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Seismic Response Of Multi-storey Building Using Artificial Neural Network

Rajshree Charan[1, *], Alpesh Patel [2]

[1] Assistant Professor, Applied Mechanics Dept. The Maharaja Sayajirao University of Baroda,390002, Vadodara, India
[2] Research Scholar, Applied Mechanics Dept. The Maharaja Sayajirao University of Baroda,390002, Vadodara, India,

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Abstract

The different parameters like base shear, drift, and top storey displacement of G+7 building is evaluated by using time history analysis and response spectrum analysis for the purpose of comparative study of both the analyses using MATLAB and an artificial neural network (ANN). The main objective of present work is to analyse earthquake of different locations like Bhuj, Kobe, Victoria and Elecentro, for time history analysis building is not connected with actuator and it is analysed during seismic motion of building using a MATLAB software. Base shear, drift and top storey displacement is evaluated during this analysis. For response spectrum analysis, first building relates to actuator at top floor. And during seismic motion of building different parameters like base shear, drift and top floor displacement are evaluated using MATLAB software and for evaluation of control force of a design actuator artificial neural network (ANN) is used. From time history analysis, response spectrum analysis test results and graphs for G+7 building it is clear that, when actuator is not connected with building it does not dissipate the energy of seismic motion and base shear of building , drift , and top floor displacement is very high, and in second case when building is connected with actuator at optimal place it gives considerable response during seismic motion of building and base shear of building, drift, and top floor displacement are can considerably reduce using control actuator system.

Keywords: Seismic response, Artificial neural network, Actuator, Base shear, Top floor displacement

1. Introduction

In recent year world –wide attention has been directed towards the use of seismic control device to mitigate the effect of dynamic loads on structure such as strong earthquake, extreme waves, high wind etc. In past, the effect of dynamic load is not considered because structure is rarely subjected to dynamics load; more so its consideration in analysis makes the solution more complicated and time consuming.
The failure of neglecting the dynamics loads may sometime become cause of disaster. Hence, now a days there is grown interest in the process of designing civil structure capable to withstand dynamic loads. Artificial neural networks are capable to detect similarities in input. even though a particular input may never have been seen previously. this property allows for excellent interpolation capabilities especially when input data is noisy.
Mohamad pasai mohram [1] use artificial neural network for predict seismic behaviour in RC building with and without infill walls. The result predicts by modes agree closely with experimental result.

Scope Of Study

In present work, artificial neural network is applied to check their efficiency in the analysis of seismic response of multi storey building
1.Active control device is used to mitigate the effect of earthquake on multi storey building.
2.Actuator provide at optimal place to reduce the displacement and storey drift of building during earthquake.
3.To develop artificial neural network model for the analysis of structure.
4.Compare the result of various parameters like storey drift, control force, floor displacement, base shear etc. in two cases, providing actuator and without actuator

Theory Of Active Control System Used in Multi Storey Building

The different type of active controls in this system mechanical device are incorporated into the building, which actively participated in the dynamic behaviour of the building in response to the measurement of its behaviour during the earthquake ground motion. in this system the structure characteristics are modified according to seismic input to the building.
It consists of:
• Sensor located on structure which record external excitation or structural response both.
• Device to process measured information and to compute necessary force according to given control algorithm.
• Actuator usually power by External sources to produce require forces are given below
• Active mass damping
• Active bracing
• Active control

*Corresponding author. Tel: +919409236669; E-mail address: charan.rajshree@gmail.com

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Active mass damping

A tuned mass damper, also known as a harmonic absorber, is a device mounted in structures to reduce the amplitude of mechanical vibrations. Their application can prevent discomfort, damage, or outright structural failure They are frequently used in power transmission, automobiles, and buildings.
Tuned mass dampers stabilize against violent motion caused by harmonic vibration. A tuned damper reduces the vibration of a system with a comparatively lightweight component so that the worst-case vibrations are less intense. Roughly speaking, practical systems are tuned to either move the main mode away from a troubling excitation frequency, or to add damping to a resonance that is difficult or expensive to damp directly. An example of the latter is a crankshaft torsional damper. Mass dampers are frequently implemented with a frictional or hydraulic component that turns mechanical kinetic energy into heat, like an automotive shock absorber.

