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Structural Resilience Enhancement and Retrofit for Core Block, FET

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ABSTRACT: Given their important role in society, protecting students and staff during natural disasters is a priority for Educational institutions. This paper explores the idea of bringing existing structures (core blocks, FETs) to resistive structures. The main purpose of the project is to evaluate the structural resilience of the building. This may require a review of the architecture, site visit, and non-destructive testing and structural analysis of the building using STAAD.Pro software, statically and dynamically, to assess the state of the data and identify potential weaknesses. analysis. Use appropriate salvage materials to reinforce the material, such as fiber-reinforced polymer (FRP) cladding, bracing, and curtain walls.

KEYWORDS: Educational Institutions, Structural Resilience, Non-destructive testing, STAAD.Pro, structural analysis.

I. INTRODUCTION

The focus on enhancing a building's structural resilience has been growing in recent years, particularly given the growing challenges caused by climate change, natural disasters, and changing engineering standards. In all the different types of organizations that are essential to the operation of society, educational establishments are essential pillars. To safeguard academic operations and maintain a seamless transition in the event of unanticipated circumstances, college buildings necessitate specialized care due to their intricate infrastructure and varied occupant profiles.

This proposal acknowledges the complex issues that buildings of this type may confront and attempts to handle the critical task of improving structural resilience and retrofitting a college building. In the field of structural engineering, "resilience" refers to a structure's capacity to adjust, absorb shocks, and quickly recover from disruptions. It goes beyond conventional ideas of strength and durability. The objective of the study is to thoroughly investigate methods for strengthening an educational institution building against a range of possible threats, such as earthquakes, severe weather, and other unanticipated structural weaknesses.

In addition to being places for instruction, higher education institutions are frequently hotspots for innovation, research, and community involvement. When these institutions suffer disruption by structural failures, the ramifications can be extensive, affecting not only those in academia directly but also the larger fabric of society. This project acknowledges the urgent need to fund structural resilience to preserve the flow of knowledge and research, save lives, and lessen financial losses.

The project also recognizes that environmental and structural hazards are dynamic and that retrofitting requires a proactive strategy. Strategies for improving structural resilience must change along with building codes and standards. The project's goal is to provide useful insights that can be applied to comparable structures by tackling this problem in its setting as a college building. This will help to promote a more resilient culture within the educational infrastructure.



FIG 1 SEISMIC MAP OF INDIA

II. OBJECTIVE

- To identify the dimensional properties of the building.
- To assess the building's behavior under wind and seismic loads.
- To provide the retrofitting & recommendations for the building after the analysis.

III. METHODOLOGY



Fig :2 METHODOLOGY FLOW CHART

1. PROJECT INFORMATION

Location	Bengaluru, India
Project Type	Important Service & Community Building
Name of the Building	Core Block, FET

Area of the Building	2236.52m ²
Overall, Height of the Building	15.6m
Length of the Building	44.42m
Width of the Building	50.60m
Construction Materials	Concrete & Steel
Grade of Concrete(N/mm ²)	M30
Grade of HYSD Rebar(N/mm ²)	Fe500 & Fe415
Seismic Zone	II Zone Factor – 0.10
Response Reduction Factor	3.0
Importance Factor	1.5
Type of the Building	G+3

Table :1 PROJECT INFORMATION

2. TOOLS & STANDARD CODES USED

The tools which are adopted for this project:

- Autodesk AutoCAD
- STAAD.Pro Connect Edition
- Microsoft Office (Excel, MS Word & PowerPoint Presentation)

Various standard Codes which include as per IS Code & other International codes.

Code	Description
IS 456:2000	General Construction in Concrete Code ofPractice
IS 875:1987 (Part 1)	Code of Practice for Design Loads (Other than Earthquake Loads for Buildings and Structures) Part 1: Dead Load – Unit Weight for Building Materials and Stored Materials
IS 875:1987 (Part 2)	Code of Practice for Design Loads (Other than Earthquake Loads for Buildings and Structures) Part 2: Imposed Loads/ LiveLoads
IS 875:2015 (Part 3)	Code of Practice for Design Loads (Other than Earthquake Loads for Buildings and Structures) Part 3: Wind Loads
IS 1893:2016 (Part 1)	Criteria for Earthquake-Resistant Design ofStructures
UBC-97	Uniform Building Code

