

Analysis of a Green Building Structure Under Dynamic Loading Condition using ETABS

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ABSTRACT

Present world is requesting supportable practices in varying backgrounds and development industry isn't unique. The maintainability idea in development industry has made some amazing progress yet there is need for new turns of events and creations.

One of the key aspect of sustainable construction is the concept of green buildings. It is the type of buildings that are environment friendly as well as resource efficient. There are several systems for assessing the green building and rating them accordingly. In India, there exist 3 major rating systems but all of these systems only account for very large buildings or small commercial buildings. This exploration center around attempting to oblige a little existing private structure into the structure of one of the rating frameworks SVAGRIHA (Basic Flexible Reasonable Green Rating for Incorporated Living space Evaluation) for changing over the halfway customary structure into green structure. The structure condition was examined and green structure ideas were suggested. A basic expense investigation for the extra works and frameworks were likewise finished to show the efficient part of transformation to green structure. A bunch of suggestion to better the green structure rating frameworks as well with respect to regulatory level were given.

This research presented comparative analysis of a 17 storey conventional structure and a sustainable structure considering similar loading conditions designed using ETABS. The comparative analysis was conducted on parameters of storey moment, storey diplacmenet, storey drift and storey shear. In this study material replacements were scheduled such as low carbon footprint material replacing a certain percentage of cement in foam concrete for R.C.C. members. In this research work for modelling and dynamic analysis ETABS tool is considered.

Keywords: ETABS, Structural Analysis, Energy Efficiency, Low Carbon, Building, Environment.

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79

I. INTRODUCTION

India is a fast growing country. Rapid industrialization, increasing population, infrastructure development and destruction of natural resources lead to construction of green building. Green structure is a design that is ecologically mindful and asset effective all through its life cycle. Green structure is likewise known for its maintainability and elite execution.

Warm solace concentrates on conventional private structures of India that is known for its utilization of regular and uninvolved strategies for an agreeable indoor climate, are under progress. Detached techniques for accomplishing warm solace inside the structures are the best answer for give a solid and energy effective indoor climate. This is of preeminent significance for structures in the jungles where mechanical frameworks with high energy utilization are utilized to condition the indoor climate for warm solace. Individuals are compelled to rely upon such frameworks since, larger part of the structures are planned without giving satisfactory significance to detached techniques for controlling the indoor climate. Much of the time, inability to give the expected warm circumstances has brought about distress, chronic sickness and efficiency misfortune. As of now, there is a consistent need to assess the warm states of the indoor conditions to learn further and continue with the exploration in detached plan.

Water is a critical and finite resource. It covers over 71% of the Earth's surface and is essential for life, playing a key role in the production of food, human health and sustaining the natural environment.

However, water, particularly of drinking water quality, is becoming increasingly scarce in most of the populated regions of the planet. The strain is on to lessen water interest by diminishing wastage, to reuse or reuse however much as could reasonably be expected, and to take a gander at different method for limiting our effect on the water climate. Generally we should be more effective with our water usage.

Discarding waste has tremendous ecological effects and can lead to difficult issues. Some waste will ultimately decay, however not all, and in the process it might smell or create methane gas, which is hazardous and adds to the nursery impact. Squander that isn't as expected made due, particularly excreta and other fluid and strong waste from families and the local area, are a serious wellbeing peril and lead to the spread of irresistible infections. Unattended waste lying around draws in flies, rodents, and different animals that thus spread sickness. Typically the wet waste disintegrates and delivers a terrible scent. This prompts unhygienic circumstances and subsequently to an ascent in the medical conditions. Plastic waste is one more reason for weakness. Subsequently unnecessary strong waste that is created ought to be constrained by going to specific preventive lengths.

