Dynamic Behavior of Elevated Storage Reservoir with Different Structural Modifications

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Abstract - *Elevated Storage Reservoir (ESR) Or Generally Say Water Tank Is the Multi-Purpose Structure Which Primary Function Is Not Only Provide the Water but Also to Convey and Store Different Types of Liquids from One Point to Other. ESR Are Classified on Bases of Their Shapes and Function of Structure. In Past Few Months It Been Seen That Water Is Not Only Primary Need to Survive but Also It Is the Key Reason to Change the Climatic Cycle and Reason to Start Uneconomical Imbalance Throughout the World. The ESR Also Plays an Important Role While Any Natural Disasters as It Is Been Already Proved Through All Past Situations Which Happened in All Over the World.*

In This Thesis, We Are Going to Discuss About the Dynamic Behaviour of ESR Under Seismic Forces with Some Structural Modifications Like Change Upper Geometrical Structure of ESR With Different Liquid Capacities and Application of Dampers.

***Key Words*: (Displacements, Dampers, Dynamic Behaviour, Elevated Storage Reservoir, Natural Frequencies, Structural Modifications, Story Drift)**

1. INTRODUCTION

1.1 GENERAL- Elevated liquid tanks and especially the elevated water tanks are considered as important city services in many cities. Their safety performance during strong earthquakes is of critical concern. They should not fail after earthquake, so that they can be used in meeting essential needs like preparing drinking water and putting out fires. The failure of these structures and the subsiding of water may cause some hazards for the health of city due to the shortage of water or difficulty in putting out fire during critical conditions. Many studies concentrated on the seismic behavior analysis, and design of tanks, particularly ground tanks. In the past decade most of these studies have focused on the elevated tanks. In the past earthquakes elevated tanks have been of the vulnerable structures and their seismic behavior has not been convenient being damaged. Thus, past earthquakes have shown that due to failure of lifeline structures, such as elevated tanks with insufficient eismic resistance, firefighting and other emergency response Water supply is a life line facility that must remain functional following disaster

Most municipalities in India have water supply system which depends on elevated tanks for storage. Elevated water tank is a large elevated water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. In major cities the main supply scheme is augmented by individual supply systems of institutions and industrial estates for which elevated tanks are an integral part. These structures have a configuration that is especially vulnerable to horizontal forces like earthquake due to the large total mass concentrated at the top of slender supporting structure. So, it is important to check the severity of these forces for particular region. Liquid storage steel tanks are very important structure since they have widely used in industries and nuclear power plants.

1.2 Earthquake Resistant Design System –

It can be said that there are as many types of lateral systems as there are engineers. However, most of the systems can be grouped into three basic types:

(1) Shear wall system,
(2) Moment Resisting Frame system,
(3) Bracing system,
(4) Base isolation System, and
(5) Dampers System.

Earthquake resistant design of engineering structures is one of the most important methods of mitigating risk of damage from future earthquakes. Such designs are based on the specification of ground motion which can be expected in the event of an earthquake. However, for earthquake-resistant design of some important structures like dams and nuclear power plants, located in seismically active areas, it is desirable to have a reliable site-specific design accelerogram. Available records of strong ground motion, after suitable modifications, have been used in the past for detailed dynamic analysis of engineering structures. However, synthetic accelerograms are now increasingly being used in earthquake engineering. Knowledge of regional and local seismicity and seism tectonics, a suitable earth model and source characteristics of the design earthquake are required for this purpose.

1.3 Viscous Dampers - Energy is absorbed by silicone-based fluid passing between piston-cylinder arrangements. In this damper, by using viscous fluid inside a cylinder, energy is dissipated. Due to ease of installation, adaptability and coordination with other members also diversity in their sizes, viscous dampers have many applications in designing and retrofitting.

