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ARTICLE

"Integrated" Solution and Engineering Application of Assembled Cable-Stayed Pedestrian Landscape Overbridge

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ABSTRACT

The construction of modern cities emphasizes the nature and harmony among the "people", "things" and "environment", reflecting the harmony and unity of the formal beauty, functional beauty and surrounding environment of architecture. Based on the introduction of the design concept of the assembled pedestrian overbridge, through the Jianhua Building Materials Group's first "pre-fabricated low-rise tower-stayed pedestrian landscape overbridge" project in China, this paper proposes a solution that can improve the landscape design of the overbridge and reduce the construction complexity of the overbridge, the assembly product supply and the construction process "integration" under the premise of ensuring the safety and stability of the pedestrian overbridge, whose prefabricated production and assembly construction, shortening the construction period, reducing energy consumption, reducing pollution, and obtaining good social comprehensive benefits.

1. Introduction

"Pedestrian landscape overbridge" is the window of modern urban culture and city image. Its scheme design, material supply and construction process reflect the ability and level of urban construction and management. The traditional "pedestrian landscape overbridge" project mostly adopts the cast-in-place mode, which faces poor overall performance, long construction period, poor quality stability, and at the same time exacerbates the contradiction between people and vehicles, and is accompanied by various pollutions and other problems. Integrating the development and experience of assembling overbridges in China's outer sections, following the principles of "safety, application, economy, aesthetics, durability and environmental protection", Jianhua Building Materials Group is aiming at the "Nanjing Pukou District Pedestrian Crossing Street Landscape overbridge" project, innovative technology, and adopting "full prefabricated assembled twin tower cable-stayed structure", and the engineering design and technical staff on-site service, draw the design plan, communicate and adjust with the customer, and carry out the full prefabricated production of the product, so that the project can be changed from cast-in-place to pre-assembled, which completely solves the problem that the engineering project is chaotic due

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to the disjunction between planning and design, material supply and construction, improves the construction efficiency and reduces the impact on the traffic environment.

2. Design Ideas of Assembled Pedestrian Overbridge

2.1 Overall Design Ideas

To maximize the proportion of overbridge factory assembly prefabrication, save installation time, reduce cast-in-place construction process, reduce dust, noise and other pollution, except for underground foundation engineering, the rest of the components are assembled prefabricated. The superstructure main bridge body, stair beam body and overbridge deck pavement layer are assembled by prefabricated sections. The auxiliary components such as railings, expansion joints and lighting can be completed before the assembly according to the requirements of the overall design; the lower pile foundation and the enlarged foundation are completed on site and the piers and cover beams are prefabricated in the factory, and the construction site and the foundation are installed and installed.

2.1.1 Main Bridge Body Design Ideas

(1) The difficulty in assembling the pedestrian overbridge segment is how to avoid the duplication and waste of cost investment and reuse as much as possible to achieve economic benefits. Therefore, the design should not only pay attention to the general performance of the component design for a specific overbridge, which requires analyzing the distribution of the road section in the target area to determine the span of the overbridge span, which can be determined based on the existing overbridge distribution data.

(2) Before the design, the constraints in the construction should be considered. For example, the lifting load and operability of the car are limited. The lifting weight of the beam should not be too large, which is recommended not to exceed 70-80t. The main overbridge adopts equal-section box girder and single-box single-chamber structure; Assembled overbridges need to be prefabricated at the factory, which requires that the choice of beam height in the design should not be too much to pursue the optimal ratio and should be too discrete. Some applicable height modulus should be selected according to the span of the overbridge.

2.1.2 Stair Beam Design Ideas

Stair beam: It has two characteristics with respect to the main overbridge: the appearance of the line shape and the fluctuation range of the span are small. Therefore, in the design, it is more inclined to adopt the flexible connection mode of the steel-mixed section, which is convenient for secondary use after dismantling.

