論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Application of PP-ECC on Rigid-Framed Bridges for Improving Structural Performance
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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9789号, 授与年月日:2015年3月26日, 学位の種別:課程博士, 審査員:二羽　淳一郎,廣瀬　壮一,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9789号, Conferred date:2015/3/26, 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	土木工学	専攻	申請学位（専攻分野）： Academic Degree Requested
学生氏名： Student's Name	張 鋭 ZHANG, Rui		博士 （工学） Doctor of
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Bridges are vital components of transportation that requires a high degree of protection to ensure their safety during a strong earthquake. The extensive damages of RC bridges observed in the past earthquakes such as Northridge, Kobe and 2011 Great East Japan earthquakes triggered extensive researches on the behavior of beam-column joint connections for designing and constructing a safer infrastructure, which further resulted in the improvements of design codes focusing on providing sufficient ductility in the vulnerable structural member to prevent its brittle failure during a major seismic event. Accordingly, for reinforced concrete (RC) structures, a considerable amount of steel reinforcements are required to be provided in these vulnerable regions, such as the plastic hinge in the beam end adjacent to the column face in a beam-column joint connection in the rigid-framed railway bridges, to confine the concrete to realize the formation of ductile inelastic behavior in the plastic hinge. However, the increased and elaborated reinforcement details bring the difficulties in fabricating this complicated steel reinforcement cage as well as placing and consolidating concrete in it during the construction phase. The contradiction between increased high cost for design and construction due to these complicated reinforcements with accordingly raised requirements on seismic performance becomes more and more apparent.

In this research, a cementitious composite combined with fabricated polypropylene fibers named Polypropylene Fiber Reinforced Engineered Cementitious Composites (PP-ECC) with improved bond properties exhibiting the pseudo strain hardening and multiple fine cracking of ECC was utilized to reduce the transverse reinforcements in beam-column joint connections of rigid-framed bridges. PP-ECC also has a higher strain at the compressive strength than that of normal strength concrete. PP-ECC exhibits the strain hardening behavior and its yield and ultimate tensile strength is greater than 2.5 N/mm2 and 3.0 N/mm2, respectively. The tensile strain capacity of PP-ECC is greater than 2.5%. All above described mechanical properties of PP-ECC makes PP-ECC an ideal material for enhancing the shear capacity of structural members. Compared to the widely used polymer fibers such as polyvinyl alcohol (PVA) fibers or polyethylene (PE) fibers, polypropylene (PP) fiber is softer, costs lower and disperses faster, which all results in better workability. In addition, because of the hydrophobic and non-polar nature of PP fiber, PP-ECC has better durability in an alkaline environment.

Since this research mainly focused on the shear reinforcing effect of PP-ECC in the beam and the beam-column joint connection, the shear reinforcing effect of PP-ECC was investigated in advance by conducting monotonic loading tests with a total of seven beams including two conventional steel reinforced concrete (RC) beams with and without stirrups and five PP-ECC beams with various stirrup ratios ranging from the level of RC control beam to zero. Having been confirmed that the PP-ECC could be an alternative to stirrups, the T-shaped exterior one-sixth scaled beam-column joints of existing structure following Japanese railway design standards, “Design Standards for Railway Structures and Commentary (Concrete Structure)” (Railway Technical Research Institute, 2004) were prepared and tested under a lateral cyclic load. This kind of T-shaped exterior joint consists of an intermediate beam, the joint and the columns

above and below the joint. The dimensions of the beam and the column and the quantity of rebars including arrangement and detailing of the specimens resembled with the as built configuration of the rigid-framed bridge. Based on the findings in monotonic loading tests of beams, the transverse reinforcements in RC beam-column joints with the purpose of reinforcing the shear capacity were reduced by the replacement of PP-ECC in the joint, the beam and the column, one after another.

The experimental results reveal that PP-ECC is effective to enhance the shear capacities of beam when the matrix is replaced from normal strength concrete to PP-ECC. Based on the results of monotonic loading beam tests, the shear capacities of the beams with stirrups and without stirrups increased 20.6% and 107.6%, respectively, by replacing concrete with PP-ECC. It indicates that the feasibility that the certain amount of stirrups can be replaced by PP-ECC. In the experiments of beam-column joints, the specimens with the reduction of transverse reinforcements by using PP-ECC exhibits comparable structural performance, in terms of load capacity, energy dissipation and stiffness degradation to that without reduction of transverse reinforcements. It indicates that the PP-ECC could be a replacement of the transverse reinforcement in beam-column joint connection specimens to reduce the congestion in the beam-column joint connection.