figure. 1 and Figure. 2.

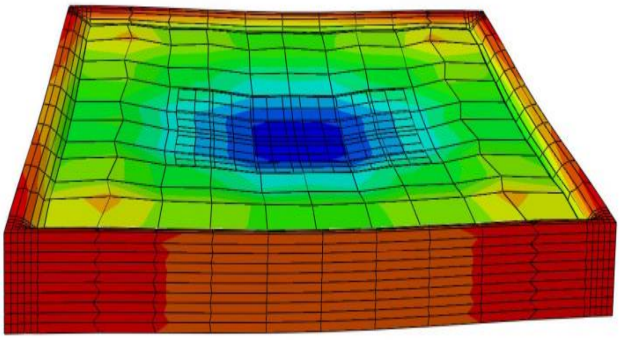

Figure 1. The pavement mechanics of deformation under center loading

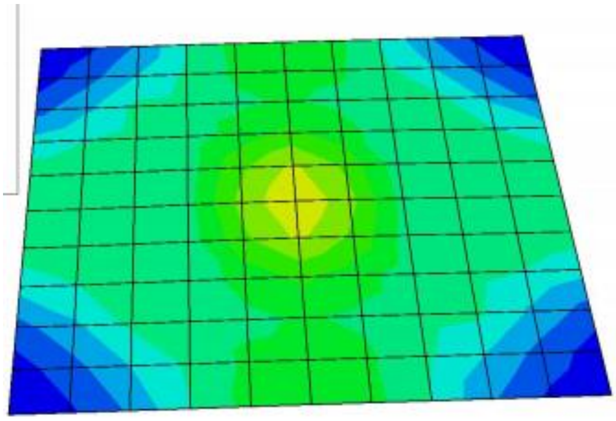

Figure 2. The bottom pavement mechanics of stress under center loading

3.2 Study on the Pavement Structure Mechanical Response under Different Modulus of Foundation Response

When the aircraft load acts on the center of the pavement slab, the maximum deformation of the fast composite concrete pavement slab occurs at the center of the pavement slab.When the elastic modulus of the soil foundation is fixed, the maximum deformation value of the fast composite panel decreases

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with the increase of the thickness of the plate. When the thickness of the plate increases to 12 cm, the decrease of the maximum deflection value is no longer obvious, and the influence of the thickness of the plate on the maximum deflection can be ignored. When *K* increases from 30MPa to 70MPa, the deformation of slab bottom decreases greatly.When the plate thickness is 12cm, the maximum deformation of the plate bottom decreases from 5.67 mm to 2.06 mm with a reduction of 64%, see Figure. 3.

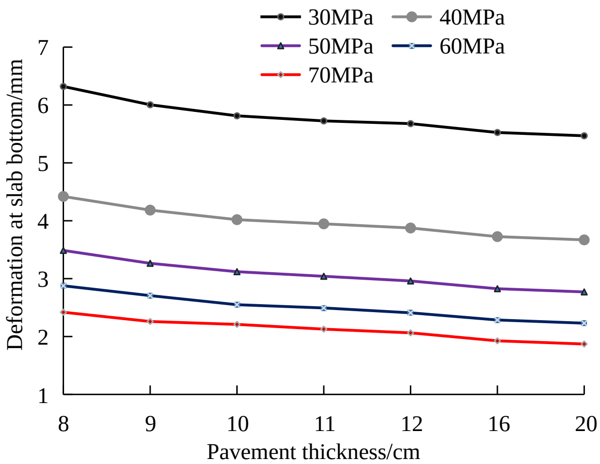

Figure 3. Relationship of the deformation at bottom and pavement thickness

The bending tensile stress of the concrete at the bottom is inversely proportional to the thickness of the slab. The maximum bending tensile stress of the concrete at the bottom is generated at the center of the slab.Taking K = 60MPa as an example, when the thickness of precast pavement slab increases from 8cm to 20cm, the bending tensile stress of concrete at the slab bottom decreases from 12.32MPa to 2.12MPa, with a reduction of 83%.Therefore, the thickness of the slab has a great influence on the bending and tensile stress of the slab bottom concrete.The elastic modulus of the foundation also has a certain influence on the bending tensile stress of the concrete at the bottom of the slab. The larger the elastic modulus of the soil foundation is, the smaller the bending tensile stress of the concrete at the bottom of the slab is, but its influence is far less obvious than the thickness.When the thickness of the slab is more than 14cm, the bending tensile stress of the concrete at the bottom is basically less than 5MPa, which is less than the bending tensile strength of the concrete, see Figure. 4.

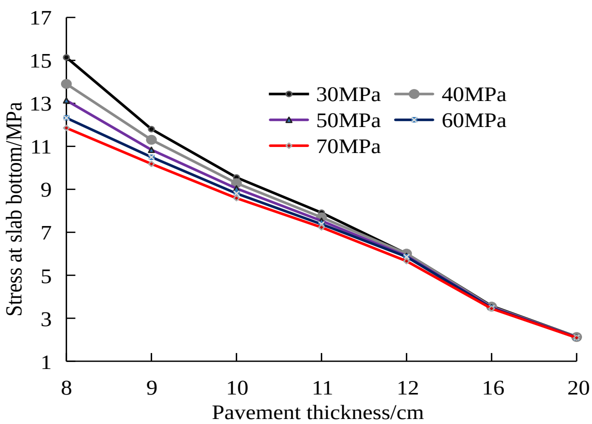

Figure 4. Relationship of the bottom mechanical response and pavement thickness

The effectiveness of slab to slab connection is the key to fast assembly of composite pavement. The different location of the articulated mechanism of composite pavement has great influence on the mechanical response of concrete pavement.As the welding position of the connector moves up along the plate thickness direction, the stress of the connecting mechanism increases continuously. When it is arranged in the middle of the plate thickness, the stress of the connecting mechanism is the

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largest.When the center of the connector is 3cm from the bottom of the plate, the maximum stress of the connector is 436MPa, and the maximum stress of the connecting shaft is 164MPa. Therefore, The connectors on the outside of the steel frame should be arranged near the bottom of the plate.

4. Conclusion

Through the establishment of the finite element model of the fast assembling composite pavement structure, the main parameters affecting the mechanical properties of the steel prestressed precast pavement and their influencing laws are discussed.Under the action of aircraft load, the thickness of steel prestressed composite pavement mainly affects the bottom stress of pavement,with the increase of plate thickness, the stress at the bottom of plate decreases.The elastic modulus of soil foundation mainly affects the maximum deformation of steel prestressed composite pavement slab. The larger the elastic modulus of soil foundation is, the smaller the deformation of slab bottom is.

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