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Seismic Response Reduction of Building Using Active Control

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Abstract

In this present paper, there is a study related to the behaviour of a multi-storey building and its different parameters like top storey displacement, base shear, control force etc. The active control system is applied to 5 storey buildings subjected to a seismic load of four different earthquakes, namely Bhuj, Kobe, elcentro, elalamo. The comparative study between one actuator and two actuators shows and their effectiveness in the control of seismic control.

Keywords: *- Active Control System, Actuators, Bhuj, Elcentro, Elalamo, Kobe, Seismic Control*

INTRODUCTION

The number of natural hazards is increasing nowadays. The amount of damage done by these natural hazards is very much. So to study these hazards and to minimize the effects caused by these hazards are very important. So to study these natural calamities, various methods have been invented and the comparative study of these systems is going on for the best possible outcome so that the risk management can be decreased. Different types of methods have been developed for the control of a multi-storey building's behavior. And there are different methods to analyze these comparative studies of the behavior of multi-storey buildings. During the natural calamity, the structures have to go through serious vibrations during its lifetime. These vibrations can range from harmless to very serious, which can damage a structure very badly.

PROTECTION OF STRUCTURE FROM SEISMIC LOAD

1. The Traditional Technique of a seismic Design – by increasing the stiffness of structures by enlarging the section of columns, beams, shear walls, or other elements.

2. Modern Approach through Structural Controls – By installing some devices, mechanisms, substructures in the structure to change or adjust the dynamic performance of the structure.

BASIC PRINCIPLES OF SEISMIC RESPONSE CONTROL

The basic principle of seismic response control of a structure is to introducing the mechanisms which can decrease the response of the building and also dissipate the energy of an earthquake. The following are the different methods for seismic energy control and energy dissipation.

1. Passive control systems
2. Active Control systems
3. Semi-active control systems
4. Hybrid control systems

SCOPE OF STUDY

In today's world, there is a tremendous urge for disaster management and disaster risk management. There is great research going on for disaster management. An earthquake is also a natural calamity that should be properly studied and proper steps should be taken to diminish the hazardous effects caused by it. It also brings secondary calamities like a tsunami, which has its own ill effects. So my objective of doing the research in my master's degree is to how we can prevent or minimize the earthquake's effect on a multi-storey building. I have used an active control system for diminishing the displacement and energy dissipation of an earthquake. An actuator is an active control system element that absorbs the earthquake energy. I have also carried out research about which storey the actuators are most effective. I have used a linear quadratic algorithm for the computation of my results. I am using MATLAB software for the uses of a linear quadratic algorithm. It is a very effective tool for a comparative study of different cases. There is a response history of different earthquakes and according to which I am going to calculate the effects of the position of the actuators, which are most preferable.

1. To study the effect of providing actuator at different storeys and to study the placement of the actuator, which is best suited for 5 storey building.
2. To study the effect of placing two actuators at different storeys and to

study the effectiveness of two actuators over one actuator.

3. To know the effectiveness of placing the actuators over the uncontrolled building.
4. To find out the best-suited placement of actuators for the control force.

ACTIVE CONTROL SYSTEM IN A BUILDING

After the development of passive devices such as base isolation and TMD, the next steps are to control the action of these devices in an optimal manner by an external energy source. Such a system is called an active control system. In recent years significant progress has been made on the active control for civil engineering structures. Also, a few models explain that there is great promise in the technology and that one may expect to see several dynamic control systems in the foreseeable future. The philosophy of the past conventional a seismic structure is to respond passively to an earthquake. In contrast, in the DIB, which we propose, the building itself functions actively against earthquakes and attempts to control the vibrations. The sensor distributed inside and outside of the building transmits information to the computer installed in the building, which can make analyses and judgments. If the buildings possess intelligence pertaining to the earthquake, it amends its own structural characteristics minutes by the minute.

