SEISMIC EVALUATION OF MULTI-STORIED RC BUILDING WITH FLUID VISCOUS DAMPER USING RESPONSE SPECTRUM ANALYSIS

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Abstract - *Earthquakes are usually caused when rock underground suddenly breaks along a fault. Earthquake directly affects a structure by increasing the energy within the system. This study considers, Performance of G+15 building of rectangular and square plan under lateral load and seismic loading with seismic zone V, based on soil type II (medium soil) and reduction factor 5 for special RC moment-resisting frame. It is evaluated by Static and Response Spectrum analysis for various load combinations as per IS: 1893:2002. Analysis of this structural systems are computed using E-TABS 2015 software. To check the performance of the building by considering, storey displacement of both building with and without Fluid viscous damper(FVD). The object of the study is to compare the results obtained from static and response spectrum analysis of rectangular building with square and rectangular column cross section and square building with square and rectangular column cross section with and without FVD.*

Key Words: **ETABS 2015, Fluid viscous damper(FVD), Response Spectrum analysis, Rectangular building, Square Building**.

1. INTRODUCTION

An earthquake is shaking of earth surface by waves emerging from the source of disturbance in the earth by virtue of release of energy in the earth's crest. The earthquake waves motivate most of lateral loads on structures. Because of this, structures can experience a large deflection or complete collapse, depending on type of building, magnitude of earthquake, zone factors and other parameters. The collapse of structures can lead to loss of life and property damage, resulting in greater financial losses and social aliments. Therefore, structures are designed to resist earthquakes. For many decades, the formation of earthquake resistance design depends on material harmony to eliminate earthquakes triggered by structural systems. In seismic active zone structures are subjected to various lateral loads such as, earthquake load and wind load also in addition with gravity loads.

The performance of structure during an earthquake depends on the severity of the earthquake and the structural characteristics. Such as material, sectional properties, and structural systems have a significant effect on lateral load resisting capacity of the structure. However, many codes have specific design specifications for seismically protected buildings, but there is still need of some modified rules for energy dissipation protective systems. The use of these structural control systems is very much limited in India. In the present study, an attempt has been made to introduce fluid viscous dampers into a rectangular and square plan with rectangular and square column cross-section with and without FVD.

1.1 FLUID VISCOUS DAMPERS

It is one of the energy dissipation devices, FVD have been greatly used in the vibration control of various structural and mechanical systems. These dampers have been widely used in the military and aerospace industry for many years and have recently been adopted for structural applications in civil engineering. It has the unique ability to simultaneously reduce both deflection and stresses within the structure. Because FVD varies its force only with velocity, which causes response which is essentially not in phase with stresses. A modern fluid viscous damper works in significant amount of fluid pressure, making the damper small, compact and also easy to install. This type of damper is usually less expensive to purchase, install and maintain than other types of dampers.

FVD has a stainless-steel piston rod and a self-contained piston displacement accumulator unit with a bronze shield head. The damper cylinder is filled with compress able viscous fluid (silicone oil) which is generally non-toxic, non-flammable, thermally stable and environmental friendly. Longitudinal section of fluid viscous damper is shown in figure-1.

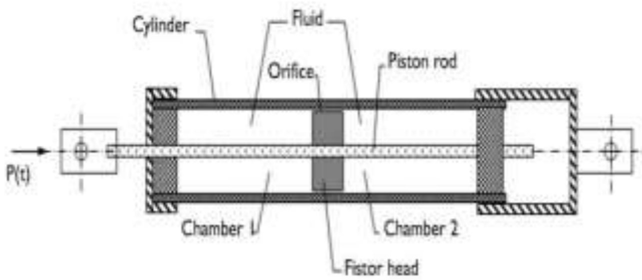

Fig 1: Longitudinal section of Fluid viscous damper

1.2 Working

FVD work on the principle of fluid flow through orifices. These devices resemble the normal shock absorber those found in vehicles. FVDs contains a stainless-steel piston which moves through chambers filled with silicone oil. The silicone oil is inert, non-toxic, non-flammable, stable and long lasting. Because of the pressure difference between the two chambers and the seismic energy, the silicone oil flows through an orifice in the piston head and transformed into heat, which emitted into the atmosphere. When the FVD is exposed to external excitations, it makes the cylinder to move back and forth the piston rod with piston will make reciprocating motion. The two chambers separated by the piston head. In this process, the collision occurred between the molecules of the damping medium, the damping medium of the cylinder, and the throttling damping power produced by the damping medium through the piston, all these action combines together to constitute the damping force. The role of FVD is to alter the mechanical energy caused by the winds earthquakes or other structural vibrations, into the inner energy of the damping medium. Dampers temporarily use moderate reduction temperatures to store energy. The heat is ultimately consumed by natural cooling. In this way, the fluid viscous dampers protect the structure from damage. FVDs can operate over temperature fluctuations ranging from -400C to +700C. The damping force of a fluid viscous damper can be calculated using,

