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Performance analysis of RCC and steel concrete composite structure under seismic effect

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***Abstract*— Due to their benefits over traditional reinforced concrete and steel structures, such as ease and speed of construction, steel-concrete composite structures are becoming more and more common. Understanding how this type of construction behaves when employed in buildings becomes crucial in light of this. The usage of building frames made of reinforced concrete beams and composite steel-concrete column sections is the main subject of this study. To accomplish this goal, the seismic analysis of the buildings was selected to assess the effectiveness of the buildings designed and examined in accordance with Indian and American standards, respectively. The results were compared in order to assess the effectiveness of the aforementioned standards. The building used for the study had a rectangular layout, a 30-meter elevation, and no visible plan or vertical irregularities. The building's gravity loads taken into account are compliant with IS 875 Parts 1 and 2. However, because seismic analysis was the main emphasis of the study, the gravity loads employed for both buildings were retained to be the same. According to Indian specifications, HYSD415 grade steel and M30 grade concrete were utilised in the building's design. The materials chosen for the RCC-based building are identical to those used for composite buildings.**

***Index Terms*— Composite Section, Fast Non-linear Analysis (FNA), RCC .building, Time History Method.**

I. INTRODUCTION

Fast-paced and high-strength building is now required in many areas of the construction industry. The requirement for homes and office space in urban areas is expanding at a very fast rate as a result of the huge number of people moving to cities from all parts of the country. The construction industry must employ high rise building technologies to accommodate numerous people in the constrained area available in cities in order to meet the demands of the growing urban population. As previously noted, maintaining a high-rise building's construction pace while meeting its stringent strength criteria is crucial from a variety of perspectives the buildings. RCC, or reinforced cement concrete, has historically been employed to meet this need. RCC has a distinct set of benefits and, as a result, has been one of the most popular construction techniques for a very long time. But new ideas for building structures with greater strength and in less time are emerging as a result of the development of modern machinery and construction procedures.

The use of steel-concrete composite constructions is becoming increasingly important in the construction of high-rise buildings, bridges, and other structures. Concrete's compressive strength and structural steel's great resistance to stress and compression are typically combined in the sections of steel-concrete composite constructions. Therefore, when these characteristics are integrated into a section, the resulting section is a very effective and relatively light section that is most frequently used in the construction of high-rise, multi-story structures and bridges over highways. Steel concrete buildings give a few additional advantages in addition to the high qualities of strengths from concrete and structural steel. When compared to RCC or steel buildings, they are significantly lower maintenance, which provides them an advantage in becoming a favoured economic solution over the course of the structure's life. They also offer strong resistance to corrosion, making them extremely durable. To give you a better perspective, it has been determined that composite constructions weigh less than RCC structures by as much as 25%. This leads to less work being required for the structure's erection and installation, saving labour and construction costs. In the building of steel concrete composite structures, these financial savings can be as high as 10% when compared with the traditional RCC framed structures and around 7% when compared with steel structures

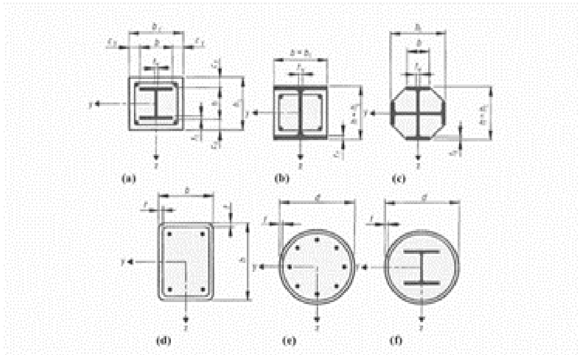


Fig. 1: *Types of steel-concrete Composite column Section*

II. OBJECTIVE OF STUDY

1. To design composite RC midrise structure by using appropriate code
2. To evaluate performance of composite midrise structure for series of ground motion data
3. To compare performance of composite RC structure with conventional RC structure for selected ground motion data

III. MODELLING AND MATERIAL PROPERTIES

For the study, a G+9 storeyed building regular in plan is considered. The structure is modelled using SAP2000 software and analysed using four different time history (TH) records of ground motion. To reduce the dynamic response under lateral load, Composite column Section are applied to the structure.

