Dynamic Response Of Hybrid Slab Configurations Under Seismic Loading

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Abstract- *This study evaluates the seismic performance of a 15-storey (G+15) reinforced concrete building using finite element analysis (FEA) in accordance with IS 1893:2016 provisions. The structure was analysed through Modal analysis and Response Spectrum analysis to assess parameters such as natural period, storey displacement, and drift. Results show that the hybrid slab system incorporating core walls and drop panels exhibits superior seismic performance, achieving lower displacement and greater stiffness compared to the conventional flat slab system. The inclusion of core walls and drop panels provides an effective balance between flexibility, stability, and economy, making the hybrid slab configuration suitable for mid-rise buildings in seismic-prone regions.*

Keywords: Seismic performance, flat slab, hybrid slab, dynamic analysis, storey drift, base shear, core wall, drop panel

1. INTRODUCTION

This project involves the design and analysis of a 15-storey (G+15) reinforced concrete building with different structural systems, including RC beam–slab, flat slab, and hybrid configurations. The models incorporate core walls and drop panels and are compared in terms of structural performance, cost-effectiveness, and constructability to assess the influence of various slab systems on overall building behavior

1.1 Classification of structural system

Three structural systems were considered to evaluate the seismic performance of a 15-storey (G+15) reinforced concrete building designed as per IS 1893:2016. Type 1 represents the conventional RC beam–slab system, offering high stiffness and moment resistance but with greater weight and longer construction time. Type 2 is a hybrid system with RC beam–slab construction in the lower floors and flat slabs above, aiming to reduce self-weight and improve efficiency. Type 3 adopts flat slabs in the lower floors and RC beam–slab construction above to study the effect of flexible lower storeys on seismic response. All models have a 32 m × 32 m base plan with 4 × 4 bays and are analyzed under identical loading and seismic conditions.

1.2 Objective of the study

The study evaluates the seismic performance of flat slab and hybrid slab systems under dynamic loading using finite element analysis (FEA). Conventional RC beam–slab and flat slab systems, with and without drop panels and core walls, are compared to assess their effectiveness. The influence of structural configuration and building height on key seismic parameters such as time period, displacement, and storey drift is examined. The effect of drop panels on enhancing stiffness and reducing seismic vulnerability is also analyzed to identify the most efficient slab system with improved seismic resistance and overall stability

2. PRELIMINARY DATA CONSIDERED FOR ANALYSIS

Building Models and Geometry

Six reinforced concrete building models were developed for the 15-storey (G+15) structure, incorporating conventional RC beam–slab, flat slab, and hybrid slab systems with and without core walls and drop panels to assess seismic performance.:

Table -1: 6 STRUCTURAL SYSTEMS NOMENCLATURE

S.L. No.	Structural System	Nomenclat--ure
1	First floor with RC beam slab and above floors with Flat slabs	1B15F
2	First floor with RC beam slab and above floors with Flat slabs with Core, Drop	1B15FWCD
3	First half portion of building floor with RC beam slab and above half floors with Flat slabs	8B8F
4	First half portion of building floor with RC beam slab and above half floors with Flat slabs with Core, Drop	8B8FWCD

5	First half portion of building floor with Flat slab and above floor with RC Beam slab	8F8B
6	First half portion of building floor with Flat slab and above floor with RC Beam slab with Core, Drop	8F8BWCD

Building Dimensions:
•Total Height: 45 m (15 storeys)
• Storey Height: 3 m
• Plan Dimension: 32 m × 32m (square)
• Bay Width: 8 m

Material Properties and Sections

Concrete and Steel Properties:
• Grade of Concrete: M30
• Compressive Strength of Concrete: 30 N/mm²
• Modulus of Elasticity (Concrete): 27,32 N/mm²
• Grade of Steel (Reinforcement): Fe 550
• Rebar Strength: 550 N/mm²

Section Dimensions (Common for all systems):
• Beam: 600 mm × 600 mm (Rectangular RCC section)
• Column: 1000 mm × 1000 mm (Rectangular RCC section)
• Slab: 220 mm thickness, Flat Slab: 400 mm thickness
• Core (Central shear wall): 300 mm thickness, thickness of drop 100mm and 4m x 4m (square)

Special Elements:
• Diagrid (DG): CHS 1000 × 40 mm
• Outrigger (OT): 600 mm thickness wall
• Belt Truss System (BTS): RHS 600 × 1000 × 30 mm

