



UNIVERSITI PUTRA MALAYSIA

**SEISMIC ASSESSMENT AND STRENGTHENING OF EXISTING
RESIDENTIAL REINFORCED CONCRETE BUILDINGS**

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**SEISMIC ASSESSMENT AND STRENGTHENING OF EXISTING
RESIDENTIAL REINFORCED CONCRETE BUILDINGS**

By

SAMIRA JILANI KOJOURI



**Thesis submitted to School of Graduate Studies, Universiti Putra Malaysia, in
fulfilment of the requirement for the degree of Master of Science**

March 2010

DEDICATION

To my parents who have supported me patiently all the time

Thank you

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Professor Abang Abdullah Abang Ali

Faculty : Engineering

The ability of assessment tools to forecast the vulnerability of buildings to prevent collapse during an earthquake is essential for existing buildings. Seismic vulnerability assessment techniques are classified as quick and exact assessment categories.

The aim of this study is to develop a numerical tool that can be used to evaluate existing reinforced concrete buildings against earthquake shaking. The vulnerability and retrofitting of low to medium rise reinforced concrete framed buildings (3, 4, 6 and 8 story) located in high zones of seismicity in Iran was carried out.

In order to reduce the time of assessment, a quick check of buildings is essential. To achieve this purpose a numerical tool has been proposed based on FEMA 310 (Tier 2 and 3) for RC framed buildings in earthquake prone areas.

Quick assessment methods do not have the ability to deduce the exact deficiencies of buildings. Nonlinear pushover analysis is a useful tool for the exact evaluation of existing buildings to give a good estimation of the overall displacement demands, base shears and plastic hinge formation. In order to determine the exact deficiencies of buildings the nonlinear static pushover analysis based on FEMA 356 was applied.

The computational procedure to calculate the base shear force according to FEMA 356 is complicated and most of the time the effect of P- Δ is not considered. To fulfil this objective a computer program was developed to consider the effect of P- Δ on two and three dimensional models of RC framed buildings, and the capacity curve was obtained as a result of the nonlinear static analysis.

The performance capacity level of RC framed buildings was found by idealizing the capacity curve. Hence the computer program developed idealizes the pushover curve according to FEMA 356. Consequently by using the developed program the buildings are evaluated in different performance levels. Results of pushover analysis were validated with the commercial software SAP2000.

Due to the lack of codes to design the new retrofitted members a design procedure for new retrofitted members of buildings is provided. Eventually the appropriate retrofit is suggested for vulnerable buildings and members.

The final results show that the quick assessment method is reliable at the global level. The pushover analysis is a useful tool to predict the failure mechanism of columns and beams in order to capture the exact assessment of buildings.

Results of the retrofitted buildings show that the chevron steel bracing are more appropriate than the shear wall and RC jacketing due to the increase in strength without an increase in the weight of buildings and need for retrofitting of the foundation. For brittle structures with very weak strength, additional shear walls will be appropriate while for brittle structures with mechanism of strong beams and weak columns, RC jacketing will be effective.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**PENILIAN SEISMIK DAN PENGULCUHAN BANGUNAN PERUMAHAR
KONKRIT BERTETULANG SEDIA ADA**

Oleh

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Keupayaan kaedah penilaian untuk meramalkan ketahanan bangunan bagi mengelakkan keruntuhan semasa gempa bumi adalah penting untuk bangunan sedia ada. Teknik penilaian ketahanan gempa dikelaskan sebagai kategori penilaian cepat dan tepat.

Tujuan kajian ini adalah untuk membina satu kaedah numerikal yang boleh digunakan untuk menilai bangunan konkrit bertetulang sedia ada terhadap gegaran gempa bumi. Ketahanan dan pengukuhan bangunan kerangka konkrit bertetulang berketinggian rendah dan sederhana (bangunan 3, 4, 6 dan 8) dijalankan di zon tinggi gempa bumi di Iran.

Bagi mengurangkan masa yang diperlukan untuk penilaian, satu semakan cepat untuk bangunan adalah penting. Untuk mencapai tujuan ini satu kaedah numerical

telah dicadangkan berdasarkan FEMA 310 (Tingkat 2 dan 3) untuk bangunan kerangka konkrit bertetulang di kawasan kejadian gempa bumi.

Kaedah penilaian cepat tidak mempunyai keupayaan untuk menilai kekurangan yang tepat untuk bangunan. Analisis pushover tidak linear adalah kaedah berguna untuk penilaian sebenar bangunan sedia ada bagi memberi anggaran yang baik untuk keperluan ubahbentuk keseluruhan, ricih tapak dan pembentukan engsel plastik. Bagi menentukan kekurangan yang tepat sesebuah bangunan analisis pushover statik tidak linear berdasarkan FEMA 356 digunakan.

