論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Behavior of Pretensioned PC Beams Strengthened in Flexure and Shear using Externally Bonded CFRP Sheets
著者(和文)	NGUYEN THI THU DUNG
Author(English)	Thi Thu Dung Nguyen
出典(和文)	学位:博士（工学）, 学位授与機関:東京工業大学, 報告番号:甲第9981号, 授与年月日:2015年9月25日, 学位の種別:課程博士, 審査員:二羽　淳一郎,北詰　昌樹,岩波　光保,竹村　次朗,佐々木　栄一
Citation(English)	Degree:, Conferring organization: Tokyo Institute of Technology, Report number:甲第9981号, Conferred date:2015/9/25, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	Civil Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 (Engineering) Doctor of
学生氏名： Student's Name	NGUYEN Thi Thu Dung	指導教員（主）： Academic Advisor(main)	Prof. Junichiro NIWA
		指導教員（副）： Academic Advisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The damages of prestressed concrete (PC) girders due to deterioration have been increasingly reported in many countries. In order to enhance the structural performance of the damaged members for the prolonged use and avoid an unfavorable failure, an effectively practical strengthening technique is required. This study aims to investigate the behavior of pretensioned PC beams strengthened in flexure and shear using externally bonded carbon fiber reinforced polymer (CFRP) sheets. Two experimental programs were carried out. The first program focused on the behavior of pretensioned PC beams having ruptured strands strengthened in flexure by CFRP sheets. The second one studied the strengthening effects of various parameters on enhancement of shear capacity and shear resisting mechanisms of pretensioned PC beams without shear reinforcement strengthened by CFRP sheets. The thesis contains 7 chapters.

In Chapter 1, the general background of the requirement in strengthening PC beams and the proposed strengthening method using externally bonded CFRP sheets are introduced. Subsequently, the aims and methodology of the study are shortly described.

Chapter 2 provides the basic knowledge on the structural behaviors of PC beams in flexure and shear. The properties and the advantages of CFRP sheets are reviewed. Furthermore, the existing studies on strengthening PC beams using externally bonded CFRP sheets are summarized.

In Chapter 3, the experimental program of PC beams having ruptured strands strengthened in flexure by CFRP sheets are presented. The ruptures of strands were simulated by cutting prestressing strands at the middle of the span. When the strands are ruptured, the flexural capacity and stiffness of damaged beams decreased significantly. The damaged PC beams, then, were strengthened by externally bonded CFRP sheets. The experimental parameters included the length of CFRP sheets, number of layers, presence of U-shaped anchorages and wrapping sheets. The experimental results revealed that the flexural capacity and the stiffness of the PC beams having ruptured strands could be increased significantly by bonding CFRP sheets. The increase in the thickness of bonded sheets results in a reduction of the tensile stress resisted by the remaining prestressing strands.

Chapter 4 explains the various failure modes occurred in the PC beams having ruptured strands strengthened in flexure by CFRP sheets. The failure behaviors depend on the length and the total

thickness of the bonded sheets. When the thickness of bonded sheets increases, the failure tends to change from debonding induced by flexural cracks to debonding from the sheet ends due to the stress concentration and loss of prestress at the sheet ends. Thus, the increase in the total thickness of the bonded sheets needs to be considered with a sufficient sheet length. In addition, the comparison between the calculation based on the equations in the recent guidelines of ACI and JSCE and the experimental results was performed.

Chapter 5 presents the details of the experiment of pretensioned PC beams without shear reinforcement strengthened in shear using the externally bonded CFRP sheets. The effects of CFRP ratio, thickness and stiffness of the sheets, wrapping type and effective prestress in the strands on the strength, stiffness of the strengthened PC beams are investigated. The higher effectiveness of strengthening can be obtained in the beams strengthened with higher amount of CFRP sheets or PC beams having higher effective prestress. However, the increase in the sheet thickness may not improve the shear capacity compared to the use of the thinner sheets. Furthermore, the insufficient anchorage bond length in case of U-shaped strips may lead to an abrupt failure by debonding of the sheets.

Based on the experimental results in Chapter 5, the shear resisting mechanisms and failure behaviors of the strengthened beams are presented in Chapter 6. The outcomes imply that the shear force in PC beams without shear reinforcement strengthened by externally bonded CFRP sheets is resisted by beam action, arch action and bonded CFRP sheets. The increase in the amount of CFRP and higher prestressing level in the strands maintain the performance of these actions. As a result, the higher effectiveness of strengthening can be obtained. Nevertheless, when the beams are over-reinforced, the increment of shear capacity is limited by either strength of concrete in compression or tensile strength of the bonded sheets. The sheet with high elastic modulus effectively restrains the diagonal crack, hence, remains the stiffness of the beam. Moreover, the predictions of the increment of shear capacity of the strengthened beams based on the recent design guidelines of ACI and JSCE showed highly inconsistent with the experimental results. It is apparent that the effect of prestressing and the inverse effect of sheet thickness have not been considered in the equations of the design guidelines.

Finally, the conclusions of the study and the recommendations for further research are given in Chapter 7.