Loading Conditions

Gravity Loads (as per IS 875-1987 Part I & II):
• Super Imposed Dead Load: 1.5 kN/m²
• Live Load: 4.0 kN/m²
• Mass Source: 100% dead load + 25% live load

Seismic Load Parameters (as per IS 1893-2016):
• Seismic Zone: Zone V
• Zone Factor (Z): 0.36
• Soil Type: medium Soil
• Importance Factor (I): 1.2
• Response Reduction Factor (R): 5
• Damping Ratio: 5%

MODELS USED FOR FE ANALYSIS

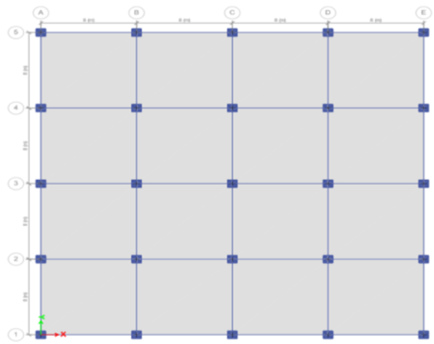

Fig -1: Plan of G+15 Floor Models

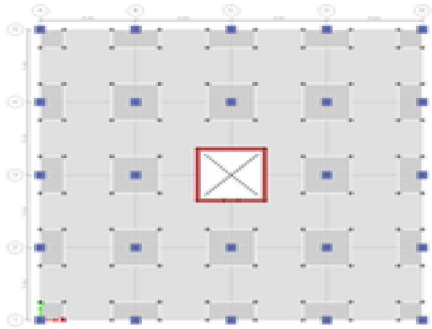

Fig -2: Plan of G+15 Floor Models

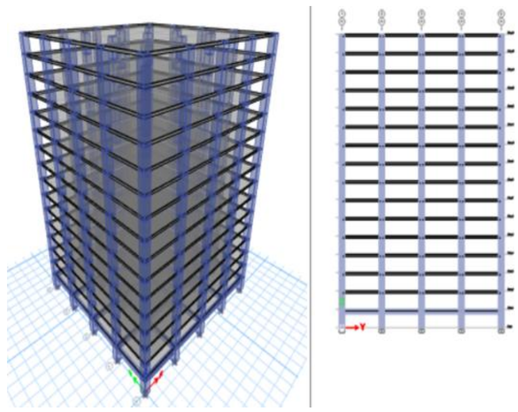

Fig -3: 3D View and Elevation G+15[1B15F]

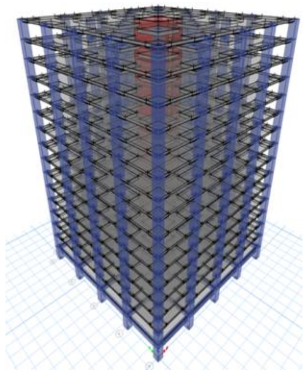

Fig-4: 3D View and Elevation G+15[1B15FWDC]

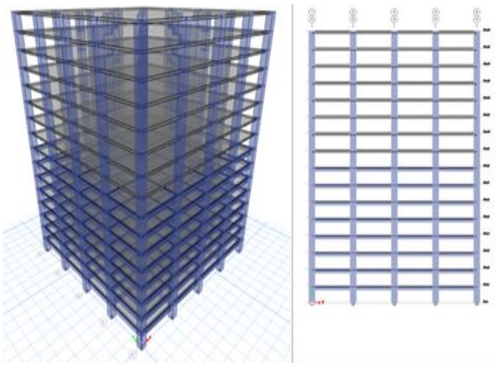

Fig-5: 3D View and Elevation G+15[8B8F]

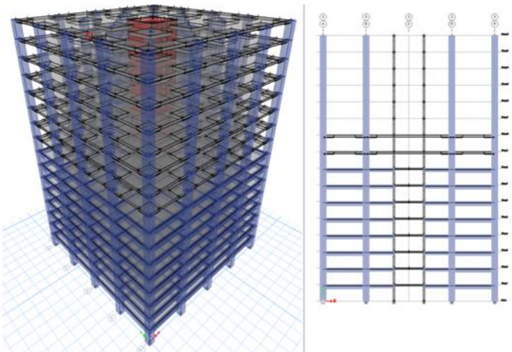

Fig-6: 3D View and Elevation G+15[8B8FWDC]

