STATIC LOADING TEST FOR PRESTRESSED CONCRETE MEMBERS SUBJECTED TO TORSION AND AXIAL FORCE

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1. INTRODUCTION It is important to know torsion mechanical properties for such as the large-sized gravity type structures and PC segment type immersed tunnel which receive non-uniformed subsidence of soft ground, the PC floating type structures which receive wave force from slant direction and the pile type PC structures which receive eccentric load by an earthquake or loading of a vessel in recent years [1]. Thus, static loading tests were carried out under various combinations of axial force and torsion in order to investigate mechanical properties and behaviors of PC members subjected to torsion and axial force.

2. TEST PROGRAMS

2.1 Specimens The dimensions and outline of the specimens are shown in Fig. 1. The length of the specimen was 1300mm and cross section was square with 200mm×200mm by any specimens. Reinforcement of end boxes for each specimen was performed using outside steel plate arranged in the range of 200mm and 300mm from both ends respectively. The steel reinforcement was four D13 (SD295) steel bars for longitudinal reinforcement, and D10 (SD295) steel bar for transverse reinforcement at 100mm spacing. SBPR ϕ16 PC steel bar was used to introduce prestress for specimens, and prestress used for the specimens is 150kN (3.75N/mm^2 for concrete). The list of test specimens is presented in Table 1.

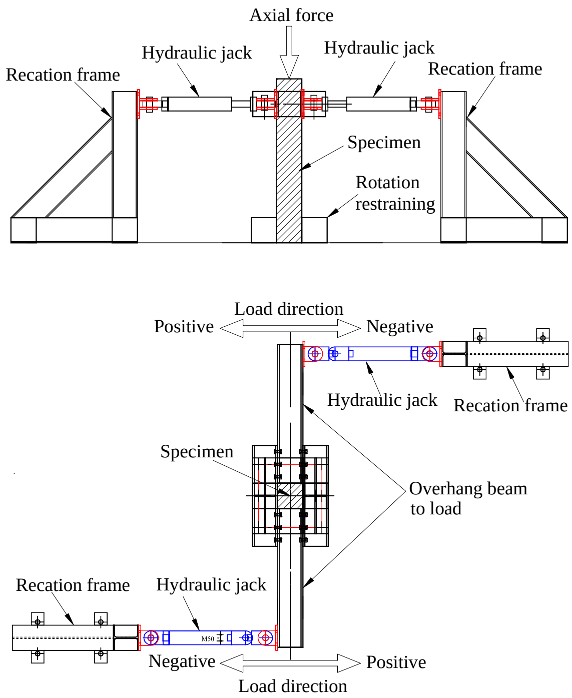

Fig.2 Test set-up

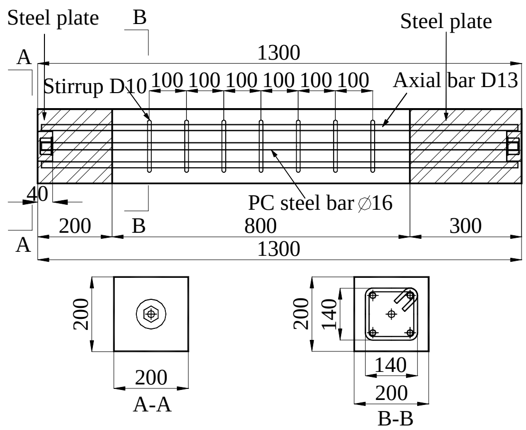

Fig. 1 Details of specimens

Table 1 List of test specimens

Specimen	Prestress	Axial force
No. 1	0 kN	150 kN
No. 2	150 kN	0 kN
No. 3	150 kN	150 kN
No. 4	150 kN	300 kN
No. 5	150 kN	450 kN
No. 6	150 kN	600 kN

2.2 Test procedures Fig.2 shows the loading set-up. Test platform was fastened to the strong floor using anchor bolts. The specimen was fixed at bottom end and other end was free for torsion and axial force. A cyclic torsional moment was applied through the overhang beams, and two hydraulic jacks were installed to apply reversal tensile or compressive forces. The axial force was adjusted to keep constantly until the end of loading test.

3. EXPERIMENTAL RESULTS

3.1 Torsion rigidity Torque-rotation curves of specimen No. 1 and No. 2 are plotted in Fig. 3 together for comparison. No. 1 specimen and No. 2 specimen had the same level of force at axial direction, 150kN axial force for No. 1 specimen and 150kN prestress for No. 2 specimen. The torque-rotation relationships for No. 1 and No. 2 specimen were similar at cycle one and cycle two. But at cycle three, the torque-rotation relationships for No. 1 and No. 2 specimen are great different, not only the torsion rigidity but also the torque resistance of No. 2 specimen largely dropped than No. 1 specimen. The main

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reason can be considered as the loss of pre-stress. Torque-rotation curves of specimen No. 2 and No. 6 are plotted in Fig. 4 together for comparison. The parameter for No. 2 to No. 6 specimen was the level of the axial force. The torque-rotation relationships for all specimens are similar at each cycle, and bearing capacity of specimen was greatly influenced by axial force. The higher axial force applied, bearing capacity became higher. But the level of the axial stress was limited under 7 f_t, too high level of the axial force will lead to brittle fracture by concrete reached compressive strength.

