



2020「中技社科技獎學金」

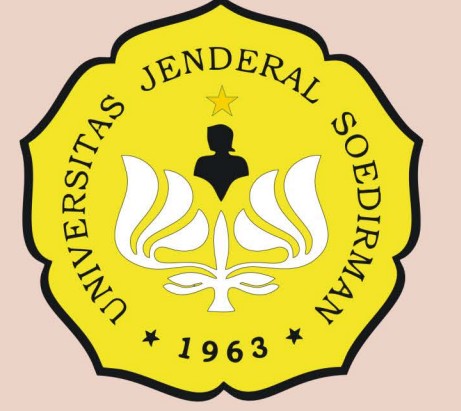
2020 CTCI Foundation Science and Technology Scholarship

境外生研究獎學金

Research Scholarship for International Graduate Students



EXPERIMENTAL AND NUMERICAL STUDIES ON THE BEHAVIOR OF RC T-BEAMS STRENGTHENED WITH FRP RODS AND FRP SHEETS UNDER MONOTONIC AND CYCLIC LOADING



Yanuar Haryanto

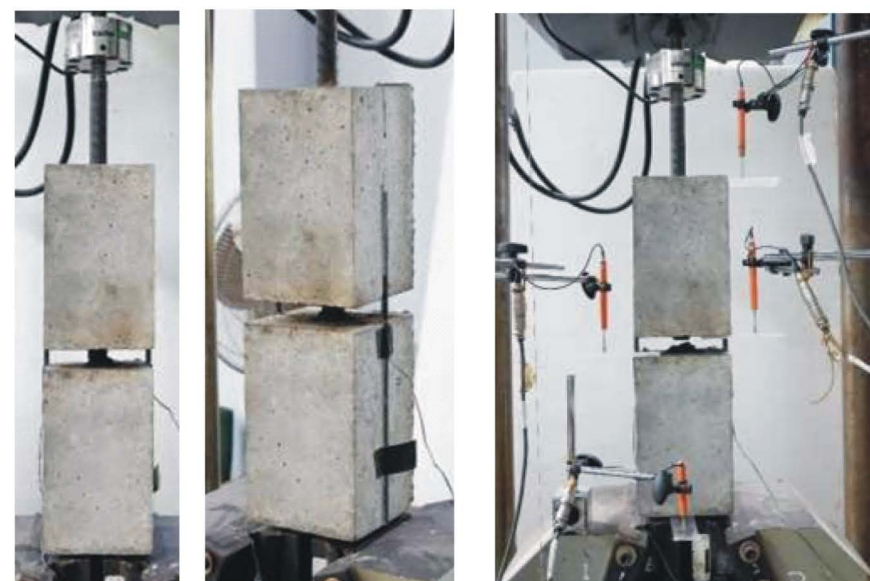
Adivisor: Professor Hsuan-Teh Hu, Professor Han Ay Lie, Professor Fu-Pei Hsiao
Department of Civil Engineering, National Cheng Kung University

Abstract

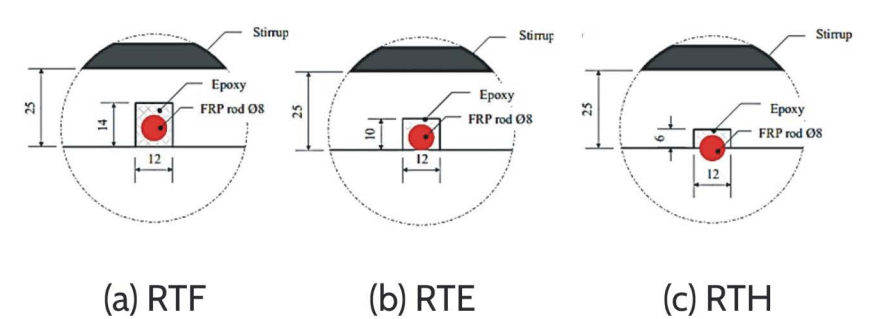
The use of Near Surface Mounted (NSM) strengthening technique to retrofit reinforced concrete (RC) members using Fiber Reinforced Polymer (FRP) rods has been increasing in recent years. It is important to continue the research into experimental test and accurate numerical modeling so that engineers and the scientific community have access to a better understanding on the bond performance of FRP rod embedded in concrete with various depth and the response of RC T-beams strengthened in the negative moment region with NSM FRP rods under monotonic and cyclic loading.

