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Seismic Response Evaluation of Large Spanned Dome supported by Multi-storey Substructure incorporating Spine Frames

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Abstract

Seismic response of lattice shell roofs with substructure is known to be complicated as these roofs exhibit various closely spaced modes whose amplitudes are highly dependent on parameters like rise to span ratio of the dome and ratio of stiffness of the roof to the substructure. It has been observed that when the out of plane stiffness of the roof becomes large, the response characteristics become relatively simpler and can be used to present design criteria for the ultimate limit state[1].

Studies of medium spanned roof systems with single storey substructures are available wherein a simplified procedure to evaluate the seismic response has been proposed by using amplification factors[2]. However, literature reviews indicate that studies on seismic response of large spanned roofs are very limited. This study aims to investigate seismic response of large spanned domes by exploring the scale effects. It is found that in comparison with the medium spanned domes, the prominent modes in the large spanned domes have shifted towards the right, if perceived by mapping these modes on the design spectrum. One of the implications of this is that the magnitude of roof excitation in the large span case can be up to two times more than that expected in the medium span case. The second implication is that the higher modes, mainly the ones with significant participation must be taken into account while considering the response of large roofs. The acceleration distributions, especially the vertical accelerations are found to be very sensitive to the dominant mode shapes. Another aspect of this study is to capture the effects of post-yield substructure stiffness, which has been accomplished by incorporating multiple spine frames in the substructure. Taking into account all these factors, a simple procedure to evaluate the equivalent static loads for design is developed. The maximum acceleration distributions in the horizontal and vertical directions are proposed using response spectrum analysis and equivalent linearization techniques. These distributions are then used to obtain the equivalent static loads for design. The accuracy of the proposed method is also discussed by comparing the responses like axial forces and bending moments with those obtained from non linear time history analyses. The results obtained from this method were found to be consistent with the time history results. It is concluded that this simple yet efficient method can be employed in the preliminary stage of seismic design of such large roofs.

References

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