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SEISMIC RETROFIT OF SUBSTANDARD RC BEAM-COLUMN JOINTS BY PLANAR JOINT EXPANSION

Preeda Chaimahawan

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A Thesis Presented

by

Preeda Chaimahawan

Doctor of Philosophy
School of Civil Engineering and Technology
Sirindhorn International Institute of Technology
Thammasat University
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Preeda Chaimahawan

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Approved as to style and content by

Advisor and Chairperson of Thesis Committee

Assoc. Prof. Amorn Pimanmas, Ph.D.

Co-Advisor

Prof. Somnuk Tangtermsirikul, D.Eng.

Committee Member and
Chairperson of Examination Committee

Assoc. Prof. Pennung Warnitchai, D.Eng.

Committee Member

Asst. Prof. Mongkut Piantanakulchai, Ph.D.

External Examiner : Prof. Hiroshi Shima, D.Eng

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Abstract

In this thesis, a joint retrofitting technique called "planar joint expansion" is proposed. In this method, the beam-column joint is two-dimensionally enlarged by cast in-situ concrete or steel bracket. The planar joint expansion can be independently installed in transverse and longitudinal directions. The method is comparatively easy in application. Since conventional materials are used, the method is cost-effective and architecturally acceptable.

Eight half-scale beam-column specimens were tested under quasi-static cyclic loads. One was control specimen and the other 7 specimens were retrofitted with square and triangular expansions. The specimen size and reinforcement details of retrofitted specimens were identical with those of the control specimen except in the retrofitted parts and. Test result indicated brittle joint shear failure in control specimen and beam flexural failure in retrofitted specimens. The strength, stiffness, ductility and energy dissipation of retrofitted specimens were increased. The planar joint expansion could reduce joint shear stress and anchorage bond stress of beam bars within the joint. The plastic hinge could be relocated from column face. The triangular and square expansions performed equally well. Pre-formed construction joints did not render poor cyclic behavior. The steel bracket and cast in-situ concrete joint expansions also perform equally well. A better performance of the proposed method is proved if ductility in beam is improved.

Common to any strengthening technique, planar expansion method has limitations. The method may produce undesirable shear failure in beam and column due to shortened member length. Thus special consideration must be exercised in strengthening design to prevent member shear failure.

The nonlinear finite element analysis was applied to simulate the behavior of the specimens. The FEM analysis employs the smeared crack approach for modeling beam, column and joint, and employs the discrete crack approach for modeling the interface between strengthening part and existing beam-column connection. The FEM shows good comparison with test results in terms of load-displacement relations, hysteretic loops, cracking process and the failure mode. The FEM analysis illustrates the flow of force in planar expansion.

Furthermore, a strut and tie model to design planar joint expansion is also proposed. The model is based on complex flow of internal forces analyzed by FEM and experiment. The model can predict close value of maximum column shear force, failure mode and joint shear force. The accuracy of model was also agreed with measuring strain steel.

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