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Resilience of Steel Framing Structures over Reinforced Concrete (RC) Structures for Seismic Safety Using ETABS

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Abstract: This study focuses on seismic resilience of steel framed structure over reinforced concrete structure by using a structural design software named ETABS. Structural Analysis was conducted for a simple layout, both steel frame and RCC frame were analysed and found the analysis it was clarified that steel framing structure shows more resilience against seismic wave in seismic prone region like Bangladesh. Through this comprehensive analysis of both framing systems, steel emerges as a superior alternative, offering strength, flexibility, precision, and sustainability. The findings underscore the importance of steel framing to ensure the safety and resilience of structures in seismic-prone regions like Bangladesh, contributing to a safer and more sustainable built environment. Till now we are not declaring straight off that steel structures are 100% seismic resistant but the study shows a pathway in manufacturing a totally safe structure under seismic effect to ensure the safety of our living, After this theorical Analysis we started to believe in lightweight & safe structures, if we design our structures with steel frames highly considered the seismic effects and other lateral forces applying some innovation of mechanical engineering as well to create smart joints which will inhabit the failure due to lateral forces.

Keywords: Seismic challenge, steel I section, light-weight structure, lateral load resisting system

I. Introduction

Earthquake happens mechanically and a few instances happens with unpredictable and resulting from a speedy launch of strength within side the earth ensuing earthquake waves. Some important steps should be followed through the development technique to make sure that building is constructed seismic wave resistance. Seismic wave proof systems are the ones which can be constructed to resist the outcomes of a seismic wave. Systems which can be both earthquake-evidence or have a minimum wave effect that is called earthquake resistance construction. Buildings may be absolutely secure from the outcomes of seismic waves through modification of framing system & increase in resilience of materials. The primary motive of seismic wave resistant construction, subsequently, in Quaker susceptible places, constructing should consist of guarantee balance accessibility, and durability, in addition to an excessive stage of security**.** Bangladesh, situated in a seismically active region, faces the constant threat of earthquakes (Shobhit Kumar, Preeti Agarwal, 2022). With nearly 50 minor tremors witnessed in recent times within last 5 years, the information provided by the Meteorological Department, Bangladesh has been shaken by 47 earthquakes from January 2018 to September 2021.The repeated earthquakes mean that the fault lines are active. So right now, this country's vulnerability to seismic activities is evident, and the potential for minor tremors to escalate into major earthquakes necessitates a proactive approach to construction. Conventional RCC structures, while prevalent, but the question is if they are capable withstand the seismic effect? Some of them can be survived which are built with proper concern and obviously not old structures but may not provide a total assurance & the required level of seismic resistance. Therefore, a shift towards alternative construction materials and methods is imperative. Highlighting the urgent need for a proactive approach to construction due to the potential escalation of minor tremors into major earthquakes. The prevalent use of conventional Reinforced Concrete (RC) structures has been used widespread, the allowable stress of concrete used in Bangladesh, with a maximum of 3000 psi, presents a critical consideration in earthquake-prone regions and worries about their ability to provide the necessary level of seismic resistance. One critical aspect to consider is the inherent limitation of concrete in terms of tensile strength and intermolecular strength when, Concrete being relatively brittle, is keen to cracking and failure under lateral forces such as those induced by earthquake vibrations. On the other hand, steel exhibits superior tensile strength and ductility, making it a more resilient material in the face of seismic events. The ability of steel to bend without collapsing ensures that structures incorporating steel framing can withstand lateral forces associated with earthquakes, mitigating the risk of catastrophic failure.

Strong joints in steel framing further contribute to the overall structural integrity, reinforcing the capacity to endure seismic stresses. Recognizing these vulnerabilities in conventional construction practices, it becomes imperative to shift towards alternative construction materials and methods that prioritize seismic safety. Although a few limitations of steel structures like Corrosion, fire resistance, design limitations, architectural limitations noise vibration, but with various applicable solutions like fire resistant painting, Corrosion protection, knee bracing at base and joint, etc are interestingly potent. Incorporating the findings of other researchers, this evaluates similar analysis relative themes, and establishes a clear correlation between their work and the

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objectives of the present study, contributing essential support and context for the research questions and hypotheses. Here, most of the studies shows pathways through kind of results like However, faster construction may brand Steel building economically viable. Further, Steel structures are expected to show better performance under earthquake due to higher ductility, the deflection rate due to lateral shear of the RCC structure is quite higher than STEEL. In presence of seismic effect oscillation or vibration time period for steel frame structure is more as compared to RCC structure because of greater strength or stiffness of steel. Here, a study shows the time period for steel and RCC frame structure of a G+12structureis 5.92sec. & 2.13 sec. respectively (Ritesh J. Raut, Sagar R. Raut, 2019), (Cirella, G.T.; Semenzin, E.; Critto, A.; Marcomini, 2014).The base shear found in RC structure is more as compared to steel frame structure. Over those findings this study also explores a different innovation like the framing system and the structure expects to survive any seismic or lateral effect through constructing an ideal span length within 8 to 12 feet which will be considered equal in both direction or L/W ratio is 1. The structural members should be designed following appropriate seismic zone coefficients according to local building codes (Booth, E.D.; Key, D. London, UK,2006).Therefore, resilient construction practices are crucial for safeguarding the resources, built environment and ensuring the safety of its inhabitants in the face of seismic challenges. This article explores the benefits of steel framing reducing the dead load of structures strength and sustainable in the face of seismic challenges.

