Comparative Analysis of Diagrid Structural System with Moment Frame, Shear Wall and Brace Tube as Inner Core

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Abstract — The diagrid structural system is an innovative and modern approach in architecture and engineering. It is especially suited for high-rise buildings because of its unique diagonal grid of steel or concrete members. This system provides excellent resistance to lateral forces such as wind or seismic load. The integration of a diagrid system with an inner core structural system offers a balanced combination of strength, efficiency, architectural flexibility, and economic benefits. One of the key features of the diagrid system is the careful optimization of the angle of these diagonal members because diagonal angle directly impacts both the structural strength and the building's architectural design. The right angle ensures that the building efficiently handles gravity and lateral loads. This study aims to analyze various aspects of the diagrid core structural system. Specifically, it compares different types of inner cores such as shear walls, moment frames, and braced tubes combined with the diagrid system. The analysis covers important factors like Time period, story Displacement, story Drift, base shear and Cost comparison. ETABS software is used for the analysis and loads according to Indian standards. The Study evaluate that The Diagrid Shear wall(DSW) system, the most stable but Expensive, is best for medium-rise buildings in high seismic zones at angle of diagrid 80°, where safety is the priority. The Diagrid Brace tube (DBT) system provides a balanced option with a good performance, offering a practical compromise between flexibility and lateral resistance, particularly for areas with moderate seismic activity at angle of Diagrid 77° and 80°.

Keywords: Diagrid structure, Inner core system, Moment frame, Shear wall, Braced tube, Seismic performance, ETABS, High-rise buildings

I. INTRODUCTION

Tall buildings have become increasingly important in modern cities, driven by rapid urbanization, rising population densities, and limited availability of land in metropolitan areas. According to the Council on Tall Buildings and Urban Habitat (CTBUH), a structure is considered tall when it exceeds 50 meters in height—a definition that also corresponds with Indian standards. This classification highlights the growing global significance of tall buildings in contemporary urban development.

Tall buildings are not just built to save space, they also provide an efficient way to include homes, offices, and shops in one small area. This helps make better use of land and reduces the need for cities to spread out. As a result, tall buildings support more sustainable urban development.

One of the key innovations in high-rise structural design is the diagrid system. This approach involves a network of diagonal structural elements—typically steel or concrete—arranged along the building's perimeter. By replacing conventional vertical columns, the diagrid reduces material usage and opens up new possibilities for architectural expression. Its high stiffness and strength make it especially effective in resisting lateral forces such as wind and seismic loads, which are crucial in tall building design.

Diagrids not only support both vertical and lateral loads but also enable complex and dynamic architectural forms. Prominent examples include the IBM Building in Pittsburgh, the Capital Gate Tower in Abu Dhabi, and the Guangzhou West Tower in China—the tallest diagrid structure constructed to date. These projects demonstrate the structural efficiency and design flexibility inherent in the diagrid system, proving its adaptability across a wide range of building geometries and functions.

Recent studies have increasingly focused on how diagrid systems perform during seismic events. Findings suggest that compared to traditional framed structures, diagrids experience lower shear lag and exhibit greater lateral stiffness. These characteristics enhance their seismic resilience, making them a promising solution for high-rise buildings in earthquake-prone regions. This study seeks to analyze the structural behavior of diagrid systems under both vertical and lateral loads, with the goal of evaluating their potential to improve earthquake resistance in tall building design.

