Study on Non-Linear Behaviour of Reinforced Concrete (G+6) Apartment under Repeated Earthquake Model Excitations by Using ETABS and FEM

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Abstract— Current practices in earthquake engineering only apply single earthquake on building structure during modeling and analysis. However, in real earthquake event, the tremors always occur repeatedly until two (or) three times after the first tremor. This phenomenon can affect the stiffness and strength of the structural system. Due to lack of time, any rehabilitation action is impractical. Thus, the building may experience greater damage due to several repeated tremors. This project gives a brief idea about the non-linear behavior of generic reinforced concrete building under excitation of single and repeated earthquake.

Non-Linear behaviour of structure, in term of inter storey drift ratio were presented using incremental dynamic analysis curve. The results from analysis demonstrate that the repeated earthquake phenomenon require greater inter storey drift demand compared to single earthquake. This is a nature of earthquake and in technical views it is called as repeated earthquake phenomenon. Thus, in reality the earthquake load might hit the structure more than one time during an earthquake event.

The present project is to study on Non-Linear behaviour of the reinforced concrete G+6 apartment under repeated earthquake modal excitations using ETABS which in turn reduces the modal value, so that the sudden collapse of the building can be resisted. Dynamic load cases which includes both wind and seismic loads should be applied and non-linear analysis should be performed.

Keywords: Non-linear behaviour, repeated earthquake model, Story drift, FEM and ETABS

I. Introduction

INDIA is a large country that has more than its share of major natural hazards like drought, floods, earthquake and cyclones throughout its history of civilization. The ten-year period of the International Decade for Natural Disaster Reduction (IDNDR), came as a good opportunity for the country to look back at what had been done in the past, new initiatives taken during the decade, and plan ahead for reducing the impact of natural hazards on its people, settlements and economic development. Earthquakes occur due to movements along faults that have evolved through geologic and tectonic processes. Often, they occur without any prior warning and are therefore unpredictable.

The structural systems which have linear inertia, damping and restoring forces, are analyzed by linear methods. Whenever, the structural system has any or all of the three reactive forces (i.e. inertia, damping and stiffness) having non-linear variation with the response parameters, namely displacement, velocity, and acceleration; a set of non-linear differential equations is evolved. To obtain the response, these equations need be solved. The most common non-linearity is the stiffness and the damping non-linearity. The stiffness non-linearity comprises of two types namely the geometric non-linearity and the material non-linearity.

Most the damping non-linearity are of a non-hysteretic type. Most structures under earthquake excitation undergo yielding. Hence, it is necessary to discuss material non-linearity exhibiting hysteretic behaviour. non-linearity, restoring action shows a hysteretic behaviour under cyclic loading. For the geometric non-linearity, no such hysteretic behaviors exhibited. Damping non-linearity may be encountered in dynamic problems associated with structural control, offshore structures, and aerodynamics of structures.

A. *Scope of the Present Investigation*

Structural stability and nonlinear behavior of structures are briefly explained in this project. Due to strong earthquake ground motion, the structural response goes over the linear elastic limit. If structures have large deformation capability, earthquake energy is absorbed by nonlinear and inelastic behavior. However, for structures with small deformation capability, structural failure may be triggered due to strong ground motion.

II. Review of literature

When strain of materials and deformation of members grow up due to increasing deformation of structures, the corresponding stress and restoring force are no longer proportional to the strain or deformation. This is called nonlinearity of materials and members; in other words, the relation between stress and strain or force and deformation does not show linear curves. Usually, relations between stress and strain or force and deformation show softening type nonlinearity, which is favorable for seismic design of structures, because proportionally high stress and force will not be generated when the structures show large displacement due to large earthquake motion. Exceptionally, hardening type nonlinearity is found in high strain range of rubber material which is used in seismic isolation bearings. The hardening nonlinearity can be used to prevent large deformation which occurs due to large earthquake, if large deformation has to be limited for some reasons like pounding with adjacent structures.

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS 2013 features an intuitive and powerful graphical interface coupled with unmatched modelling, analytical, design, and detailing procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviours, making it the tool of choice for structural engineers in the building industry.

III. METHODOLOGY

This chapter says that how to model a structure in auto cad, converted in to ETABS format, Define material properties, frame dimensions, slab dimensions, primary loads assignment, and check Model and about preliminary analysis. It provides idea about tools used in this chapter. You can understand Auto CAD export and ETABS import.

