國立臺北科技大學
土木工程系土木與防災碩士班

碩士學位論文

鋼筋混凝土雙核心柱中柱耐震性能之研究

The Study of Seismic Capacity of Double-Core Reinforce Concrete Columns

研究生：陳哲生

指導教授：張順益 博士

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摘　要

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指導教授：張順益 博士

關鍵詞：雙核心柱中柱 2.0、高軸力、耐震性能、連續環繞之箍筋、內核主筋、主筋挫屈、挫屈軟化、彎勾束制、圍束效應、NRCCSM

為了驗證雙核心柱中柱具有優異的耐震行為，本研究除了將透過實體試驗來驗證雙核心柱中柱(包括雙核心柱中柱 2.0)的耐震性能之外，也將提出其可靠的模擬分析方法。在實體試驗方面，共規劃 3 組實尺寸柱構件試體，包括 1 組傳統柱、1 組雙核心柱中柱及 1 組雙核心柱中柱 2.0，在國家地震工程研究中心大型結構實驗室之多軸試驗系統機台上，進行固定高軸力之水平反覆位移載重試驗。在模擬分析方面，除了採用 TEASPA 之外，本研究特別提出 NRCCSM（Novel Reinforced Concrete Column Simulation Model）來模擬柱構件之撓曲破壞彎矩-轉角曲線，並將模擬分析結果與反覆載重試驗結果相比較，可以充分驗證模擬分析方法之合理性及可靠性。

經由反覆載重試驗及針對試體的模擬分析研究，可以獲得以下的結論：

(1) 雙核心柱中柱及雙核心柱中柱 2.0 採用連續環繞之箍筋，為完整閉合結構，不但具有更佳的圍束效果，還可承受主筋外擠的力量而不脫開，確保核心混凝土不向外崩

落。尤其是內核主筋因受箍筋充分束制及外核的保護，除了沒有鋼筋挫屈的現象之外，鋼筋網格亦未發生嚴重變形而能確保內核心混凝土不向外崩落。因而在外核之混凝土保護層或主筋喪失強度而發生破壞後，內核心混凝土及主筋仍可維持其強度，確保柱體能繼續維持其承載力，進而提升柱體的耐震性能;

(2) 雙核心柱中柱 2.0 外核主筋因受 180 度彎勾束制，不易因脫鉤而失去圍束效應，能有效延後主筋的挫屈破壞，進而減緩強度及勁度的衰減以及遲滯迴圈的頸縮現象，因而能有效提升韌性強度；

(3) 由實驗結果可以充分證實雙核心柱中柱 2.0 在高軸力作用下仍能具有極為優異的耐震行為。雖然其最大側向剪力強度與雙核心柱中柱差異不大，但韌性強度明顯優於雙核心柱中柱。因此非常適用於設計中、高層鋼筋混凝土建築物底層的柱構件，能以經濟斷面的設計來滿足高軸力的耐震需求；

(4) 提出NRCCSM 模擬分析方法來建立柱構件彎矩-轉角關係，不論在極限彎矩值、極限轉角值及性能曲線型態趨勢上，都具有較佳的模擬結果，可作為後續評估柱構件撓曲破壞非線性行為模擬分析的參考。

ABSTRACT

Title: The Study of Seismic Capacity of Double-Core Reinforce Concrete Columns

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Researcher: Che-Sheng Chen

Advisor: Shuenn-Yih Chang, Ph.D.

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To substantiate the enhanced seismic capacity of double-core reinforced concrete columns with the same size but different reinforcement details, both experimental and analytical simulation methods are adopted. A total of three reinforced concrete columns were fabricated and cyclically loading tested under a specific high axial load. These three columns have the same size but different reinforcement details. One has a uni-core with the reinforcement details based on the current code while the other two have a double-core with different reinforcement details. All the experimental works were conducted at the National Center for Research on Earthquake Engineering (NCREE). On the other hand, the software TEASPA with the proposed NRCSSM was used to compute the moment-drift ratio relationship for each specimen. It is

shown that the analytical method can provide reliable results when compared to the experimental results.

As a summary of this experimental and analytical studies, the following conclusions can be drawn:

(1) The two double-core reinforce concrete columns have continuous, closed hoops and thus they exhibit better confinement when compared to the uni-core specimen. They can withstand the extrusion of the longitudinal rebars and then no collapse of the concrete core can be ensured for the inner core. The profile of the failure mode was the collapse of the concrete cover first during the test. Then, the rupture of concrete core in the outer-core was found. The fracture or buckling of the longitudinal rebars occurred for the outer-core under large drift ratio. In general, there was no collapse of concrete core or the fracture or buckling of the longitudinal rebars for the inner-core after the failure of the double-core concrete columns.

(2) The double-core reinforced concrete column with continuous, closed hoop in addition to 180-degree hooks can have the best confinement of the three specimens. Therefore, the fracture or buckling of the longitudinal rebars was delayed and thus both the stiffness degrading and strength degrading were slowed down. As a consequence, this specimen has the best seismic capacity, such as the better stiffness and strength, less pinching effect and better ductility, among the three specimens.

(3) The experimental results shows that the double-core reinforced concrete column with continuous, closed hoops in addition to 180-degree hooks can still have good seismic behaviors under high axial loads. Although its shear strength is roughly the same as that of the other double-core reinforced concrete column, it has much better ductility. Therefore, it is very suitable for the seismic design of the high-rise buildings that can use an economic section to meet the seismic demand under high axial load.

(4) The NRCCSM model is proposed to establish the moment-drift ratio relationship of reinforced concrete columns. It seems that it can be used to reliably simulate the seismic behaviors of the reinforced concrete columns under high axial loads when compared to the test results.