OPTIMIZATION OF ENERGY DISSIPATION OF EARTHQUAKE RESISTANT BUILDING USING GA & PBO

LUCKY BHUTIA.M.Tech. Final Semester Student in Structure Engineering
Department of Civil Engineering
Indoglobalcollege of Engineering &technology
Abhipur(Mohali)
Punjab,India.

GURPREET SINGH Astt. Professor
Department of Civil Engineering
Indoglobal college of Engineering & technology
Abhipur (Mohali)
Punjab,India

ABSTRACT

Earthquakes are one of nature's greatest hazards to life on this planet. Prevention of earthquake has become increasingly important in recent years. Numerous recent studies have been made for the stability and safety of structures furnished with different types of structural control systems, such as viscous dampers. A challenging issue in this field is the optimization of structural control systems to protect structures against severe earthquake excitation. As the safety of a structure depends on many factors, including the failure of structural members and movement of each structural node in any direction, the optimization technique must consider many parameters simultaneously. However, the available review for energy dissipation system based on earthquake applicable only to simple SDOF and MDOF system.Our optimization has based on pbo to minimize the effect of an earthquake on realistic structure responses, considered three directional displacements for structural nodes for seismic responses and safety excitation. This reports on the development of a multi objective optimization procedure for energy dissipation systems based on pollination based optimization, the model was applied to an example of three-dimensional reinforced concrete framed building and its structural seismic responses were investigated. The results showed that the optimized control system effectively reduced the seismic response of structures, thus enhancing building safety during earthquake excitations.

INTRODUCTION

Earthquakes generally occur due to a sudden release of energy with the violent shaking of ground. Much of the surface of the earth is subjected to earthquakes from time to time. An earthquake is spasm of ground shaking originating from part of the earth‘s crust. Earthquakes are one of the nature‘s greatest hazards to life. The impact of this phenomenon is sudden with no warning to make preparation against any damages and collapse to building. Prevention of disaster or damage caused by earthquake has become increasingly important nowadays. Disaster prevention includes reduction in dissipation energy in earthquake building. The new structure can be build more resistant to earthquake by adopting proper design methodology and by reducing energy dissipation released by earthquake in structure.The inside of our earth consists of many layer like crust, mantle, inner and outer cores. Formed by complex process over countless years, they continue to be active. Once in a while, the disturbance below the earth gets transmitted to the surface, causing earthquake. Scientific observation gives us further explanation. The crust of the earth is broken up into number of rigid plates of rock between 15 and 100 kilometers thick which are moving very slowly at about 20-120 mm per year relative to each other (see Fig. 1.1).