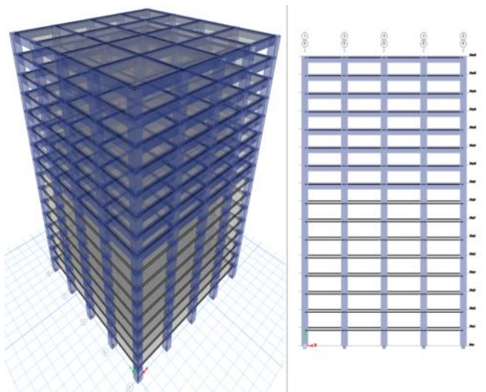

Fig-7: 3D View and Elevation G+15[8F8B]

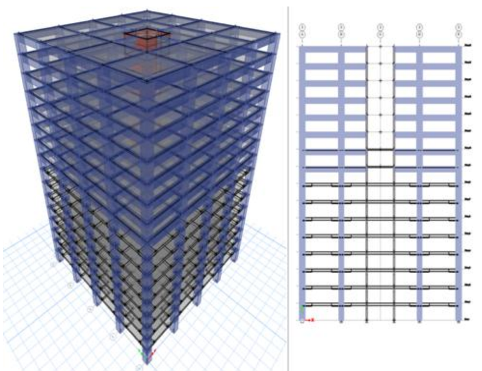

Fig-8: 3D View and Elevation G+15[8F8BWDC]

3. RESULTS AND DISCUSSION

3.1 Modal Analysis

Table-2: MODE 1 TIME PERIOD OF ALL STRUCTURES

Sl. No.	Model	Computed Period (s)	IS 1893:2016 (s)
1	1B15F	3.031	1.303
2	1B15FWCD	1.637	1.303
3	8B8F	2.431	1.303
4	8B8FWCD	0.942	1.303
5	8F8B	2.231	1.303
6	8F8BWCD	1.536	1.303

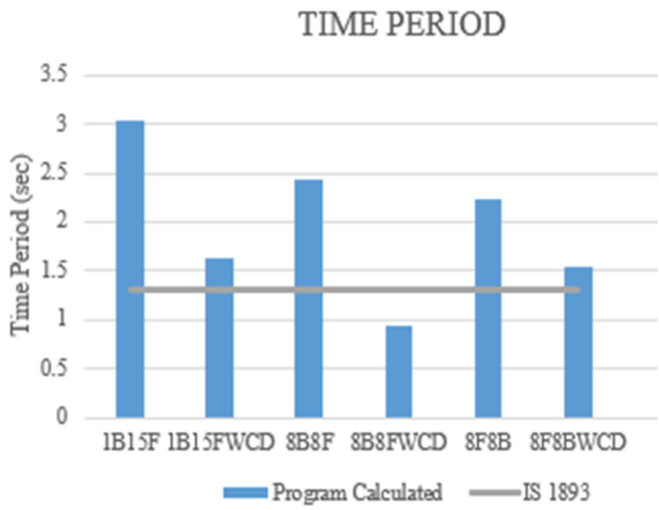

Chart -1: Modal time period of all structure

3.2 Base Shear from Time History Analysis

Table-3: Corrected Dynamic Base shear for all models (10^6) IN kN

Model	Corrected Dynamic Base Shear (KN)
1B15F	5064.43
1B15FWCD	8528.72
8B8F	5062.63
8B8FWCD	10054.30

8F8B	5937.31
8F8BWCD	9198.81

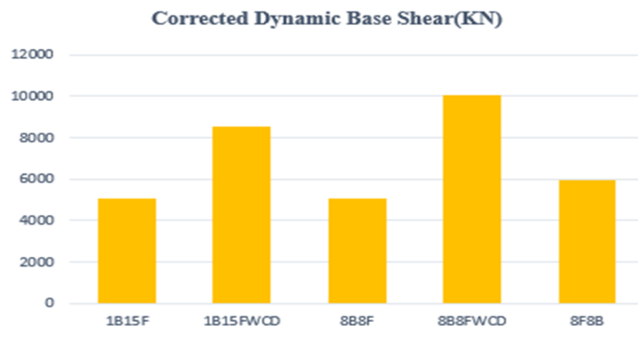

Chart -2: Max Base shear of All Structure

3.3 Storey Displacement

Table-4: MAX STOREY DISPLACEMENT IN (mm)

Model	Max Storey Displacement IN (mm)
1B15F	82.24
1B15FWCD	39.52
8B8F	57.88
8B8FWCD	37.59
8F8B	43.68
8F8BWCD	34.70

