PRESTRESSED CONCRETE BEAMS PRODUCTION PROCESS

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ABSTRACT:

Prestressed beams have an important key role in making the prefabricated halls and other constructions (for example the bridges) that require high bearing power. Production is accomplished in the factory where industrial production is used. Prestressing is considered as a case when additional loading is added to an element by force.
Production of these beams is usually complex process. Despite that fact, prestressed beams have numerous advantages as compared to traditional reinforced concrete and this is why they're widely used in every part of the world. Referring to the methods of prestressing, production process uses pre-tensioning and post-tensioning. Referring on how the connection between prestressed wires and concrete was done there are bonded and unbonded post-tensioned concrete.
No matter what kind of prestressing was used, the objective of the production process is to produce beams which meet requirements to be effective and economical. In practice, batch and serial production are often used in order to achieve transportability, assemblage and accuracy of production.

1. INTRODUCTION

In order to achieve a long range in building construction and to increase durability, prestressed concrete is most common used nowadays. Although production process of concrete elements with prestressed wires is considerably more expensive than traditional reinforced concrete, advantages of construction with prestressed wires are numerous. That is the reason why production process of prestressed beams must constantly be bettered and improved.
Predsressed concrete manufacturing process is usually done in factory but it can also be done to the construction-site. The objective of manufacturing process mentioned above is to achieve industrial production. Production of prestressed concrete elements is accomplished by using serial and batch production. This is the way to achieve accuracy of production, transportability and assemblage.
The objective of work "Prestressed concrete beams production process" is to describe technology and process of making the prestressed concrete elements. Some of the methods of prestressing and the most important production stages that used during production are presented in this work.

2. THEORETICAL BASICS

In this chapter will be summarized the basic principles on prestressed concrete that are very important for easily understanding its using and realization of production process [4].

2.1. Brief history of prestressed concrete

The first prestressed element was a concrete lintel patented in 1890. by Henry Jackson, an American engineer from San Francisco. In 1928. it was made the first prestressed concrete beam with high quality and strength while the International Federation for Prestressing and European Concrete Society were founded later [2,4].

2.2. Prestressed concrete definition

Prestressed concrete means when an "artificial" compressive force is introduced to areas where tensile stresses are developed. That force than eliminates tensile stresses and allow concrete element to be with no cracks. Prestressing is additional load introduced by force where tensile rods and cables inside the element accept previously mentioned "artificial" force which is than transported to concrete element as a compressive force [1].

2.3. Advantages and disadvantages of prestressed concrete

Advantages of prestressed concrete are following:

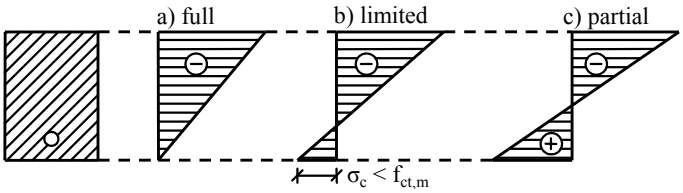
- element is with no cracks for all stages of loading which increases durability of construction,
- controlling of the prestressing force allows all unwanted occurrences to be eliminated,
- deformation caused by fluctuation of load are less,
- achieving long ranges with the same dimensions of element.

Disadvantages of prestressed concrete are following:

- significant cost of production process and making the prestressed elements,
- there is need for controlling the prestressed force and quality maintenance,
- during production it is required special equipment, gang of labourers, high precision in design [4].

2.4. Levels of prestressing

Nowadays, there are three levels of prestressing that are described below.
Full prestressing (picture 1-a) is a technique when cracks have not been occurred in concrete under service load, level of prestressing is 1.
Limited prestressing (picture 1-b) is a technique when cracks in concrete have been occurred but cracks width is limited. Tensile stress can also be occurred but its value is less than value of concrete tensile strength. Level of prestressing is less than 1.
Partial prestressing (picture 1-c) is a technique where cracks in concrete can also be occurred but only for a specified load and cracks width is restricted. Level of prestressing is between 0,4 and 0,7 [1,4].



Picture 1: Levels of prestressing in prestressed elements

3. MATERIALS FOR MAKING PRESTRESSED BEAMS

3.1. Concrete, steel, grout

Prestressed concrete beams production process uses high quality concrete which must have high tensile strength, low value of shrinkage and creep and also the durability.

