SEMIACTIVE CONTROL OF FIXED OFFSHORE JACKET PLATFORMS

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DECEMBER, 2009

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by

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Submitted

in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

HAUZ KHAS, NEW DELHI – 110 016, INDIA

DECEMBER, 2009

CERTIFICATE

This is to certify that the thesis entitled **"Semiactive Control of Fixed Offshore Jacket Platforms"**, being submitted by Mr. Sudip Paul, to the Indian Institute of Technology, Delhi, for the award of **'DOCTOR OF PHILOSOPHY'** in Civil Engineering is a record of the original bonafide research work carried out by him under our supervision and guidance. He has fulfilled the requirements for submission of this thesis, which to the best of our knowledge has reached the requisite standard.

The material contained in the thesis has not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

I express my deep sense of gratitude to Prof. T. K. Datta, Department of Civil Engineering, Indian Institute of Technology, Delhi for his valuable guidance and constant encouragement during all phases of the present work. I am also indebted to him for his kind help and support. I also express my gratitude to Prof. S. Kapuria, Department of Applied Mechanics, Indian Institute of Technology, Delhi for his valuable guidance and support towards this work.

I express my deep gratitude to my parents for their blessings and encouragements that helped me throughout my research work and finally, in achieving the target.

I am thankful to the management of my organization, Engineers India Limited, for granting me permission to pursue the Ph.D. Engineering and Technology Development (ETD) Department has provided me the necessary support and environment, for which I am grateful to all concerned. Specifically, I am thankful to Dr. Sengupta, Mr. Salpekar, Mr. Sahu, Mr. Subramanyam and Mr. Vinay Kumar for their encouragement and support. I would like to extend very special thanks to all my colleagues, Mrs. Ila Das, Mr. Bhaskar Pal, Mr. Prabal Ghosh, Dr. Rajeev Jain, Mr. K. Gurumurthy, Mr. Neeraj Kumar Gupta, Mr. Balaji Srinivasan, Mr. Krishnakant, Mr. Pankaj Kumar and Mrs. Harsh Ginotra for their help and support during this work.

I am greatly indebted to Dr. G.G.S. Achary and Dr. Krishna Veni for their continuous help and encouragement throughout this period and for all forms of assistance at some personal critical phase during this period.

Finally, many hours spent in carrying out this work were hours that would otherwise have been spent with my wife, Indrani and son, Rishabh. I do not have words to express my gratitude for their love, patience, inspiration and sacrifices.

(Sudip Paul)

ABSTRACT

Reduction of response quantities of offshore structures for wave forces are less well investigated compared to that of onshore structures subjected to environmental loading. In particular, semiactive control of offshore structures has not been much attempted, although it has a great potential in practical use. Here, semiactive control of offshore jacket structures with semiactive hydraulic dampers (SHDs) is taken up for a detailed investigation. The performance of the control scheme in controlling the top deck displacement, acceleration and base shear is evaluated. For this purpose, a few popular semiactive control algorithms are implemented for offshore structures, like steel jacket platforms. The specific objectives of the study include i) to develop and use semiactive control algorithms namely, clipped optimal control, bang bang control, LQR control and fuzzy logic control for the control of fixed offshore jacket platforms using SHDs, ii) to study the performance of the control algorithms for different sea states and for different jacket lengths, and iii) to conduct a parametric study to compare the relative performances of different control algorithms and to investigate the maximum reduction of different responses possible for jacket structures.

Semiactive control of fixed offshore jacket platform using widely used LQR control algorithm is presented first. The optimal control force as obtained from LQR control algorithm based on the solution of a Riccati equation is used for obtaining the optimum damping coefficient. The optimum damping coefficient for the damper is chosen by using a variable damping coefficient method, and a max-min damping coefficient method.

Semiactive control of offshore jacket platform using clipped optimal and bang bang control algorithms are then presented. Unlike the LQR control algorithm, the clipped optimal control algorithm uses the measured structural accelerations, damper displacements and damper forces as the feedback parameters. Using the measured feedback quantities, Kalman state of the system is estimated, and the optimal control force is obtained by multiplying the same with full state feedback gain matrix, which is obtained by minimizing the performance function of the controller. Based on the measured and desired control forces, the damping coefficient of the SHD is clipped between its two extreme values. Bang bang control algorithm is based on Lyapunov theory. A Lyapunov function is obtained for the controlled system and the derivative of the Lyapunov function is used to obtain the control law.

For developing fuzzy logic control algorithm, the input fuzzy parameter is considered as acceleration or displacement, and the output fuzzy parameter is considered as the damping coefficient. Fuzzy controllers are developed based on acceleration as input and as both acceleration and displacement as inputs. For fuzzification, triangular input functions and trapezoidal output functions are used.

A detailed parametric study of the semiactive control of offshore jacket platform is carried out using three jackets in water depths of 122 m, 183 m and 244 m, respectively and two sea states namely a regular sea state (12m/11 sec) and a random sea state with significant wave height of 9.7 m. Some of the important results of the study include:

1. All the control algorithms, considered here, are effective in reduction of top deck acceleration.

2. Influence of parameters of each of the control algorithms is studied and optimum values are reported for best possible reduction of responses.
3. For a particular control algorithm, the percentage reduction of responses is varying with the variation of water depth for the fixed jacket platform.
4. In general, the percentage reduction of responses is more with regular sea state compared to that of random sea state.
5. Some of the control algorithms perform better in reduction of top deck displacement and base shear.

The evaluation of the control strategies is carried out using only a theoretical model of an offshore jacket platform in 183 m water depth and no experimental validation is made.

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