A Performance Analysis of Various Damping Systems on Rcc Structures Subjected To Time History Analysis

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Abstract*- There are several techniques available to minimize the vibrations of the structure ,dampers are one of them.This paper includes different types of dampers as a vibration control device like Negative stiffness damper , Friction damper , Base isolation ,TMD etc. This paper represents the effectiveness of using NSD for controlling vibration of structure with comparison of other damping systems. In this work an attempt is made to analyze G+3 structure with the help of Staad-Pro software.This work has selected Time history analysis method. A total three loading conditions are applied at the base of the structure. First one is a Earthquake loading, the second one is time history as per spectra of IS-1894 (Part -1):2002 for 5% damping at rocky soil with (PGA = 1g) and the third one is 1940 El Centro Earthquake record with (PGA = 0.313g).*

Keywords- RCC , Damping, TMD, Staad-Pro

I. INTRODUCTION

A) Introduction

Vibration control is having its roots primarily in aerospace related problems such as tracking and pointing, and in flexible space structures, the technology quickly moved into civil engineering and infrastructure-related issues, such as the protection of buildings and bridges from extreme loads of earthquakes and winds.

The number of tall buildings being built is increasing day by day. Today we cannot have account of number of low-rise or medium rise and high rise buildings existing in the world. Mostly these structures are having low natural damping. So increasing damping capacity of a structural system, or considering the need for other mechanical means to increase the damping capacity of a building, has become increasingly common in the new generation of tall and super tall buildings. But, it should be made a routine design practice to design the damping capacity into a structural system while designing the structural system.

The control of structural vibrations produced by earthquake or wind can be done by various means such as modifying rigidities, masses, damping, or shape, and by providing passive or active counter forces. To date, some methods of structural control have been used successfully and newly proposed methods offer the possibility of extending applications and improving efficiency.

The selection of a particular type of vibration control device is governed by a number of factors which include efficiency, compactness and weight, capital cost, operating cost, maintenance requirements and safety.

B) Scope of the Work

- From the previous studies, it is understood that commonly used seismic protection strategies are to make a structure ductile which reduces shear force and acceleration but simultaneously increase inelastic excursions other is damper and base isolation device which reduces inter storey drift but leads to contribute to acceleration and base shear. To overcome this an adaptive passive device to reduce simultaneously the deformations/ accelerations and base shear of the structure is used.
- In the present work, an attempt is made to study and verify code provisions associated, with damping and stiffness with particular reference to NSD.
- Effects on seismic response parameters of structures such as time period, understory displacement, acceleration etc are studied before and after the introduction of NSD.
- By varying number and position of NSD within a building frame effects are studied.

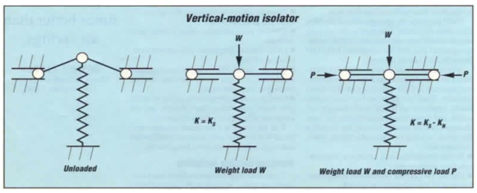


Fig.1: Negative Stiffness Mechanism by D. Platus

C) The objectives of present work are,

1. The existing analysis of NSD used for chevron bracing is applied to various multi-story frames and the results are verified with those available in literature.
2. Dynamic analysis is done to let all relevant parameters like time period, base shear, drift and mode participation.
3. Effects of Damping on structure is studied to verify IS code provisions.

II. DAMPING SYSTEMS IN RCC

A) Passive Energy Dissipation:

All vibrating structures dissipate energy due to internal stressing, rubbing, cracking, plastic deformations, and so on; the larger the energy dissipation capacity the smaller the amplitudes of vibration. Some structures have very low damping of the order of 1% of critical damping and consequently experience large amplitudes of vibration even for moderately strong earthquakes. Methods of increasing the energy dissipation capacity are very effective in reducing the amplitudes of vibration. Many different methods of increasing damping have been utilized and many others have been proposed.

