INFLUENCE OF BRACING ELEMENTS ON THE SEISMIC RESPONSE OF MULTISTOREY FRAMES

by

Seyit Çeribaşı

B.S. in C.E., Boğaziçi University, 1998

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science
in
Civil Engineering

Boğaziçi University
2001

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my thesis supervisor, Prof. Gülay Altay and Dr. Sami And Kılıç for their continuous support and inspiration that they provided throughout the preparation of this thesis.

My sincere gratitude is also due to my advisory committee, Prof. Turan Özturan and Prof. Nesrin Yardımcı for their useful suggestions and comments.

Heartfelt thanks are also due to my friends, Göksel Gökalp, H. Bora Keskin and Didem Özevin for their friendship, moral support and help during my difficult times.

ABSTRACT

INFLUENCE OF BRACING ELEMENTS ON THE SEISMIC RESPONSE OF MULTISTOREY FRAMES

The aim of this study is to deal with the influence of energy dissipation devices (braces) on the seismic response of multistorey frames. A base frame and five retrofitted frames are designed. Behavior of the original and retrofitted frames was evaluated by conducting two-dimensional, inelastic static and dynamic response analyses using the nonlinear computer program DRAIN-2DX.

The sections of the conventional frame are designed such that the frame is safe under static loading, but it fails when subjected to dynamic loading. The section types and lengths of all of the braces are exactly the same. This is very advantageous for the purpose of monitoring the response of geometrically differently designed bracing systems. Results of the analysis for every frame are compared. For comparison storey displacements, storey shears, mean maximum bending moments of the columns are considered. In addition to these a vertical analyse is made for Frame 1 to see the effectiveness of the braces of different stories.

A time history analysis is applied for all of the frames. The longitudinal accelogram (East-West) of Düzce earthquake is used in the analysis.

ÖZET

ÇAPRAZ ELEMANLARIN ÇOK KATLI ÇERÇEVELERİN SİSMİK TEPKİSİ ÜZERİNE ETKİSİ

Bu çalışmanın amacı enerji dağıtıcı elemanların çok katlı çerçevelerin sismik kuvvetlere karşı tepkisi üzerine etkilerini irdelemektir. Bir tane temel çerçeve ve beş tane de iyileştirilmiş çerçeve tasarlanmıştır. Orijinal çerçevenin ve iyileştirilmiş çerçevelerin davranışları lineer olmayan DRAIN-2DX paket programı kullanılarak; iki boyutlu, elastik olmayan statik ve dinamik tepki analizleri yürütülerek hesaplanmıştır.

Temel çerçevenin elemanları; çerçeve statik yükler altında güvenli fakat dinamik yükler altında çökecek şekilde tasarlanmıştır. Tüm çaprazların kesit tipleri ve uzunlukları birbirinin tam olarak aynıdır. Bu, geometrik olarak farklı dizayn edilmiş çapraz sistemlerin tepkisini gözlemek amacı için çok avantajli bir durumdur. Çerçevelerin analizlerinin sonuçları karşılaştırılmıştır. Karşılaştırma için; kat deplasmanları, kat kesme kuvvetleri, kolonların ortalama maximum burulma momentleri göz önüne alınmıştır. Bunlara ek olarak farklı katlardaki çaprazların etkinliğini görmek için Çerçeve 1 için dikey bir analiz yapılmıştır.

Tüm çerçeveler için zaman aralığı analizi uygulanmıştır. Analizde Düzce depreminin boyuna (Doğu-Batı) akselogramı kullanılmıştır.

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LIST OF SYMBOLS/ABBREVIATIONS

b	Web width of section
e	Eccentricity of the column
f_{cd}	Design strength of concrete
f_{yd}	Design yield strength
F	Vector of nodal internal forces
$\hat{F}$	Effective vector of internal forces
F_x	Area of cross-section
h	Height of section
H	Horizontal nodal force
I_x	Moment of inertia around x direction
k_1	Depth constant of equivalent rectengular stress block
$\hat{K}$	Effective tangent stiffness matrix
K^t	Tangent stiffness matrix
M	Mass matrix
M'_d	Final moment of the frame
M_o	Initial moment of the frame
N	Vertical force on the column
q	Structural.behavior factor
R	Vector of externally applied nodal loads
t	Time
T_N	The shortest natural period of the system
u	Vector of incremental displacement
$\dot{u}$	Velocity vector
$\ddot{u}$	Acceleration vector
V	Shear force

δ	Secondary column displacement
Δ	Increment
Δ_{el}	Displacement resulted from the seismic action
$\in$	Strain
ϕ	Diameter of steel bars
σ	Stress
θ	Constant of Wilson θ method

BEM	Boundary element method
CF	Conventionally designed frame
FEM	Finite element method
MDOF	Multi degree of freedom
REST	Restore to static state
SDOF	Single degree of freedom

1. INTRODUCTION

A bracing system is typically a highly redundant combination of elements, and any assessment of its behaviour is now viewed as being a task that only the computer can accomplish. The configuration and type of bracing system proposed must be conveyed to the computer along with member sizes and connection characteristics. The computer will then advise the designer where limit states have been exceeded, and the designer will then attempt to adjust the original design to correct the identified deficiencies.

If unacceptable structural deficiencies detected in a building something have to be done for safety of human, the structure and whatever may be affected by possible behaviours of the building in the future in any conditions. For structures in an earthquake area the structural deficiencies mostly result from designing the building according to codes, which do not support dynamic or exactly earthquake conditions. These type buildings may safely resist to static loadings but also may collapse or have unacceptable damage under unexpected, cyclic, high, lateral loadings caused by an earthquake [1].

There are several methods to improve lateral load resisting capacity of a building. Adding shear walls, reducing the existing mass, strengthening the columns, using base isolation systems, adding bracing systems to the building are some of the methods for increasing structural capacity of an unsafe building.

Functionally, bracing systems provide lateral stability for a building by resisting winds and earthquakes. Both earthquakes and winds create nonstatic responses in building systems.

In recent years, the seismic response of frames with energy dissipation devices has been the subject of intense research. However only a small amount of these studies deal with the influence of the vertical distribution of these devices on the building response [2], [3]. Figures 1.2-1.7 show 5 typical distributions of the bracing systems and a conventional frame (Figure 1.2). In this study all of these frames are analysed.

1.1. Structural Models

Load is uniformly distributed on the beams and is assumed to be 5 t/m for whole the building.

Five different reinforced concrete ductile moment-resisting frames with different distributions of energy dissipating bracings and a conventionally designed (CF) frame are analysed in this study. They are named as frames 0, 1, 2, 3, 4, and 5 respectively in Figures 1.2-1.7. All the frames have the same amount of bracing steel. The reinforced concrete elements of the frames are the same and the amount of steel used for the bracing system is the same for all frames. For every frame the geometrical distribution of the frame is different from each other.

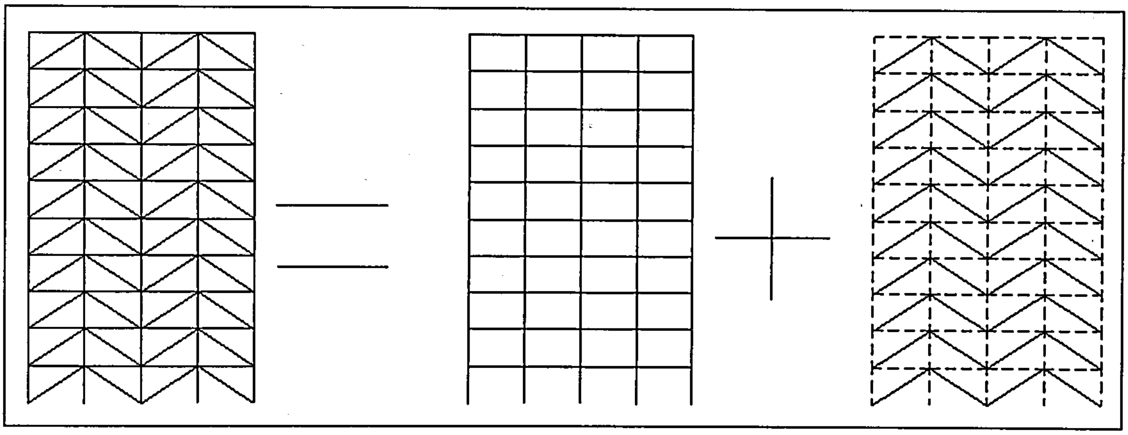

Figure 1.1. Combined frame dissipator system

The design procedure may be clearer by explaining three types of frames shown in Figure 1.1 . The first frame is the fully braced final system, the second frame is the subsystem which is the same for all of the analysed frames, and the last frame is the bracing system which is different for each frame. The length of the braces is the same for every bracing system; in this way it will be easier to monitor the effect of geometric shape. Another important property of the bracing system that should be explained is that the vertical distribution of the braces used in the subsystems does not change.

