

論文 / 著書情報
Article / Book Information

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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

系・コース : Architecture and
Department of, Graduate major in Building
Engineering

系
コース

申請学位 (専攻分野) : 博士
Academic Degree Requested Doctor
of (Engineering)

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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

In this thesis, the complex seismic response interaction between multiple roof and substructure modes in domes with multistorey substructures was examined to develop equivalent static loads following the amplification factor approach, which may serve as a basis for integrating seismic demands in the preliminary design of gridshell roofs. Below are summaries and key findings from each chapter.

In Chapter-1, the background and motivation behind this research were presented. The literature review indicated that there are relatively few studies available for roofs with multistorey substructures. While there exist well-established response-reduction factors for the design and estimation of the inelastic design spectra of conventional multistorey braced frames, their application to substructures of curved gridshell roofs had not yet been explored. It was concluded that there was a need to develop effective yet simple formulations as equivalent static loads for incorporating seismic demands in the preliminary design of domed roofs with multistorey substructures, particularly in areas of high seismic hazard, which formed the main objective of this thesis.

In Chapter 2, the seismic response of a large-scale dome (150m span) with multistorey substructures was explored, which alternatively incorporated spine frames and buckling-restrained braces. The choice of the models was inspired by the preliminary substructure design of a recent project realised in Japan. For substructures with higher modes lying on the constant acceleration region of the design spectrum, the higher modes may contribute significantly and may even govern the overall response of the roof. Adding spine and braced frames in the substructure proved to be effective in reducing the roof response. Despite the reduced roof response associated with the fundamental substructure mode, the elastic higher substructure modes interacted with the roof's higher modes and notably amplified the response. According to the Architecture Institute of Japan (AIJ) and International Association for Shell and Space Structures (IASS) recommended equivalent static loads based on substructure first mode and roof amplification factors, this higher mode response was underestimated. Based on this study, it was concluded that it is imperative to quantify the interaction between the higher mode of the substructure and the roof in order to improve the accuracy of the current static loads.

In Chapter-3, the roof-substructure interaction in single- and multi-storey models was investigated by performing parametric studies on 60, 100 and 150m double-layered domes featuring a range of substructure stiffness and roof-substructure mass ratios using response spectrum analysis. The contribution of each substructure mode to the overall roof response was characterised by a newly proposed dominance response ratio.

In Chapter-4, amplification factors were proposed to quantify the additional response from the higher substructure mode (the T2 mode) coupled with the roof modes to develop a generalised equivalent static design procedure for domes with multistorey substructures. The vertical response amplification was found to be sensitive to the period ratios of the T1 and T2 modes to the roof O1 mode with peak amplification from the T2 mode reaching up to a value of 3. The horizontal response amplification was primarily a result of the substructure T1 interacting with the roof's predominant modes while the peak amplification contribution from T2 mode towards the horizontal response was found to be around 1.

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備考 : 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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論文要旨

THESIS SUMMARY

系・コース : Department of, Graduate major in	Architecture and Building Engineering	系 コース	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名 : Student's Name	Nair Deepshikha		指導教員 (主) : Academic Supervisor(main)	Prof. Toru Takeuchi
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

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The greatest benefit from the proposed methodology was for substructures with dominant T2 modes (in the period range $0.2 < R_{T2} < 2$), with the percentage of roof members with underestimated forces up to around 100% when considering only the T1 mode reducing to just 1% when considering both T1+T2 modes. The method saw the least improvement for stiffer first mode dominated substructures, where the T1 mode's contribution alone produced a conservative response estimate leading to similar accuracy even after considering the T2 mode.

In Chapter-5, the RSA-based amplification factor approach was applied to single-storey buckling restrained braced frames with varying post-yield stiffness by investigating the applicability and effectiveness of Newmark's and Krawinkler's formulations of ductility-based reduction factors (R-factor approach) in estimating the peak inelastic accelerations of the substructure. Kasai's equivalent linearisation method estimated the substructure response with accuracies very similar to the NLRHA for all the studied models. This method used in combination with the proposed amplification factor approach is an efficient alternative to the NLRHA method to estimate a conservative envelope of the peak accelerations and the equivalent static loads for the preliminary design of the dome.

In Chapter-6, the accuracies of the proposed R-factor approach were investigated for 60m and 150m multistorey BRBFs, and the scope of application of the proposed methodology was discussed. While multistorey structures exhibit significant higher mode response, for all (60m and 150m span) models analysed, the Newmark method was found to present the most conservative roof accelerations (and thereby the roof member forces) among the investigated methods based on the R-factor approach. For BRBFs with low (first-mode) post-yield stiffness ratios ($p \leq 2\%$), Newmark's method in combination with the first and second mode amplification factors provides a conservative DBE level roof response as less than 6% of the roof members had underestimated member responses if compared to the mean NLRHA response. For structures with $p > 2\%$ (typically found in countries like Japan with moment connections), the more conservative Kasai method is recommended.

Finally, Chapter-7 provides a summary of the results obtained in each chapter, along with the main conclusions.

To summarise, seismic response of domes with multistorey BRBFs with fundamental periods in the range $0.4s \leq T_1 \leq 1.5s$ and post-yield stiffness ratios of up to 25% have been analysed with target global roof displacement ductility μ reaching up to approximately 8 at the DBE level. The proposed static loads were found to be conservative and the median roof member responses (using the Kasai method) for all models in the studied range were well above the mean NLRHA responses, for all three (SLE, DBE and MCE) earthquake levels. The Newmark method also provided similar accuracy for models with lower post-yield stiffness. The developed equivalent static loads using amplification factors have thus been confirmed as an efficient alternative for the NLRHA for all models in the studied range.

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