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OPTIMIZATION OF FLUID VISCOUS DAMPER CHEVRON BRACING ARRANGEMENT IN G+9 RCC STRUCTURE

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ABSTRACT

Seismic activity is unpredictable in nature which results a structural damage and collapse eventually a great loss to human life and the aspects of property. With this concern, much consciousness has been initiated by research and development of structural control techniques such as passive and active system are associated in the forms of Tuned Mass Damper (TMD), Fluid Viscous Dampers (FVD), Base Isolation etc. In the present study an experiment has been made by considering (G+9) RCC structure with the propagation of seismic analysis using SAP-2000. The structure will be analyzed with the installation of fluid viscous damper (FVD) positioned at various patterns of total 17 Types have adopted on trial based in chevron bracing system. The effectiveness of the analyzed modals should be clearly observed as the resultant structural behavior, such as Displacement, story drift, drift ratio& base reaction etc. The best optimal arrangement of dampers will be suggested for structural response of vibrating system.

Keywords: Seismic Activity, Fluid Viscous Damper, Base Reaction, Displacement, Story Drift, Drift Ratio.

I. INTRODUCTION

Here Strong earthquakes can occur at irregular intervals, often separated from each other by long intervals. This is why the earthquakes in many of the threatened countries is very often underestimated and regarded as a rather theoretical item. The amount of damage that is caused by earthquakes could increase in the future. This will not be due to a growth in the number and sternness of earthquakes, but rather to the increase in world population, linked to the growing number of crowded urbanite cities and the increasing value of property and quantifiable in these areas. More than three-quarter of the mega cities in the world, are located as threatened zones. Over the past fifty years, the earthquakes are characterized into two groups such as near-field quakes and far-field quakes based on the distance of the place of recording the earthquake from the fault. Later, its definition was improved and other factors also inclined this categorization. Over the past years, the research studies concentrated on the studies of impact of ground motion in the near-field quake on the structural performance. The devastating effects of the recent upheavals such as the Northridge quake (1994), Kobe quake (1995), and Taiwan quakes (1999) on the buildings of the cities adjacent to a fault, and with regard to close location of many of the cities of India to the active faults indicates the worth of the research.

Over the recent year's heavy cost have been paid for accurate recognition of the forces of an earthquake by the research institutes of the world with the purpose of declining its damage, the increasing need for more research studies on the effects that resulted from the trembling is felt in the theoretical and laboratory scales. The most efficient way to avoid a disaster caused by earthquakes is employing earthquake- resistant design in seismically active regions.

- **Control Systems and Dampers:**

Control systems:

Generally, we have four different types of control systems which can be accepted for considering the dampers in structure such as

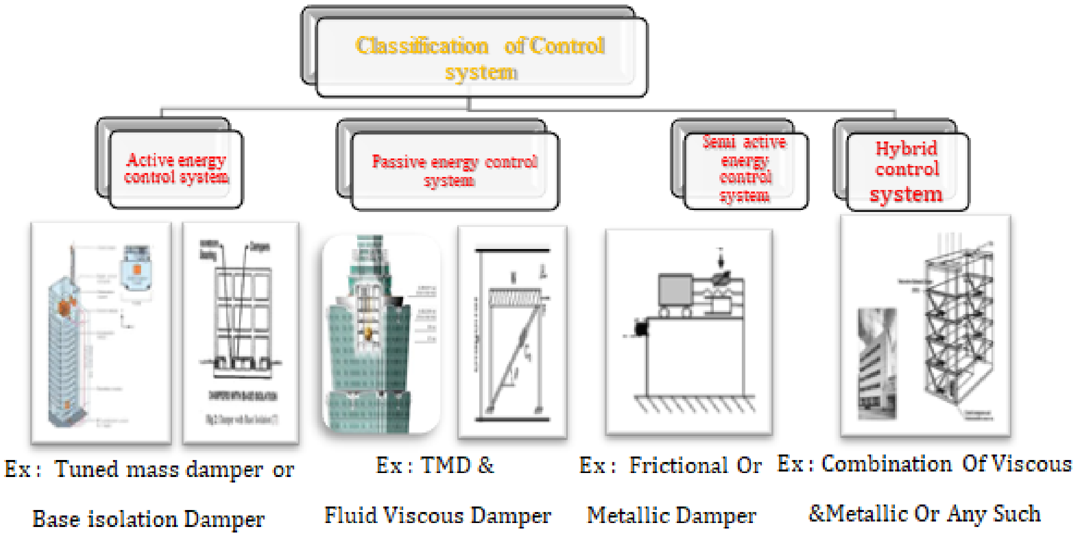

Fig 1: Classification of control systems

- **Energy dissipations devices:** The devices that absorbs the vibrations coming from the structure due to a seismic incident. Which aids the structure to be an shaking resistant structure. The devices can be machine-driven dissipators of vibrators arranged to the structure. One of the best instances for energy dissipation devices are **dampers**.
- **Dampers:** the devices which are used to absorb or dissipate the vibration instigated by the earthquake to the structure and to intensification the damping and stiffness of the structure.
- **Classification of Dampers:** Dampers are classified based on their act of chafing, metal (Flowing), Viscous, Viscoelastic, shape memory alloys (SMA) and mass inhibitions. About the advantages of using inhibitions, we can infer to high energy absorbance, easy to fit and replace them as well as direction to other structural members.