Artificial Neural Network

An Artificial Neural Network (ANN) is an information processing system which was developed as a generalization of mathematical model of human cognition. An ANN is a mathematical model that tries to simulate the structure and functionalities of biological neural networks. Network works in a similar way to a human brain. It finds solution (i.e., Produces an output) for a problem in given situation (i.e., from given Input).
The basic processing elements of neural networks are called artificial neurons or simply neurons. Often, they are simply called as nodes. Neurons perform as summing and non-linear mapping junctions. The nodes acquire knowledge through a process of learning by changing the weights associated with each input. They store this knowledge in terms of weights on completion of learning process and use it to find the output A neural network is a network made up of such inter-connected neurons which is inspired from studies of the biological nervous system.

Architecture Of Neural Network

The neurons are assumed to be arranged in layers and neurons in the same layer behave in the same manner. All the neurons in a layer usually have a same activation function. Within each layer, the neuron is either fully interconnected or not connected at all. The neurons in one layer can be connected to neurons in another layer. The arrangement of neurons in the layers and the connection pattern within and between layers is known as network architecture.
Input layer:
The neurons in this layer receive the external input signals and perform no computation but simply transfer the input signals to the neurons in another layer.
Output layer:
The neurons in this layer receive signals from neurons either in the input layer or in the hidden layer.
Hidden layer: The layer of neurons that are connected in between the input layer and the output layer is known as hidden layer.
Various techniques to reduce the earthquake effect on top floor displacement

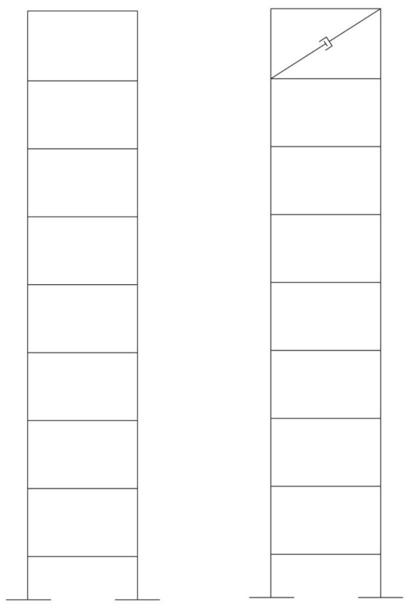

Fig.1 G+7 building not connected with actuator and connected with actuator

1)The ACI-code for ductile detailing of rc structures requires special confining reinforcement to be provided over the full height of column that are likely to sustain short column effect. The special confining reinforcement (i.e., closely spaced closed ties) must extend beyond the short column into the columns vertically above and below by a certain distance for details of special confinement reinforcement.
2) Connect the top floor of building with actuator, so when earthquake come it automatically reduce the effect of earthquake force on a building.
In this paper we selected a method of design active actuator, and we design actuator at top floor of G+7 building.
the reason why we connected a building with actuator on top floor is
It is obvious that the displacement of short column is greater than the long column just because of its high stiffness. When earthquake occur due to large stiffness of short column earthquake is gravitated more to short column as compared to long column. So, we always design ground floor column as long column and top floor column is short column but due to earthquake there is more deflection occur in a top floor displacement.

Result And Discussion

There are two cases exist, in first case building is connected with actuator and in second case the building is not connected with actuator that by using LQR function and artificial neural network different parameters evaluated like top floor displacement, base shear, drift are calculated for four places which is Bhuj, Kobe, Victoria, Elcentro and graphs are drawn for both the cases. for an example the Kobe graphs are shown below.

1) Time interval vs Excitation
In above graph the time interval vs excitation is plot. Excitation is measured in m/ sec2 while time interval is measured in sec and W= weight of building (18 ton).

