CERTIFICATE

This is to certify that the project entitled **"OPTIMIZATION OF SHEAR WALL FOR HIGH RISE BUILDINGS"** is a bonafide of **Mr. SHAIKH TALHA (14CES46), Mr. KHAN AYAZ (14CES18), Mr. KHAN FAISAL (14CES28)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of Bachelor of Engineering" in "Civil Engineering".

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APPROVAL SHEET

This project report entitled "**OPTIMIZATION OF SHEAR WALL FOR HIGH RISEBUILDINGS**" by **Mr. SHAIKH TALHA(14CES46), Mr. KHAN AYAZ (14CES18), Mr. KHAN FAISAL(14CES28)** is approved for the Bachelor's degree of "Civil Engineering

Examiners

1. …………………………
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Supervisors:

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2. …………………………

Date:

Place: Panvel

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included; I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

In the present construction industry, the buildings that are constructed are gaining significance in general, those with best possible outcomes with reference to optimal sizing and reinforcing of the structural elements mainly beam and column members in multi-storey RC structures in particular. The concept of "Best possible outcome" is called optimization. Optimization plays an important role in structural design, the very purpose of which is to find the best solutions from which a designer or a decision maker can derive a maximum benefit from the available resources. Shear wall provides large strength and stiffness to the building in the direction of their orientation which considerably reduces lateral sway of the building and there by reduces damage to the structure. If a high rise R.C. Structure is designed without shear wall the beam and column sizes are large and so many problems arises at the joints and due to this it is difficult to place and vibrate the concrete at such places and displacement is more which in turn induces heavy forces on the structure therefore shear wall become essential from the point of view of economy. By providing shear wall the structure become safe and durable and also more stable the function of shear wall is to increase rigidity for wind and seismic load resistance

CONTENTS

Chapter 1

Introduction

1.1 GENERAL

In Structural Engineering, a shear wall is a structural system composed of shear panels to counter effects of lateral load acting on structure. Wind and Seismic loads are the most commonly loads that shear walls are designed to carry. Reinforced concrete shear wall structures are widely used in tall buildings for its excellent seismic behaviour. In modern civilization, tall buildings have rapidly developed worldwide. Tall buildings are symbols of civilized congested and populated society. It is certainty resemble of economic growth, the force and image of a civilization. A tremendous variety of architectural shapes and complex structural layouts are designed. The design strategies discussed here will contribute to only optimum design environments using the minimum amount of resources. Concrete shear walls provide a cost effective means to resist seismic lateral loads and thus they are frequently used as the primary lateral load resisting system in reinforced concrete buildings. Shear walls with high flexural stiffness typically assist with limiting inter storey drifts in buildings, consequently reducing structural and non-structural damage during
seismic events. With the added benefits of structural system, shear walls make an excellent choice for resisting lateral loads in concrete buildings. The main objective of this study is to

analyse and design of 20 storey building with shear walls using ETABS. It stands for (Three-Dimensional) Analysis of Building System. The analysis and design is done to satisfy all the checks as per Indian standards

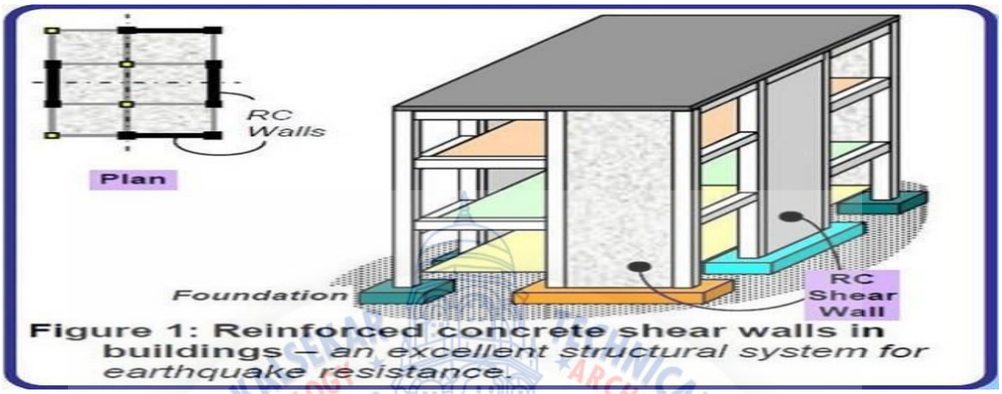


Fig 1. Shear walls in Buildings

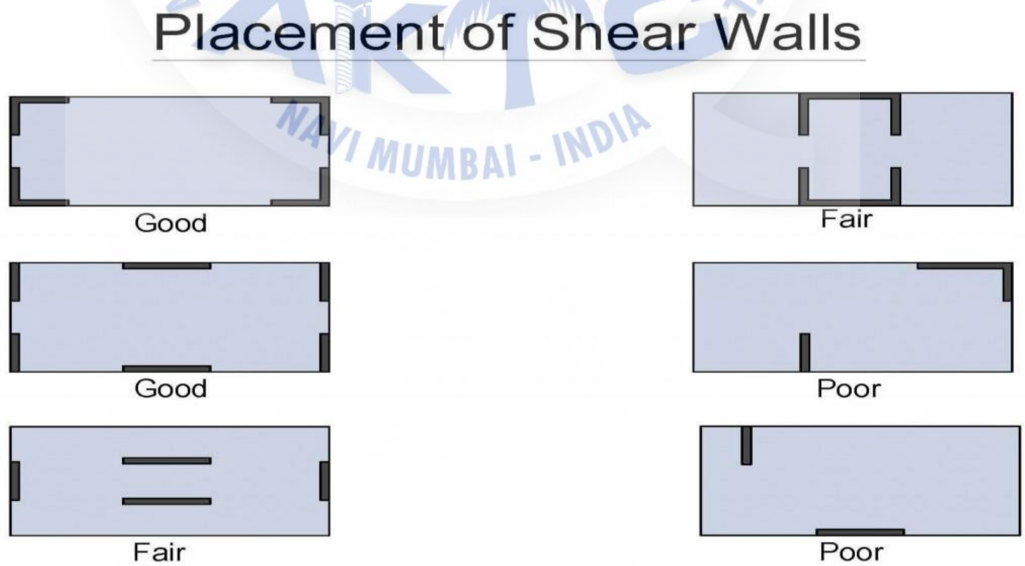


Fig 1.2 Placement of shear walls

1.2 OPTIMIZATION

Optimization is the act of obtaining the best result under the given circumstances. In design construction and maintenance of any engineering system many technological and Managerial decisions has to be taken at several stages. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. Hence, Optimization can be defined as the process of finding the conditions that gives the minimum or maximum value of a function, where the function represents the effort required or the Desired benefits.

1.3 AIM

To do the optimization of shear wall in high rise buildings with the following objectives below

1.4 Objective of Work

- To Design a shear wall for high rise Building
- To optimize design of shear wall to increase its efficiency with Cost
- To study the Variation of displacement

Chapter 2

Literature Review

2.1 General

A 30 storey building is designed to illustrate effectiveness of proposed optimal design. Influence of Aspect ratio on the concrete consumption and the steel consumption of the Superstructure are analysed for this typical RC shear wall structure. Authors have aimed for Minimizing total structural material consumption and done optimization process.

A 19 storey residential building is analysed with and without shear walls for Earthquake Loads, Shear walls were introduced by authors near stairs and lift and the shape as L. Internal Stresses and Intensities were checked. Lateral forces in direction in which shear wall were Constructed, also torsional moments were reduced by using shear walls for the building.

Authors have modelled a building with 20 stories using software ETABS. To study RC Buildings without shear wall, shear wall at corners, shear wall at boundaries, shear wall at interior. They concluded that shear wall at corners gives less displacement values in hard soil condition for Severe seismic zone. Providing shear wall at corners will perform better and efficient.

To observe the seismic effect and wind effect on tall building, Authors have designed a G+20 story's building (frame with shear wall, frame with shear core, only frame). Results by Providing frame + shear walls +shear core authors arrived an optimized design and also volume of Concrete.

Authors studied and determined the optimum Structural configuration of a multi-storey Building by changing the shear wall locations. Shear wall positioned for three different cases for a 15 storey high rise building was done. Analysing was carried out, they observed deflection was Reduced and reached within the permissible deflection after providing the shear walls at failure Positions.

Authors have studied a 45 storey high rise building, optimization techniques are used in This project the size of shear wall is same throughout the building and then analysis is done from The result, the failed shear wall dimensions are increased to resist the whole structure, in this way The optimization was done for number of time till the whole structure became stable to resist the Forces.

Optimum Structural configuration of a multi-storey building by changing the shear wall Locations radically were carried out by authors. 10 storey residential building was analysed and designed. It was Found out that Shear Wall at the corner provides more strength with less steel and Concrete as compare to other locations of the Shear Wall, Also Shear walls are more resistant to Lateral loads in an irregular multi-storeyed building.

In this Research authors have designed three models, Model 1 is bare frame structural System and other two models are dual type structural system with central core wall and corner Shear wall. An earthquake load is calculated as per IS 1893(PART-1)-2002 and applied to (G+20) Storey R.C building in zone-2 and zone-5. The analysis is performed using ETABS

The main Aim of Author was to study the nonlinear behaviour of a reinforced concrete Shear wall with different reinforcement arrangements in a three story building subjected to a step- Wise increasing lateral earthquake load. It helped a lot to get information about deformations, Initial cracks, tensile cracks, crushing, steel stresses and plastic deformations.

Three completely different cases of shear wall position for a building were analysed. Earthquake load was calculated IS 1893 (PART–I): 2002. STAAD professional software was used For the analysis of structures. Authors concluded Shear walls in high seismic regions need special Description as a result of its smart unstable behaviour.

Studying research works related to enhancement of shear walls and their behaviour towards Lateral loads were done by authors. Because shear walls resists major portions of lateral loads in the Lower portion of the buildings, As in India base floors are used for parking and garages or officers And upper floors are used for residential purposes. Research was carried mainly on cyclic load tests It was found out that internal shear walls are more efficient than external shear walls when Compared with cyclic load tests.

