別紙４（課程博士）

Date of Submission:

平成　28　年　07　月　22　日

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Abstract

論文内容の要旨　（博士）

Title of Thesis 博士学位論文名	Performance Assessment of Low Ductility Reinforced Concrete Shear Walls Retrofitted by Carbon Fiber Sheets under Cyclic Loading （炭素繊維で補強された低靭性鉄筋コンクリート造耐震壁の繰り返し載荷における性能評価）

(Approx. 800 words)

(要旨　1,200 字程度)

Earthquakes are caused by a sudden release of energy from the movement between tectonic plates; besides geological faults and volcanism. As Peru is located in a high seismic hazard zone, it is necessary to improve the seismic response of buildings against earthquakes. In addition, in recent years, large scale construction of medium-rise building that use low ductility reinforced concrete (LDRC) walls has become commonplace in Peru. These walls do not have boundary columns but instead have a small quantity of reinforcing bars at each end and therefore expected to fail in flexural mode.

LDRC walls do not have a large deformation capacity in comparison with conventional RC walls, whereby, to improve seismic response of buildings composed by LDRC walls against earthquakes, might be possible by increasing its deformation capacity through carbon fiber sheet (CFS) confinement method.

Two verification tests were conducted by using CFS as a retrofitting method in Toyohashi University of Technology (TUT), Japan. The first test was conducted over three LDRC walls (Without CFS, full wall retrofitted with CFS and edges retrofitted with CFS). The second test was conducted over another three similar walls following the same retrofitted pattern of the first experiment but with a partial height retrofitted with CFS. From those tests, it was verified that carbon fiber sheets delay the concrete crushing of the wall base that occurs during flexural failure and that deformation performance was improved.

To verify the confinement effect of CFS, a third experiment was conducted using concrete samples with CFS by changing the size, shape and number of CFS layers. In total, 39 concrete samples (Circular shape: 8-ϕ150x300mm, Square shape: 9-150x150x300mm, 2-150x150x450mm, Rectangular shape: 4-150x300x300mm, 2-150x300x450mm, 5-100x300x200mm, 2-100x300x300mm, 5-100x400x200mm, 2-100x400x300mm) were tested under compressive loading (monotonic and cyclic). From the experiment, it was confirmed that deformation performance was improved and the strength of the concrete was increased due to the confinement provided by the CFS. However the stress-strain relationship of concrete with CFS depends on the geometry of the concrete sample.

A model of stress-strain relationship of concrete with or without CFS confinement was proposed and compared with the experimental results. The proposed model for the stress-strain relationship of unconfined concrete under cyclic loading is based on Darwin & Pecknold's model, Noguchi's model, Naganuma's model and Lam & Teng's model. This model takes into consideration three linear functions after reaching the maximum strength of the concrete. Besides, this model considers the plastic strain deformation during the unloading path, and the inner loop during the compressive stage.

Regarding to the monotonic stress-strain relationship of concrete with CFS confinement, the proposed model is based on Nakatsuka's model which has two linear functions after reaching B-point up to the rupture of the CFS. Considering the influence of the parameters which affects the stress-strain relationship of the concrete confined with CFS, such as sample shape, aspect ratio and effective confinement ratio of the section, modified Nakatsuka's model is introduced for the monotonic stress-strain relationship of concrete with CFS confinement.

For the cyclic hysteresis rules of concrete with CFS confinement, the proposed model for unconfined concrete was used by using the monotonic stress-strain relationship of concrete with CFS confinement, and following the same rules to generate the hysteresis loops. By using the proposed model, a uniaxial test simulation over the samples of the third experiment was conducted in order to validate the model. Both, monotonic and cyclic simulations gave a good match with the experimental results.

A software of Finite Element Method, STERA_FEM, was developed taking into consideration: four nodes isoparametric planar element, incompatible element, 9 Gaussian points, the proposed model for concrete with or without CFS confinement, equivalent uniaxial stress-strain relationship of concrete for each principal direction considering the bi-axial stress-strain relationship of concrete by using the maximum stress surface of concrete, smeared crack model with the Menegotto-Pinto hysteresis model for reinforcing steel, elastic-brittle model for CFS.

Finally, a numerical simulation were conducted and compared with the experimental results of the six walls (retrofitted with CFS and non-retrofitted) under cyclic loading.

Further studies on the shape coefficients for circular, square and rectangular shaped are suggested improving the non-linear hysteresis of concrete retrofitted with CFS, by increasing the data with a large range of concrete types, using different amount of CFS as a confinement method and considering the aspect ratio and effective confinement ratio of the section.