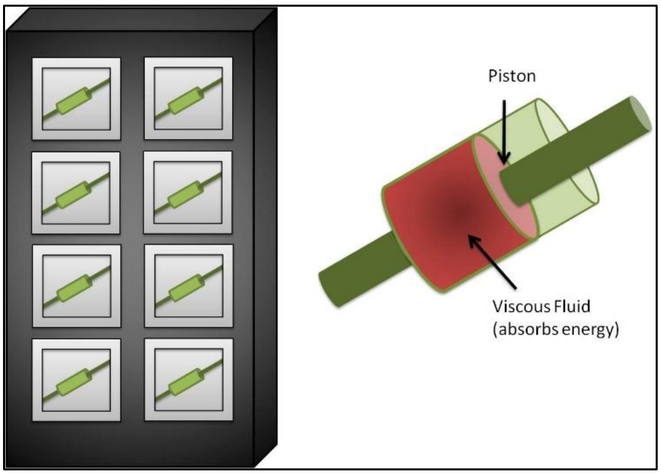


Figure 1: Viscous dampers

1.4 Scope & Objective - In this study different factors affecting the seismic performance of the water tank are deeply studied, to know the exact behavior of the structure during earthquake. By this one can find the change in the behavior of structure with respect to change in the shape of structure. Following factors are considered and their performance is studied with respect to strength, stiffness, displacement and story drift etc.

1 Effect of different loading with different structural modifications such as composite column and damper.

2 Effect of application of dampers on elevated water tank.

3 Conduct the comparative and detailed analysis the expected dynamic behavior of ESR with above structural modifications with and without considering the loadings.

4 Also study the results as story drift analysis and displacement analysis and base shear; so as to predict the expected risk and failures.

2. SUMMERY OF LITERATURE REVIEW –

Elevated water tanks, which typically consist of a large mass supported on the top of a slender staging, are particularly susceptible to earthquake damage. Thus, analysis & design of such structures against the earthquake effect is of considerable importance. After details study of all the papers, following points are to be consider at the time of seismic analysis of elevated water tank

1 In India, there is only one IS code i.e. IS 1893: 1984, in which provisions for aseismic design of elevated water tanks are given. IS 1893(Part-1): 2002 is the fifth revision of IS 1893, still it is under revision

2 Most elevated water tank are never completely filled with water. Hence, a two – mass idealization of the tank is more appropriate as compared to one-mass idealization.

3 Earthquake forces increases with increase in Zone factor & decreases with increase in staging height. Earthquake forces are also depending on the soil condition.

4 Most of the research work had done on staging height, types of staging, patterns to be consider etc.; but there was lack of gap in exact analysis of ESR with damper.

5 After the study of literature, it is clearly seen that no research had been done considering the effect of dampers to ESR with respect to different capacities with application of composite columns and with different loadings and different heights.

3. METHEOLOGY –

The methodology worked out to achieve the above-mentioned objectives is as follows:

In this present project of elevated water tank with composite column will be model in Etabs and their Performance will be check under Seismic forces, for that following models will be prepares. A study is undertaken which involve Equivalent Static method for analysis of elevated water Tank and study the behavior of the structure. Material used structural steel of grade Fe 500 Mpa and M30Mpa the methodology worked out to achieve the above-mentioned objectives is as follows:

i) Review the existing literatures
ii) Select of water tank with different shape and capacity for the study

Table no 1: - Description of models.

Models	Capacity Lit
M1	10,00,000
M2	10,10,000
M3	10,20,000
M4	10,30,000

M5	10,40,000
M6	10,50,000

Table no 2: - Dimensions of tank

Circular (D and H)
28.24x1.6
28.24x1.616
28.24x1.632
28.24x1.648
28.24x1.664
28.24x1.68

Abbreviations to use -

A – water tank with loading no damper.

B - water tank without loading no damper.

C - water tank with loading with damper.

D - water tank without loading with damper.

E - water tank with composite column with loading no damper.

F - water tank with composite column without loading no damper.

G - water tank with composite column with loading with damper.

H - water tank with composite column without loading with damper.