The author presented a methodology developed for generation of interaction diagrams for Shear walls, and making a more accurate description of the capacity of the shear wall cross section When under axial compression and lateral bending the methodology helpful and tries to give a More good technique for design of RCC shear walls, and making design process more definitive.

Chapter 3

Methodology

3.1 APPROACH

- Problem statement

Building Type	Residential
No of Storeys	20
Zone	3
Type of soil	soft
Grade of Concrete	M25

- Understand a response spectrum method of analysis
- Model a 20 storey high rise building in CSI ETABS (2016)
- Optimize and design
- Draw the conclusion based upon finding

3.2 CSI ETABS

ETABS is an engineering software product that caters to multi-story building analysis and Design. Modelling tools and templates, code-based load prescriptions, analysis methods and Solution techniques, all coordinate with the grid-like geometry unique to this class of structure.

3.2.1 Why it is used?

ETABS is software created by csi. It is used to model and analyse structures mainly buildings and their components to see how a building behaves under various loads.

3.2.2 What are its advantages?

Minor improvements are made every version. CSI, the company of ETABS is in close Association & touch with NICEE, IIT Roorkee and other IITs. Design processor of ETABS is improved in every way possible, like in beams.

3.3 Response spectrum method

In order to perform the seismic analysis and design of a structure to be built at a particular Location, the actual time history record is required. However, it is not possible to have such records At each and every location. To overcome the difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the Response spectrum method of seismic analysis for prediction of displacements and member forces In structural systems. The method involves the calculation of only the maximum values of the Displacements and member forces in each mode of vibration using smooth design spectra that is the average of several earthquake motions. Response spectra thus helps in obtaining the peak Structural responses under linear range, which can be used for obtaining lateral forces developed in structure due to earthquake thus facilitates in earthquake-resistant design of structures.

3.3.1 Response Spectrum Method of Analysis

It provides a technique for performing an equivalent static lateral load analysis. It allows a clear understanding of the contributions of different modes of vibration. It offers a simplified method for finding the design forces for structural members for earthquake. It is also useful for approximate evaluation of seismic reliability of structures. The concept of equivalent lateral forces for earthquake is a unique concept For seismic design, these maximum stresses are of interest, not the time history of stress Equivalent lateral force for an earthquake is defined as a set of lateral force which will produce the same peak response as that obtained by dynamic analysis of structures. The equivalence is restricted to a single mode of vibration. A modal analysis of the structure is carried out to obtain mode shapes, frequencies & modal participation factors. Using the acceleration response spectrum, an equivalent static load is derived which will provide the same maximum response as that obtained in each mode of vibration. Maximum modal responses are combined to find total maximum response of the structure. The first step is the dynamic analysis while, the step is a static analysis. The first two steps do not have approximations, while the third step has some approximations. As a result, response spectrum analysis is called an approximate analysis; but applications show that it provides mostly a good estimate of peak responses. Method is developed for single point, single component excitation for classically damped linear systems. However, with additional approximations it has been extended for multi point-multi component excitations & for non-classically damped systems.

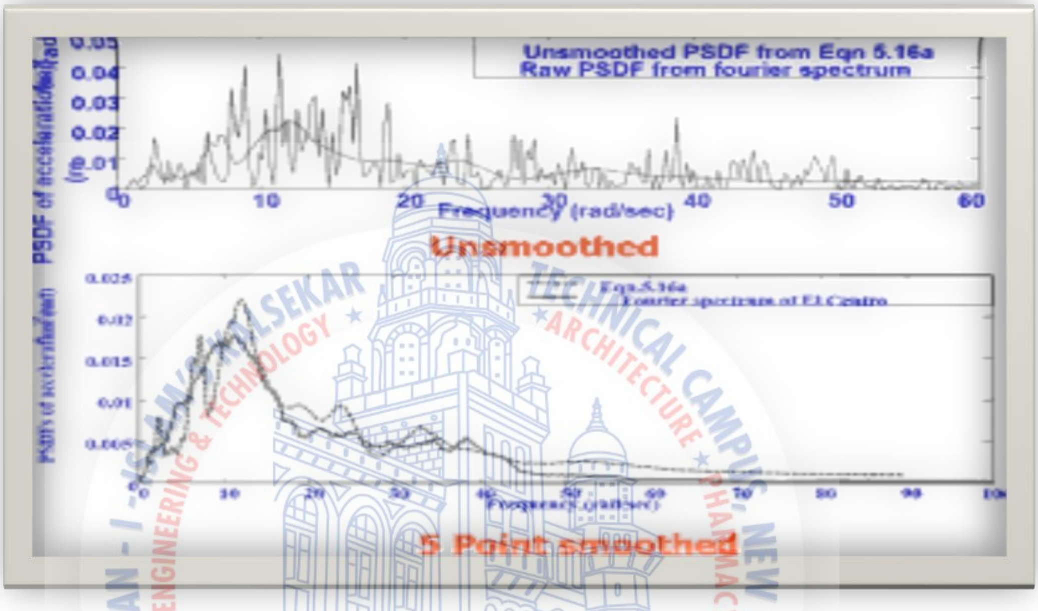
3.3.2 Equation of motion for MDOF system under single Point excitation

- Since both response spectrum & mode shape properties are required in obtaining, it is known as modal response spectrum analysis.
- It is evident from above that both the dynamic & static analyses are involved in the method of analysis as mentioned before.
- As the contributions of responses from different modes constitute the total response, the total maximum response is obtained by combining modal quantities.
- This combination is done in an approximate manner since actual dynamic analysis is now replaced.

3.3.3 Spectrum

A response spectrum is a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators varying natural frequency, which are forced into motion by the same base vibration or shock. The resulting plot can then be used to pick off the response of any system, given its natural frequency some values from the ground response spectrum (calculated from recordings of surface ground motion) for correlation with seismic damage. If the input used in calculating a response spectrum is steady-state periodic, then the steady-state result is recorded. Damping must be present, or else the response will be infinite. For transient input (such as seismic ground motion), the peak response is reported. Some level of damping is generally assumed, but a value will be obtained even with no damping. Response spectra can also be used in assessing the response of linear systems with multiple modes (multi- degree of freedom systems), although they are only accurate for low levels of damping is performed to identify the modes, and the response in that mode can be picked from the response spectrum. These peak responses are then combined to estimate a total response. A typical combination method is the square root of the sum of the squares (SRSS) if the modal frequencies are not close. The result is typically different from that which would be calculated directly from an input, since phase information is lost in the process of generating the response spectrum.

The main limitation of response spectra is that they are only universally applicable for systems. Response spectra can be generated for systems, but are only applicable to systems with the same non-linearity, although attempts have been made to develop non-linear seismic design spectra with wider structural application. The results of this cannot be directly combined for multi-mode response.



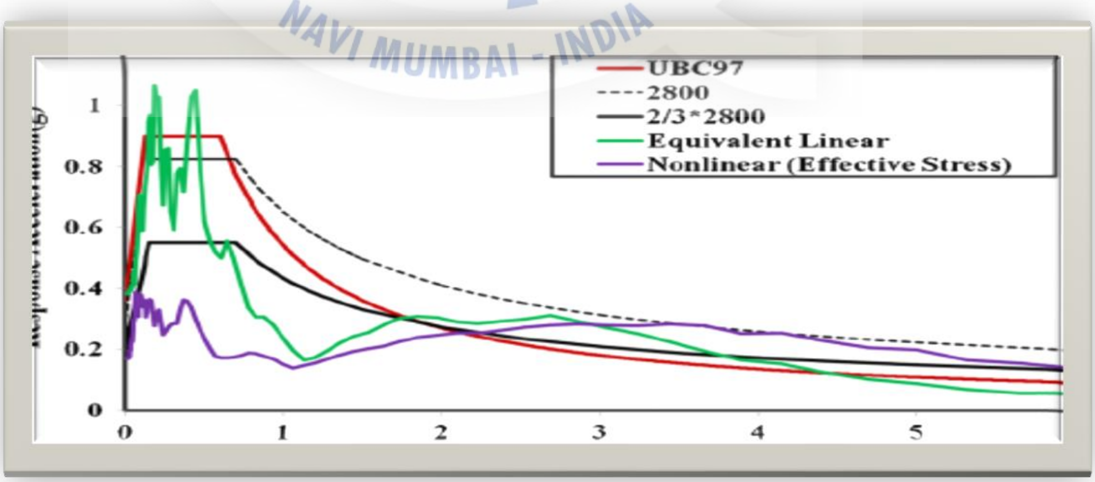


Figure 1.1(a) shows an ideal one story structure model. It has a rigid girder with lumped mass m which is supported on two massless columns with a combined lateral stiffness equal to k. The energy loss is modelled by a viscous damper, also shown in the figure. This structure has only one degree of freedom, the lateral displacement of the girder. Under the action of the earthquake ground motion, wg , the structure deforms, Figure 1.1(b). The relative displacement of the girder with respect to the ground is u. The total displacement of the girder is u—(—ug) = u + u$. Figure 1.1(c) shows the free body diagram of the girder, in which fx denotes the inertia force, fs the spring (or the column) force and f denotes the damping force.