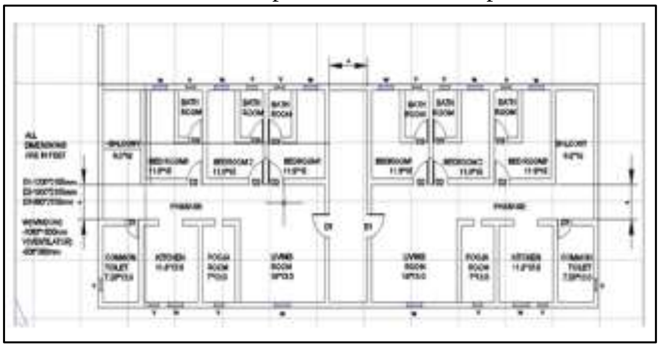


Fig. 3.1: Architectural Ground Floor Plan

A. Import to ETABS

Save the auto cad model in the working folder. Then open e tabs icon  in desktop.

- Go file → import → .DXF/.DWG File of Floor Plan…. Hit left button on mouse.

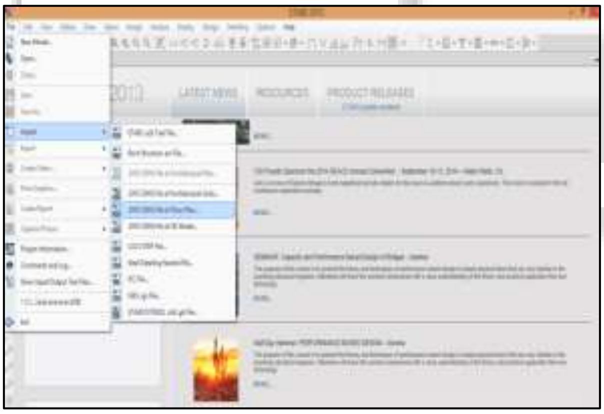


Fig. 3.2: ETABS Startup Interface

B. Define Material Prosperities

Go to define → material properties → add new material then → ok

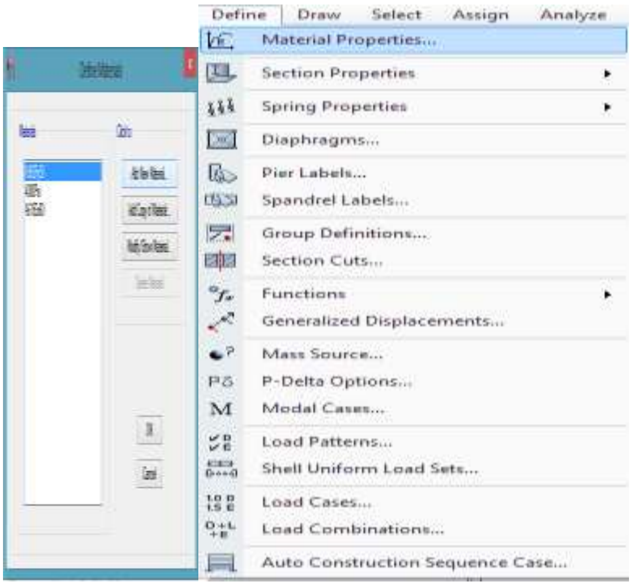
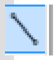


Fig. 3.3: Defining material properties

- A992Fy50, 4000psi, A615Gr60 are default materials in the software.
- Add copy of material… is used; define already existing material with another name.
- Modify /show material….is used; change the existing material properties.
- Hit add new material property icon, change all properties as shown below.

C. Draw Beam, Column and Slab Elements

- Draw  draw beam/column/brace objects  draw beam/column/brace.

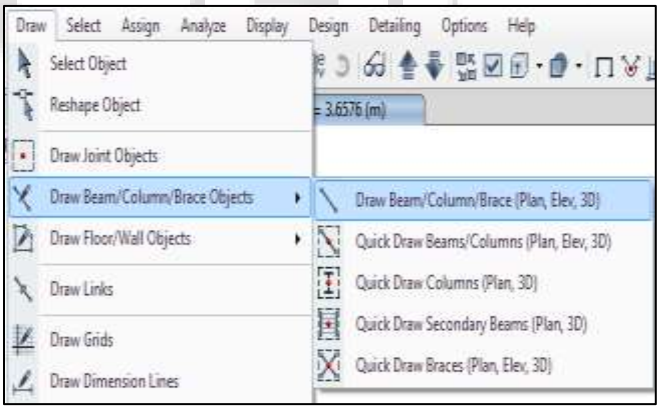


Fig. 3.4: Draw Beam, Column and Slab Elements

D. Creation of 3-D Model

EDIT → Story and Grid system → Quick add STORY UP TO STORY 7 → then ok

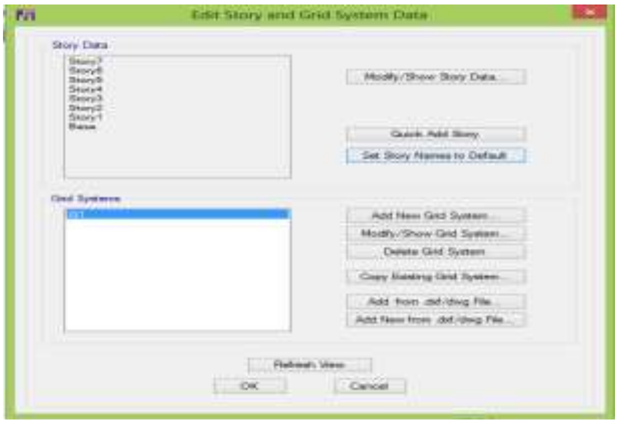


Fig. 3.5: Extension of Stories

– Edit → replicate → story → select all story in the replication hit apply and then ok.