Passive energy dissipation systems utilizes a number of materials and devices for enhancing damping, stiffness and strength, and can be used both for natural hazard mitigation and for rehabilitation of aging or damaged structures. In recent years, efforts have been undertaken to develop the concept of energy dissipation or supplemental damping into a workable technology and a number of these devices have been installed in structures throughout the world (Soong and Constantinou 1994; Soong and Dargush 1997). In general, they are characterized by the capability to enhance energy dissipation in the structural systems in which they are installed. This may be achieved either by conversion of kinetic energy to heat, or by transferring of energy among vibrating modes. The first method includes devices that operate on principles such as frictional sliding, yielding of metals, phase transformation in metals, deformation of visco-elastic solids or fluids, and fluid orificing. The later method includes supplemental oscillators, which act as dynamic vibration absorbers.

B) Types of Passive Control Devices

i) Metallic Yield Dampers

One of the effective mechanisms available for the dissipation of energy, input to a structure from an earthquake is through inelastic deformation of metals. The idea of using metallic energy dissipators within a structure to absorb a large portion of the seismic energy began with the conceptual and experimental work of Kelly et al. (1972) and Skinner et al. (1975).

Several of the devices considered include torsional beams, flexural beams, and V-strip energy dissipaters. Many of these devices use mild steel plates with triangular or hourglass shapes so that yielding is spread almost uniformly throughout the material. A typical X-shaped plate damper or added damping and stiffness (ADAS) device is shown in Fig.

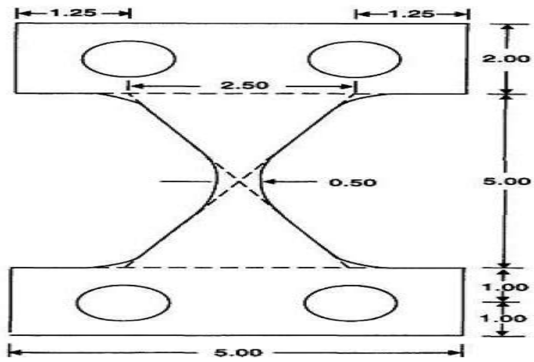
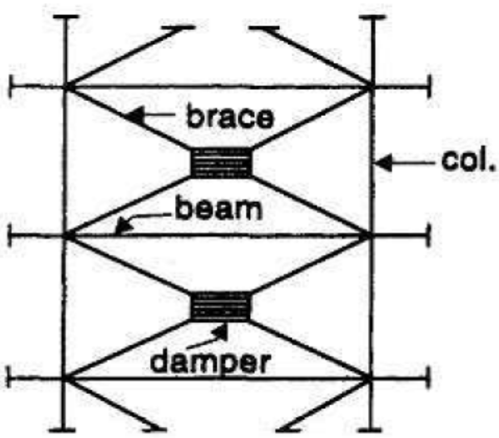


Fig 2: X-shaped ADAS device

ii) Friction Dampers

Friction provides another excellent mechanism for energy dissipation, and has been used for many years in automotive brakes to dissipate kinetic energy of motion. In the development of friction dampers, it is important to minimize stick-slip phenomena to avoid introducing high frequency excitation. Furthermore, compatible materials must be employed to maintain a consistent coefficient of friction over the intended life of the device. The Pall device is one of the damper elements utilizing the friction principle, which can be installed in a structure in an X-braced frame as illustrated in the figure (Palland Marsh 1982)



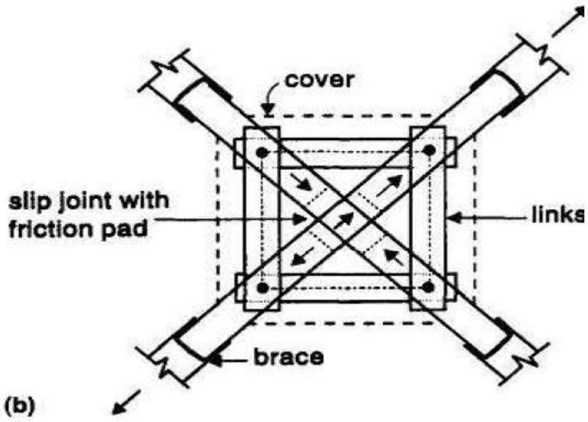


Fig 3: Pall Friction Damper

iii) Viscoelastic Dampers

The metallic and frictional devices described are primarily intended for seismic application. But, viscoelastic dampers find application in both wind and seismic application.