The best results for efficient use of prestressing can be achieved if concrete with compressive strength above 30 MPa is used in production. This is the way for achieving the requirements for economical justification of produced elements and also the justified usage of prestressing.
Steel for prestressing must also be with high quality. Some of the requirements for steel are: high tensile strength, low stress relaxation, weldability, low sensitivity to corrosion, good adhesion, resistance to fatigue and geometric precision.
In addition to steel and concrete other important material is grout that is used for filling the space between tendons and duct. The grouting is accomplished under pressure. In that way, tendons are protected from corrosion and good connection between tendons and concrete is achieved. Grouting may not be applied at the temperatures below +5°C, ideal temperature is around +15°C. Grouting material, it is usually a colloidal cement grout, must have some requirements such as: fluidity, compressive strength, reduction in volume, reduction in water segregation, frost resistance. Because ventilation is needed, the grout is injected in lowest point of the duct [2,4].

4. PRESTRESSED CONCRETE BEAMS PRODUCTION PROCESS

Concrete prestressed elements are produced according to project documentation in the factory with all equipment that is necessary for production and quality of production must be achieved. Nowadays, production process is accomplished using the equipment of newest technology generation.
In production process there are two methods for prestressing:
- pre-tensioning,
- post-tensioning (bonded and unbonded concrete) [3,5].

4.1. Pre-tensioning

Phases of production process are as follows:
1) preparing the mould,
2) placing of reinforcement,
3) prestressing,
4) casting of concrete,
5) removing the mould,
6) storage [5].

4.1.1. Preparing the mould

Before any of the production process phase is applied, the mould must first be prepared. For production of one prestressed beam, quantity of concrete can be above than 4m^3. Therefore, moulds that are used for purposes like this must be very strong and that is the reason why steel moulds shown at the picture 2-a/b are most commonly used today [2,3].

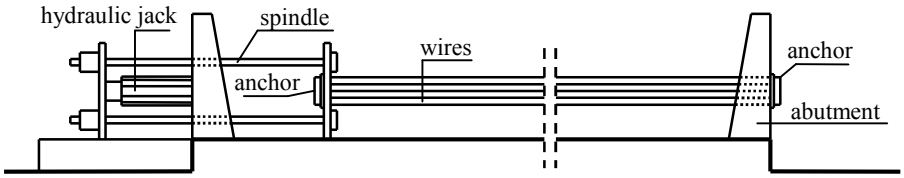
Picture 2: Moulds for making the prestressed concrete

4.1.2. Placing of reinforcement

In addition to wires which will be used for prestressing, every concrete element has traditional reinforcement (in the top and bottom of element, vertical shear reinforcement) that always must be present, no matter which method of prestressing is applied. In pre-tensioned concrete, wires for prestressing are places to the mould together with traditional reinforcement [1,5].

4.1.3. Prestressing

This type of production uses long line method of prestressing with parts shown at the picture 3. Picture shows that one end of wires is strongly connected to the abutment by an anchor. Other end of wires via anchor and spindle is connected with hydraulic jack. Wires are tensioned by hydraulic jack to the sufficient prestressing force. So wires remain tensioned and casting of concrete can begin [1].



Picture 3: Equipment for pre-tensioning

4.1.4. Casting of concrete

Quantity of concrete needed to make an element depends on element dimensions and it's specified according to project documentation. Casting of concrete must be performed with no interruption. Ideal temperature is 14-20 °C. After concrete has been placed into the mould, compacting of fresh concrete mast be performed. When concrete achieve compressive strength around 30 MPa, connection between wires and anchors is released and prestressed element was made [1].

4.1.5. Removing the mould

Mould can be removed from an element when concrete has achieved sufficient strength. Removal must be taken with a care in order not to damage the edges of element. In prestressed concrete beams production where prestressed force is applied, it is recommended to remove the mould after concrete has achieved maximum compressive strength and that is for 28 days after casting the concrete [1,5].

4.1.6. Storage

By removing the mould production process is finished so the next phase is storage (picture 4).

