International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Assessment of Sesmic Behaviour and Global Warming Potential of RC Building

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A B S T R A C T

It is essential to understand how RC buildings perform during seismic activities and their potential influence on global warming. This will enable them to enhance the strength as well as the environmental impacts of construction projects. In the infrastructure of today, it must be safe and strong but sustainable in its design and usage. By these factors, engineers as well as architects can develop designs that can resist earthquake forces without increasing carbon emissions from the construction and usage of the structures. It utilizes two important software tools for checking the structure and the environment: namely, Staad.Pro and Autodesk Revit. It works with Staad.Pro to analyze how well RC buildings perform under earthquakes-the stability, movement, and strength. This assists one in carrying out a proper check on how well an earth can handle when many earthquakes occur in the region. Using Staad.Pro, engineers can create models of different load combinations and study how the building reacts to various earthquake strengths to make sure it meets safety rules.

Autodesk Revit facilitates Building Information Modeling, making it easier to integrate design with environmental studies. In addition, Revit computes the Global Warming Potential for your building, by displaying information regarding material utilization and usage, and resultant emissions. Revit could help designers understand the environmental impact of the building during its entire life. Actually, one considers the carbon in the material and the energy when the building is in use to support the greenness factor of design. staad PRO and Revit work in tandem to provide an integrated system for the checking of strength and environmental robustness capabilities of RC buildings during earthquakes. This two-part method helps tackle the challenges of today's building needs: safety and sustainability, in line with worldwide goals of lowering carbon emissions and enhancing disaster readiness in the development of cities.

Keywords: Building information modelling (BIM), Staad pro, LCA

1. INTRODUCTION

India, being situated in a seismically active region, is highly susceptible to damaging earthquakes. With the rapid urbanization and increasing demand for land, high-rise buildings have become essential to accommodate residential and commercial needs. However, the design of these structures requires careful consideration of seismic loads to ensure their stability and safety during earthquakes. In tall buildings, lateral forces caused by seismic activity are particularly critical as they can induce undesirable stresses, vibrations, and sway, potentially leading to structural failure.

Seismic design involves ensuring that a structure can withstand minor earthquakes without damage, moderate earthquakes with minimal structural damage, and major earthquakes without collapsing. For the present study, a high story building is analyzed under two seismic analysis methods the Seismic Coefficient Method and the Response Spectrum Method. Key seismic parameters, including base shear, storey moment, and lateral forces, are considered to assess the building's performance in zones with varying seismic risk (Zone V).

In structural engineering, designing for seismic resistance incorporates factors like a building's natural frequency, damping, foundation type, importance, and ductility. Specially designed ductile frames, called Special Moment Resisting Frames (SMRF), are essential for high seismic performance. design, promoting safer high-rise buildings in earthquake-prone areas.

2. LITARATURE REVIEW

- B. srikanth ET AL (2013) reported that; Earthquakes have consistently posed severe risks to life, property, and infrastructure, especially in densely populated and industrially advanced areas. With a significant portion of India prone to seismic hazards, earthquake-resistant design for high-rise structures has become essential. This study evaluates the seismic response of a symmetric, multi-storied building using two analysis methods: the Seismic Coefficient Method, per IS Code recommendations, and the Response Spectrum Method, which includes modal analysis using the building's stiffness matrix. Focusing on Zones II and V, as specified by the IS Code, the study compares responses such as base shear, lateral forces, and story moments between these two seismic zones.