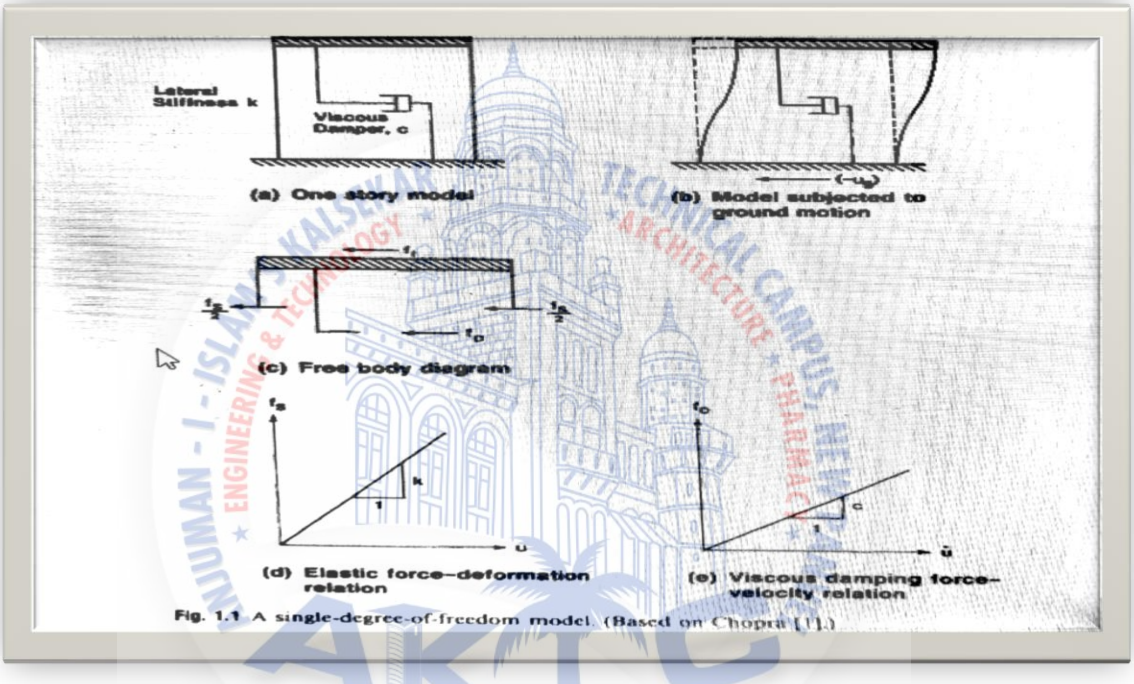
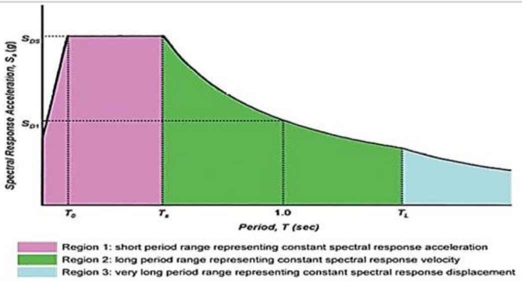
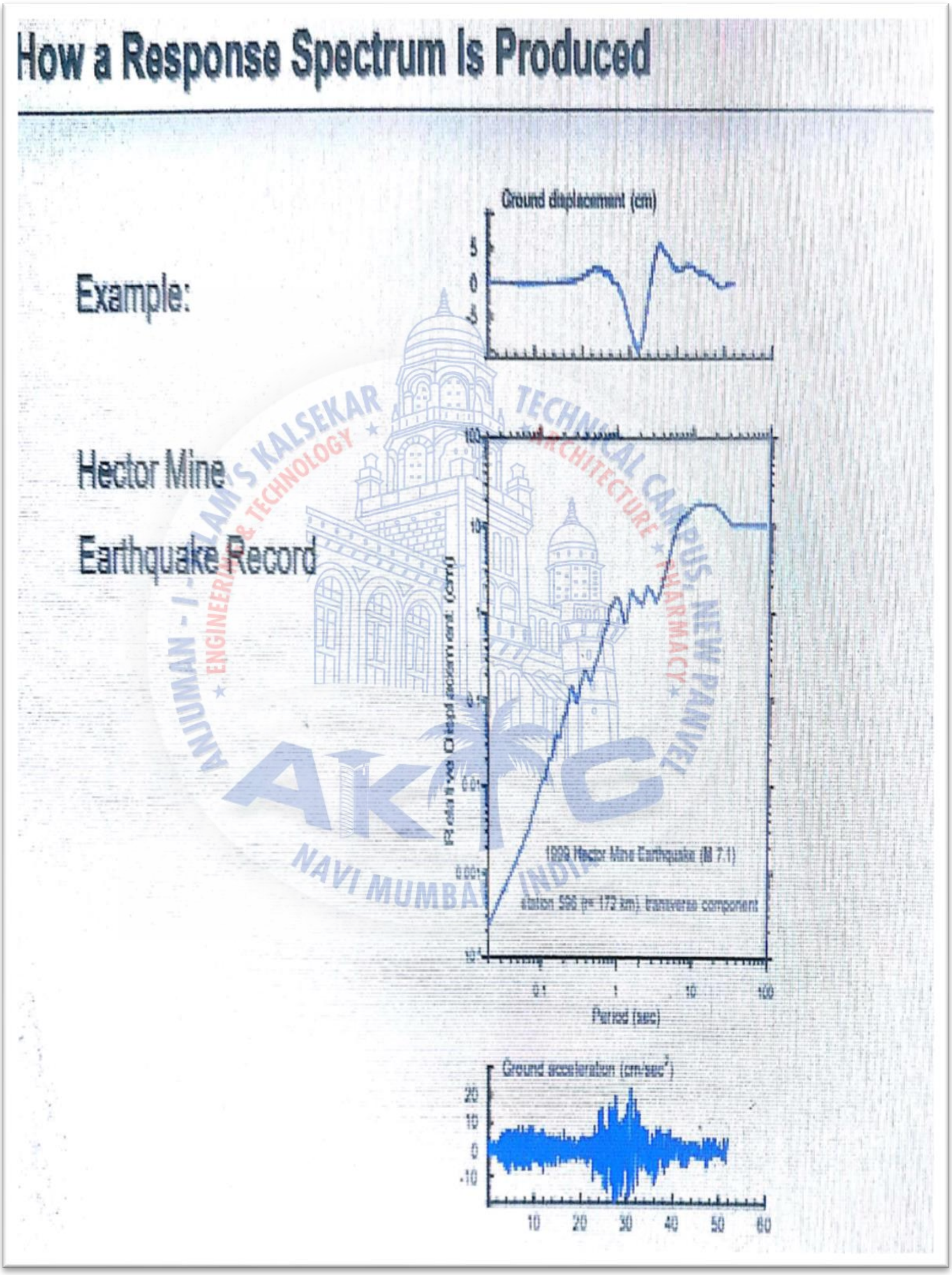
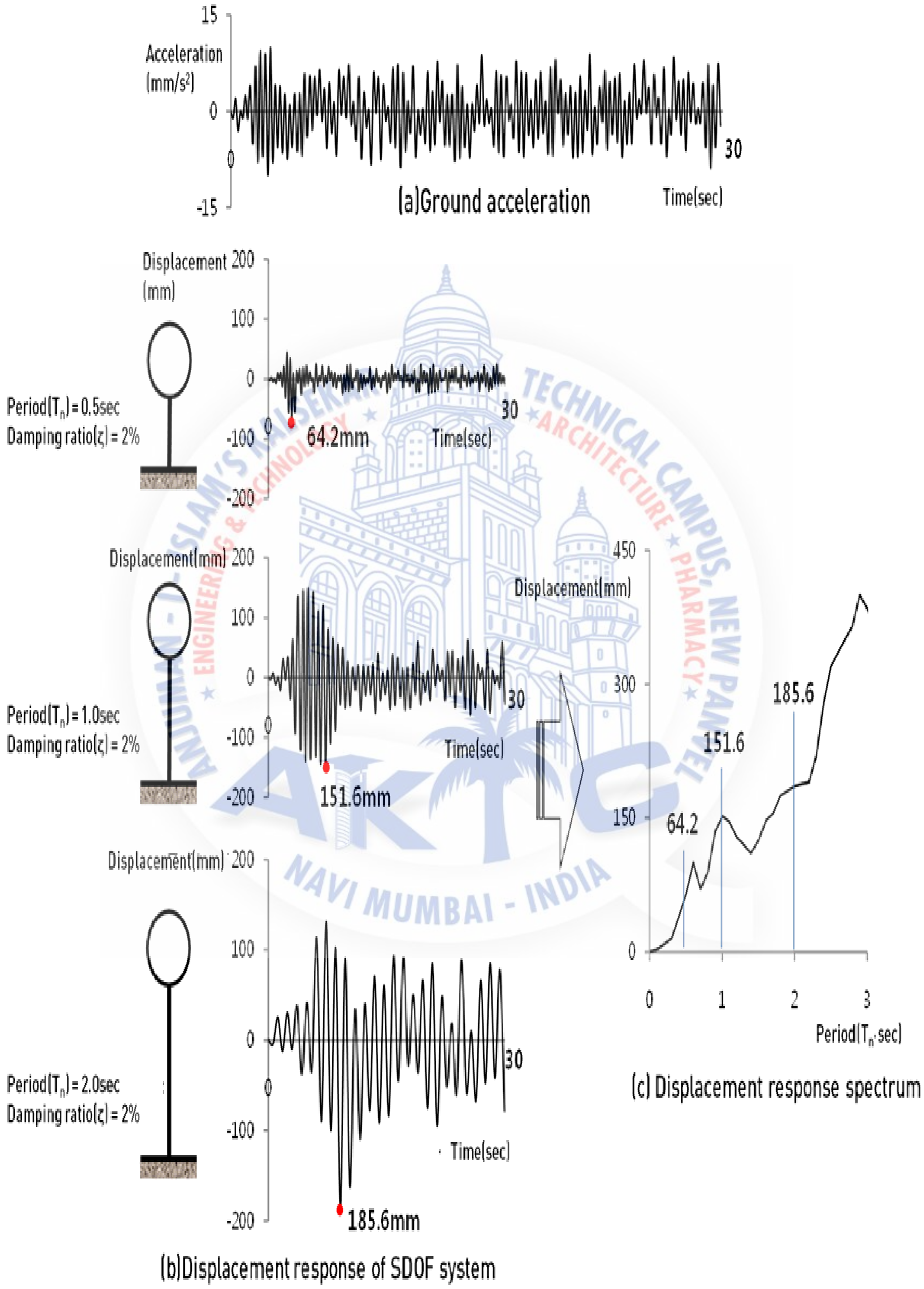


Fig. 1.1 A single-degree-of-freedom model. (Based on Chopra [1].)