Their application in civil engineering structures began in 1969 when approximately 10,000 viscoelastic dampers were installed in each of the twin towers of the World Trade Center in New York to reduce wind-induced vibrations. Further studies on the dynamic response of viscoelastic dampers have been carried out, and the results show that they can also be effectively used in reducing structural response due to large range of intensity levels of earthquake. Viscoelastic materials used in civil engineering structure are typical copolymers or glassy substances. A typical viscoelastic damper, developed by the 3M Company

Inc., is shown in Fig. It consists of viscoelastic layers bonded with steel plates.

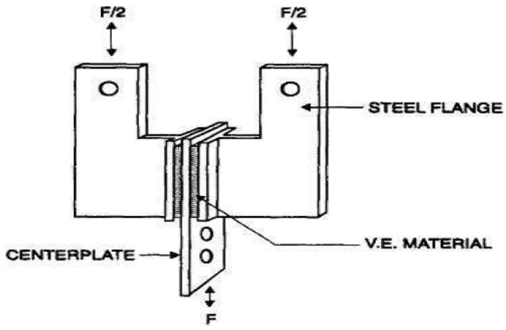


Fig. 4: Viscoelastic damper

iv) Viscous Fluid Dampers

Fluids can also be used to dissipate energy and numerous device configurations and materials have been proposed. Viscous fluid dampers, are widely used in aerospace and military applications, and have recently been adapted for structural applications (Constantinouet al.1993). Characteristics of these devices which are of primary interest in structural applications, are the linear viscous response achieved over a broad frequency range, insensitivity to temperature, and compactness in comparison to stroke and output force. The viscous nature of the device is obtained through the use of specially configured orifices, and is responsible for generating damper forces that are out of phase with displacement. A viscous fluid damper generally consists of a piston in the damper housing filled with a compound of silicone or oil (Makris and Constantinou 1990; Constantinou and Symans1992).A typical damper of this type is shown in Fig.

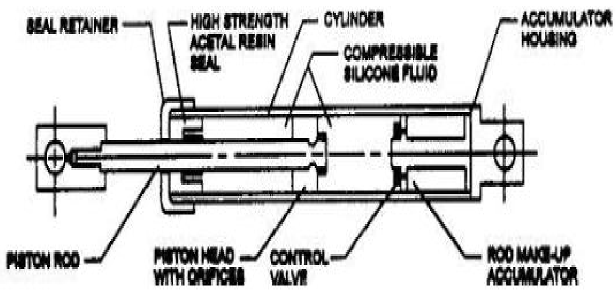


Fig 5: Taylor device fluid damper

v) Tuned liquid damper

A properly designed partially filled water tank can be utilized as a vibration absorber to reduce the dynamic motion of a structure and is referred to as a tuned liquid damper (TLD). Tuned liquid damper (TLD) and tuned liquid column damper (TLCD) impart indirect damping to the system and thus improve structural performance (Kareem 1994). A TLD absorbs structural energy by means of viscous actions of the fluid and wave breaking.

Tuned liquid column dampers (TLCDs) are a special type of tuned liquid damper (TLD) that rely on the motion of the liquid column in a U-shaped tube to counter act the action of external forces acting on the structure. The inherent damping is introduced in the oscillating.

