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Application of Prestress in Construction of Building Engineering

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Abstract. With the acceleration of the urbanization process, the housing construction industry is increasing, and it also promotes the continuous improvement of its construction technology. The pre-stressed construction technology of housing construction is one of the new technologies promoted by the Ministry of Construction. At this stage, the pre-stressed construction technology of housing construction is gradually widely used and plays a very important role in the construction of housing. Adopting bonding prestressing technology in construction projects can solve the span problem of concrete structures and enhance the load capacity of equipment. In the process of project construction, it can effectively reduce the size of the concrete cross-section and the amount of steel bars, improve the space utilization rate, and increase the economic benefits of the project. The application of prestress in engineering construction has a very good effect.

Keywords. Housing construction, prestress, construction technology

1. Introduction

Zhu Xinshi [1] studied prestress technology and material equipment. Hu Di [2] studied the basic principles of prestressed concrete structure design. Feng Dabin [3~5] Research on the construction of post-tensioned prestressed concrete and related materials. Wang Ruixue [6~9] et al. Application of unbonded prestressed concrete in building construction process and analysis of some problems.

2. Project Overview

Shanghai Chongming Youyou Dongdao Plaza Project is located in Chenjia Town, Chongming District, Shanghai. The base area is about 80,000 square meters, and the total construction area is about 68,900 square meters. The project is divided into two parts: a five-star hotel building and a single commercial building. Among them, the five-star hotel has five floors above ground, and the basement floor is the hotel backyard, equipment room and underground garage combined with peace and war. The total building height is 19.95 meters.

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The hotel public area of the project is a reinforced concrete frame structure, and the prestressed part is part of the prestressed beam of the roof structure. The prestressed reinforcement on the roof of the hotel banquet hall: frame beam 2-9φs15.2 and prestressed secondary beam: 2-9φs15.2, a total of eleven prestressed beams. The pre-stressed beams are all tensioned at one end and fixed at the other end, and are constructed using bonded pre-stressed post-tensioning technology.

3. Prestressed Construction Characteristics

3.1. Features of Prestressed Structure

(1) The span of structural column spacing is large, and the span of prestressed beam axis spacing reaches 24.3 meters.

(2) The pre-stressed beam adopts pre-stressed and bonded post-tension technology, and adopts post-tensioning method with bonded anchor system.

According to the design requirements, the prestressed tendons are made of high-strength and low-relaxation steel strands, with a diameter of φs15.2, the ultimate strength standard value Fptk=1860MPa, the bonded prestress is made of metal bellows, and the prestressed beam concrete strength grade is C40, The tension end adopts clip-type anchorage, and the fixed end adopts extrusion type anchorage; the concrete strength level should reach 100% during tension.

3.2. Technical Characteristics in Prestress Construction

3.2.1. Prestressed Tendons Layout Characteristics

The prestressed beam reinforcement of this project is 2-9Φs15.2, and the metal bellows used have an inner diameter of Φ80 and an outer diameter of D88, which are arranged symmetrically. The project proposal: the columns, secondary beams, and floors associated with the prestressed beams of this layer. The concrete strength grade of other parts is C40, and the concrete is poured at one time. During the concrete pouring construction, the inserted vibrator should avoid contacting the metal bellows to prevent it from breaking and causing slurry leakage. A smaller vibrator can be used to remove It is better to insert the construction at the gap of the bellows.

3.2.2. Prestressed Tension End Node Structure

For the setting of the tension end of the prestressed tendons, please refer to the 06SG429 atlas, and adopt the recessed embedded anchorage method to solve the problem; after the prestress construction is completed, the C40 micro-expansion fine stone concrete is used to seal the anchorage.

3.2.3. Prestressing Sequence and Method

Determining a reasonable prestress application process and application sequence is the key to the prestress construction of this project.

