

IMPROVING QUALITY IN CONSTRUCTION OF PRESTRESSED REINFORCED CONCRETE BEAMS IN VIETNAM WITH AUTOMATIC CONTROL SYSTEM OF FORCED WEDGE LOCK AND PRESTRESSED TENSION

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1. INTRODUCTION

In recent years, prestressed reinforced concrete structure has been widely applied all over the world. In Vietnam, prestressed technology was first applied in the 1970s. Prestressed reinforced concrete structure proved the advantages in the field of construction and especially in bridge construction. All the modern bridge construction technologies such as cantilever bridge, launching bridge and cantilever erection... are used prestressed reinforced concrete structure. Applying prestressed reinforced concrete structure to bridge structures provides numerous benefits. Furthermore, prestressed reinforced concrete structure will be more and more frequently used in structures where member size and durability are important design parameters.

For construction of prestressed structure, it is necessary to invest in the special equipment for tensile work. The equipment for tensile work is one of the important equipment systems in construction of prestressed reinforced concrete structure. In developed countries, the prestressed tensile equipment was particularly interested by the machine manufacturer such as Tensa automatic control system of Paul Company (Germany), VSL jack system, OVM jack system (China)... In Vietnam, most of the prestressed tensile equipments are imported from many different companies around the world. In addition, 80% of the prestressed tensile equipments are imported from China. These equipments are widely used as a relatively cheap price, easy maintenance and repair.

In the construction of prestressed reinforced concrete beams, the basic parameters such as the actual tensile load, tendon elongation, camber of the beam, speed of tensile work and the forced wedge locking are important contents deciding the quality of beams.

In Germany, application of automatic control system of forced wedge lock and prestressed tension are interested. The basic parameters are programmed and checked in accordance with current construction technology. In Vietnam, the automatic control system equipments are manufactured and sold by Paul Company. However, the import prices are very high. Since Vietnamese financial resources are limited, so the import of this equipment is very difficult issues at present. In Vietnam, there are a lot of prestressed tensile equipments. However, most of the existing equipments in Vietnam are of free wedge lock and manual control. If the automatic control system is used, the quality in construction will be improved.

2. RESEARCH CONTENTS

2.1 Objectives of the study

Research design and successfully fabricated the automatic control system of forced wedge lock and prestressed tension. The system operation follows prestressed tension process of current construction technology and the level of domestic manufacturing. In addition, products have low price and accepted in the market. The prestressed tensile system consists of 3 main parts: prestressed tensile device with forced wedge lock, hydraulic power possible with automatic control, automatic control system.

2.2 Selecting prestressed tension device with forced wedge lock

The prestressed tension device includes jack, tool anchorage, forced wedge lock part (with free wedge lock technology has a spacer). In the world, most of these devices are applied hydraulic actuator type. In Vietnam, bridge projects are often used cable with 7 and 12 strands. The diameter of strands is 12,7mm or 15,2mm. Stroke of jacks are $H = 200 \div 250$ mm. The working pressures of hydraulic system are $50 \div 70$ MPa. By studying and comparing advantages and disadvantages of equipment available in the world, the basic parameters of prestressed tension device with forced

wedge lock are selected.

2.3 Selecting hydraulic power suitable for automatic control

The hydraulic power includes hydraulic pump, distributor and valve system. Hydraulic pump is device processing the power of the engine to the pressure of the fluid flow. The distributor is used to change the flow from the pump to the branch and distribution of liquid in the pipe. The hydraulic valves protect the safety for engine, the prestressed tension device and keep the tensile load... Thus, the operation of device can be programmed in accordance with current construction technology.

2.4 Selecting automatic control system

The system of automatic control tension device is responsible for controlling operation of device accordance with current construction technology, automatic checking all the basic parameters such as the actual tensile load, cable elongation and preventing incidents may occur. All the basic parameters are displayed on the screen and save to the computer.

Based on a literature review about the control systems of prestressed tension device, PLC (Programmable Logic Controller) technology is selected to the overall design for the automatic control and flow chart of automatic control system is programmed. In addition, the suitable components and equipments are selected.

2.5 Applied solution

2.5.1 Digitization of tensile force and showing tensile force during the construction process

In Vietnam, tensile load of the existing prestressed tension device is determined through pressure gauge indicator. The pressure gauges are mostly spring pressure gauges with low accuracy, low quality, less sensitive. The researchers proposed the solution of digitization the tensile load through the pressure sensor and converter. Thus the tensile load will be measured more accurately and automated process control, showing tensile force, control and adjust tensile process following the program. In addition, the operation of system will be programmed in accordance with current construction technology.