ACTIVE CONTROL SYSTEM

The system consists of three basic elements:

1. Sensors to measure external excitation and/or structural response.
2. Computer hardware and software to compute control forces on the basis of observed excitation and/or structural response.
3. Actuators to provide the necessary control forces.

The active system has to necessarily have an external energy input to drive the actuators. On the other hand, passive systems do not require external energy and their efficiency depends on the tunings of the system to expected excitation and structural behavior. As a result, the passive systems are effective only for the modes of the vibrations for which these are tuned. Thus the advantage of an active system lies in its much wider range of applicability since the control forces are worked out on the basis of actual excitation and structural behavior. In the active system, when only external excitation is measured system is said to be open-looped. However, when the structural response is used as input, the system is in closed-loop control. In certain instances, the excitation and response are used and are termed as open-closed loop control.

CONTROL FORCE DEVICES

Many ways have been proposed to apply control forces to a structure. Some of these have been tested in the laboratory on scaled-down models. Some of the ideas have been put forward for applications of active forces are briefly described in the following:

ACTIVE-TUNED MASS DAMPERS (TMD)

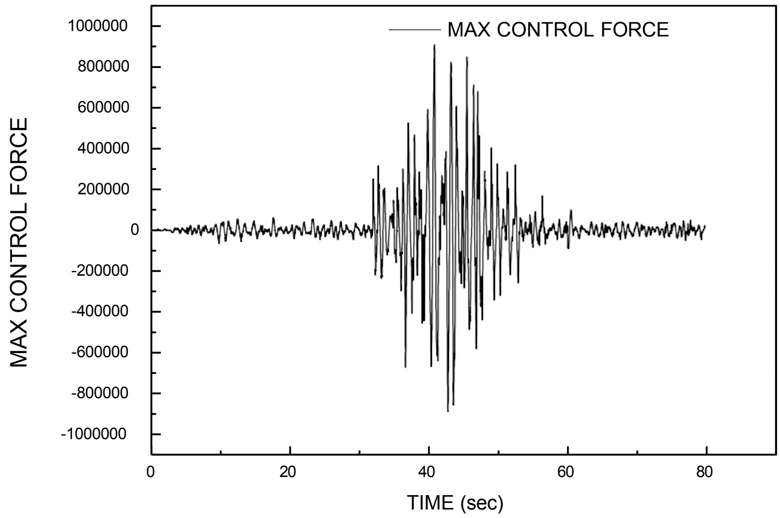
These are in passive mode have been used in a number of structures, as mentioned earlier. Hence active TMD is a natural extension. In this system, 1% of the total building mass is directly excited by an actuator with no spring and dashpot. The system has been termed as Active Mass Driver (AMD). The experiments indicated that the building vibrations are reduced by about 25% by the use of AMD.

TENDON CONTROL

Various analytical studies have been done using tendons for active control. Even with the active control system off at low excitations, the tendon will act in passive modes by resisting deformations in the structures, though, resulting in tension in the tendon. At higher excitations, one may switch over to Active mode, where an actuator applies the required tension in tendons.

LINEAR QUADRATIC ALGORITHM BY MATLAB

I have used MATLAB software for my project work. I have taken a multistory building of 4 storeys. This four storey building was subjected to 4 different earthquakes, namely Bhuj, elcentro, elalamo, Kobe. I have used LQA programming in MATLAB software for my results computation. I have used actuators for the control of the different parameters of the building. The different parameters are top storey displacement, storey drift, base shear, control force etc. the LQA technique has been proven a very useful tool for the computation of the different parameters for the important results. I have one actuator for the first case and used 2 actuators for the second case to study the importance of placing the actuators. The following are the results of my project.



RESULTS

The following are the results of study.