II. Analysis/Experiment to compare the resilience

(a)Design Approach for RCC:

The structural plan was analysed for possible placement of column. Main beams were placed connecting columns. The Geometrical layout was prepared using AutoCAD & E-tabs. The structure to be analysed is a G+5 stored residential Building. Beams Columns were of standard size designed in hand calculation applying WSD method.The structural design process, attention to factors such as seismic considerations, soil analysis, and adherence to local building codes

(G. Hemalatha,' Uma. S. G, Muthulakshmi).

(b) Design Approach for STEEL:

For the justification to the comparative study carried out here the layout has been kept same for both structures. Wide flanged sections are used with appropriate thickness of webs are for beams& column design, with high bending & buckling resistance. All sections are elected from AISC shape database and allowable stress of steel is 18730 psi/130 MPa is used to design sections which is less than 0.66fy of A36 grade steel. Beam sections are identified through section modulus & Column sections are identified cross-sectional area from AISC shape database table. No Secondary beams bracing or knee bracing are provided around the building to resist the lateral load. The maximum span length is 10 feet which is all equal for every span in both structures (M. Saravanan1· Rupen Goswami· G. S. Palani. 2018).

Here, the analysis is conducted on both STEEL & RCC framing system on a G+5 stored structure with Basement and roof top water reserve tank. The maximum following loads has been considered: DEAD LOAD = SELF WT OF STRUCTURE. FLOORFINISSH=20 Psf. PARTATION WALL LOAD=30 Psf. LIVE LOAD= 80 Psf. ROOF LIVE LOAD = 20 Psf. LIVE LOAD OF WATER= 499.2 Psf. [Hight of the water reservoir is 8 feet] 10-inch-thick Parapet Wall around two water reservoir = 1 K/ft. DESIGN CODE: ACI 318-05/IBC 2003 AISC-LRFD93.

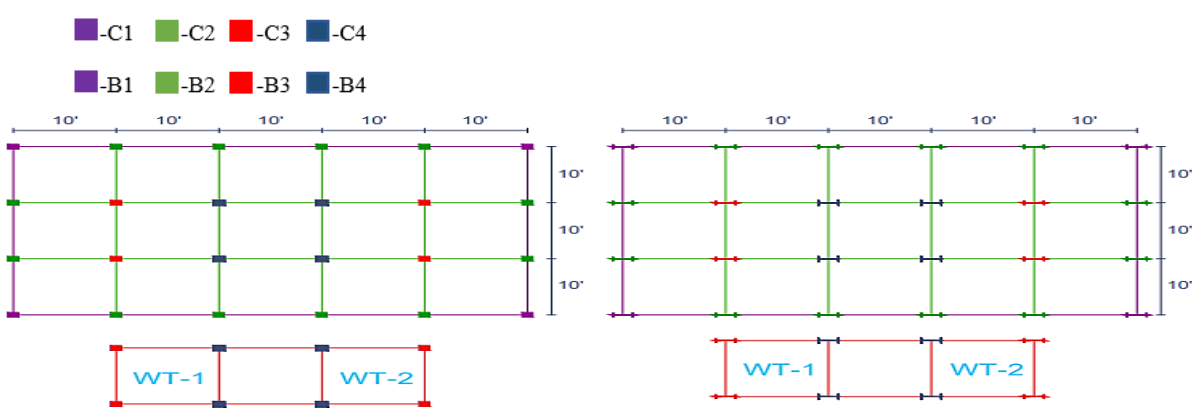

Fig. 1: Floor-plan of frame sections (RCC and STEEL).