DESIGN RESPONSE SPECTRUM




How a Response Spectrum Is Produced
Example:
Hector Mine
Earthquake Record
Ground displacement (cm)
5
0
-5
1999 Hector Mine Earthquake (M 7.1)
station 596 (r= 172 km), transverse component
0.1
1
10
100
Period (sec)
Ground acceleration (cm/sec²)
20
10
0
-10
10
20
30
40
50
60


15
Acceleration
(mm/s²)
0
-15
30
Time(sec)
(a)Ground acceleration
Displacement (mm)
Period(Tn) = 0.5sec
Damping ratio(ζ) = 2%
64.2mm
Period(Tn) = 1.0sec
Damping ratio(ζ) = 2%
151.6mm
Period(Tn) = 2.0sec
Damping ratio(ζ) = 2%
185.6mm
Time(sec)
(b)Displacement response of SDOF system
Displacement(mm)
64.2
151.6
185.6
Period(Tn-sec)
(c) Displacement response spectrum

3.3.4 Time History Analysis

Time-history analysis provides for linear or nonlinear evaluation of dynamic structural response under loading which may vary according to the specified time function. Dynamic equilibrium equations, given by K u (t) + C $^{d}/_{dt}$ u (t) + M d$^{2}/_{dt}$ u(t) = r(t), are solved using either modal or direct-integration methods. Initial conditions may be set by continuing the structural state from the end of the previous analysis

Step Size – Direct-integration methods are sensitive to time-step size, which should be decreased until results are not affected.

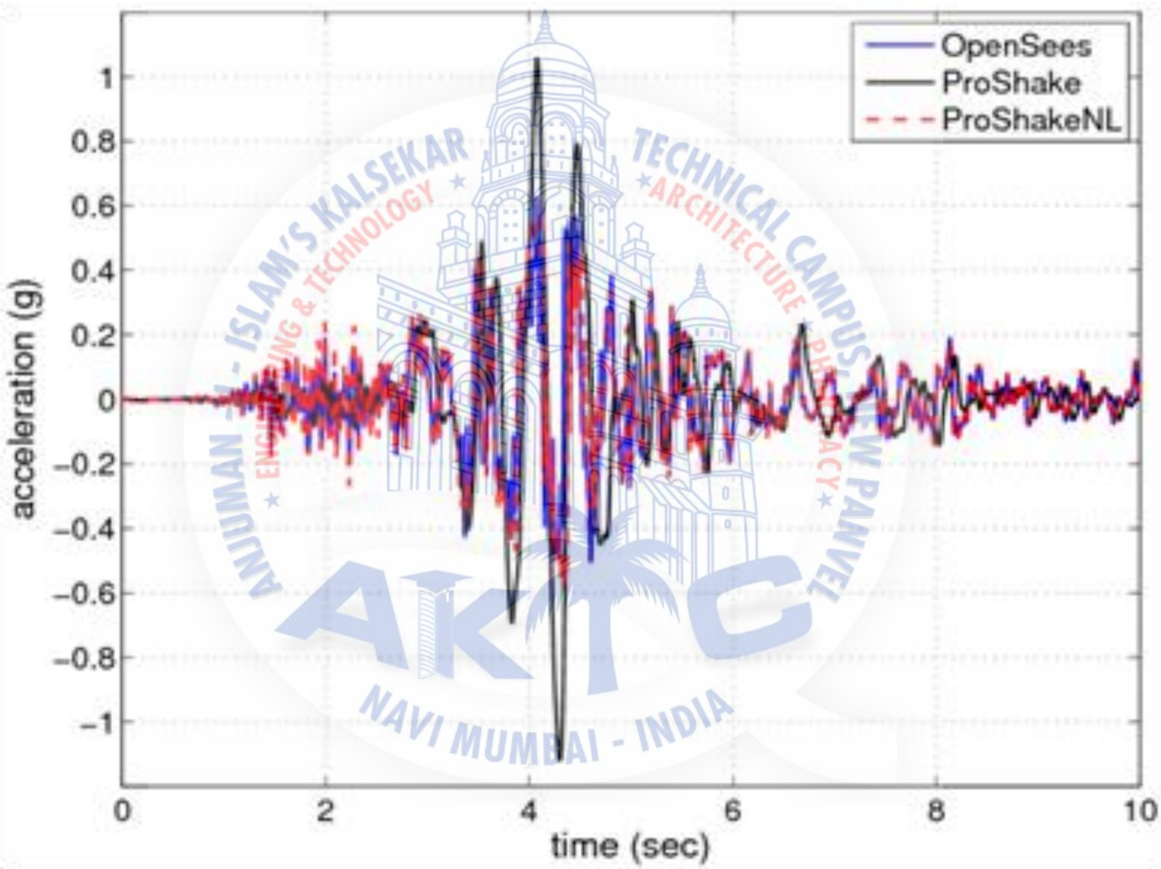
HHT Value – A slightly negative Hilbert-Hughes-Taylor alpha value is also advised to damp out higher frequency modes, and to encourage convergence of nonlinear direct-integration solutions.

Nonlinearity – Material and geometric nonlinearity, including P-delta and large-displacement effects, may be simulated during nonlinear direct-integration time-history analysis.

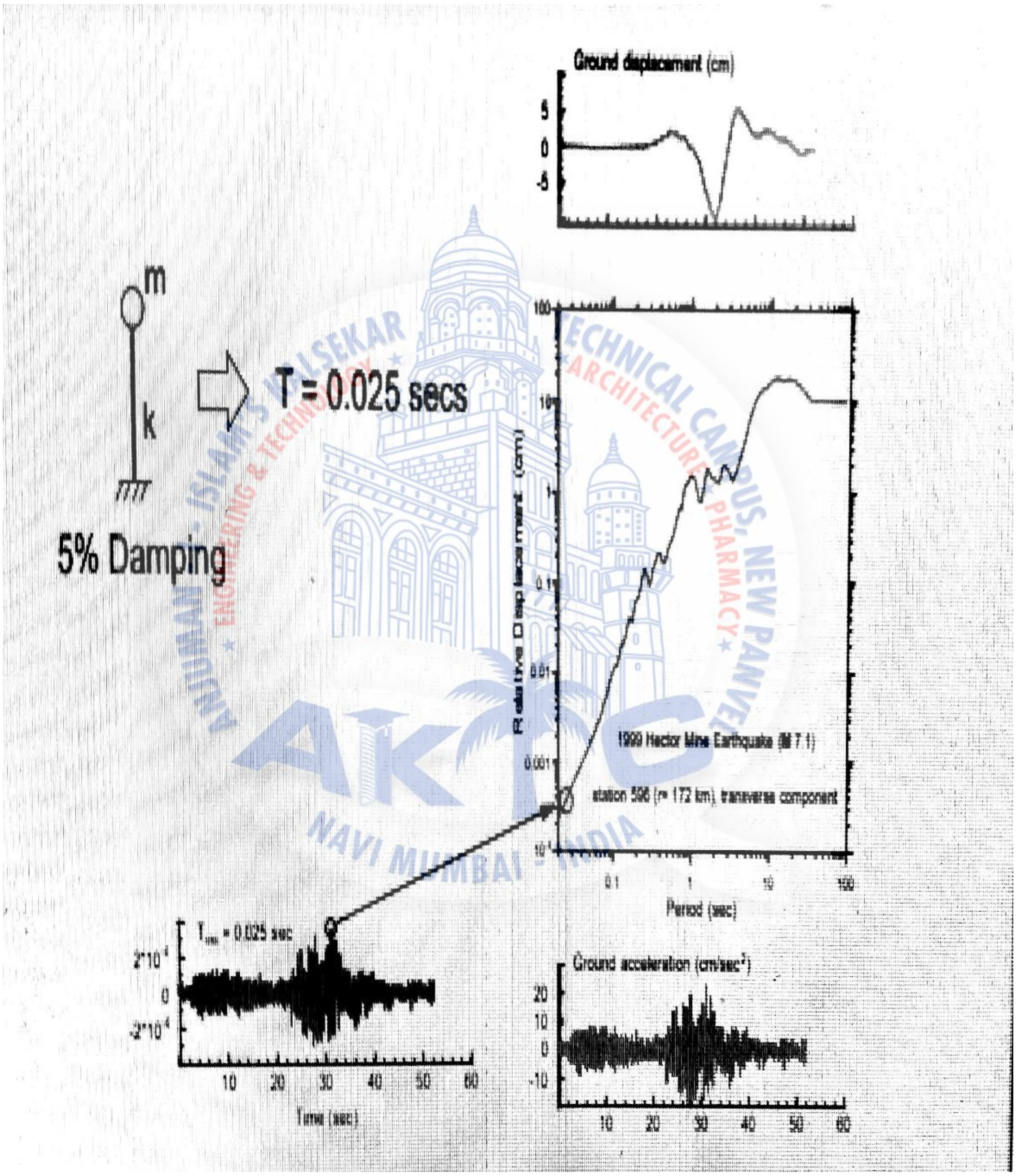
Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion. Static techniques are applicable when higher mode effects are not important. This is for the most part valid for short, regular structures. Thus, for tall structures, structures with torsional asymmetries, or no orthogonal frameworks, a dynamic method is needed. In linear dynamic method, the structures is modeled as a multi degree of freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix.

The seismic input is modelled utilizing time history analysis, the displacements and internal forces are found using linear elastic analysis. The playing point of linear dynamic procedure as for linear static procedure is that higher modes could be taken into account. In linear dynamic analysis, the response of the building to the ground motion is computed in the time domain, and all phase information is thus preserved.

Just linear properties are considered. Analytical result of the equation of motion for a one degree of freedom system is normally not conceivable if the external force or ground acceleration changes randomly with time, or if the system is not linear. [35]. such issues could be handled by numerical time stepping techniques to integrate differential equations. In order to study the seismic behaviour of structures subjected to low, intermediate, and high frequency content ground motions, dynamic analysis is required. Two, six, and twenty-story regular as well as irregular RC buildings are modelled as three dimension. Material properties, beam and column sections, gravity loads, and the six ground motions listed in Table 4.3 are assigned to the corresponding RC buildings and then linear time history analysis is performed. The linear time-history analysis results for



OpenSees
ProShake
ProShakeNL
acceleration (g)
time (sec)
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
0
2
4
6
8
10



Ground displacement (cm)
m
k
5% Damping
T = 0.025 secs
Relative Displacement (cm)
1999 Hector Mine Earthquake (M 7.1)
station 596 (r= 172 km), transverse component
Period (sec)
Ground acceleration (cm/sec²)
Time (sec)

3.3.5 Difference in Response spectrum and time history analysis

A full time history will give the response of a structure over time during and after the application of a load. To find the full time history of a structure's response, you must solve the structure's equation of motion.