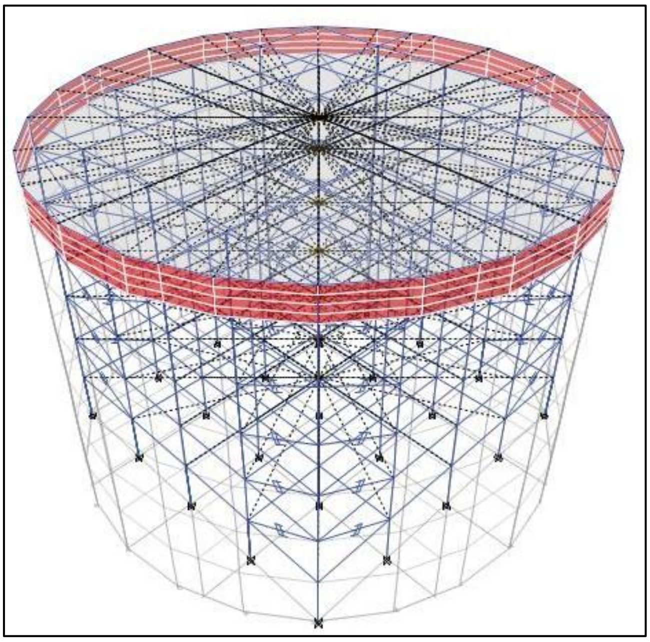


Figure no. 2-Typical Model of Circular Water Tank in E -TABS

4. RESULTS -

The results are very staggered manner with varying and are detailed as in 3 main cases as first one is story displacement analysis, second one is story drift analysis and last one is base shear analysis.

The time history analysis and response spectrum analysis may be carried out and may take for further future analysis, but this thesis mainly carried above three analysis only.

The results are as detail as:

4.1 story displacement analysis-

Table no 3: - Variation in Displacements in X-Dir. Vrs. Various Capacities in case of A, C, E & G

Variation in Displacements in X-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
A	12.4	12	16.5	16.6	16.2	16.2
C	9.8	5.6	3.8	3.8	5	5
E	23.3	19.7	13.2	10.6	14.2	14.2
G	3.7	3.8	2.6	10.6	3.7	3.7

Graph no 3: - Variation in Displacements in X-Dir. Vrs. Various Capacities in case of A, C, E & G

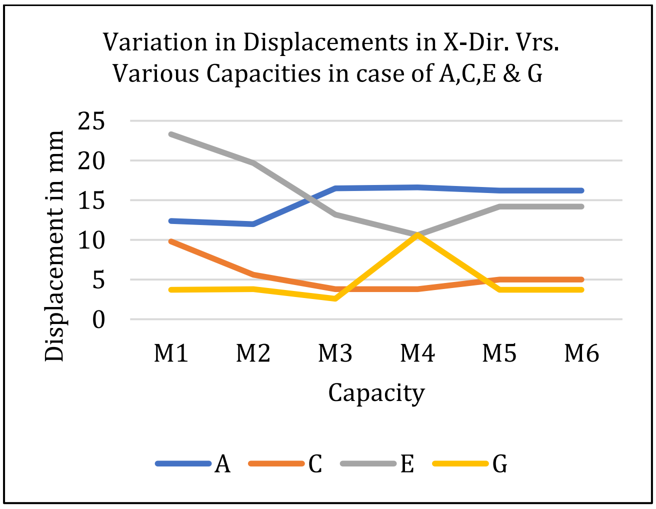


Table no 4: - Variation in Displacements in X-Dir. Vrs. Various Capacities in case of B, D, F & H

Variation in Displacements in X-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
B	15.6	19.2	15.1	15.1	15.3	15.3
D	9.8	5.2	3.8	3.8	4.1	4.1
F	11.8	14.9	14.9	10.6	10.8	10.8
H	3.7	3.8	2.6	2.6	3.7	3.7

Graph no 4: - Variation in Displacements in X-Dir. Vrs. Various Capacities in case of B, D, F & H

