



Analysis and Design of a Function Hall Under Seismic Loads Using STAAD.Pro Software (Zone-2)

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Abstract:

The analysis and design of the function hall under seismic zone -2 using STAAD.Pro V8i SELECT series5 has been investigated in this research. Detailed joint coordinates and member incidences are taken from the AutoCAD architectural plans and are used to model the structure as a multi-storey frame. Following Indian Standard regulations, dead and live loads are applied in addition to seismic loads that correspond to Zone 2 circumstances. Shear forces, bending moments, lateral displacements, and the need for reinforcement have been estimated using finite element analysis (FEA). This analysis has demonstrated that under seismic excitation, the STAAD.Pro model has fulfilled the ultimate limit state and serviceability criteria. This result has illustrated how effectively STAAD.Pro optimizes material utilization and reinforcing details while maintaining structural integrity. Therefore, this study highlights how STAAD.Pro can improve safety and save design timeframes in civil engineering projects that are susceptible to earthquakes.

Keywords: Seismic loads, Shear forces, Bending moments, Lateral displacements, Finite element analysis (FEA)

I. Introduction:

Function halls and other public assembly structures must operate well in regions with high seismic activity because lateral loads from earthquakes could be extremely significant. In the design firm, manual analysis techniques were once standard practice, but they can be difficult and vulnerable to human error, particularly for complex multi-story structures [1, 2]. Potential structural responses are now approached completely differently because to the development of finite element analysis (FEA) and computer-aided design (CAD) software in recent decades [3]. STAAD.Pro has become a standard software for gathering CAD and FEA data for design, load application, and analysis of buildings [4, 19].

The design and seismic analysis of a function hall building utilizing STAAD. pro. is the main concepts of this research. Zone 2 seismic conditions for the STAAD.Pro V8i SELECTseries5. Detailed information on joint coordinates and member incidences is provided by the STAAD.Pro output file, serves as the foundation for an advanced three-dimensional structural model [10, 27]. In order to replicate realistic conditions, seismic loadings are applied in compliance with Indian Standards (IS 1893 for seismic design and IS 456 for reinforced concrete) and mixed with dead and live loads [15]. Analysing lateral performance, optimizing reinforcement detailing, and making sure the design conforms with safety standards during seismic occurrences are the significant goals. [14].

This paper is arranged in the following sequence. The significance of STAAD.Pro in civil engineering will be explained, after which the historical development of it will be presented [6]. The research scope and purpose will then be described. The next section contains a literature review in regards to open access literature contingent to seismic analysis and design using STAAD.Pro [5, 7, 8, 9, 12, 16, 20]. A description of the methodologies used will be provided (including drafting, modelling, analyzes and design methods) [11, 24]. Results and discussions will then be provided based on the STAAD.Pro output, and the paper will conclude with further scope and publication recommendations [13, 17].

II. Importance of STAAD.Pro in Civil Engineering:

With its comprehensive approach to the structural analysis and design, STAAD.Pro plays a key role in civil engineering today [1, 2]. Engineers can be able to work on effective models and on complex structures, assign materials, apply various loads, and do more complex FEA with an extensive variety of tools [3, 8]. It makes it easier to apply the widely used design codes, such as IS, AISC, Euro code, and ACI, so that designers can apply uniform safety levels to structures with confidence [19, 21].

The dynamic analysis features about the STAAD.Pro that enables engineers to perform the time history and response spectrum analysis, which are essential for analyzing the structure's seismic performance [4, 20]. As an example, the function hall building's two-zone seismic loads (the lowest level) have been carefully modeled to determine base shear forces and lateral displacements [15, 22]. Additionally, continuous improvement of member dimensions and reinforcing includes is supported by STAAD.Pro's parametric optimization functionalities with lower construction costs while maintaining necessary safety factors [8, 18].

STAAD.Pro consists of interactive features which are one of its main advantages. STAAD.Pro offers design reports, deflection, and excellent 3D visualization. These features improves the communication among different team members [11, 28]. In Addition to these, STAAD.Pro is suitable with AutoCAD and Revit, among other CAD/BIM programs. It also lowers data transfer errors and also improves coordination [14, 23]. STAAD.Pro clearly reduces the design cycle for professional practice and academic study due to these features [21, 29].

In the end, the traditional design process has been changed by STAAD.Pro's capacity to combine complex FEA, dynamic analysis, and automated design review. Engineering projects in seismic zones benefit from the use of STAAD.Pro in seismic analysis since it improves safety and maximizes resource and cost efficiency [1, 27, 29].