- Tejas Gorle ET AL (2020) reported that; Structural design, particularly for multi-storied buildings, demands thorough seismic analysis to ensure safety and resilience under earthquake loads. This study investigates the seismic response of an RC (reinforced concrete) G+8 frame residential building in various seismic zones (II, III, IV, V) using STAAD Pro V8i software. Key structural responses such as base shear, displacement, axial loads, joint displacements, and story drift are analyzed. The linear static method, based on IS 1893 (Part 1): 2002, was used to assess lateral seismic forces. Given population growth, urbanization, and limited land, high-rise buildings have become essential, but many are inadequately designed for lateral seismic forces, raising the risk of failure in an earthquake. The study emphasizes the importance of considering factors like natural frequency, damping, foundation type, and ductility to enhance earthquake resistance. Structural designs optimized for ductility can bear lower lateral loads and better distribute moment forces, aided by the response reduction factor \(R \) for various structures. The analysis compared ordinary moment-resisting frames with special moment-resisting frames, finding that a well-designed structure with adequate ductility and earthquake-resistant features is crucial to withstanding seismic impacts.
- Ping Hong ET AL (2019) reported that; Due to population growth and land limitations, constructing high-rise buildings has become essential. Traditional manual design methods for such structures are time-consuming and prone to errors, which is why structural design software like STAAD Pro is preferred for precision and efficiency. STAAD Pro, or "Structural Aided Analysis and Design," is widely used in civil engineering for tasks such as wind and seismic analysis, supporting multiple load combinations and adhering to Indian Standard Codes (IS456:2000, IS1893:2002, IS875:1987, IS1893:2016). Key benefits of STAAD Pro include ease of use, code compliance, versatility, and time savings. Structural analysis must account for various loads, including dead load (structure's self-weight), live load (temporary load), wind load, and seismic load (earthquake-induced lateral forces). Seismic analysis, essential for earthquake resistance, helps design safer structures that perform better under seismic stress by incorporating ductile detailing for resilience. This project focuses on the seismic analysis and design of a G+9 RCC building using STAAD Pro. With STAAD Pro's capabilities, the software was used to evaluate dead and live loads, and to design beams, columns, slabs, and footings. STAAD Pro's precision and suitability for multi-story seismic design make it ideal for ensuring building safety in earthquake-prone areas.
- Mohamed A.Abadelaal ET AL (2023) reported that ; To assess the sustainability of concrete structures using the Building Information Modeling and Life Cycle Assessment (BIM-LCA) integrated approach. The research focuses on evaluating the environmental impacts, energy consumption, waste, and cost of different types of concrete mixes. The paper also explores the use of Analytical Hierarchy Process (AHP) to compare and select the most sustainable concrete alternative based on criteria such as CO2 emissions, embodied energy, and cost. The ultimate goal is to provide engineers with computerized models and guidelines that improve the sustainability of construction projects.
- Alexander Hollberg ET AL (2019) reported that; The study finds that embodied GWP during the design phase is twice as high as for the completed building, mainly due to the use of placeholder materials refined later. The paper discusses three alternatives to automatic quantity take-off to improve the accuracy of BIM-based environmental assessments. BIM-based approaches offer advantages in quantifying embodied environmental impacts, such as global warming potential (GWP), throughout the building lifecycle. BIM has been utilized for conducting Life Cycle Assessments (LCAs) of buildings, allowing for the evaluation of various environmental impacts such as energy consumption and material usage.

Results

Based on experimental study finally we concluded and analyzed loads by the STAAD PRO software and developed our Revit modal and finally deploy our models into open click LCA and get the carbon dioxide levels for developing sustainable building.