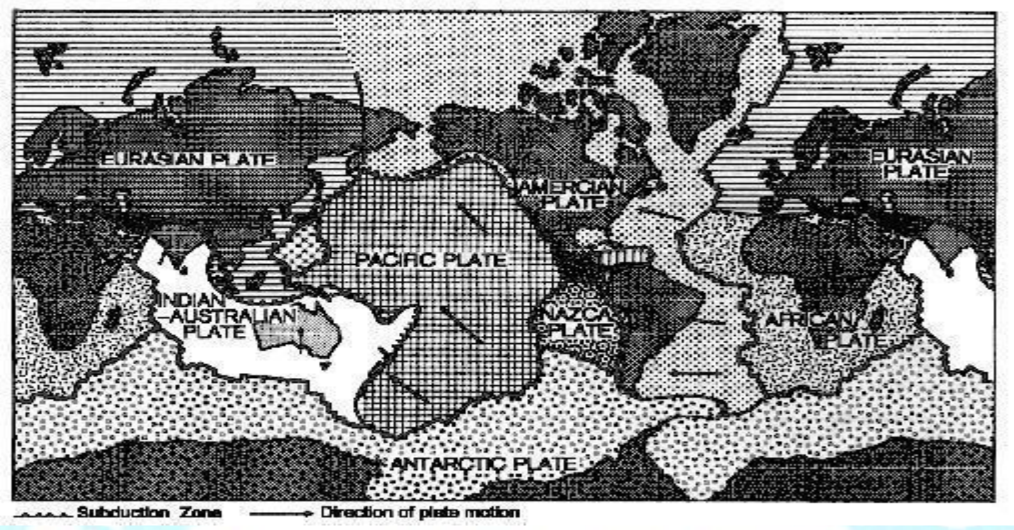
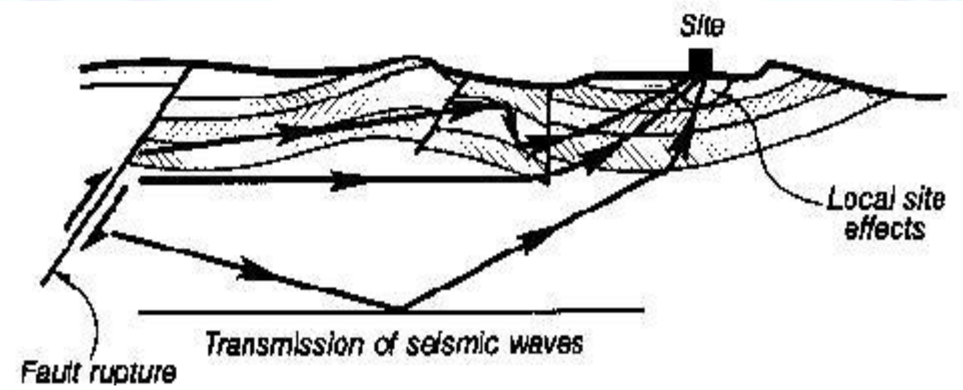


Fig. 1.1-Coastal plate boundaries of the earth

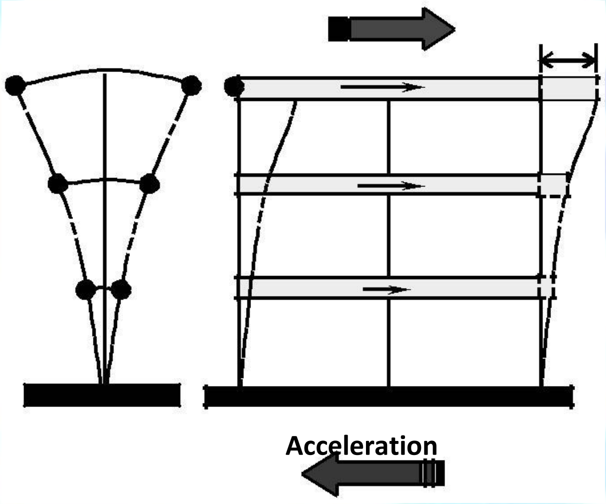
This jostling between the plates causes stresses to build up in the edge regions of the plates. Earthquakes generally occur due to a sudden release of energy when the accumulated strain at some part near the edges of plates becomes so great that rupture of the rock occurs along the plane of a fault. The resulting sudden movement along the fault causes the transmission of the complex set of shock waves through the earth that we describe as an earthquake (see Fig. 1.2). The *fault* can break through to the earth‘s surface. The place of initial rupture on the fault is known as the *focus* of the earthquake. The *epicenter* of the earthquake is the point on the earth‘s surface directly above the focus. Most of the world‘s earthquakes occur in the edge regions of the plates but intraplate earthquakes can also occur at faults away from the edges of the plates.



HOW BUILDINGS RESPOND TO EARTHQUAKES

Effect of Mass and Height

The earthquake as well as wind load acting on the buildings are termed as lateral loads‘ since their effect is felt mainly in the horizontal direction. This contrasts with the weights of the building (and occupants), which act vertically down due to gravity. Forces due to earthquake, called *seismic forces*, are induced in a building because of the heavy masses present at various floor levels. Such forces are called inertial forces, is calculated by the products of the masses and their respective accelerations. If there is no mass, there is no inertial force. Accelerations generated by the seismic waves in the ground get transmitted through the vibrating structure to the masses at various levels, thereby generating the so-called horizontal seismic forces. The building behaves like a vertical cantilever, and swings horizontally almost like an inverted pendulum, with masses at higher levels swinging more (fig.3). Hence, the generated seismic forces are higher at the higher floor levels. Because of the cantilever action of the building (fixed to the ground and free at the top), the forces accumulate from top to bottom. The total horizontal force acting on the ground storey columns is a sum of the forces (seismic loads) acting at all the levels above. This is termed as the *base shear* and it leads to highest stresses in the lowermost columns.