Ax ial performance of the diagonal elements, decreasing the need for internal columns. The diagrid system can be constructed without corner columns. Perimeter diagonal elements carry the gravity and lateral loads. This system also allows for complex and curved configurations, such as Capital Gate Tower in Abu Dhabi and Tornado Tower in Qatar. The study of diagrid systems has increased in recent years. Leonard [1] studied the influence of shear lag on tall buildings with diagrid tube and framed tube systems. They found that the diagrid building experienced less shear lag effect because of its higher structural stiffness. Moon et al. [2] developed a simple design methodology for determining preliminary design sizes for the diagonal elements. Mele et al. [3] presented a methodology to assess the axial forces of the diagonals. Other design studies have recommended varying angles throughout the height of the structure for diagrid systems (Moon [5]; Moon [6]; Zhang et al. [7]). Kim et al. [8], Kim and Lee [3], and Mashhadiali and Kheyroddin [9] evaluated the inelastic seismic performance of diagrid tubes. Kim and Lee [10], Kim and Kong [11], Mashhadiali and Kheyroddin [12] investigated progressive collapse behavior of diagrid tubes. The behavior of large-scale bracing systems showed that they decreased the lateral displacement, drift ratio, and uplift forces and increased ductility and shear absorption over results from other bracing arrangements. Lee et al. [13] evaluated the seismic performance of axi-symmetric diagrid structures with circular plan shape based on the ATC-63. It was concluded that the seismic safety for an identified earthquake decreases as the vertical irregularity increases. Lacidogna et al. [14] analyzed the structural performance of diagrid systems combined with an inner closed-section and open-section shear wall core. They used an analytical formulation, called General Algorithm (GA) to perform the structural analysis. The inner shear wall had a significant impact on the torsional rotations. Chengqing Liu and Dibing Xu [15] investigated the seismic performance of diagrid core-tube structures with varying equivalent stiffness ratios and brace angles (71°, 77°, and 80°). Their study revealed that increased stiffness ratio and seismic intensity lead to redistribution of shear forces, reduced story shear coefficients, and amplified shear lag. Azadeh Jalali and Ali Massumi [16] analyzed the impact of internal core types (braced vs. moment-resisting) and diagonal brace angles (50.19°, 60.95°, and 67.38°) on diagrid tower performance. Braced cores improved ductility and load capacity, while brace buckling remained a key failure mode. A brace angle of 50.19° with a moment frame core exhibited the highest ultimate load capacity. Di Wu et al. [17] performed shake table tests on a scaled diagrid-core model, demonstrating elastic behavior under SLE, and localized damage under DBE and MCE. Significant axial force variation among same-story diagonals was noted. Despite local failures, the structure showed strong overall ductility and resilience. Ismael Asadi and Hojjat Adeli [18] emphasized the sustainability and aesthetic versatility of diagrid structures. While twisted and curved diagrids reduce wind effects and dead loads, structural integrity is compromised if more than 11% of diagonal members in a story fail, highlighting a collapse threshold. Jinkoo Kim and Young-Ho Lee [19] assessed seismic behavior of diagrids with angles between 50.2° to 79.5°, comparing them to tubular systems. Diagrids showed higher stiffness but also brittle failure due to brace buckling. Circular-plan diagrids performed better than square ones, and brace angles between 60° and 70° yielded optimal seismic performance. Dengjia Fang and Chengqing Liu [20] explored mechanical behavior and deformation of steel diagrids under vertical and lateral loads using experimental and FEM analyses. A close match between theoretical and experimental results was found, with less than 13% deviation. Analytical models for stiffness and displacement were developed. C. Rahul and J.K. Lokesh [21] studied the impact of slab type (flat vs. conventional) and diagonal angle (41°–64°) on seismic performance. Flat slabs reduced displacement, while conventional slabs offered better shear resistance. An optimal brace angle of 56°–61° was identified for balanced performance across slab systems.

II. METHOD

To evaluate how buildings respond and perform under loads, different types of analysis are used. These include both linear and nonlinear methods. Linear analysis involves three main types: linear static (also called equivalent static) analysis, linear dynamic (response spectrum) analysis, and linear time history analysis. Nonlinear analysis includes nonlinear static (pushover) analysis and nonlinear time history analysis.

Equivalent static analysis mainly considers the fundamental mode of vibration and is not suitable for tall buildings over 50 meters. Response spectrum analysis helps account for the effects of higher modes. In linear time history analysis, the structure's response is calculated step-by-step over time using ground motion data that matches the design response spectrum for the site.

Nonlinear time history analysis requires more computing power and is used to study key parameters like drift ratio, energy dissipation, and residual inter-story drift under earthquake ground motions. On the other hand, nonlinear static (pushover) analysis is simpler, faster, and gives clear insights. It helps identify how the structure behaves, including internal forces, element deformations, failure patterns, and when different parts start to yield.

This research paper focuses on using response spectrum analysis to understand how the inner core and outer diagrid system share lateral forces and perform during earthquake and find out efficient structural system in terms of maximum story displacement, inter story-drift, base shear and time period.

III. OVERVIEW OF ANALYSIS

A total of 18 structural models have been considered for analysis in this study to evaluate the seismic performance of diagrid systems with various inner core configurations. The models are designed with three different types of inner core systems: moment-resisting frame, braced tube, and shear wall. Additionally, the diagrid angle is varied at 72°, 77°, and 80° to study its effect on the lateral behavior of the structure. Previous research has shown that the diagrid angle significantly influences the axial and bending behavior of diagonal members, which in turn affects the overall stiffness, stability, and lateral load resistance of the structure. For example, diagrid angles closer to 80° tend to improve vertical load-carrying efficiency but may reduce lateral stiffness, while angles in the range of 60° to 75° enhance lateral stiffness and seismic performance Dibing Xu [16].

Moreover, to investigate the influence of building height, two different structure heights are considered 129.6 meters (36 storeys) and 172.8 meters (48 storeys). Tall buildings are more sensitive to lateral loads such as wind and earthquakes, and the distribution of stiffness and strength throughout the height of the structure becomes critical. By combining different diagrid angles with varying inner core systems and building heights, this study aims to identify the most effective structural configuration for maximizing seismic resistance and minimizing drift and displacement.

The variation in diagrid angle directly affects the geometry of load paths, which modifies how lateral forces are transferred and resisted by both the perimeter diagrid and the core system. For instance, a steeper diagrid angle (closer to vertical) results in longer diagonal members, reducing their effectiveness in resisting lateral shear. On the other hand, shallower angles result in a denser diagonal arrangement that contributes more significantly to lateral stiffness but may increase material usage. Thus, balancing the diagrid angle with the type of core is essential for achieving efficient structural performance.

Through this parametric study, the interaction between diagrid geometry, core type, and building height is explored in depth to better understand their impact on key seismic performance parameters such as base shear, storey drift, Storey displacement.

