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Study on adaptability of large-space "saddle-shaped" shell overall roof greening

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ABSTRACT

Large-space buildings have large spatial scale, complicated structures and dense people. Roof systems are key parts of their enclosures. The structural systems of large-space buildings need light materials and reasonable stresses while cover soils suggest load increase and structural bearing capacity adaptability change. In this paper, comprehensive adaptability of the overall cover soil of saddle-shaped shell structures and energy efficiency are simulated and evaluated through Sap2000 software and Design Builder software. The findings are that cover soil greening can greatly save energy for buildings of "saddle-shaped" shell structures and structural thicknesses increase linearly with cover soil load increase, the structures are highly adaptive to cover soil, and it is positively significant to combine large space "saddle-shaped" shell structures with cover soil greening. The integration of the relationship among the "saddle-shaped" shell structure, energy-conserving effect, and cover soil load provides further research basis for the practical application of the overall roof greening of "saddle-shaped" shell structure.

1. Introduction

1.1. The cause: consideration of energy-saving design for large space buildings

1.1.1. Dense development of urban buildings

The constant development of urbanization not only influences people's way of life but also greatly affects the quality of environment. In recent years, most parts of China have set new records in temperature in summer, and especially it is hotter in urban centers than in outskirts. Many meteorologists don't believe this phenomenon is caused by global warming but by the heat island effect resulting from overdevelopment of cities and decrease of virescence [1]. With the rise of cities, land has been exploited frequently and intensively. Urban greening, as the important link in urban environment, helps the urban development continue and safeguards urban residents' living quality. Therefore, urban greening must be attached importance to.

1.1.2. Environmental effect of rooftop greening

Modern urban buildings are dense, public open-air green space is seriously lacking, and buildings must depend on innovative greening methods for creating unique green space. Roof greening is an energy-saving design method that has gradually acknowledged and practiced both at home and abroad in recent years. Roof greening takes roofs of buildings as structure foundation, some or all parts of which are covered with vegetation and soil. On the one hand, roof greening improves external urban environment. On the other hand, it creates a comfortable spatial environment inside that is warm in winter and cool in summer. Roof greening is to construct a sustainable landscape system on a building. Meanwhile, it creates environment and landscape benefits. It is an environmental method that can be used and promoted on a large scale in urban architecture in China.

1.1.3. Why is it difficult to realize the overall roof greening on buildings of large space?

The application of the technology of roof greening on buildings of large space has been improved and popularized with each passing day, but it is still difficult to realize overall roof greening. Take Bourbon Bean Dome Tennis Court in Japan (Fig. 1), Bercy Arena in Paris (Fig. 2)and Yangzhou Sports Park in China (Fig. 3) for example. Although the energy-saving design method of roof greening is used on the above-mentioned three sports facilities, the area of cover

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Fig. 1. Bourbon Bean Dome Tennis Court.

Fig. 2. Bercy Arena.

Fig. 3. Yangzhou Sports Park.

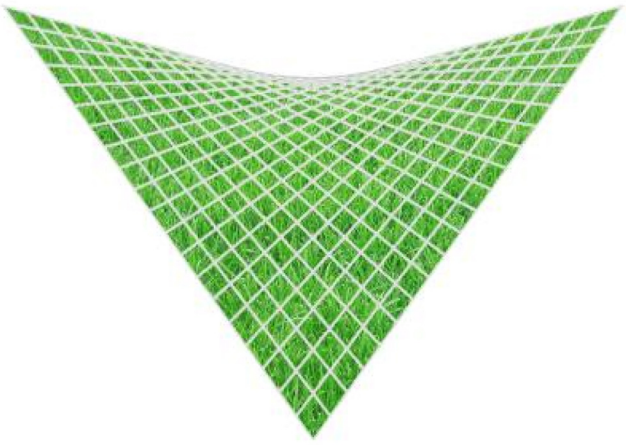

Fig. 5. The design of cover soil greening on "saddle-shaped" shell structures.

soil is only limited to the periphery of the venues and the roofs of the accessory occupancy, and most of the roofs of the buildings of large space remain exposed, which does not in effect improve the energy-saving environment of the buildings of large space.

It is difficult to realize overall roof greening on buildings of large space because it is associated with its span, structure selection and mode of construction. Large-space buildings have huge structural spans. Overall roof greening on conventional steel structures and concrete frame structures will cost a lot. Osaka Municipal Central Gymnasium in Japan completed in 1996 has round dome prestressed reinforced concrete shell structures. The diameter of the roof structure is 110 m [2]. The overall cover soil greening is applied on its large-space roof. It is the only existing large-space building on which overall roof greening is applied (Fig. 4).

1.2. Conception: the overall cover soil design of "saddle-shaped" shell of large space

As the roofs of large-space buildings have large spatial span and wide coverage, the application of overall roof greening on large-space buildings can better show the energy-saving significance in urban architecture. But as the application is restricted by the structures and the span, there remains great deficiency in the research of energy efficiency of large-space roof greening. With a view to this deficiency, we have come up with an innovative conception: To design overall roof greening based on "saddle-shaped" shell structures (Fig. 5).

The "saddle-shaped" (hyperbolic paraboloid) shell structures, as one of the main three shell types, can make the best use of the compression resistance of concrete and the tensile resistance of reinforcing bars, thus realizing the best utilization of materials [3]. The thin and light shells can keep the form stability of structures well. Thus, saddle-shaped shell structures are inherently

Fig. 4. Osaka Municipal Central Gymnasium in Japan.

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