- Viscous damper
- Viscoelastic damper
- Friction damper
- Tuned mass damper
- Yielding damper
- Magnetic damper
- Mass damper

Viscous Dampers: It is a seismic energy absorber by silicone-based fluid transient between piston-cylinder arrangements. Viscous damper inhibitions are used in high-rise constructions and low-rise constructions in seismic zones. It can function over an encompassing temperature reaching from 40°C to 70°C. Viscous damper condenses the vibrations induced by both strong breeze and quake.

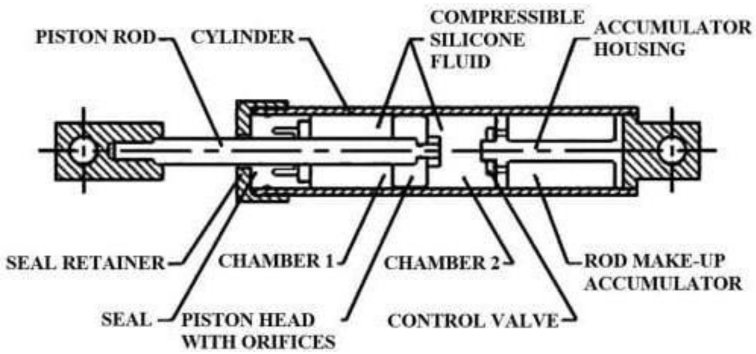

Fig 2: Schematic Detailing of Viscous Damper Components

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II. METHODOLOGY

The analysis is carried out on a G+9 RCC building on SAP2000 software. The total 18 models are created on the Sap2000 with and without the installation of viscous dampers. The analysis carried the effect on building under the different loads such dead load, live load and earthquake and wind etc., into it based on software mechanism. Indian standard codes used are IS 456:2000 and IS:875:1987 part2,3 and for seismic data is taken as per the IS 1893(PART1):2002. The linear static analysis method is adopted for analysis of G+9 building.

III. MODELING AND ANALYSIS

In the present study a linear symmetric RCC structure is considered and modeled by using a software package SAP-2000. This structure plan size is 32x20m with lengths along x-direction are 5m,4m,5m,4m,5m,4m, and 5m and in y-direction are 4m,3m,5m,5m,3m.5m, and 4m with structure height 30m.Thus the ideology has to observe and identify best optimum arrangement of damper in structure and to observe the behavioral changes of G+9 structures, for ordinary (without) and viscous damper installation building (chevron system).

Table 1: Sectional Details

Site Area	800sqm
Carpet area	640sqm (32m x 20m)
Structural dimension:	
Slab thickness	150mm (6”)
Beam	450mm x 230mm
Column	600mm x 450mm
Wall thickness	Exterior 230mm
	Interior 110mm
Material details:	
Concrete	M35
Steel	Fe 500
Brick	A1Grade (standard size)

Table 2: Considerable Loads

Load Types	Values
Dead load	1.5 KN/m
Live load	3 KN/m
Floor finish	1 KN/m

Seismic loads are optimized in both the direction of X and Y and for design considerations Is 456:2000 is utilized. Seismic coefficients Seismic Zone v, Zone Factor 0.36, Medium soil, Soil type II, Damping coefficient 5% (0.05).

Table 3: Load patterns

Name	Type	Self-Weight Multiplier	Auto Load	Static Type
Dead	Dead load	1	-	Linear static
Live	Live load	0	-	Linear static
EQ X	Seismic load	0	IS 1893-2002	Linear static
EQ Y	Seismic load	0	IS 1893-2002	Linear static
Wind X	Wind load	0	IS 875-1987	Linear static
Wind Y	Wind load	0	IS 875-1987	Linear static

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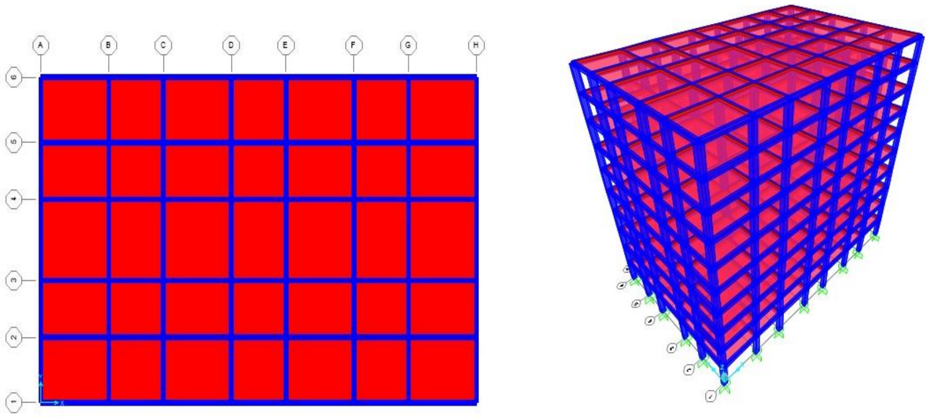