IV. MODELING AND ANALYSIS OF 36 STORY DIAGRID WITH INNER CORE

A diagrid structural model based on the West Tower (Guo, 2011) was designed with a floor plan of 30 × 30 meters. The building has 36 floors in total, each with a height of 3.6 meters, making the overall height 129.6 meters. The diagonal members of the diagrid are placed at a 77° angle. The structure is divided into four modules, with each module covering four floors.

The structure is located in a seismic III It is built on a site classified as Category I (soil type), The floors are designed to carry a dead load 1kN/m² and a live load of 3 kN/m² each. Concrete-filled steel tubular (CFST) members are used as the columns of the inner tube. I-shaped steel beams are used as ring beams and as link beams connecting the outer diagrid to the inner core.

The inner core consists of reinforced concrete shear walls, which changed with design variations. The Diagrid member are modeled using the ETABS V21. The ring beams, link beams, and coupling beams are modeled with frame elements. Floor slabs use M40 concrete, with Characteristic compressive strength of 40 MPa. The shear walls and CFST elements use M40 Grade concrete, which has a compressive strength of 40 MPa. shell elements are used to simulate the reinforced concrete shear walls. The steel used is Fe345, with a yield strength of 345 MPa.

The specific dimensions of all components are provided in Table 1, and the structural model is illustrated in Figure 1. The structural periods are listed in Table 2.

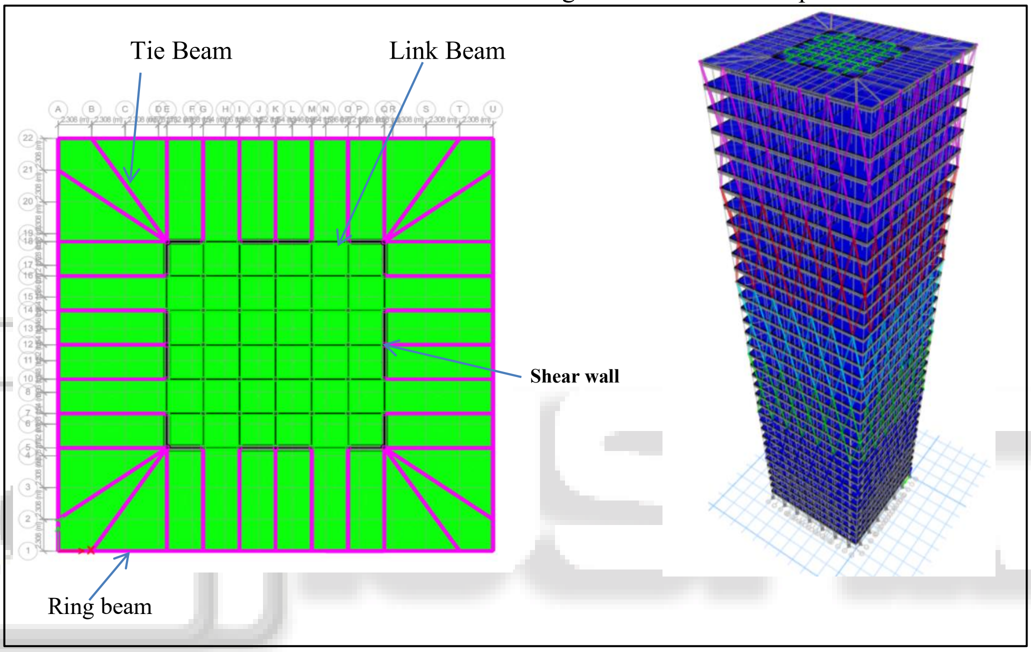

Fig. 1: Plane view and 3D view of model

Description		Dimensions(mm)
Diagrid size	1-6 Storey	500 × 40
	7-12 Storey	480 × 39
	13-18 Storey	460 × 38
	19-24 Storey	440 × 37
	25-30 Storey	420 × 36
	31-36 storey	400 × 35
Column size (CFST)	1-6 Storey	400 × 25
	7-12 Storey	380 × 24
	13-18 Storey	360 × 23
	19-24 Storey	340 × 22
	25-30 Storey	320 × 21
	31-36 Storey	300 × 20
Description		Dimensions(mm)
Shear wall	1-12 storey	400
	13-24 storey	350
	25-36 storey	300
Tie beam	1-36 storey	500 × 180 × 10.2 × 17.2
Ring beam	1-36 storey	400 × 130 × 8.9 × 16
Link beam	1-12 storey	450 × 400
	13-24 storey	400 × 350
	25-36 storey	350 × 300

Table 1: Dimension of member

Time period (Seconds)									
Mode	DMF	DBT	DSW	DMF	DBT	DSW	DMF	DBT	DSW
	72^0			77^0			80^0		
1	1.914	1.884	1.761	2.128	1.901	1.875	2.272	2.207	1.958
2	1.909	1.877	1.758	2.119	1.895	1.873	2.256	2.194	1.951
3	0.802	0.788	0.773	1.086	0.796	0.985	1.294	1.246	1.128
4	0.562	0.55	0.504	0.664	0.555	0.556	0.718	0.683	0.585
5	0.561	0.548	0.503	0.661	0.553	0.555	0.713	0.679	0.583
6	0.293	0.285	0.272	0.383	0.288	0.345	0.452	0.434	0.393
7	0.293	0.285	0.258	0.357	0.287	0.288	0.39	0.365	0.304
8	0.283	0.278	0.258	0.356	0.281	0.288	0.387	0.362	0.303
9	0.201	0.195	0.172	0.248	0.197	0.207	0.275	0.263	0.235