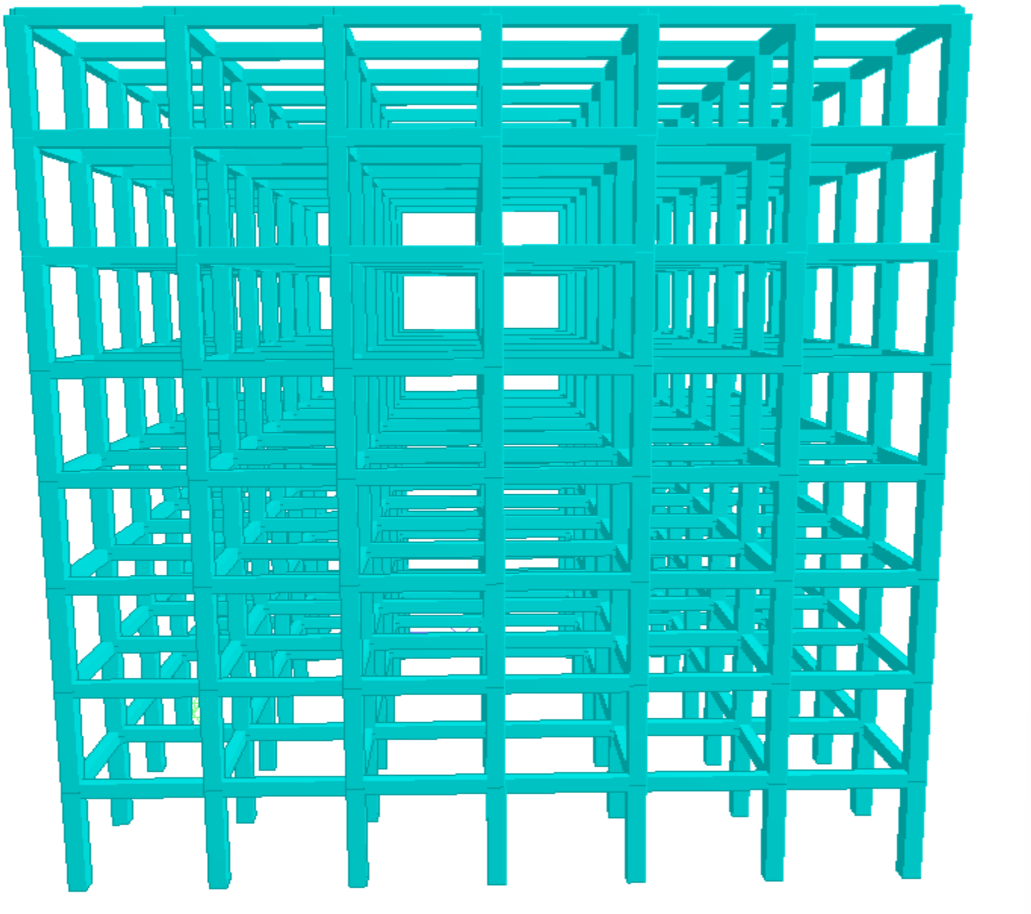
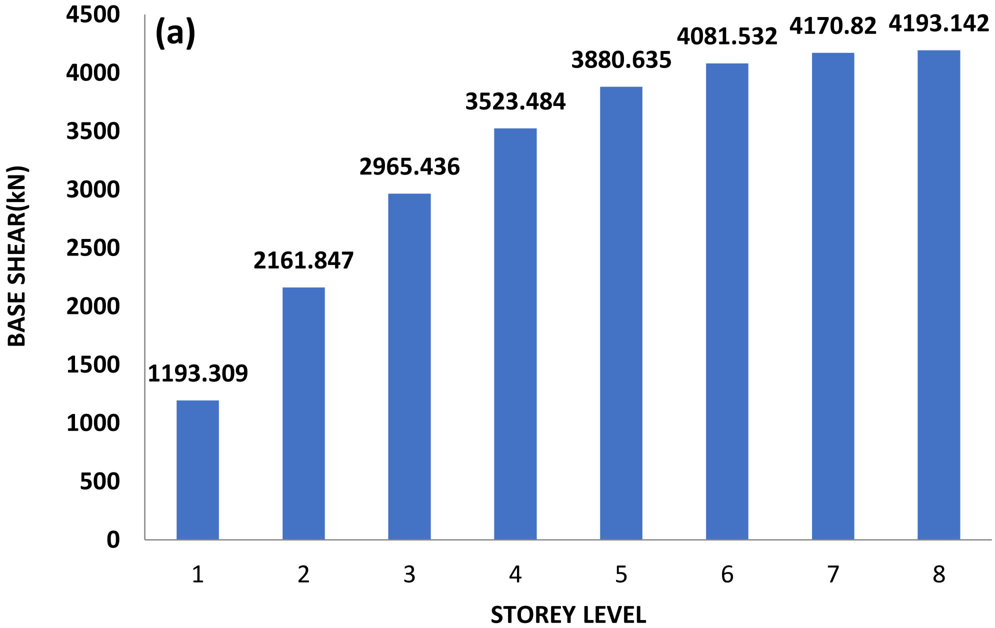


Fig:1 Staad pro model

Staad pro results:



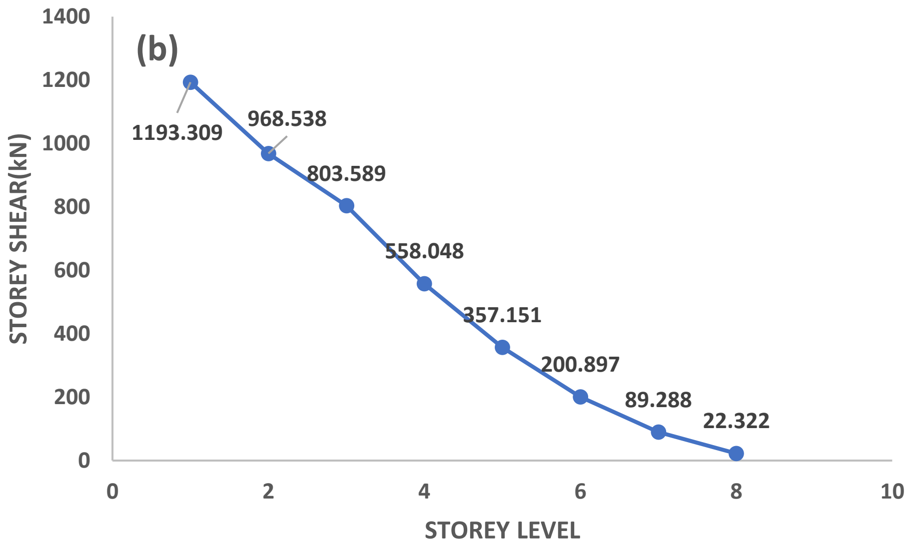

(b)
STOREY SHEAR(kN)
STOREY LEVEL
1193.309
968.538
803.589
558.048
357.151
200.897
89.288
22.322

Fig. 2

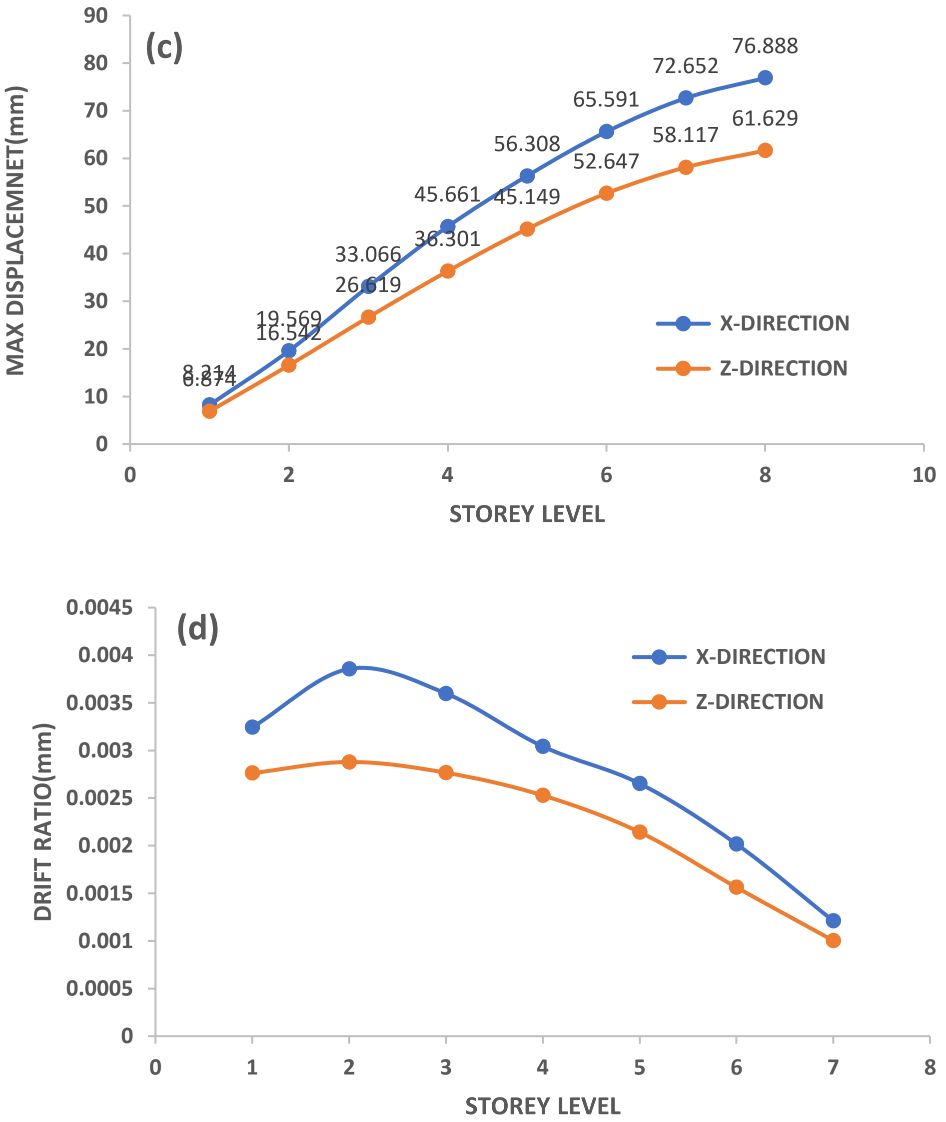

(c)
MAX DISPLACEMNET(mm)
STOREY LEVEL
X-DIRECTION
Z-DIRECTION
8.214