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behaviour by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping.

It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance.
.Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement.

Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis. In time history analyses the structural response is computed at a number of subsequent time instants. In other words, time histories of the structural response to a given input are obtained ad a result. In response spectrum analyses the time evolution of response cannot be computed.

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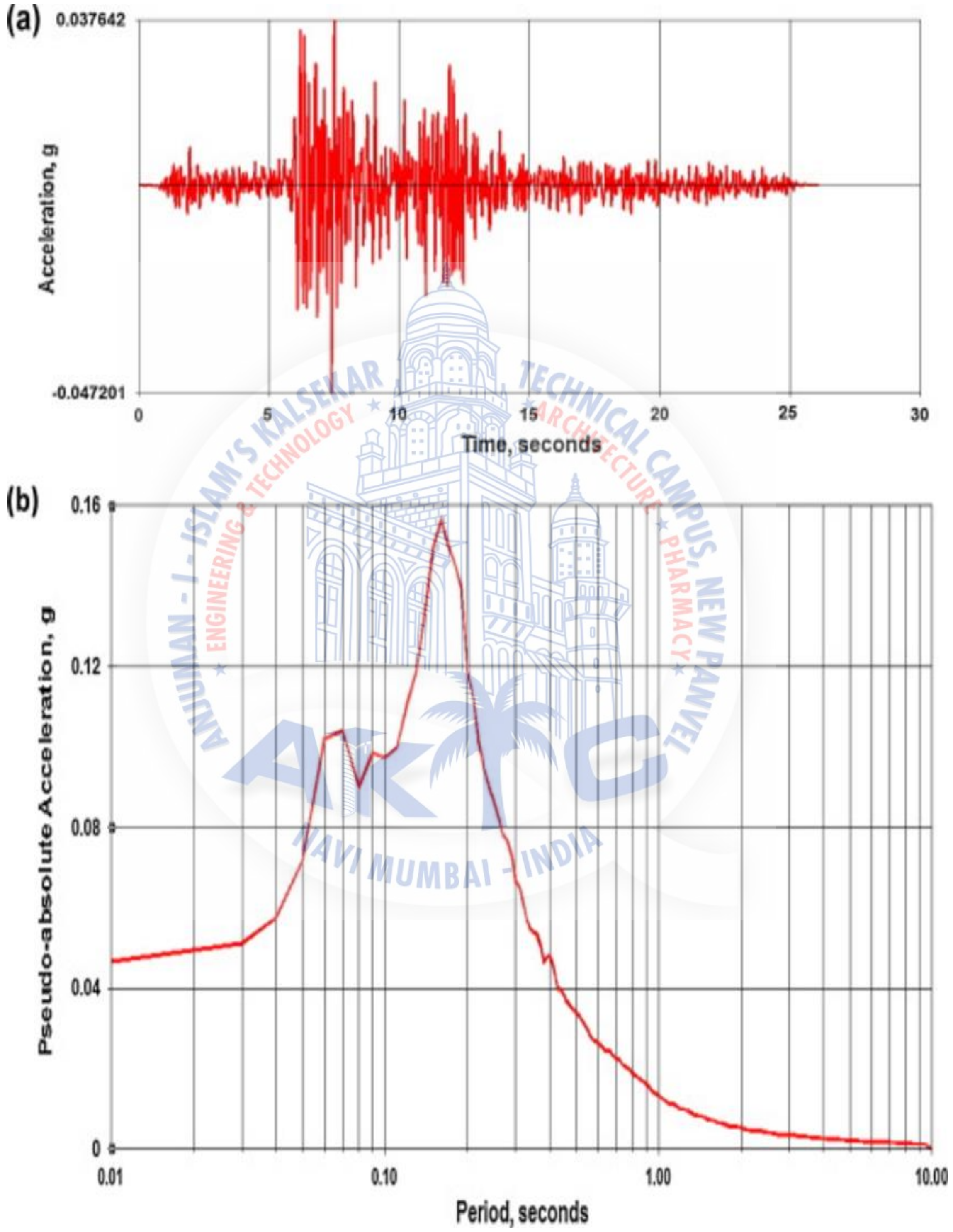
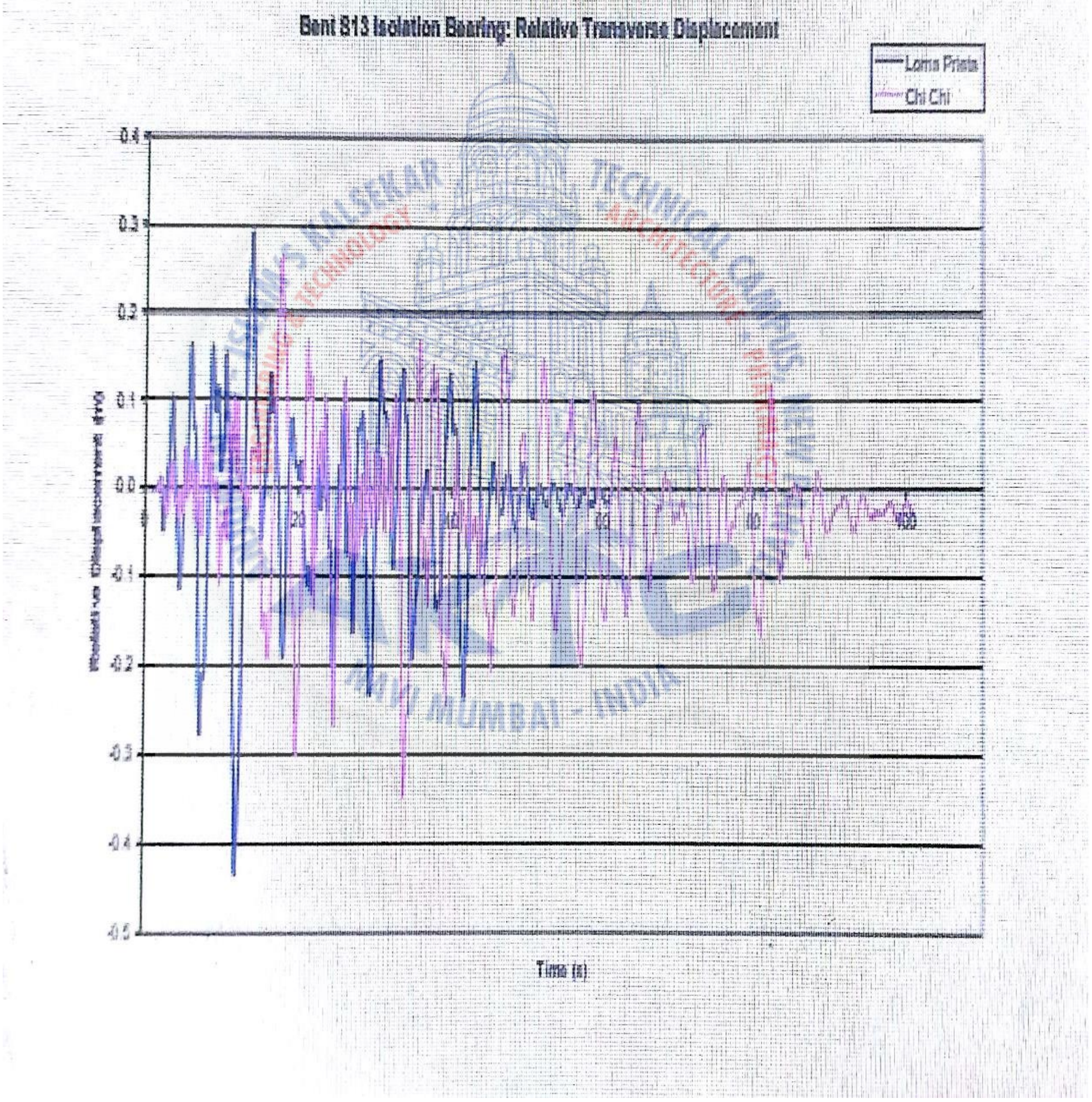