CASE 1: 1 ACTUATOR

BHUJ EARTHQUAKE

LOCATION	Xclqrmn[TOP STOREY	Driftrmn[DRIFT]	ulqrmax2[MAX. FORCE	BSun_max
1	0.0325	0.0074	1.95E+06	1.48E+06
2	0.0262	0.0044	1.20E+06	1.26E+06
3	0.0222	0.0033	9.08E+05	1.25E+06
4	0.0193	0.0033	8.14E+05	1.27E+06
5	0.0173	0.0033	7.46E+05	1.24E+06

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
2.63E+06	0.0092	0.0619
2.63E+06	0.0092	0.0619
2.63E+06	0.0092	0.0619
2.63E+06	0.0092	0.0619
2.63E+06	0.0092	0.0619

ELALAMO EARTHQUAKE

LOCATION	Xclqrmn[TOP STOREY	Driftrmn[DRIFT]	ulqrmax2[MAX. FORCE	BSun_max
1	0.0165	0.0038	1.10E+06	7.57E+05
2	0.0134	0.0022	6.69E+05	6.23E+05
3	0.0114	0.0018	5.02E+05	6.47E+05
4	0.0098	0.0017	4.22E+05	6.56E+05
5	0.0088	0.0018	3.80E+05	6.12E+05

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
2.64E+06	0.0105	0.0699
2.64E+06	0.0105	0.0699
2.64E+06	0.0105	0.0699
2.64E+06	0.0105	0.0699
2.64E+06	0.0105	0.0699

ELCENTRO EARTHQUAKE

LOCATION	Xclqrmn[TOP STOREY	Driftrmn[DRIFT]	ulqrmax2[MAX. FORCE	BSun_max
1	0.0605	0.0152	4.18E+06	5.68E+06
2	0.055	0.0086	2.82E+06	5.96E+06
3	0.05	0.0068	2.37E+06	6.27E+06
4	0.0457	0.0065	2.19E+06	6.39E+06
5	0.0423	0.0063	2.12E+06	6.51E+06

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
1.26E+07	0.0364	0.2278
1.26E+07	0.0364	0.2278
1.26E+07	0.0364	0.2278
1.26E+07	0.0364	0.2278
1.26E+07	0.0364	0.2278

KOBE EARTHQUAKE

LOCATION	Xclqrmn[TOP STOREY	Driftrmn[DRIFT]	ulqrmax2[MAX. FORCE	BSun_max
1	0.0813	0.0201	5.48E+06	2.97E+06
2	0.0743	0.0112	3.66E+06	2.55E+06
3	0.0678	0.0086	3.03E+06	2.65E+06
4	0.0624	0.0067	2.65E+06	2.81E+06
5	0.059	0.0074	2.49E+06	2.76E+06

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
6.53E+06	0.0256	0.1567
6.53E+06	0.0256	0.1567
6.53E+06	0.0256	0.1567
6.53E+06	0.0256	0.1567
6.53E+06	0.0256	0.1567

CASE 2: 2 ACTUATORS

BHUJ EARTHQUAKE

LOCATION	Xclqrmn[TOP	Driftrmn[DRIFT]	ulqrmax1[MIN.FORC	ulqrmax2[MAX.	BSun_max
1--3	0.01125	0.0016	8.6317	55.0157	72.7299
3--5	0.0085	0.0013	19.3937	45.1994	69.7054
10--6	0.0065	0.0014	14.58535	28.5469	75.6355
7--9	0.0068	0.00145	14.5257	28.4921	75.4829
3--8	0.0066	0.00125	21.0274	29.29445	68.50575
4--9	0.0064	0.00135	25.0695	25.0695	68.30805
2--8	0.0067	0.0012	20.6125	31.9454	68.83365
1--7	0.00705	0.00125	19.28325	38.2993	69.28975
2--9	0.00685	0.0012	23.3937	28.0143	70.811
1--10	0.0081	0.00145	28.41155	30.9861	75.20535
1--2	0.0143	0.00255	7.9806	84.1257	79.7763