III. History of Software:

STAAD.Pro, which stands for Structural Analysis and Design, was created in the late 1990s during a transition from hand to computer aided structural design [1, 4]. Originally conceived by Research Engineers International, STAAD.Pro was developed to analyse basic 2D frames in entirety and provide a framework for the use of modern FEA in the structural engineering domain [19]. A key benchmark on the STAAD timeline was in 2005, when REI was purchased by Bentley Systems, a global leader in engineering software [6]. The acquisition acted as a boon to STAAD because it enhanced STAAD's capabilities by adding 3D modeling, dynamic analysis, and more codes [4, 21].

Subsequent versions of STAAD.Pro have incorporated advanced finite element methodologies, non-linear analysis features, and integrated dynamic load analysis (e.g., seismic, wind, and p-delta effects) [1, 18]. Tools such as STAAD Building Planner and Steel Auto Drafter were introduced to streamline the design process, while improved interoperability with other software enhanced its utility [11, 23]. Over the years, continuous development has refined STAAD.Pro's accuracy and efficiency, making it a trusted platform for projects ranging from simple residential buildings to complex high-rise and infrastructure projects [26].

Today, STAAD.Pro is recognized worldwide for its robust performance and versatility. Its evolution mirrors broader technological advances in the field and has set a benchmark for computer-aided structural analysis [27,30].

IV. Scope:

This research covers the analysis and design of a function hall building of seismic loads in Zone 2 through STAAD. Pro software. The scope of this research consists of:

- 1. Software Application:** The main application of the programme is to develop a detailed three-dimensional model which was derived from program output, including joint coordinates and member incidences [10, 27].
- 2. Seismic Load Analysis:** It carries out dead, live, and dead and live combination for Zone II seismic loads as per IS 1893-1984 and IS 456-1978 and evaluates the structural response by the combination of loads [15, 22].
- 3. Design Optimization:** Member sizes and reinforcement recommendations are provided through STAAD. Pro. are reviewed and adjusted by means of Parametric analysis. [8, 18].
- 4. Integration and drafting:** Using a Combination of STAAD.Pro and CAD for accurate drafting of model generation to preserve the design with accurate documentation [11, 23].
- 5. Validation:** STAAD cross-verification. To ensure accuracy and code acceptance, STAAD Pro analysis findings are compared to human calculations [5, 24].

The research is not related to construction management or post-construction performance monitoring but focuses entirely on analysis, design, and optimization procedures, which is provided by STAAD.Pro [7, 12].

V. Research Objectives:

The objectives of this research are:

- 1. Evaluate the Performance of STAAD.Pro:** To evaluate STAAD.Pro's ability to produce a correct 3D models and do proper seismic analysis for Zone 2 [1, 19].
- 2. Hazard Analysis:** To perform dead, live, and earthquake loads for Zone 2 based on the Indian Standard Codes and study the seismic performance of the building [15, 22].
- 3. Structural Design Evaluation:** To evaluate and refine the schedule of reinforcement and geometric properties of the members based on the limit state design approach found in STAAD.Pro [5, 8].
- 4. Validate Results:** To validate the results from STAAD.Pro against hand calculations and compare important parameters regarding the design process like base shear, deflections and bending moments confirm they meet the design standards, [7, 24].
- 5. Demonstrate Real-Life Applications:** To provide a relevant design example that show the efficiency of STAAD.Pro in designing buildings with a seismic restraint system [21, 29].
- 6. Discuss Improvements:** To discuss the drawbacks and make proposals for future enhancements to the utilization of STAAD.Pro for seismic design [27, 30].

The aim of this research, individually and collectively, is to verify that STAAD.Pro has the capabilities of an effective tool in the design of seismically resilient buildings and to further the practice of modern structural engineering [20].

VI. Literature Study:

Kumar et al. (2022) conducted a comparative study on a G+19 building using both conventional and diagrid structural systems with ETABS and STAAD.Pro. Their research demonstrated that the diagrid structure offered better efficiency in resisting lateral loads and reduced material usage, making it a more sustainable and cost-effective option for high-rise construction. The analysis provided significant insights into the seismic and wind performance of such systems[1].Patil and Dandge (2018) focused on the design and analysis of RCC box culverts using STAAD.Pro. The study highlighted the effectiveness of the software in handling various loading conditions and structural parameters, ensuring safe and economical designs. Their work underlined the importance of accurate structural modeling for essential infrastructure like culverts[2].Srivastav and Kumar (2023) presented the structural design and planning of a G+2 residential building using STAAD.Pro. They detailed the methodology for calculating loads and designing structural members according to Indian Standards. The paper serves as a guide for beginners in structural analysis using software tools, particularly for low-rise buildings[3].