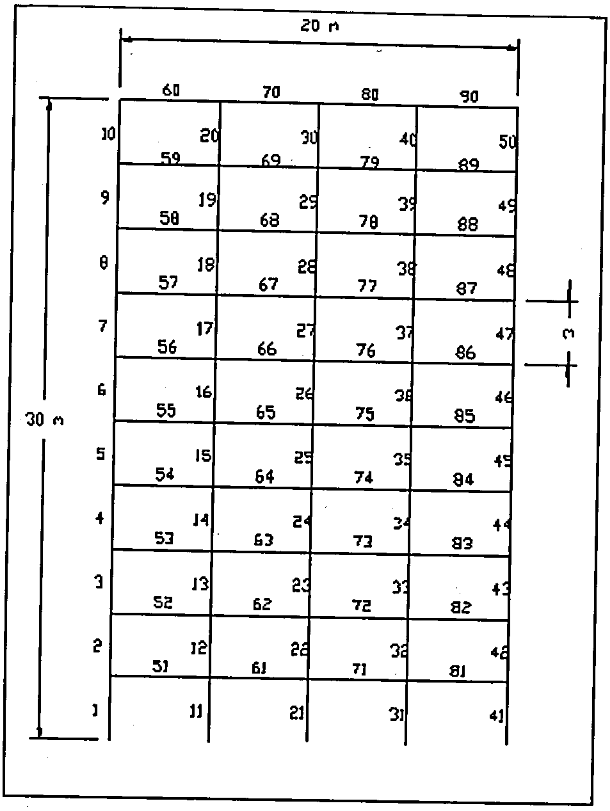

Figure 1.2. Frame 0

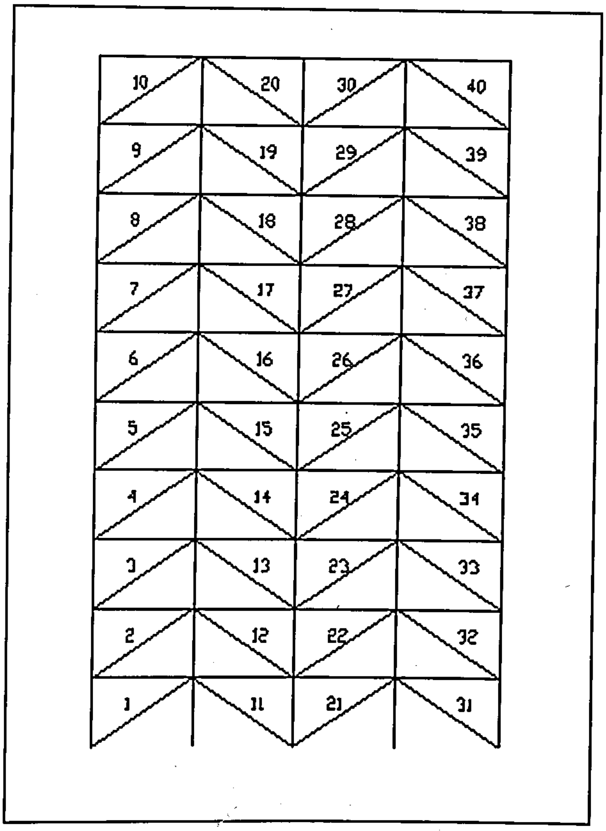

Figure 1.3. Frame 1

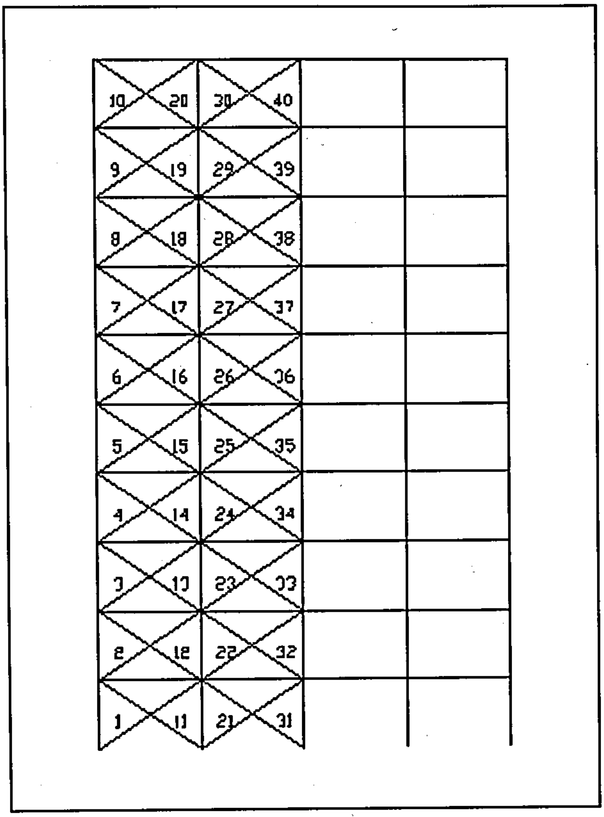

Figure 1.4. Frame 2

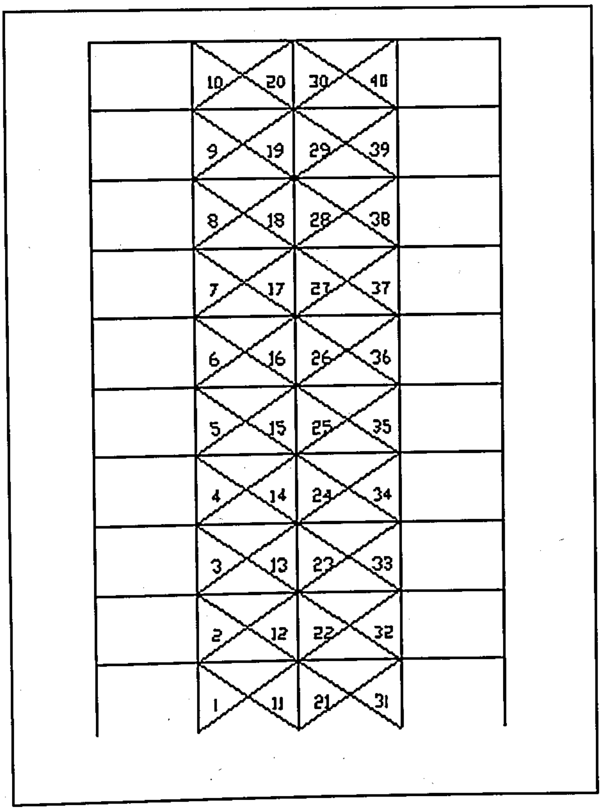

Figure 1.5. Frame 3

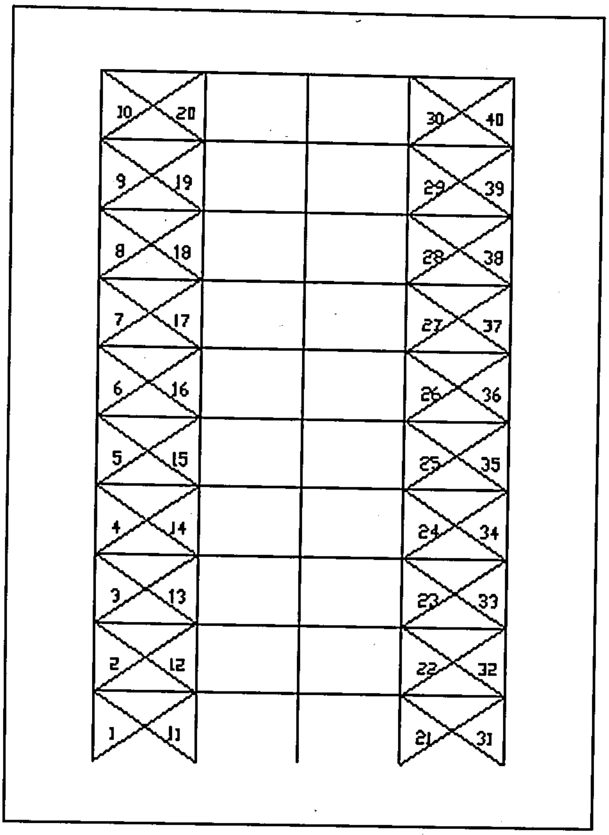

Figure 1.6. Frame 4

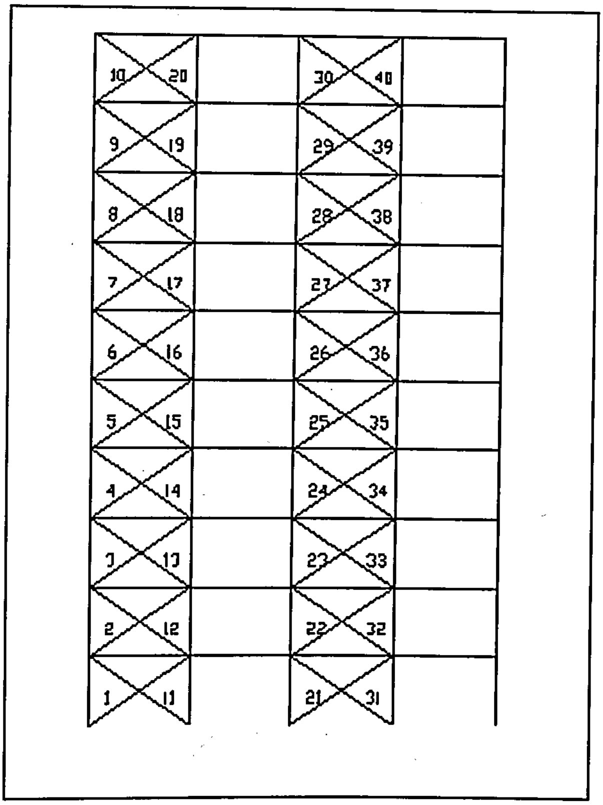

Figure 1.7. Frame 5

1.2. Structural Sections

1.2.1. Beams

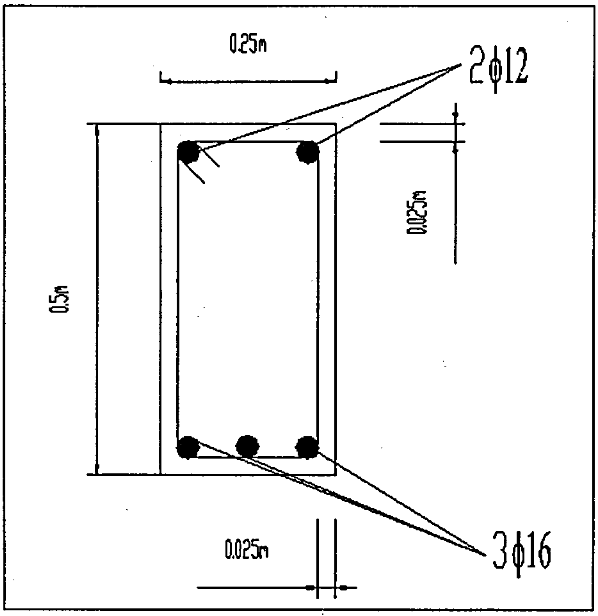

Figure 1.8. Cross-section of the beams used in the frames

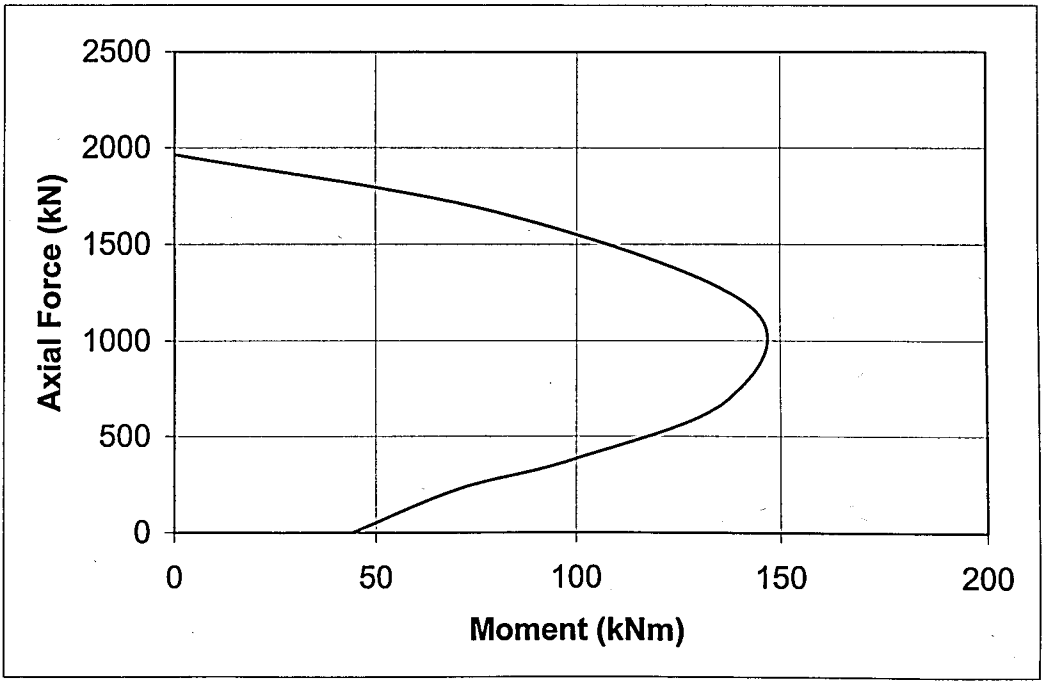

Figure 1.9. M-N interaction curve for the beams used in the frames

Properties of the Concrete and reinforcement steel of the beams are as follows:

Concrete Type=C25

f_{cd}=17 Mpa

f_{yd}=191 Mpa

k_1=0.85

1.2.2. Columns

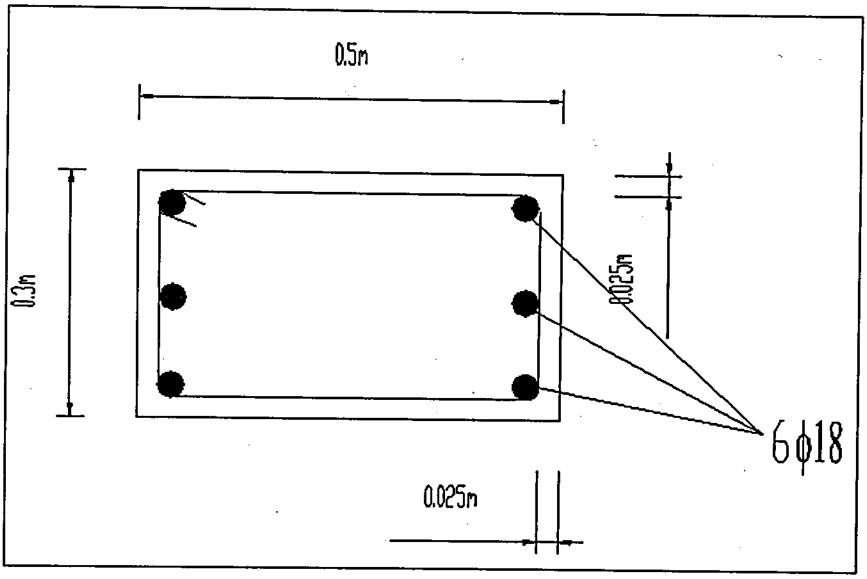

Figure 1.10. Cross-sections of the columns used in the frames

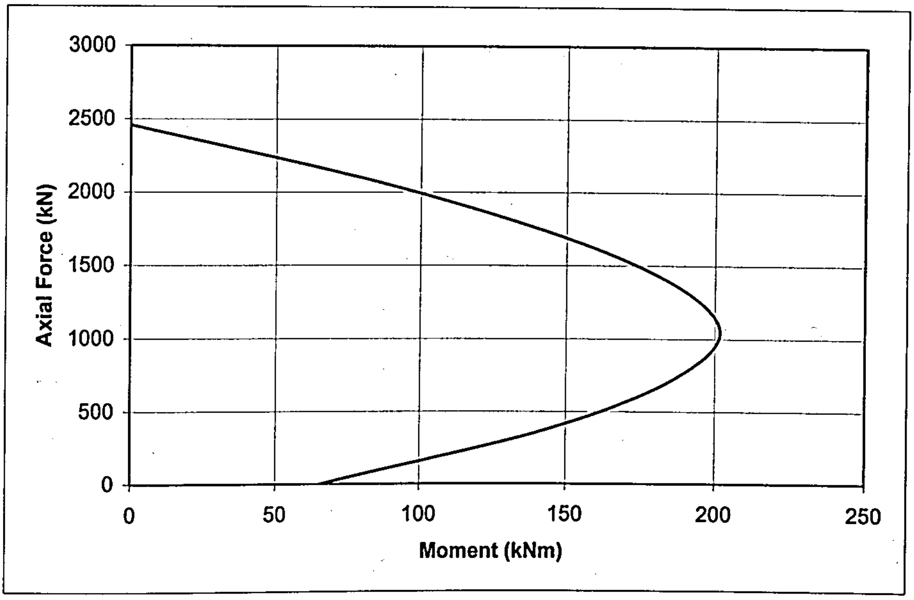

Figure 1.11. N-M interaction curve for the columns used in the frames

Properties of the Concrete and reinforcement steel of the columns are as follows:

Concrete Type= C25

f_{cd}=17 Mpa

f_{yd}=191 Mpa

k_1=0.85

Table 1.1. Yield surface types

Element Type	Yield Moments (kNm)		Yield Forces (kN)	
	Positive	Negative	Compression	Tension
Column	6.583E+01	-6.583E+01	-2.459E+03	4.382E+02
Beam	4.420E+01	-4.420E+01	-1.965E+03	2.806E+02

1.2.3. Braces

I200 is used for all the braces. The lengths of the braces used in the frames are the same and the braces are equally distributed to the stories but their configuration changes for every frame.

Steel Type=St 37

For I200;

F_x=33.5 cm^2 (Area of the section)

I_x =2140 cm^4 (Moment of inertia of the section)

h =200 cm (height of the section)

b =90 cm (web width of the section)

Under earthquake forces the behavior of the braces used in the frames is as in the Figure 1.13; they yield under tension at 801 kN and buckles under compression at 70.4 kN. If they did not buckle the idealized brace behavior would be as in Figure 1.14. In that case the area of the hysteretic loops would be much more which directly refers to the energy absorption capacity of the braces. But it is known that slender members buckle according to Euler Buckling Formula.

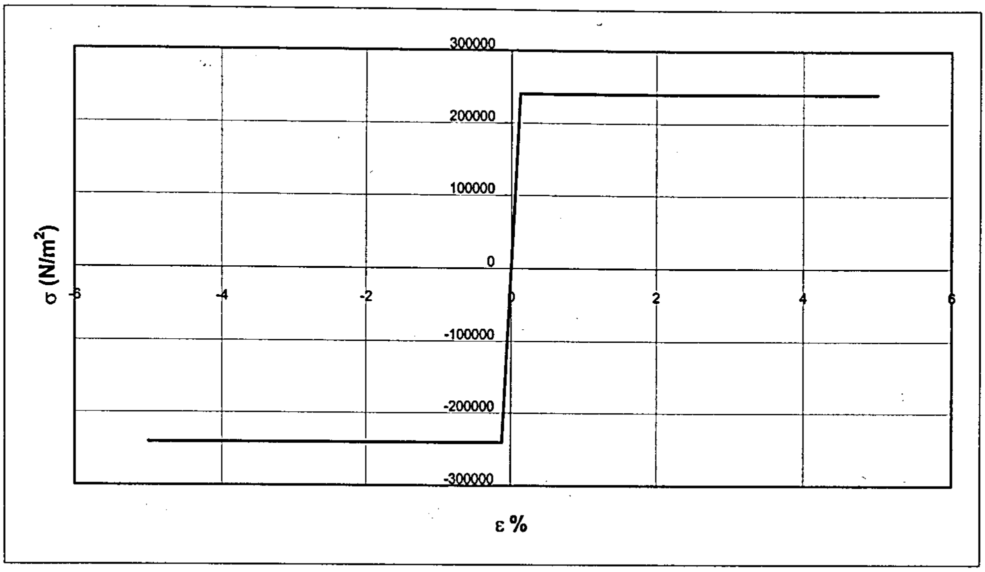

Figure 1.12. Idealized behavior for steel

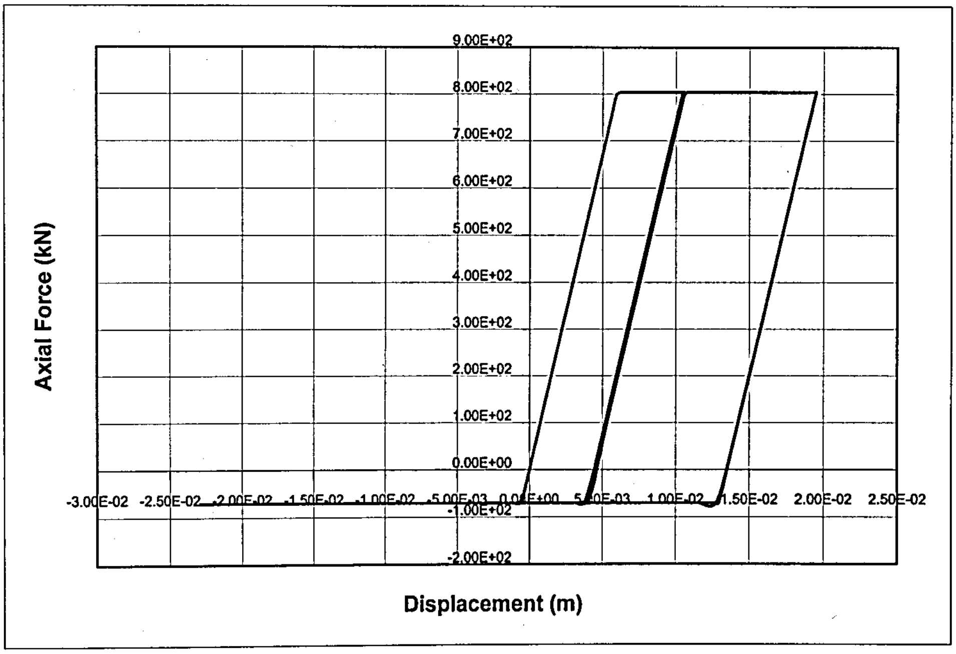

Figure 1.13. Idealized behavior for the steel braces (braces are assumed to buckle in compression)

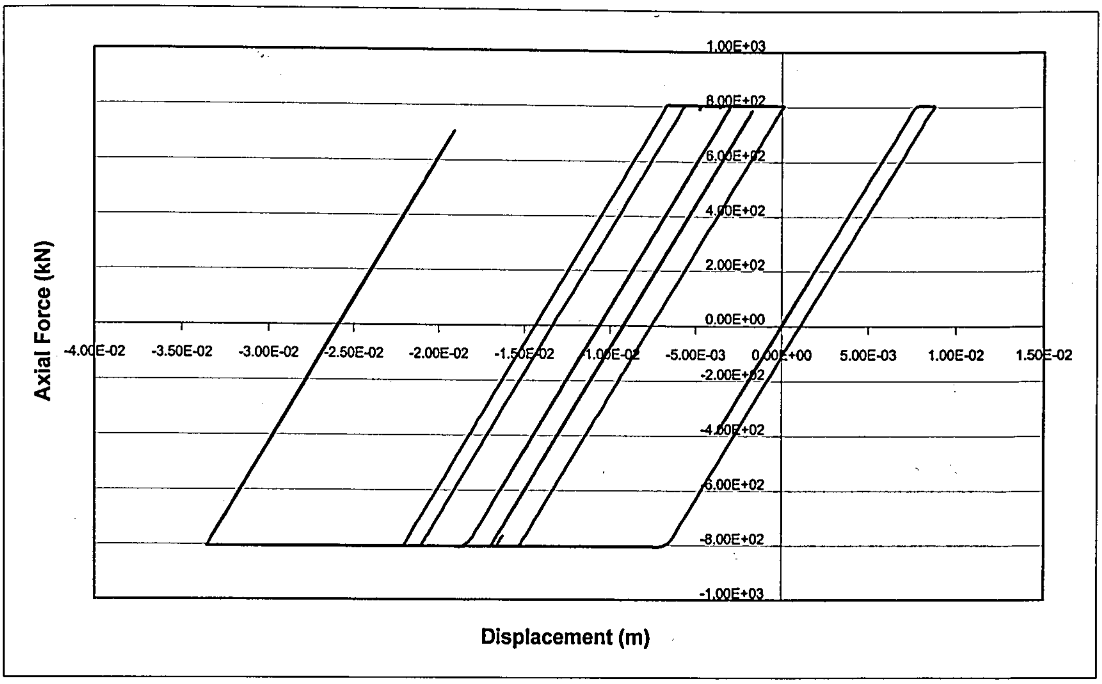

Figure 1.14. Idealized behavior for steel braces (braces are assumed to yield in compression)

2. INELASTIC ANALYSIS OF BUILDINGS FOR EARTHQUAKE ACTIONS

Inelastic dynamic, earthquake response, analysis of buildings with realistic MDOF models occurred in mid-sixties, when Clough and Benuska published an extensive study on the earthquake behaviour of plane frames, based on inelastic dynamic solutions. Since then, such analysis have been used mostly as a research tool to carry out a great deal of parametric studies, which together with a large volume of experimental work and field observations have increased considerably our knowledge on this subject and provided a better understanding of inelastic building behaviour in strong earthquakes [4].