Table 2: Time period

According to Table 2, the fundamental mode period is greater than 1 seconds. The table also shows that as the slope of the diagrid's perimeter increases, the natural period increases for structures with a moment frame, braced frame, and shear wall. In all the analyzed structures, both the internal core and the diagonal elements on the perimeter have rigid joints, allowing them to work together in resisting both gravity and lateral loads.

V. RESULT AND DISCUSSION

Among all the models, the DSW 72° (Model-3) showed the lowest lateral displacement of 175.77 mm, followed closely by DSW 77° (Model-6) with 176.28 mm. These two models outperformed the others in minimizing the horizontal sway of the structure under earthquake loading. On the other hand, the highest displacement was recorded for DMF 80° (Model-7) at 246.13 mm, indicating reduced lateral stiffness at a steeper diagrid angle in combination with a moment frame core.

For maximum story drift, several models exhibited excellent performance. DBT 72° (Model-2), DSW 72° (Model-3), DBT 77° (Model-5), and DSW 77° (Model-6) all recorded the lowest drift value of 0.0016, indicating better control over inter-story movement. The highest drift of 0.0026 was again seen in DMF 80° (Model-7), which reinforces the observation that the moment frame core becomes less effective at higher diagrid angles.

Base shear represents the total lateral force transferred to the base of the building during an earthquake. The models with an 80° diagrid angle showed the lowest base shear values, with DMF 80° (Model-7) at 19067.25 kN and DMF 80° (Model-8) at 191635.14 kN. Although these values are favorable in terms of base force, they must be balanced against the corresponding high displacement and drift values.

		Lateral Displacement(mm)	Max. Drift (mm)	Base shear(kN)
Model-1	DMF 72 ^{O}	182.99	0.0017	21601.69
Model-2	DBT 72 ^{O}	180.90	0.0016	21696.48
Modal-3	DSW 72 ^{O}	175.77	0.0016	23031
Model-4	DMF 77 ^{O}	190.23	0.0018	21515.23
Model-5	DBT 77 ^{O}	188.18	0.0016	21705.71
Model-6	DSW 77 ^{O}	176.28	0.0016	23218.30
Model-7	DMF 80 ^{O}	246.13	0.0026	19067.25
Model-8	DBT 80 ^{O}	239.45	0.0023	19163.142
Mode-9	DSW 80^O	227.70	0.0024	19923.10