The performance of a single-degree-of-freedom structure with a TLD subjected to sinusoidal excitations was investigated by Sun(1991), along with its application to the suppression of wind induced vibration by Wakahara et al. (1989). Welt and Modi (1989) were one of the first to suggest the usage of a TLD in buildings to reduce overall response during strong wind or earthquakes.

vi) Tuned Mass Dampers

The concept of the tuned mass damper (TMD) dates back to the 1940s (Den Hartog 1947). It consists of a secondary mass with properly tuned spring and damping elements, providing a frequency-dependent hysteresis that increases damping in the primary structure. The success of such a system in reducing wind-excited structural vibrations is now well established. Recently, numerical and experimental studies have been carried out on the effectiveness of TMDs in reducing seismic response of structures (for instance, Villaverde(1994)

C) Classification of Control Methods

i) Active Control

An active control system is one in which an external power source the control actuators are used that apply forces to the structure in a prescribed manner. These forces can be used to both add or dissipate energy from the structure. In an active feedback control system, the signals sent to the control actuators are a function of the response of the system measured with physical sensors (optical, mechanical, electrical, chemical, and so on).

ii) Passive Control

A passive control system does not require an external power source. Passive control devices impart forces that are developed in response to the motion of the structure. Total energy (structure plus passive device) cannot increase, hence inherently stable.

iii) Hybrid Control

The term "hybrid control" implies the combined use of active and passive control systems. For example, a structure equipped with distributed viscoelastic damping supplemented with an active mass damper near the top of the structure, or a base isolated structure with actuators actively controlled to enhance performance.

iv) Semi-active Control

Semi-active control systems are a class of active control systems for which the external energy requirements are less than typical active control systems. Typically, semi-active control devices do not add mechanical energy to the structural system (including the structure and the control actuators), therefore bounded-input bounded-output stability is guaranteed. Semi-active control devices are often viewed as controllable passive devices.

III. METHODOLOGY

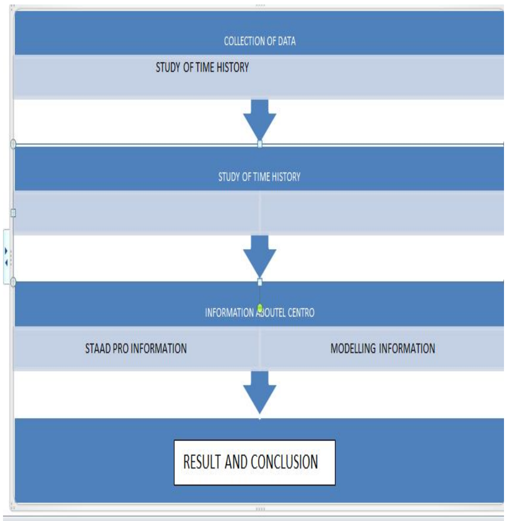


Fig 6: Flow Chart

Buildings are subjected to ground motions. The ground motion has dynamic characteristics, which are peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), frequency content, and duration. These dynamic characteristics play predominant rule in studying the behavior of RC buildings under seismic loads. The structure stability depends on the structure slenderness, as well as the ground motion amplitude, frequency and duration. [23] Based on the frequency content, which is the ratio of PGA/PGV the ground motion records are classified into three categories [38]:

1) High-frequency content PGA/PGV > 1.2
2) Intermediate-frequency content 0.8< PGA/PGV< 1.2
3) Low-frequency content PGA/PGV < 0.8