Fig 3: (a) Plan view (b) 3D view

3.1 Classification of Dampers:

Generally fluid viscous dampers are arranged in a Chevron Bracing system and Diagonal Bracing system, presently we have adopted chevron bracing system. Considering the trial-and-error approach methods, various patterns of diagonal bracing systems are arranged in total of 17 types of bracing arrangement.

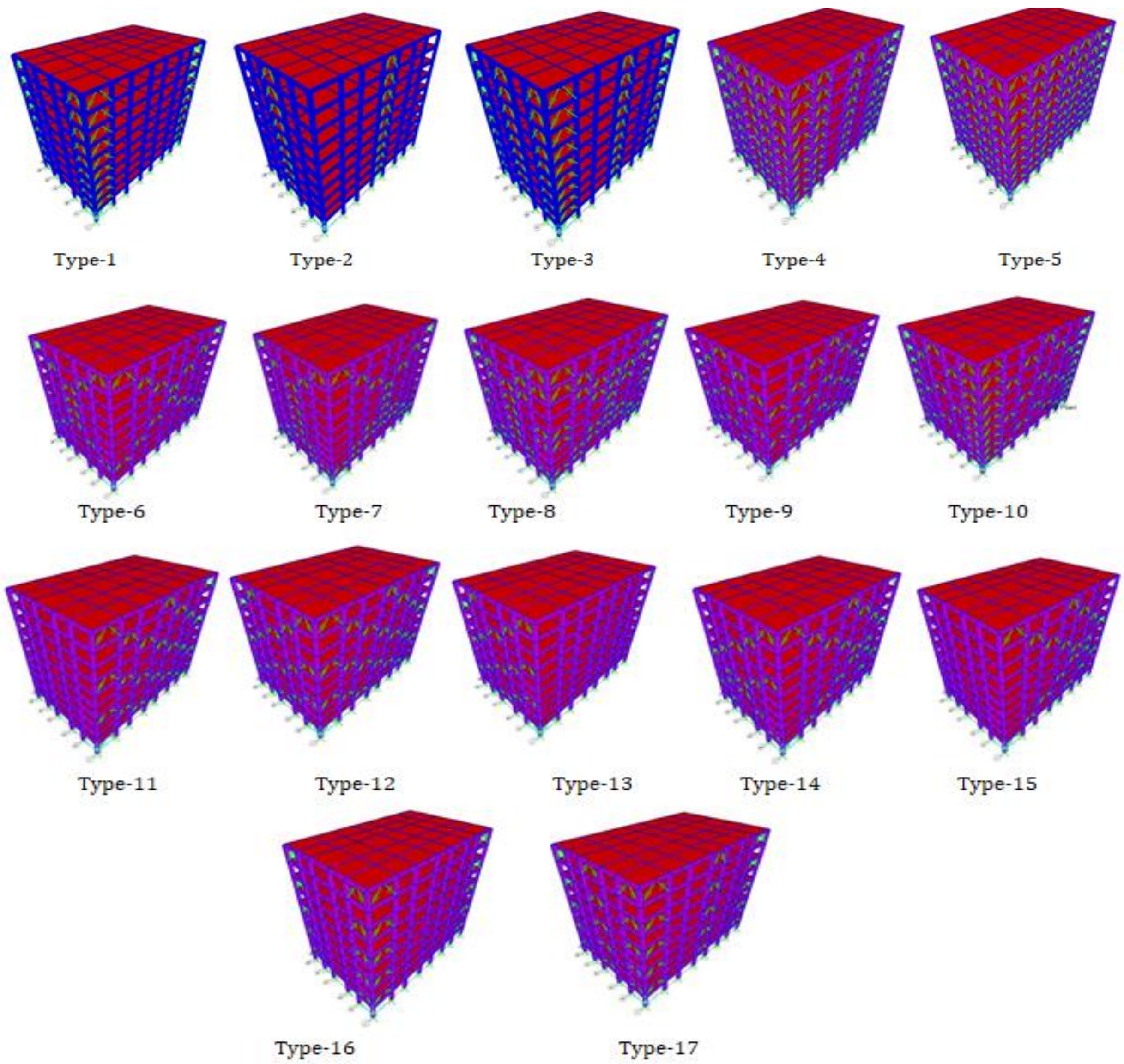

Fig 4: 3D View of building with different types of arrangement of bracing (FVD)

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In these patterns dampers are arranged in the portal frames of structure, diagonal aspect of the external bays in both (x & y) directions. The dampers are positioned in various patterns such as wing pattern. X pattern format and others w.r.t axis at the external corners of floors to counter act the forces due to seismic event on structure and dissipation of energy can be studied by such various arrangements and helps to choose best possible optimal arrangement of chevron bracing.