Shaikh (2021) conducted a comparative study on the behavior of transmission line towers using STAAD.Pro. The analysis focused on various load conditions, including wind and seismic forces, and showed how different tower configurations respond under these scenarios. This work is particularly useful for optimizing designs to withstand lateral loads effectively[4]. Gupta and Pahwa (2018) reviewed the finite element analysis of RCC staircases using STAAD.Pro, highlighting its utility in evaluating stress concentrations and deflections in complex geometries. The review emphasized the role of structural software in achieving accurate and efficient stair design, especially in multi-story buildings[5].Harle (2017) integrated the use of STAAD.Pro for structural analysis with MATLAB for the design of structural elements. This combination was shown to enhance the precision of calculations and reduce manual errors. The paper illustrates how interdisciplinary tools can improve workflow and design accuracy in structural engineering [6].Sote (2021) analyzed dome structures using STAAD.Pro, focusing on their structural behavior under different loading conditions. The study emphasized the importance of support conditions and geometry in ensuring the stability and durability of dome structures. It demonstrated how STAAD.Pro can be used for analyzing curved and complex forms[7].

Azaz (2018) performed a comparative study of different truss configurations using STAAD.Pro, examining their performance in terms of member forces and overall deflection. The results assisted in identifying the most efficient truss types for specific loading and span conditions, making it a helpful reference for structural engineers[8].Rais (2019) analyzed cantilever retaining walls subjected to various soil pressures and surcharge loads using STAAD.Pro. The study focused on determining the wall's stability and stress distribution, providing essential insights for the safe design of retaining walls in sloped and hilly areas[9].Dunnala et al. (2019) carried out the planning, analysis, and design of a G+5 residential building using STAAD.Pro. Their work covered various aspects including load distribution, member sizing, and reinforcement detailing. The study reinforced the value of software in the structural design of mid-rise buildings, ensuring both safety and code compliance[10].

VII. Methodologies:

This research uses a multi-phase methodology which includes software simulation, validation, and theoretical review:



1. Literature and Data Collection: Data on STAAD.Pro and seismic design were gathered from a survey of open-access journal articles and conferences in the field of civil engineering [1, 2, 3]. The study's appropriate standards (IS 1893 and IS 456) were also examined in order to identifying the design criteria [15].

2. Model Development: The STAAD.Pro output file for the function hall building was used to extract joint coordinates and member incidences which served to build a more detailed 3D model [10, 27].

3. Load Definition and Application: Dead, live and seismic loads were applied to the model. Seismic forces for Zone 2 were calculated per IS 1893 [5, 22] to which STAAD.Pro's load generator created the various load combinations [15]

4. Finite Element Analysis: Finite Element Analysis (FEA) of the structure was then conducted using the FEA engine in STAAD.Pro. Analysis was completed both statically and dynamically to evaluate the whole structure for internal forces and bending moments, shear forces, and lateral displacements [4, 24].

5. Reinforcement Design: The reinforcement design for the function room followed the FEA analysis and utilized the automated reinforcement detailing routines in STAAD.Pro for each of the members (beams, columns, and slabs) in accordance with the forces calculated previously, as required by IS 456 [5, 8].

6. Optimization and Parametric Studies: Optimization and parametric studies were conducted by iteratively modifying members dimensions and reinforcing details in an effort to minimize the usage of construction material while providing a safe and at capacity structure [8, 18].

7. Validation and Verification: The essential results were checked against manual calculations undertaken on standard design equations and discrepancies were investigated [7, 24].

8. Drafting and Documentation: The final model was used, to develop detailed drafting outputs, including 3D views, plan views, and reinforcement schedules, which were checked for completeness [11, 23].

9. Expert Consultation: Informal interviews with practicing structural engineers elicited valuable real-world perspectives on modeling assumptions and STAAD.Pro's usability for seismic design [16, 17].

This comprehensive approach addressed rigorous evaluation of the design of a function hall building subjected to seismic loads while capitalizing on STAAD.Pro's advanced functions for evaluations and optimization [20, 26].