Concept of Green Building

Construction industry has both negative and positive impacts on the environment, economy and society. According to estimates buildings consume more than 30% of energy utilizing 40% of resources while simultaneously generating 40% of wastes and 35% of harmful green-house gases (Mane 2017). Green structure is the act of making designs and utilizing processes that are naturally capable and asset effective all through a structure's lifecycle from siting to plan, development, activity, upkeep, redesign and deconstruction. This training grows and supplements the traditional structure configuration worries of economy, utility, strength, and solace. Green structure is otherwise called a manageable or elite building (Choudhary, 2018).Green execution structures safeguard valuable regular assets and work on our personal satisfaction. There are various highlights which can make a structure 'green'. These include:



- Effective utilization of energy, water and different assets
- Utilization of sustainable power, like sun based energy
- Contamination and waste decrease measures, and the empowering of re-use and reusing
- Great indoor natural air quality
- Utilization of materials that are non-poisonous, moral and practical
- Thought of the climate in plan, development and activity
- Thought of the personal satisfaction of tenants in plan, development and activity
- A plan that empowers variation to a changing climate

II. Review of Literature Summary

Svetlana Pushkar et.al (2022) in the exploration paper, a five-story supported concrete private structure was retrofitted with: Case 1: substantial wall reinforcing (CWS)- customary cement + ordinary green rooftop; Case 2: CWS-squander included concrete + squander based green rooftop; Case 3: seismic seclusion segments (SIC)- regular cement + traditional green rooftop; and Case 4: SIC-squander included concrete + squander based green rooftop. Palekastro, Nuweiba, Tabas, and Erzincan ground movements were utilized for an underlying unique time-history examination of the retrofitted structures. Life cycle appraisals of cases 1-4 were performed utilizing ReCiPe 2016 midpoint and endpoint assessments. A two-stage investigation of fluctuation (ANOVA) was utilized to break down the ReCiPe endpoint results.

Results expressed that Case 3 and Case 4 were significantly more desirable over Case 1 and Case 2, though as per the ecological assessments, Case 4 was the most desirable over different cases. Wakale Yogesh Namdev et.al (2022) research paper introduced plan and examination of G+26 story place of business utilizing ETABS programming. While planning every one of the powers that actuate on the structure were thought of and in Post examination of the design, greatest shear powers, twisting minutes, most extreme story dislodging, conduct of working to seismic power, story solidness, story float and different responses was figured.

Results expressed that the highest level of removal is expanding from first story to last one. End expressed that construction was protected in stacking like dead burden, live burden, wind load and seismic burden. Part aspects (Shaft, Section, Chunk, Balance) are changed by working out the heap type and it's amount applied on it CSi Detail gives min. width of bars, thickness of piece and same for segment, balance.

Xiao-guang Zhao and Chun-Ping Gao (2022) research paper explained the meaning of energy-saving plan components from the parts of demonstrating programming choice, envelope energy-saving plan, and lighting energy-saving plan. Appropriately, the attributes and interaction of building energy proficiency investigation in light of BIM were proposed. At long last, the energy-saving impact assessment technique for green structure in view of BIM was given, and a model showed that the energysaving plan strategy for green structure in light of BIM proposed in the examination work had great plausibility and viability.

You energy-saving plan of green structures in view of BIM innovation proposed in this paper can not just give a reference to the top to bottom examination of BIM innovation yet additionally offer specialized help for the wide application in the field of green structures.

III.Objectives of the Research



a) To understand the concept of Green building or sustainable high rise structure.

b) To study the seismic behavior of G+16 green building by using IS 1893:2002.

c) To design the earthquake resistant structure and present comparative analysis between a conventional stucture and sustainable structure for zone III and soft soil. d) To compare the results of story drift, shear force, bending moment, building torsion, base shear.

e) To study the multi story buildings in ETABS software.

f) Conduct cost analysis between a sustainable structure and conventional structure.

IV.Methodology

Step 1- the research papers from different authors were summarized to understand the behaviour of connected towers and the research done till date.