Table:2 CODES USED

3. BUILDING LAYOUTS

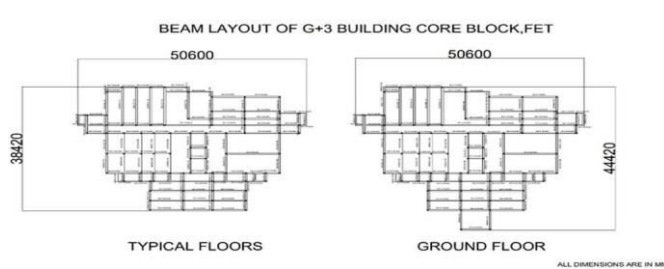


Fig: 3 BEAM LAYOUT OF THE STRUCTURE

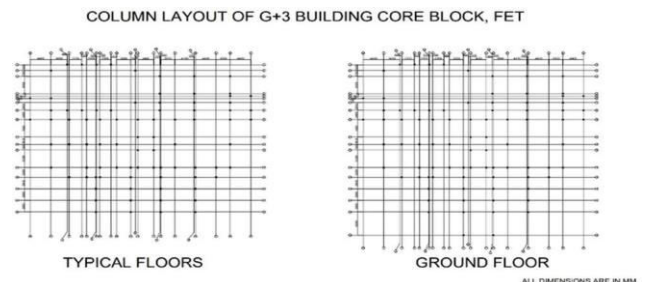


Fig: 4 COLUMN LAYOUT OF THE IV. IV. IV.

IV. STRUCTURE

1. STAAD.Pro MODELING

The Modelling in STAAD.Pro is done in different steps.

- Step 1: Extract the Plan from AutoCAD
- Step 2: Place the Nodes
- Step 3: Plot the nodes by adding Beams
- Step 4: Define Geometry
- Step 5: Define Section Properties
- Step 6: Define Material Properties Step
- 7: Provide the supports
- Step 8: Define Loads
- Step 9: Define Load Combinations
- Step 10: Assign the Loads
- Step 11: Run Analysis
- Step 12: Check the required analysis results

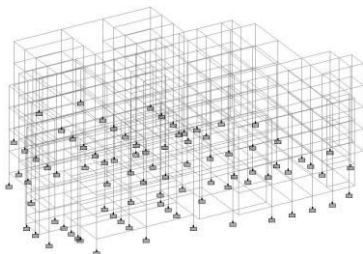


Fig: 5 GEOMETRY MODEL

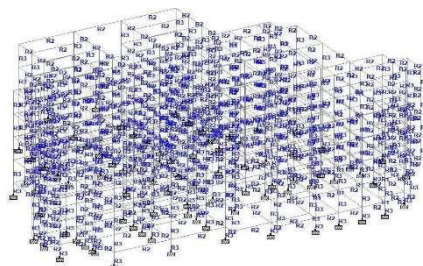


Fig: 6 PROPERTIES MODEL

2. Performing NDT (Non-destructive Tests)

A fundamental technique in civil engineering is non-destructive testing (NDT), which enables engineers to evaluate the condition of materials and structures without inflicting any harm. Throughout a structure's existence, this is essential for maintaining safety, cutting expenses, and directing decision-making.

REBOUND HAMMER TEST

Objective:

To perform the rebound hammer test for assessing the compressive strength of concrete in existing structures.

Equipment Required:

Rebound hammer (Schmidt hammer) Grinding stone (for calibration) Testing surface (concrete structure) Cleaning brush Protective gear (safety glasses, gloves, etc.)



Fig: 7 REBOUND HAMMER

Procedure:

Preparation:

Ensure the testing surface (concrete structure) is clean and free from loose particles or debris. Wear appropriate protective gear to ensure safety during testing.

Calibration:

Before starting the test, calibrate the rebound hammer using the grinding stone provided with the equipment.

Follow the manufacturer's instructions for calibration, which typically involves grinding the surface of the calibration anvil until it achieves a specified rebound value.

Repeat the calibration process as recommended by the manufacturer or at regular intervals to maintain accuracy. Testing: Hold the rebound hammer firmly against the concrete surface perpendicular to the surface being tested.

Ensure that the plunger of the rebound hammer is in contact with the concrete surface. Press the trigger to release the spring-loaded plunger, which will strike the concrete surface. Record the rebound value displayed on the rebound hammer's scale.