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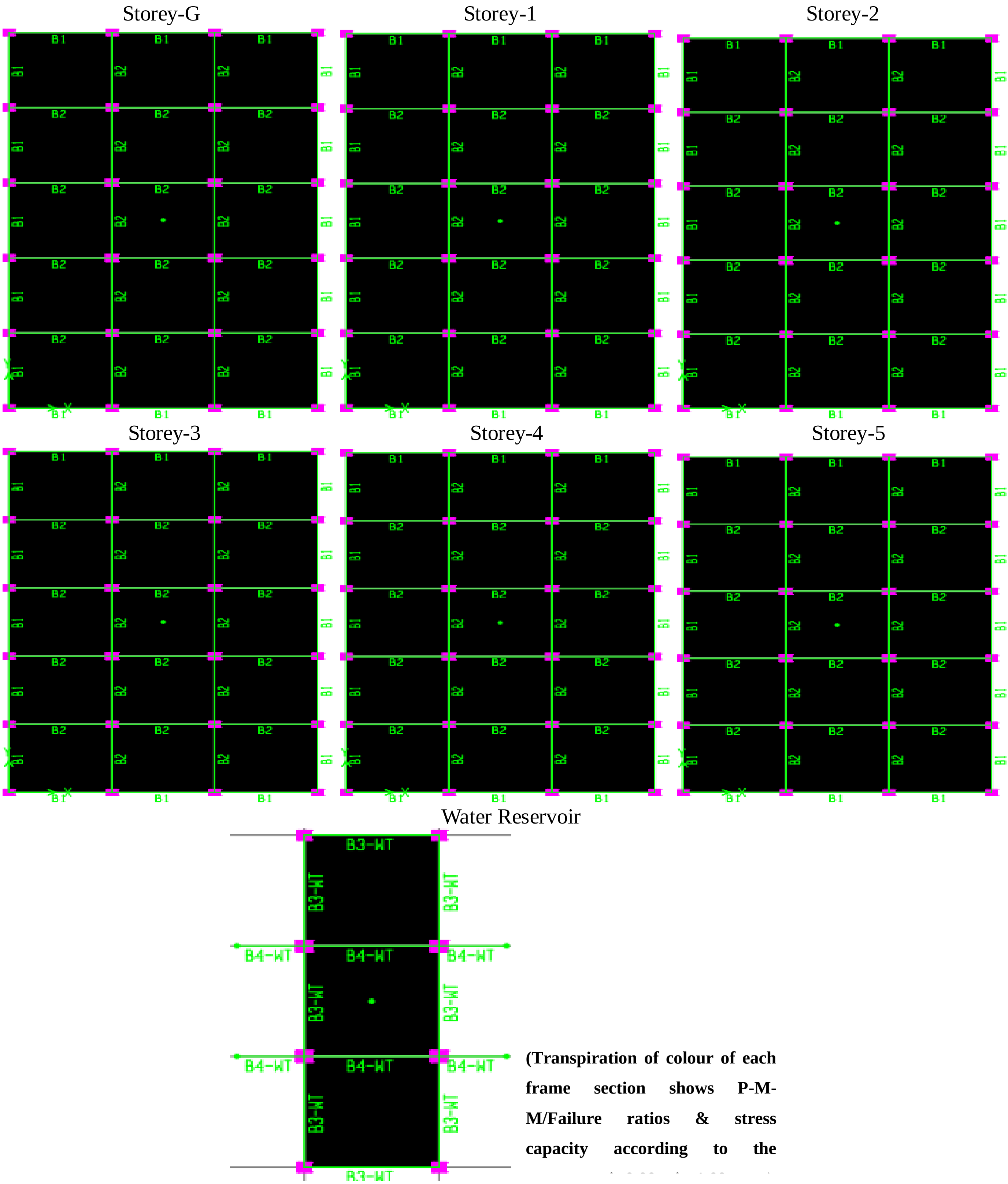

Fig. 2: Analysis output of RCC structure without seismic load.

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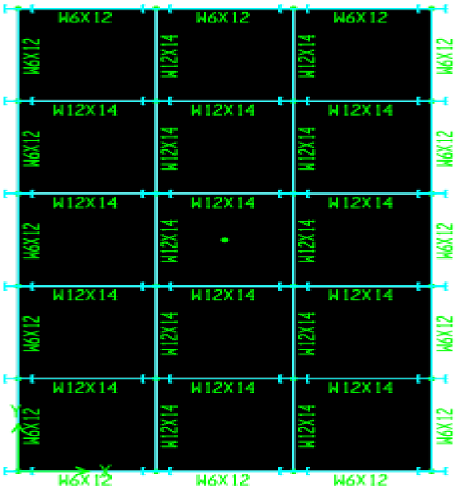
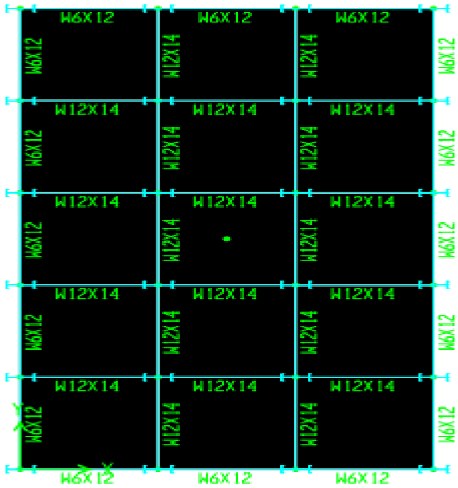
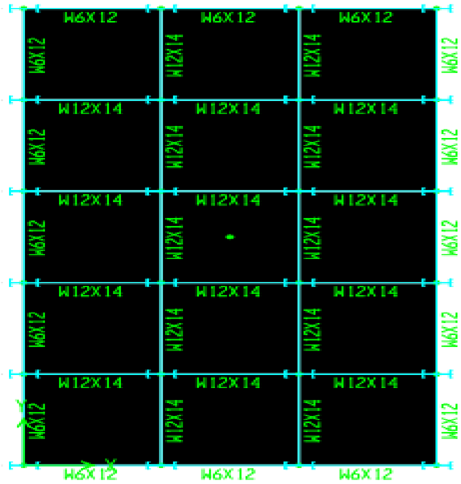
Storey-G