The following tensioning plan was adopted during construction:

The prestressed tendon of each beam should be tensioned once. If the jack stroke is not enough during tensioning, it can be repeatedly stretched back and forth; the

tensioning sequence is: first tension any prestressed tendon at any hole, and then tension the same an adjacent hole of prestressed tendons

3.2.4. Binding Sequence of Non-prestressed Tendons at Beam-column Joints

(1) According to the general situation of non-prestressed steel reinforcement, full consideration should be given to the influence on the height of the prestressed reinforcement.

(2) Because the pre-stressed tendons are arranged in a secondary parabolic shape, brackets must be welded (or tied) to the stirrups to fix the position of the sagittal height. When supporting the mold, the double-sided or single-sided template and the beam end template should be left before sealing. To ensure pre-stress construction. When the steel bar is blanked, it should be considered that the main reinforcement in the column should be free of the anchor pad or the spacing of the holes.

(3) When the position of prestressed tendons conflicts with ordinary steel bars or other pipelines, the position of prestressed tendons should be ensured first.

(4) The S-shaped tie bars between the waist bars in the prestressed beams shall be tied up after the corrugated pipe is laid.

(5) For the dense steel bars at the intersection of the vertical steel bars and stirrups in the column, the arrangement and design of the pre-stressed bar channels and the ordinary steel bars should be carried out. The pre-stressed corrugated pipe and steel strand must be put through and the pre-stressed fixed End or tension the end anchor plate, and then tie the fixed column stirrups.

(6) According to the number of bundles arranged in the prestressed beam, when the beam stirrups are tied, a gap of not less than 150mm should be left at the crossing position of the corresponding corrugated pipe in order to pass through the prestressed corrugated pipe and meet the requirements of the corrugated pipe and the beam body. The distance between the side protective layer is required.

4. Prestressed Construction

4.1. Prestress Operation Process

The specific operation process of the installation of the prestressed beam template and the binding of steel reinforcement on the building project floor is that during the installation of the beam template, the template next to the stress cannot be installed first during the installation. The position of the prestressed reinforcement can be adjusted in time to bind the general steel and when piercing the prestressed tendons, the position of the anchor plate at the tension end should be fixed to ensure the tightness of the prestressed beam side template.

4.2. Prestressed Construction

4.2.1. Laying the Beam Bottom Plate and Binding the Skeleton Steel Bars

After the upper and lower rows of main bars and stirrups of the prestressed beam are lashed, the prestressed tendons can be interspersed. The on-site slab bottom mold can be laid at the same time, but due to the high beam height, pre-stressed scaffolding needs to be set up on both sides of the beam. The side mold and the template at the tension end of the beam must be reserved. After the partial joints are completed, the molding of the beam side template is performed. If the on-site beam and slab bottom formwork are laid separately, a working bent frame shall be set up on the beam side to facilitate stacking materials and safe construction.

In order to meet the requirements of the design height of the prestressed tendons, the height of the ordinary steel bars of the cross beams should be reviewed during the preparation of the laying plan to determine the binding sequence of the ordinary steel bars of the cross beams. If there is a conflict between ordinary steel bars and pre-stressed steel bars, the pre-stressed steel bars should mainly be avoided by ordinary steel bars. At the same time, the avoidance or change plan should be proposed in time and reported to the supervisor and relevant design units for approval.

4.2.2. Determine the Height of the Tunnel, Electric Welding (or Effectively Tying) the Support Reinforcement

During construction, you can first determine the mid-span height of the tunnel and the height of the inverted bend on the bound stirrups (after the cushion is completed). It must be noted that the prestressed steel bar curve in the design drawing is marked with the center of the tunnel. Therefore, the bottom outer diameter of the corrugated pipe should be used as the baseline when determining the height of the support reinforcement. The corrugated pipe specification used in this project is d=88mm (for 9 holes), so the bottom outer diameter of the corrugated pipe should be deducted as 44mm. The support steel bars adopt Φ12mm and above steel bars, the length is the same as the width of beam stirrups, and the horizontal spacing is generally not more than 1000mm.

After the support steel bars (beam internal bracing can be used) are completed, the on-site quality personnel should conduct a timely review and process acceptance.