Step 2: In order to initiate the modelling of the case study, firstly their's need to initialize the model on the basis of defining display units on metric SI on region India as ETABS supports the building codes of different nations. The steel code was considered as per IS 800:2007 and concrete design code as per IS 456:2000.

O Use Saved User Default Settings		0
O Use Settings from a Model File		0
Use Built-in Settings With:		
Display Units	Metric SI	~ ()
Region for Default Materials	India	~ 0
Steel Section Database	Indian	\sim
Steel Design Code	IS 800:2007	~ 0
Concrete Design Code	IS 456:2000	~ 0

Fig 3.1 Model Initialization

Step 3: ETABS provides the option of modelling the structure with an easy option of Quick Template where the grids can be defined in X, Y and Z direction. Here in this case, 5 bays in considered in both X and Y direction with a constant spacing of 5m making the model symmetrical in nature. G+16 storey structure is considered with typical storey height of 3m.



rid Dimensions (Plan)					Story Dimen	sions			
Uniform Grid Sp	acing				Simple	e Story Data			
Number of Grid	Lines in X Direction		5		Num	ber of Stories	17	1	
Number of Grid	Lines in Y Direction		5		Туріс	cal Story Height	3		m
Spacing of Gride	s in X Direction		5	m	Botto	om Story Height	3		m
Spacing of Grid	s in Y Direction		5	m					
Specify Grid Lat	beling Options		Grid Labels						
O Custom Grid Spa	acing				⊖ Custo	om Story Data			
Specify Data for	r Grid Lines		Edit Grid Data		Spec	ify Custom Story Data		Edit Story Data	
dd Structural Objects									
				3					
Blank	Grid Only	Steel Deck	Staggered Truss		Flat Slab	Flat Slab with Perimeter Beams	Waffle Slab	Two Way Ribbed Sla	

Fig 3.2 New Model Quick Template

Step 4: Next step is to define material properties for concrete and steel. Here in this case study, M30 concrete and rebar HYSD 500 is considered and its predefined properties are available in the ETABS application.

Material Name				
	M30		_	
Material Type	Concrete		~	
Directional Symmetry Type	Isotropic	Isotropic ~		
Material Display Color		Change		
Material Notes	Modif	y/Show Notes		
Material Weight and Mass				
 Specify Weight Density 	O Spe	cify Mass Density		
Weight per Unit Volume		24.9926	kN/m³	
Mass per Unit Volume		2548.538	kg/m³	
Mechanical Property Data				
Modulus of Elasticity, E		27386.13	MPa	
Poisson's Ratio, U		0.2		
Coefficient of Thermal Expansion	. A	0.000013	1/C	
Shear Modulus, G		11410.89	MPa	
Design Property Data				
Modify/Sho	w Material Property	Design Data		
Advanced Material Property Data				
Nonlinear Material Data		Material Damping F	Properties	
Tim	e Dependent Prop	erties		
Modulus of Rupture for Cracked Def	lections			
Program Default (Based on C	Concrete Slab Desi	gn Code)		
O User Specified				

Fig 3.3 Defining Properties of Concrete M30.



eneral Data				
Material Name	FOAM CONC	RETE		
Material Type	Concrete	Concrete ~		
Directional Symmetry Type	Isotropic		\sim	
Material Display Color		Change		
Material Notes	Modify	/Show Notes		
Naterial Weight and Mass				
 Specify Weight Density 	O Spec	ify Mass Density		
Weight per Unit Volume		24.9926	kN/m³	
Mass per Unit Volume		2548.538	kg/m³	
Nechanical Property Data				
Modulus of Elasticity, E		27386.13	MPa	
Poisson's Ratio, U		0.2		
Coefficient of Thermal Expansion, A		0.000013	1/C	
Shear Modulus, G		11410.89	MPa	
Design Property Data				
Modify/Show Ma	aterial Property	Design Data		
dvanced Material Property Data				
Nonlinear Material Data		Material Damping F	roperties	
Time De	pendent Prope	rties		
Andulus of Rupture for Cracked Deflection	ons			
Program Default (Based on Conce	rete Slab Desig	n Code)		
O User Specified				
ОК	C	ancel		