TIME HISTORY (a) RESPONSE SPECTRUM (b) AT A SITE

Nonlinear Time History Analysis



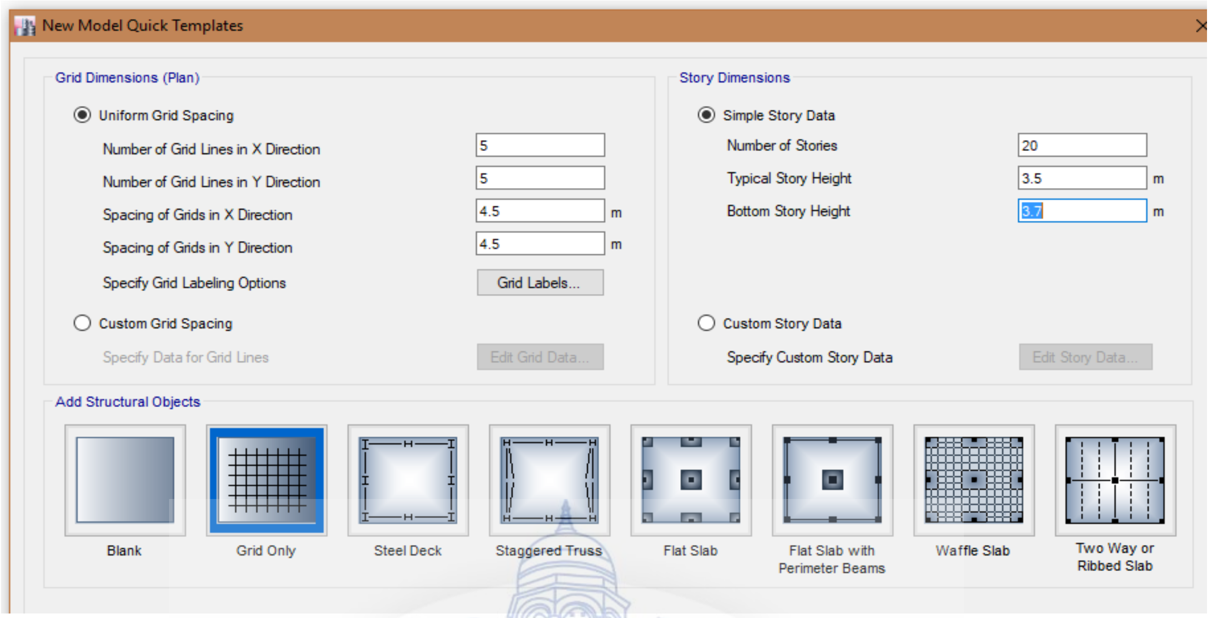
Chapter 4

STRUCTURAL MODELLING

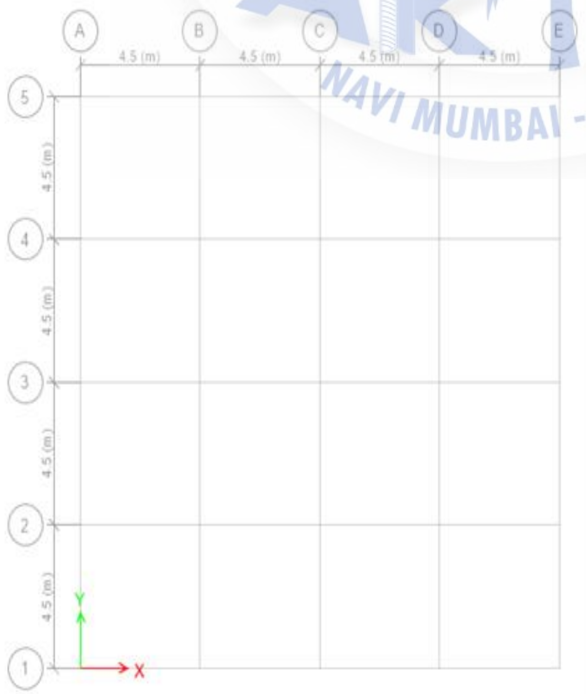
Modelling Details

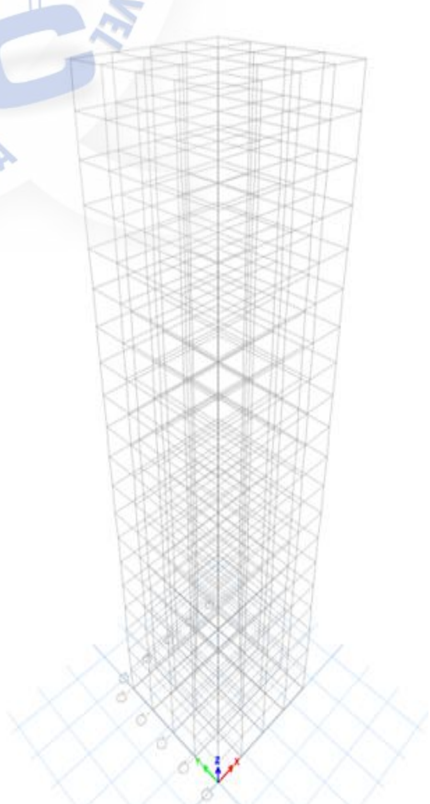
A 20 story building has been modelled with following details

The SI system of units has been used for modelling and analysis purposes. M20 concrete and Fe415 steel has been used to all concrete and steel sections. The size of beam and column has been selected in order to have safe design of the building from Prasanna M. and Jenny C (2014).



Fe415 steel has been used to all concrete and steel sections



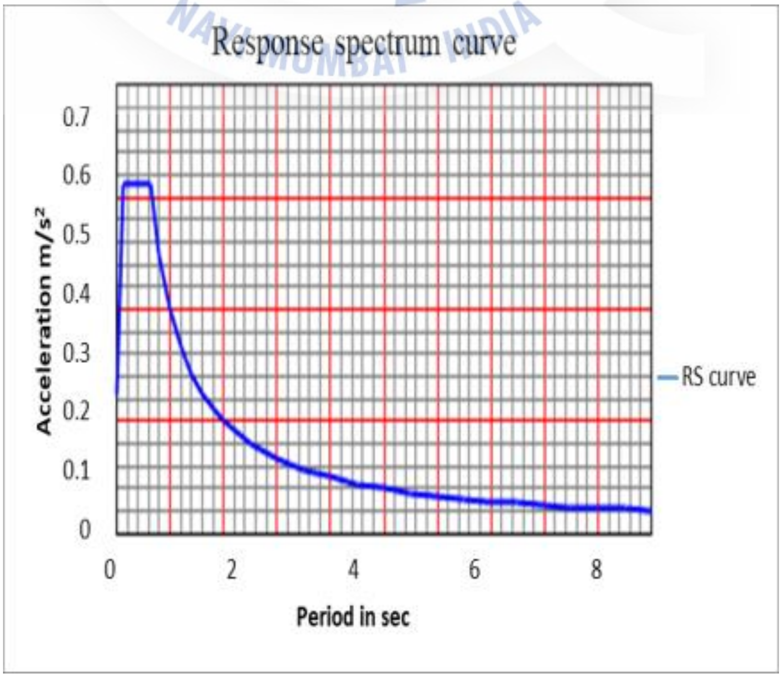


Properties of structure studied

- Assumed Preliminary data considered for 12 stories RCC frame is as follows:
- Type of structure: Twenty storied rigid jointed RCC building
- Number of stories Twelve (G+20)
- Floor height 3.5 m
- Imposed load 2 KN/m^2
- Materials Concrete (M30), Reinforcement (Fe 415)
- Size of Columns 650 mm x 650 mm (story 1-7), 450 mm x 450 mm (story 8-12)
- Size of Beams 400 mm x 800 mm (outside beams), 400 mm x 600 mm (internal beams)
- Depth of slab 150 mm
- Response Spectra as per IS1893-2002.

Load Combinations:

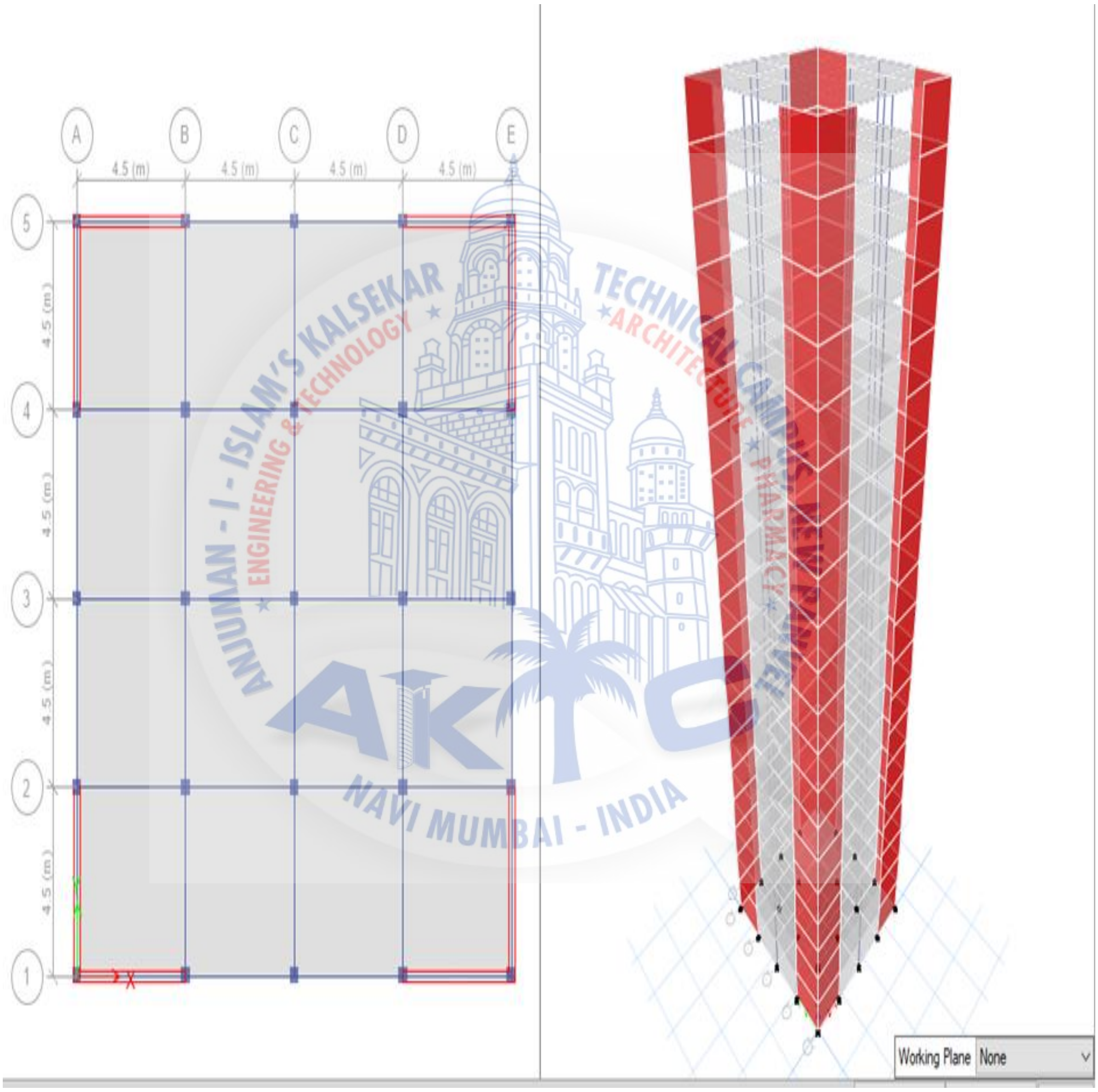
For better understanding of functions of shear walls only lateral forces has been considered for analysis of the structures. Even if load combinations other than lateral loads give more drift, they are not considered for analysis