4.2.3. Laying Bellows

After the support reinforcement is installed, the corrugated pipe can be laid.as shown in figure 1, the length of each corrugated pipe is generally about 6m, and the length of the casing is 300mm. Before threading into the corrugated pipe, the casing should be screwed onto the other end of the corrugated pipe, and then the casing should be reversed and connected to the other corrugated pipe after passing through the tunnel. .

The bellows joints must be firm and tight, and the two sections of working pipes must be pressed tightly, and the construction is as follows.

Before wearing the bellows, check the appearance quality at the same time. If the bellows is found to be damaged, replace it.

Figure 1. Laying the construction site.

4.2.4. Prestressed Tendon Threading

The piercing platform can use ordinary scaffolding. The piercing rib adopts a single piercing method. Before threading, wrap the ends of the steel strands tightly with black tape, and then thread them from one end to the other. Be careful not to hard top when it is difficult to penetrate, to prevent the bellows from being broken. Instead, the steel strand should be gently drawn, pushed and turned back and forth, and if necessary, check whether the corrugated pipe is smooth, otherwise, it should be smoothed. After the piercing is completed, the tunnel should be bound and fixed in time. The on-site quality personnel should conduct visual inspection of the bellows, and repair them in time if any holes are found.

4.2.5. Set the Grouting Bleeding Hole

Setting principle: For prestressed tendons tensioned at two ends, a bleeding hole is generally set at the height of each prestress curve of each beam of each span, and the horizontal spacing should not exceed 30m. The pre-stressed tendons tensioned at one end must be provided with bleeding holes at the fixed end. Specific method: Cover the corrugated tube at the bleeding hole with a layer of sponge gasket and a plastic arc pressure plate with a mouth, and tie it with an iron wire and a corrugated tube, and then insert a 25 reinforced hose into the mouth and lead it out of the beam The top surface is about 300mm higher than the top surface and fixed. Construction according to the following figure 2.

Figure 2. Bleeding hole setting.

4.2.6. Installation of Tension End Anchor Plate

As shown in figure 3, after the position of the corrugated pipe is fixed and the threading is completed, the anchor pad and spiral ribs can be installed. The end template must be fixed with the end anchor backing plate by pulling bolts. At the same time, ordinary

steel bars should be used to fix it to prevent deviations from occurring when pouring and tamping concrete. The end anchor pads and spiral reinforcements are difficult to install because they are located in the denser part of the supporting steel bars, and their positions should be accurate. At the same time, it must be ensured that the backing plate is perpendicular to the tangent line of the tunnel.

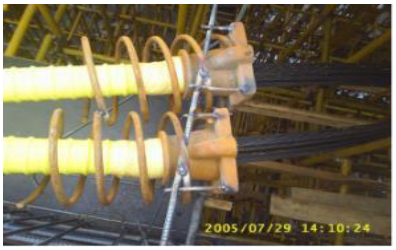

Figure 3. Prestressed anchor plate.

4.2.7. Strand Protection

Since the beaming is carried out before pouring and tamping the concrete, after the installation of the anchor pad, the exposed steel strands within the working length of the pad should be protected, and the prestressed channels and the grouting holes on the pad should be sealed to prevent other substances damage it. Specific method: Use waterproof tape to wrap the exposed steel strands.

4.2.8. Acceptance

After all the above work is completed, the on-site quality personnel should check the number of steel strands through the tunnel and the height of the vector, and carry out the quality self-inspection of the pre-stress sub-project team, and ask the relevant quality inspection department to carry out the concealed project acceptance.

4.3. Concrete Pouring

When pouring concrete, it is absolutely necessary to avoid the vibrating rod from strongly impacting the prestressed tendons to prevent the vibrating rod from deviating the prestressed tendons. The steel bars at the tension end are concentrated, and the concrete must be vibrated and compacted when pouring and tamping to prevent voids and other phenomena.

4.4. Prestressed Tension

4.4.1. Preparation before Stretching

(1) Equipment calibration

The tensioning equipment adopts the oil pump and YCW-250 hydraulic jack produced by the professional factory, and adopts the 1.6-level shock-resistant oil pressure gauge (as shown in the picture).