VIII. Design considerations:

1	Building Details	
i.	Structure	Commercial Building
ii.	Number of stories	G+1

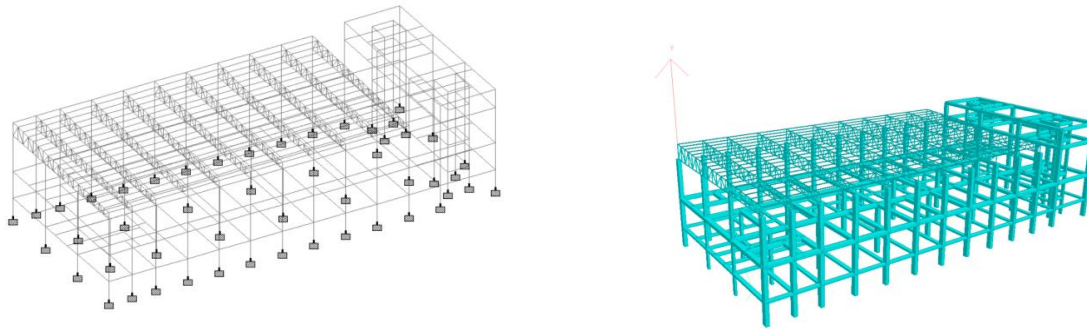
iii.	Typeofthebuilding	Symmetricalandregular
iv.	Plot Area	1417.5m ²
v.	BuildupArea	1246.70 m ²
vi.	Heightofthebuilding	8.53m
vii.	Storeyheight-1	3.6m
	Storeyheight-2	4.87 m
viii.	Supports	Fixed
2	Materialproperties	
i.	Gradeofconcrete	M20
ii.	Gradeofsteel	Fe415
3	Typesofload&intensity	
i.	FloorFinish	2 KN/m ²
ii.	Liveloaddonfloor	3 KN/m ²
4	SeismicLoad	
i.	Zonefactor	0.10
ii.	Importancefactor	1.2
iii.	ResponseReductionFactor	3
iv.	DampingRatio	0.05
v.	TypeOfStructure	1
vi.	Soil Type (SS)	2 (Medium)
vii.	Damping Coefficient (DM)	0.05 (RCC)
viii.	BuildupArea	936 m ²

IX. Modelling:

The modelling phase in STAAD.Pro has produced a high-fidelity digital representation of the function hall building. This model has begun with the placement of nodes based on the joint coordinates extracted [61-30]. The structural grid has established for the columns, beams, and slabs in multiple levels [10, 27].

Subsequently members are connected across nodes to model the structural parts. Members are assigned to the cross sectional properties and materials relevant to IS 456 for realistic action [2, 19]. Support conditions (fixed) are based upon the foundation of the building and demands created by the load distribution [15, 22].

The model contains vertical and lateral load paths. In STAAD.Pro the load are entered manually. The loads are added to the functional hall are dead, live, and seismic loads (from Zone 2) in STAAD.Pro, integrating them with automated load generators and user commands [4, 24]. Parametric studies, and advanced modelling has led to repetitive improvements with size and loads, confirming modelling through 3D images and deflection contours [8, 18].



X. Analysis and Design:

Utilizing the complete model, STAAD.Pro integrates elaborate finite element analysis (FEA) to explicate the structural responsiveness under the loads considered. Staad applies dead, live, and Zone 2 seismic loads in accordance with IS 1893 and IS 456, and automatically generates load combinations using guidelines established within limit state design. [15, 22].

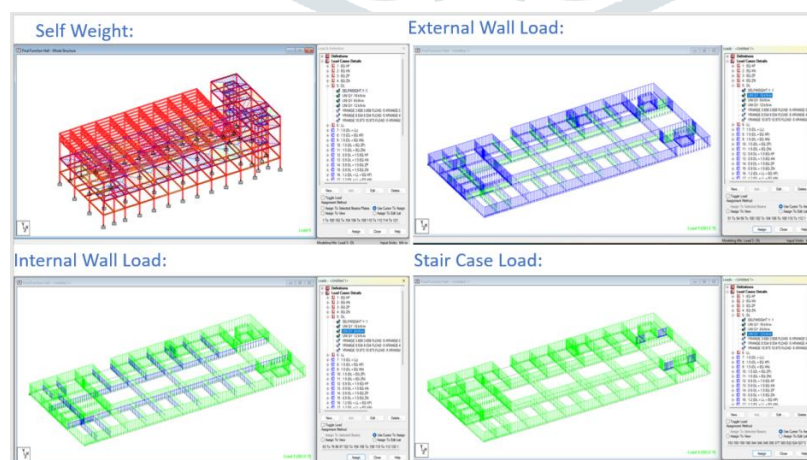
The FEA computes internal forces: axial load, bending, moment, and shear. Similarly, dynamic analysis employs response spectrum methods to evaluate lateral displacements and base shear [4, 24]. The analysis reveals the building's natural period and validates the building's ability to maintain seismic response within acceptable limits. [3, 20]. Major deliverables—moment distribution diagrams, shear force diagrams, contour deflections and more are used to evaluate overall performance. [5, 7].