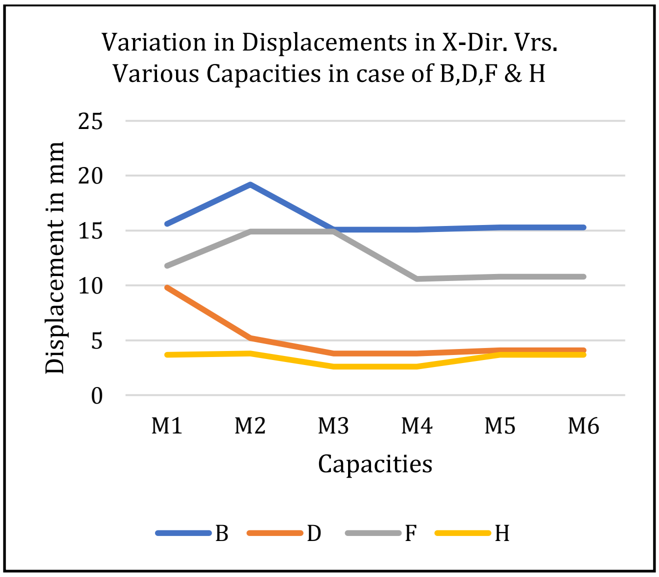


Table no 5: - Variation in Displacements in Y-Dir. Vrs. Various Capacities in case of A, C, E & G

Variation in Displacements in Y-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
A	19	30	25.7	25.7	25.4	25.5
C	21.1	9.7	5.9	5.9	7.1	7.1
E	39.4	37.1	23.1	19.3	24	24
G	6.6	7.5	4.6	19.4	5.6	5.6

Graph no 5: - Variation in Displacements in Y-Dir. Vrs. Various Capacities in case of A, C, E & G

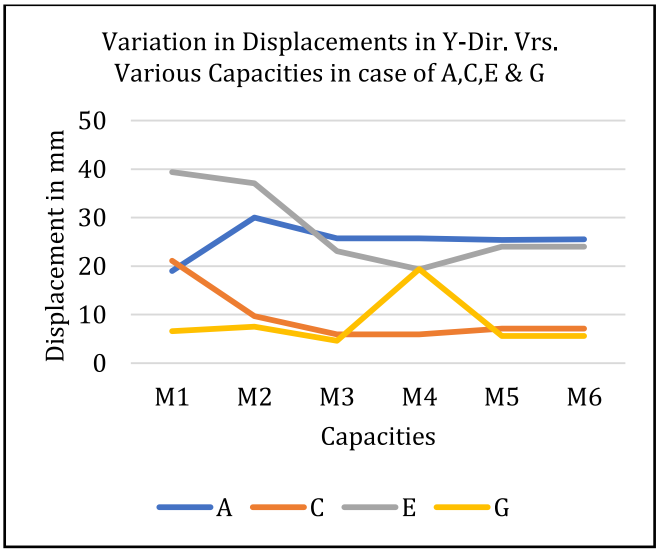
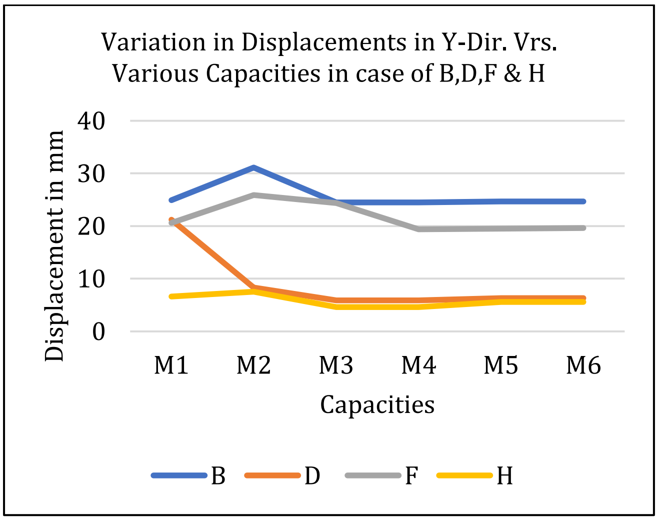


Table no 6: - Variation in Displacements in Y-Dir. Vrs. Various Capacities in case of B, D, F & H

Variation in Displacements in Y-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
B	24.9	31.1	24.5	24.5	24.7	24.7
D	21.2	8.3	5.9	5.9	6.3	6.3
F	20.6	25.9	24.4	19.4	19.5	19.6
H	6.6	7.5	4.6	4.6	5.6	5.6

Graph no 6: - Variation in Displacements in Y-Dir. Vrs. Various Capacities in case of B, D, F & H



4.2 story drift analysis –

Table no 7: - Variation in Drifts in X-Dir. Vrs. Various Capacities in case of A, C, E & G