2.1.3 Lower Structure Design Ideas

According to the applicable part, the pier is pre-formed, and the bottom of the column is reserved with flanges, which are connected with the cover beam and the pile foundation by bolts. The abutment, the enlarged foundation and the pile foundation are cast on site.

2.1.4 Affiliated Structures

Railings and drain pipes are reserved for railing joints on the main beam. They can be assembled on the spot before assembly or hoisting. The expansion joints, supports and anti-collision facilities are all shaped products.

2.2 The Advantages of the "Integration" Scheme

2.2.1 Construction Advantages

The engineering innovation adopts a full prefabricated pedestrian landscape structure;

The hoisting and assembling of the low-tower towers are carried out in the side zone, which does not affect the traffic of the current motorway; the lifting of the three prefabricated panels on the top of the motorway is carried out at night. During the day, the anti-drop net protection of the top of the tower column, the tower column and the I-beam set up on the top of the pedestrian stairway cap will not affect the normal driving of the motorway during the day.

2.2.2 Late Maintenance Advantages

Steel fiber concrete wedge extrusion anchoring device is adopted, which has strong durability and corrosion resistance; the cable stays with low-relaxation super-strength galvanized steel wire, and the cable life can reach 30 years, exceeding the standard requirements of 20 years.

2.2.3 Construction Period Advantages

The overall construction period is shortened by half (the traditional construction period is 6 months and the current construction period is 3 months).

3. Engineering Application Case

3.1 Case Background

Puzhu North Road, Pukou District, Nanjing is an import-

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ant passage to the Yangtze River Tunnel. There are four large residential quarters and the Australian Forest Shopping Plaza on the west side of the Puzhu North Road. Therefore, the traffic volume is large and people Large flow rate; traffic status: The residents on the south side of the residential area to the north side of the bus stop need to go to the Puliu intersection to bypass the distance of about 600m. Therefore, the addition of a pedestrian crossing overbridge at the site can better alleviate the travel needs of surrounding residents and reduce the traffic safety hazards that may result from the crossing of guardrails and crossing roads.

3.2 Structural Design

The full width of the overpass main overbridge is 5.06m, the net width is 4.0m; the span is arranged as: (10+34+10) m; it is a prefabricated assembled low-rise tower cable-stayed overbridge with a main span of 34m and a side span of 10m. 2.8m ramp and stairway; the overbridge deck of the main overbridge is a reinforced concrete overbridge deck with side main beams, with a beam height of 0.45m-0.55m and a plate thickness of 0.2m. The main tower is a garden-shaped tower column, and the above-mentioned overbridge beam is a rectangular hollow steel pipe with a tower height of 8.1 m; below the overbridge beam, the concrete-filled steel tubular pier with a rectangular section is 6.72m high. The stay cable is a steel strand + PE sheath, and the ends are anchor head anchors, which are respectively anchored on the steel tower column and the side main beam. Its engineering structure design is shown in Figure 1:

Figure 1. Project structure design drawing

3.3 Structural Calculation

The analysis model of cable-stayed overbridge was established by using Midas Civil finite element software. The whole overbridge is divided into 118 units and 123 nodes, of which the cable is only the truss unit and the rest parts are beam units. The boundary conditions consist of 6 general supports and 22 elastic connections. The analysis model of the cable-stayed overbridge is shown in Figure 2 below:

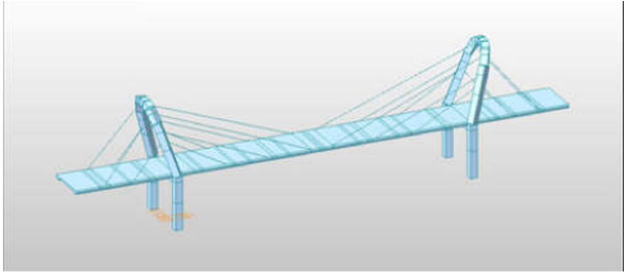

Figure 2. Cable-stayed overbridge analysis model

3.4 Construction Scheme

3.4.1 Construction Preliminary Scheme Design and Steps

(1) The cable-stayed overbridge deck adopts cantilever assembly construction method, and the construction process is foundation pile foundation construction—cap construction —main tower construction—overbridge cantilever assembly—stayed cable tension anchorage—overbridge deck closure;

