

Effect of Heating Temperature on Residual Load Carrying Capacity Properties of Pretensioned Prestressed Concrete

Osaka Institute of Technology	Student Member	○Dennise
Osaka Institute of Technology	Regular Member	Yasuhiro Mikata
Osaka Institute of Technology	Regular Member	Susumu Inoue

1. Introduction

In recent years, fire damage to bridges and viaducts have been reported. In the case of estimating the residual load-carrying capacity of pre-tensioned PC girders after a fire, it is necessary to clarify the relationship between the maximum heat-receiving temperature of the PC members and the residual strength. It has been found that the heat-receiving temperature of the internal PC tendons can be determined with relatively high accuracy by analysis when there is no spalling of the cover concrete. On the other hand, when spalling of the cover concrete occurs, the heat-receiving temperature of the PC steel varies greatly depending on the depth of the spalling. Therefore, it is essential to consider the effect of spalling in the evaluation of the residual load-carrying capacity of PC structures, however, no method has been established yet.

2. Purpose

The purpose of this study is to investigate the effect of heating time and temperature on the spalling conditions of the cover concrete. In addition, the maximum heat-receiving temperature of the internal PC tendons and to quantitatively evaluate the effect of these relationships on the residual load-carrying capacity.

3. Specimen Outline

The PC girder details were as follows: top width 640 mm, bottom width 700 mm, total length 5300 mm, and pre-tensioned PC girder 1) (pre-tensioned PC girder (AS-05) as specified in JIS-A-5373). The design compressive strength of the concrete 50 N/mm².

4. Heat test

A horizontal heating test furnace (4m x 3m) was used. For the fire curve, a heating curve (HC900) was selected, in which the maximum temperature of the hydrocarbon

curve HC curve (1100°C) specified by Eurocode3 2) was modified to 900°C. The heating time was 60 minutes. Heating tests and load-bearing tests were conducted on specimen 60HC900-1. For comparison, a specimen N-2 without a heating test was used. The bottom surface of the heated PC girder is shown in Figure-3 after natural cooling and removal. The concrete has spalled to such an extent that the entire transverse stirrups and the PC steel are exposed. The maximum depth of the spalling was 61mm. The depth of the spalling was smaller in the center than at both ends.

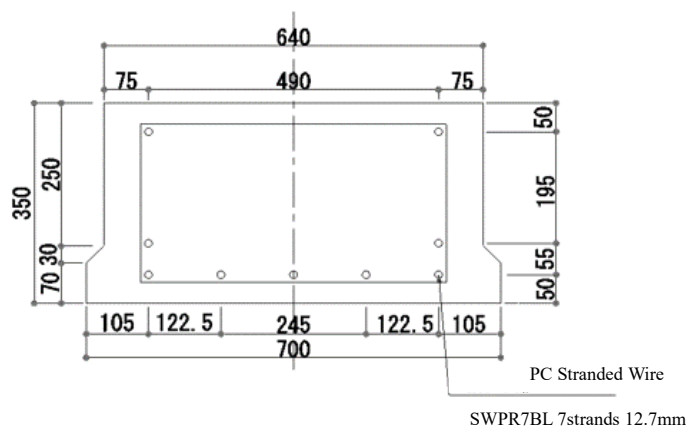


Figure-1 Cross Section of Concrete Specimen

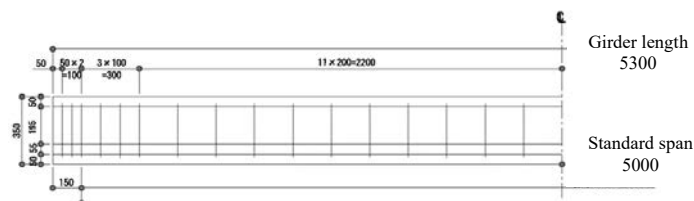


Figure-2 Side Section of Concrete Specimen

Keyword Pretensioned Prestressed Concrete, Hydrocarbon Heating Curve, Spalling, Crack

Contact 5-16-1 Ohmiya, Asahi-ku, Osaka, 535-8585 Japan,
Osaka Institute of Technology, Ohmiya campus Building 9 TEL : 070-1430-1817

5. Loading Test

The static loading test was conducted using the two-point concentrated load method with the bending span of 1000 mm and the shear span of 1850 mm, and monotonically increasing loads were applied until failure.

Figure-4 and 5 show the crack of each specimen after the loading test. It also shows flexural cracks occurred from the bottom edge near the center of the span in both specimens, and the concrete in the compression zone was crushed. In case N-2, flexural cracking occurred at a load of 220 kN. Finally, at a load of 380 kN, flexural tension failure occurs, and the flexural compression zone is crushed. In the case of 60HC900-1, flexural cracking occurred at a load of 180 kN and flexural tension failure occurs at a load of 330 kN.

Figure-6 shows the load-displacement relationships. In case of comparing the measured maximum load values of each specimen where 60HC900-1 is 332.5 kN and N-2 is 387.9 kN, a decrease of 14% can be observed and it also shows that the initial stiffness and displacement of maximum load decreased due to heating.

The reason for the decrease in the maximum load and initial stiffness of 60HC900-1 are considered to be the decreasing cross-sectional area and decreasing prestress due to spalling of the cover concrete

6. Conclusion

The conclusions obtained in this study are as follows. The concrete has spalled to such an extent that the entire transverse stirrups and the PC tendons are exposed. The maximum depth of the spalling was 61mm. The measured maximum load values of each specimen where 60HC900-1 is 332.5 kN and N-2 is 387.9 kN, a decrease of 14% can be observed and it also shows that the initial stiffness and displacement of maximum load decreased due to heating.

Acknowledgment

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Figure-3 Explosion Spalling condition after heat test

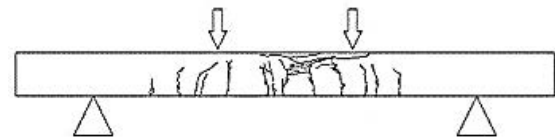


Figure-4 Crack Condition after Loading Test (N-2)

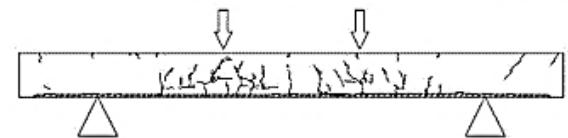


Figure-5 Crack Condition after Loading Test (60HC900-1)

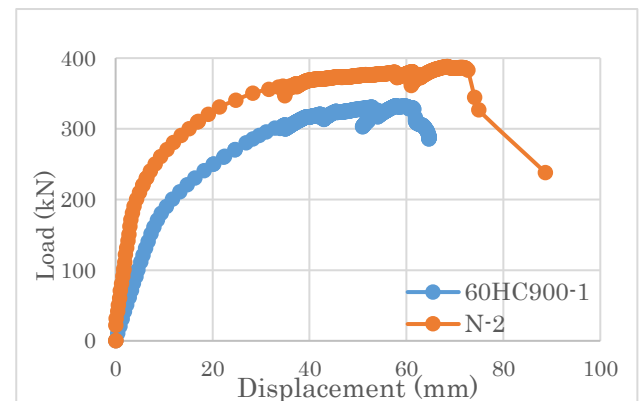


Figure-6 Load - Displacement Relationships

References

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- 2) Eurocode3: Design of steel structures Part1.2: General rules Structural fire design,2003.4