Picture 4: Storage of prestressed elements

Storage must be taken with a care. The most important is transportation of an element to the place of storage. During the process of storage elements may not be damaged and must be perfectly placed without providing the freedom of movement. In addition, elements must be on the straight surface without possibility for bending moment to be occurred [1,2,3,].

4.2. Post-tensioning

Phases of production process are as follows:
1) preparing the mould,
2) placing of reinforcement and duct,
3) casting of concrete,
4) removing the mould,
5) prestressing,
6) storage [5].

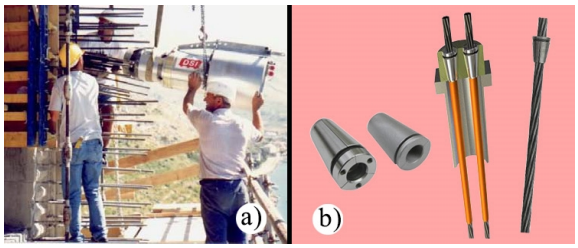
Production process is similar as a process previously described with some differences. Phases of production such as: preparing the mould, casting of concrete, removing the mould and storage can be done in quite the same way as process described above. Therefore, next text will describe only a production phases that are essentially different from the phases of previous prestressing method [1,4].

4.2.1. Placing of reinforcement and duct

In this phase only traditional reinforcement is placed to the mould. In addition, in the mould is also placed a duct (usually steel or plastic pipes) and prestressing wires will be put through the duct later. Now concreting can be applied. When concrete has thoroughly hardened mould can be removed. After mould has been removed presressing can be applied and that is what makes this method of prestressing different from pre-tensioning [1].

4.2.2. Prestressing

In this case prestressing is applied by hydraulic jack (picture 5-a) after concrete has achieved maximum compressive strength. Of course, wires or cables must first be placed into the duct. At the one end of beam, cables are permanently anchored (usually into the concrete) by dead anchor. At the other end there is an active anchor used for anchoring the wires after prestressing. Nowadays, there are many tolls for anchoring the cables and wires at the end of beam (picture 5-b) [2,3].



Picture 5: Hydraulic jack for prestressing and equipment for anchoring

After prestressing, force is transferred to concrete element by anchors that are at the ends of beam. Cables used for prestressing can be grouted with injection material. This type of prestressing is called bonded post-tensioned concrete. Instead of grouting, cables can have a permanent freedom of movement relative to the concrete. This type of prestressing is called unbonded post-tensioned concrete. In order to protect cables and wires from corrosion and to provide a bond between tendons and the concrete, today is more acceptable to use bonded pre-tensioned concrete [1,2,3].

In this type of prestressing, it is important to mention that all cables may not be tensioned immediately after beam was made. During the storage, only some wires can be tensioned in order to transport the beam to the storehouse.
Tensioning the all wires is applied during the assemblage of an element to the structure. As more parts of construction has been assembled (for example the bridges) a more wires must be prestressed.
It is also important to say that post-tensioning can be performed in two ways:

- internal (cables are inside of the concrete element),
- external (cables are outside of the concrete element).

At the picture 6 is shown external prestressing [4].

Picture 6: External prestressing

5. CONCLUSION

In order to get economically justified prestressed beam by production process, a steel used in it must have a nominal yield strength. The most important materials are concrete and steel and many features of prestressed elements depend on them. In order to meet construction requirements, production process of prefabricated elements are constantly studying. This allows production process to be more bettered and improved and so production becomes faster and economical. Long ranges of world's bridges, halls and other constructions nowadays can't be made without using the prestressed concrete. Those ranges can't be achieved by using the concrete with traditional reinforcement.
In order to achieve successful production there is not any phase in production may be neglected and any one of these phases may not be considered as more important than the others. All stages during the production must be accomplished by the roles and with a maximum care.
Making the work called "Prestressed concrete beams production process" allows the mentioned beams to be clearly understood as a products or elements needed for assembling the construction and which are also the part of construction.
Prestressing is one of the most important branch in area of building construction. It is also one of the main topic for writing many works, books and doctoral dissertations published every year. It was a great pleasure to have the opportunity to write the work on this topic for conference like ROME 2013.
Nowadays, production of prestressed concrete beams and its using in building construction are irreplaceable when making concrete constructions and long range constructions. In addition, using of prestressed elements will also be irreplaceable in the future.

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