Repeat the test at multiple locations on the concrete surface to ensure representative results. Note any deviations in surface conditions or anomalies that may affect test accuracy.

Interpretation of Results:

Refer to the rebound hammer's calibration chart provided by the manufacturer to convert rebound values into compressive strength estimates.

Compare the obtained rebound values with standard ranges or specifications to assess the condition of the concrete. Note that rebound values may vary depending on factors such as concrete mix design, surface moisture, age of concrete, and presence of reinforcement.

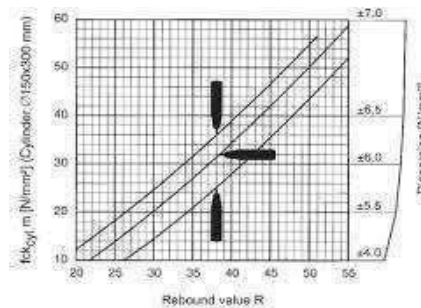


Fig: 8 GRAPH REPRESENTATION

RESULT:

By considering the above chart the compressive strength of concrete used is **30N/mm²**

1. LOADING

Dead load or Self Weight:

The dead loads are applied to the structural members by using STAAD.Pro software. The weight of the members is calculated by multiplying the breadth, depth, or thickness by the Density of the concrete.

The dead load of a structure refers to the static weight of all permanent components, materials, and fixtures that make up the building itself.

Loads applied on different members for their dimensions:

1. Beam 1 - 580mm X 450mm: -6.5 KN/m
2. Beam 2 - 400mm X 310mm: -3.1KN/m
3. Columns - 360mm X 360mm: -3.2KN/m (-ve) the sign indicates the global Y direction

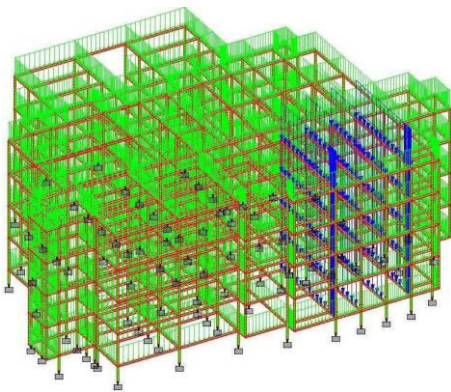


Fig: 9 DEAD LOAD ON BEAM 11

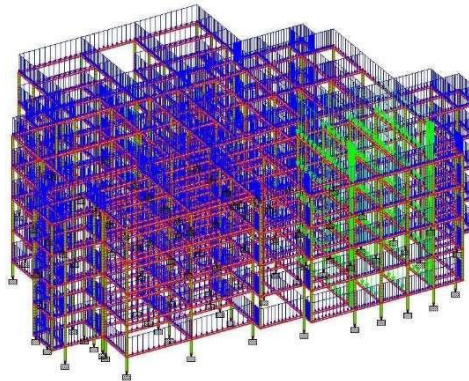


Fig: 10 DEAD LOAD ON BEAM 12
BEAM 13

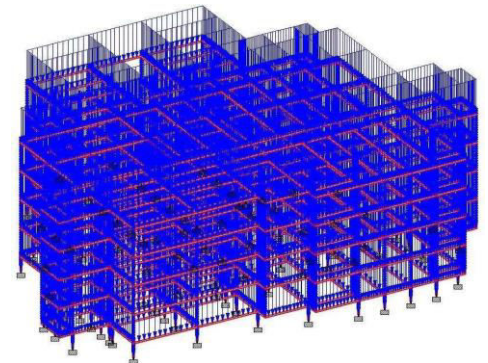


Fig: 11 DEAD LOAD ON
BEAM 13

Live Loads or Impact Loads:

Live loads are applied to all the structural members as per IS 875 Part-2. Live load, also known as imposed load or occupancy load, refers to the dynamic and transient forces exerted on a structure by movable or variable elements such as people, furniture, vehicles, equipment, and stored goods. These loads are not constant and can change over time depending on the activities within the structure. Live loads are typically considered in building design to ensure that the structure can safely support the maximum expected loads without experiencing excessive deformation or failure. Examples of live loads include the weight of occupants in a building, vehicles on a bridge, furniture in a room, or equipment on a floor. Impact load refers to the sudden and temporary increase in live load caused by dynamic actions such as the movement of people or vehicles, which may lead to additional stresses on the structure.

