STRUCTURAL CONTROL SYSTEM FOR MID RISE BUILDINGS

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ABSTACT

In recent year's considerable attention as been paid to research and development of structural control devices with particular emphasis on mitigation on seismic response of buildings. Control system has been recognized as a very efficient tool for controlling the seismic response of a structure during an earthquake. This paper presents Seismic design concept in which super structure is divided into several segments. Each segment may comprise a few stories and is interconnected by additional vibrational isolation systems. The seismic response of a typical segmental building subjected to the El Centro earthquake inputs are evaluated and compared with the response of the corresponding fixed-base and conventional base-isolated buildings.

Keywords: Isolators, Segmental Concept, Structural Control System, New Design Approach, SAP 2000.

I. INTRODUCTION

For seismic design of building structures, the traditional method, *i.e*., strengthening the stiffness, strength, and ductility of the structures, has been in common use for a long time. Therefore, the dimensions of structural members and the consumption of material are expected to be increased, which leads to higher cost of the buildings as well as larger seismic responses due to larger stiffness of the structures. Thus, the efficiency of the traditional method is constrained. To overcome these disadvantages associated with the traditional method, many vibration-control measures, called structural control, have been studied and remarkable advances in this respect have been made over recent years. Structural Control is a diverse field of study. Structural Control is the one of the areas of current research aims to reduce structural vibrations during loading such as earthquakes and strong winds. Vibration control is the mechanism to mitigate vibrations by reducing the mechanical interaction between the vibration source and the structure, equipment etc to be protected Structural control relies on stiffness (i.e. energy storage) and damping (i.e. energy absorption/dissipation) devices in a structure to control its response to undesirable excitations caused by winds and moderate earthquakes. This control has, in most cases, been achieved passively by means of bracing systems and shear walls, which do not require any additional external energy input. More recently, we have seen the emergence of more modem passive structural control systems. The segmental and base isolation systems are examples of such relatively modern passive systems.

II. PROBLEM DESCRIPTION

Number of stories	16
Height of storey	3m
Number of storey in segment	4
Damping ratio	5%
Plan Area	8mx8m
Size of Beams	0.3x0.45m
Column schedule	
1st to 8th floor	0.3mx0.9m
9th to 12th floor	0.3mx0.75m
13th to 16th floor	0.3mx0.6m
Ground motion	El Centro Earth quake
Analysis type	Time History

III. METHODOLOGY

In the present study 16 storey building with fixed base, base isolated building and segmental building i.e. isolator provided at the floor level is considered. In order to investigate the feasibility of isolation system at intermediate levels of buildings, analytical study is carried out for buildings of 16 story height. The segmental building concept can be viewed as an extension of the conventional base isolation technique with a distributed flexibility in the superstructure. To reduce the base displacement, segmental-approach is being adopted for present study. In present study 16 story building is divided into 4 segments, Absorption and dissipation of earthquake energy are afforded by isolators at all 4 levels rather than just at the base level. Dynamic characteristics of segmental building are investigated using rubber bearing. Analysis is Performed using SAP software. Lateral stiffness of particular isolator system is found by apply the load P at the different levels in fixed base building. After the application of load at different level, displacement is achieved. Then the stiffness is calculated by P/Δ effect.

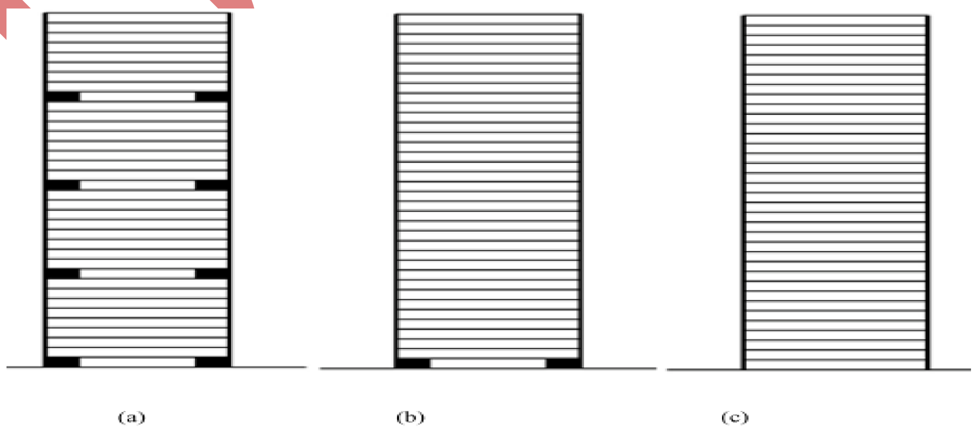

Fig 1: (A) Segmental Building (B) Base Isolation Building (C) Fixed Base Building.

