SEISMIC RESPONSE STUDY OF MULTI-STORIED REINFORCED CONCRETE BUILDING WITH FLUID VISCOUS DAMPERS

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Abstract - *When an earthquake occurs, it causes enormous damage in terms of property loss, human lives, and structural collapse. As a result, structural remodeling is a must. Damping Contributes significantly to Earthquake Resistant Structures' overall design by reducing their ability to deform when loaded from the sides. There are a variety of damper options available. Fluid viscous dampers (FVD) are employed in this study to gauge the reaction of reinforced concrete structures (RCB). The time period is reduced to 90% by employed FVD in Time History analysis. Structures' Base Shear is reduced by 70% while using FVD250.*

Key Words: Damping, FVD, time period, Base shear

1. INTRODUCTION

One of the most common civil engineering disasters is earthquake. Seismic activity causes structural deterioration in buildings. Earthquake-resistant systems may be implemented to improve the building's capacity to withstand earthquakes. The damper is one of the most common and effective earthquake resistance measures. Throughout the building. In a passive control system, seismic energy is dispersed. In the case of an earthquake, this device flexes. Dams absorb earthquake energy. dampens ground movement during earthquakes by dispersing it structure. There are several dampers on the market now, including pall friction dampers Stabilizer, such as a mechanical or hydraulic strut or a damper installed on a strut. A viscous liquid. The FVD damper is one of the most effective and easiest to install dampers.

Energy is dispersed in this damper by the use of a viscous fluid contained within a cylinder. As a result of their simple installation, versatility, and collaboration with other components, viscous dampers may be used in a wide range of design and retrofit applications.

1.1 Literature Review

Structural Analysis

The primary goal of structural analysis is to determine an object's response to a force. People, furniture, wind, snow, etc. can all contribute to this activity, but it can also be the result of an earthquake, a nearby explosion, or some other type of stimulation. All of these loads, including the structure's own weight, are inherently dynamic since they weren't present at some earlier moment in time. Static vs. dynamic analysis may be distinguished based on whether the applied action has sufficient acceleration in contrast to the structure's inherent frequency. Inertia forces (Newton's first law of motion) can be neglected if a load is applied slowly enough. This simplifies the static analysis. As a result, structural dynamics is a sort of structural analysis that deals with dynamic loads. It is possible to employ dynamic analysis to find dynamic displacements, time histories, and modal analysis.

Analysis using ETAB

B. S. Taranath in "Building Design for Tall Buildings" complex non-linear time is necessary for seismic ground movements, which are then compared to the design satisfies the specified safety level.

Liya Mathew & C. Prabha It was reported in "Effect of Fluid Viscous Dampers in Multi-Storied Buildings" in 2014 that new protection methods had been created to increase earthquake safety and minimize structural damage.1 The fluid viscous damper (FVD) is prominently featured in this application. This work also studies reinforced concrete structures

1.2 Objective

1. Buildings with square and rectangular designs, with and without FVD, will be compared for their seismic reaction.
2. To determine the effects of FVD on the structure's displacements. To determine the reduction in base shear in RC structures by the use of FVD. Structures that have and don't have FVD can be studied to see how the time period differs.
3. Compare FVD structures to Time History and Pushover.

2. METHODOLOGY

2.1 Modal analysis

In a modal analysis, the frequency modes or natural frequencies of a system are calculated, but the full-time historical response to an input is not always included. a system's inherent frequency simply depends on the structure's stiffness and the mass it contains (including self-weight). Load function isn't an issue.

This is how it's done:

1. Determine the inherent modes and natural frequencies of a structure.
2. Calculate each mode's answer.

2.2 Determined Analysis ETABS

The ETABS computer application is used for the building's study and design. Some of the most essential facets of the modelling process are covered in the following sections.

