Lateral Stability of Tall Building Using Peripheral Bracing Systems

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Abstract:
A glance into lateral load resisting systems would reveal two principal types of load sharing in a building. The first is by deflection of members inplane or out of plane known as bending while the second is by inplane forces such as skin forces in shells and axial forces in bracing members of braced frames. The investigation carried out is to understand the effect of peripheral bracing in a structure and the corresponding lateral stability achieved due to bracing.

Methodology:
The use of peripheral bracing in building frames is studied by modeling of structures in design software packages such as ETABS. Due to architectural constraints bracing can be adopted only along the periphery of a building. The lateral deflections of six different types of bracings for a model are studied in relation to the lateral deflection of the same model fully unbraced. The modeling is repeated by increasing the number of stories to find the variation of lateral deflection with height. Thus a total of 14 models are adopted for the first phase of this investigation and the relative performances of different types of bracings are studied for each model in relation to the fully unbraced model.

For the second phase of this investigation the difference between the performance of models, one with peripheral bracing and peripheral columns and the other with only peripheral bracing without peripheral columns are studied. This investigation is the result of a basic concept that braces can take both gravity as well as lateral forces due to their inclined geometry and thus the contribution of peripheral columns to lateral load resistance may be understood. If this load sharing by columns is not of significant value then elimination of these columns would be an option so as to obtain cost effectiveness in a structure as well as architecturally aesthetic concept. The results are tabulated to understand the effect of this peripheral bracing in resisting loads.

The modeling is carried out and the height of model is gradually increased to study the performance of braced frames.

Model details:
Base plan size: 30m x 40m.
Floor to floor height: 3m
Dead load due to floor finish and partition: 2.5KN/m².
Live load: 2KN/m².
Dead load due to floor finish on roof: 1KN/m².

Results:
For 1st investigation:

- Live load on roof: 1.5KN/m².
- Slab type: deck sheet
- Grade of concrete for deck sheet: M20
- Grade of steel in first model: Fe250
- Structural members: differs as per model.
- Spacing of columns: 5m
- Earthquake zone: IV
- Importance factor: 1
- Soil type: II
- Time period: As per IS 1893:2002 part-1.
- Wind speed: 47m/s
- Other wind parameters: As per IS 875 part-3.
Lateral deflections due to earthquake

For 2nd investigation:

Lateral deflections due to wind

Lateral deflections due to wind
Conclusions:
The study of the relative performance of different bracing systems on a given model in comparison to the fully unbraced model reveals a moderate reduction in lateral deflection especially in the more slender direction. Hence bracing systems can serve as an additional stabilizing component. The study reveals lesser lateral deflection in models other than SCBF type-2 bracing and EBF type-2 bracing. The best performance in terms of both stability (reduced deflection) and economy is achieved using SCBF type-1 bracing, SCBF type-3 bracing and EBF type-1 bracing. Though SCBF type-4 does give a good result in terms of reduced lateral deflection the weight of bracings is more (100% more than SCBF type-1 bracing). The optimum combination of bracing and tube systems gives a relatively effective means of reducing lateral deflection.

An extension of the first study reveals certain aspects of the behavior of braced frames. A careful observation into the structural configuration leads to an interesting query of whether peripheral bracings could be used to take both gravity as well as lateral loads. Hence the relative performance of structure with peripheral columns and then without peripheral columns (but retaining corner columns) is studied and the results are tabulated. The results reveal very little increase in lateral deflection which leads to the conclusion that these columns contribute very little to the bending stiffness of structure and thus majority of both gravity as well as lateral loads are taken by bracings. This leads to increased cost optimization of structure as well as an architecturally aesthetic structural system by way of excluding these columns.

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