6.874
19.569
16.542
33.066
26.619
45.661
36.301
56.308
45.149
65.591
52.647
72.652
58.117
76.888
61.629
(d)
DRIFT RATIO(mm)
STOREY LEVEL
X-DIRECTION
Z-DIRECTION

Fig. 3

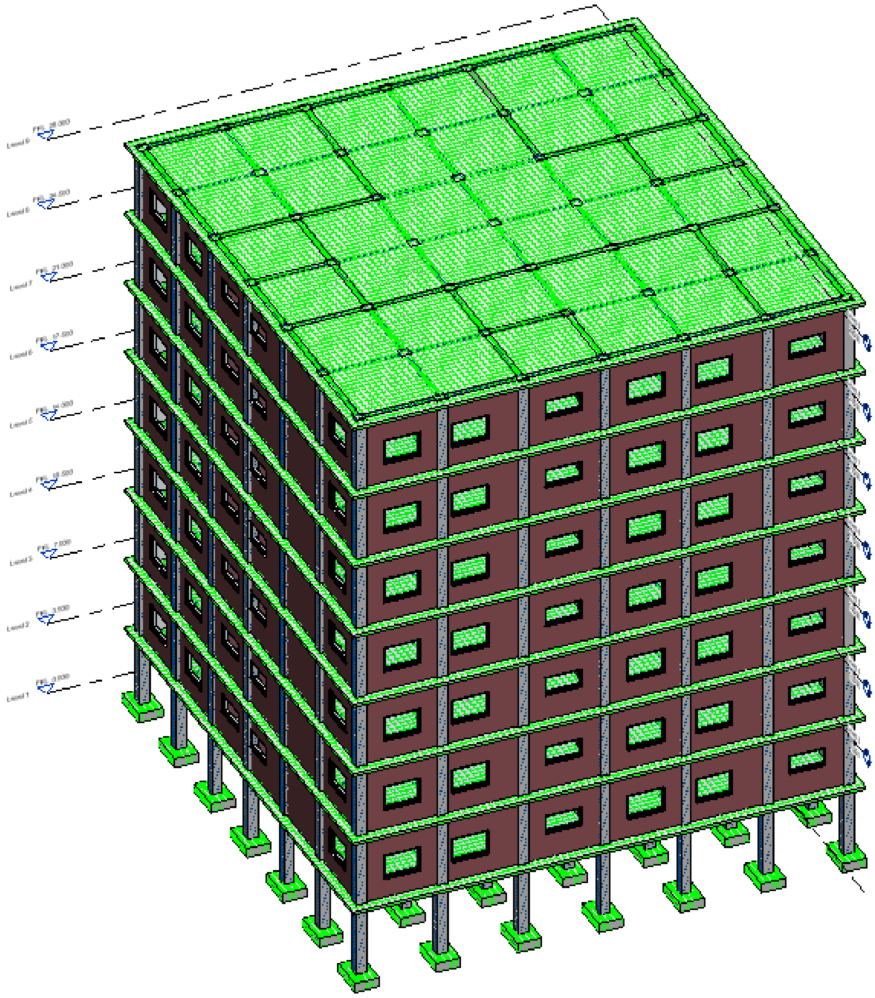
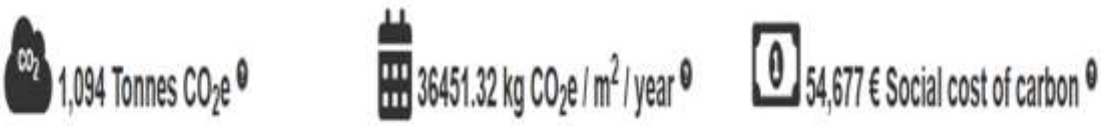