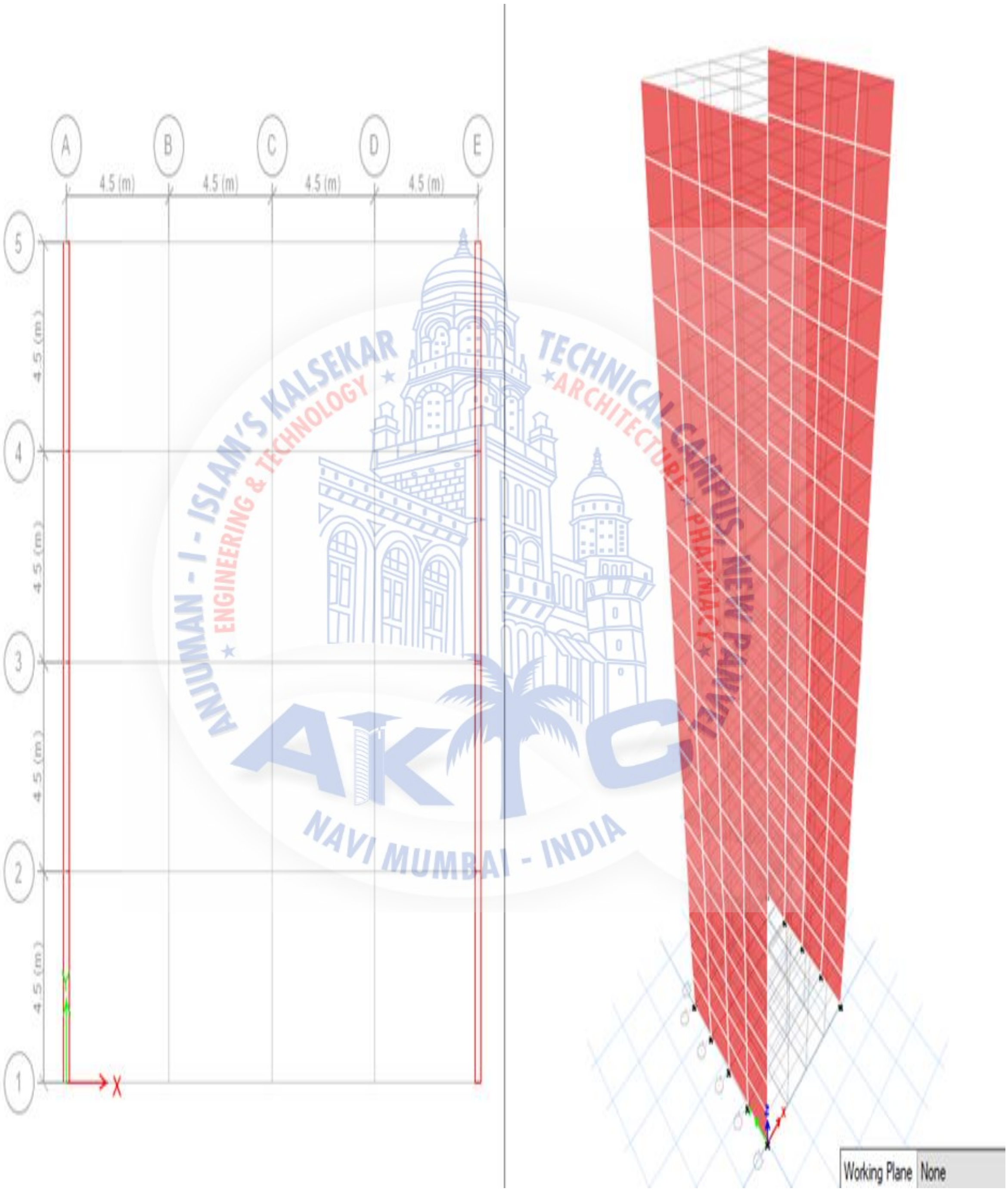
Various locations of shear Walls:

Combination 1

In this arrangement of shear walls, they are provided at corners of the buildings

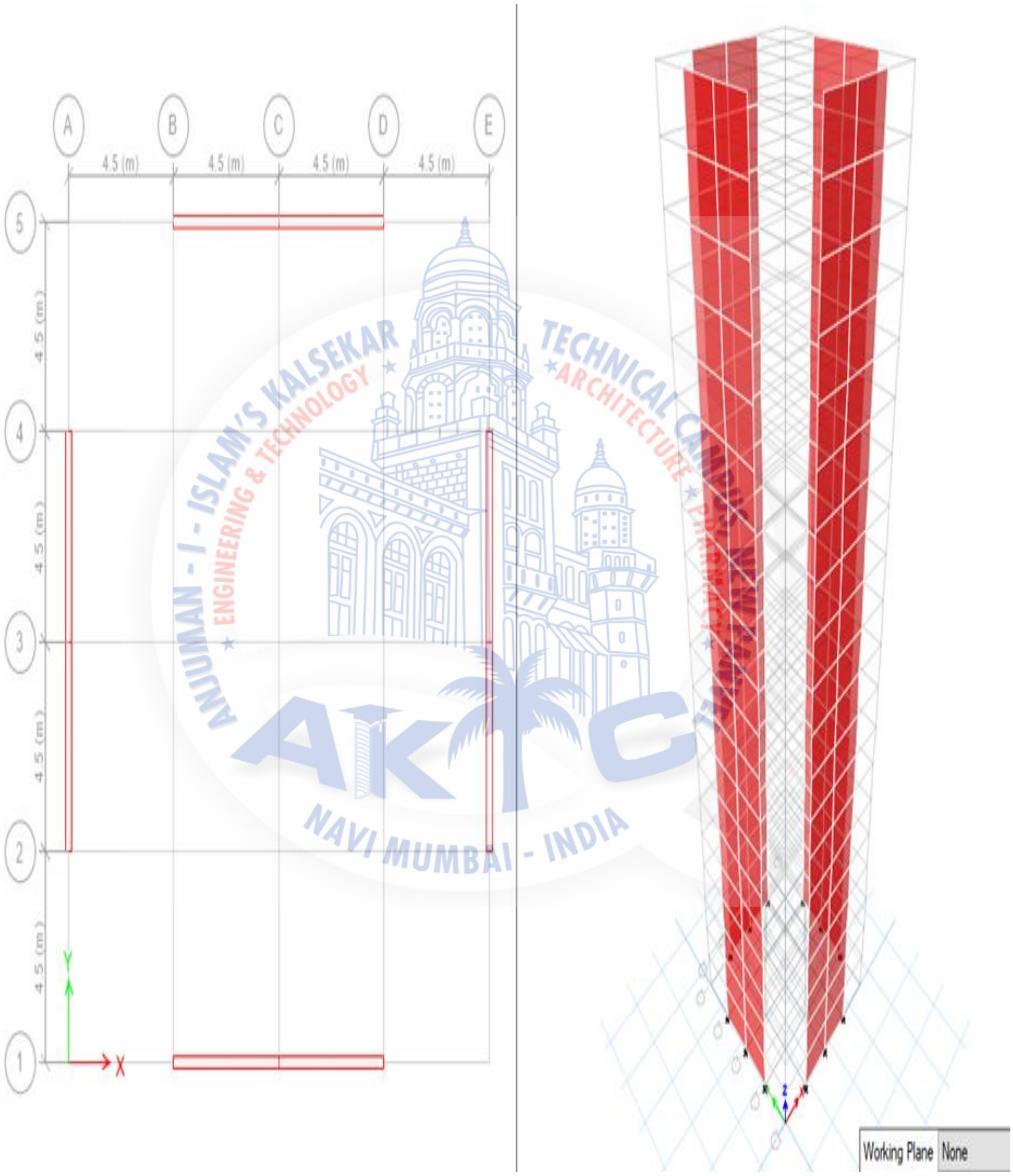


Combination 2: in this arrangement the Y direction of the building has been left without shear wall