$$F = C\,V^{\alpha}$$

Where F is damping force, C is damping co-efficient, V is velocity of piston relative to the cylinder and α is the damping exponent.

2. DETAILS OF REINFORCED CONCRETE BUILDING

The modelling of RC rectangular building is built up of 14 bays in X-direction 7 bays in Y-direction. And square building is built as 7 bays in both X and Y directions. 15 story frames made up of M25 grade concrete and Fe 500 grade steel is considered in this study. A plan is considered with width of each bay being 6m. Story height is taken as 3m. Hence the total width of the rectangular frame is 84X42m and square frame is 42X42m and height is 45m respectively. The support conditions are assumed to be fixed and reduction factor taken as 5 (SMRF) soil type 2(medium) and seismic zone V. The beam and column sizes are taken as 400 x 650mm and 450 x 900mm respectively. Slab thickness is taken as 150mm resting on all floor beams and a live load on 4kN/m2 on all floors and finish load of 1.5kN/m^2 and 2kN/m^2 on roof and finish load 1kN/m^2 on roof are considered, wall load is 10kN/m on floor throughout beam length. As per IS 1893:2002 (Part 1), a live load reduction factor of 0.5 for all floors except roof is applied in seismic analysis.

The dampers are provided in all the corners of the building respectively. It resulted in 8 dampers in each story of the building and hence a total of 120 dampers for building. Fluid viscous dampers manufactured by Taylor Devices Inc., USA are considered in this study.

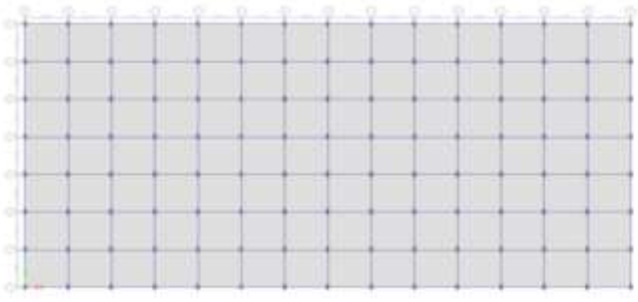

Fig1: Plan of rectangular building with rectangular column (RBRC)

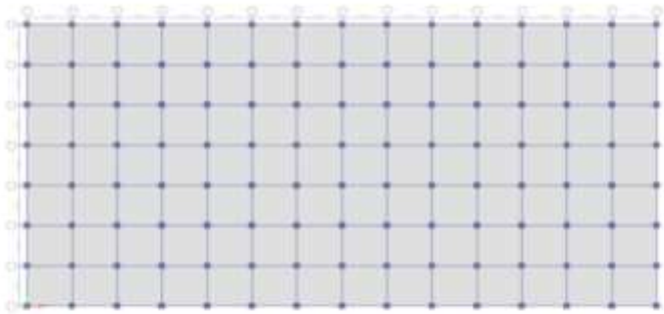

Fig2: Plan of rectangular building with square column (RBSC)

Fig3: Plan of square building with rectangular column (SBRC)

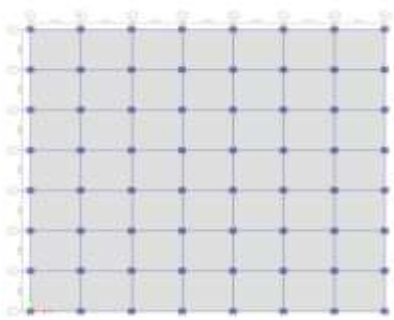

Fig4: Plan of square building with square column (SBSC)

3. MODELLING AND ANALYSIS

The modelling and analysis of bare frame structure and structure with FVD are made using the ETABS 2015 computer program. The modelling of structure elements and fluid viscous dampers varies with the type of bracing considered to mount the damper to the frame. Link factor called Damper – Exponential is used to model FVD. The mass and weight of the damper element should be calculated. And also bracing used to connect should be calculated and entered. The fluid viscous dampers inserted in single diagonal bracings are active in the local axial direction. Therefore, directional properties only select an active degree of freedom U1 is selected directional property and because its behavior is non-linear, the non-linear option is chosen. Rotating inertia R1, R2, and R3 is entered zero, because there will be no provision for rotation.

