Response of Tall Building Structures using Panel Elements with In-Plane Rotational Stiffness

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[2007 AEES Conference]

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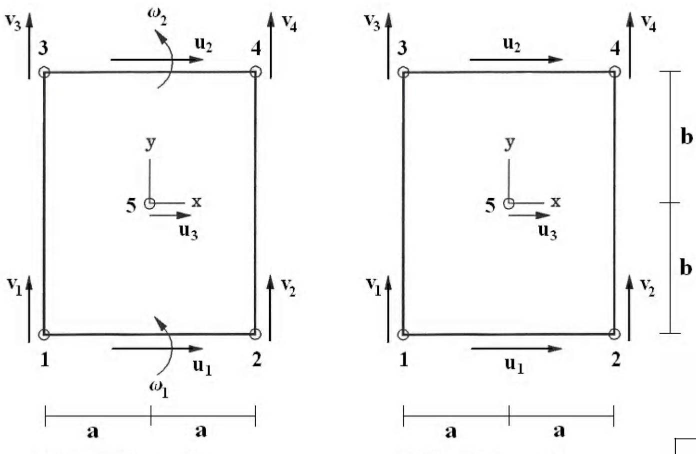
Summary: Generally, strain based finite elements are useful to assess the response of tall buildings. It should be noted that use of many lower order finite elements may reveal some analytical problems in analysis of tall buildings. The absence of an appropriate in-plane rotational stiffness in some finite elements and the existence of parasitic shear effects in the governing displacement functions of the element are of the most known effects which may appear in the finite element analysis of tall building structures. The proposed finite elements in this study, have been developed based on the strain functions which can model the general behaviour of shear wall panels and wide column elements in a tall building. Furthermore, based on using the assumption of horizontal strains which are negligible in all heights of the element, a unified lateral displacement will be obtained for the proposed panel elements. Hence, the rigid body motion of the floor slabs is simply employed to the mathematical formulation of the proposed elements. The proposed panel elements can be simply used in modelling and analysis of tall buildings.



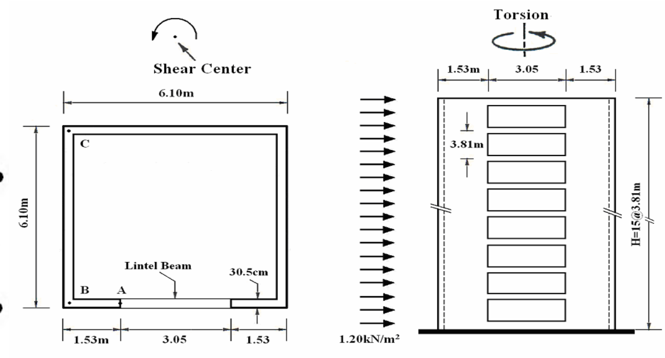
(a) Panel Element Ps9 (b) Panel Element Ps7

The presented strain based panel elements Ps9 and Ps7

$$(\varepsilon_x)_{PS9} = 0 \qquad (\varepsilon_x)_{PS7} = 0$$

$$(\varepsilon_y)_{PS9} = \alpha_4 + \alpha_5 x + \alpha_6 xy \qquad (\varepsilon_y)_{PS7} = \alpha_4 + \alpha_5 x$$

$$(\gamma_{xy})_{PS9} = \alpha_7 + \alpha_8 y + \alpha_9 y^3 \qquad (\gamma_{xy})_{PS7} = \alpha_6 + \alpha_7 y$$



Shear core supported building

Analytical results for the shear core supported building

	ϕ_{Top} (10^{-3}rad)	σ_A (kg/cm²)	σ_B (kg/cm²)	σ_C (kg/cm²)
The Panel Element PS7	3.41	-32.6	8.7	44.5
The Panel Element PS9	3.49	-37.1	8.4	45.2
Smith *et al* 1972 (The Continuum Method) (Open section structure)	2.95	-36.8	4.1	45.3
Smith *et al* 1972 (The Continuum Method) (Closed section structure)	3.32	-36.2	4.3	44.9
Macleod *et al* 1977 (The Frame Method)	2.67	-44.3	6.3	40.7
Ha *et al* 1989 (6DOFD Finite Elements)	2.85	-35.4	6.9	39.7
Ha *et al* 1989 (6DOFS Finite Elements)	3.38	-35.2	7.7	42.2
Pekau *et al* 1996 (The Finite Storey Method)	3.70	-37.3	5.0	47.4

Conclusion: Application of many of lower order finite elements in tall building analysis may lead to some considerable errors in analytical results. This is because of the problem of parasitic shear which renders the lower order finite element too stiff under action of bending mode especially in coarse meshes. The existence of parasitic shear effects in a number of lower order plane stress finite elements arises from their inability to represent a bending mode deflection. The presented finite elements PS7 and PS9 are able to represent the state of pure bending and are also free of parasitic shear effects. Furthermore, it is generally needed to one layer of the finite elements PS7 and PS9 per each storey of lateral load resistant systems in tall buildings.