Table I: Design data for the building

Sr. No.	DESIGN DATA FOR THE BUILDING		
1.	Geometric Details of Building		
a)	No. of storeys		G + 9
b)	Plan dimensions		25 X 25 m
c)	Type of structure		SMRF
d)	Type of building		Regular in plan
e)	Typical storey height		3m
2.	Material properties		
a)	Grade of concrete		M30
b)	Grade of steel		Fe500
c)	Density of reinforced concrete		25 kN/m³
d)	Density of steel		78.5 kN/m³
3.	Load Details		
a)	Dead Load	Self-Weight	
		Wall Load External (230 mm) Internal (150 mm)	12 kN/m 7.8 kN/m
		Floor Finish	1.5 kN/m^2
b)	Live load	At floor	3 kN/m^2
		At terrace	1 kN/m^2
c)	Earthquake Load		As per IS 1893:2016 (Part 1)
4.	Seismic Properties		
a)	Seismic zone		IV
b)	Zone factor (z)		0.24
c)	Response reduction factor (R)		5
d)	Importance factor (I)		1
e)	Soil type		II
f)	Damping ratio		0.05
5.	Indian Building Steel Section Specifications		
a)	Steel Section Used		ISMB 200
b)	Depth of The Section		200. mm
c)	Width of Flange		100mm
d)	Thickness of Flange		10.8mm
e)	Thickness of Web		5.7mm

Member Properties as per Design:

Table II: Beam Section Properties

Table III: Column Section Properties

Thickness of slab = 150 mm

Parameter	Building Designed using Indian standards
Size of Outer Beam	(230 X 350) mm
Stirrups for Beams	8 mm spaced at 250 mm c/c
Size of the Inner Beam	(230 X 400) mm
Stirrups for Inner Beam	8 mm spaced at 150 mm c/c

Strength Ratio

Parameter	Building Designed using Indian standards
Size of Lower column	(550X500) mm
Reinforcement Details for Lower column	10 Bars of 25 mm
Stirrups for Lower Column	10 mm spaced at 250 mm c/c
Size of the Upper Column	(500 X 450) mm
Reinforcement Details for Upper Columns	14 Bars of 20 mm
Stirrups for Upper Columns	10 mm spaced at 150 mm c/c
Steel section used in Columns	ISMB 200

IS 13920 suggests a factor called the strength ratio for determining whether the strong column-weak beam mechanism is being used at building joints. The strength ratio is defined as the ratio of the sum of column moment carrying capacity. to the moment carrying capacity of beams meeting at any given joint in the structure The moment capacities calculated for the strength ratio do not include the forces generated in the structural members, but are determined by the members' characteristics. According to IS 13920, the strength ratio at any given joint must be greater than 1.4. If a joint fails to meet this demand, the columns at that joint are considered gravity members and are not included in the lateral load resisting system, or they must be strengthened to meet the deemed criteria.