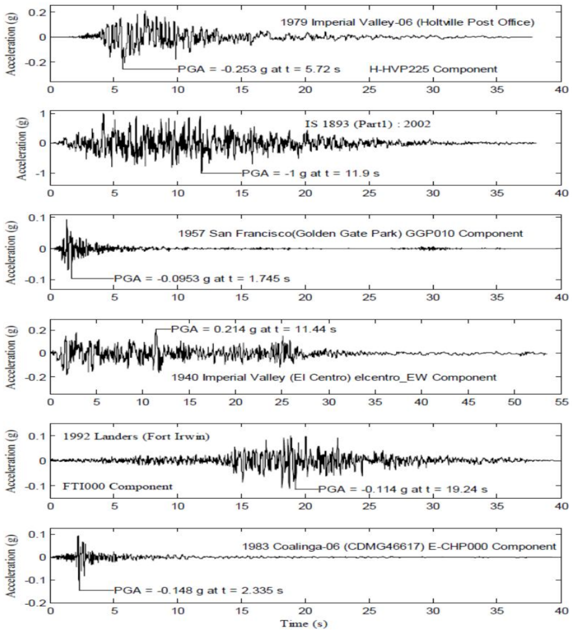


Fig 6: PGA

IV. PROBLEM STATEMENTS

Design of frame structure in software(STAAD.PRO).
The following data are taken for analysis of the frame:

1) Grade of concrete M30
2) Grade of steel Fe415
3) Type of the structure Multi- storey rigid jointed plane frame.
4) Size of columns 0.230 m × 0.450m
5) Size of beams 0.230 m × 0.450m
6) Depth of slab 0.150 mm
7) Modulus of elasticity 200×10^3 N/m²
8) Earthquake zone III& V
9) Time History Load-El-centro

i) Frame Structure Without Damper

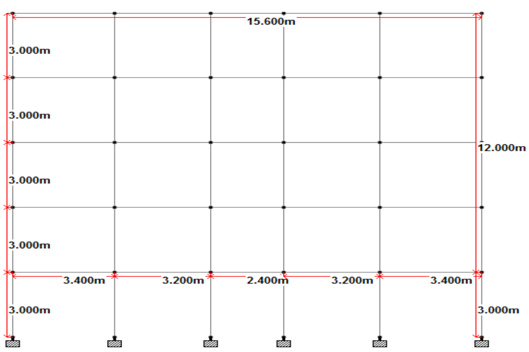


Fig 7: Frame Structure Without Damper

ii) Frame Structure With Base Isolation

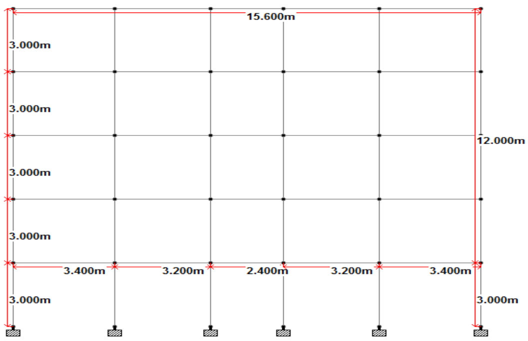


Fig 8: Frame Structure With Base Isolation

iii) Frame Structure with Negative Stiffness Damper

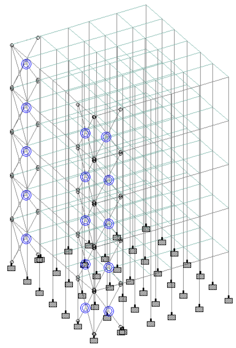


Fig 9: Frame Structure with Negative Stiffness Damper

V. RESULTS AND DISCUSSION

After analysing Time-Acceleration,Time Velocity,Time Displacement is compared for El-centro data and final resultant deformation is shown below

Table no 1 : Comparison between model A ,model B , model C ,model D

.	Model A	Model B	Model C	Model D
Storey Drift	16	14.6	9.4	9.8
Base Shear	200 KN	200 KN	200 KN	200 KN
Time Acceleration	323 e-3	3 e-3	121e-3	118e-3
Time Velocity	22.2 e-3	22.1 e-3	21.1 e-3	21.0 e-3
Time Displ.	10 mm	8.6 mm	3.4 mm	3.8 mm