2.1. Inelastic Member Idealization

One of the main obstacles preventing the introduction of non-linear, dynamic analysis of buildings is the large number of available idealizations at different levels of sophistication and the lack of a standard model for which a consensus among the experts could be established.

In general, there are three levels of sophistication that have been used:

At the first level, a complete building may be idealized as a condensed structural model, in which a single non-linear element replaces an entire frame story even the complete structure. In this last case the entire building is reduced to a SDOF system with a multi linear force-deformation relationship, determined from non-linear, static, pushover analysis with gradually increasing lateral forces. The model, in which frame stories are idealized by a single non-linear element, is based on assumed shear beam type of that most frames exhibit. The assumption is not valid for shear walls, which are far coupled systems and must be modelled accordingly, e.g. by plastic hinge elements, with one element per shear wall segment between consecutive floors.

The second level of sophistication corresponds to models in which structural members, beams or columns, are idealized as distinct elements and all inelastic deformations are concentrated at their two ends. This is the most widely used idealization for 2-D analysis. Beam and beam-column models that limit all inelastic action at the two ends belong to the plasticity idealizations and are known as point hinge models. There are two such models, developed originally for inelastic beams in two dimensions: the one-component and two-component models. The first consists of an elastic beam with a nonlinear rotational spring at each end, while the second consists of two beams, one elastic and the other elastoplastic acting in parallel.

At the third level of sophistication spread plasticity models are classified by predicting the spread of yielding along the member. The most detailed of them is the fiber model, in which a member is discretized in several sections and each section is divided into smaller subsections (fibers) where the stress and strain are monitored. Such models require excessive computational power. Moreover they are numerically very sensitive and thus they are rarely used, even as research tools [4].

2.2. Nonlinear Dynamic Analysis

Realistic earthquake engineering problems involve material and geometric nonlinearities. Material nonlinearities are due to the inelastic constitutive material behavior of the structure or its foundation soil. Geometric nonlinearities are usually due to contact conditions between the structure and its foundation. Analysis of these nonlinear dynamic structural systems is usually done by the time domain FEM (Finite Element Method). The BEM (Boundary Element Method) is also successfully applied to small scale problems of inelastic dynamic structural analysis. The FEM discretizes the systems in space and time integration techniques are usually employed to solve the resulting nonlinear matrix equations of motion.

2.2.1. Time Integration of Materially Nonlinear Dynamic Equations

For a materially nonlinear structural system the governing equations of motion are:

$$M\ddot{u} + C\dot{u} + F = R \tag{2.1}$$

where M is the mass matrix, C is the damping matrix, F is the vector of the nodal internal forces, R is the vector of the externally applied nodal loads and $\ddot{u}$, $\dot{u}$ are the acceleration and velocity vectors of the finite element assemblage. The usual approach for solving the above system of nonlinear differential equations of the second order is an incremental step-by-step direct time integration. Thus assuming that the solution for the discrete time t is known, the solution for the discrete time t+Δt is obtained, where Δt is an approximately chosen time increment.

Equation (1) written at time t+Δt takes the form

$$M^{t+\Delta t}\ddot{u}+C^{t+\Delta t}\dot{u}+F^{t+\Delta t}=R^{t+\Delta t} \tag{2.2}$$

and since the solution is known at time t one can write

$$F^{t+\Delta t}=F^{t}+F \tag{2.3}$$

This vector is approximated by

$$F\cong K^{t}u \tag{2.4}$$

where u is the vector of incremental displacement and K^{t} is the tangent stiffness matrix defined as

$$K^{t}=\frac{\partial^{t}F}{\partial^{t}u} \tag{2.5}$$

and solution for u results in an approximate value of the displacement

$$u^{t+\Delta t}=u^{t}+u \tag{2.6}$$

and corresponding approximate values of stresses and nodal forces at time t+Δt. Then one proceeds to the next time step calculations.

The approximation introduced by the use of equation (2.4) may lead to considerable error, so iterations are used within every time step to reduce that error. The most popular iteration method for this kind of problems is based on the classical Newton-Raphson algorithm. Thus, knowing an increment of displacements, defining new total displacements, the solution procedure previously described can be repeated using the currently known total displacements instead of those at time t for k=1,2,3...

$$ {}^{(k-1)}\hat{K}^{t+\Delta t}\,\Delta u^{k} = R^{t+\Delta t} - {}^{(k-1)}F^{t+\Delta t} - \hat{F} \qquad (2.7) $$

$$ {}^{(k)}u^{t+\Delta t} = {}^{(k-1)}u^{t+\Delta t} + \Delta^{(k)}u \qquad (2.8) $$

In the above equations $\hat{K}$ denotes the effective tangent stiffness matrix, which is a function of K, M and C; $\hat{F}$ denotes the effective vector of internal forces, which is a function of M and C both being defined by the particular time integration algorithm used.

In the above iterative approach the calculations require the evaluation and factoring of a new tangent stiffness matrix within every time step. Another efficient iterative scheme is the Modified Newton-Raphson method in which the tangent stiffness matrix is calculated at time t, the beginning of the time step, and is used during all iterations within that time step [4].

2.2.2. Time Integration Algorithm for Large Systems

Table 1 provides the necessary steps for time integration of the nonlinear equations of the motion according to the Wilson θ method [5]. Table 2 presents the steps of Modified Newton-Raphson iteration used within every time step of the time integration algorithm. Wilson θ method is always stable for $\theta \geq 1.37$ and usually provides very good results for $\theta=1.42$. When $\theta=1$ the method reduces to the linear acceleration method which obtains conditionally stable results, if $\Delta t<0.551\ T_N$, where T_N is the shortest natural period of the system. In order to improve computational efficiency in the solution of nonlinear dynamic problems by direct time integration techniques, especially when these problems are large various techniques such as reduction and substructuring are usually employed [5].

The method of substructuring is ideally suited to problems involving large structural systems with local nonlinearities, material or geometric ones. The whole structure is divided into linear and nonlinear substructures so that only the properties of the nonlinear part are modified during step-by-step time response analysis.

Table 2.1. Wilson θ method for nonlinear dynamic analysis

A.	Initial calculations 1. Solve $M\ddot{u}^0 = R^0 - C^0\dot{u} - F^0$ for $\ddot{u}^0$ 2. Select Δt and θ 3. $A = \frac{6}{\theta\Delta t}M + 3C$ and $B = 3M + \frac{\theta\Delta t}{2}C$
B.	Calculations for each time step 1. $\delta\hat{R} = \theta\Delta R + A\dot{u}^t + B\ddot{u}^t$ 2. Determine the tangent stiffness matrix K^t 3. $\hat{K}^t = K^t + \frac{3}{\theta\Delta t}C + \frac{6}{\theta^2\Delta t^2}M$ 4. Solve for δu from $\hat{K}^t$ and $\Delta\hat{R}$ using modified Newton-Raphson iteration of Table 2 5. $\delta\ddot{u} = \frac{6}{\theta^2\Delta t^2}\delta u - \frac{6}{\theta\Delta t}\dot{u}^t - 3\ddot{u}^t$ and $\Delta\ddot{u} = \frac{1}{\theta}\delta\ddot{u}$ 6. $\Delta\dot{u} = \Delta t\ddot{u}^t + \frac{\Delta t}{2}\Delta\ddot{u}$ and $\Delta u = \Delta t\dot{u}^t + \frac{\Delta t^2}{2}\ddot{u}^t + \frac{\Delta t^2}{6}\Delta\ddot{u}$ 7. $u^{t+\Delta t} = u^t + \Delta u$, $\dot{u}^{t+\Delta t} = \dot{u}^t + \Delta\dot{u}$, $\ddot{u}^{t+\Delta t} = \ddot{u}^t + \Delta\ddot{u}$
C.	Repetition for the next time step. Replace t by $t + \Delta t$ and implement steps from 1 to7 in B for the next time step.

Table 2.2 Modified Newton-Raphson iteration

A.	Initialize data $u^{t+\Delta t^0} = u^t$, $F^0 = F^t$, $\Delta R^1 = \Delta \hat{R}^t$, $\hat{K}_T = \hat{K}^t$
B.	Calculations for each iteration , k=1,2,3,... 1. Solve $\hat{K}_T \Delta u^k = \Delta R^k$ for Δu^k 2. $u^{t+\Delta t^k} = u^{t+\Delta t^{(k-1)}} + \Delta u^k$ 3. $\Delta Q^k = F^k - F^{k-1} + (\hat{K}_T - K^t)\Delta u^k$ 4. $\Delta R^{k+1} = \Delta R^k - \Delta Q^k$
C.	Repetition for the next iteration. Replace k by k+1 and repeat the calculation steps from 1 to 4 in B.