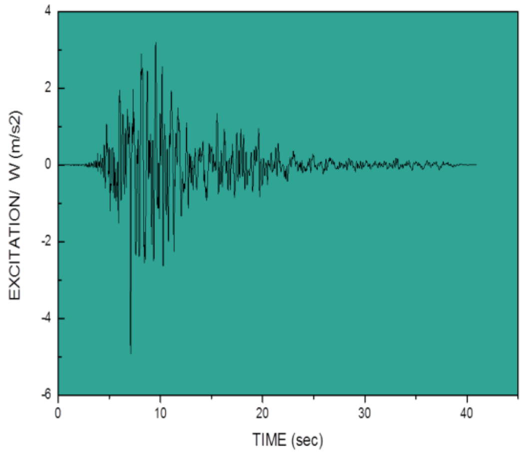

Fig 2. Time history vs (excitation/w)

Graph shows that at the starting when time t=0 to 5 sec the excitation is minimum. And as the time is increase (pass) the value of excitation is also go increase at the time t=5to 15 sec the excitation felt maximum. And again, after than time is increase the value of excitation is gradually decrease. After t=20 sec the value of excitation is gradually decrease.

2)Time interval vs Control force

In above graph the time interval vs control force is plot. Control force is measured in kn while time interval is measured in sec.

Graph shows that at the starting when time t=0 to 5 sec the excitation is minimum so the control force corresponding to excitation is also minimum. And as the time is increase (pass) the value of excitation is also go increase at the time t=10 to 20 sec the excitation felt maximum so corresponding control force apply by actuator is also go increase automatically. And again after than time is increase the value of excitation is gradually decrease.after t=20 to 40 sec the value of excitation is gradually decrease so corresponding control force is also go decrease during that time.

3) Time interval vs Base shear

There are two value plots in above graph. First the red and dotted line which indicate the uncontrolled base shear in this case building is not connected with actuator.

In second case the black straight line which indicate the base shear while building relates to actuator.

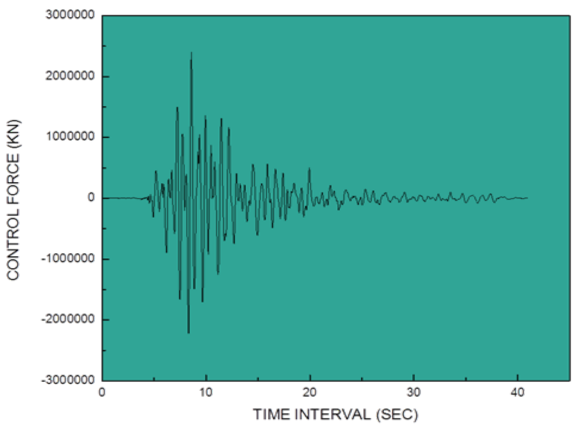

Fig 3. Time interval vs control force

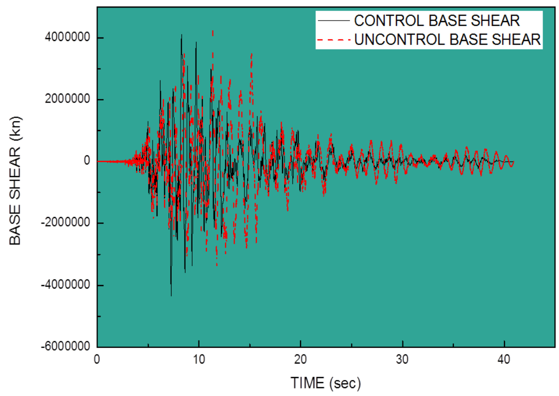

Fig 4. Time history vs base shear

Graph clearly show that when we connected building with actuator base shear of building is minimum (black straight line).in second case it shows that when building is not connected with actuator the base shear of building is maximum (red dotted line).

At the time of starting earthquake when t=0 to 20 the base shear of building is maximum, just because as per excitation graph during this time the excitation is also maximum. Now at the time of t= 20 to 40 sec the base shear is minimum just because the excitation during this time is minimum .and after that as time increase the value of excitation is also go decrease, so the value of corresponding control force is also go decrease in control base shear as well as un control base shear. But compare to control base shear have a less value as compared to un control base shear.

4) Time interval vs Top floor displacement

There are two value plots in above graph. First the red and dotted line which indicate the top floor displacement while building is not connected with actuator.

In second case the black straight line which indicate the top floor displacement while building relates to actuator.