Seismic forces generated by masses vibrating

OPTIMISATION METHOD FOR RESISTANCE TO EARTHQUAKES

Particle Swarm Optimization (PSO) algorithms is a population-based probabilistic optimization algorithms first proposed by Eberhart and Kennedy in mid 1990s each iteration step, they compare the cost function value of a finite set of points, called *particles*. The change of each particle from one iteration to the next is modeled based on the social behavior of birds flocking or fish schooling. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it is achieved so far. (The fitness value is also stored.) The value is called pbest. Another —best value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbor of the particle. This location is called Ibest. When a particle takes all the population as its topological neighbors, the best value is a global best and is called gbest.The particle swarm optimization concept consists of, at each time step, changing the velocity of accelerating each particle toward its pbest and Ibest location. Acceleration is weighted by random term, with separated random number being generated for acceleration towards pbest and Ibest.

SIMPLE GENETIC ALGORITHM

Genetic Algorithms (GA) are algorithms that operate on a finite set of points, called a population. The different populations are called generations. They are derived on the principles of natural selection and incorporate operators for (1) fitness assignment, (2) selection of points for recombination, (3) recombination of points, and (4) mutation of a point. Our GA is an implementation of the simple GA described by Goldberg (1989), but we use a Gray (Press et al., 1993) rather than a pure binary encoding to represent the independent variables as a concatenated string of binary numbers. The simple GA iterates either until a user-specified number of generations is exceeded, or until all iterates of the current generation have the same cost function value. In the numerical experiments, we used a population size of 14, a maximum of 50 generations, 1 elite point and a probability for recombination and mutation of 1 and 0:02, respectively. We selected a small population size because the number of independent variables is small and because we expected the cost function to have no significant local minima. The choice of a small population size was balanced by a high probability of recombination and mutation. Small population sizes have also been used successfully in the solution of other small scale building optimization problems, see Caldas and Norford (2002). The idea of smart structures where sensors measure the response of a structure during dynamic loading due to strong ground motions and actuators apply internal forces to compensate for the effects of the external forces. Although extensive research has advanced structural control techniques over the last few decades, the optimization of control systems remains a challenging issue due to the complexity of structural seismic responses and the performance of the controllers.Efficient parallel algorithms for optimizing an integrated structural and control system using a combination of vector computations and multitasking approaches to accelerate their performance. They considered nodal displacements, stresses, closed-loop eigen values, and corresponding damping factors as optimization constraints. The efficiency of vectorization and parallel optimization processing for improving computational speeds was evaluated by applying the developed algorithm to the optimization of large-sized problems.