Table 3: Result

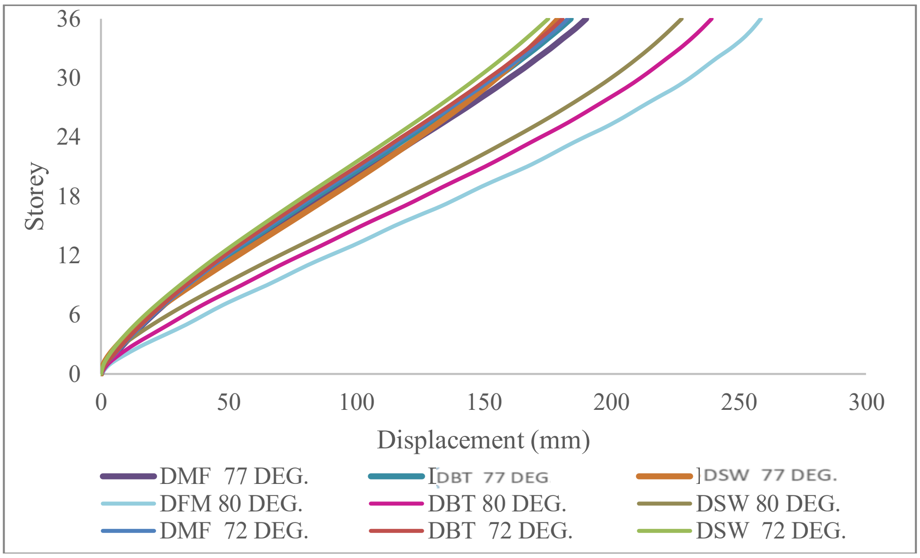

Fig. 2: Storey Displacement

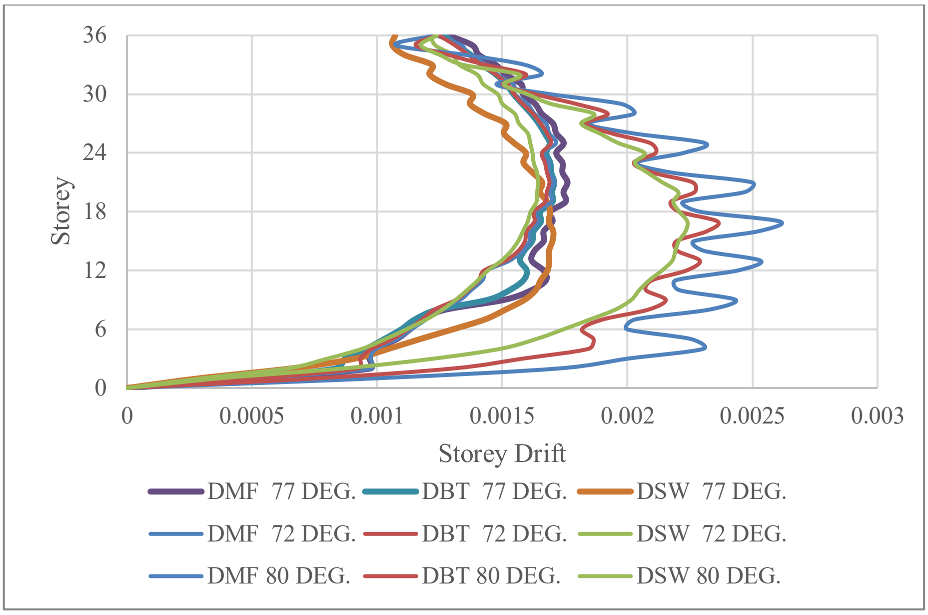

Fig. 3: Storey-Drift

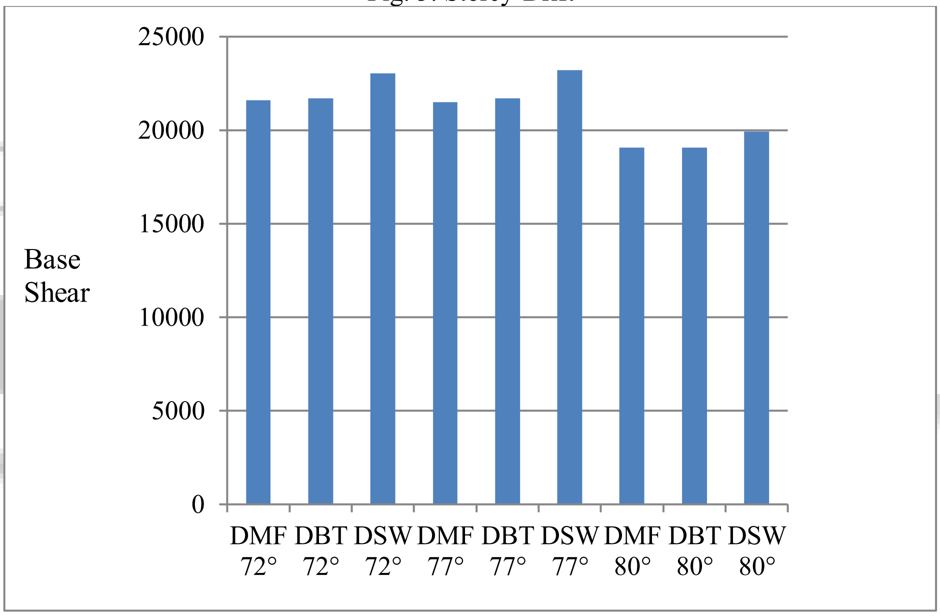

Fig. 4: Maximum Base Shear

When evaluating all three seismic performance parameters—lateral displacement, story drift, and base shear—the DSW 77° (Model-6) stands out as the most balanced and effective configuration. It provides: One of the lowest displacements (176.28 mm), excellent drift performance (0.0016), and a reasonable base shear value (23218.30 kN).

This suggests that a shear wall core combined with a moderate diagrid angle (77°) achieves the best overall seismic behavior for the 36-story diagrid structure. It effectively balances lateral stiffness, and load distribution, making it a strong Structural configuration for high-rise buildings in earthquake-prone regions.

VI. Modeling and Analysis of 48 Story Diagrid with Inner Core

A diagrid structural model based on the West Tower (Guo, 2011) was designed with a floor plan of 30 × 30 meters. The building has 48 floors in total, each with a height of 3.6 meters, making the overall height 172.8 meters. The diagonal members of the diagrid are placed at a 77° angle. The structure is divided into four modules, with each module covering four floors.

The structure is located in a seismic III It is built on a site classified as Category I (soil type), The floors are designed to carry a dead load 1kN/m² and a live load of 3 kN/m² each. Concrete-filled steel tubular (CFST) members are used as the columns of the inner tube. I-shaped steel beams are used as ring beams and as link beams connecting the outer diagrid to the inner core.