1. Defining the slab sections
2. Static evaluation of equality
3. The lateral load pattern in multimodal or SRSS systems

2.3 Time history analysis procedure

Step 1: Calculation of Modal Matrix

Step 2: Calculation of Effective Force Vector

Step 3: Calculation of Displacement Response in Normal

Co-ordinates

Step 4: Calculation of Displacement Response in Physical

Co-ordinates

Step 5: Calculation of Effective Earthquake Forces at Each Storey

2.4 Pushover Analysis in ETABS

ATC 40 and FEMA 273 hinge properties are pre-programmed into the ETABS, but it also allows you to enter custom material or hinge properties. There is a P-M2-M3 (PMM) hinge that yields based on the interaction of the column axial load and bending moment when the building is subjected to lateral loading. ETABS only deals with buildings where uncoupled moment M2 and M3, Torsion T, axial force p and V2 and V3 force displacement relations can be defined and the column axial load changes under lateral loading

3. MODELLING

3.1 Design Data

Steel grade Fe 500 is utilized for all of the building's slabs and beams, while concrete grade M25 is used for the columns.

The following is a list of the members:

1. A square column is one with a dimension of 600 mm by 600 mm.
2. Rectangular Columns: 1200mm*300mm.
3. 230mm*600mm Interior Beams.
4. 230mm*600mm Exterior Beams.

There are two slab sizes:

1. Panel Area = 6m*6m=36
2. 125 mm thick

Table -1: Story Data

Name	Height mm	Elevation mm	Master Story	Similar to	Splice Storey
Story10	3000	30000	Yes	None	No
Story9	3000	27000	No	Story10	No
Story8	3000	24000	No	Story10	No
Story7	3000	21000	No	Story10	No
Story6	3000	18000	No	Story10	No
Story5	3000	15000	No	Story10	No
Story4	3000	12000	No	Story10	No
Story3	3000	9000	No	Story10	No
Story2	3000	6000	No	Story10	No
Story1	3000	3000	No	Story10	No
Base	0	0	No	None	No

3.2 Loads

Applied Loads:-

In the gravity direction, the shell loads acting on slabs are Dead=1.5kN/m2 and Live=4kN/m2. The Dead=5.25kN/m frame loads are given to the beams in a consistent manner.

Code IS1893:2002 provides the seismic loads EQ-x and EQ-y directly in load patterns. Code IS875:1987 is also used to provide wind loads wind-x and wind-y.

Table -2: Load Patterns

Name	Type	Self-Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
EQ-x	Seismic	0	IS 1893 2002
EQ-y	Seismic	0	IS 1893 2002
Wind-x	Wind	0	Indian IS87:1987
Wind-y	Wind	0	Indian IS87:1987

3.3 MODELLING OF DAMPERS

FVD with base plate is picked here for the modelling of the structure since it is simple to fit. The clevis-base plate layout of fluid viscous dampers and lock-up mechanisms is depicted below.