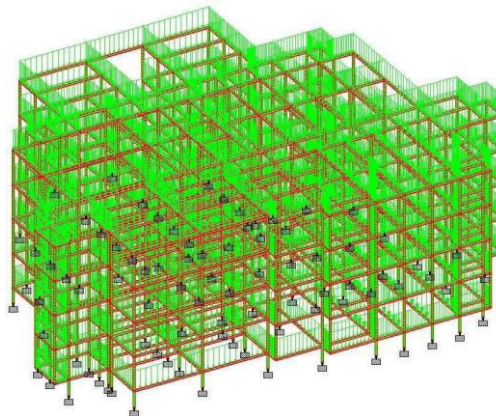


Fig: 12 LIVE LOAD ON ALL THE STRUCTURAL MEMBERS

Earthquake Loads:

Seismic loads, also known as earthquake loads, are forces exerted on structures due to the ground shaking during an earthquake. These loads are dynamic and can cause significant damage if not properly accounted for in the design and construction of buildings and other structures. Seismic loads are influenced by factors such as the magnitude and duration of the earthquake, the soil conditions, and the characteristics of the structure itself.

Seismic Zone	II Zone Factor – 0.10
Response Reduction Factor	3.0
Importance Factor	1.5
No.of Floor	G+3

Table: 3 FACTORS CONSIDERED FOR EARTHQUAKE LOADS

Wind Loads:

Wind loads are applied on the structure as per IS 875 Part-3:2015. Factors to consider for Wind loads:

Basic Wind Speed (V_b) is 33m/s for Bengaluru as per IS 875 Part-3 page-51 Terrain Category is 1 as per IS 875 Part-3 page-5

Risk Coefficient (K_1) is 1 as per IS 875 Part-3 page-7 Topography Factor (K_3) is 1 as per IS 875 Part-3 page-8

The importance factor for the cyclonic region (K_4) is 1 as per IS 875 Part-3page-9 The wind directionality factor (K_d) is 0.90 as per IS 875 Part-3 page-9

The area averaging factor (K_a) is 1.0 as per IS 875 Part-3 page-10 The combination factor (K_c) is 0.90 as per IS 875 Part-3 page-16 Design Wind Speed $V_z = K_1 \times K_2 \times K_3 \times K_4 \times K_b$ from page-5

Wind pressure $P_z = 0.6 \times V_z^2$ from page-9

Design Wind pressure $P_d = P_z \times K_a \times K_d \times K_c$ from page 9

Terrain and height multiplier (K_2) is 1.05 from page-8 table-2

Response Spectrum Analysis:

Finding out what kind of ground vibrations an earthquake is likely to cause in the college building is the first step. This takes into account the location of the building, past seismic activity, and building codes. Using material attributes, measurements, and the building's current structural components, a comprehensive computer model of the college structure is produced. Using material attributes, measurements, and the building's current structural components, a comprehensive computer model of the college structure is produced. The building's response in terms of forces, stresses, and displacements at crucial areas is then computed by RSA software. The findings of the investigation are contrasted with the seismic resistance criteria of the building code. This aids in locating holes in the current framework.