The jack tensioning equipment is calibrated by a qualified testing unit, and a corresponding calibration report is issued. The service life is 6 months.

The jack and oil pump supporting equipment are calibrated using a hydraulic pressure testing machine with an error of 1%. Re-calibration should be done in the following situations:

1) The oil pressure gauge does not return to zero or is damaged or malfunctioning;

2) Exceeding the effective period of use;

3) Seriously broken or slipped wire;

4) When the elongation does not meet the requirements and there is doubt about the tension;

5) After the jack is seriously leaking or repaired.

(2) Retest inspection of main materials of prestress

Before tensioning, a re-inspection report of the steel strands and anchors should be obtained from the relevant inspection department, and all of them should be confirmed as qualified.

(3) Sign the notice of tension

Before tensioning, confirm that the component concrete strength, technical data and tensioning safety facilities are qualified, and the supervisor signs the tensioning notice before entering the site for pre-tensioning.

(4) End cleaning and anchor installation

Only after obtaining the tensioning notice can the formal pre-tensioning procedure be entered.

Tensioning operation of prestressed steel strand:

(a) Pass the strands of each end steel strand into each hole of the anchor in order.

(b) Put the working anchor into the backing plate positioning ring, and close to the anchor backing plate, insert the clip, and tighten with a hammer;

(c) Install the limit plate, the steel strand passes through the limit and enters the jack;

(d) Before installing the jack, the jack axis is required to coincide with the steel beam axis;

(e) Install tool anchors.

(5) Precautions for prestressing tension

(a) For the installation of the limit plate and the jack, the fixtures should be cleaned, and there should be no oily debris, and the beam end anchor pad and steel strands should be cleaned to maintain a sufficient working length;

(b) When installing the jack, it is necessary to keep the center of the tunnel, the center of the anchor and the center of the jack in a line to ensure that the direction of the tension end of the wire bundle is perpendicular to the anchoring pad;

(c) Butter should be applied to the tool clip to ensure the smooth release of the working clip;

(d) The jack and the oil pump are operated by a dedicated person, and the elongation value of the jack is measured in time, and the form is filled in carefully and carefully;

(e) If the sliding wire is broken or the anchor is damaged during tension, the operation should be stopped immediately, inspection and detailed records should be made. If the sliding wire is broken beyond the specified requirements, the steel bundle must be replaced.

4.4.2. Technical Requirements for Prestressing Tension

According to the design requirements of the tensile strength of prestressed concrete, the concrete strength of the tensile member during tension shall not be less than 100% of the concrete design strength grade value (or in accordance with the design requirements);

The tension sequence of the prestressed beam is: follow the symmetrical tension in sequence;

During tensioning, the holes, anchors and jacks should be three-centered, and the tensioning process should be uniform. After the tension is completed, check whether there are cracks at the ends and other parts, and fill in the tension record form.

When the concrete construction of this layer is completed and the concrete strength reaches the tensile requirement, the prestressed tensioning and grouting can be carried out, and then the prestressed beam bottom form and beam bottom support of this layer can be removed.

4.4.3. Tension Procedure

Tensioning procedure: 0~initial stress (10% control stress, reading the amount to measure the elongation value)~103% control stress (reading the amount to measure the elongation value, holding the load for 2 minutes)~anchoring~unloading.

4.4.4. Tension Sequence

When the concrete strength in the construction area reaches the required tensile strength, the prestressed tendons in the area can be tensioned; the tensioning should be carried out sequentially, symmetrically, and simultaneously from the middle to the two sides.

4.4.5. Tension Control Stress

According to the design requirements of this project, the tension control stress of the prestressed tendons is taken as:

$$\sigma con=0.70\times fptk=0.70\times 1860=1302\ (Mpa)$$

Tensile force Np: $Np=\sigma con\times Ap$

The maximum tension of each tunnel is determined by the respective design scheme.