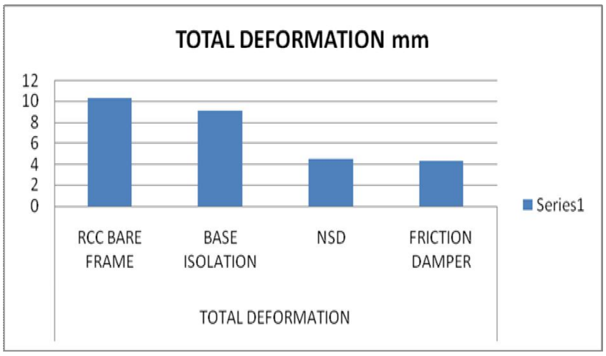


Fig 10: Total Deformation

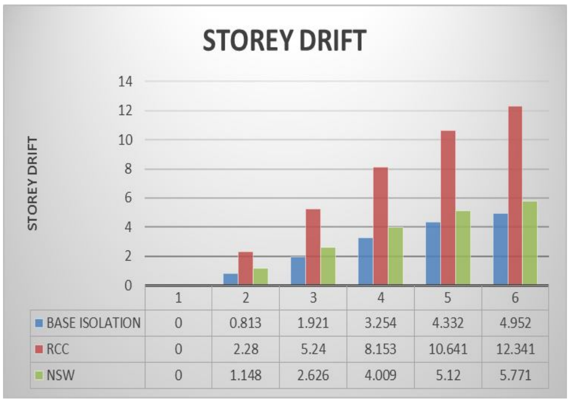


Fig 11: Storey Drift

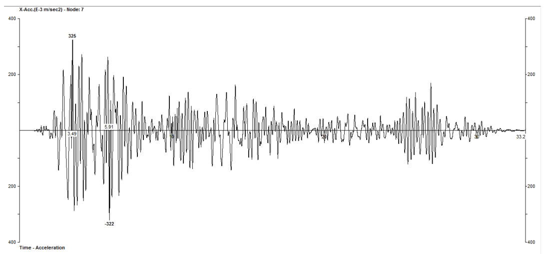


Fig 12: Time Acceleration(Node 7 X-dir.)

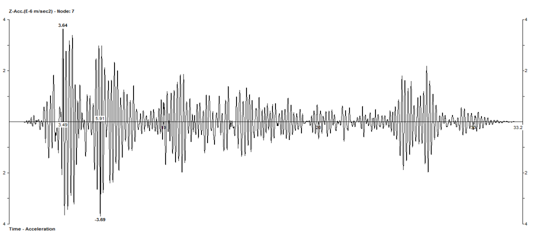


Fig 13: Time Acceleration (Node 7 Z-dir)

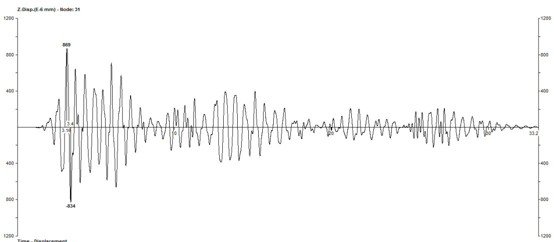


Fig 14: Time Displacement (Node 31 Z-dir)

VI. CONCLUSION

In first part of study, validation of G+4 building is done in accordance with base shear calculation as per IS 1893:2002 for earthquake case.

In later part, the study of low rise building is done using previous earthquake data. For checking non linearity effect of structure Time history analysis is applied in given model using Time History method Time vs deformationTime vs velocity, Time vs acceleration is obtained and following results are obtained.

1) The natural frequency of G+4is increased nearly 15-20% by using NSD which implies decrease in time period.
2) After analyzing for earthquake zone-III it was observed that the storey drift along X direction and along Z direction reduces by 35% in negative stiffness damper and friction damper as well.
3) The peak displacement values are observed less as 35% in NSD as compared to RCC bare frames, friction damper and base isolation
4) RC frame with NSD shows more interstorey deformation i.e. Presence of NSD in structure makes it flexible.
5) As structure tends towards flexibility, the seismic response of RC frame improves as the column shear is reduced to a considerable amount. Overall in this study negative stiffness damper proves most effective damping system can be used for construction practice.

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