BONDING PROPERTIES OF CFRP STRAND SHEET AND CFRP PLATE ON RC BEAM

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論 文 名　: BONDING PROPERTIES OF CFRP STRAND SHEET AND CFRP PLATE ON RC BEAM
（CFRPストランドシートおよびCFRPプレートのRCはりに対する付着特性）

区　　分　: 甲

論 文 内 容 の 要 旨

A lot of reinforced concrete (RC) structures have been required to retrofit or strengthen due to decrease of their loading capacities caused by age, environmental influences, poor design and construction, lack of maintenance, and damage caused by heavy earthquake and so on. Carbon fiber reinforced polymer (CFRP) has been successfully used to retrofitting these RC structures because of its excellent properties. However, there are a number of problems to be solved related to the external composite CFRP-concrete performmance.

Therefore, in order to establish more reliable and rational design, the bonding properties of CFRP-concrete interface must be an important task to be evaluated. Related to the bonding properties in this external composite system, some issues are addressed in this study. In this study, both CFRP-concrete bonding test and RC beam test as well as a finite element analysis were carried out to examine the CFRP-concrete bonding properties and the strengthening effect for RC beam. The used types of CFRP are CFRP strand sheet and both high tension and high modulus types of CFRP plate. Also, the variation of adhesive types are epoxy, MMA (methyl methacrylate) and PCM (polymer cement mortar), as well as polyurea soft layer to improve the CFRP plate-concrete bonding behavior. To discuss this matter, this dissertation is divided into six chapters.

Chapter 1 presents the research background of this study, problem statement, research objective, contribution of research, limitation and the dissertation arrangement as outline of the research.

Chapter 2 presents the information about FRP, adhesive and the application of CFRP strengthening method to RC members. In other parts of this chapter previous studies related to the FRP/CFRP strengthening methods were described. Some factors, theory of bonding properties and bonding characteristics were also briefly presented. Finally, the issues addressed in this study were also discussed in this chapter.

Chapter 3 presents the application of CFRP strand sheet strengthening method on RC beams. Three kinds of adhesive materials were used in this experiment. They were epoxy, MMA (methyl methacrylate) and PCM (polymer cement mortar). Seven RC beams comprising one non-retrofitted beam (specimen N) as a control beam and six retrofitted beams for three kinds of adhesive materials with one layer and two layers of CFRP strand sheet were tested in this study. The dimensions of RC beams specimens were 200mm x 300mm x 2200mm. FEM analysis was performed to confirm the experimental results. The results indicated that all the strengthening with CFRP strand sheet could improve the capacity of RC beam. The failure mode of specimen with CFRP strand sheet strengthening method was found to be highly dependent on the type of adhesive. Epoxy resin, MMA resin and PCM could be recommended as adhesive material to the CFRP strand sheet strengthening method. However, some experimental and FEM analytical results did not show a fairly good agreement. It was found that the bond slip interface model could be required to be corrected.

Chapter 4 discusses the investigation of bonding behavior of CFRP strand sheet and concrete. Both experiment and analysis were conducted to evaluate the performance of CFRP strand sheet and concrete strengthening method. The bonding test was done based on JSCE-E543-2007. In this test, two kinds of adhesive materials such as MMA and PCM were used. The variation of layers of CFRP strand sheet were one, two and three layers. Three specimens were prepared for each type. The results showed that the typical failure of bonding test was the interfacial failure occurred on only one side of the prism. From the results, MMA specimens showed the average maximum load of two and three layers increased by 17.5% and 30.8%, respectively, compared with the single layer. Meanwhile, PCM specimens showed that there was an increase in average maximum load of 30.7% for two layers compared with the single layer. It can be proved that MMA and PCM were fairly good adhesive material for CFRP strand sheet strengthening method. At the end of this chapter, applications of the bond slip used to the RC beams analysis were tested previously.

Chapter 5 investigates the bonding properties of the CFRP plate and concrete. This chapter also describes the effect of the bonding behavior on polyurea soft layer for both high tension and high modulus types of CFRP plates. The specimen had a total bonding length of 590mm on both sides in this test. The test results showed that specimens with soft layer had more different failure mode than without soft layer specimen. The polyurea soft layer could enhance significantly the performance of bonding behavior on the high tensile type of CFRP plate. However, polyurea soft layer did not give sufficient effect on the high modulus type. This was because high modulus type without soft layer specimens had longer effective bond length than used bonding length of specimen itself. At the end of this chapter, a simple equation has been proposed for the rational design.

Chapter 6 offers conclusion and recommendations for future research.