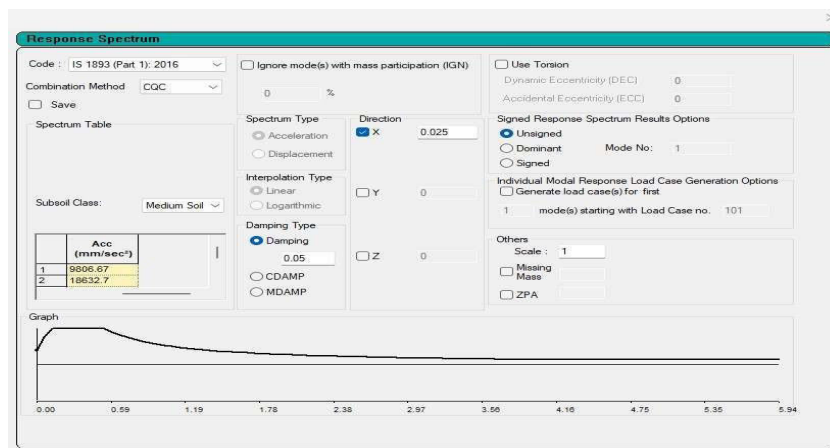


Fig: 13 RSA in X-DIRECTION

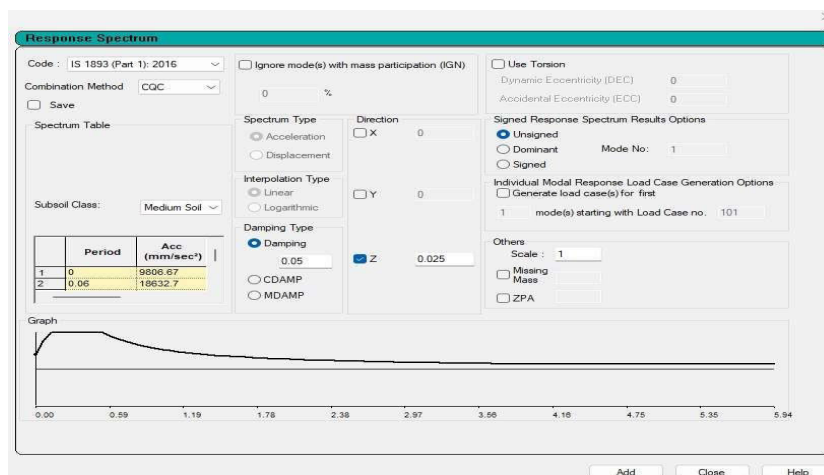


Fig: 14 RSA in Z-DIRECTION



V. EXPERIMENTAL RESULTS

1. Node Displacements

	Node	L/C	Horizontal X m	Vertical Y m	Horizontal Z m	Resultant m	Rotational rX rad	rY rad	rZ rad
Max X	468	43 COMB - 1.5 DEAD + 1.5 WIND (2)	0.014	-0.002	0.002	0.015	0	0	-0.001
Min X	468	75 COMB - 0.9 DEAD + -1.5 WIND (2)	-0.014	-0.001	-0.002	0.014	0	0	0
Max Y	70	12 WIND (-Z) IS875 RECT CLAD [-CPI]	0	0.002	-0.001	0.002	-0.001	0	0
Min Y	594	4 1.5(DL+LL)	0.002	-0.011	-0.004	0.012	-0.001	0.001	-0.001
Max Z	583	57 COMB - 1.5 DEAD + -1.5 WIND (8)	-0.001	-0.001	0.03	0.03	0.002	-0.001	0
Min Z	568	73 COMB - 0.9 DEAD + 1.5 WIND (8)	-0.002	0	-0.028	0.028	-0.001	-0.001	0
Max rX	567	4 1.5(DL+LL)	0.002	-0.004	-0.004	0.005	0.004	0	0
Min rX	517	4 1.5(DL+LL)	-0.001	-0.004	-0.004	0.005	-0.004	0	0
Max rY	574	44 COMB - 1.5 DEAD + 1.5 WIND (3)	-0.006	-0.002	-0.006	0.009	-0.001	0.003	0
Min rY	574	76 COMB - 0.9 DEAD + -1.5 WIND (3)	0.006	-0.001	0.004	0.008	0	-0.002	0
Max rZ	575	4 1.5(DL+LL)	0	-0.004	-0.002	0.004	0	0	0.003
Min rZ	571	4 1.5(DL+LL)	0.001	-0.004	0	0.004	0	0	-0.003
Max Rst	568	57 COMB - 1.5 DEAD + -1.5 WIND (8)	0.001	-0.005	0.03	0.031	0.001	0.002	0

Table: 4 NODE DISPLACEMENTS

Discussion: From the results obtained there is no huge or noticeable displacement occurred in the nodes and the structure is resilient from the Dynamic Loads.