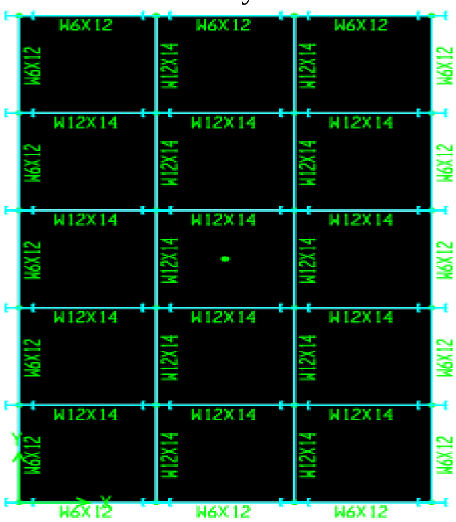
Storey-1



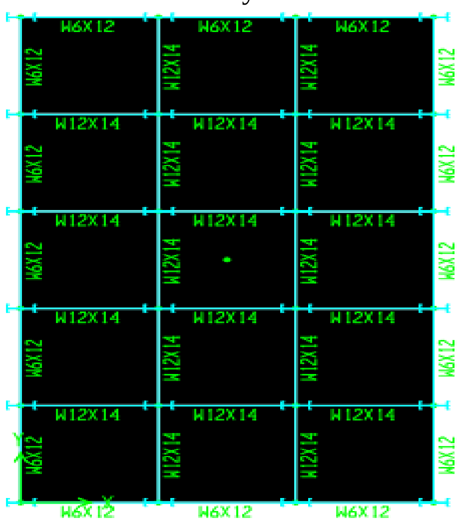
Storey-2



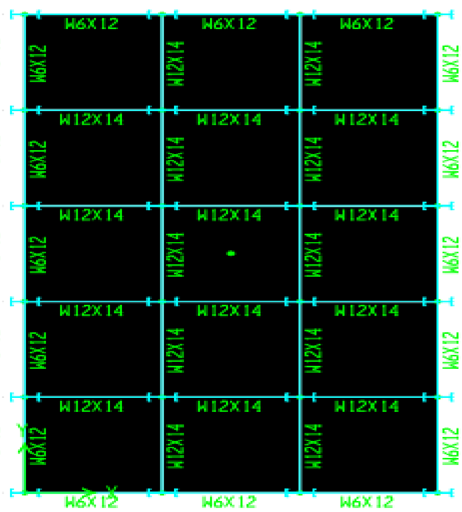
Storey-3



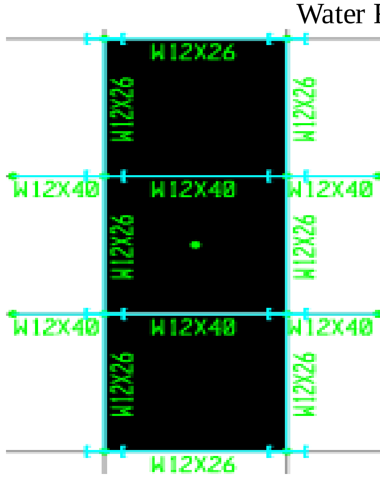
Storey-4



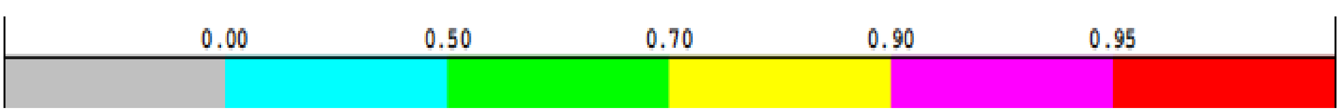
Storey-5



Water Reservoir



Transpiration of colour of each frame section shows P-M-M/Failure ratios & stress capacity according to the parameter is 0.00 min-0.95 max.



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Analysis reports without seismic effect are presented in Figure 2 & Figure 3, though the frames are not designed as seismic resistant but herein all members' negative colour or O/S (overstressed) haven't been identified for both RC and STEEL that means the structure passed successfully.