Research Focus

A. MODELING OF DOUBLE SHEAR LAP TESTS



(a) Set up (b) FRP rod (c) Cutting of pull-off bar
Fig. 1 Assemblage and pull-off bar cutting



(a) RTF (b) RTE (c) RTH
Fig. 2 Specimen classification

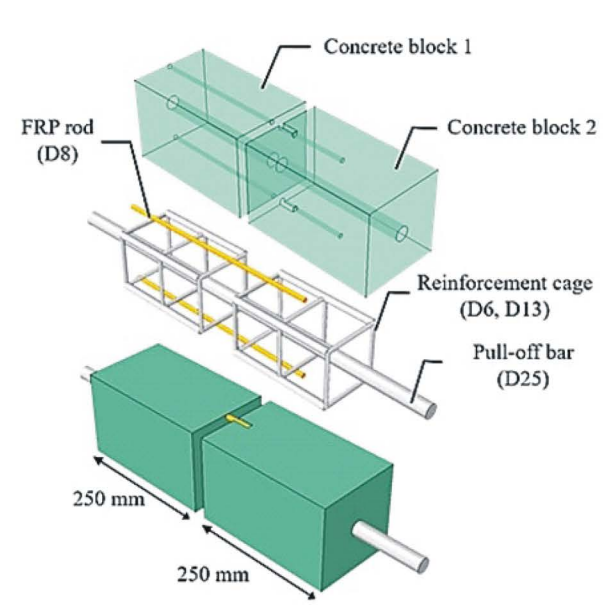
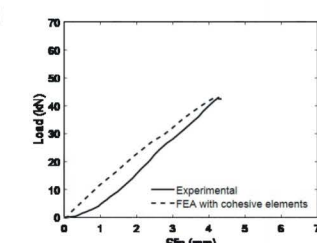
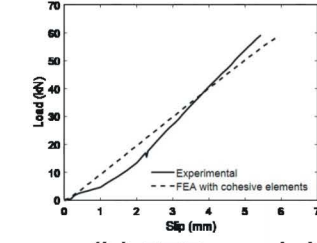


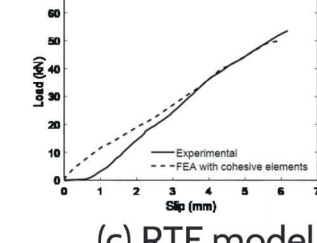
Fig. 3 Geometry of double shear lap test model