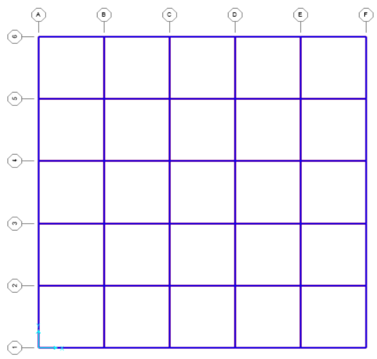


Fig. 2: Plan of the RCC frame building models

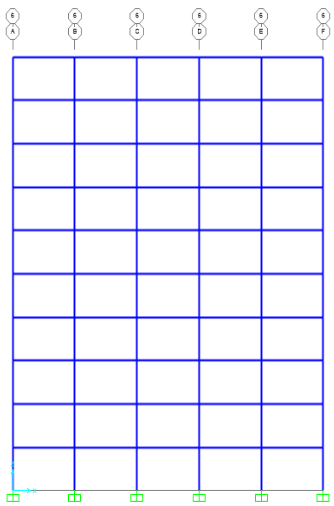


Fig. 3: Elevation of the RCC frame building models

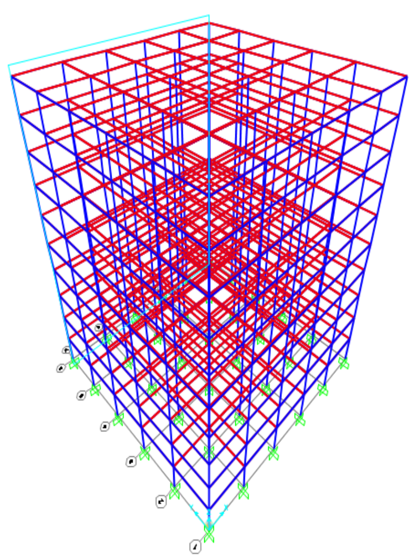


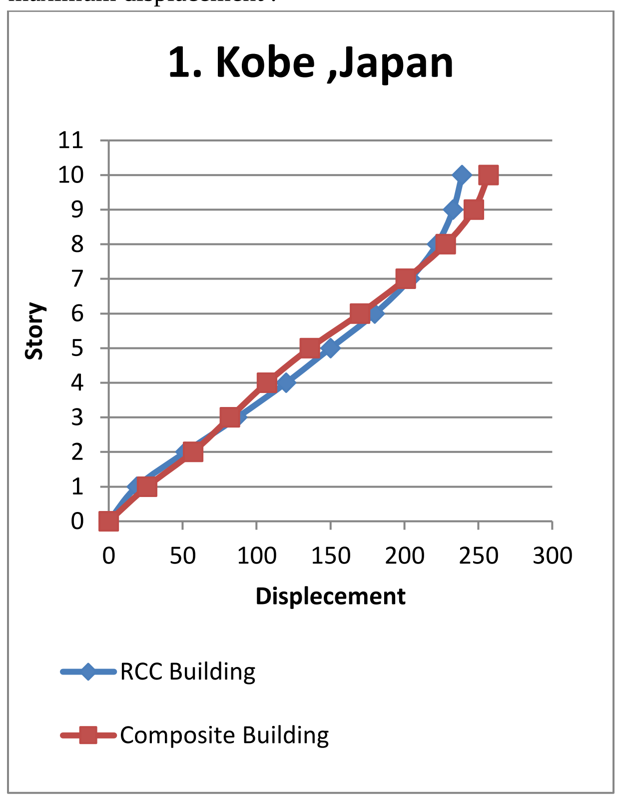
Fig. 4: : 3-D view of the RCC frame building models

IV. RESULTS AND DISCUSSION

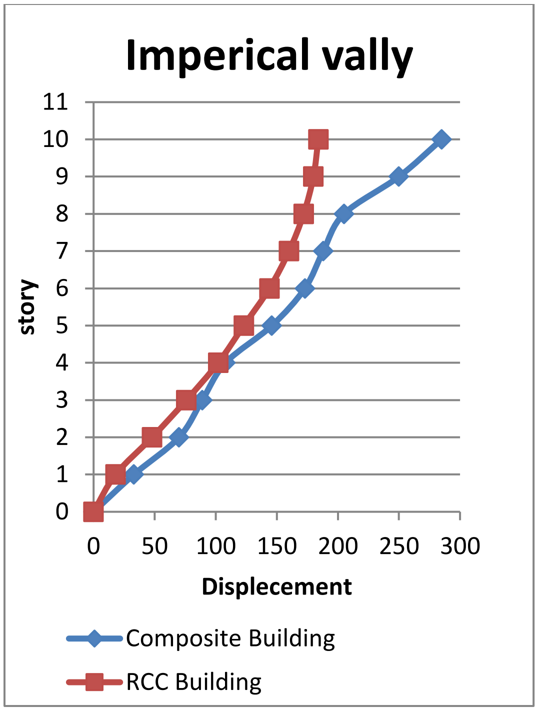
In the current study, Composite I Sections are employed to minimize the seismic effects of the G+9 RCC building that is subjected to the earthquake load. Dynamic analysis is performed with SAP2000 software and the time history approach. The symmetric model ensures that the values in both directions are equal. To evaluate the seismic behaviour of a reinforced concrete structure, two observed variables are used as story drift and storey displacement.