IV. RESULTS AND DISCUSSION

The analysis carried out on basic two fundamental approaches on the model structures (i.e., regular building without damper and with damper installed building), considering various arrangements of dampers, we have optimized trial and error system for 17 different bracing types of models with various positioned. The results obtained from the analysis are compared w.r.to each other for the better optimization pattern with minimum bracing arrangement.

4.1 Storey Displacement

It is displacement triggered by the lateral forces on each Storey level of the structure. Lateral displacement will be more on top Storey (whose drift ranges from h/50 – h/2000). Hence, after evaluating the structure with different bracing arrangements, the results obtained for 18 models including both without and with damper installation and their comparison are shown in following tabular form.

Table 4: Lateral displacements of buildings (18 Model)

DISPLACEMENTS											
Floors		G	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
With Out Damper (mm)		4.9	12.96	21.35	29.6	37.6	45.3	52.1	57.9	62.1	64.6
With Damper	**Type-1**	4.1	7.3	9.88	16.49	23.74	31.23	38.59	45.59	51.9	57.57
	Type-2	1.2	5.16	11.49	18.91	26.74	34.51	41.811	48.33	53.92	58.51
	Type-3	2.8	5.1	7.1	8.1	10.14	11.23	12.1	12.5	14.3	16.1
	Type-4	4	7.3	10.14	12.48	14.37	15.86	17.1	20.6	24.1	27.3
	Type-5	3.4	6.3	8.9	11.1	12.8	14.2	15.3	16	16.4	16.43
	Type-6	7.4	16.91	18.44	19.5	20.4	24.1	27.8	28.5	29.3	29.9
	Type-7	2.5	3.7	5.12	6.4	11.4	19.9	27.4	28.6	29.3	29.8
	Type-8	3.1	5.2	7.6	9.4	11.3	12.1	12.89	13.6	14.1	14.14
	Type-9	2.6	4.9	7.4	8.6	10.2	12.1	13.14	15.9	17.2	18.54
	Type-10	3.7	6.6	9.2	11.1	12.6	14	14.9	15.2	15.6	16.73
	Type-11	2	4	5.9	7.1	8.2	9.3	9.7	10.16	10.53	10.55

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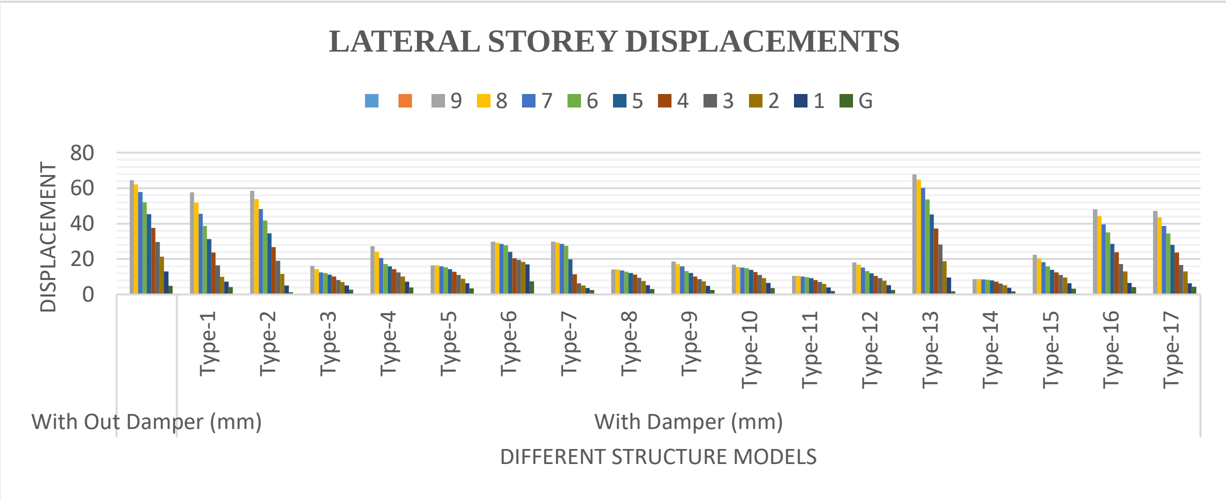
	Type-12	2.6	5.3	7.8	9.2	10.54	12.02	13.16	15.16	16.8	18.15
	Type-13	1.9	9.5	18.8	28.2	37.3	45.2	53.6	60.1	64.9	67.68
	Type-14	1.89	3.73	5.19	6.23	7.23	8.03	8.27	8.48	8.6	8.7
	Type-15	3.2	6.4	9.6	11	12.5	14	15.9	18.2	20.3	22.4
	Type-16	4.2	6.6	13	17.1	23.9	28.6	35.1	39.5	44.3	48
	Type-17	4.4	6.4	13	16.7	23.7	28	34.5	38.6	43.5	47.1



Graph 1: Displacement of story's with and without dampers

4.2 Displacement Reduction Percentage

Observing the various types of arrangements in building we can generalize that after installation of dampers the displacement is reduced gradually, with the minimum reduction of 9.43% (Type-2) and 86.53% (Type-14) as the maximum when compared to the displacements of structure which has no dampers.