2. Support Reactions

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kN-m	My kN-m	Mz kN-m
Max Fx	167	27 COMB - 1.2 DEAD + 1.2 LIVE + -1.2 WIND (2)	73.809	862.394	6.136	7.066	0.006	-61.965
Min Fx	171	19 COMB - 1.2 DEAD + 1.2 LIVE + 1.2 WIND (2)	-65.754	852.765	2.409	1.142	-0.427	61.137
Max Fy	119	4 1.5(DL+LL)	-8.701	1585.637	-145.363	-90.353	-0.614	4.171
Min Fy	163	7 WIND (-X) IS875 RECT CLAD [+CPI]	3.5	-110.755	-17.994	-24.693	0.354	-5.789
Max Fz	156	49 COMB - 1.5 DEAD + 1.5 WIND (8)	-19.542	1083.873	118.006	98.318	0.107	11.608
Min Fz	119	57 COMB - 1.5 DEAD + -1.5 WIND (8)	-12.745	1252.391	-155.295	-125.64	-1.507	8.989
Max Mx	156	49 COMB - 1.5 DEAD + 1.5 WIND (8)	-19.542	1083.873	118.006	98.318	0.107	11.608
Min Mx	119	57 COMB - 1.5 DEAD + -1.5 WIND (8)	-12.745	1252.391	-155.295	-125.64	-1.507	8.989
Max My	185	56 COMB - 1.5 DEAD + -1.5 WIND (7)	65.674	992.304	-63.21	-57.85	4.638	-50.382
Min My	185	72 COMB - 0.9 DEAD + 1.5 WIND (7)	-6.109	489.975	4.622	21.194	-3.385	13.228

Max Mz	171	43 COMB – 1.5 DEAD + 1.5 WIND (2)	-62.743	716.412	1.681	0.476	-0.542	64.908
Min Mz	167	51 COMB – 1.5 DEAD + -1.5 WIND (2)	72.857	724.269	6.717	8.079	0.013	- 66.178

Table: 5 SUPPORT CONDITIONS

Discussion: The provided supports are fixed supports. The above table shows the reactions that took place at the supports when they were subjected to dynamic loads. By observing the results obtained, the supports are in correct condition under dynamic loads without any substantial reactions.

3. Beam End Forces

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN- m
Max Fx	172	4 1.5(DL+LL)	119	1585.637	8.701	145.363	-0.614	90.353	-4.171
Min Fx	216	7 WIND (-X) IS875 RECT CLAD[+CPI]	67	-110.755	-3.5	17.994	0.354	-9.496	-0.861
Max Fy	85	4 1.5(DL+LL)	20	93.059	335.37	-1.437	-10.685	2.781	319.568
Min Fy	84	4 1.5(DL+LL)	21	22.414	-150.672	-0.954	0.208	-0.159	138.812
Max Fz	172	57 COMB - 1.5 DEAD + - 1.5 WIND (8)	20	1234.568	12.899	153.067	-1.507	-165.187	15.519
Min Fz	209	49 COMB - 1.5 DEAD + 1.5 WIND (8)	60	1066.051	19.542	-118.006	0.107	125.894	25.522
Max Mx	70	4 1.5(DL+LL)	17	84.552	296.326	1.139	28.028	-2.59	291.193
Min Mx	8	4 1.5(DL+LL)	8	-5.767	26.656	-1.004	-25.74	2.313	17.275
Max My	313	57 COMB - 1.5 DEAD + - 1.5 WIND (8)	71	150.79	0.714	-79.791	-2.215	162.869	1.033
Min My	172	4 1.5(DL+LL)	20	1559.264	8.701	145.363	-0.614	-185.837	12.361
Max Mz	85	4 1.5(DL+LL)	20	93.059	335.37	-1.437	-10.685	2.781	319.568
Min Mz	13	4 1.5(DL+LL)	14	25.603	121.838	-0.174	10.708	0.552	- 173.552

Table: 6 BEAM END FORCES

Discussion: By applying various loads like Dead, Live, Wind & Seismic loads on the structural members, the members will experience the Shear force (Fy) and Bending Moments (Mz). Beam number 85 is experiencing the maximum shear force and Bending moment. So, the beam is designed respectively to withstand the forces & moments.

VI. CONCLUSION

The dimensional properties of the building are identified and the length, width, height & area of the building is 44.2m, 50.60m, 15.6m & 2236.52m² respectively.

The building i.e., core block, FET is analysed using STAAD.Pro Software under dynamic loads. From the analysis results, the structural elements, such as beams, columns, and connections, were able to withstand the simulated dynamic loads without exceeding their capacity limits, indicating that the proposed retrofitting strategies have successfully improved the building's ability to resist seismic, wind, or other dynamic forces.

The conclusion recommends ongoing monitoring, maintenance, and periodic inspections to ensure the long-term performance and resilience of the retrofitted building structure.

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