Storey Displacement:

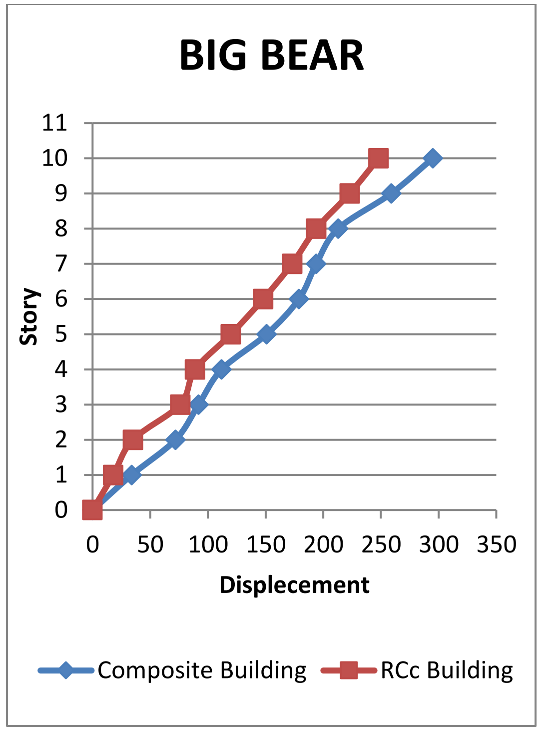
The TH response of all six G+9 story building model cases is represented as in Fig. 4 in terms of storey displacements. The model with Composite Sections undergo significantly greater displacement than models with RCC.. Model with TH. Big Bear has a maximum displacement .



