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INFLUENCE OF SYMMETRIC SETBACKS ON THE PERFORMANCE OF HIGH-RISE BUILDINGS UNDER BLAST AND EARTHQUAKE LOADING

by

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This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

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May 2008

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ABSTRACT

With the increase in terrorism worldwide, blast loading has received considerable attention. Blasts due to bomb explosions have become a new threat to buildings designed for normal static loads in Sri Lanka. Earthquakes are generally considered to be among the worst natural disasters on Earth. Reinforced concrete structures built in zones of low seismicity such as Sri Lanka, have not had seismic effect taken into consideration in the design. The seismic performance evaluation and upgrading for non-seismic designed building structures is the most urgent issue for seismic hazard mitigation. As such it is prudent to undertake detailed studies to better understand the behaviour of typical high-rise buildings in Sri Lanka under these two extreme events.

Computer simulation has become an efficient tool in the analysis of structures under extreme loads. This study explores three-dimensional nonlinear dynamic analyses of a typical high-rise building in Sri Lanka under blast or earthquake loadings, with and without setbacks. A setback is a common geometric irregularity consisting of abrupt reduction of floor size in multistorey buildings above certain elevations. Setbacks usually arise from urban design demands for illumination and aesthetic requirements. These 20 storey reinforced concrete buildings have been designed for normal (dead, live and wind) loads. The influence of the setbacks on the lateral load response due to blasts and earthquakes in terms of peak deflections, accelerations and bending moments at critical locations (including hinge formation) is investigated. Structural response predictions were performed with the finite element analysis program SAP2000, using non-linear direct integration time history analyses.

Results obtained for buildings with different setbacks are compared and conclusions drawn. From the comparisons it is revealed that buildings having symmetrical setbacks that protect the tower part above the setback level from blast loading show considerably better response in terms of peak displacement and inter-storey drift, when compared to buildings without setbacks, while the detrimental effects of symmetric setbacks for seismic response are not that significant. Further it is revealed that there needs to be a balance between the stiffness and mass of the building to get the optimum response under seismic loading. From the analyses it is revealed that

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these twenty storey tall buildings with shear walls and frames that are designed for just normal loads perform reasonably well, without catastrophic collapse, when subjected to a blast that is equivalent to 500 kg TNT at a standoff distance of 10 m, and also when subjected to a seismic excitation having a PGA of 0.1g. The study helps to understand the relative performance of buildings with different setbacks, designed for normal static loads subjected to blast and earthquake loadings.

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ACKNOWLEDGEMENT

I am extremely grateful and indebted to my main supervisor Prof. Priyan Dias, Head/Department of Civil Engineering for his able guidance, valuable advice, immense patience, encouragement and constructive suggestions throughout the course of this study. His immense patience and availability for comments whenever approached even amidst his heavy pressure of work throughout the entire period deserves warm appreciation.

I am deeply indebted and obliged to my co-supervisor Prof. Thishan Jayasinghe for encouraging me to start this research, for his guidance and valuable assistance in numerous ways. Without his inspiration and assistance this study would not have been what it is.

My special thanks to Prof. David Thambiratnam of QUT, Australia, for his enthusiastic support in securing the short term scholarship to QUT, and valuable guidance, constructive criticism and encouragement during my stay at QUT and thereafter.

I am much grateful to the Vice Chancellor Prof. Malik Ranasinghe, Dean of the Faculty of Engineering Prof. Ananda Jayawardana and Prof. Lakshman Ratnayake for their ready assistance in securing the short term scholarship to QUT.

My sincere gratitude to Dr. Kapila Perera, former Director ITUM for providing me with the necessary funds to carry out my research. I am much indebted to him for kindly granting the study leave to do my research. I am also thankful to Dr. T.A.G. Gunasekera, Director ITUM for the support and encouragement.

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I wish to express my deep appreciation of the help and encouragement given to me by Mrs. Priyanganee Samarasekera, Head, Division of Civil Engineering ITUM.

I am thankful to the members of the Higher Degrees Committee for their continuous monitoring of this research.

My thanks go to Prof. Kulathilaka, Coordinator of the Progress Review Committee for his valuable advice and guidance.

I wish to express my deep appreciation to my husband Asoka, daughter Venuri and son Ashan for their loving support, encouragement and patience without which this thesis would not have been possible. I am immensely grateful to my brother Susantha for his wholehearted support and encouragement.

I also wish to thank all those who have helped me to carry out this research successfully.

DECLARATION

This thesis is a report of research work carried out in the Department of Civil Engineering University of Moratuwa, between March 2001 and December 2007. Except where references are made to the other work, the contents of this thesis are original and include nothing, which is the outcome of work done in collaboration. The work has not been submitted in part or in whole to any other university.

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In Memory of my mother and father

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