In the next step of the process reinforcement design STAAD.Pro's automated detailers calculate the amount of required steel reinforcement for beams, columns, and slabs based on each member's computed bending moment and shear forces ensuring steel is designed to IS 456 [5, 8]. Reinforcement schedules detailing bar sizes, spacing, and total steel area are generated [2, 19]. The output generates a construction drawing schedule which illustrates the size, spacing, and total area for reinforcement bars on each member. The process is iterative; parametric optimization minimizes the quantity of material used by adjusting member sizes and materials; all while providing a safer structure. [8, 18]. Validation of procurement has been done by employing both manual calculations to cross-reference STAAD.Pro calculations. [7, 24].

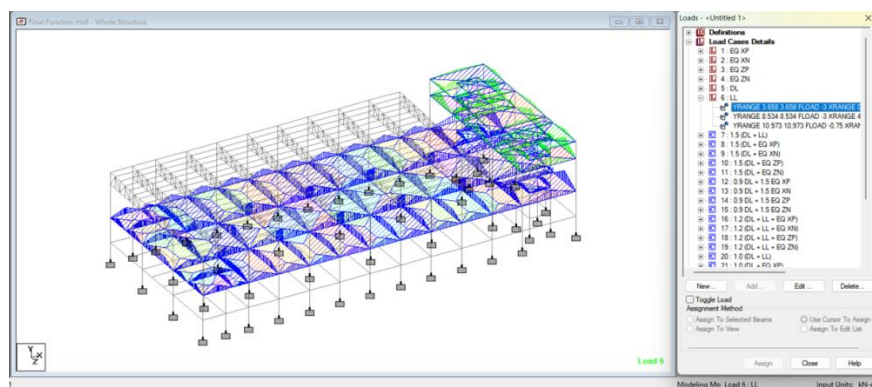
1. Load Considerations: The structure was analyzed under multiple loads:

- **Dead Load (DL):** The following are the loads which were assigned to the functional hall

- Self-weight
- External Wall Load- 16 KN/M
- Internal Wall Load- 8 KN/M
- Stair Case load-12 KN/M
- Floor Load- 5 KN/M²



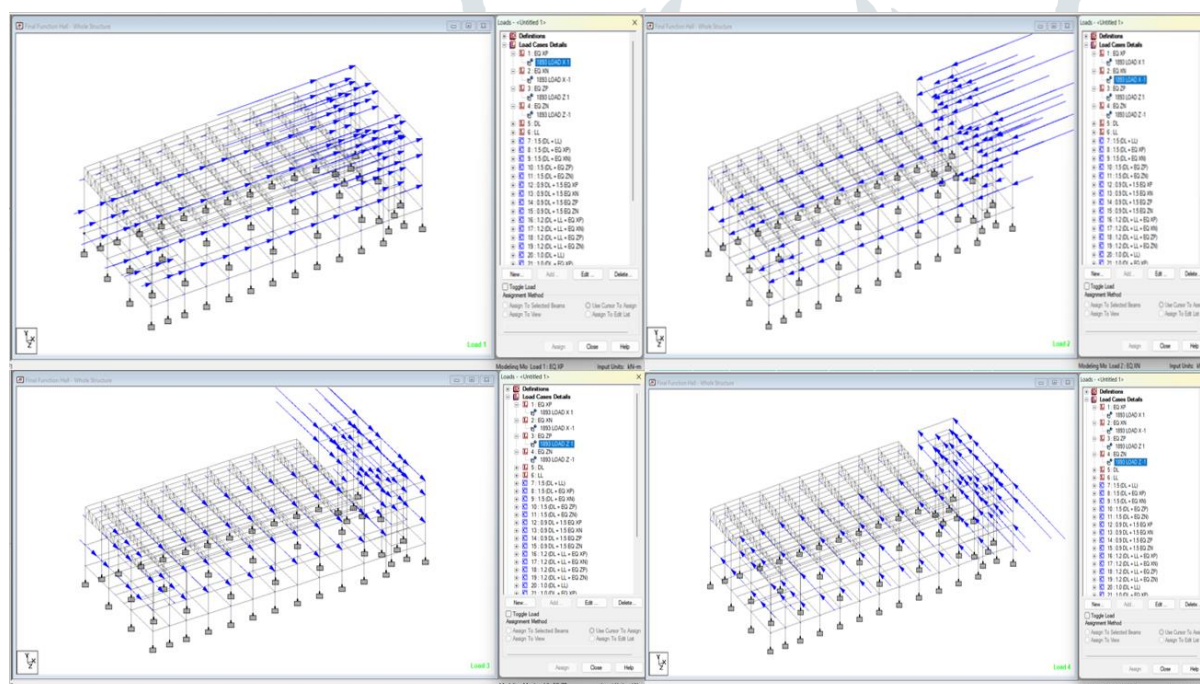
- **Live Load (LL):** Live Loads were taken as per IS 875 (Part 2).