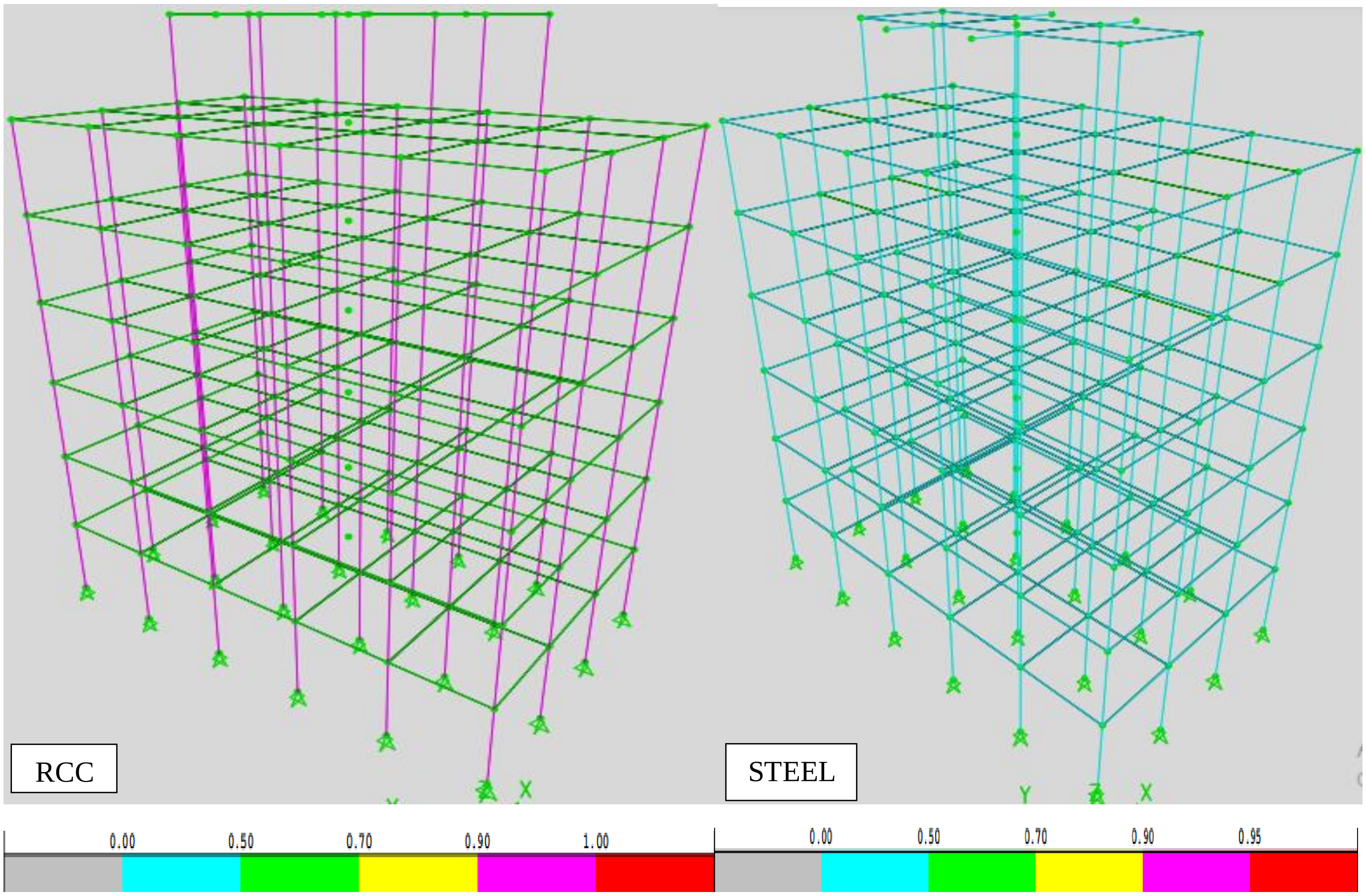

Fig. 4: P-M-M ratio / Stress capacity check and cooperation.

Using ETABS v9.6.0(Figure: 4)Before assigning seismic load (following code: UBC 94) in the Figure4,the structural analysis shows the successful distribution of vertical loads (before appalling seismic load) in both STEEL and RCC frames. After analysed and designed, stability and deformations are checked and all are satisfied. Let's compare the self-weight and pertinent properties, providing valuable insights of this study to find out lightweight and strong framing system. The sections for RC are as usual rectangular and for STEEL I sections are used (Lavitha & Gokul. P. V), (Apoorv Joshia, Rahul Yadav).

Table I: Comparing the Self-weights of the designed sections for both structures.

RCC	STEEL	RCC	STEEL
B1= 125 lb/ft	$W6 \times 12 = 12\ lb/ft$	C1= 125 lb/ft	$W24 \times 68 = 68\ lb/ft$
B2= 175 lb/ft	$W12 \times 24 = 24\ lb/ft$	C2= 125 lb/ft	$W24 \times 68 = 68\ lb/ft$
B3= 262.5 lb/ft	$W12 \times 26 = 26\ lb/ft$	C3= 125 lb/ft	$W24 \times 68 = 68\ lb/ft$
B4= 291.6 lb/ft	$W12 \times 40 = 40\ lb/ft$	C4= 175 lb/ft	$W24 \times 103 = 103\ lb/ft$

The data from Table I substantiate that steel frame sections are lightweight designing for any loading condition.