Variation in Drifts in X-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
A	0.000285	1.00E-05	0.000261	0.00026	4.60E-05	4.60E-05
C	1.40E-05	1.50E-05	1.00E-05	1.00E-05	6.30E-05	6.30E-05
E	4.90E-05	0.000314	7.00E-06	9.00E-06	4.10E-05	4.10E-05
G	1.10E-05	1.20E-05	8.00E-06	8.00E-06	4.10E-05	4.10E-05

Graph no 7: - Variation in Drifts in X-Dir. Vrs. Various Capacities in case of A, C, E & G

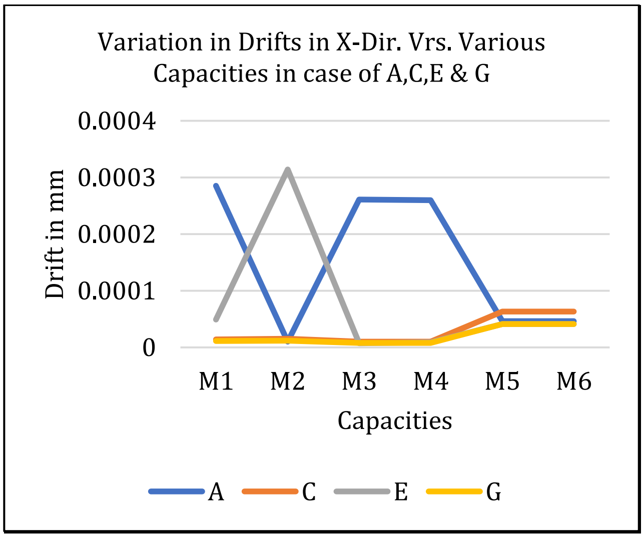


Table no 8: - Variation in Drifts in X-Dir. Vrs. Various Capacities in case of B, D, F & H

Variation in Drifts in X-Dir. Vrs. Various Capacities						
CASE	M1	M2	M3	M4	M5	M6
B	0.000194	9.00E-06	7.00E-06	7.00E-06	4.60E-05	4.60E-05
D	1.40E-05	1.40E-05	1.00E-05	1.00E-05	6.20E-05	6.20E-05
F	9.00E-06	1.20E-05	7.00E-06	9.00E-06	4.10E-05	4.10E-05
H	8.00E-06	8.00E-06	6.00E-06	6.00E-06	3.00E-05	3.00E-05

Graph no 8: - Variation in Drifts in X-Dir. Vrs. Various Capacities in case of B, D, F & H

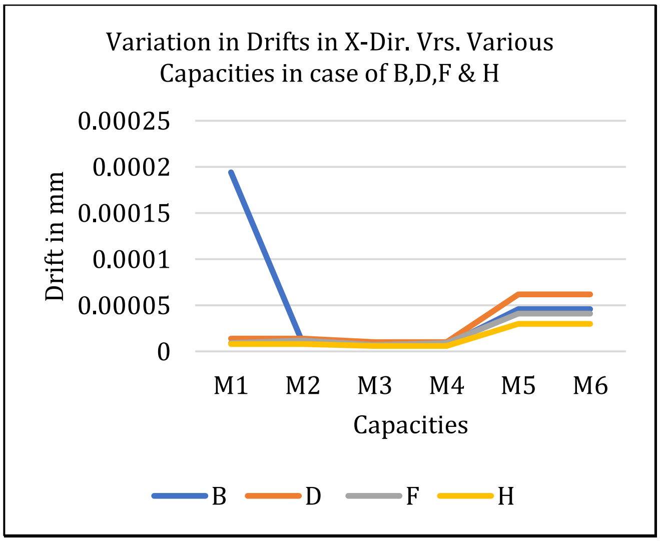


Table no 9: - Variation in Drifts in Y-Dir. Vrs. Various Capacities in case of A, C, E & G