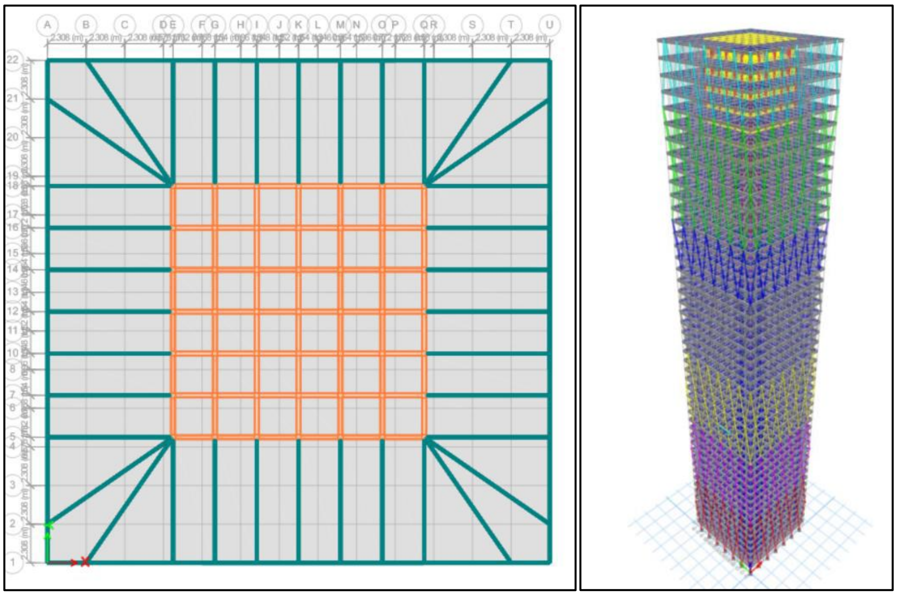

Fig. 5: Plan and 3D view of Diagrid with inner core 48 Storey

The inner core consists of reinforced concrete shear walls, which changed with design variations. The Diagrid member are modeled using the ETABS V21. The specific dimensions of all components are provided in Table 4, and the structural model is illustrated in Figure 5. The structural periods are listed in Table 5.

Description		Dimensions(mm)
Diagrid size	1-6 Storey	540 × 42
	7-12 Storey	520 × 41
	13-18 Storey	500 × 40
	19-24 Storey	480 × 39
	25-30 Storey	460 × 38
	31-36 storey	440 × 37
	37-42 Storey	420 × 36
	43-48 Storey	400 × 35
Column size (CFST)	1-6 Storey	440 × 27
	7-12 Storey	420 × 26
	13-18 Storey	400 × 25
	19-24 Storey	380 × 24
	25-30 Storey	360 × 23
	31-36 Storey	340 × 22
	37-42 Storey	320 × 21
	43-48 Storey	300 × 20

Table 4: Dimension

Time period (Seconds)									
MODE	DMF	DBT	DSW	DMF	DBT	DSW	DMF	DBT	DSW
	72^0			77^0			80^0		
1	3.02	2.989	2.777	3.244	3.19	2.835	3.4	3.329	2.994
2	3.013	2.982	2.774	3.233	3.181	2822	3.383	3.313	2.986
3	1.079	1.064	1.034	1.453	1.414	1.367	1.726	1.66	1.513
4	0.834	0.812	0.748	0.962	0.925	0.648	1.034	0.988	0.859
5	0.831	0.809	0.746	0.959	0.923	0.656	1.028	0.982	0.857
6	0.425	0.41	0.375	0.522	0.507	0.475	0.615	0.59	0.541
7	0.424	0.409	0.374	0.505	0.478	0.374	0.549	0.515	0.44
8	0.388	0.382	0.372	0.503	0.477	0.372	0.545	0.512	0.438
9	0.29	0.278	0.251	0.349	0.327	0.251	0.38	0.357	0.323

Table 5: Time period

According to Table 5, the fundamental mode period is greater than 2 seconds. The table also shows that as the slope of the diagrid's perimeter increases, the natural period increases for structures with a moment frame, braced frame, and shear wall. In all the analyzed structures, both the internal core and the diagonal elements on the perimeter have rigid joints, allowing them to work together in resisting both gravity and lateral loads.

VII. RESULT AND DISCUSSIONS

In this research paper, the seismic performance of 48-story diagrid structures was evaluated using three different core systems—moment-resisting frame (DMF), braced tube (DBT), and shear wall (DSW)—combined with diagrid angles of 72°, 77°, and 80°.The assessment focused on three critical parameters: lateral displacement, maximum inter-story drift, and base shear, each of which plays a key role in determining structural behavior during seismic events.

		Lateral Displacement(mm)	Max. Drift (mm)	Base shear(kN)
Model-1	DMF 72 ^{O}	260	0.0019	31431.24
Model-2	DBT 72 ^{O}	265.24	0.0018	32135.76
Modal-3	DSW 72 ^{O}	252.43	0.0017	34667.25
Model-4	DMF 77 ^{O}	306	0.0023	33227.08
Model-5	DBT 77 ^{O}	293	0.0021	34890
		Lateral Displacement(mm)	Max. Drift (mm)	Base shear(kN)
Model-6	DSW 77 ^{O}	274	0.0019	35325
Model-7	DMF 80 ^{O}	350	0.0025	32530
Model-8	DBT 80 ^{O}	330.058	0.0023	33625.43
Mode-9	DSW 80^{O}	295.84	0.0021	34630.22

Table 1: Result

Lateral displacement, which represents the total horizontal deflection of the structure during seismic loading, was lowest in the DSW 72° model, with a recorded value of 252.43 mm. The DSW 77° configuration followed closely, showing a displacement of 274 mm. Both models were better than the others at staying strong and controlling Displacement. Conversely, the DMF 80° model exhibited the maximum displacement of 350 mm, indicating a reduction in lateral stiffness at higher diagrid angles when paired with a moment-resisting frame.