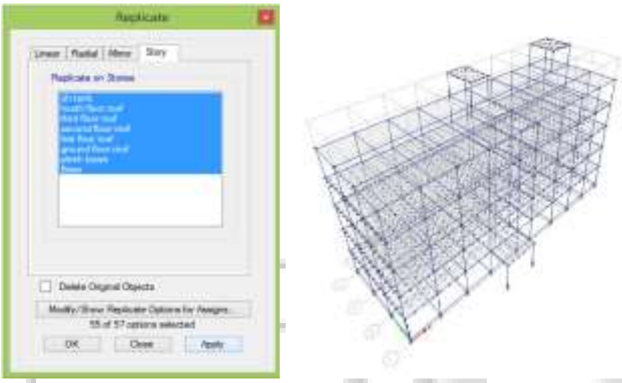


Fig. 3.6: Replication of Story Data

E. *Assign Loads to Frame And Slab Elements*

Select → Select → object type Beam → select close.

– Assign → frame loads → distributed → load pattern name → uniform load → apply close.
– Select → Select → object type…. → floors → select close.
– Assign → shell loads → distributed → load pattern name dead uniform load Load 4KN/m^2 → applies → close.
– Select → Select → object type…. → floors → select close.
– Assign → shell loads → distributed → load pattern name → live → uniform load load 3KN/m^2 → applies → close.
– Assign → joint → restraints → FIXED OK.

F. *Run Analysis*

– Analysis → check model → check all tick marks ok.

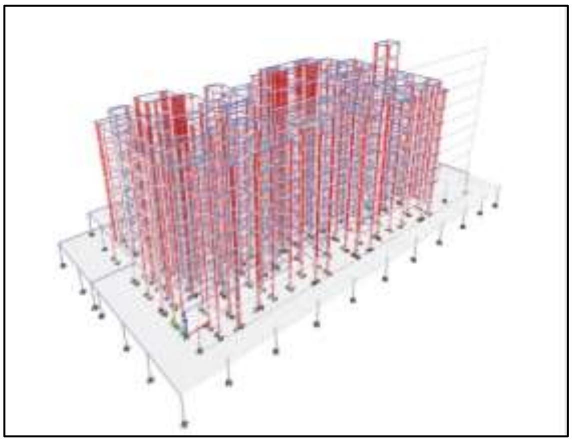


Fig. 3.8: Deflected Shape after analysis

IV. Advanced Analysis and Design

This chapter provides you information about advanced earth quake lateral force analysis, defining the earth quake load patterns, load combinations, force and stress diagrams, story response plots for EQX and EQY and design frame members

Define → load pattern → loads EQX → add new loads → select Auto lateral loads IS18932002 → type seismic → then ok

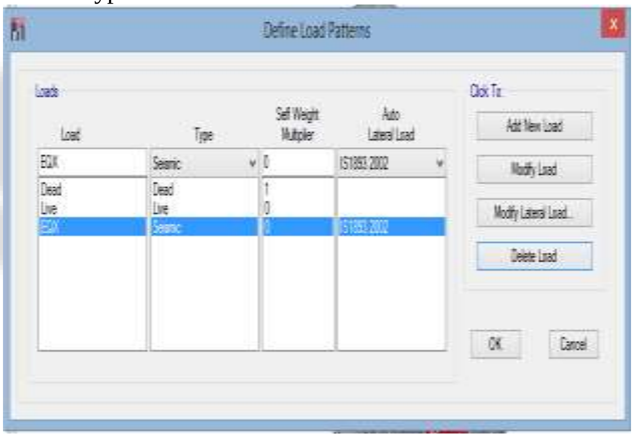


Fig. 4.1: Defining Load Patterns

A. *Member Forces and Slab Stresses*

Go to display → forces/stress diagrams → member force diagram for frames.