(2) The No. 3 prefabricated overbridge deck supported on the main tower beam shall be temporarily consolidated first, and the temporary consolidation shall be released after the overbridge deck is closed, and the permanent support shall be placed;

(3) The main tower is prefabricated in sections, and the steel pipe should be welded to maintain the vertical and horizontal lines of the main tower. The stay cable is anchored after the tensile stress of the design. When anchoring, it should be noted that the offset angle of the stay cable is consistent with the design value;

(4) When assembling all prefabricated blocks, attention should be paid to the alignment of the anchored steel bars with the reserved holes and filled with mortar;

(5) The dimensions of each section shall be strictly controlled during the prefabrication of each section, and shall be pre-assembled before the formal assembly to adjust the size of the prefabricated section;

(6) After the construction of the structural system is completed, the overbridge deck leveling layer and the waterproof layer are constructed;

(7) The reinforced concrete overbridge deck is connected to the main truss by pre-embedded studs, paying attention to the reserved holes.

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3.4.2 Superstructure Construction Plan and Steps

Side brackets and non-motor vehicle lanes are erected with door brackets → hoisting + assembling main towers → assembling non-motor vehicle road top prefabricated panels + installing tension cable stays → using the first prefabricated panel at the top of the motor vehicle lane at night + Install the first stay cable → install the anti-drop net with the tower column to strengthen the safety protection measures during the day → install the second and third motor vehicle road top prefabricated panels in the night and install the second and third diagonal stay cables.

3.4.3 Main Beam Construction and Steps

(1) The short platform composite type pull-type hanging basket construction process (YJGF16-98 method): it consists of a hanging basket platform, a tripod and a servo system (staying system, suspension system, walking system, anchoring system, horizontal support system, fine-tuning positioning system);

(2) The cable system uses the stay cable to transmit the vertical load of the front end of the hanging basket to the main tower of the cable-stayed overbridge, and reduces the vertical load of the hanging basket on the main beam. Another function of the pulling rope is to complete the system conversion, that is, the cable is anchored on the hanging basket during construction, and the cable is anchored on the main beam after construction; during the suspension process of the main beam, the hanging basket platform is suspended by the front suspension bar and the pulling rope of the tripod to jointly bear the weight of the beam section;

(3) After the main beam is assembled, the rope is unwound from the front section of the platform and converted into a permanent beam of the main beam; the fulcrum of the walking boom is moved from the tripod to the main beam, and the template is lowered along the front and rear booms of the tripod by a main beam height, and the template is respectively hung by the hook and the running boom;

(4) Raise the front and rear booms to move the tripod forward, and the hooks move along the beam rails and the travel booms along the tripod rails to move the formwork platform to a new position; lower the front and rear booms and reconnect them to the formwork platform. The completion effect of all the projects in this case is shown in Figure 3 below:

Figure 3. Project completion effect drawing

4. Conclusion

The first case of Jianhua Building Materials Group's innovative use of the "pre-prefabricated low-rise tower-stayed pedestrian landscape overbridge" project in the construction of modern cities in China, which is based on its strong R&D and innovation capabilities and comprehensive service capabilities, and cooperates with construction units to connect the entire industrial chain of design, production, construction and management to provide an integrated "integrated" solution; in 2016, the "Guiding Opinions on the Development of Prefabricated Buildings" issued by the State Council of China proposed to use 10 years or so to increase the proportion of fabricated buildings in new construction areas from less than 5% to 30%. As an industry benchmarking enterprise, how to use the modern BIM method and 3D technology to realize the industrial chain standardization, scale and integration is a new exploration and practice topic in modern urban planning and construction.

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