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305
153.47015	0.0046	0.0305

ELALAMO EARTHQUAKE

LOCATION	Xclqrmn[TOP	Driftrmn[DRIFT]	ulqrmax1[MIN.FORC	ulqrmax2[MAX.	BSun_max
1--3	0.0058	0.0009	3.5254	30.058	37.18275
3--5	0.0043	0.00075	5.6707	22.38035	35.21775
10--6	0.0035	0.00075	7.9614	13.1798	35.45615
7--9	0.00365	0.00075	7.47295	13.00285	37.43525
3--8	0.00345	0.00065	9.975	14.8837	32.80315
4--9	0.00335	0.00075	11.66125	11.7711	33.3639
2--8	0.0035	0.00065	9.69925	16.27835	35.0857
1--7	0.0037	0.0007	7.8574	19.24065	35.09335
2--9	0.0036	0.00065	11.67665	14.2872	35.97735
1--10	0.0042	0.0008	13.2606	15.7	39.87735
1--2	0.00745	0.00135	4.49375	48.05365	39.2385

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825
86.84435	0.00295	0.01825

ELCENTRO EARTHQUAKE

LOCATION	Xclqrmn[TOP	Driftrmn[DRIFT]	ulqrmax1[MIN.FORC	ulqrmax2[MAX.	BSun_max
1--3	0.02515	0.0032	33.3481	145.0695	371.1001
3--5	0.02	0.0028	59.29995	130.3813	405.2151
10--6	0.0152	0.003	44.80645	81.14185	441.61865
7--9	0.01595	0.00335	42.49415	81.6457	470.2848
3--8	0.0155	0.00275	58.96425	86.64785	441.95505
4--9	0.01505	0.00275	67.7353	70.40975	432.40275
2--8	0.01585	0.00275	60.8683	94.12855	453.7213
1--7	0.0167	0.00295	59.37265	112.9027	445.60185
2--9	0.016	0.00275	70.80665	83.3745	462.0264
1--2	0.0299	0.0048	25.4061	193.9948	343.22735
1--10	0.01875	0.0036	81.22685	93.8786	497.53525

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714
493.44945	0.01135	0.0714

KOBE EARTHQUAKE

LOCATION	Xclqrmn[TOP	Driftrmn[DRIFT]	ulqrmax1[MIN.FORC	ulqrmax2[MAX.	BSun_max
1--3	0.0339	0.00355	38.64805	178.3956	148.93935
3--5	0.02725	0.003	53.27785	149.4365	165.0103
10--6	0.0203	0.00455	62.11065	105.7036	232.25635
7--9	0.02145	0.00485	67.9766	107.5584	248.58155
3--8	0.02055	0.0037	87.12135	101.2823	221.87965
4--9	0.01985	0.0039	84.6039	102.333	208.5414
2--8	0.021	0.0037	83.82135	109.1484	232.2531
1--7	0.02275	0.0042	83.25045	133.1727	230.57925
2--9	0.0209	0.00365	90.05735	100.4324	230.91015
1--2	0.0402	0.0065	39.64535	254.1776	167.9565

UNCONTROL BASE SHEAR	UNCONTROL DRIFT	UNCONTROL TOP FLOOR DISPLACEMENT
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705
259.72755	0.00665	0.04705

CONCLUSION

The following are the conclusions of the study:

RESULT FOR 1 ACTUATOR

1. Maximum decrease in the base shear is observed when the actuator is placed at the top storey (5th storey).

2. Maximum decrease in the top storey displacement is observed when the actuator is placed at the top storey (5th storey).

4. Maximum decrease in storey drift is obtained when the actuator is placed at 5th storey.

RESULTS FOR 2 ACTUATORS

1. Minimum top storey displacement is observed when the actuators are placed at 4-9th storeys.

2. Maximum control force is observed when the actuators are placed at 1-2th storeys.

3. Minimum base shear is obtained when actuators are placed at 1-3th storeys.

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