Variation in Drifts in Y-Dir. Vrs. Various Capacities						
CASES	M1	M2	M3	M4	M5	M6
A	3.10 E-04	9.00E-06	0.000234	0.000233	4.00 E-05	4.00 E-05
C	1.60 E-05	1.70E-05	1.00E-05	1.00E-05	6.30 E-05	6.30 E-05
E	1.20 E-05	0.000269	5.00E-06	7.00E-06	3.20 E-05	3.20 E-05
G	1.00 E-05	1.10E-05	7.00E-06	7.00E-06	3.60 E-05	3.60 E-05

Graph no 9: - Variation in Drifts in Y-Dir. Vrs. Various Capacities in case of A, C, E & G

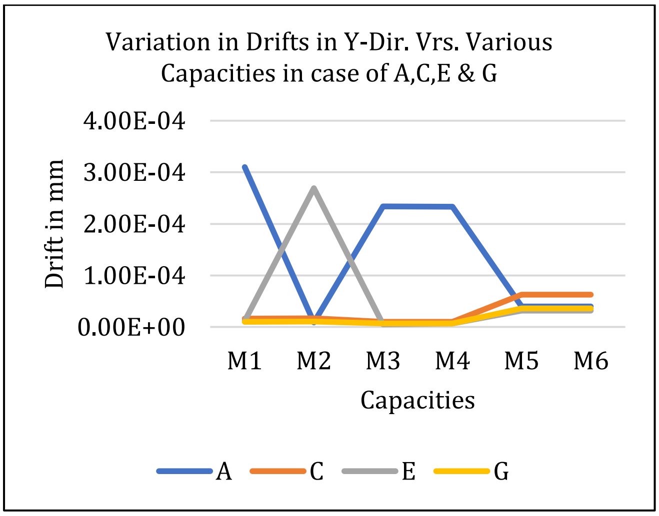
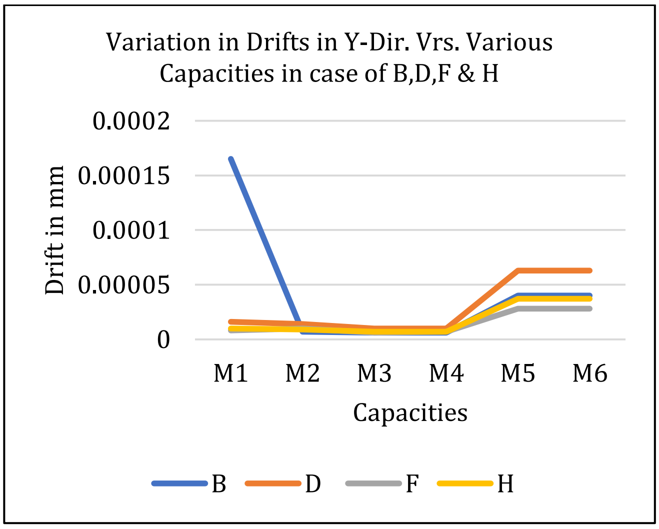


Table no 10: - Variation in Drifts in Y-Dir. Vrs. Various Capacities in case of B, D, F & H

Variation in Drifts in Y-Dir. Vrs. Various Capacities						
CASES	M1	M2	M3	M4	M5	M6
B	0.000165	7.00 E-06	6.00 E-06	6.00 E-06	4.00 E-05	4.00 E-05
D	1.60E-05	1.40 E-05	1.00 E-05	1.00 E-05	6.30 E-05	6.30 E-05
F	8.00E-06	1.00 E-05	6.00 E-06	7.00 E-06	2.80 E-05	2.80 E-05
H	1.00E-05	9.00 E-06	7.00 E-06	7.00 E-06	3.70 E-05	3.70 E-05

Graph no 10: - Variation in Drifts in Y-Dir. Vrs. Various Capacities in case of B, D, F & H



4.3 base shear analysis

Table no 11: -Variation in Base Shear in Both Dir. Vrs. Various Capacities in case of A, C, E & G

Variation in Base Shear in Both dir. Vrs. Various Capacities						
CASES	M1	M2	M3	M4	M5	M6
A	854.748	849.0633	658.0059	658.2898	658.5833	658.8668
C	1254.751	1249.059	858.0059	858.2915	858.5813	858.8649
E	849.9812	818.4704	642.5088	679.0567	643.1871	643.2879
G	1285.224	1279.614	888.7849	889.1504	889.5207	889.8849