After defining the directional properties (U1), specify non-linear properties of the damper in a specific direction. The values of stiffness, damping co-efficient and damping exponent should be entered in the non-linear properties. The stiffness is calculated based on the cross-sectional area of the steel section (ISRO 100) used for bracing and the length of bracing. The value of stiffness is taken as 261800kN/m in this study. On response spectrum analysis is carried out on zone V.

Response spectrum is just a plot of maximum or steady-state response (displacement, velocity or acceleration) of the oscillators of the natural frequency series, which forced into motion by the same base vibration or shock. The resulting plot can then be used to pick the response of any linear system, given its natural frequency.

Response spectra is an extremely useful tool for earthquake engineering to analyses the efficiency of seismic structure and equipment in earthquakes, since many are essentially simple oscillators (also known as single degree of freedom systems). Thus, if you can find the natural frequency of the structure, then the maximum response of the building can be estimated by going through the value from the ground response spectrum for the proper frequency. In most building codes in seismic areas, this value is the basis for calculating the forces to be designed to resist earthquakes.

4. RESULTS AND DISCUSSION

After the analysis values of different plan and different column cross-section with and without fluid viscous dampers, the response quantities are obtained for bare frame and the damped framed and the results are compared. The response quantities considered in this study is maximum storey displacements, due to earthquake in each story level. The reduction in each of these responses at each story level is found out and the percentage reduction is also determined for bare frame and damped frame in zone V. From the observation RBRC the reduction % of displacement of static analysis of building with and without damper is 35.21%, in response spectrum analysis 35.20%, and in RBSC static analysis the reduction % is 33.38% and response spectrum analysis is 33.39% in X-axis, and in SBRC static analysis reduction % is 33.25% and in response spectrum analysis is 33.25% and for SBSC static analysis the reduction % is 33.26%, in response spectrum analysis it is 33.26% in both axis. From the observation RBRC the reduction % of displacement of static analysis of building with and without damper is 35.72%, in response spectrum analysis 35.16%, and in RBSC static analysis the reduction % is 32.83% and response spectrum analysis is 32.76%, and in Y-axis. Since the considered plans are not symmetric in shape and have different column cross-section, the response quantities are also different in rectangular building but in square building it is symmetric in shape so response quantities are same in both the directions.

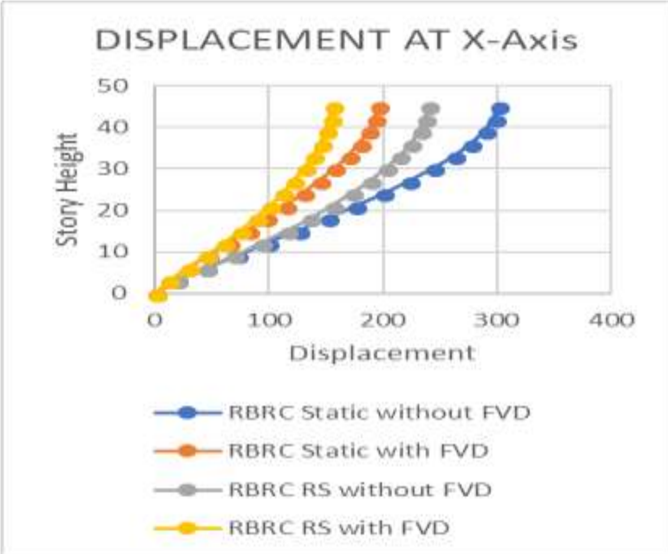

Chart -1: Displacement at X-axis at Rectangular building with Rectangular column (RBRC)