(a) RTH model

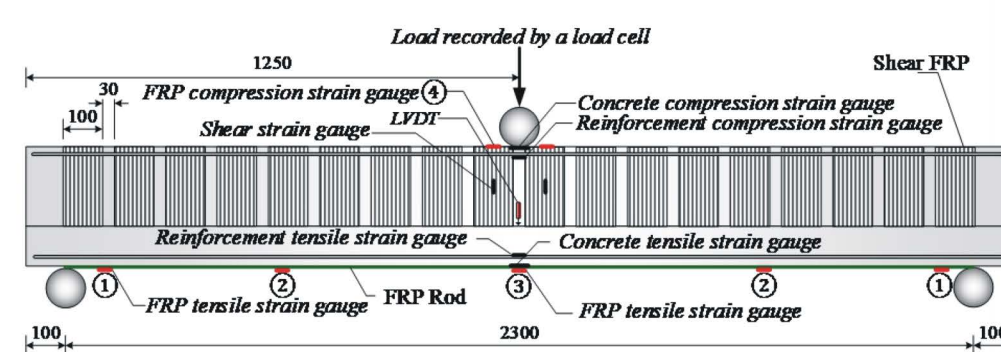


(b) RTE model

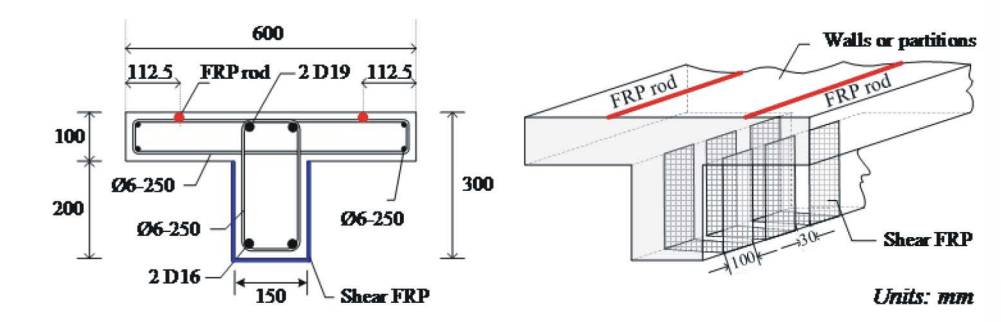


(c) RTF model
Fig. 4 Numerical validation

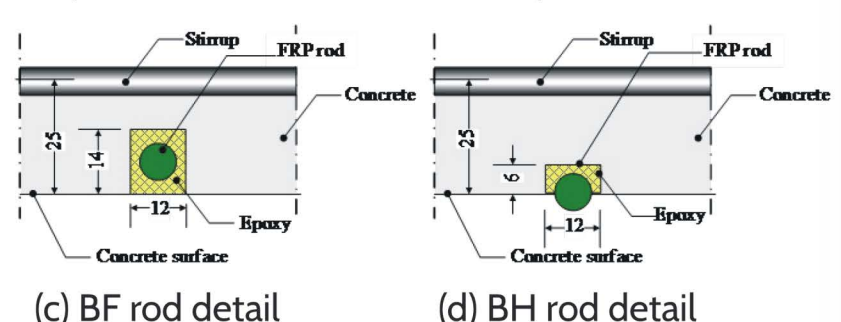
B. MODELING OF NSM FRP STRENGTHENED RC T-BEAMS UNDER MONOTONIC LOADING



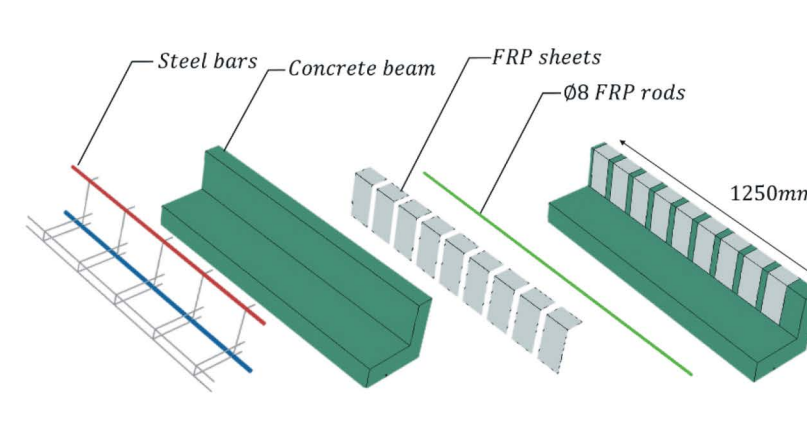
(a) Test setup and measuring instruments