- **Seismic Load (EQ):** Applied as per IS 1893:2016 for **Zone 2** conditions

STAAD DEFINITION PARAMETERS:

SEISMIC PARAMETERS	VALUES	CODAL PROVISIONS IS 1893:2016-
Zone Factor	0.1 (Zone = II)	Clause-6.4.2
Response Reduction factor (RF)	3 (OMRF)	Clause-7.2.6
Importance Factor (I)	1.2	Clause-7.2.3
Soil Type (SS)	2 (Medium)	Clause-6.4.2.1
Damping Coefficient (DM)	0.05 (RCC)	Clause 7.5.3



- **Load Combinations:** The load combinations are defined as per IS 456 Table 18 (Clauses 18.2.3.1, 36.4.1 and -4.3) for reinforced concrete structures, ensuring safety under extreme conditions.

2. Material Properties and Design Parameters

The structural design follows **Limit State Design (LSD)** principles, ensuring both **strength** and **serviceability**.

a) Concrete Strength (FC)

- **FC (Compressive Strength of Concrete):** Defines the characteristic strength of concrete used in structural elements.
- **M20 Grade** is used for the design of the **Function Hall** which ensures adequate load-carrying capacity and durability.

b) FYMAIN & FYSEC (Primary and Secondary Reinforcement Strengths)

- **FYMAIN:** Defines the main reinforcement strength in beams and slabs.

- **Fe500** are selected to optimize load distribution while ensuring structural ductility
- **FYSEC**: Specifies the strength of secondary reinforcement used for temperature and shrinkage control.
- **Fe415** are selected to optimize load distribution while ensuring structural ductility.

c) Torsion Considerations

- The **TORSION parameter** accounts for twisting forces in beams and slabs.
- STAAD.Pro calculates **torsional moments**, ensuring compliance with **equilibrium and compatibility torsion provisions of IS 456**.
- Additional reinforcement is provided in critical locations where torsional effects are significant.

3. Optimization and Validation

- The **STAAD.Pro results** are validated using **manual calculations** to ensure accuracy.
- **Material efficiency** is optimized by adjusting **section sizes and reinforcement layouts**.
- Iterative **design refinements** ensure that the structure meets **code compliance** while reducing material costs.

S.NO	SCHEDULE OF COLUMNS			FOUNDATION TO UPPER FLOORS		
	COL TYPE	MIX	SIZE (x,y)	MAIN STEEL	TIES & LINKS	C/S COLUMN
1.	C1 (10 No.)	M-25	9'x18'	8#16mm	#8@7" c/c 1 TIE + 1 TIE	
2.	C2 (2 No.)	M-25	12'x18'	8#20mm	#8@7" c/c 1 TIE + 1 LINK	
3.	C3 (2 No.)	M-25	9'x24'	12#16mm	#8@7" c/c 1 TIE + 1 TIE	
4.	C4 (36 No.)	M-25	15'x24'	16#16mm	#8@7" c/c 1 TIE + 1 TIES	