2.3. Geometric Nonlinearity (P-Δ Effects)

P-delta effects can be considered if desired. This is done by adding a geometric stiffness matrix to the stiffness matrix for each element, and accounting for P-delta effects in the resisting force computation. The geometric stiffness is changed at each event in a static analysis. It can be kept constant for dynamic analysis, or alternatively allowed to change. Most structural systems under the action of seismic forces, because of their inelastic response, sustain large horizontal displacements resulting in creation of large secondary effects [6]. The frame below in Figure 2.1 for some external reason (an earthquake in this case) is displaced by Δ. Each of the two W/2 column loads can be analysed into an axial force on the column with a value W/2 and a horizontal one

$$\Delta H_{1,2} = \frac{\Delta}{h}\frac{W}{2} \tag{2.9}$$

Thus the floor is loaded with an additional (second-order) horizontal force equal to

$$\Delta H = \frac{\Delta}{h} W \tag{2.10}$$

In the case of a seismic action the displacement Δ is equal to Δ_{el}, which results from the seismic loading, multiplied by a behavior factor, q, of the structure:

$$\Delta = \Delta_{el} q \tag{2.11}$$

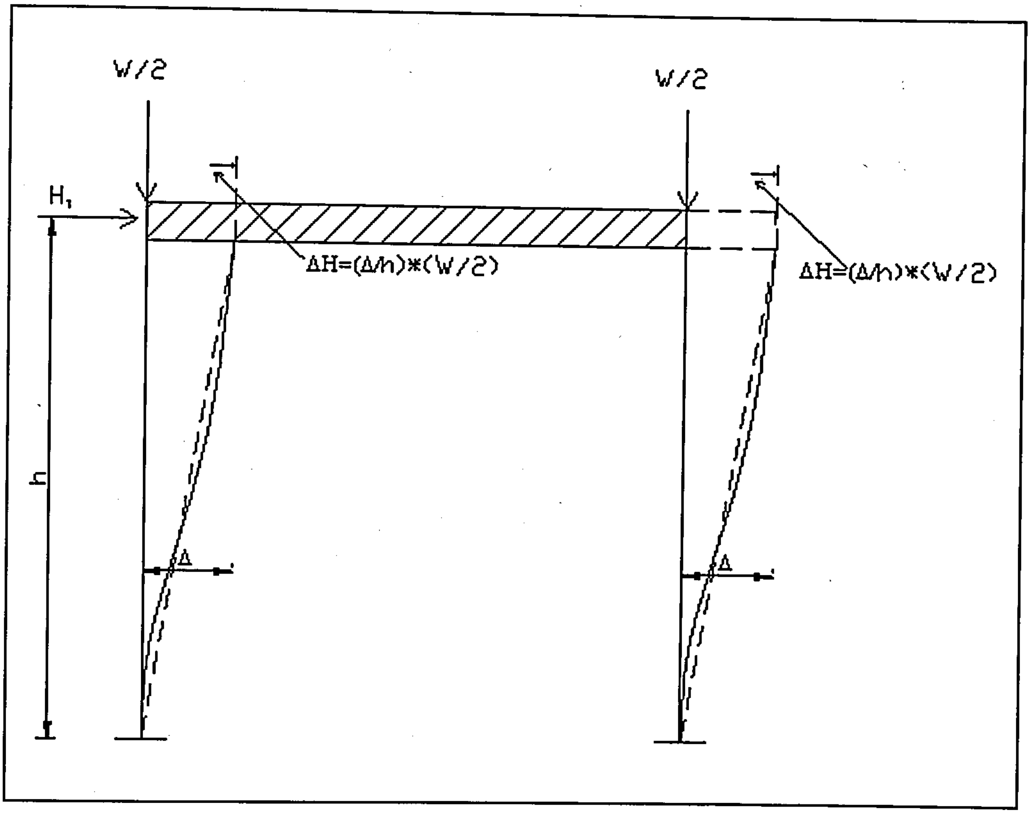

Figure 2.1. Simple representation of P-Δ effects

Therefore, the additional shear force of the storey, because of the second order effects, is equal to

$$\Delta V = \frac{\Delta_{el} q}{h} W \tag{2.12}$$

In the above relations, V is the shear force of the storey due to the seismic actions, Δ_{el} the relative lateral displacement of the top in relation to the bottom of the storey, known as inter-storey drift, q the behavior factor of the structure, h the storey height and W the total gravity load above the storey.

In general, cross-sectional dimensions of columns are small as they are compared to their height. They are slender members. Therefore additional moments are created due to deformations. The axial load and moment on the column can be replaced by the axial load acting at a certain eccentricity e. Due to the deflection of the column, the line representing the centroid of the column will be displaced and will not coincide with the line of action of the axial force. This will create an additional moment, equal to the axial force multiplied by the displacement or deflection. This additional moment, which has been created by the deformation of the column, is called `second order moment`. To obtain the design moment the second order moments should be added to the first order moments.

The presence of the second order moments can be illustrated by the Figure 2.2. The column shown is hinged at both ends and is subjected to an axial force placed at an eccentricity of e (this is equivalent to a uniaxial force and moment of $M_o = N*e$). The first order moment is constant along the height of the column, $M_o = N*e$. Since the column deflects due to bending, the column centre line is displaced and the original eccentricity is increased by δ. Then, the moment at any section becomes:

$$M'_d = N(e+\delta) = Ne + N\delta \tag{2.13}$$

In the above equation, Ne is the first order moment, which would normally be obtained from a linear analysis and denoted as M_d. The second term $N\delta$ is the second order moment. Then Equation (2.13) can be rewritten as:

$$M'_d = M_d + N\delta \tag{2.14}$$

Obviously for the case shown in the Figure 2.2 the maximum moment occurs at the midheight of the column where the deflection is maximum.

In building frames the loading and boundary conditions of the column are much more complicated than the one shown in Figure 2.2. In sway frames the second order moments become more critical due to displacement of column ends relative to each other. Such a

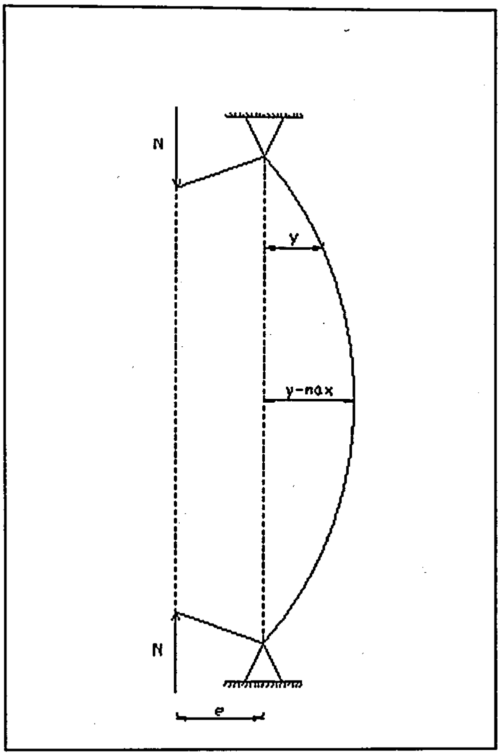

Figure 2.2. Location of the maximum moments in a column

case is shown in Figure 2.3. Depending on the deflected shape of the column, maximum first and second order moments may not occur at the same section [7].

Depending on the deflected shape of the column, maximum first and second order moments may or may not occur at the same section.

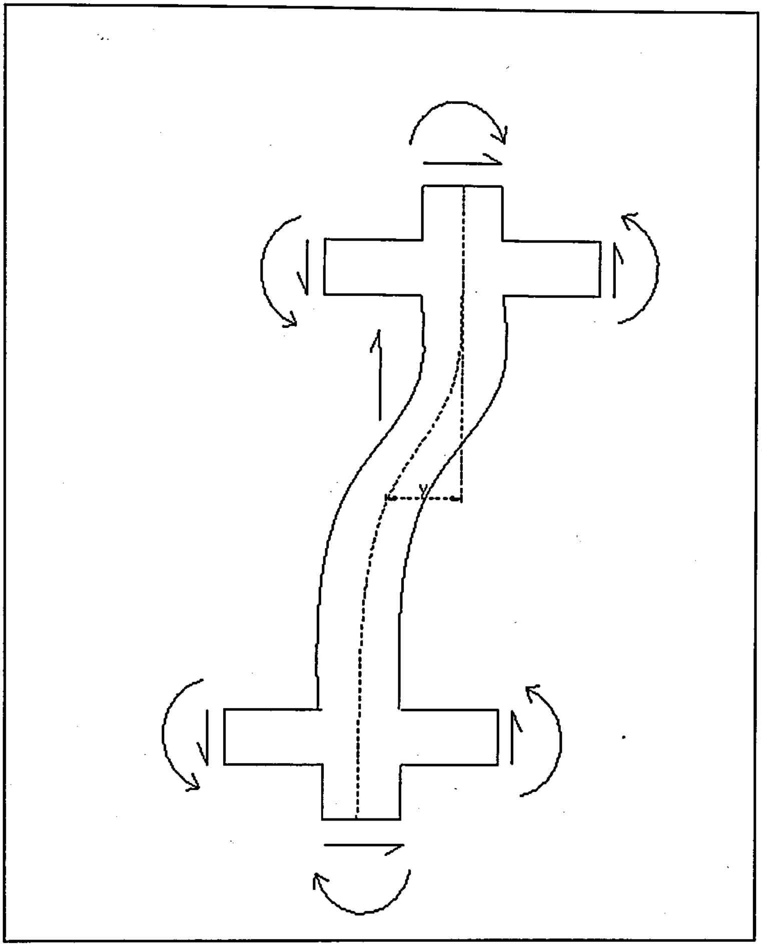

Figure 2.3. Complex behavior of column under loading

3. MODELING AND ANALYSIS BY D2DX

DRAIN-2DX is an improved version of the DRAIN-2D general purpose computer program for static and dynamic analysis of plane frame structures. It performs nonlinear static and dynamic analyses, and for dynamic analysis considers ground accelerations (all supports moving in phase), ground displacements (supports may move out of phase), imposed dynamic loads (e.g., wind), and specified initial velocities (e.g., impulse loading). Static and dynamic loads can be applied in any sequence. For example, a dynamic analysis can be performed to damage applied to investigate its behavior in the damaged state. If a static load follows a dynamic load, a special "restore to static state" (REST) analysis is performed to bring the structure to rest before the static load is applied. The structure state can be saved at the end of any analysis, and the analysis can be restarted from any saved state. The step-by-step integration scheme for dynamic analysis varies the time step during the analysis, on the basis of input error tolerances. Energy balance computations are performed, identifying the static work, the energy absorbed by viscous damping, the kinetic energy, and the input energy. Mode shapes and periods can be calculated for any state. Linear response spectrum analyses can be performed for the unstressed state. Static nonlinear analysis is performed by an event-to-event scheme, where each event corresponds to a significant change in stiffness. The element library contains: Type01, inelastic truss bar; Type02, simple inelastic beam column; Type04, simple inelastic connection, which allows for translational as well as rotational force transfer; Type06, elastic panel element, which allow vertical, horizontal extensional and flexural stiffnesses to be input; Type09, inelastic link element, that can act in compression/tension with initial gap or axial force; and Type15, "fiber" beam-column element for steel and reinforced concrete members. The elements include capabilities for event and internal energy calculations. Inelastic static analysis can be carried out, with the ability to trace sequences of hinge formation and to continue into the post-buckling range.

Scientific basis of the structural frame analysis is based on Newton's laws and equations of motion, dynamic equilibrium, conservation of energy, step-by-step integration, matrix mathematics [8].

3.1. Loads

Loads are input as patterns (for static loads) or as records (for dynamic loads). The loads for any analysis segment are defined as combinations of patterns or records. If desired, new patterns and records can be added in any analysis session.

3.1.1. Static Nodal Loads Patterns

Each pattern consists of loads applied on nodes. Static nodal loads can be applied in gravity or static analysis segments. The loading for any analysis segment can be any combination of the available patterns.

In this study static loads are calculated as 5 t/m uniformly distributed on every beam. These loads are converted to point loads and moments, which applied on nodes for, program inputs.

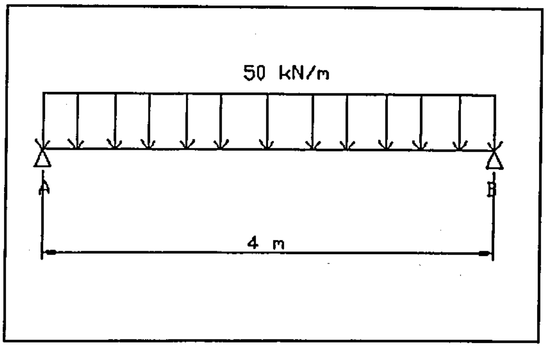

Figure 3.1. Loading is uniform for all of the beams

3.1.2. Ground Acceleration Record

Translational or rotational records can be specified. As many records as desired may be defined, a maximum of three (X direction, Y direction, and AY rotation) directions can be used for a ground acceleration analysis.