(b) Specimen details and FRP rod placement



(c) BF rod detail (d) BH rod detail
Fig. 1 Experimental setup and beams detail



(a) Schematic of one-quarter of the beam

C. TESTS OF NSM FRP STRENGTHENED RC T-BEAMS UNDER CYCLIC LOADING

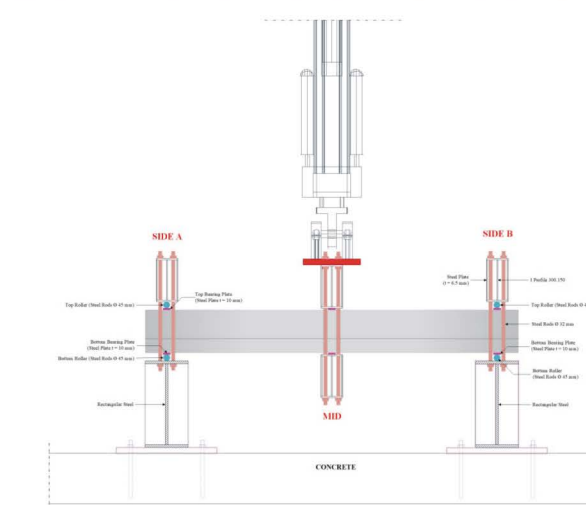
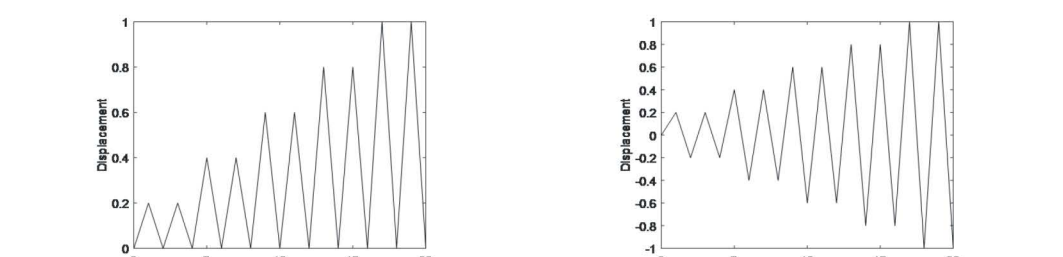


Fig. 1 Experimental setup



(a) Loading-unloading protocol (b) Reverse cyclic loading protocol
Fig. 2 Proposed loading protocol



Fig. 3 Strong wall at National Center for Research on Earthquake Engineering (NCEE)

Summary

The final numerical results of double shear lap tests were very similar but generally showed a slightly lower value for the slip with an average difference of 0.46% and the ultimate load also had a bit lower peak with an average of difference 3.37%. The finite element model developed and validated in this research is considered appropriate to model and analyze RC T-beams strengthened in the negative moment region with NSM FRP rods under monotonic loading. It also has the ability to perform accurate and efficient parametric studies which are focused on designs of several configurations of strengthening using FRP materials. It is expected that engineers and the scientific community have access to a better understanding on the response of RC T-beams strengthened in the negative moment region with NSM FRP rods under cyclic loading.

Selected Journal Publications:

- Haryanto, Y., Han, A. L., Hu, H.-T.*, Hsiao, F.-P., Hidayat, B. A. and Widyaningrum, A., "Enhancement of Flexural Performance of RC Beams with Steel Wire Rope by External Strengthening Technique", Journal of the Chinese Institute of Engineers, accepted (SCIE).
- Haryanto, Y., Hu, H.-T.*, Han, A. L., Wariyatno, N. G. and Hidayat, B. A., "Predicting the Flexural Capacity of Reinforced Concrete Beams Strengthened with Non-metallic Materials Using Analytical Method", Journal of Engineering Science and Technology (JESTEC), accepted (ESCI).
- Haryanto, Y., Hu, H.-T.*, Han, A. L., Hsiao, F.-P., Teng, C.-J. and Hidayat, B. A., "Nonlinear 3D Model of Double Shear Lap Tests for the Bond of Near-surface Mounted FRP Rods in Concrete Considering Different Embedment Depth", Periodica Polytechnica Civil Engineering, in review (SCIE).
- Haryanto, Y., Hu, H.-T.*, Han, A. L., Hsiao, F.-P., Teng, C.-J., Hidayat, B. A., "Modeling of RC T-beams Strengthened in the Negative Moment Region using NSM FRP Rods at Various Depth of Embedment", Computers and Concrete, in review (SCIE).
- Haryanto, Y., Hu, H.-T.*, Han, A. L., Hsiao, F.-P., Teng, C.-J., Hidayat, B. A., Wariyatno, N. G., "Negative Moment Region Flexural Strengthening System of RC T-Beams with Half-Embedded NSM FRP Rods: A Parametric Analytical Approach", Journal of the Chinese Institute of Engineers, in review (SCIE).



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