4.4.6. Measuring Method of Elongation Value

Since the pre-stressed tendons are placed freely in the tunnel at the beginning of the tension, and there are certain gaps between the various parts of the tension end, a certain tension can be used to tighten them. Therefore, you should first stretch to the initial stress (ten percent of the tension control stress), measure the elongation of the prestressed tendon, then stretch to twice the initial stress, measure the elongation again, and finally stretch To control the stress, measure the elongation value for the third time and calculate the measured elongation value $\triangle L1$. After the calculated elongation value meets the requirements, unload the anchoring return stroke and remove the jack, and the tension is completed.

4.4.7. Tension Quality Control

The tensioning method is mainly based on the tension stress control, and the elongation value verification is a supplementary method. The tension stress control is controlled by the reading on the pressure gauge matched with the jack after calibration. In order to ensure the accuracy of stress control, a 1.0-level shockproof pressure gauge is specially adopted. The reading of the pressure gauge is calculated by the numerical interpolation method according to the jack calibration book and the tension control stress, and is accurate to one decimal place. The corresponding control stress is reached when the corresponding meter reading is reached during tension. Since the pre-stressed tendons are placed freely in the tunnel at the beginning of the tension, and there are certain gaps between the various parts of the tension end, a certain tension can be used to tighten them. The measurement of the tensile length of the prestressed tendon is performed after the initial stress is established.

4.5. Hole Grouting

Grouting should be carried out as soon as possible after the prestressing tension is completed. Before the grouting of the tunnel, the gap between the anchorages at the bonded tension end shall be sealed. The grouting adopts pure cement slurry, and the technical conditions of cement slurry should meet the following requirements:

- The cement paste is mixed with ordinary Portland cement of grade 42.5 and above;
- The water-cement ratio is 0.40～0.45, and additives containing chlorides and other additives that have a corrosive effect on the prestressed tendons are not allowed;
- The bleeding rate of cement slurry shall be controlled at 2% within 3 hours after mixing, and the bleeding rate of cement slurry shall not exceed 3% at most;
- The consistency of cement slurry should be controlled between 12 and 18 seconds.

4.6. Anchor Protection

The bonded prestressed tendons can cut the excess steel strand within the working length 24 hours after the grouting is completed. The cutting is carried out with a portable grinding wheel cutting machine, and the length of the strand outside the anchor is not less than 30 (mm). Finally, C45 micro-expanded fine stone concrete was used to seal the exposed anchors, so as to achieve the purpose of complete sealing.

5. Prestress Quality Control Standard

a) Unqualified materials shall not be put into use. All engineering materials used should have quality assurance certificates (or factory certificates). At the same time, random inspections and retests of incoming materials must be carried out in accordance with regulations, and they can be put into use only after being qualified. Sampling inspections and re-tests must be "witness sampling and sample delivery".

b) Welding machines, tensioning tools, cutting equipment, etc. must be maintained and maintained. Ensure that they are in good working condition.
c) Professionals or special operators who enter the site must hold valid qualification certificates to work. Teams that do not meet the requirements and undocumented personnel are strictly prohibited to work.
d) Carry out self-inspection, mutual inspection and handover inspection carefully. On-site quality personnel must strictly control the quality and conduct full-time inspections carefully.
e) Positioning of the channel must be accurate and reliable. The allowable deviation of the pipeline position must not be greater than ±1cm in the plane, and the vertical direction must not be greater than 0.5cm.
f) The shrinkage of the anchor clip should be less than 6mm.
g) The enclosed protection of anchors shall meet the following requirements:
   - Effective measures should be taken to prevent corrosion of anchors and mechanical damage;
   - The thickness of the protective layer of the protruding anchor end anchor should not be less than 50mm;
   - The thickness of the protective layer of the exposed prestressed tendons: in a normal environment, it should not be less than 20mm; in an environment prone to corrosion, it should not be less than 50mm.

6. Concluding Remarks

Adopting bonding prestressing technology in construction projects can solve the span problem of concrete structures and enhance the load capacity of equipment. In the process of project construction, it can effectively reduce the size of the concrete cross-section and the amount of steel bars, improve the space utilization rate, and increase the economic benefits of the project. The application of prestress in engineering construction has a very good effect.

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