For dynamic loading a time history analysis is done. For this kind of analysis some dynamic input should be used. In the analysis used in this study, longitudinal (east-west) ground acceleration record of Duzce Earthquake is used. It includes 5180 acceleration values, which change in a time duration of 0.005 seconds. 25.9 seconds is accepted and applied as effective duration. Time varying acceleration inputs are shown in Figure 3.2. In the analysis dynamic loads are applied in the presence of static loads. When the earthquake data applied to the original non-braced frame, it collapses at the sixth second. None of the braced frames experiences any collapse during the earthquake.

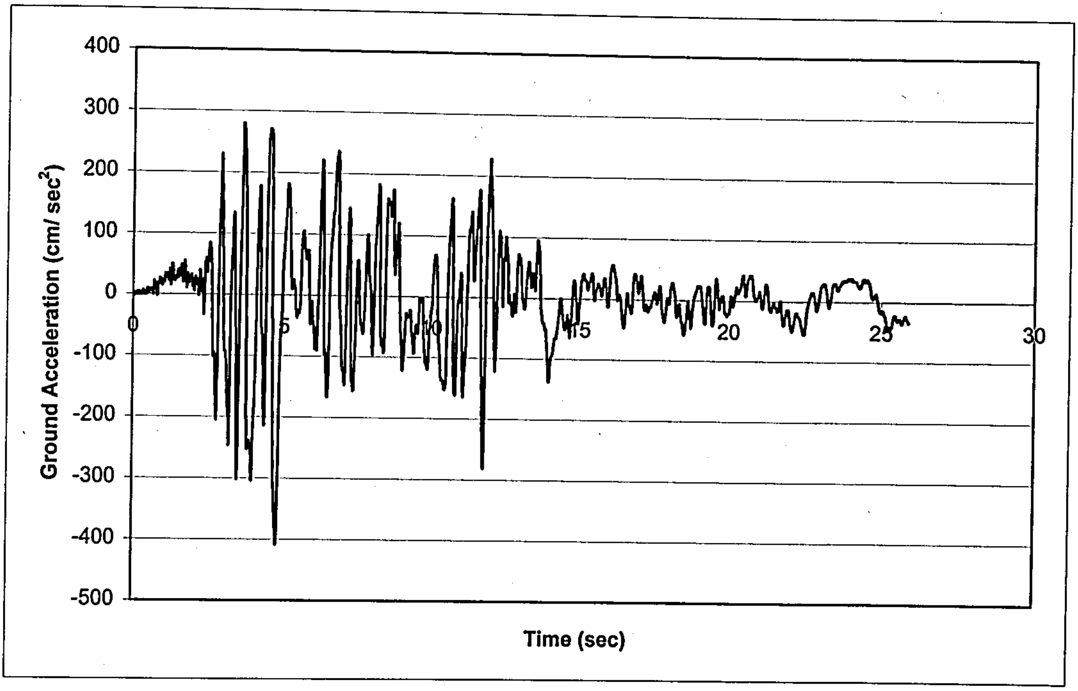

Figure 3.2. Ground acceleration records of Düzce Earthquake

3.2. Analysis Procedure

In a static analysis the load will typically be applied in a number of steps. Within any step the program further selects a load substep size, by determining when the next stiffness is then modified, and an analysis is performed for the next substep. The analysis segment ends when all of the load has been applied, or alternatively when a specified displacement is reached

In a dynamic analysis the time step may be specified to be constant or variable. If the time step can vary, upper and lower error tolerances to control the step size must be specified. The program computes an error measure in each step. If this measure exceeds the upper tolerance in any step, the time step is reduced and the step is reduced and the step is repeated.

Other options are available for dynamic analysis, including (a) event computations within time steps (in which case each time step may be divided into substeps) and (b) corrections at the end of each time step to improve energy balance and equilibrium [9].

4. ANALYSIS AND COMPARISONS OF THE FRAMES

4.1. Analysis of Maximum Storey and Tip Displacements of the Frames

Story drift is a very important criterion for building behavior. Building codes have limited range for interstorey drift and tip displacement. Shear deformation is the major component of the storey drift. Braced frames can be developed as to provide an exclusively axial load path to transfer shear from level to level and this will reduce the shear component of storey drift.

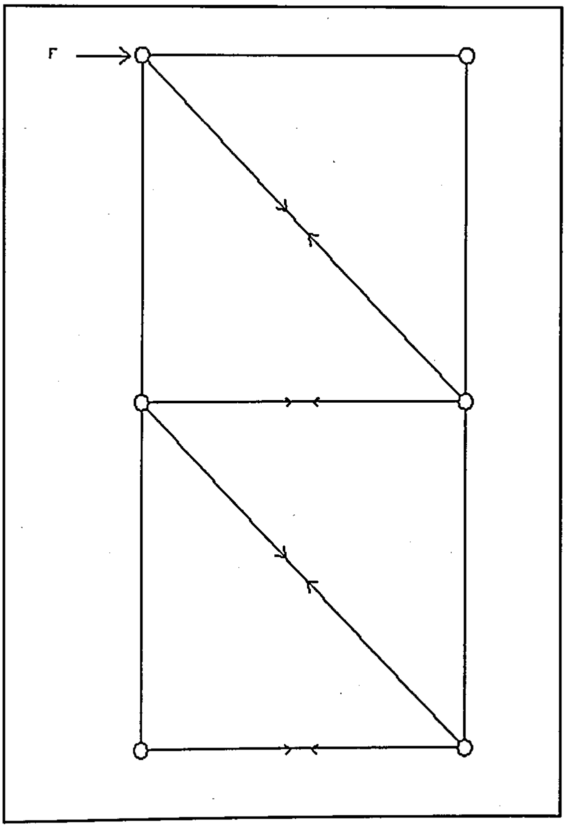

Figure 4.1. Load path for a diagonally braced system

From the results of interstorey drift analysis Frame 1 gives the optimum results. The same result is obtained if the tip displacements are compared. The difference is very significant.