EXPERIMENTAL SETUP

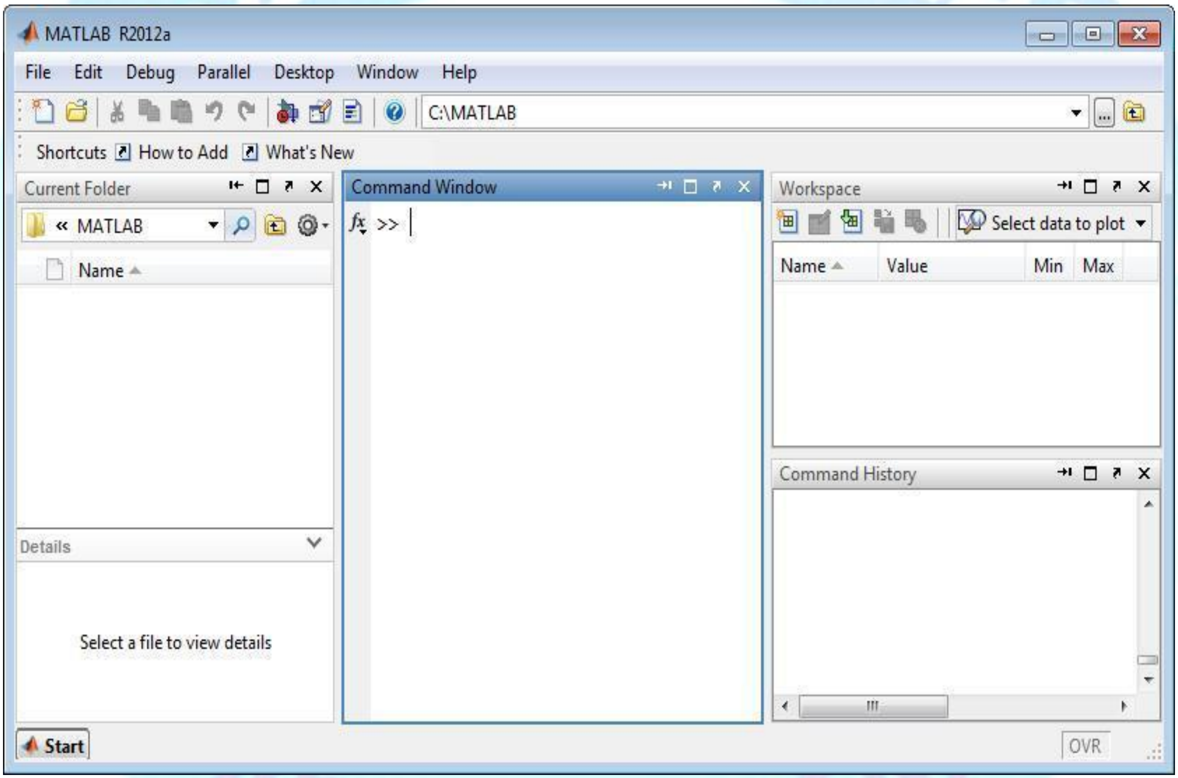
MATLAB is an intelligent programming bundle which was created to perform numerical calculations on vectors and grids. At initially, it was basically a Matrix-Laboratory. Regardless, today it is significantly more competent:

- It can do completely present day delineations in two and three estimations.
- It contains an irregular state programming lingo which makes it exceptionally easy to code entrapped estimations including vectors and grids.
- It can numerically handle nonlinear starting quality normal conscious conditions.
- It can numerically clarify nonlinear cutoff regard normal deferential conditions.
- It contains a wide arrangement of hardware stash which grant it to play out a broad

assortment of employments from science and building.

Arithmetic is the crucial building square of science and planning, and MATLAB makes it easy to

handle an expansive segment of the computations included. You should not consider MATLAB another complexity programming vernacular; however as a serious analyst that gives you access to examining charming issues in science, planning, and number-crunching. Besides, passage is available by using only somewhat number of charges and limit in light of the way that MATLAB's vital data segment is a system (or an array).This is a basic component of MATLAB it was expected to social affair a great deal of data in bunches and to perform investigative operations on this data as individual shows instead of as get-togethers of data. This makes it easy to apply convoluted operations to the data, and it makes it astoundingly difficult to treat it horribly. In strange state coding dialects you would as a rule need to take a shot at all of data autonomously and use circles to cycle over every one of the pieces. In MATLAB this can regularly do perplexed things in one, or two or three, clarifications (and no circles). Additionally, in an unusual state tongue various experimental operations require the use of cutting edge programming groups, which you have to and, agreat deal more deplorable, to grasp taking after the interfaces to these packs are as regularly as could reasonably be expected exceptionally snared and the documentation must be scrutinized and aced.
When you start MATLAB, the desktop appears in its default group



Select a file to view details

In MATLAB, on the other hand, these operations have simple and consistent interfaces which are quite easy to master. For an overview of the capabilities of MATLAB, type

```
>> Demo
```

in the Help Navigator and click on MATLAB. The
desktop includes these panels:

Current Folder —Access your files.