Combination 3

In this arrangement, both sides have been given equal area of shear walls



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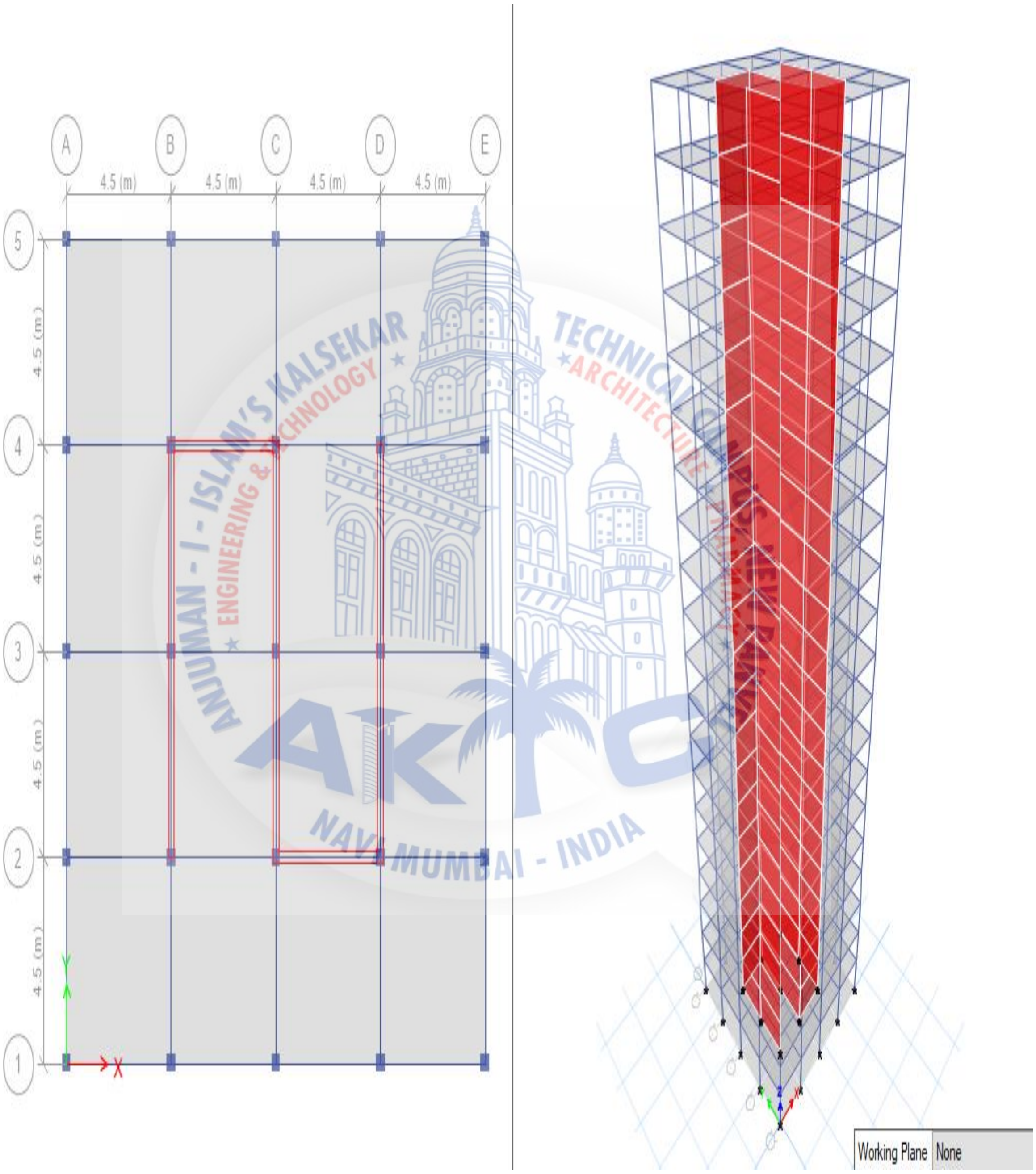
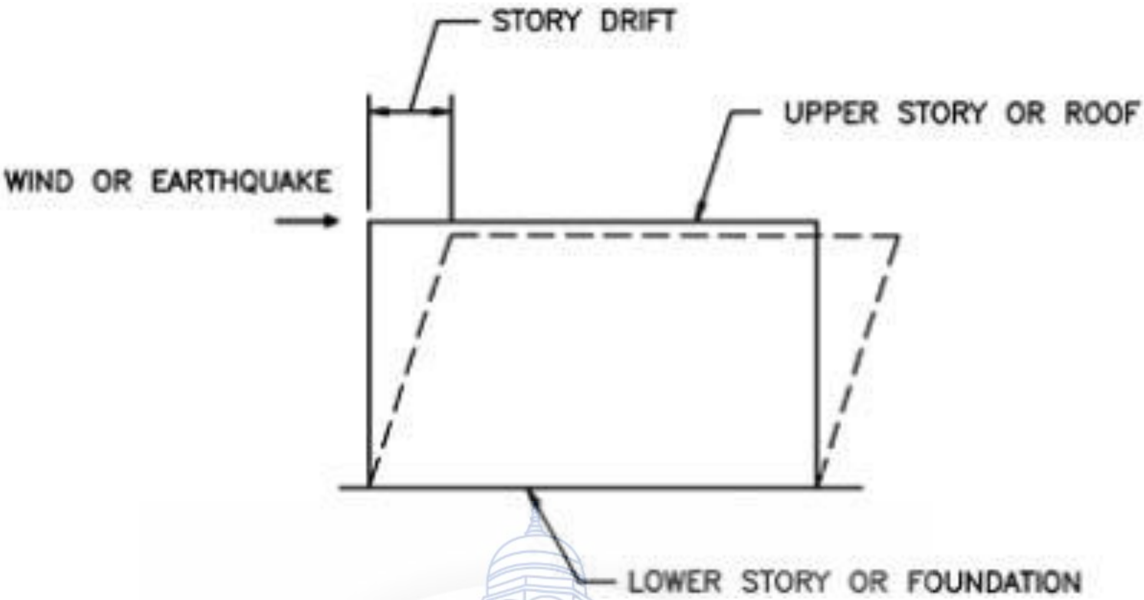
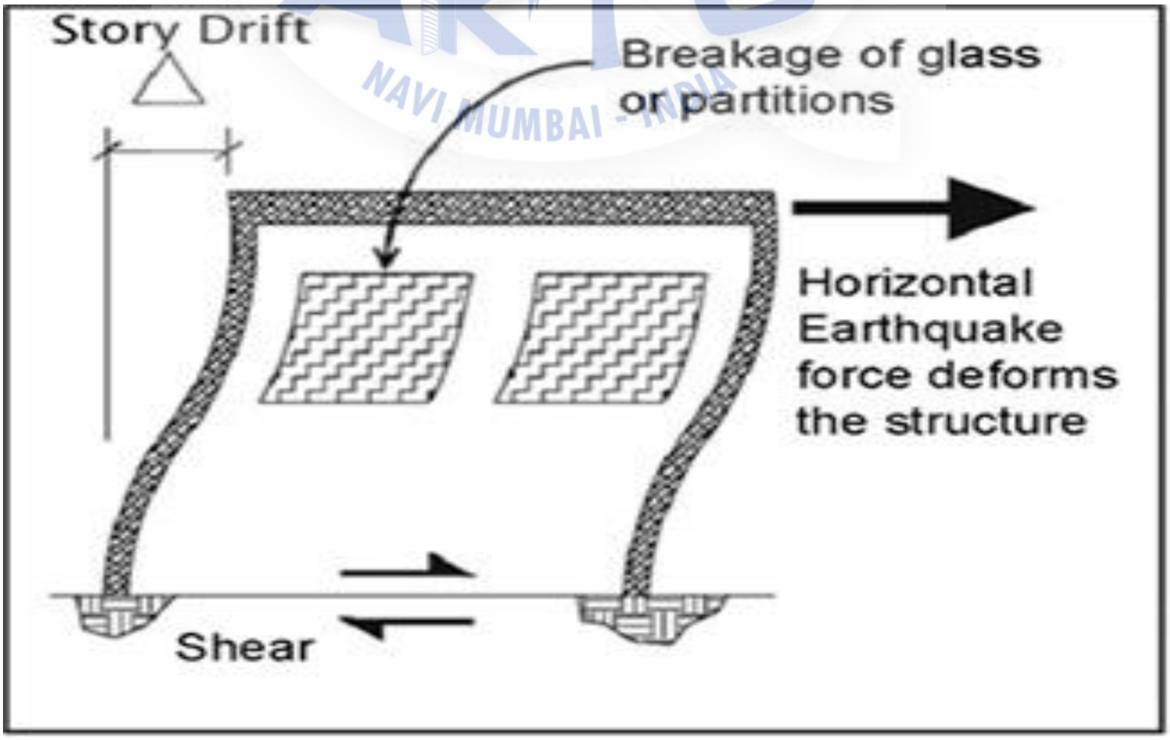
Combination 4: In this combination, shear walls are provided along an assumed lift location




STORY DRIFT
UPPER STORY OR ROOF
WIND OR EARTHQUAKE
LOWER STORY OR FOUNDATION


Story Drift
Δ
Breakage of glass or partitions
Horizontal Earthquake force deforms the structure
Shear

Chapter 5

Results

The top story drift in mm has been calculated in all cases as shown in following tables.

FIRST COMBINATION				
Case Combo	Step Type	Step	Direction	Drift
EARTHX	Step By Step	1	X	0.0857931271
EARTHX	Step By Step	2	X	0.0835791973
EARTHX	Step By Step	3	X	0.0836987113
EARTHy	Step By Step	1	X	0.0843971231
EARTHy	Step By Step	2	Y	0.0842575155
EARTHy	Step By Step	3	X	0.0817571375
EARTHy	Step By Step	4	Y	0.0836738731
EARTHy	Step By Step	5	Y	0.0731971353
RSX	Max		X	0.0793717577

In the second combination, it can be seen that the Y direction showing large drift due to less rigidity

Combination 2				
Case Combo	Step Type	Step	Direction	Drift
EARTHX	Step By Step	1	X	0.0657321457
EARTHX	Step By Step	2	X	0.0673654783
EARTHX	Step By Step	3	X	0.0683698713
EARTHy	Step By Step	1	X	0.0167698712
EARTHy	Step By Step	2	Y	0.0167698712
EARTHy	Step By Step	3	X	0.0167698712
EARTHy	Step By Step	4	Y	0.0167698712
EARTHy	Step By Step	5	Y	0.0167698712
RSX	Max	0	X	0.0683698713
RSY	Max	0	Y	0.0167698712

The increase in the drift is more than 100% when there in so shear wall or less rigidity.

In the third combination, it can be seen that both direction shows equal amount of drift, but it can be noted that the drift has increased as compared to the Combination 1

Combination 3				
Case Combo	Step Type	Step	Direction	Drift
EARTHX	Step By Step	1	X	0.0725798713
EARTHX	Step By Step	2	X	0.0725798713
EARTHX	Step By Step	3	X	0.0725798713
EARTHy	Step By Step	1	X	0.0725798713
EARTHy	Step By Step	2	Y	0.0725798713
EARTHy	Step By Step	3	X	0.0725798713
EARTHy	Step By Step	4	Y	0.0725798713
EARTHy	Step By Step	5	Y	0.0725798713
RSX	Max		X	0.0725798713

In case of combination 4 it can be seen that the drift has been reduced to 55 mm at top story which is significantly lower that all other cases.

Combination 4				
Case Combo	Step Type	Step	Direction	Drift
EARTHX	Step By Step	1	X	0.0554865731
EARTHX	Step By Step	2	X	0.0554865731
EARTHX	Step By Step	3	X	0.0554865731
EARTHy	Step By Step	1	X	0.0554865731
EARTHy	Step By Step	2	Y	0.0554865731
EARTHy	Step By Step	3	X	0.0554865731
EARTHy	Step By Step	4	Y	0.0554865731
EARTHy	Step By Step	5	Y	0.0554865731
RSX	Max		X	0.0554865731

Chapter 6

Conclusions

In the second combination, it can be seen that the Y direction showing large drift. This happened due to less rigidity in the Y direction. If the areas of shear walls are reduced it causes reduction in the flexural rigidity which results in increase of drifts. The increase in the drift is more than 100% when there in so shear wall or less rigidity.

In the third combination, it can be seen that both direction shows equal amount of drift, but it can be noted that the drift has increased as compared to the Combination 1

In case of combination 4 it can be seen that the drift has been reduced to 55 mm at top story which is significantly lower that all other cases.

Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. They also provide adequate strength and stiffness to control lateral displacements.

The shape and plan position of the shear wall influences the behaviour of the structure considerably**. Structurally, the best position for the shear walls is in the centre of each half of the building**. This is rarely practical, since it also utilizes the space a lot, so they are positioned at the ends. It is better to use walls with no openings in them. So, usually, the walls around lift shafts and stairwells are used. Also, walls on the sides of buildings that have no windows can be used.

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