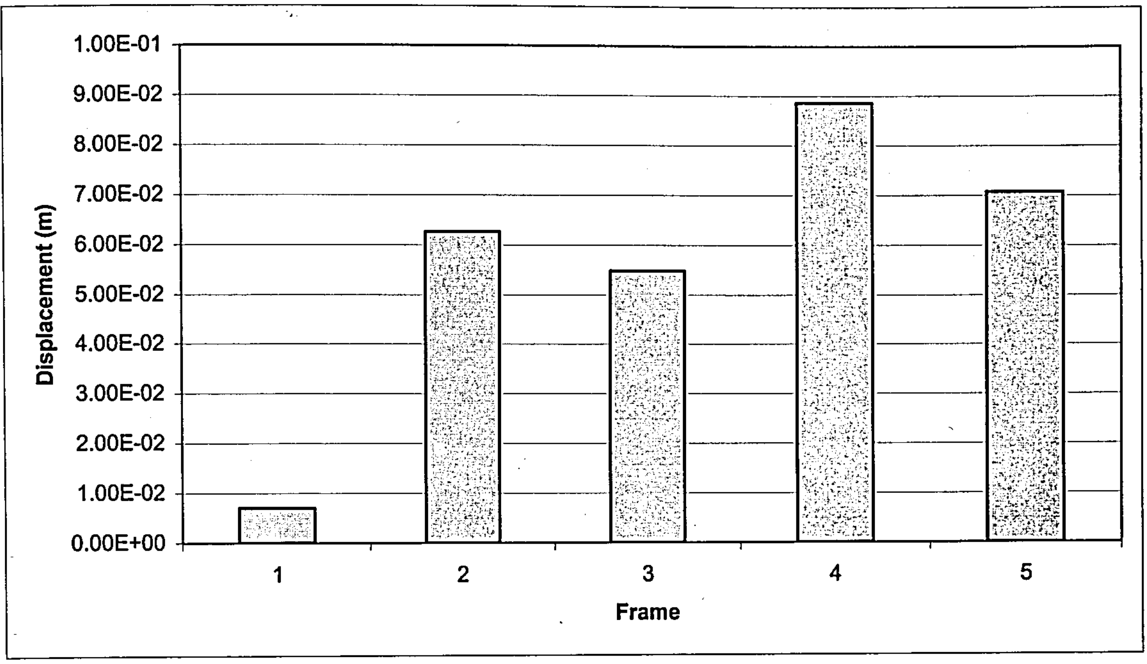

Figure 4.2. Comparison of maximum first storey displacements

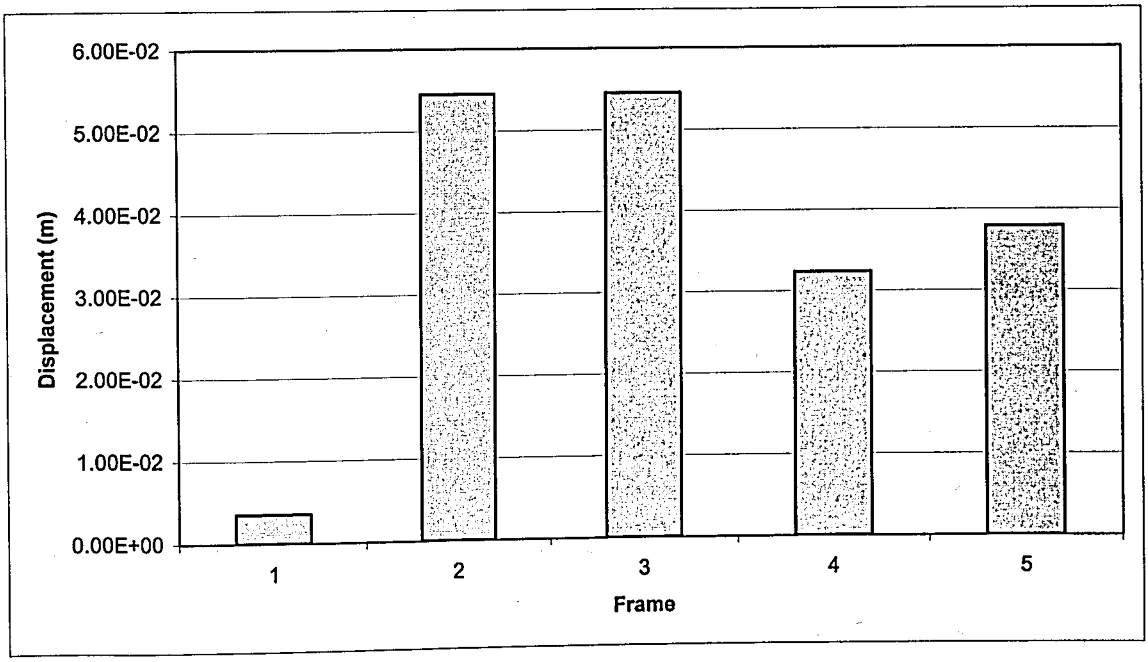

Figure 4.3. Comparison of maximum second storey displacements

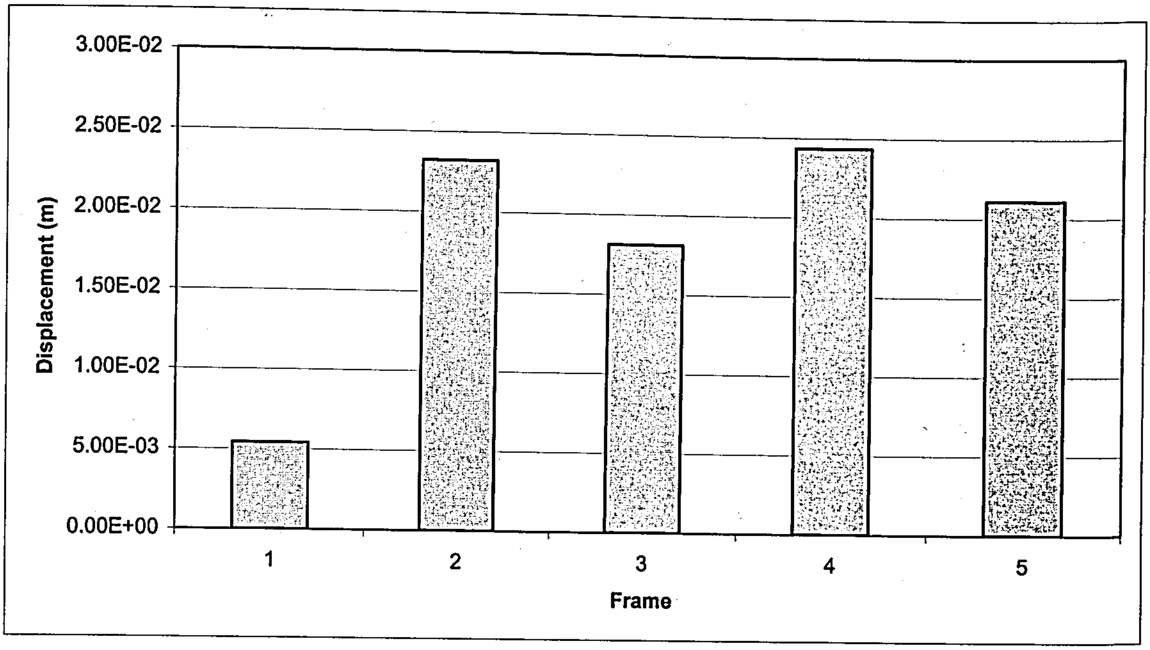

Figure 4.4. Comparison of maximum third storey displacements

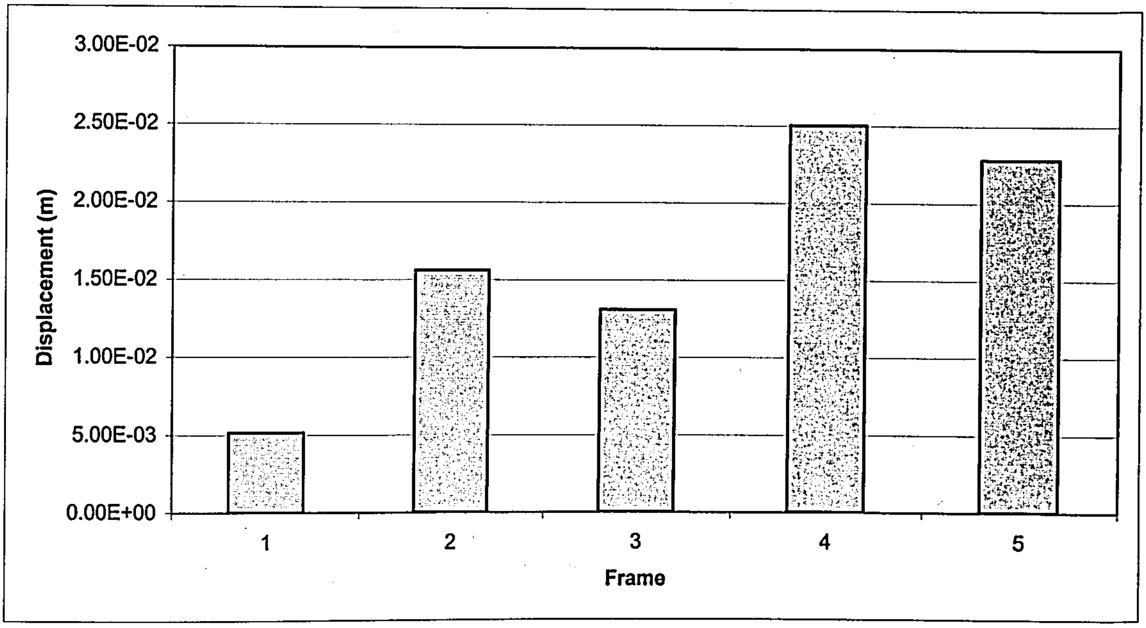

Figure 4.5. Comparison of maximum fourth storey displacements

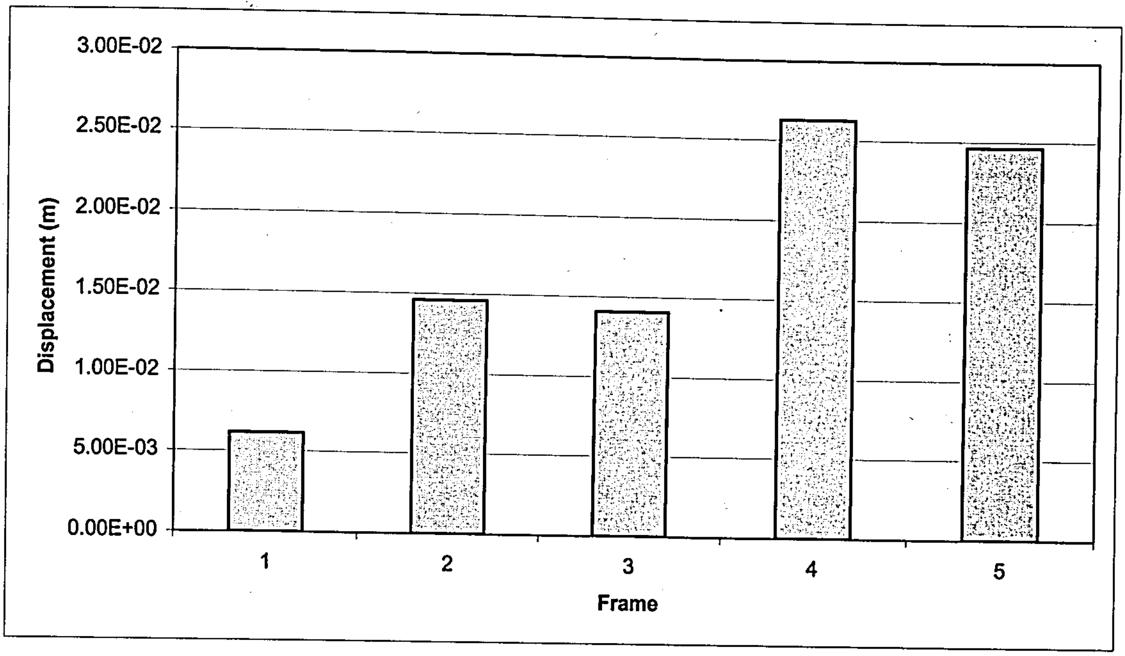

Figure 4.6. Comparison of maximum fifth storey displacements

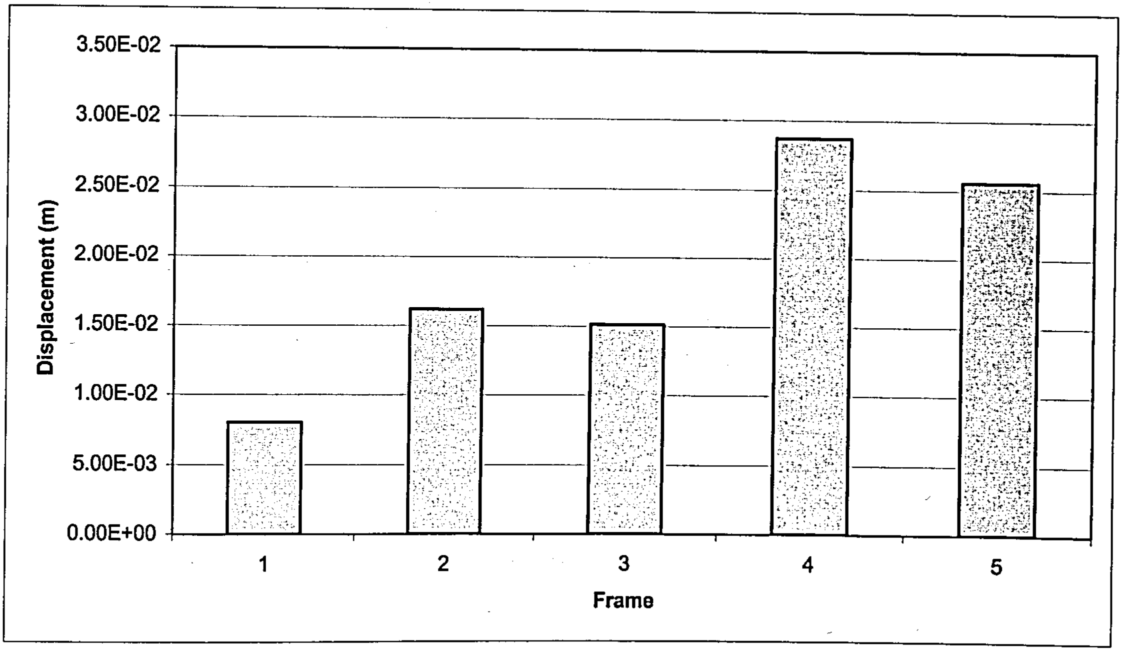