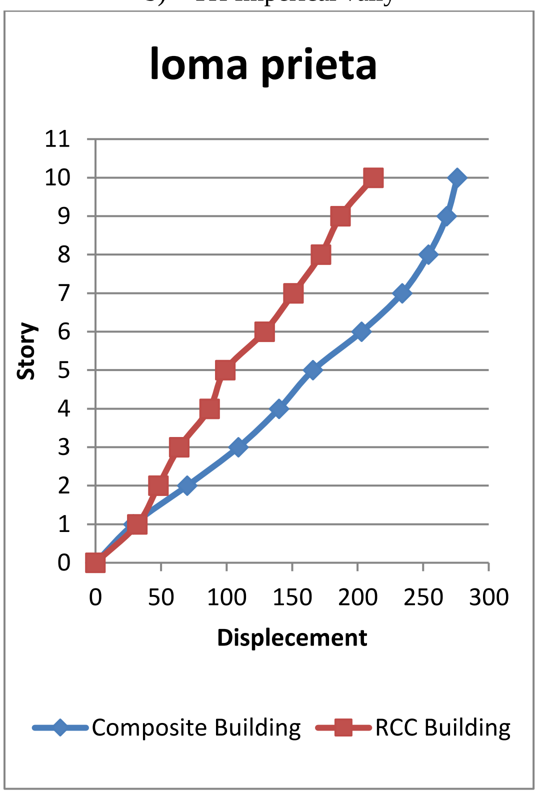
a) TH - Kobe Japan



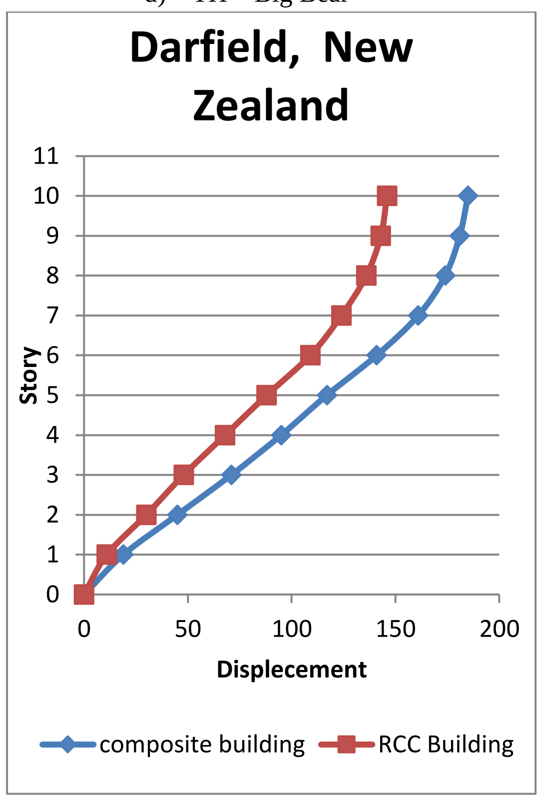
b) TH Imperical vally



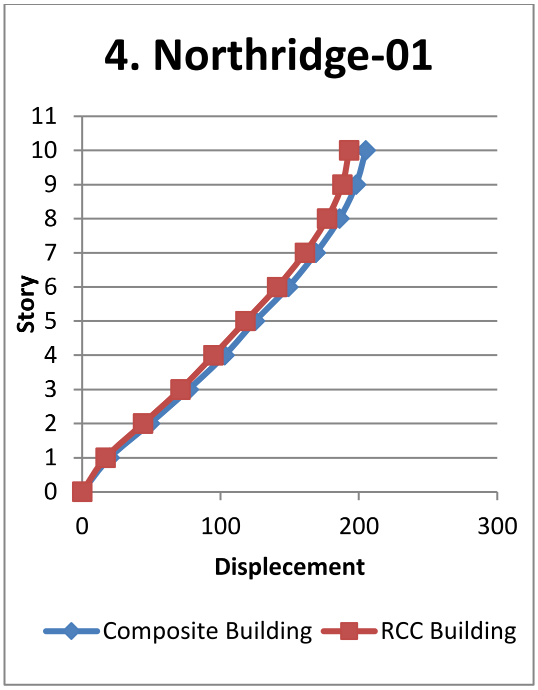
d) TH – Big Bear



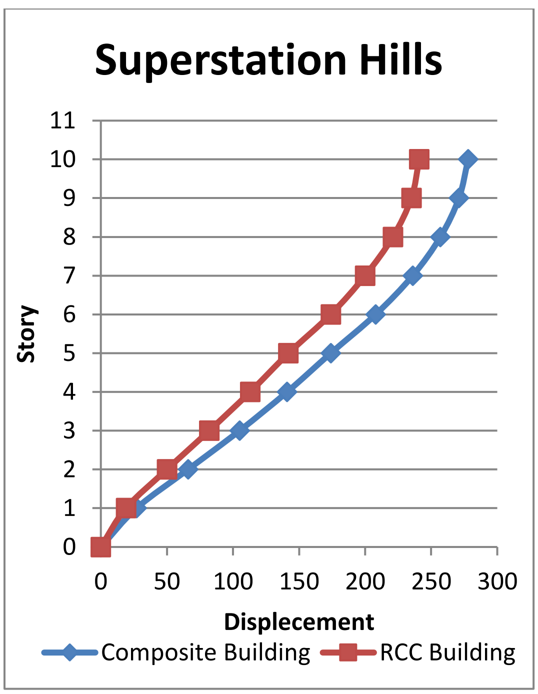
c) TH – loma prieta



e) TH -Darfield



f) TH - Northridge-01

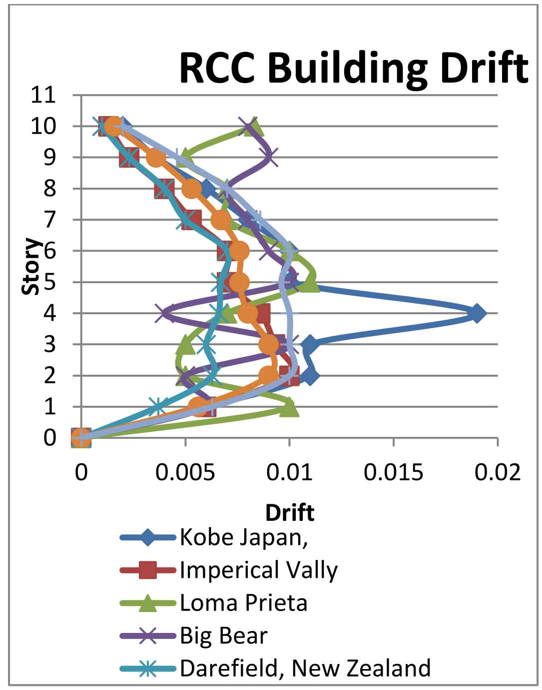


g) TH - Superstation Hills

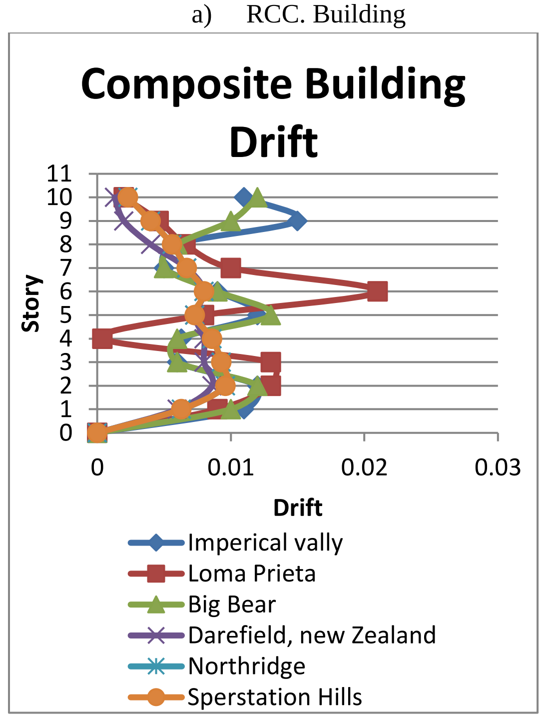
Fig. 5: Comparison of storey displacement for ground motions a) Kobe Japan b) Northridge c) El Centro 1940 d) Imperial Valley e) Superstation Hills. E) – Big Bear f) Darfield

Storey Drift:

The TH response of all seven G+9 story building model cases is represented as in Fig. 6 in terms of storey drift. Steel section are effective at reducing storey drift as indicated by the larger drift values for model without Composite as compared to other models.