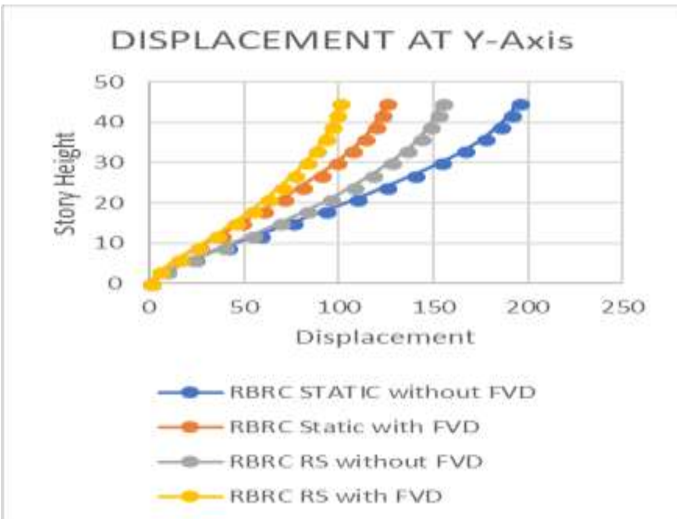

Chart:2 Displacement at Y-axis at Rectangular building with Rectangular column (RBRC)

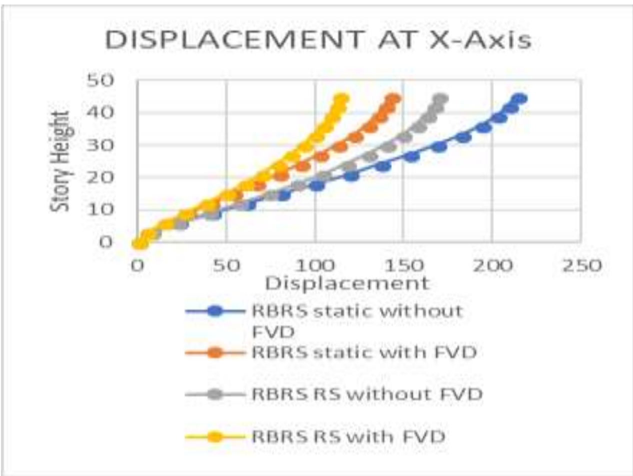

Chart:3 Displacement at X-axis at Rectangular building with Square column (RBSC)

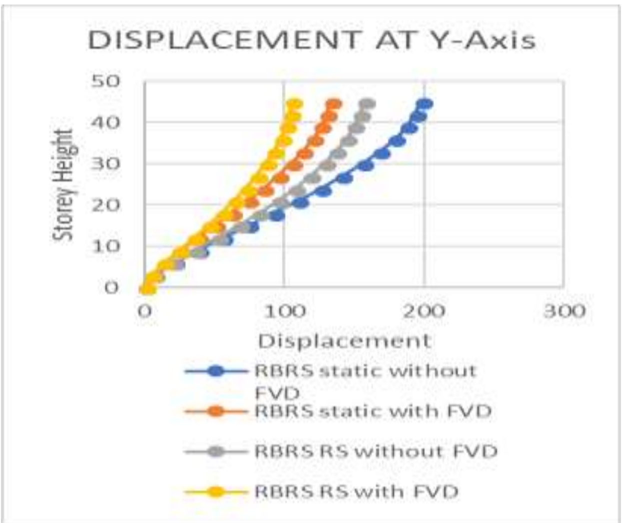

Chart:4 Displacement at Y-axis Rectangular building with Square column (RBSC)

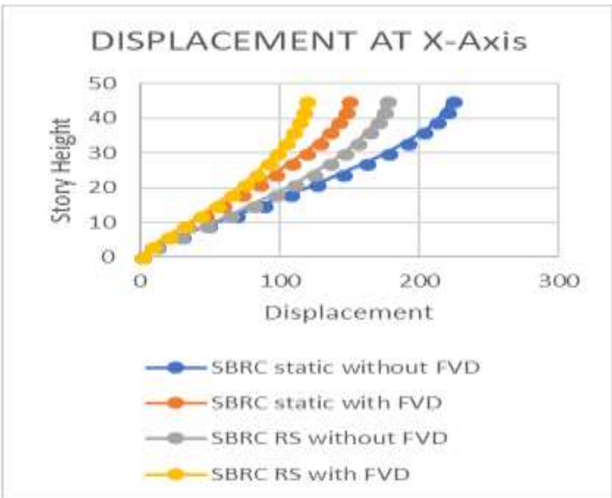

Chart:5 Displacement at X-axis at Square building with Rectangular column (SBRC)