Fig4: Revit model

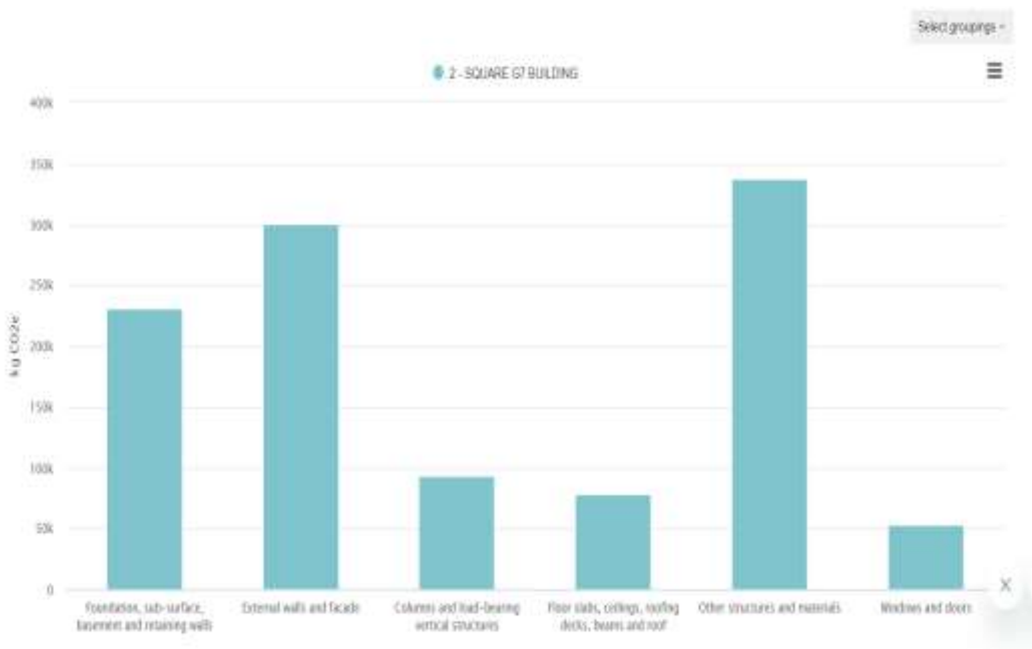
Life Cycle Assessment Results

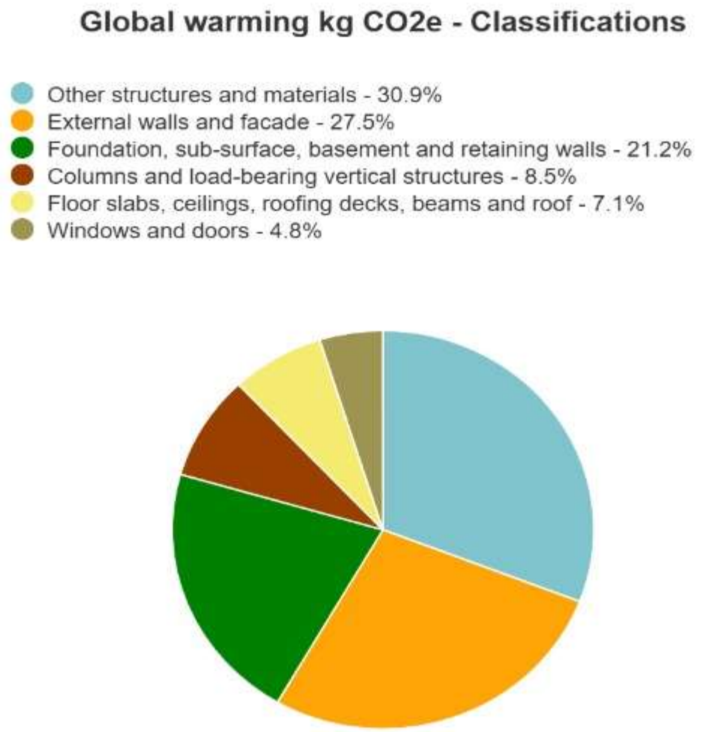


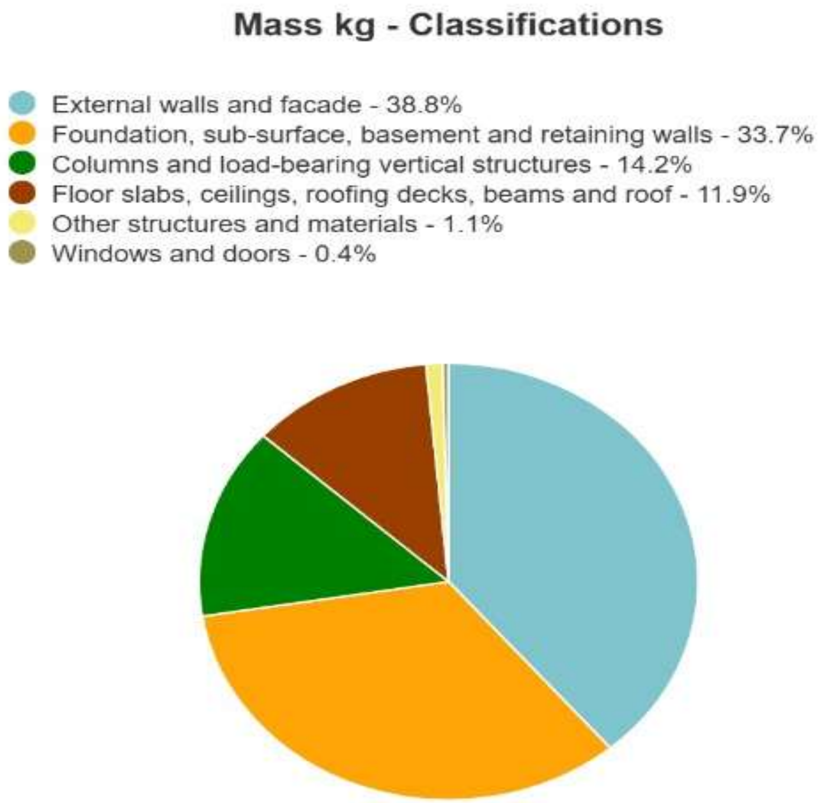
Global warming kg CO_2e - Life-cycle stages

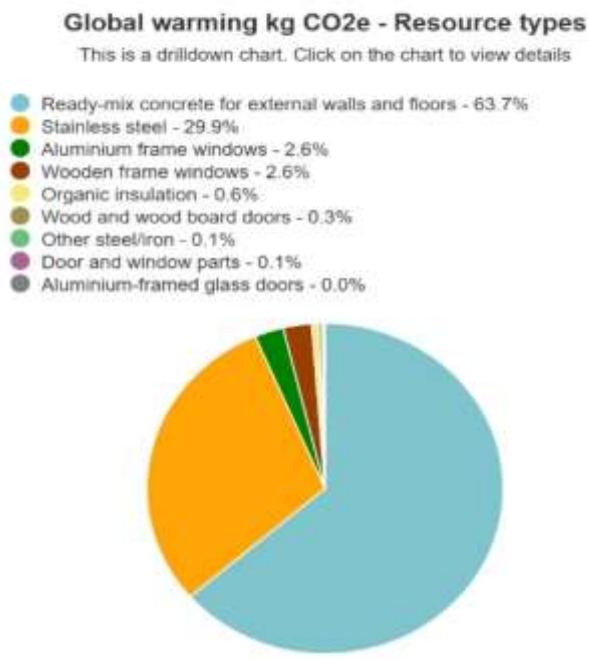
Item	Value	Unit	Percentage %
A1-A3 Materials	1,000,000	kg CO_2e	92.53 %
A4 Transport	46,000	kg CO_2e	4.23 %
A4-leg2 Transport leg 2	140	kg CO_2e	0.01 %
C2 Waste transport	20,000	kg CO_2e	1.84 %
C3 Waste processing	190	kg CO_2e	0.02 %
C4 Waste disposal	15,000	kg CO_2e	1.37 %