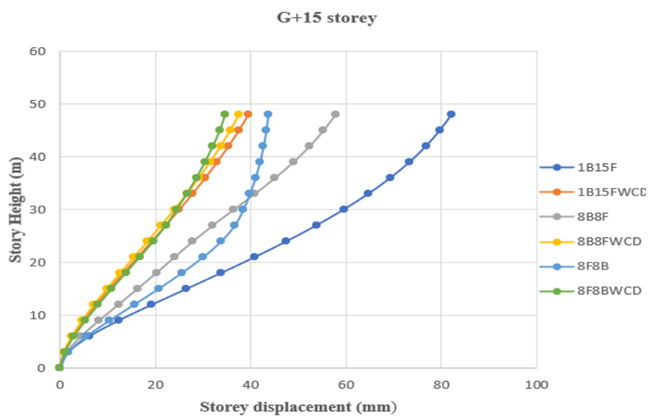

Chart -3: Max Displacement of All Structure

3.4 Inter Storey Drift Ratio

Table-5: MAX INTER STOREY DRIFT RATIO (10^{-3})

Model	MAX INTER STOREY DRIFT RATIO (10-3)
1B15F	2.4
1B15FWCD	1.1
8B8F	1.3
8B8FWCD	0.9
8F8B	1.5
8F8BWCD	0.9

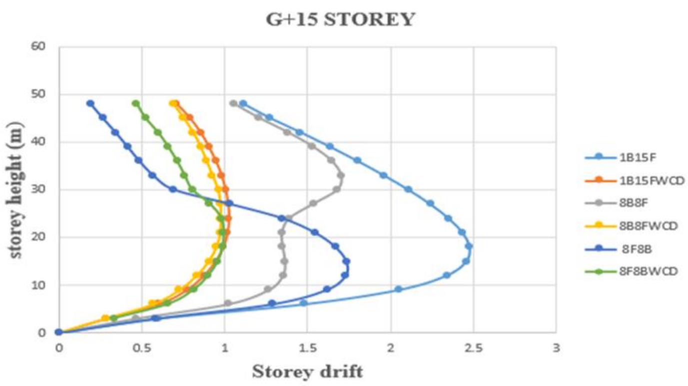

Chart -4: Max Inter Storey Drift of All Structure

4. CONCLUSIONS

Modal Analysis

Models with core walls and drop panels show better seismic performance, with 1B15FWCD, 8B8FWCD, and 8F8BWCD increasing base shear by 68.4%, 98.5%, and 54.9%, respectively. Among base systems, 8F8B performs best, offering balanced stiffness and improved seismic resistance.

Base Shear Response

The introduction of core walls and drop panels greatly enhances the lateral load resistance of all models. The 1B15FWCD, 8B8FWCD, and 8F8BWCD systems exhibit base shear improvements of 68.4%, 98.5%, and 54.9%, respectively, compared to their non-core counterparts. Among the original configurations, the 8F8B model demonstrates the highest base shear, indicating superior performance in resisting seismic forces

Lateral Displacement

Incorporating core walls and drop panels leads to a marked reduction in lateral displacement. The 1B15FWCD, 8B8FWCD, and 8F8BWCD models show displacement reductions of 51.9%, 35.1%, and 20.5%, respectively, compared to their non-core versions. Among the basic configurations, the 8F8B model exhibits the least displacement, indicating greater stiffness and better seismic control.

Drift Ratio and Damage Control

The integration of core walls and drop panels effectively minimizes inter-storey drift, enhancing overall rigidity. The 1B15FWCD, 8B8FWCD, and 8F8BWCD models show drift reductions of 54.2%, 30.8%, and 40%, respectively, compared to their non-core systems. Among the base configurations, 8B8F records the lowest drift, demonstrating better control of lateral deformation.

System Ranking & Performance

Models with core walls and drop panels perform much better in earthquakes by increasing strength and reducing movement. The 1B15FWCD, 8B8FWCD, and 8F8BWCD models show higher base shear by 68.4%, 98.5%, and 54.9%, along with reduced displacement and drift compared to their normal versions. Among the three main configurations (1B15F, 8B8F, and 8F8B), the 8F8B system performs best, as it shows higher base shear, lower displacement, and better overall stability. Overall, the 8B8FWCD model gives the best seismic performance, proving that core walls and drop panels greatly improve stiffness and safety during earthquakes.

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