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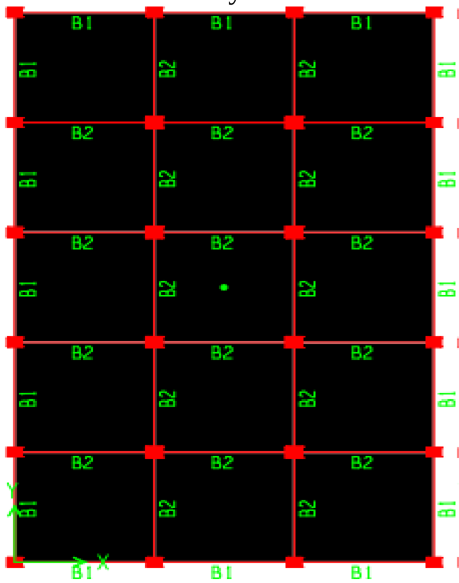
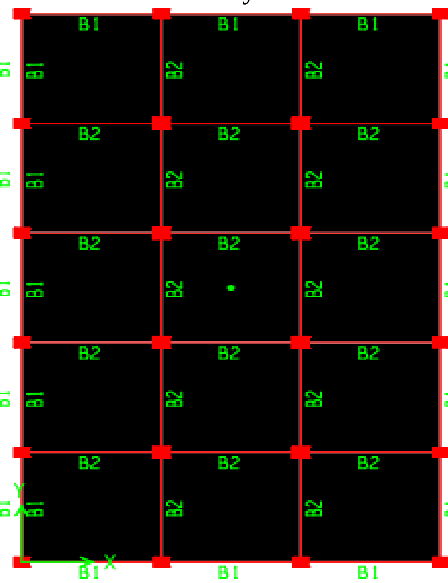
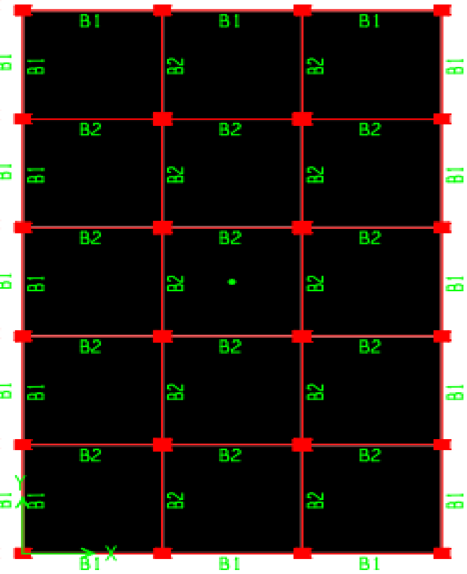
Storey-G



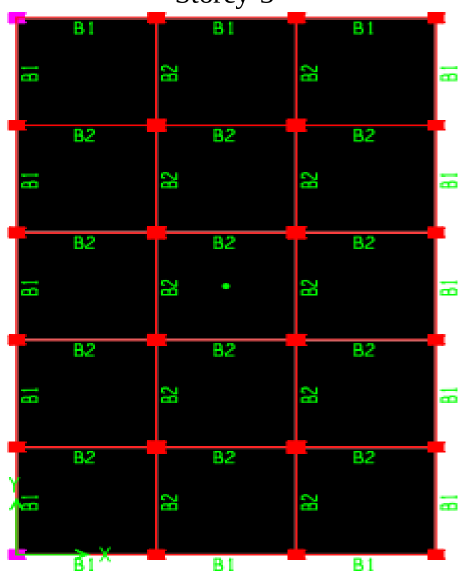
Storey-1



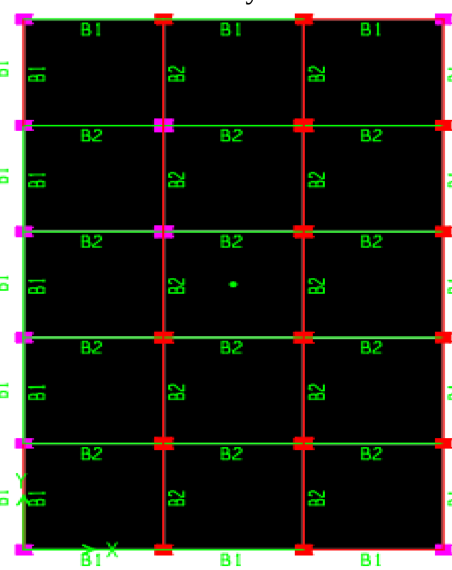
Storey-2



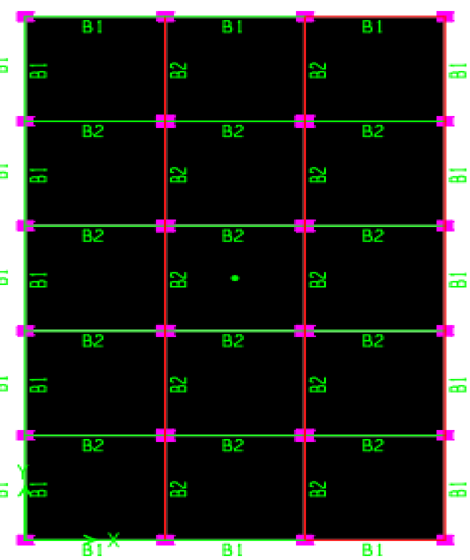
Storey-3



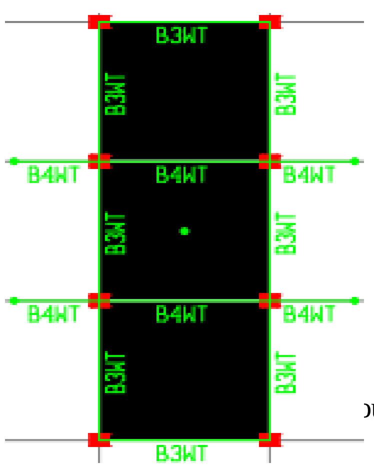
Storey-4



Storey-5



Water Reservoir



output of RCC structure with the application of seismic load (UBC-94).