Table 5: Lateral displacements of buildings (18 Model)

Types of Structural Models	**Maximum Displacement**
	% reduction comparing with Regular building
Type -1	10.88
Type -2	9.43
Type -3	**75.1**
Type -4	57.73
Type -5	74.57
Type -6	53.72
Type -7	53.87
Type -8	78.11
Type -9	71.3
Type -10	74.1

Type -11	**83.67**
Type -12	71.9
Type -13	10.1
Type -14	**86.53**
Type -15	65.33
Type -16	25.69
Type -17	27.1

To maximize the performance of viscous dampers, the optimization study on the location of chevron bracing arrangement at various elemental positions was conducted on seventeen alternative arrangements are made w.r.to Regular building. The results are summarized in Table 4.2. As expected, the fundamental period of vibration of the braced structure declines due to the increased stiffness. In most the trial cases, the period decreases due to the added stiffness resulting from the use of dampers.

Eventually comparing all 17 types of arrangement effective reduction in lateral story displacement have been observed in following three systems.

- Double wing shape bracing (Type – 14)
- Diagonal sequence in large face of structure (Type – 11)
- Centre and corner bracing (Type – 3)

The results show that the Type – 14, Type – 11 and type – 8 are the best in vibration's period they were compared with non-braced and damped models.

➢ **Double wing shape bracing (Type – 14)**

The arrangement of dampers is in a double wing pattern in a structure which has reduced the 86.53% of displacement with that of non-braced frame building.

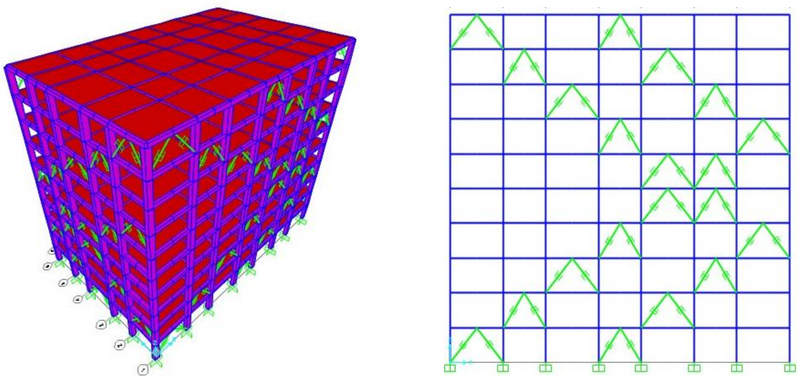
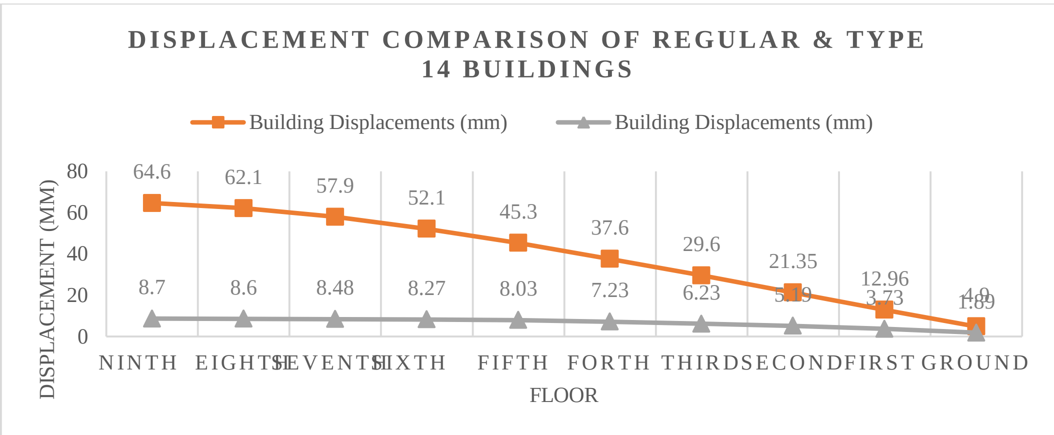
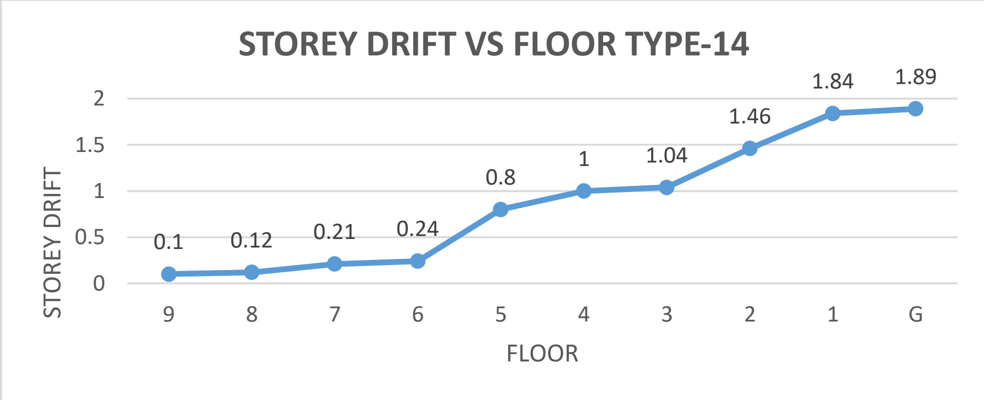