Material Name	HYSD500		
	Rebar		
			<u> </u>
	Uniaxial	(
Material Display Color		Change	
Material Notes	Mod	fy/Show Notes	
Material Weight and Mass			
Specify Weight Density	O Spe	ecify Mass Density	
Weight per Unit Volume		76.9729	kN/m³
Mass per Unit Volume		7849.047	kg/m³
Mechanical Property Data			
Modulus of Elasticity, E		200000	MPa
Coefficient of Thermal Expansion, A		0.0000117	1/C
Design Property Data			
Modify/Show Mat	erial Propert	y Design Data	
Advanced Material Property Data			
Nonlinear Material Data		Material Damping Pr	operties
Time Dep	endent Prop	perties	

Fig 3.4 Defining Properties of Rebar HYSD 500

General Data				
Material Name	PANEL WAL	PANEL WALL		
Material Type	Aluminum	Aluminum V Isotropic V		
Directional Symmetry Type	Isotropic			
Material Display Color		Change		
Material Notes	Modi			
Naterial Weight and Mass				
Specify Weight Density	O Spe	cify Mass Density		
Weight per Unit Volume		26.6018	kN/m³	
Mass per Unit Volume		2714.472	kg/m³	
Mechanical Property Data				
Modulus of Elasticity, E		69637.05	MPa	
Poisson's Ratio, U		0.33		
Coefficient of Thermal Expansion,	A	0.0000131	1/C	
Shear Modulus, G		26179.34	MPa	
Design Property Data				
Modify/Show	Material Property	/ Design Data		
Advanced Material Property Data				
Nonlinear Material Data		Material Damping P	roperties	
Time	Dependent Prop	erties		
Time	Dependent Prop	erties		

Fig Properties of Pannel Wall

Step 5: Defining section properties for Beam, Column. Beam size of 500x350mm, Column size of 500x500mm and Slab size of 150 mm is considered in the study.

General Data		
Property Name	BEAM 500X350 (FOAM CONCRETE)	
Material	M30 ~	2
Notional Size Data	Modify/Show Notional Size	3
Display Color	Change	< + •
Notes	Modify/Show Notes	• •
Shape		• • •
Section Shape	Concrete Rectangular V	
Section Property Source		
Source: User Defined	Property	Modifiers
Section Dimensions	M	odify/Show Modifiers Currently Default
Depth	500 mm	
Width	350 mm	
		Modify/Show Rebar
		ОК
	Show Section Properties	Cancel
	e Area Over Column	



eneral Data				
Property Name	OLUMN 500>	500 (FOAM CONCRE	TE)	
Material	M30		×	2
Notional Size Data	Modify/S	how Notional Size		3
Display Color		Change		• * • •
Notes	Modif	y/Show Notes		• •
паре				
Section Shape	Concrete Rec	tangular	~	
ection Property Source				
Source: User Defined				Property Modifiers
ection Dimensions				Modify/Show Modifiers
Depth		500	mm	Currently Default
Width		500		Reinforcement
width		500	mm	Modify/Show Rebar
				ОК

Fig 3.5 Defining the section properties of Beam



Slab Material M	ilab 130	
	130	
NUL LOL DU		<u> </u>
Notional Size Data	Modify/Show Notional Size	
Modeling Type S	hell-Thin N	<
Modifiers (Currently Default)	Modify/Show	
Display Color	Change	
Property Notes	Modify/Show	
Type Si Thickness	lab 125	mm
Thickness	125	mm

Fig 3.7 Defining the Properties of Shell-thin slab

D			
Property Name	PANEL WALL		
Property Type	Specified	~	
Wall Material	PANEL WALL	\sim	
Notional Size Data	Modify/Show Notional Siz	e	
Modeling Type	Shell-Thin	\sim	
Modifiers (Currently Default)	Modify/Show		
Display Color	Change		
Property Notes	Modify/Show		
operty Data			
Thickness	100		mm
Include Automatic Rigid Zone A	rea Over Wall		

Fig Pannel Wall

Step 6: Assigning Fixed Support at bottom of the structure in X, Y and Z direction in both the considered cases.