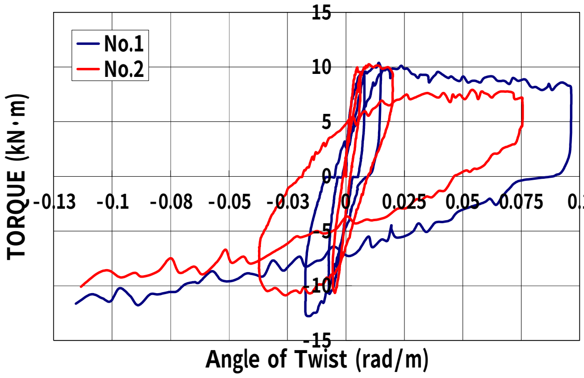

Fig. 3 Torque-rotation diagram (No.1, No.2)

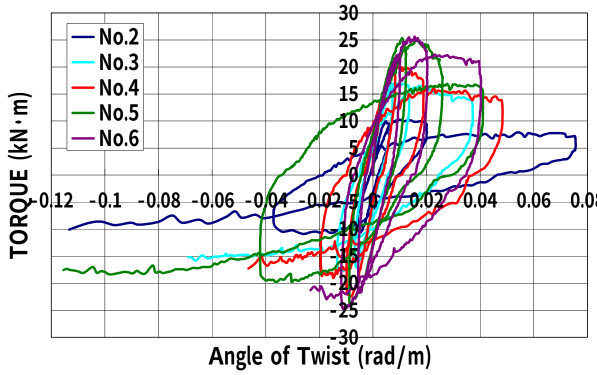

Fig. 4 Torque-rotation diagram (No.2 to No.6)

3.2 Description of the crack pattern Fig. 5 shows the crack pattern of the specimens. Black color shows the wider cracks and red color shows the narrower cracks. The first crack which occurred by positive load was observed when the load was near the maximum load in cycle one, and simultaneously with occurrence of the first crack, many cracks were occurred through the other sides of specimen. And the first crack which occurred by negative load was also observed when the load was near the minimum load in cycle one, and thereafter behaviors of specimen were similar to the case when positive load was applied in cycle one. In cycle two and cycle three, with the increase of the load, the cracks were widen and spread to the other sides of the specimen, and in the final stage, the cracks was connected to four sides of specimen and the specimen was destroyed. On the other hand, through the loading test, it was observed that the direction of the cracks was greatly influenced by axial force. In all specimens, the higher axial force applied, the angle of the cracks became smaller to longitudinal axis.

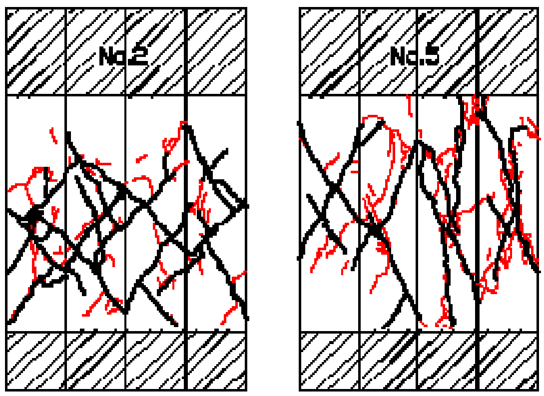

Fig. 5 Developed elevation of cracks

3.3 Strain of the specimens

(1) Reinforced bars Fig. 6 showed the torque-strain diagram of stirrup which was set in the center of each specimen. The strain of the stirrups was little until the occurrence of the crack. It confirms that before the occurrence of crack, the torque resistance of the stirrups can be ignored. After the occurrence of the cracks, the strain of the stirrups became large and greatly resisted to torque. By the way, the behavior of strains at longitudinal bars was similar to stirrups. **(2) Concrete** Fig. 7 showed the torque-strain diagram of 45 degrees concrete gauge. It was approximately linear up to cracking and thereafter it became nonlinear. It also confirms that the torque resistance of the concrete can be regard as an elastic member in practical design before the occurrence of crack.

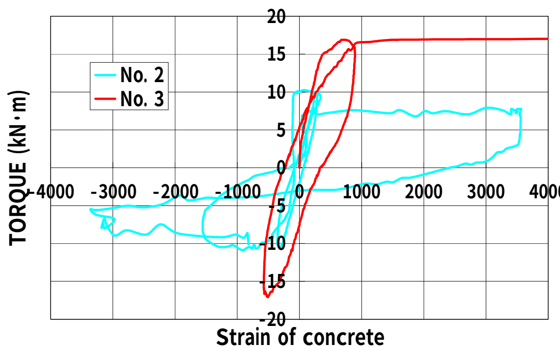

Fig. 6 Torque-strain diagram of stirrup

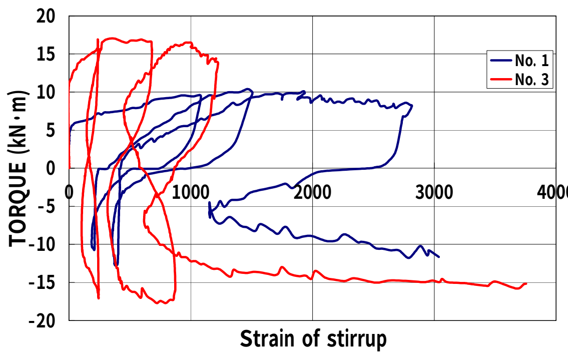

Fig. 7 Torque-strain diagram of concrete

4. CONCLUSIONS Through the loading tests and theoretical mechanics analysis, following conclusions are obtained. (1) Axial force not only influences the torque resistance capacity of specimen, but also influences the direction of the cracks of specimen. (2) When receive a cyclic torsion moment, mechanical behaviors of the specimen are mostly the same both at positive load direction and negative load direction. (3) After cracks were occurred and widened, prestress level will be lost, both torsion rigidity and torque resistance of specimen will be largely dropped.

REFERENCE:

[1] Yamada, M., Kiyomiya,O. and Yokota, H.: Torsional properties of long caisson fabricated by hybrid members, Transactions of the Japan Concrete Institute., Vol. 13, 1991