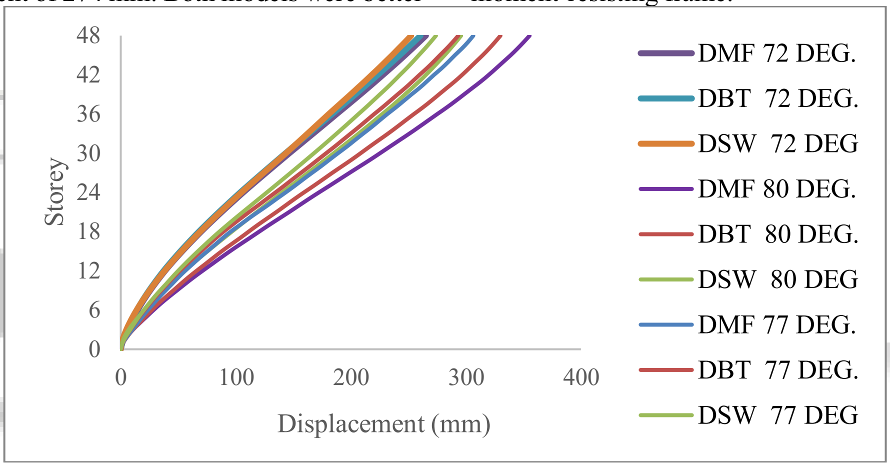

Fig. 1: Storey-Displacements

Inter-story drift, reflecting the relative movement between consecutive floors, is a critical indicator of non-structural damage and occupant safety. The lowest drift values were observed in the DSW 72° (0.0017), DBT 72° (0.0018), and both DSW 77° (0.0019). These results demonstrate effective drift control. In contrast, the DMF 80° model displayed the highest drift at 0.0025, suggesting a decline in performance at steeper diagrid inclinations with moment frames.

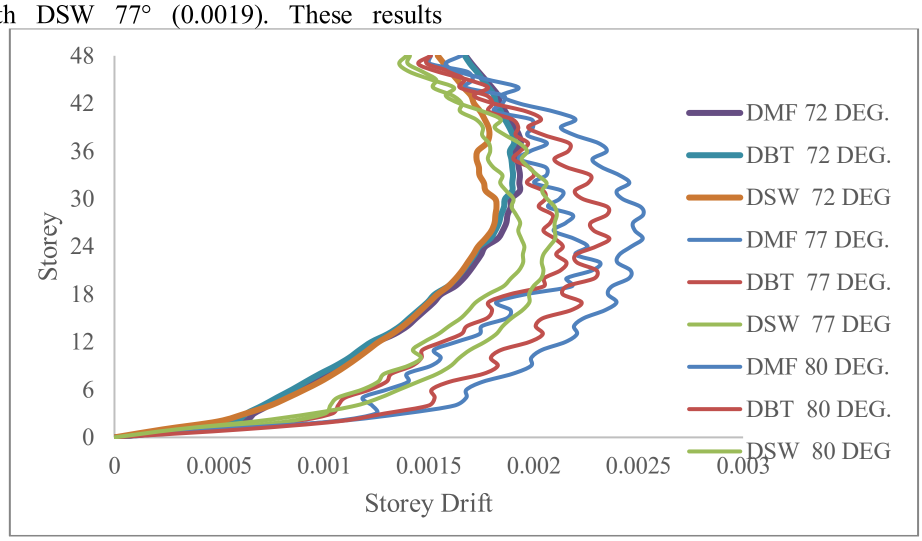

Fig. 2: Inter-Storey Drift

Base shear refers to the total seismic force exerted at the base of the structure. Higher base shear values were noted in models with DSW 77° experienced the highest at 35,325 kN. likely due to increased mass participation and lateral force transfer. Among all configurations, the DMF 72° model has lowest base shear at 31,431.24 kN. Despite the elevated base shear, the DBT 77° model maintained superior performance in displacement and drift criteria.