Command Window —Enter commands at the command line, indicated by the prompt (>>).

Workspace —Explore data that you create or import from files.

Command History —View or rerun commands that you entered at the commandline. You may exit the program using the quit command. When doing so, all variables are lost.

In any case, summoning the order spare filename before leaving causes all variables to be composed to a twofold document called filename. Mat. When we begin MATLAB once more, we may recover the data in this document with the charge load filename. We can likewise make an ASCII (content) document containing the whole MATLAB session on the off chance that we utilize the charge journal filename toward the starting and toward the end of our session. This will make a content record called filename (with no expansion) that can be altered with any word processor, printed out and so forth. This record will incorporate all that we wrote into MATLAB amid the session (counting blunder messages yet barring plots). We could likewise utilize the summon spare filename toward the end of our session to make the double document depicted above and additionally the content record that incorporates our work.

SIMULATED RESULTS

Story no.	**Optimum damper damping coefficient (kN.sec/m)**
1	800
2	400
3	200
4	100
5	200
6	100

Peak displacements in the X (horizontal) direction during the optimization process for all stories

Peak maximum displacement (mm) Using GA

Story No	Optimization process (0-1000 generations)			Reduction due to optimization	
	First	Mid	End	mm	%
1	5.76	1.06	.88	4.88	84.7222
2	20	2.73	2.13	17.87	89.35
3	34	2.96	2.2	32.69	93.6945
4	43.44	2.93	2.14	41.3	95.07
5	50.74	3.08	2.19	48.55	95.68
6	53.1	3.22	2.4	50.70	95.48

Comparison Analysis peak displacement in the X (horizontal) direction.

Item	Story no	Reduction due to optimization (%)	
		GA	PBO
Peak Maximum Displacement	1	84.7222	72.18
	2	89.35	85.09
	3	93.6945	91.08
	4	95.07	92.93
	5	95.68	93.83
	6	95.48	93.71
Peak minimum Displacement	1	82.84	90.25
	2	91.62	95.94
	3	94.44	97.37
	4	96.07	98.29
	5	96.47	98.75
	6	95.94	98.27
Peak movement Displacement	1	79.84	70.81
	2	90.27	88.12
	3	94.28	92.9053
	4	97.30	96.1998
	5	96.02	94.99
	6	95.88	94.86

Comparison Analysis peak displacement in the Z (horizontal) direction

Item	Story No	Reduction due to optimization (%)	
		GA	PBO
Peak Maximum Displacement	1	72.46	53.19
	2	90.43	86.31
	3	93.86	91.17
	4	95.00	92.7
	5	95.57	93.56
	6	95.16	93.18
	1	76.16	87.7
	2	91.08	95.38
Peak minimum Displacement	3	94.42	97.13
	4	95.98	98.10
	5	96.48	98.88
	6	96.10	98.19
Peak movement Displacement	1	78.66	68.62
	2	91.21	89.18
	3	94.63	93.28
	4	97.44	96.32
	5	96.19	95.17
	6	96.10	95.09

The optimum viscous dampers that can minimize the response of considered model of reinforced concrete framed structure under severe earthquake multi support excitation at the completion of the optimization procedure (after 251 generations) are identified and tabulated in Tables.

Summary of the analysis results

Seismic response	**Section plastic hinges**	**Total Plastic hinges**	**Story no.**						**Avg. Reduction%**
			1	**2**	**3**	**4**	**5**	**6**	
Plastic hinge reduction (%)	93.3	98.4	-	-	-	-	-	-	95.85
Peak horizontal displacement amplitude reduction in the X direction (%)	-	-	80.8	91.3	95.1	96.7	96.9	97.5	93.05
Peak horizontal displacement amplitude reduction in the Z direction (%)	-	-	75.4	91.7	95.9	96.7	96.8	96.7	92.15
Peak vertical displacement amplitude reduction in the Y direction (%)	-	-	32.7	90.2	94.5	96.0	39.0	40.5	65.48
Peak rotation reduction in the X direction (%)	-	-	75.9	64.2	66.1	71.1	61.0	62.8	66.85
Peak rotation reduction in the Z direction (%)	-	-	84.9	77.8	85.5	91.0	84.3	85.6	84.85
Peak rotation reduction in the Y direction (%)	-	-	57.5	63.2	68.2	73.7	63.2	64.8	65.10
Average reduction%	-	-	67.86	79.73	84.16	87.53	73.53	74.65	80.4833