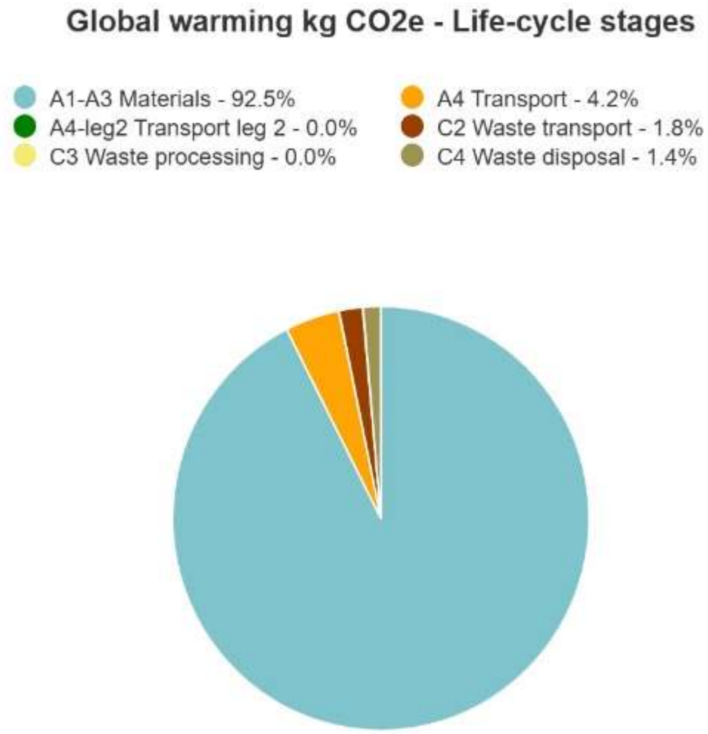
LCA for LEED, Int'l (CML) - Global warming, kg CO_2e - Compare elements




Global warming kg CO2e - Classifications
Other structures and materials - 30.9%
External walls and facade - 27.5%
Foundation, sub-surface, basement and retaining walls - 21.2%
Columns and load-bearing vertical structures - 8.5%
Floor slabs, ceilings, roofing decks, beams and roof - 7.1%
Windows and doors - 4.8%


Mass kg - Classifications
External walls and facade - 38.8%
Foundation, sub-surface, basement and retaining walls - 33.7%
Columns and load-bearing vertical structures - 14.2%
Floor slabs, ceilings, roofing decks, beams and roof - 11.9%
Other structures and materials - 1.1%
Windows and doors - 0.4%





CONCLUSION

The Seismic Coefficient Method is said to be a more conservative technique for structural designs of the top floors when compared to the response Spectrum Mitigation method and vice-versa. Having applied For IS 1893 (Part1):2016, response values have been applied and seen useful for the comparative analysis. It is recommended to utilize the Response Spectrum Method, even in the case of symmetric multi-storied buildings, owing to the nature of seismic re-analysis and design, in which case it is inevitable to notice that storey moments in response spectrum method are far lower than in seismic coefficient method. Knowing this, an appropriate alternative would be to resort to a response spectrum irrespective of the structural asymmetry. The basis of the comparison was as follows: relative displacement; maximum shear force; maximum axial force; max. bending moment; maximum tensile stress; maximum compressive stress in the different seismic zones. In all models the displacement factors is found to be less for lower zones and it goes on increasing for the higher zones. The need for incorporated design in the process of earthquake resistant G +8 RC framed building exhibited increased steel quantity in zone V as against the convention concrete design. The pragma upshot suggests that steel quantity increase from that in the structure ground floor to that at G + 8 level of the structure. A systematic integration between LCA and BIM is one way of obtaining a convenient decision-making mechanism which is one of the core concerns. It is quite easily noticeable that such tools can be simply used by the designers on a routine without the need to be LCA specialists.

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