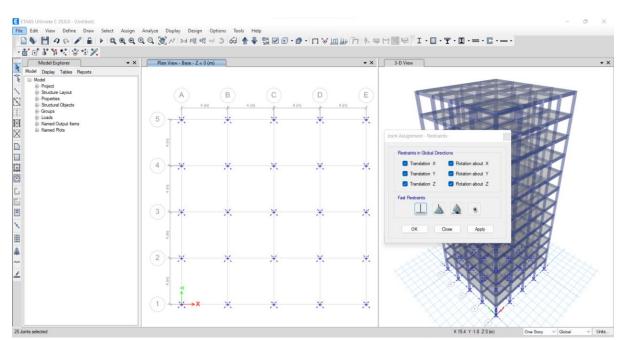


Fig 3.10 Assigning Fixed Support



Step 7: Defining Load cases for dead load, live load and seismic analysis for X and Y Direction.

.oads				Click To:
Load	Туре	Self Weight Multiplier	Auto Lateral Load	Add New Load
eq x	Seismic	~ 0	IS 1893:2016 V	Modify Load
Dead	Dead	1		
Live eq x	Live Seismic	0	IS 1893:2016	Modify Lateral Load
eq y	Seismic	Ō	IS 1893:2016	Delete Load

Fig 3.11 Defining Load Pattern

Step 8 Defining Seismic Loading as per IS 1893: 2016 Part I.

Direction and Eccentricity		Seismic Coefficients			
 X Dir X Dir + Eccentricity X Dir - Eccentricity Ecc. Ratio (All Diaph.) Overwrite Eccentricities 	Y Dir Y Dir + Eccentricity Y Dir - Eccentricity 0.05 Overwrite	Seismic Zone Factor, Z Per Code User Defined Site Type Importance Factor, I		0.16 I 1.2	~
Story Range		Time Period			
Top Story	Story17 V	 Approximate 	Ct (m) =		
Bottom Story	Base ~	Program Calculated			
actors		O User Defined	Τ=		sec
Response Reduction, R	5				

Fig 3.12 Seismic Loading

		EQ X		Design
Load Case Type Mass Source Analysis Model		Response Spectrum Previous (MsSrc1)		Notes
		Default		
ads Applied				
Load Type	Load Name	Function	Scale Factor	0
Acceleration	U1	Default Uniform	9806.65	Add
Acceleration	U2	Default Uniform	9806.65	Delete
Acceleration	U3 ~	Default Uniform	9806.65	
Modal Load Case		Modal		2
Modal Combination Meth		SRSS	1	<
	Response F	SRSS Rigid Frequency, f1	1	cyc/sec
Modal Combination Meth	Response F	SRSS Rigid Frequency, f1 Rigid Frequency, f2	0	cyc/sec cyc/sec
Modal Combination Meth	Response F F	SRSS Rigid Frequency, f1	-	
Modal Combination Meth	Response F F ion, td	SRSS Rigid Frequency, f1 Rigid Frequency, f2	0	
Modal Combination Meth Include Rigid F Earthquake Durat Directional Combination	Response F F ion, td	SRSS Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type SRSS	0	
Modal Combination Meth Include Rigid F Earthquake Durat Directional Combination	Response F F ion, td Type	SRSS Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type SRSS	0	