Graph no 11: -Variation in Base Shear in Both Dir. Vrs. Various Capacities in case of A, C, E & G

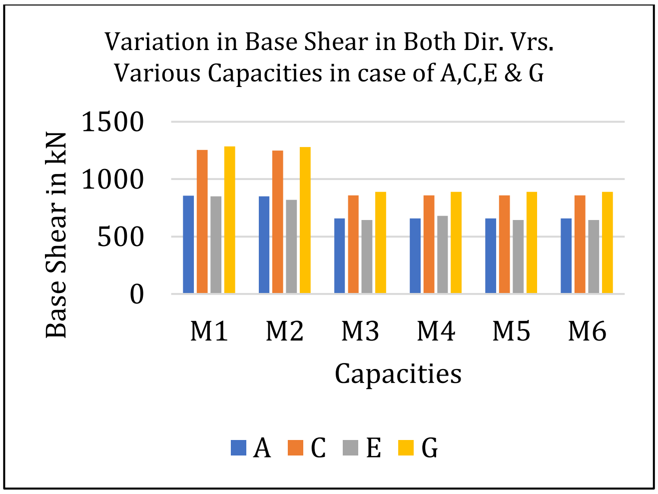
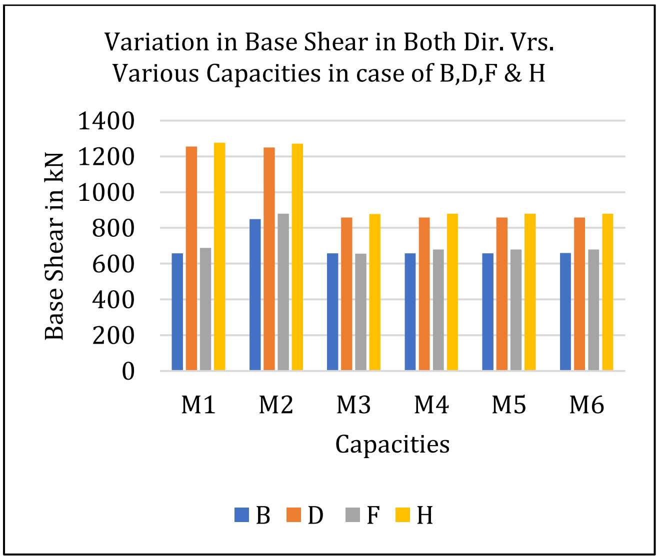


Table no 12: -Variation in Base Shear in Both Dir. Vrs. Various Capacities in case of B, D, F & H

Variation in Base Shear in Both Dir. Vrs. Various Capacities						
CASES	M1	M2	M3	M4	M5	M6
B	657.444	849.0633	658.0053	658.2966	658.5833	658.8668
D	1254.751	1249.059	858.0059	858.2915	858.5813	858.8649
F	688.0661	879.6174	655.2356	678.9018	679.2523	679.5976
H	1276.707	1271.079	878.5509	878.8981	879.2506	879.5968

Graph no 12: -Variation in Base Shear in Both Dir. Vrs. Various Capacities in case of B, D, F & H



5. Conclusions –

After the completing the analysis and from the results conclusion are as:

- The circular water Tank behaves very flaky as for staging height and modifications changes.
- In case of story displacement, the water tank deflects start from 24 mm and after doing the modifications it gets reduce up to just 3 mm only for both direction
- In case of story drift the water, tank shows quite staggered behavior in cases of with and without loading including the all changes.
- Especially in case of dampers with water tank, the change in deflection looks as nearly 10-35mm.
- In case of base shear, the water tank also shows quite miscellaneous behavior specially in case of loading with damper in both directions.
- in case of composite column, the water tank, deflection reduces as about 10-20mm as loading condition changes.
- From the 1st and last result in all water tank, the deflection reduces in very high manner as 30-35mm.
- From the above all results and all the analysis we can conclude that, as with provide dampers with composite column to the water tank, the structure will safe in above loading condition and very negligible deflection.
- After the all analysis and results we can conclude that the aim and objective of study has been justified and research work is successful with small step forward to minimize the research gap.

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