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Large-Span Architecture with Hyperbolic Composite Thin-Shell Structure

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Summary The large-span elemental erecting architecture with composite hyperbolic thin-shell structure is a scientific and technological result of structure, architecture, construction and material. The application, calculation principle and construction craft of this architecture form are introduced in this paper.

Key words: hyperbolic thin-shell, composite structure, binder

1. Introduction

The large-span architecture has been widely applied in the fields such as large scale gymnasium, airport, ware house, exhibition etc.. Thin-shell structure, cable structure and net-frame structure have been widely used. Of course, the construction of those kind of structure is difficult.

In 70's decade of this century, the structural principle, originated in the Chinese pre-fabricated hyperbolic arch bridge, has been successfully applied in the architecture design in China. The authors of this paper have participated in the design and construction of the assembly hall of the Chinese Petroleum University, which is one of the typical structure of these kinds. By elemental pre-fabricating and erecting method, 40m span hyperbolic thin-shell roof with bearing and maintenance functions are conveniently achieved. The compressive shell of the roof is composed by wire mesh concrete hyperbolic curved shell plate, and its low chord drawing member is composed by welding channel steel.

2. Structure Scheme

There are 2 types in this architecture form, one is the shell-plate structure scheme and the other is the rib-plate scheme. In the shell-plate structural scheme, the elemental hyperbolic thin-shell is divided into 5, 7, or 9 blocks along the span direction and assembled one by one on independent support frame. (Fig. 2). In the rib-plate scheme, the elemental hyperbolic thin-shell is divided into arch ribs and cross curved plates. The arch rib is parallel to the span, while the cross curved plate is perpendicular to it. The arch rib is pre-fabricated by reinforced concrete or welded with shaped steel, and divided into 2 or 3 segments for erection. The finished rib should be fixed firstly by tension rod, and then the cross curved plate are assembled between two ribs. The cross curved plate is made of wire mesh concrete, metal or glass fiber reinforced plastic(GFRP). The span of cross curved plate adopts the distance between two adjacent ribs or takes 5m, 6m, 9m, etc..(Fig. 3)

3. Key Point

An important characteristic in our study is that it provides a supplementary scheme for the natural lighting of the large-span architecture. Based on the demand for natural lighting, some of the shell part in the hyperbolic thin-shell elements are replaced by GFRP. Of course the by-product is the abundant color style on the structure. GFRP is a kind of widely used new construction material which can be easily shaped and colored, which has high strength, and which is light-penetrated. That is why we use this material.

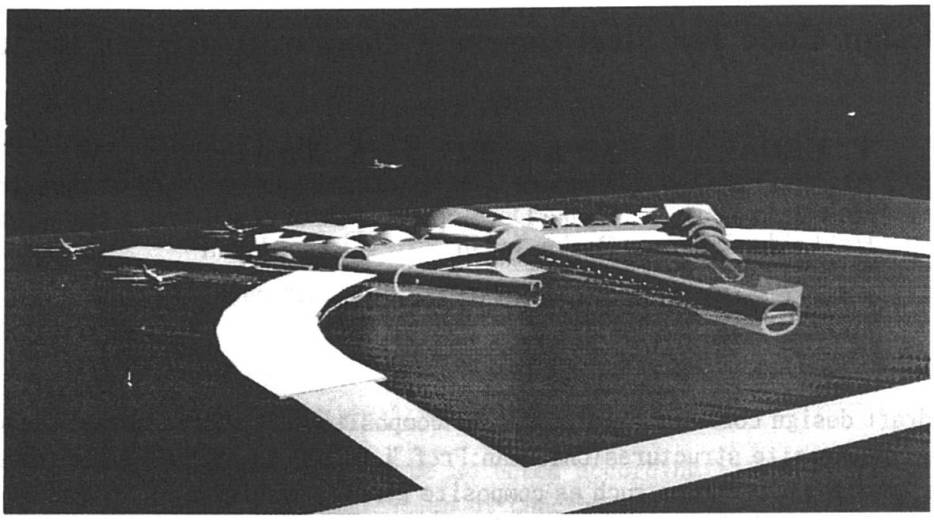


FIG.1 AN AIRPORT DESIGN

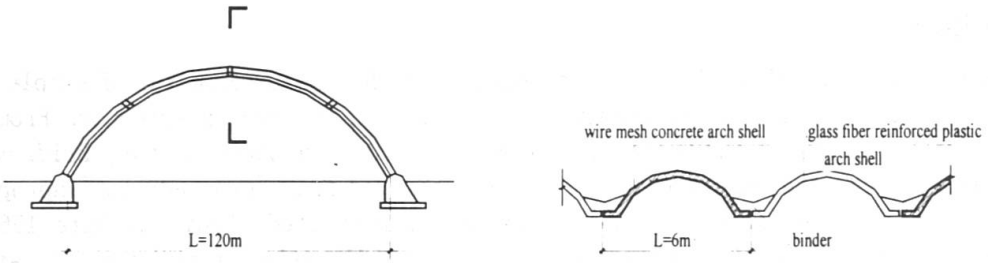
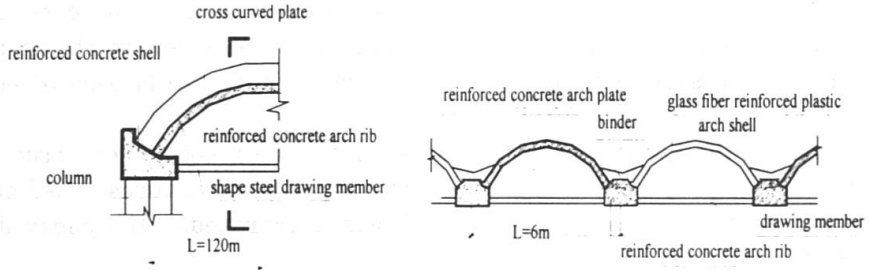


FIG.2 SHELL-PLATE SCHEME



FID.3 RIB-PLATE SCHEME

What should be pointed out is that, on designing this kind of architecture, careful consideration should be taken on the aspects of architecture scheme, structure scheme, construction scheme as well as material features so as to make ultimate use of its features and ensure its safety and utility. For example, in the construction of rib-plate structural scheme, the arch rib actually acts as the temporary support frame for the erection of cross curved plate. But after the completion of the whole element and the integration construction, the rib and the plate become an integrated bearing element. As we know, the elasticity and the expansion coefficient of GFRP can be changed by adjusting the ratio and type of glass wire, raisin and additives. This feature provides the theoretic basis and practical possibility for the design of composite element which is made by this material and other materials.