Graph clearly show that when we connect a building with actuator displacement of top floor of building is minimum (red dotted line).in second case it shows that when building is not connected with actuator the displacement of building is maximum (black straight line).

At the time of starting earthquake when t=0 to 5 the displacement of building is minimum, just because as per excitation graph during this time the excitation is also minimum. Now at the time of t= 5 to 15 sec the top floor displacement is max just because the excitation during this time is max.

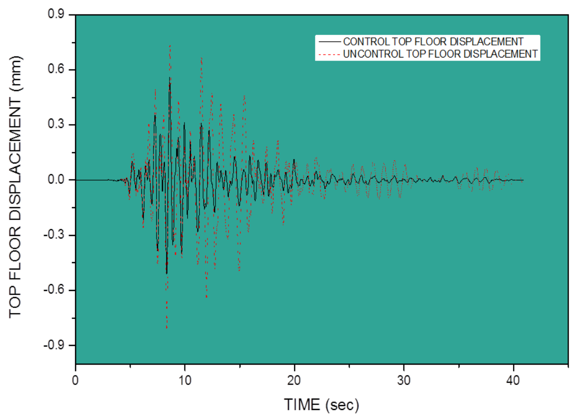

Fig 5. Time vs top floor displacement

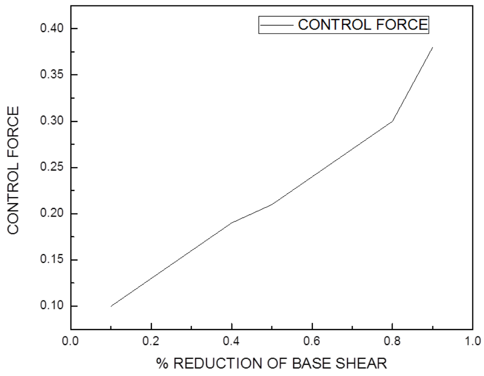

Fig.6 % Reduction of base shear vs control force

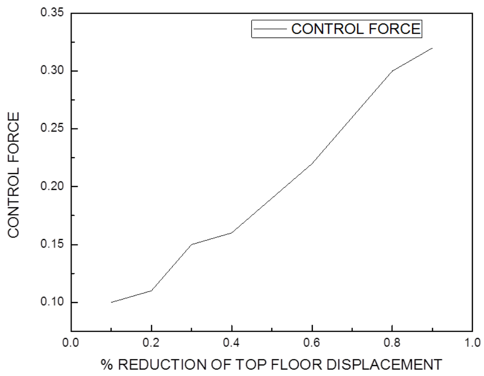

Fig 7. % Reduction of top floor displacement vs control force

1)% Reduction of Base shear vs Control force

In above graph the value of % reduction of base shear is located on x- axes and value of control force is located on y-axes.

Using this graph, it's clear that as we reduce the value of base shear percentage the control force of actuator is increase correspondingly.

2)% Reduction of top floor displacement vs control force

In above graph the value of % reduction of top floor displacement is located on x- axes and value of control force is located on y- axes. Using this graph, it's clear that as we reduce the value of base shear percentage the control force of actuator is increase correspondingly. And it's become a linear graph.

Conclusion

After doing comparative study of various parameters of building when it relates to Actuator and not connected with damper earthquake occurred at various places like Kobe, bhuj, Victoria, Elcentro. By analysing when we connected building with actuator at optimal place there is considerable reduction in floor displacement, drift, base shear and increase a control force in case of building connected with actuator.

1) In recent years worldwide, attention has been directed towards the use of control device to mitigate the effect of dynamic load such as strong earthquake, extreme waves, high wind etc. external damping device such as active damper can be used effectively under such situation.

2) The application of control device in multi storey building has been recognize as an effective alternative for protection of building. The active damper connecting in multi storey subjected to seismic event has been proved to be most effective.

3) Reduction in a percentage of base shear and percentage of top floor displacement corresponding control force is increase which show that the predicted value given by artificial neural network is true.

4) when earthquake occur the maximum effect of earthquake is shown on top floor just because of short column effect, but if we connect top floor with actuator the considerable displacement reduces by using actuator

Disclosures

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