TABLE 1: Initial Stiffness of the Building at Different Level

Storey Level	Displacements along X in mm	Displacements along Y in mm	Load P in N	K along x in N/mm	K along Y in N/mm
4th	125.524483	223.19	100000	796.6573	448.0488
8th	291.931302	433.2191	100000	342.5463	230.8301
12th	420.841118	586.7355	100000	237.6194	170.4346
16th	500.251184	677.9669	100000	199.8996	147.4998
Total initial stiffness(K)				1576.723	996.8133

TABLE 2: Stiffness of Isolators for Base Isolation Building and Segmental Building.

Type of Buiding	K along X in N/mm	K along Y in N/mm
Base Isolation Building	31600	20000
Segmental Building		
K1	15934	8961
K2	6851	4616
K3	4752	3408
K4	3998	2950

IV. RESULTS

Time history analysis has been carried out for building with fixed base, building with isolators at the base and building with isolators at segments under El Centro ground motion and the results has been compared for storey displacements, velocity, acceleration and base shear.

4.1. Natural Time Periods

Natural Time Periods of first five modes are shown in Fig 2. From the results it can be seen that time period of Fixed Base is lowest and time period of Segmental is highest for all 5 modes. It can be seen that for segmental building the natural time period is increased to 12.4 sec when compared to building with fixed base which is 4.8 sec. An increase of 7.6 sec natural time period can be seen in segmental building has compared to conventional fixed base building due to absorption of energy by the isolators.

TABLE 3: NATURAL TIME PERIODS (Sec)

Type of Building	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Fixed Base	4.822	4.0812	3.7463	1.6139	1.2847
Base Isolated	7.4799	6.779	4.368	2.0275	1.537
Segmental	12.399	11.807	5.067	3.4596	2.9973

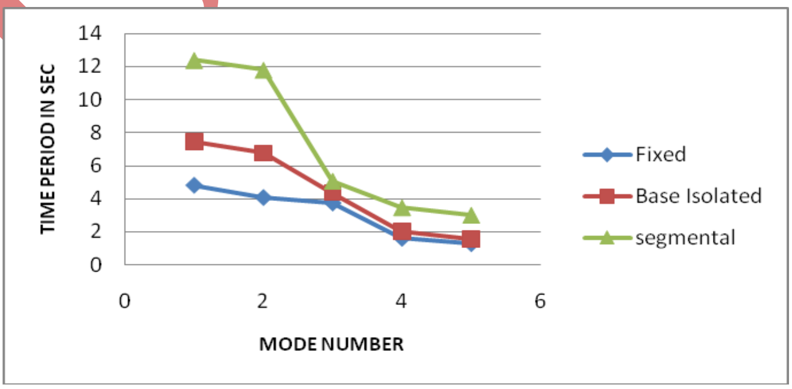

Fig 2: Natural time period in Sec

4.2. Displacement

Considerable reduction in top floor displacement can be seen in Segmental Building when compared to Base Isolation Building as shown in Fig 3. It can be seen that for fixed base building the top floor displacement is 10.5 mm where as for the segmental building it is 1.3 mm. Reduction of 9.2 mm displacement can be seen in segmental building when compared to fixed base building and reduction of 6.5 mm displacement can be seen in segmental building when compared to base isolation building.

TABLE 5: Displacement of Top Floor (Mm)

Fixed Base Building	Base-isolated Building	Segmental Building	Difference between Segmental and Base isolated building
10.531	7.78	1.293	71.49%