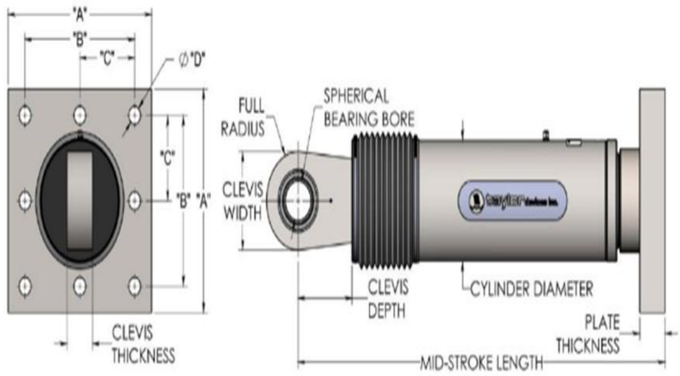

Fig -1: Fluid viscous dampers & lock-up devices clevis

4. RESULTS AND DISCUSSION

Responses when loaded in different directions

Table -3: Maximum PSA at Zero Damping

Max. Values	Load Case/Direction							
Building Modal	THX/X		THX/Y		THY/X		THY/Y	
	Period (sec)	PSA (mm/sec²)	Period (sec)	PSA (mm/sec²)	Period (sec)	PSA (mm/sec²)	Period (sec)	PSA (mm/sec²)
SBSC no Damp	0.278	1710	0.389	0.000066	0.389	0.000066	0.278	1710
SBRC no Damp	1.329	2605	0.777	0	0.412	0.000004	1.38	2276
RBSC no Damp	0.161	5417	0.769	0.000018	0.833	0.000012	0.161	3520
RBRC no Damp	1.703	1838	0.769	0.000006	0.769	0.000004	1.25	2563
SBSC With FVD	0.278	21759	0.769	0	0.714	0	0.278	21759
SBRC With FVD	0.161	41674	0.777	0	0.777	0	0.161	39347
RBSC With FVD	0.278	23603	0.714	0	0.769	0	0.278	18861
RBRC With FVD	0.16	41081	0.764	0	0.769	0	0.16	105797

4.1 Base Reactions

An estimate of the greatest lateral force that may be generated by seismic ground motion at the base of a structure is known as base shear.

Table- 4 : Base Reactions of SBSC with FVD

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	-0.0000036	-0.0000036	104889.63	1888013	-1888013	0
Live	-0.00000314	-0.0000031	49227.86	886101.5	-886102	0
EQ-X	666.51	0	0	0	-4415.29	-11997.27
EQ-y	0	666.51	0	4415.29	0	11997.27
Wind-x 1	675.03	0	0	0	1716.6	-12150.667
Wind-x 2	-675.03	0	0	0	-1716.6	12150.67
Wind-y 1	0	675.03	0	-1716.6	0	12150.67
Wind-y 2	0	-675.03	0	1716.6	0	-12150.67
THX Max	666.50	0	0	0.0000029	20451.47	20953.95
THX Min	-1164.10	0	0	-0.0000035	-24122.75	-11997.14
THY Max	0	666.5076	0	24122.75	0.0000014	11997.14
THY Min	0	-1164.11	0	-20451.47	-0.0000016	-20953.95
PushX Max	0	0	0.1	2.86	0	6892.41
PushX Min	-382.93	-0.0103	-0.09	-0.76	-1483.52	0
PushY Max	3.11	0	2765.73	26578.63	1.53	0
PushY Min	-0.25	-3099.58	-0.15	0	-49822.47	-55914.16

Table-5: Base Reactions of SBRC with FVD

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	-0.00000399	-0.00000354	104587.5405	1882576	-1882576	0.000008243
Live	-0.0000034	-0.00000302	49301.4821	887426.67	-887427	0.00000699
EQ-X	1362.2058	0	0	0	-3687.9383	-24519.7041
EQ-y	0	1051.658	0	4147.54	0	18929.8446
Wind-x 1	1370.4584	0	0	0	2305.7045	-24668.252
Wind-x 2	-1370.4584	0	0	0	-2305.7045	24668.252
Wind-y 1	0	1061.6648	0	-1939.22	0	19109.9659
Wind-y 2	0	-1061.6648	0	1939.22	0	-19109.9659
THX Max	1362.214	0	0	0.000006546	25868.8893	47756.1861
THX Min	-2653.1214	0	0	-0.0000078	-31225.2386	-24519.8518
THY Max	0	1051.6547	0	28329.68	0	18929.7851
THY Min	0	-1963.356	0	-24058.05	0	-35340.4081
PushX Max	0	0.000002126	0.0112	0.201	0	12128.8277
PushX Min	-673.8265	-0.0035	-0.5922	-10.66	-1116.759	0
PushY Max	0.0247	0	44.0179	25424.26	5869.6678	0
PushY Min	-0.4107	-6525.4811	-326.5882	0	-792.3258	-117458