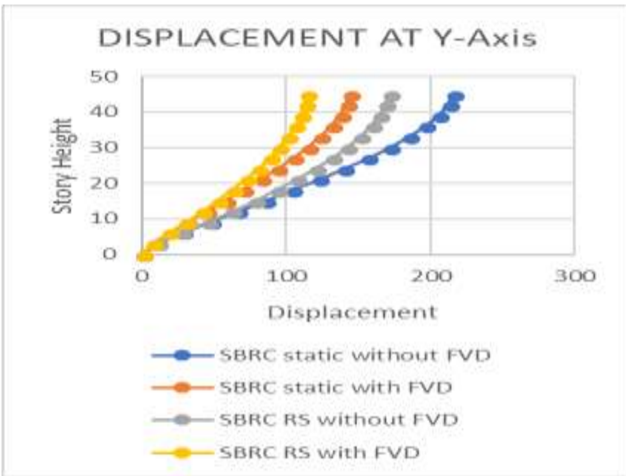

Chart:6 Displacement at Y-axis at Square building with Rectangular column (SBRC)

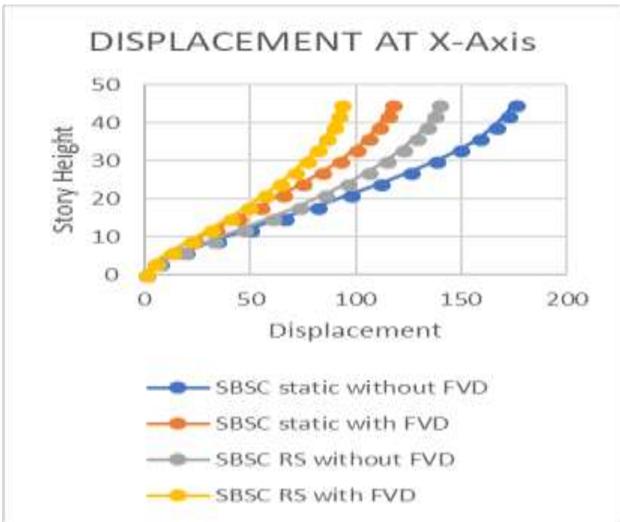

Chart:7 Displacement at X-axis at Square building with Rectangular column (SBSC)

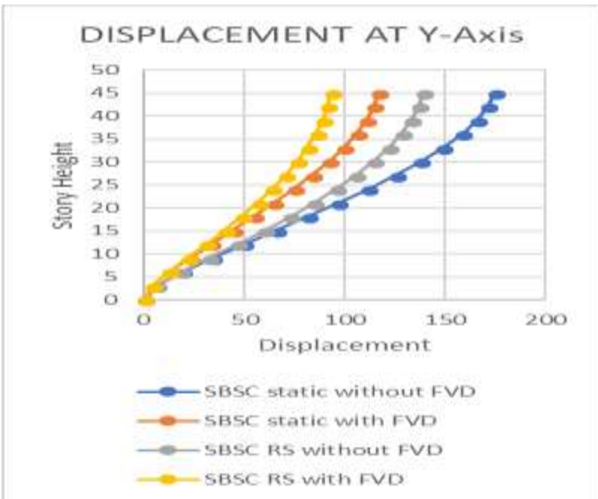

Chart:8 Displacement at Y-axis at Square building with Rectangular column (SBSC)

From the results, it is clear that fluid viscous dampers are efficient in reducing displacements considerably in seismic zone V.

5. CONCLUSION

From the results of the static and response spectrum analysis on the bare frame and damped frame, the following conclusions can be drawn. It is observed that in square frame it is symmetric in both the directions, the response quantities are also same in both the directions. Fluid viscous dampers can dissipate maximum portion of the seismic energy and hence reduce the energy input in the primary structure. The FVDs are capable of reducing both forces and displacements of the structure under seismic loads. Shear reduction in the building is obtained by providing FVD it makes structure cost effective. It can also be concluded that the fluid viscous dampers can be effectively used as one of the better alternatives for the conventional ductility-based design methods of earthquake resistant design of structures. From the observations the best percentage of reduction of displacement is more in RBRC.

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