Prosedur komputeran untuk mengira daya ricih tapak berdasarkan FEMA 356 adalah rumit dan kebanyakan waktu kesan $P-\Delta$ tidak diambil kira, bagi memenuhi objektif satu komputer program telah dibangunkan untuk mengambil kira kesan $P-\Delta$ terhadap model dua dan tiga dimensi bangunan kerangka konkrit bertetulang, dan lengkung kapasiti diperolehi sebagai keputusan analisis statik tidak linear.

Tahap prestasi kapasiti bangunan kerangka konkrit bertetulang diperolehi dengan menggunakan idealisasi lengkung kapasiti. Justeru program komputer dibangunkan bagi mengidealisasi lengkung pushover berdasarkan FEMA 356. Akibatnya dengan menggunakan program yang dibangunkan bangunan boleh ditaksir pada tahap prestasi yang berbeza. Keputusan analisis pushover disahkan dengan menggunakan perisian komersil SAP2000.

Disebabkan kurangnya kod untuk merekabentuk pengukuh baru anggota satu prosedur rekabentuk untuk pengukuh baru anggota bangunan telah disediakan.

Akhirnya pengukuh yang sesuai dicadangkan untuk ketahanan bangunan dan anggota.

Keputusan akhir menunjukkan bahawa kaedah penilaian cepat adalah boleh dipercayai pada peringkat global. Analisis pushover adalah satu kaedah yang berguna untuk meramal mekanisme kegagalan tiang dan rasuk dalam mendapatkan penilaian tepat sesebuah bangunan.

Keputusan pengukuhan bangunan menunjukkan yang penahan keluli chevron adalah lebih bersesuaian dibandingkan dengan dinding ricih dan jaket konkrit bertetulang disebabkan peningkatan kekuatan tanpa peningkatan dalam berat bangunan dan mengukuhkan asas. Bagi struktur yang tidak rapuh dengan kekuatan yang sangat lemah, dinding ricih tambahan diperlukan manakala bagi struktur tidak rapuh dengan mekanisme rasuk yang kuat dan tiang yang lemah, jaket konkrit bertetulang akan lebih efektif.

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I certify that an Examination Committee has met on _____ to conduct the final examination of **SAMIRA JILANI KOJOURI** on her **MASTER OF SCIENCE** thesis entitled "**SEISMIC ASSESSMENT AND STRENGTHENING OF EXISTING RESIDENTIAL REINFORCED CONCRETE BUILDINGS**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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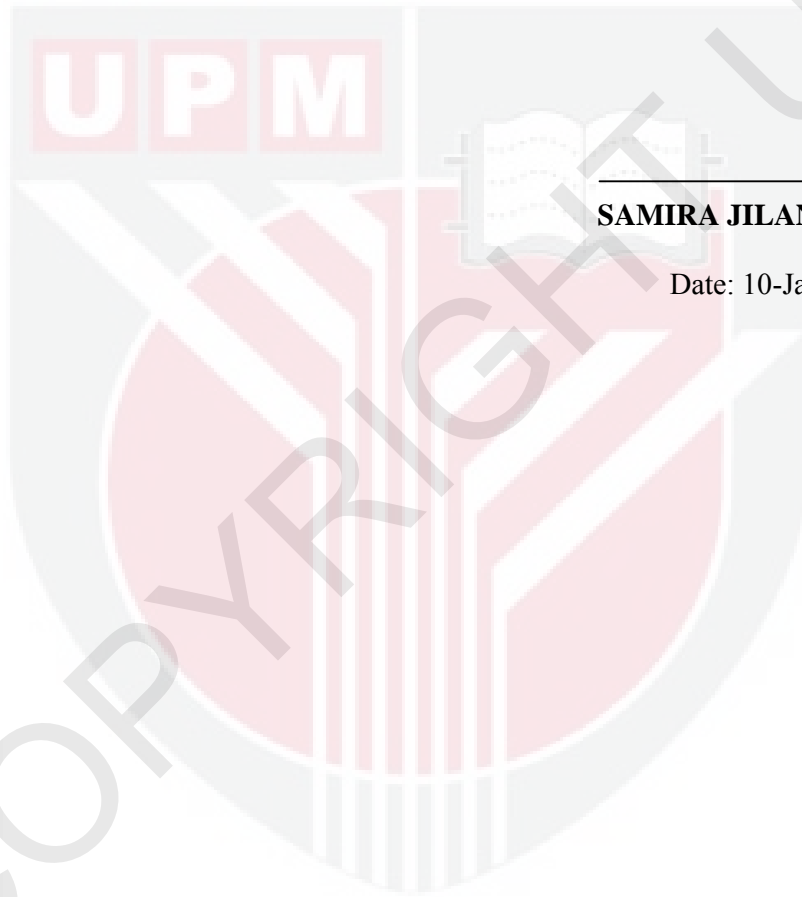
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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



SAMIRA JILANI KOJOURI

Date: 10-Jan-2010

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