Summary of the analysis results based on pbo

Seismic response	**Section plastic hinges**	**Total plastic hinges**	**Story no.**						**Avg. Reduction%**
			1	**2**	**3**	**4**	**5**	**6**	
Plastic hinge reduction (%)	93.3	98.4	-	-	-	-	-	-	95.85
Peak horizontal displacement amplitude reduction in the X direction (%)	-	-	82.3	92.8	96.6	98.2	98.4	99	94.55
Peak horizontal displacement amplitude reduction in the Z direction (%)	-	-	76.9	93.2	97.1	98.2	98.3	98.2	93.65
Peak vertical displacement amplitude reduction in the Y direction (%)	-	-	34.2	91.7	96.0	97.5	40.5	42.0	66.98
Peak rotation reduction in the X direction (%)	-	-	77.4	65.7	67.6	72.6	62.5	64.3	68.35
Peak rotation reduction in the Z direction (%)	-	-	86.4	79.3	87.0	92.5	85.8	87.1	86.35
Peak rotation reduction in the Y direction (%)	-	-	59	64.7	69.7	75.2	64.7	66.3	66.60
Average reduction%	-	-	69.36	81.23	85.66	89.03	75.03	76.15	81.76

Comparison analysis:

Table 18

Seismic response	**Avg. Reduction%**	
	GA	**PBO**
Plastic hinge reduction (%)	95.85	95.85
Peak horizontal displacement amplitude reduction in the X direction (%)	93.05	94.55
Peak horizontal displacement amplitude reduction in the	92.15	93.65
Z direction (%)		
Peak vertical displacement amplitude reduction in the Y direction (%)	65.48	66.98
Peak rotation reduction in the X direction (%)	66.85	68.35
Peak rotation reduction in the Z direction (%)	84.85	86.35
Peak rotation reduction in the Y direction (%)	65.10	66.60
Average reduction%	80.48	81.76

Sections yielding and plastic hinges in structural members

The number of beam, column and damper sections, which yielded due to earthquake excitation in the optimization process. It is obvious from this tabular that the number of yielded sections was reduced from 1.5 in the first pollinators to 2 at 250 pollinators (the middle of the optimization process) and to 1 in the final optimum case. This corresponds to a 81.76% reduction in number of yielded sections.

THESIS SUMMARY

This work developed a multi objective optimization computation procedure supported pollination algorithmic program to enhance the performance of earthquake energy dissipation Systems and to attenuate the unstable response of structures in terms of harm to structural members and concurrent displacements of all story levels through viscous degrees of freedom. The characteristics of damper devices were thought of as style parameters and optimization objective was outlined supported three-dimensional movement of structural nodes with avoidance of beam and column failures as style constraint. The developed optimization method is comprehensive computational algorithmic program and it permits the addition of any supplemental objective operate or style constraint to algorithmic program. The developed machine algorithmic program was applied to a model of a six-story concrete framed structure below a multidirectional earthquake load, and the results of the optimization were evaluated. Analysis showed that, overall, the utilization of the optimized damper devices reduced the structural unstable response by some 81.76%. This result indicates that the PBO shows better developed during this work with success optimized the earthquake energy dissipation system and might considerably increase building safety within the event of severe earthquake by 1.64 as compared to GA.

Future Work

For future enhancement artificial intelligence can be applied:

1. For real time structures.
2. For more stories than 6.
3. More parameter can be chosen for optimization.
4. Based on optimized value structure can be built and analyzed.
5. Different earthquakes of different amplitude can be applied and analyzed.