Fig 5: Double wing shape bracing arrangement



Graph 2: Type 14 Comparison of building Storey displacement



Graph 3: Type 14 building Storey drift

➢ **Diagonal sequence in large face of structure (Type – 11)**

Considering this type arrangement of dampers in such pattern in a structure have been reduced the 83.67% of displacement with that of non-braced frame building. And it has the minimum number of dampers compared to other types of arrangements only large face of structure is filled with FVD.it can be considered has the best optimum bracing arrangement pattern compared to other types of chevrons bracing system.

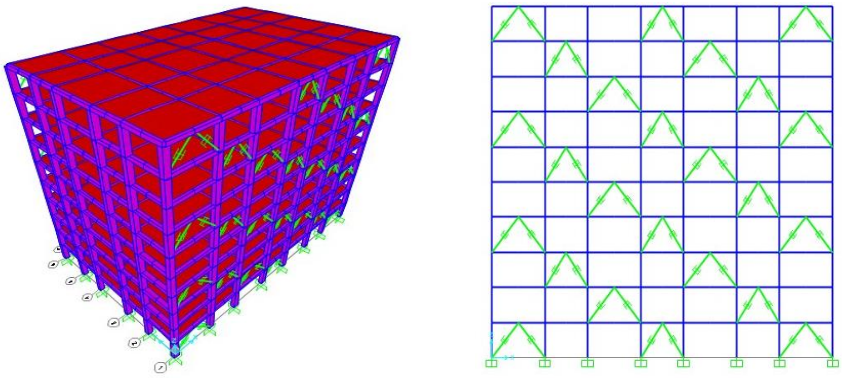
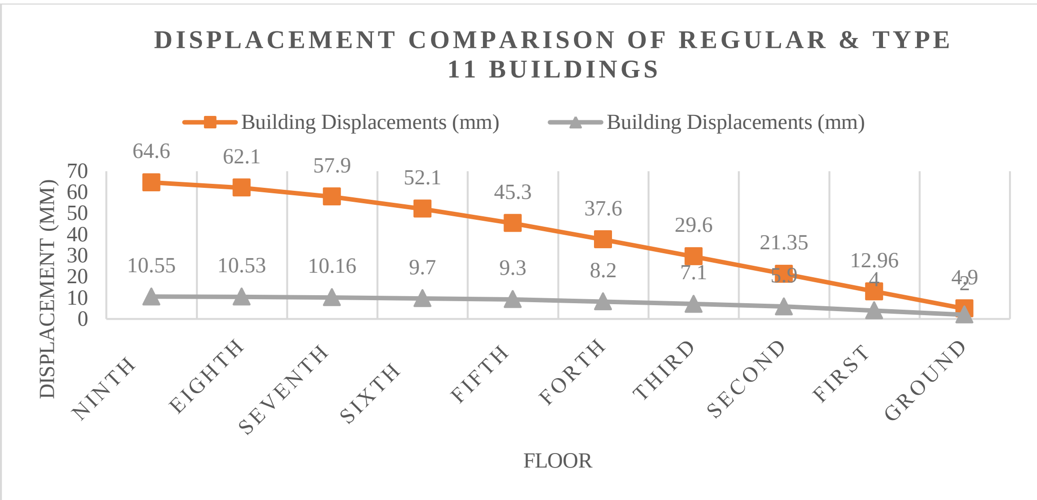