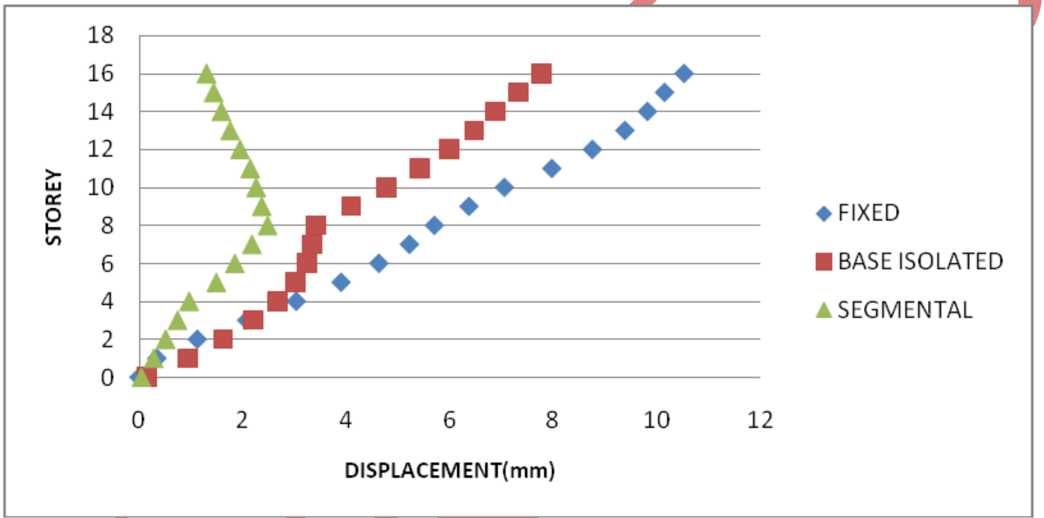

Fig 3: Plot of Displacement at Different Storey Level.

4.3. Velocity

Top floor velocity of segmental building is low as compared to the compared to the Base Isolation Building as shown in Fig 4. The peak roof velocity of fixed base building is 0.029 m/s where as for segmental building it is 0.0162 m/s .Decrease of 0.0128 m/s velocity can be seen in segmental building when compared to fixed base building.

TABLE 6: Velocity of top floor (m/s)

Fixed Base Building	Base-isolated Building	Segmental Building	Difference between Segmental and Base isolated building
0.02898	0.02269	0.01642	16.03%

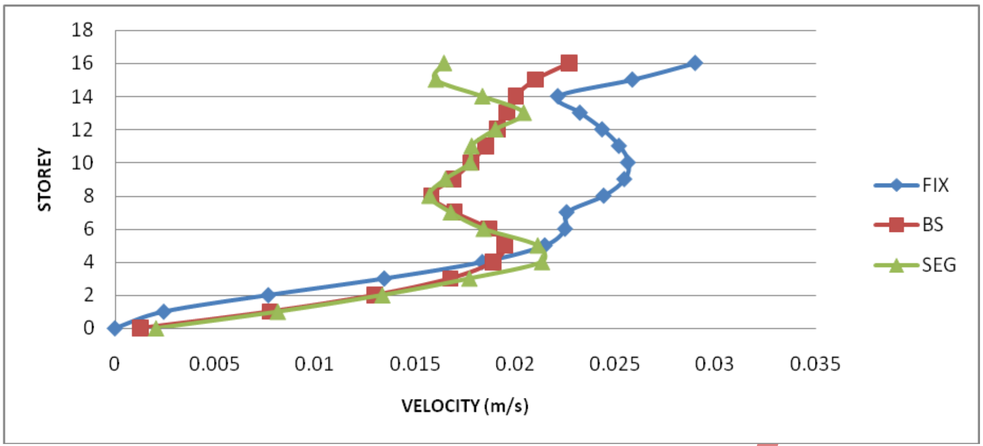

Fig 4: Plot of Velocity at Different Storey Level.

4.4 Acceleration

Peak top floor acceleration of segmental building is low as compared to the compared to the Base Isolation Building as shown in Fig 5. For building with fixed base the top roof acceleration is 0.1611m/s^2 where as for segmental building it is 0.1314 m/s^2. An average Reduction of 10.15% in peak roof acceleration is seen in segmental building as compared to fixed base building and average Reduction of 2.63% in peak roof acceleration is seen in segmental building as compared to base isolation building.