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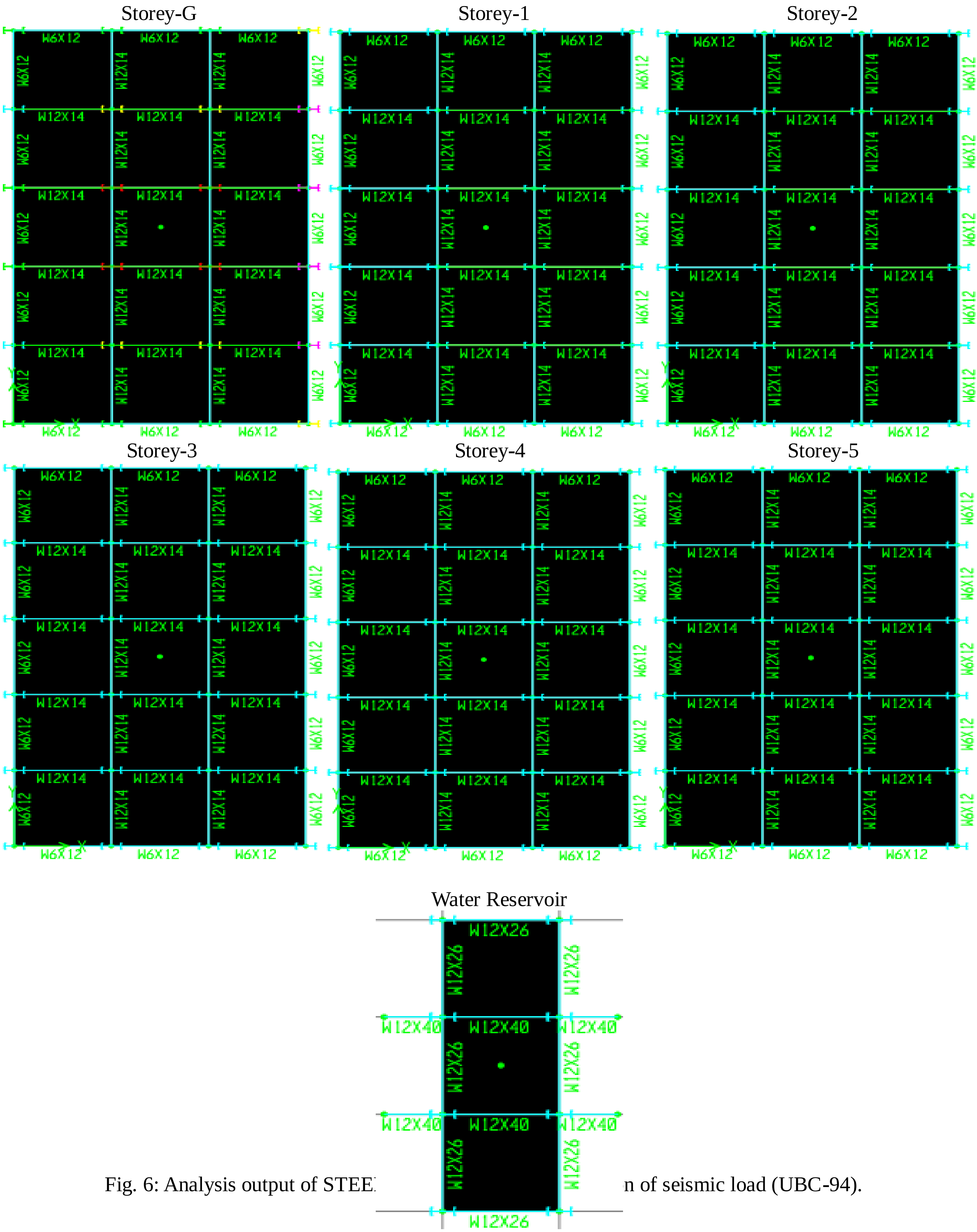

Fig. 6: Analysis output of STEE[...]n of seismic load (UBC-94).

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Analysis reports with seismic effect are presented in Figure 5& Figure 6, and some major changes for members of RCC structure have been identified almost all members at Storey (G+1,2,3) appeared negative but STEEL structure successfully passed this challenge.