Fig 6: Diagonal sequence in large face of structure arrangement



Graph 4: Type 11 Comparison of building Storey displacement

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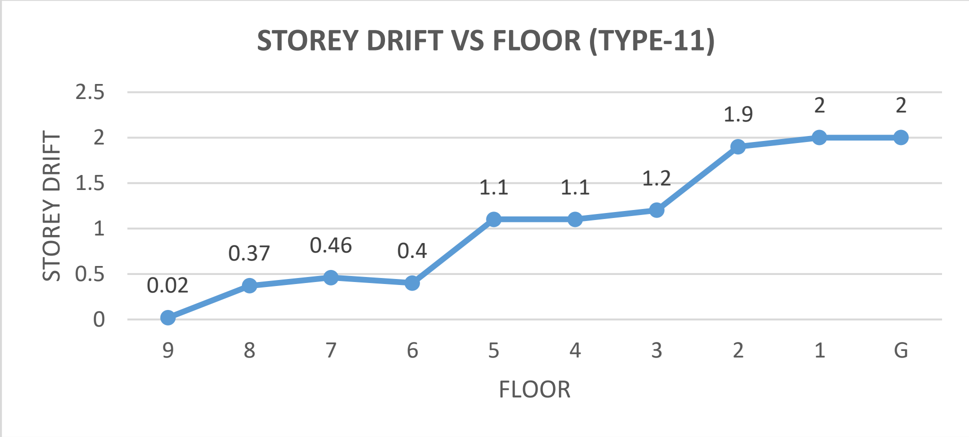


Graph 5: Type 11 building Storey drift

➢ **Centre and corner bracing (Type – 3)**

In general, intrusion of fluid viscous damper in the frame structure results in reduction of the relative floor displacement of 75.1% in the storey of the structure. Hence, the dampers arrangement in such pattern is considered as one of the most optimum bracing systems to be used in chevron bracing system.

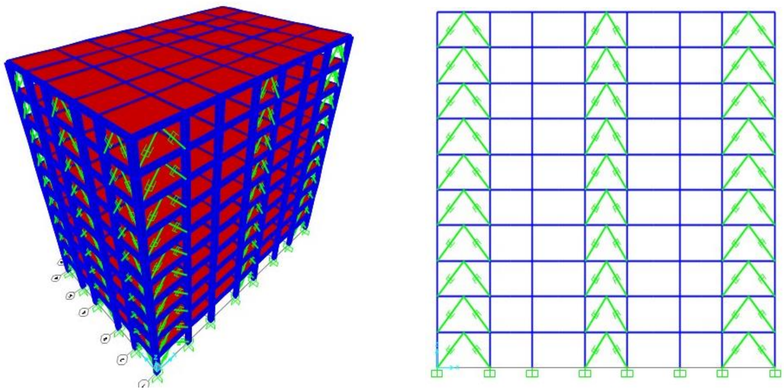
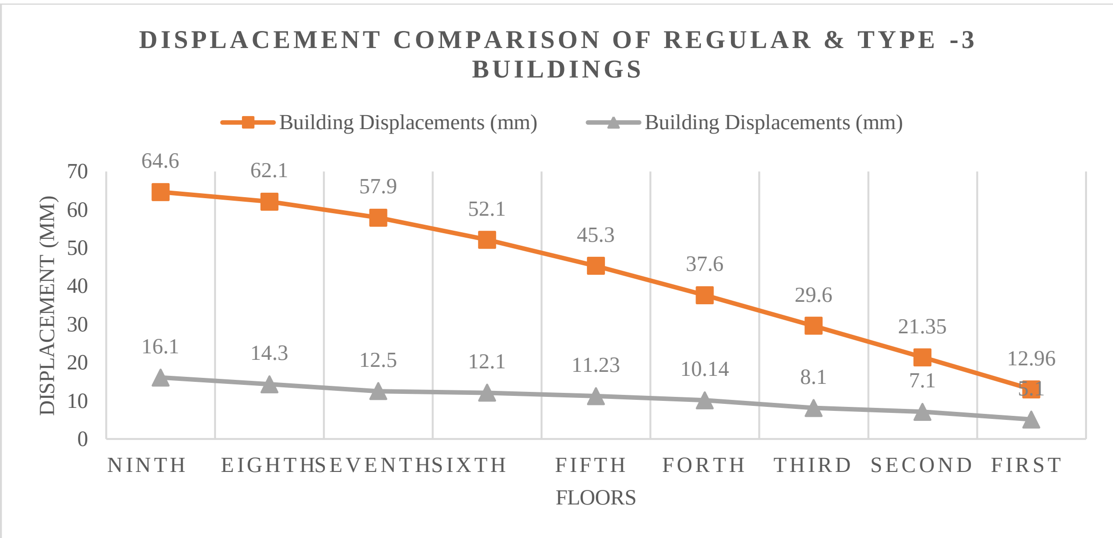