Table-6: Base Reactions of RBSC with FVD

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	-0.000003555	-0.000003852	106127.1985	1273526	-2865434	-0.0001
Live	-0.000003031	-0.000003288	49228.1629	590737.9545	-1329160	-0.0001
EQ-X	666.1333	0	0	0	48165.4507	-7993.6002
EQ-y	0	697.757	0	40160.2319	0	18839.439
Wind-x 1	439.6246	0	0	0	35310.0811	-5275.4952
Wind-x 2	-439.6246	0	0	0	-35310.0811	5275.4952
Wind-y 1	0	1068.6387	0	51324.7701	-5.614E-07	28853.2461
Wind-y 2	0	-1068.6387	0	-51324.7701	5.613E-07	-28853.2461
THX Max	666.13	0	0	0	50149.0651	14736.9854
THX Min	-1228.0821	0	0	0	-119383	-7993.5605
THY Max	0	697.7616	0	33579.4853	0.00001181	18839.5619
THY Min	0	-1109.8058	0	-41096.1076	-0.00001009	-29964.7556
PushX Max	0	0	13.9102	195.272	0	4646.2934
PushX Min	-387.3156	-0.1136	-0.0959	-0.3686	-37235.437	0
PushY Max	54.3913	0	543.587	0	10.0461	0
PushY Min	-0.0158	-1798.692	-0.4508	-107080	-14680.8833	-48221.0492

Table-7: Base Reactions of RBRC with FVD

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	-0.000001966	-0.000006048	105816.9816	1269804	-2857059	-0.0001
Live	-0.000001677	-0.00000516	49256.1582	591073.899	-1329916	-0.0001
EQ-X	144.71	0	0	0	62391.7217	-1736.5203
EQ-y	0	2316.4475	0	41878.4126	0	62544.0815
Wind-x 1	102.5717	0	0	0	46710.5913	-1230.8607
Wind-x 2	-102.5717	0	0	0	-46710.5913	1230.8607
Wind-y 1	0	3422.6708	0	51244.8298	0	92412.1128
Wind-y 2	0	-3422.6708	0	-51244.8298	0	-92412.1128
THX Max	144.7098	0	0	0	63676.8678	2235.0746
THX Min	-186.2562	0	0	0	-93667.4215	-1736.5176
THY Max	0	2316.4456	0	52095.2401	0.00001925	62544.0314
THY Min	0	-5069.3032	0	-65367.4274	-0.00001599	-136871
PushX Max	0	0	1080.5888	12967.0651	0	719.9016
PushX Min	-59.9918	-0.00003417	0	0	-75380.096	0
PushY Max	0	0	254.7276	0	0.000002347	0
PushY Min	-0.2232	-34879.5399	0	-542238	-6875.885	-941749

4.2 Story Maximum and Average Lateral Displacements

ETABS gives a simple table in the summary output with "Story Maximum and Average Lateral Displacements". This offers information of greatest to average ratio to assess torsional irregularity.

The Maximum Displacements owing to Push-X in X-direction are:

Table-8: Max. Disp. of Modals at different stories due to PushX

Story	SBSC		SBRC		RBSC		RBRC	
	no damp	FVD	no damp	FVD	no damp	FVD	no damp	FVD
Story10	111.2	8.7	85	6.9	149.6	8.6	94.6	11.1
Story9	108.8	7.6	82.2	6.1	147	7.5	93.1	9.7
Story8	104.6	6.5	78.1	5.2	142.2	6.5	90.2	8.4
Story7	98.3	5.4	72.3	4.3	134.2	5.4	85.9	6.9
Story6	89.9	4.3	64.7	3.4	122.3	4.3	80.1	5.5
Story5	79.4	3.2	55.4	2.5	106.3	3.2	72.9	4.1
Story4	66.7	2.1	44.4	1.7	86.3	2.1	63.6	2.8
Story3	51.4	1.2	32	0.9	62.6	1.2	51.2	1.6
Story2	33.2	0.4	18.7	0.3	35.8	0.4	28.1	0.6
Story1	12.5	0	6.2	0	11.6	0	9.9	0
Base	0	0	0	0	0	0	0	0

The Maximum Displacements due to Push-Y in Y-direction are:

Table-9: Max. Disp. of Modals at different stories due to PushY

Story	SBSC		SBRC		RBSC		RBRC	
	no damp	FVD	no damp	FVD	no damp	FVD	no damp	FVD
Story10	65.5	53.4	99.9	147.1	95.2	46.3	88.9	192.8
Story9	63.8	47.1	96.8	129.3	92.6	40.7	85.1	169.7
Story8	61	40.7	92	111	88.3	35	80	145.7
Story7	56.8	34.1	85.3	92.1	82.2	29.1	73.2	121
Story6	51.4	27.4	76.4	72.9	74.1	23.1	64.6	95.9
Story5	44.5	20.8	65.5	54	64.1	17.2	54.4	71
Story4	36.4	14.3	52.6	35.9	52.2	11.5	42.6	47.3
Story3	27	8.4	37.9	19.9	38.5	6.3	29.7	26.3
Story2	16.6	3.5	22.4	7.4	23.3	2.1	16.6	9.7
Story1	6.1	0	7.9	0	8.5	0	5.4	0
Base	0	0	0	0	0	0	0	0

4.3 Discussion of Results

Story Max/Avg. Displacements

An easy-to-read table containing "Storey Maximum and Average Lateral Displacements" was produced from the ETABS. To check for torsional irregularity, this offers an indicator of the maximum to average ratio

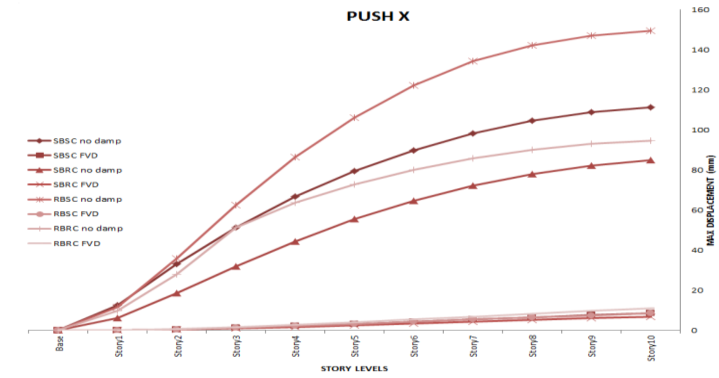

Fig -2: Comparison Maximum story displacements due to PUSH X

From the interrelation curves in figure 2 , it is found that due to insertion of FVD in the structures the displacements have been reduced by 92.17% for SBSC, 91.88% for SBRC, 94.25% for RBSC and 88.26% for RBRC.

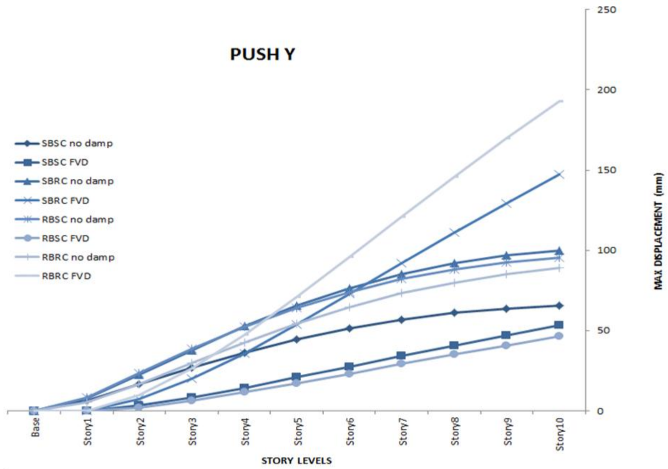

Fig -3: Comparison Maximum story displacements due to PUSH Y.

From the comparison curves in figure 3, it can be clearly predicated that due to inoculation of FVD in the structures the displacements have been reduced by 18.4% for SBSC and 51.36% for RBSC. Whereas SBRC and RBRC doesn't show any variation in this direction but overall structural displacements are within limiting values.