2.5.2 Automatically adjusts speed of tensile work in accordance with construction technology

For existing prestressed tension device, to change the speed of tensile work, have to adjust the valves by hand. Therefore, it is difficult to satisfy the construction standard. The research group has chosen to use the inverter to adjust the speed of the engine, changing the flow of hydraulic pump, leading to change speed of tensile work. On the other hand, by changing the flow of hydraulic pump with inverter will facilitate the process of automatically adjusts speed of tensile work. This is also the useful solution. The patent for useful solution is granted by Department of Intellectual Property in Vietnam (Figure 1).

2.5.3 Designed for forced wedge lock part, digitization the load of wedge lock

In Vietnam, most of the existing equipments are of free wedge lock. Therefore, to achieve design tensile load (P_k), have to pull over to $1,02 P_k \div 1,08 P_k$ then reduce the load to $0.1 P_k$ to finish free wedge lock process. Draw-in of wedges is dependent on the gap of spacer, wedge type, strand type... The research group has chosen to use the forced wedge lock technology. With this technology, when pulling up to the design load $1.0 P_k$, forced wedge lock part will automatically wedge lock. On the other hand, forced wedge lock part could be programmed and the load of wedge lock is displayed on the screen.

2.5.4 Digitization and monitoring the cable elongation

The elongation expresses the real tensile load of cable. The monitoring for the cable elongation is very important. Normally, steel ruler is often used to measure the cable elongation. The research group proposes to use sensor measuring length. With this sensor, the cable elongation will be measured more accurately. In addition, the monitoring of the cable elongation will be programmed and displayed on the screen during the construction process.

2.5.5 Monitoring the stroke of jack, prevention of incidents and accidents

Most of the existing equipments in Vietnam are manual control. Therefore, sometime has a number of incidents



Fig. 1 The patent for useful solution



Fig. 2 The automatically tensile system

caused by workers, causing losses to the contractor and project.

By using the sensor measuring length (cable elongation), the stroke of jack always be monitored during the construction process. With the pressure gauge sensor, warning system, could fully control and warning. In addition, the system could ensure safety equipment and avoid incidents or accidents.

2.5.6 Distribution of hydraulic oil flow for automatic control

The hydraulic oil for control for most of the existing tension devices in Vietnam often used to the valves controlled by hand. The research group used electromagnetic valve to control the oil flow. This type of valve can control the oil flow in the pre-installed programs and ensure the safety of equipment.

2.6 The research results

Technical parameters of the system of automatic control tension device are presented in the Table 1. The photos of the device are introduced in the Figure 2.

3. CONCLUSIONS

Research design and fabricate the automatic control system of forced wedge lock and prestressed tension; following prestressed tension process of current construction technology and the level of domestic manufacturing problem is necessary problem to improve the quality in construction of prestressed reinforced concrete beams.

The research group selected reasonable design plans for prestressed tension device with forced wedge lock, hydraulic power suitable for automatic control, automatic control system. Research results identified the basic parameters of device such as tensile load, stroke, wedge lock load...

Table 1 Basic technical parameters of the system of automatic control tension device

No	Parameter	Unit	Value
1	Prestressed tension device with forced wedge lock		
1.1	Name	KD-2100-460	
1.2	Tensile part		
	Maximum tensile load	kN	2100
	Maximum stroke	Mm	250
	Maximum working pressure of loading process	Bar	500
	Maximum working pressure of unloading process	Bar	50
	Loading piston area	cm ²	417,2
	Unloading piston area	cm ²	279,8
	Diameter of center hole	Mm	Φ 125
1.3	Forced wedge lock part		
	Maximum wedge lock load	kN	460
	Maximum stroke	Mm	30
	Maximum working pressure of wedge lock process	Bar	320
	Loading piston area of forced wedge lock part	cm ²	149
	Unloading piston area of forced wedge lock part	cm ²	11,6
1.4	The overall size (Diameter x length)	Mm	340 x 810
2	Automatic control system		
2.1	Name	DK-2100-460	
2.2	Control Type	-	Automatical, semi-automatic, manual
2.3	Warning for tensile load	kN	0÷2100
2.4	Warning for cable elongation	mm	0÷250
2.5	Display on the screen (tensile load and cable elongation)	-	LCD screen, PC screen

After manufacturing, prestressed tension device was tested with good results. The quality parameters of the device have been inspected and gotten the quality certification by Vietnam laboratory of specialized construction equipment (VILAS 267). The cost of equipment is only equal to 40-50% the cost of imported devices with the similar features.

REFERENCES

- 1) Khang, N.X., "Improving quality in construction of prestressed reinforced concrete beams with automatic control system of forced wedge lock and prestressed tension," Vietnam Ministry of Transport report, 2006-2007.