Fig 7: Centre and corner bracing arrangement



Graph 6: Type 3 building Storey drift

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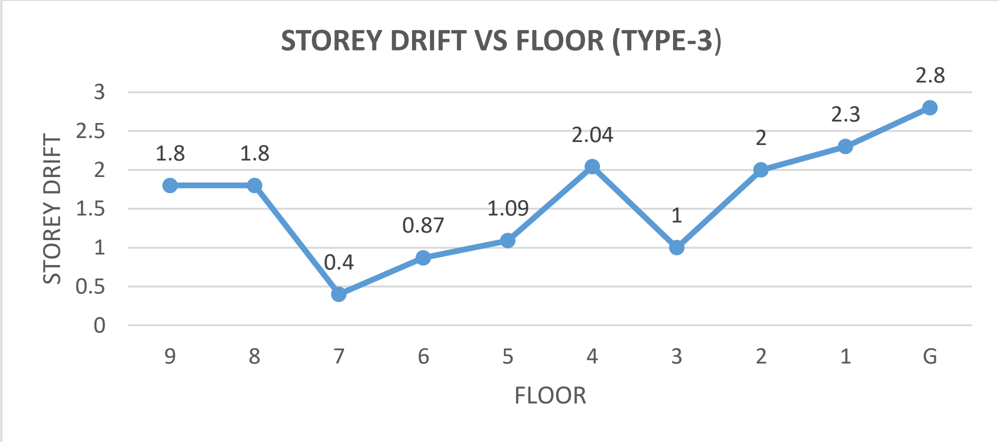

Graph 7: Type 3 building Storey drift

V. CONCLUSION

This study permitted to analyze the structural behavior, with and without viscous fluid damper for a seismic load and wind load. Numerical calculation with SAP -2000 software was used for the analysis of a G+9 building. The results display that the use of the passive control device FVD in buildings generates a very significant drop of the structural response compared to the unbraced ones. However, in the case of trial approaches of the building, the main conclusions are summarized below:

- The fundamental period gradually lessened compared to the un-braced structure.
- The maximum displacements decrease of the FVD models are in the range 9.43 % to 86.53% compared to the regular structure.
- Reduction of the maximum story drift, and drift ratio which reduces the values of story shear forces and its response.
- The benefits of structural bracing types (17 alternative models) were clearly demonstrated by the comparison data and improving performance of the structure, by which the preferential 3 types of arrangement are adopted and suggested a optimistic approaches for installation of positioned of dampers.
- Double wing shape bracing (Type – 14)
- Diagonal sequence in large face of structure (Type – 11)
- Centre and corner bracing (Type – 3)

{Among the above three types of arrangements, "Diagonal Sequence in large face of structure (Type-11)" is observed to be preferable in all the aspects}

VI. REFERENCES

[1] D.Bandyopadhyay, S.K. Bhattacharyya "Structural vulnerability assessment of old metropolitan cities in earthquake disaster mitigation" The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, Chaining (2008).

[2] Mauro Filipe Santos Monteiro "Energy dissipation systems for buildings" in (2011).

[3] Vajreshwari Umachagi et.al "Applications of Dampers for Vibration Control of Structures: An Overview" International Journal of Research in Engineering and Technology, Nov-2013.

[4] D.Demetriou et.al "Semi active tuned mass dampers of buildings: A simple control option," Am. J. Eng. Appl. Sci., vol. 8, no. 4, pp. 620–632, (2015).

[5] J.A.Inaudi et.al "Mass Damper Using Friction-Dissipating Devices," J. od Eng. Mech., vol. 121, no. 1, pp. 142–149, (1995).

[6] Liya Mathew et.al "Effect of Fluid Viscous Dampers in Multi- Storied Buildings", International Journal of Research in Engineering & Technology, Vol. 2, Issue 9, Sep 2014, 55-60.

[7] Sumyat Aye et.al "Comparative Study on Seismic Response of RC Structure Using Viscous Dampers and Viscoelastic Dampers", International Journal of Scientific Engineering and Technology Research, Vol.03,

Issue.08, May-2014, Pages:1468-1478.

[8] IJRET: International Journal of Research in Engineering and Technology eISSN: 2319- 1163 | pISSN: 2321-7308.

[9] International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-7 May, (2019).

[10] V. Umachagi et.al "Applications of Dampers for Vibration Control of Structures: An Overview," Int. J. Res. Eng. Technol., pp. 6–11, (2013)

[11] M.K.Muthukumar G et.al "Analytical modeling of damping," Indian Concr. J., vol. 88, no. 4, (2014).

[12] J.Marti et.al "Seismic Isolation and Protection Systems," Seism. Isol. Prot. Syst., vol. 1, no. 1, pp. 125–140, (2010).

[13] W.J.William et.al "Lead Damper for base isolution.pdf." Proceedings of 9th world conference on earthquake, (1998).

[14] S.K.Jain et al; "Explanatory Example on Indian Seismic Code IS 1893 (Part – I)" – IIT Kanpur,

[15] "Limit State of Analysis" – IS 456: 2000 and IS 875 :1987 part 1,2,3 for dead, live, wind loads.

[16] "Recommendations for Earthquake Resistant Design of Structures", Code of Practice – IS 1893 – 2002.