Base Shear

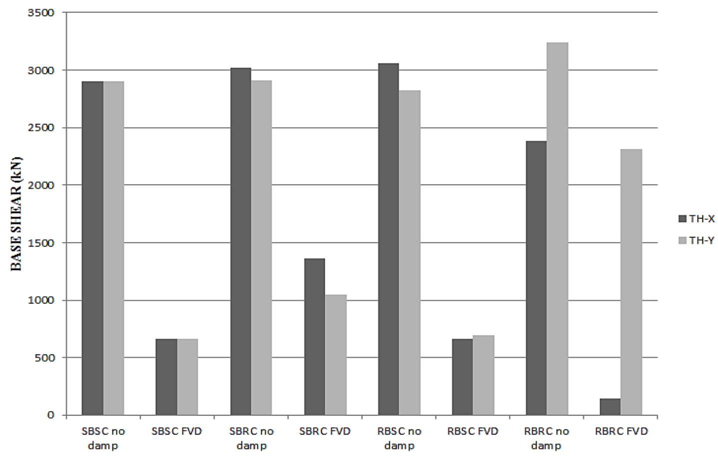

Fig -4: Comparison Base shears for Time History

From the comparison values in figure 4, it can be clearly found that due to introduction of FVD in the structures the base shears have been diminish by 77% for SBSC, 54.9% for SBRC, 78.21% for RBSC and 93.95% for RBRC in TH-X/ X-direction. Similarly, the base shears have been reduced by 77% for SBSC, 63.87% for SBRC, 75.27% for RBSC and 28.5% for RBRC in TH-Y/ Y-direction.

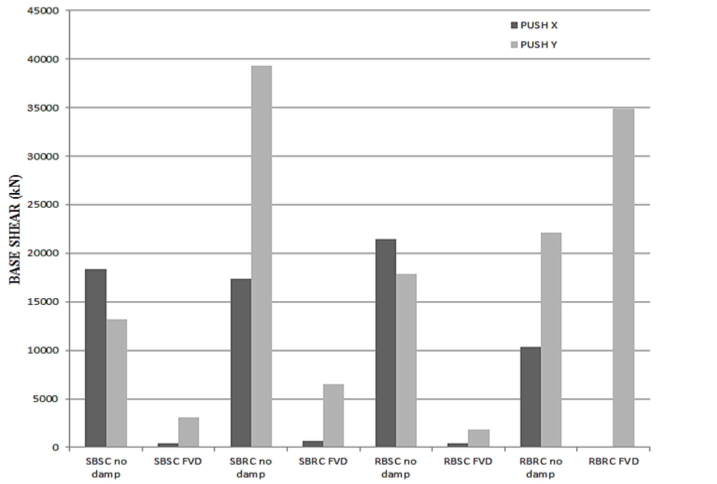

Fig -5: Comparison Base shears for Pushover

From the correlation values in figure 4, it can be precisely found that due to installation of FVD in the structures the base shears have been miniaturized by 97% for SBSC, 96% for SBRC, 98.19% for RBSC and 99.4% for RBRC in PUSH-X/ X-direction. Correspondingly the base shears have been reduced by 76.4% for SBSC, 83.4% for SBRC and 89.94% for RBSC in PUSH-Y/ Y-direction.

5. CONCLUSIONS

The following conclusions may be inferred from the data and analysis:

1. FVD can reduce the maximal PSA time period in response spectrum curves by up to 90%. In a time-history study, FVD250 reduced the structures' Base Shear by 70%. The most important thing to know Use of the FVD reduces displacements by 90%.

2. Regardless of the floor layout, square columns appear to perform better than rectangular columns in terms of structural reaction.

3. It is more difficult to assess damage to buildings using push-over analysis than time history analysis when analysing the seismic performance of structures.

5.1 Scope for future research

1. FVD250 will only be used on constructions with outside corners for the sake of this thesis.

2. Modifying the same structures with FVD500 enables them to be installed in the middle of the exterior.

3. This work may be extended to include irregular structures, unsymmetrical structures, and tall structures

4. Its application to steel structures can provide a great deal of practical solutions.

5. K-shape and M-shape can be utilised in conjunction with FVD.

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