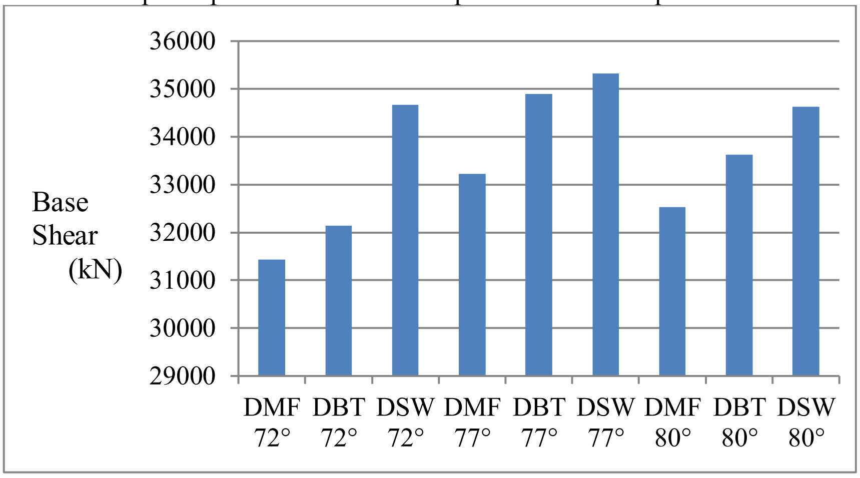

Fig. 3: Base Shear

Considering all three parameters collectively, the DSW 77° model demonstrates the most balanced and efficient structural response under seismic conditions. With a relatively low Displacement (274 mm), excellent control over drift (0.0019), and an acceptable base shear in terms of the structural Serviceability. base shear (35,325 kN), this configuration offers an optimal combination of strength and flexibility. The findings suggest that a diagrid structure incorporating a shear wall core with a 77° angle is the most effective among those studied for resisting earthquake-induced forces in high-rise buildings.

VIII. Material Comparison

	Material	Volume (m^3)	Weight (kN)
36 story (DMF)	Steel	--	66420.38
	Concrete	4819.634	--
36 story (DBT)	Steel	--	71944.13
	Concrete	5000.752	--
36 story (DSW)	Steel	--	66420.38
	Concrete	66420.38	--
48 Story (DMF)	Steel	--	106753.6
	Concrete	6334.012	--
48 story (DBT)	Steel	--	116785.8
	Concrete	5869.182	--
48 story (DSW)	Steel	--	106753.6
	Concrete	11405.92	--

IX. Conclusion

In analyzing the Diagrid Moment Frame (DMF), Diagrid with Shear Wall (DSW), and Diagrid Braced Tube (DBT) systems, the influence of diagrid angle variation (72°, 77°, and 80°) on key factors such as time period, lateral displacement, inter-story drift, base shear, and material costs becomes clear. Each system performs differently based on these factors, which are vital when choosing the right system for a specific project.

The DMF system is more flexible, and as the diagrid angle increases, so do the time period, lateral displacement, and inter-story drift. At 72° the system is stiffer, with a shorter time period, but at 80°, it becomes more flexible, with a longer time period and increased displacement and drift. The steeper the angle, the higher the lateral movement under load. The base shear also drops as the angle increases, showing a decreased ability to resist lateral forces. The DMF system requires considerable steel because of the slender diagrids and the lack of other lateral-resisting elements, leading to higher material costs, particularly at steeper angles (80°), were increased flexibility results in reduced performance. While the DMF system works well for shorter buildings, it becomes less efficient at higher diagrid angles because of the larger displacement and drift.

On the other hand, the DSW system incorporates shear walls, which enhance the structural stiffness. As the diagrid angle increases, the time period, lateral displacement, and inter-story drift stay relatively stable. At 80°, the system remains stable because of the shear walls' ability to resist lateral forces. The base shear increases slightly, reflecting the shear walls' effectiveness. However, the DSW system required higher material costs compared to the DMF system, particularly at the 80° angle, where the shear walls significantly increase the concrete volume. Nevertheless, the DSW system is ideal for high-seismic zones, where its superior lateral resistance provides better structural safety, particularly at 80°, where seismic forces are stronger.

The DBT system strikes a balance between the DMF and DSW systems. It offers a compromise between flexibility and lateral resistance, with moderate time period, lateral displacement, and inter-story drift. The base shear for the DBT system is higher than that of the DMF system, but lower than the DSW system, indicating that it resists lateral forces better than the DMF but is not as stiff as the DSW. From a cost perspective, the DBT system is more Expensive than the DSW system, especially at the 72° angle, where bracing reduces the need for extra concrete. While the steel consumption is higher due to the bracing, it remains more Exclusive than the concrete needed for shear walls in the DSW system. This makes the DBT system an option for projects that require a balance structural for high-rise structure, especially at angles like 77° and 80°, where the flexibility of the DMF system may become problematic.

The cost comparison between the three systems shows that the DMF system works best for low-rise buildings at angles of 72° and 77°, where flexibility are prioritized. While it's cost-effective for shorter structures, at steeper angles (80°), The DSW system is most stable but also the most expensive, making it ideal for high-rise buildings in high seismic at 80°, where structural safety is crucial. Despite its higher costs, it provides the best performance in terms of lateral resistance and stability. The DBT system offers a middle ground, with better lateral resistance than the DMF system at angles of 72° and 77°.

The DMF, DSW, and DBT systems each offer unique performance and cost characteristics suited to different building types and locations. The DMF system is ideal for buildings where aesthetics and flexibility are important, especially for low-rise structures at 72° or 77°. While it's cost-effective for shorter buildings, it needs extra lateral-resisting elements at 80°, making it more expensive for taller buildings. The DSW system, the most stable and might be some costly, is best for 48 story buildings in high seismic at 80°, where safety is the priority. The DBT system provides a balanced option with a good performance, offering a practical compromise between flexibility and lateral resistance, particularly for areas with moderate seismic Zone at 77° and 80°.

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