XI. Result and Discussion

The analysis of the function hall building subjected to Zone 2 seismic loads confirmed the structure was structurally sound and met design criteria. Finite element analysis verified that lateral displacements and base shear forces remained within the limits allowable by IS 1893 and IS 456 [3, 4, 15]. The response spectrum analysis confirmed that the natural period of the building was well-controlled, allowing for effective distribution of the seismic forces [20]. The moment and shear diagrams provided useful information regarding the moment and shear distribution to beams and columns and confirmed adequate reinforcement in the critical regions of beams and columns, with the automated design output closely resembling the manual calculations, thereby confirming the results are plausible [5, 8, 18]. Deflection shows the lateral displacements within serviceability limits which is subject to combination loads [7, 22]. Graphical outputs, such as renderings and sections, were produced and provided visual confirmation that the building has intact and performed well overall [11, 28]. The iterative parametric studies performed helped to fine-tune the designs and provide reductions in deflection and applied force distribution [8, 17]. The comparison to STAAD.Pro's documentation confirmed that the automated process of design reduced the overall time spent on the project, while providing a high level of accuracy [1, 2, 27].

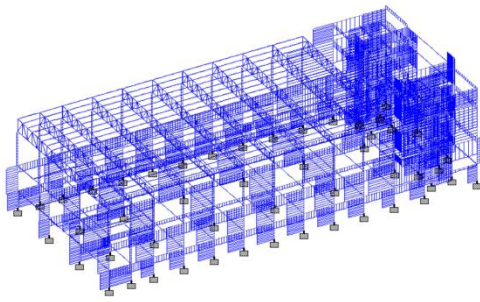


Fig: ShearForce Diagram

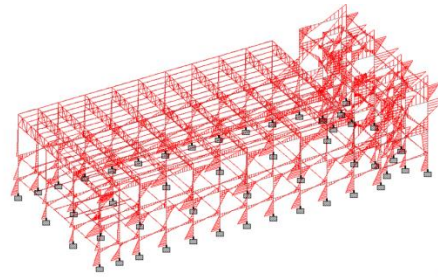


Fig: Bending Moment Diagram

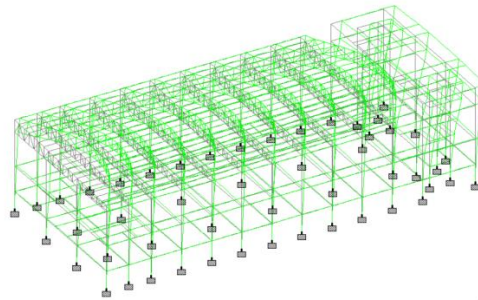
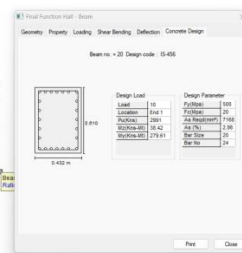
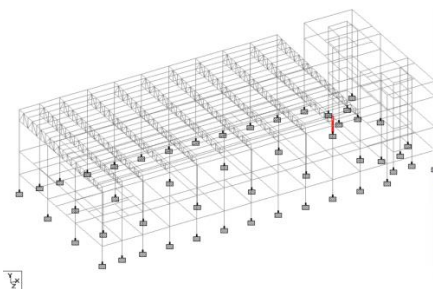


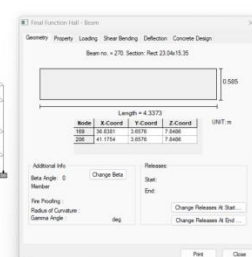
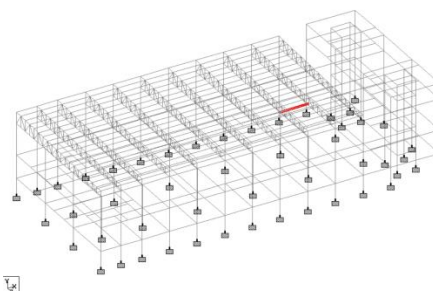
Fig: Deflection

Column Design:



COLUMN NO. 20 DESIGN RESULTS		
M20	Fe500 (Main)	Fe415 (Sec.)
LENGTH: 2438.4 mm	CROSS SECTION: 432.0 mm X 610.0 mm	COVER: 40.0 mm
** GUIDING LOAD CASE: 10 END JOINT: 80 SHORT COLUMN		
STAAD SPACE		
REQD. STEEL AREA : 7167.72 Sq.mm.		
REQD. CONCRETE AREA: 256351.44 Sq.mm.		
MAIN REINFORCEMENT : Provide 24 - 20 dia. (2.86%, 7539.82 Sq.mm.)		
(Equally distributed)		
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c		
SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)		
Puz : 4995.06	Mux1 : 452.05	Muy1 : 297.13
INTERACTION RATIO: 0.95 (as per Cl. 39.6, IS456:2000)		
SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)		
WORST LOAD CASE: 10		
END JOINT: 80	Puz : 5131.25	Mux : 478.61
	Muy : 314.05	IR: 0.88