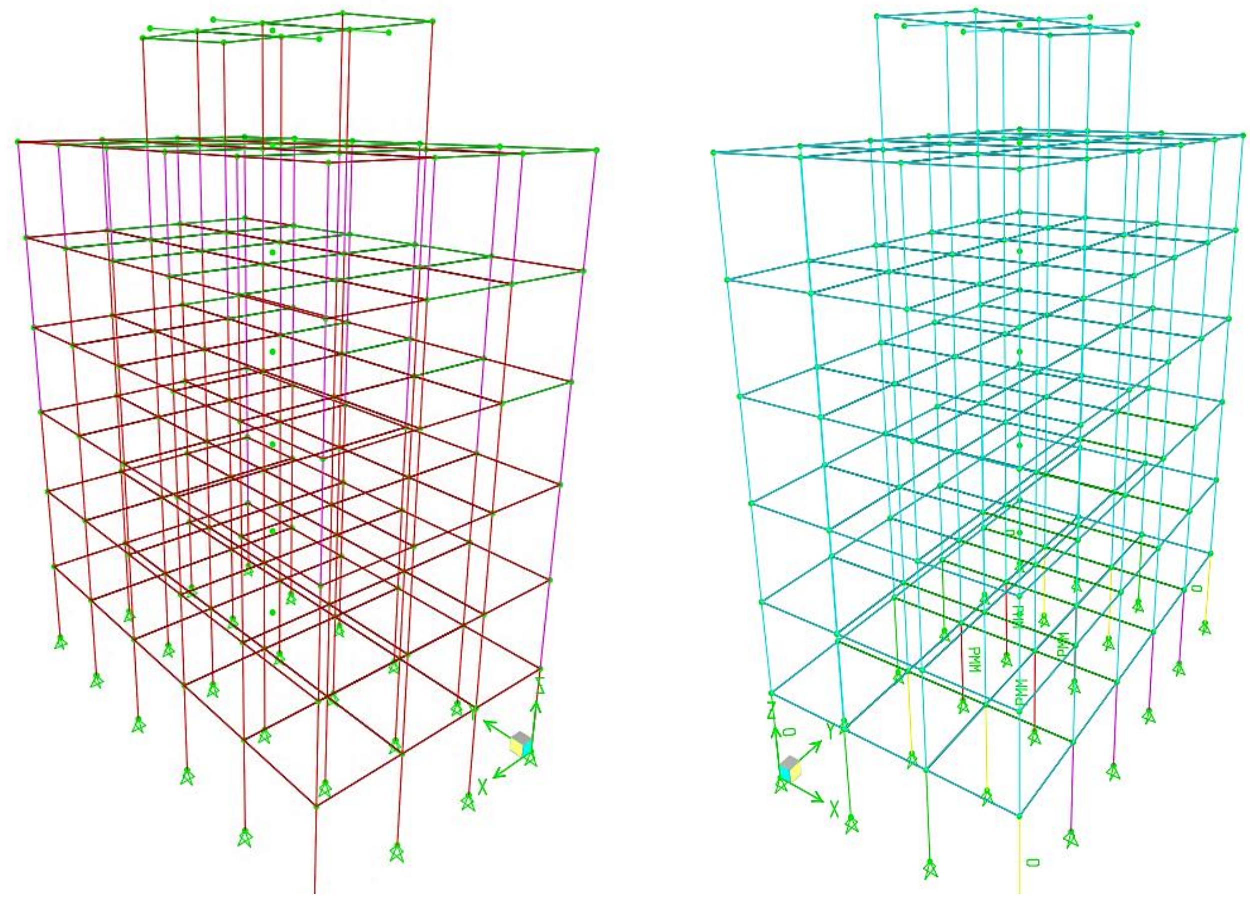
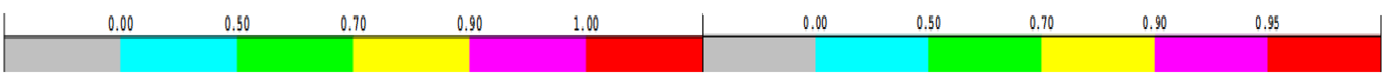


Fig. 7: P-M-M ratio / Stress capacity check and of RCC structure after applying seismic load (UBC-94).



capacity check, but for steel only four columns for them the P-M-M ratios exceeds 0.95 but cannot be considered fail thoroughly because these members are at centre and all other members around them with P-M-M ratios less than 0.5, 0.7. So, the stress capacity is higher than requirements. That shows how effective steel frames are for safety of the structures.

III. Behaviour of Structures after Assigning Seismic Loads

ETABS Analysis showed the lightweight manner of steel sections, underscoring their superiority over the relatively common RCC members. ETABS also providing reactions for each joist with absence of lateral shear generation in steel structures, a stark contrast to the inherent challenge in RC structure, stood out as a testament to the structural ingenuity of steel. The animation of deflection further illustrated the resilience of steel, with beams and columns remaining steadfast and straight against loads which means the columns and beams are not supposed to buckle or bend, conversely, visible bending experienced by RC structure reached the maximum level of stress capacity(M. A. Austin, K. S. Pister and S. A. Mahin. August 1987).

In the structural design study, initial analyses without seismic loads revealed that both steel and reinforced concrete (RC) structures exhibited satisfactory performance. However, upon applying earthquake loads based on UBC 94 standards, a notable divergence in behaviour emerged (Numerous frame sections turns red in colour transpiration or suspected as negative sections). The RC structure frames experienced failures in a majority of instances, highlighting challenges in seismic resilience. In contrast, the steel frame structure demonstrated a remarkable ability to withstand seismic forces (All frame sections of superstructure remain cerulean in colourer transpiration or suspected as strongly positive sections) with a significantly higher rate of survival.

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This discrepancy underscores the intrinsic differences in material behaviour under seismic conditions and emphasizes the robustness of steel structures in seismic design scenarios. The findings prompt a closer examination of the seismic design considerations, material properties, and detailing in RC structures to enhance their performance under earthquake loads.

IV. Conclusions

In conclusion, embracing steel framing for manufacturing structures in seismic-prone Bangladesh is a strategic move towards building resilience and ensuring the safety of inhabitants. The numerous advantages, including strength, flexibility, precision, and sustainability, position steel as a superior alternative to traditional RCC construction in seismic zones. As the soil quality all over Bangladesh are not structural fill. Therefore, if the centre of gravity deforms for any heavy self-weighted structures it is supposed to be collapsed easily. But by adopting steel framing, structures will not only withstand earthquakes but also contribute to be lightweight and more sustainable infrastructure in Bangladesh.

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