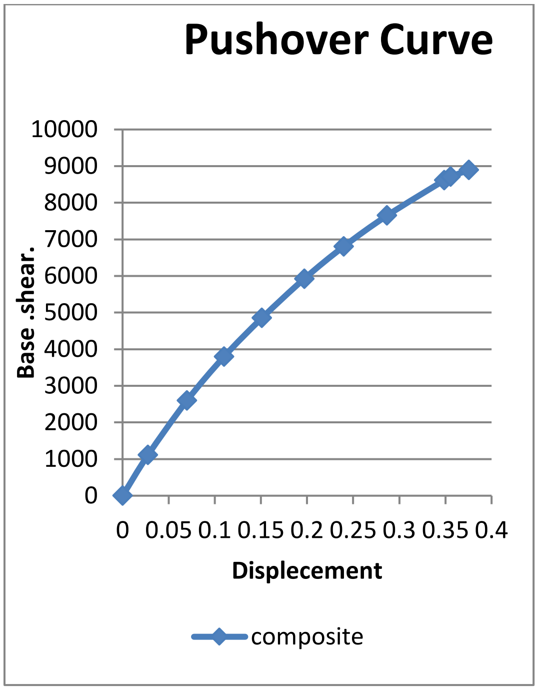
a) RCC. Building

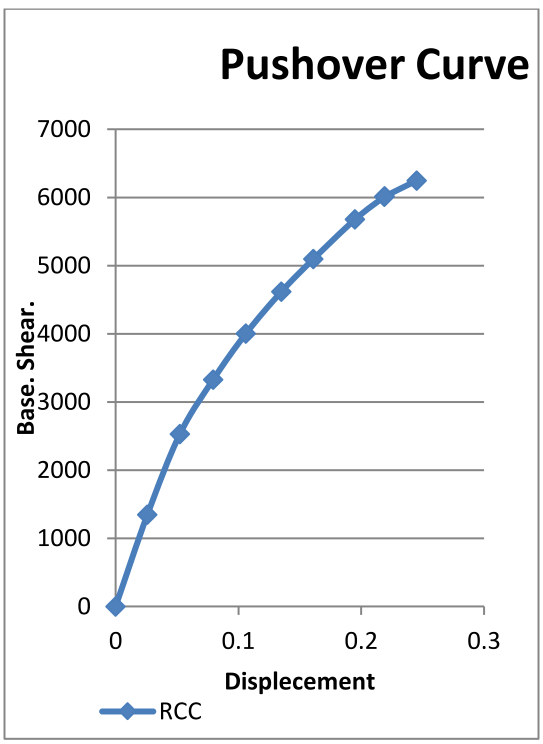


b) Composite Building

Pushover Analysis Results Comparison on RCC and Composite

Model	RCC	Composite
Ultimate displacement in mm	0. 25	0.375
Ultimate Base Shear in KN	6200	9000





V. CONCLUSION

The study of steel-concrete composite buildings and the nonlinear analysis of the structure was the primary focus of this project. A building plan and elevation with the appropriate steel-concrete composite column section and reinforced concrete beam section were chosen for this. The chosen building had a height of 30 metres (G+9 stories) and plan dimensions of 25 metres along X-direction and 25 metres along Y-direction. The concrete grade used was M30. In the case of the building designed according to Indian standards, it was supposed to be in earthquake zone 4 with an importance factor of 1, standing on medium stiff soil. The buildings were designed and analysed using a variety of design codes. The primary sizes of the structural members were chosen in accordance with IS 13920 recommendations. Sizes were initially considered in accordance with the IS Code, after which they were properly designed and grouped as needed. The final section sizes are used to perform the nonlinear static and dynamic analysis. SAP2000 computer software platform was used to perform nonlinear analysis. Three earthquake ground motions were chosen from the PEER ground motion database for the nonlinear dynamic analysis of the Composite Building, and one ground motion was chosen for the comparison of the RCC and Composite Building. Along X, nonlinear dynamic analysis is performed. Nonlinear dynamic factors such as maximum story displacements and story drift Building performance can be compared using dynamic analysis.

The conclusion are as follows,

- According to the obtained results, displacement for the Composite Building is greater than for the RCC Building.
- The model with the Steel I section has a higher Story Drift value than the RCC Building.
- As a result, it is concluded that the Composite Building is more flexible than a standard RCC building.
- In the case of a comparison of the composite building for three different ground motions the Big Bear building shows the greatest displacement for the Terrace floor.
- Avg. displacement For the composite Building from all building 254mm

- Avg. displacement For the composite Building from all building 209mm

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