Fig 3.13 Load Case Data

Function Name	response spectrum		Function 0.0	Damping Ratio 5
arameters		Defined Fun	ction	
Seismic Zone	Ш	✓ Peri	od	Acceleration
Seismic Zone Factor, Z	0.16	_	_	0.0100
Importance Factor , I	1.2	0	1	0.0192
Soil Type	Ш	 ✓ 0.67 0.8 	1	0.048 0.0401
Response Reduction Factor, R	5	1.2		0.0321 0.0267
Convert to User	Defined	1.4 1.6 1.8		0.0229 0.02 0.0178
unction Graph			Plot Optic	008
				ar X - Linear Y
1E-01 _				ar X - Log Y
			🔿 Log	X - Linear Y
1E-02 -			🔿 Log	X - Log Y
1E-03	5.0 6.0 7.0 8.0 8	0.0 10.0	(ОК
				Cancel

Fig 3.14 Defining Response Spectrum Analysis as per IS 1893-2016.

Step 9: Conducting the model check for both the cases in ETABS

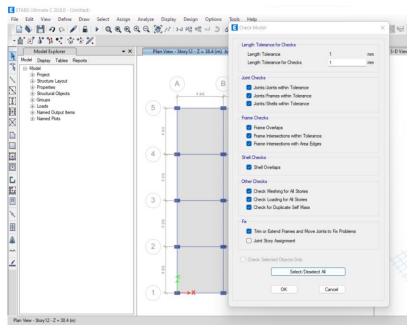
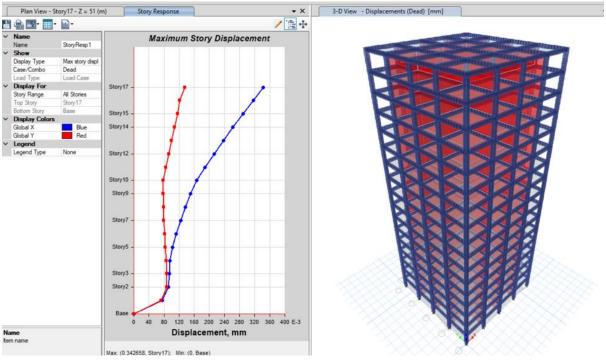
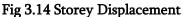


Fig 3.15 Model Check



Step 10: Analyzing the structure for dead load, stress analysis and displacement.



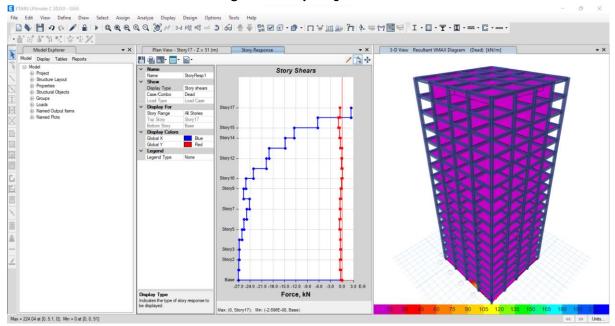


Fig 3.15 Storey Shear

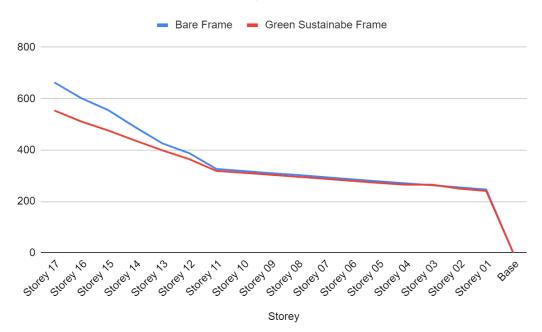
Building Description

Building Description		
Plan dimension	25mx25m	
Number of storey	17	
Typical Storey height	3m	