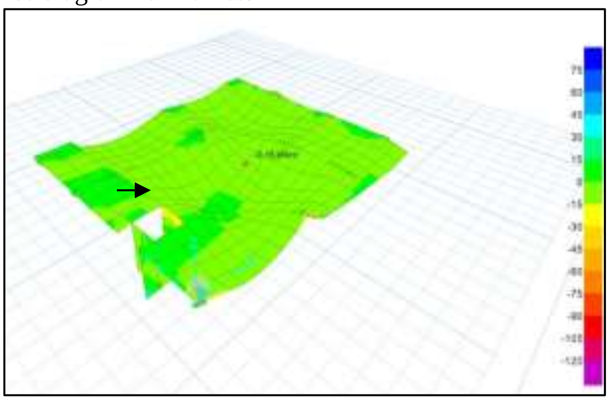


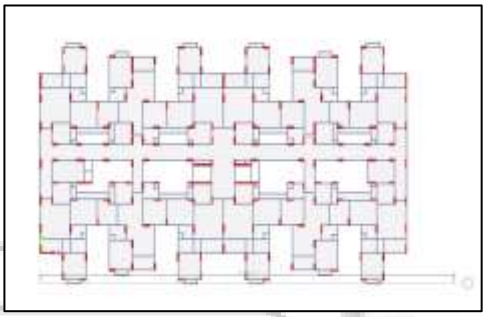
Fig. 4.2: Slab Stresses using FEM

B. Concrete Frame Design and Check

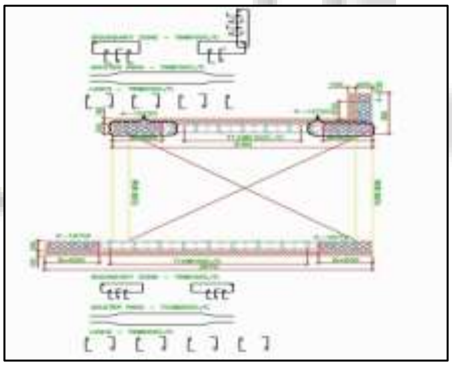
Design → concrete frame design ⟶ design preferences as IS 456:2000.

Fig. 4.3: Design Preferences

C. Concrete Design Results



D. Shear Wall Reinforcement



E. Storey Drift Values

Story	Load Case/Combo	Label	Item	Drift	X	Y	Z
					m	m	m
Story3	Dead	4	Max Drift X	0.000052	7.8994	11.3792	7.7492
Story3	Dead	4	Max Drift Y	0.000088	7.8994	2.1844	7.7492
Story3	Live	4	Max Drift X	0.000015	7.8994	11.3792	7.7492
Story3	Live	4	Max Drift Y	0.000012	7.8994	11.3792	7.7492
Story3	Super Dead	4	Max Drift X	0.000016	7.8994	11.3792	7.7492
Story3	Super Dead	4	Max Drift Y	0.000015	7.8994	11.3792	7.7492
Story3	Roof Life	4	Max Drift X	0.000013	7.8994	11.3792	7.7492
Story3	Roof Life	4	Max Drift Y	0.000014	7.8994	2.1844	7.7492
Story3	DCon1	4	Max Drift X	0.000103	7.8994	11.3792	7.7492
Story3	DCon1	4	Max Drift Y	0.000156	7.8994	11.3792	7.7492
Story3	DCon2	4	Max Drift X	0.000125	7.8994	11.3792	7.7492
Story3	DCon2	4	Max Drift Y	0.000173	7.8994	11.3792	7.7492
Story2	Dead	3	Max Drift X	0.000026	6.9088	11.3792	4.5996

F. Base Reactions

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kN	kN	kN	kN-m	kN-m	kN-m	m	m	m
Dead	0	0	3363.1481	18386.8186	-11804.0069	0	0	0	0
Live	0	0	372.5205	1956.241	-1269.7482	0	0	0	0
Super Dead	0	0	254.0666	1465.4336	-949.5983	0	0	0	0
Roof Life	0	0	131.5875	763.6024	-508.5188	0	0	0	0
DCon1	0	0	5425.8221	29778.3782	-19130.4078	0	0	0	0
DCon2	0	0	5984.6029	32712.7398	-21035.0301	0	0	0	0

V. CONCLUSION

1) From this it is clear that, shear walls are effective in reducing the dynamic response of structure for both near and far field earth quake.
2) Different thickness of shear walls is effective in reducing the dynamic response of structure for different waves of earthquake.
3) One particular shear wall is capable of diminishing the response for particular seismic excitations, may not respond well for other earthquakes. Likewise, one distinct shear wall in a structure may not counter act well in reducing the response for different angle of incidence of the earthquake.
4) It is recommended that the designer must analyze the shear wall structure under near and far field earthquakes to efficiently control its dynamic response. As different shear walls respond to various earthquake excitations differently, their effects should be considered.
5) In some cases, a combination of different thickness may be installed to overcome the deficiency of one shear wall with the other one.

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