Beam Design:



BEAM NO. 270 DESIGN RESULTS					
M20	Fe500 (Main)	Fe415 (Sec.)			
LENGTH: 4337.3 mm	SIZE: 390.0 mm X 585.2 mm	COVER: 25.0 mm			
SUMMARY OF REINF. AREA (Sq.mm)					
SECTION	0.0 mm	1084.3 mm	2168.7 mm	3253.0 mm	4337.3 mm
TOP REINF.	4335.06 (Sq. mm)	1889.66 (Sq. mm)	364.79 (Sq. mm)	364.79 (Sq. mm)	1326.49 (Sq. mm)
BOTTOM REINF.	2847.91 (Sq. mm)	363.13 (Sq. mm)	381.40 (Sq. mm)	1948.35 (Sq. mm)	2905.31 (Sq. mm)

XII. Conclusion

This research demonstrates the successful use of STAAD.Pro V8i SELECTseries 5 in the analysis and design of a function hall building in terms of structural including the effects of Zone 2 seismic loading in accordance with the Indian seismic codes. The research further includes comprehensive joint coordinate data and uses extensive finite element analysis (FEA) modelling to create a precise 3D model of the structure. The modeling allows for the simulation of dead loads, live loads and seismic loads according to the recommendations of IS 1893:2016 (Criteria for Earthquake Resistant Design of Structures) and IS 456:2000 (Code of Practice for Plain and Reinforced Concrete) [15, 22].

The limit state design approach is taken to ensure satisfactory load actions on all structural members including beams, columns and slabs. The key design actions considering base shear, bending moments, axial forces and total deflections are all thoroughly checked

before accepting the values as satisfactory. The detailing of reinforcement is then optimised to ensure the efficient use of material while ensuring structural stability and integrity. The outputs of the STAAD.Pro analysis are compared to manual calculations which further provides validity to the design outputs and process [5, 8, 24].

A major benefit of STAAD.Pro is that it simplifies the design progression, while minimizing design time, material use, and improving the safety in addition to the seismic performance of buildings [21, 29]. With its fully integrated analysis and drafting features, and optimization capabilities, STAAD.Pro is essential to be used in practice today for engineers engaged in civil and structural engineering projects. While it has one of the steepest learning curves in terms of its advanced features, STAAD.Pro has a lot of features that automate complex structural analyses and return a code-compliant, accurate structural solution, which is a crucial software for engineers with seismic-resistant building construction projects [27, 30].

XIII. Future Scope

Future studies should work towards widening STAAD.Pro's capabilities by integrating it with live structural health monitoring (SHM) systems to enhance predictive capability under seismic loading. [15, 22]. These systems could support the sensor data and machine learning to adapt in real-time to seismic forces, and to realize real-time structural modifications to reduce damage in an earthquake [23, 28]. This adaptive approach would lead to seismic engineering which would allow for a proactive response strategy, instead of just depending on pre-designed capacity. Additional research into the integration of Building Information Modeling (BIM) could further enhance collaboration among engineering disciplines to allow for effortless transitions from design to construction [11, 21]. The idea based on BIM would be to develop rich data 3D models that would enhance the structural analysis process by building in real-life constraints, material properties and construction methods will results in faster and easier methods to come up with designs that would work.

Furthermore, the use of STAAD.Pro with new structural systems such as hybrid and composite structures would allow for a more thorough evaluation of performance under extreme loading from seismic, wind, and/or impact forces [8, 18]. Research comparing STAAD.Pro to other structural analysis suites (ETABS, SAP2000) would help to differentiate and delineate best practices from each software for engineers to optimize their selection based on specific structural typologies [2, 19]. Future research should also include investigating post-earthquake performance evaluations and retrofitting to help achieve sustainable and resilient infrastructure design [26, 27]. Additionally, enhancing STAAD.Pro with advanced dynamic analysis of nonlinear and/or time-series analysis would improve the usability and applicability for complex seismic scenarios to enable engineers to simulate progressive collapse mechanisms for advanced mitigation [29, 30].

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