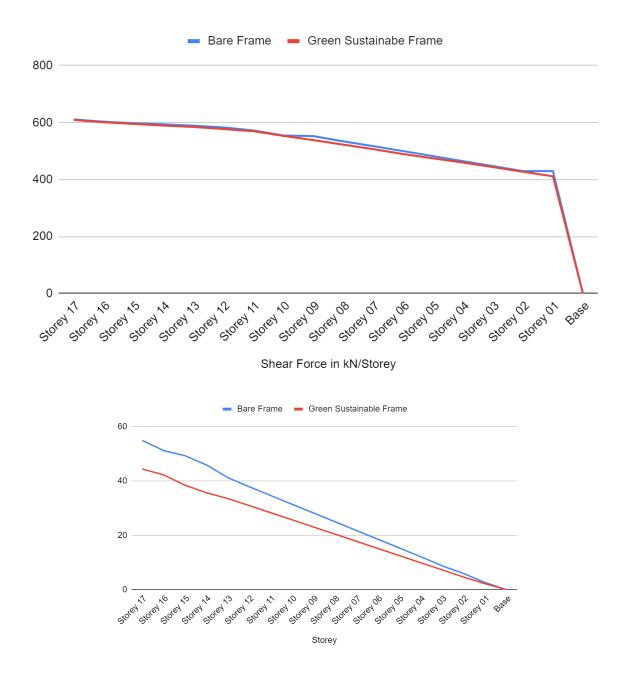


Bottom Storey Height	3m
Building Height	63m
Number of Grid in X Direction	5
Number of Grid in Y Direction	5
Spacing of Grids in X direction	5m
Spacing of Grids in Y direction	5m
Beam Size	500x350mm
Column Size	500x500mm
Slab Thickness	125mm
Panel Wall Thickness	100mm
Soil Profile Type	Soft

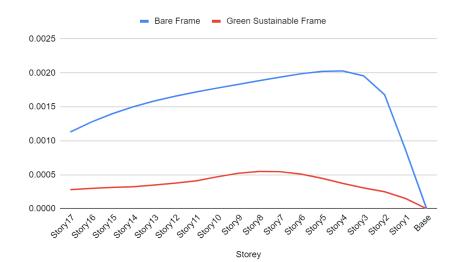
Analysis Result











V. CONCLUSION

This research presented comparative analysis of a 17 storey conventional structure and a sustainable structure considering similar loading conditions designed using ETABS. The comparative analysis was conducted on parameters of storey moment, storey diplacmenet, storey drift and storey shear. In this study material replacements were scheduled such as low carbon footprint material replacing a certain percentage of cement in foam concrete for R.C.C. members. In this research work for modelling and dynamic analysis ETABS tool is considered.

For this research work following outcomes are observed: •

Storey Moment

The general formula to evaluate storey moment is Storey moment = Storey shear x storey height/3. Storey moment was found to be quite similar to storey 11 with minimal difference whereas gap of 2.9% the storey drift divided by the storey height. Storey was more visible with increase in storey height. Green structure was found to be lightweight and was able to resist imposed loads considering seismic zone III.

Storey Shear

Storey shear factor is the ratio of the story shear force when story collapse occurs to the story shear force when total collapse occurs. Through a series of dynamic analyses, simple equations are provisionally proposed to calculate the necessary story shear safety factor that can be used to prevent story collapse. Shear force showed minimal difference in comparison to both the cases and constant rise was visible with increase in height of the structure.

Storey Displacement

Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. So, a graph showing the story displacement vs. the height of the structure looks exactly like the deflected shape. Storey displacement was found to rise with each storey height and was maximum in case of bare frame structure when compared to green building.

Storey Drift

Storey drift is the lateral displacement of a floor relative to the floor below, and the storey drift ratio is drift was maximum at storey 1 in case of conventional structure whereas the green structure was able to contain the drift even at first storey whereas relatively the drift decreases with increase in height with a mean difference of 6.89% was visible in the comparison.

Cost Analysis

The cost comparison was made as aluminium panels and foam concrete were used in case of green structure which was found to be more economical and eco friendly when compared to conventional structure. The green structure was found to be 8.4% more economical in comparison to conventional structure making it a feasible option for new structures.

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