TABLE 7: Acceleration of Top Floor (M/S^2)

Fixed Base Building	Base-isolated Building	Segmental Building	Difference between Segmental and Base isolated building
0.1611	0.1385	0.1314	2.63%

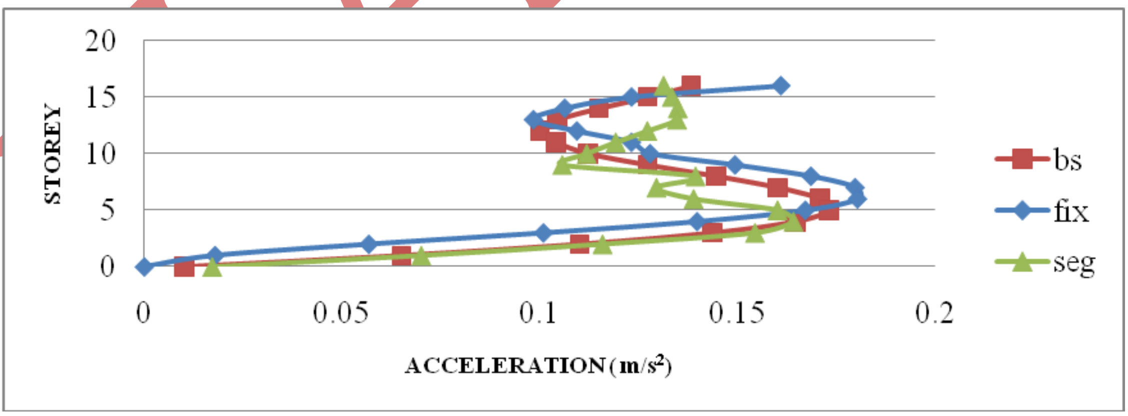

Fig 5: Plot of Acceleration at Different Storey Level.

4.5. Base Shear

Considerable reduction in Base Shear can be seen in segmental building as compared to Fixed Base and Segmental building as shown in Fig 6.Reduction of 39.29% can be seen in segmental building as compared to Base Isolation building.

TABLE 8: Base Shear (KN)

TYPE OF THE BUILDING	BASE SHEAR IN KN
FIXED	42890
BASE	14590
SEGMENTAL	6358

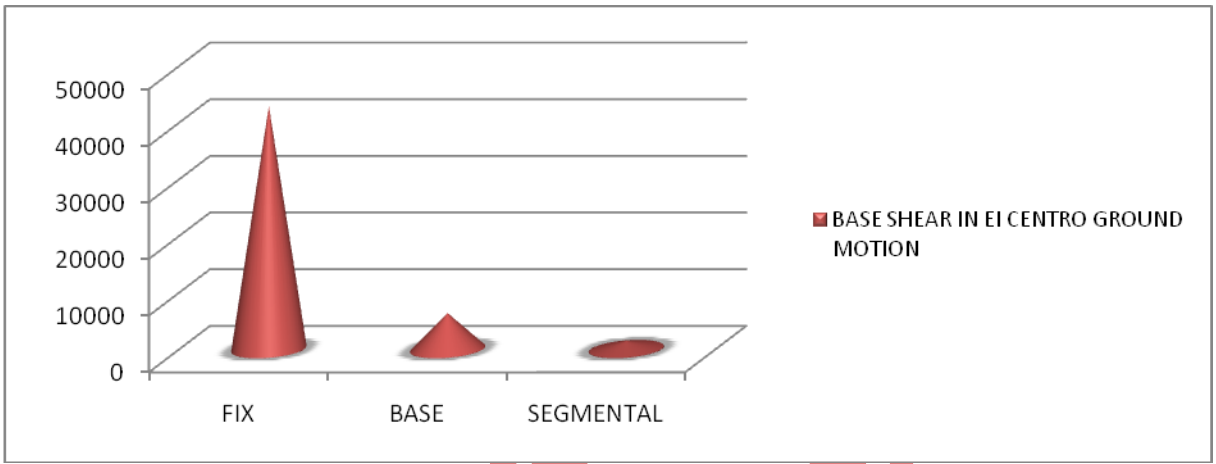

Fig 6: Base Shear in El Centro Ground Motion

VI. CONCLUSIONS

The following conclusions are drawn from present study

- Natural time period of segmental building is higher compared to equivalent base-isolated building.
- Reduction of average 71.49% is seen in segmental building compared to base-isolated building for El centro ground motion.
- Segmental building has capability similar to base-isolated building to reduce acceleration at top storey compared to fixed-base building. An average Reduction of 2.63% is seen in segmental building as compared to base-isolated.
- Average reduction of 39.29% in base shear is seen in segmental building as compared to base-isolated building for El centro ground motion.
- Hence segmental building is effective in controlling the earthquake response–displacement velocity, acceleration, Base shear of the structure.

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