Figure 4.7. Comparison of maximum sixth storey displacements

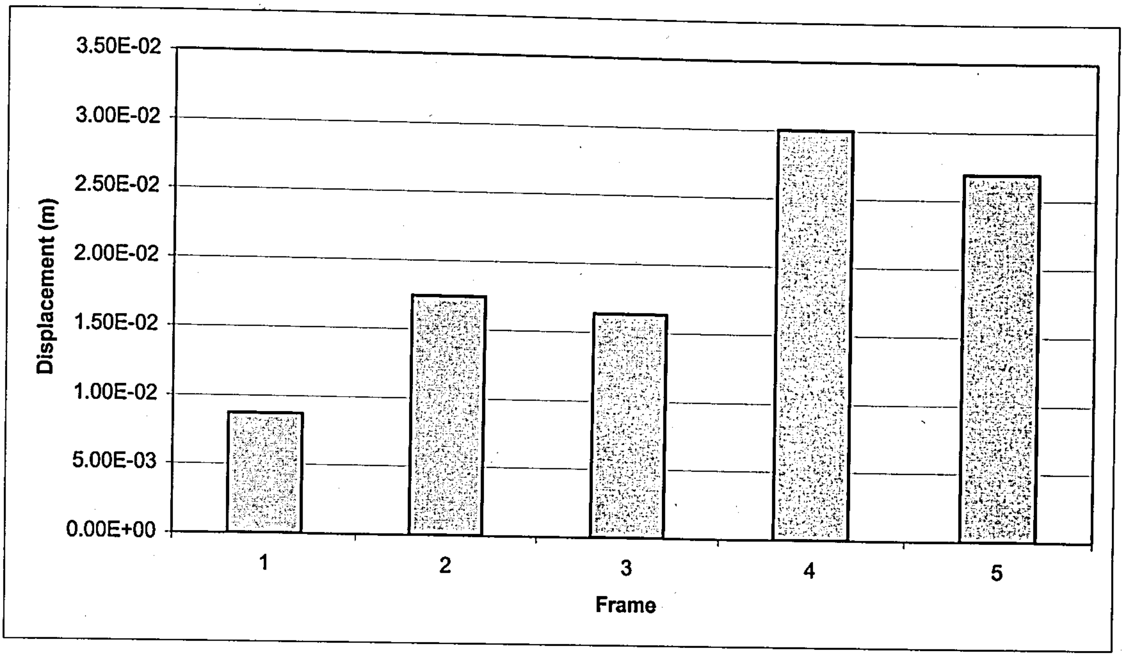

Figure 4.8. Comparison of maximum seventh storey displacements

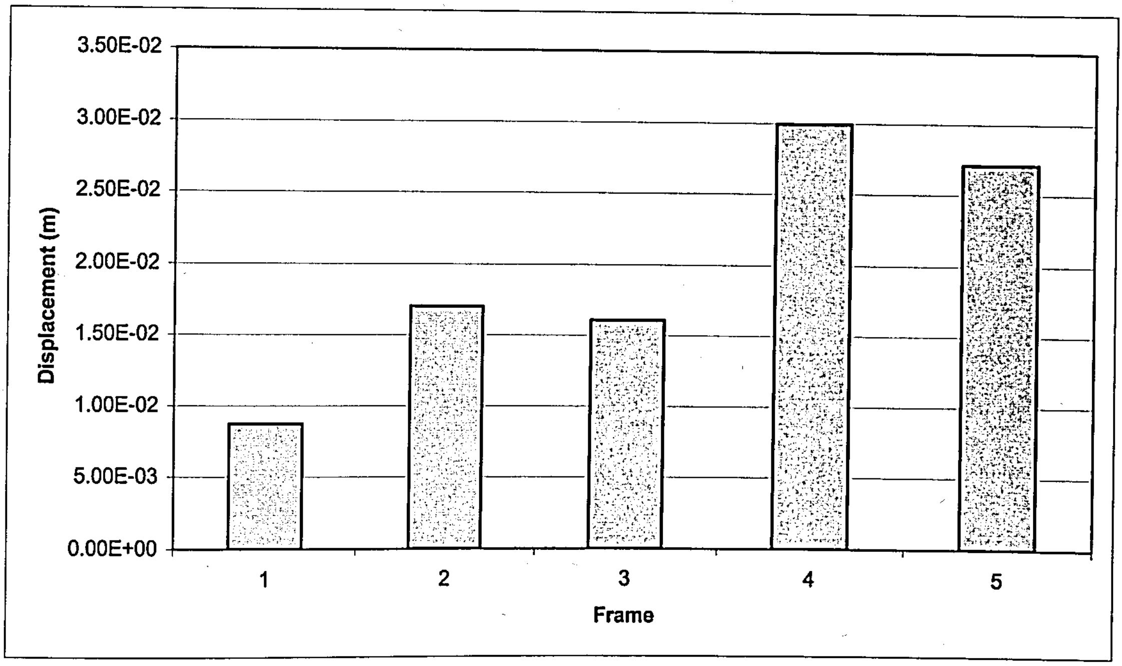

Figure 4.9. Comparison of maximum eighth storey displacements

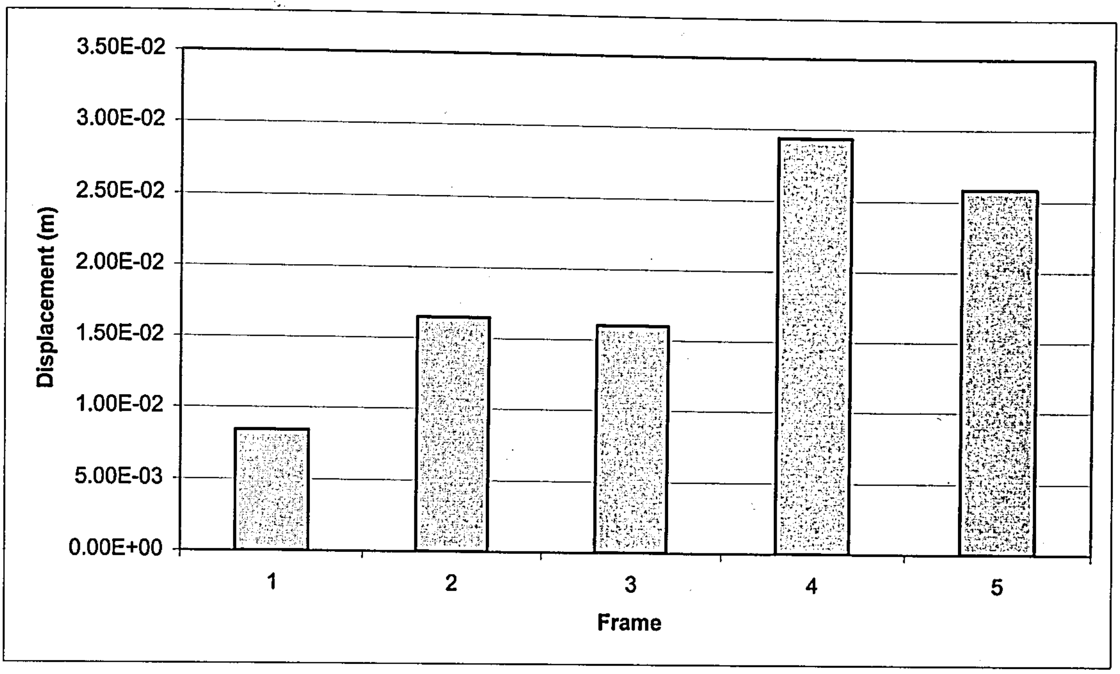

Figure 4.10. Comparison of maximum ninth storey displacements

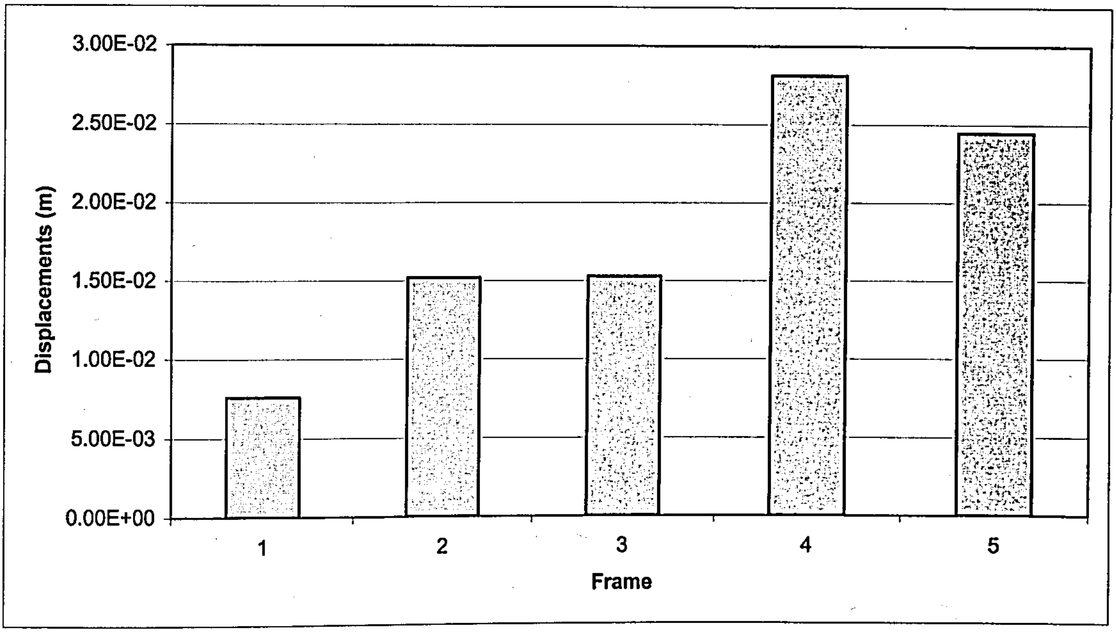

Figure 4.11. Comparison of maximum tenth storey displacements

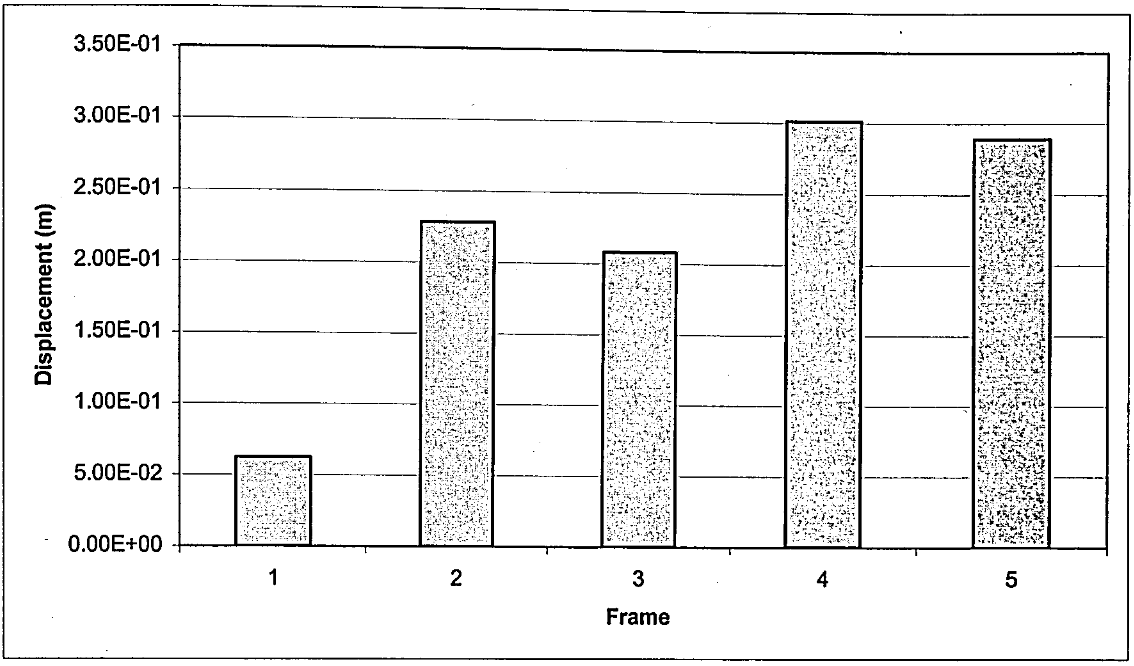

Figure 4.12. Comparison of maximum tip displacements

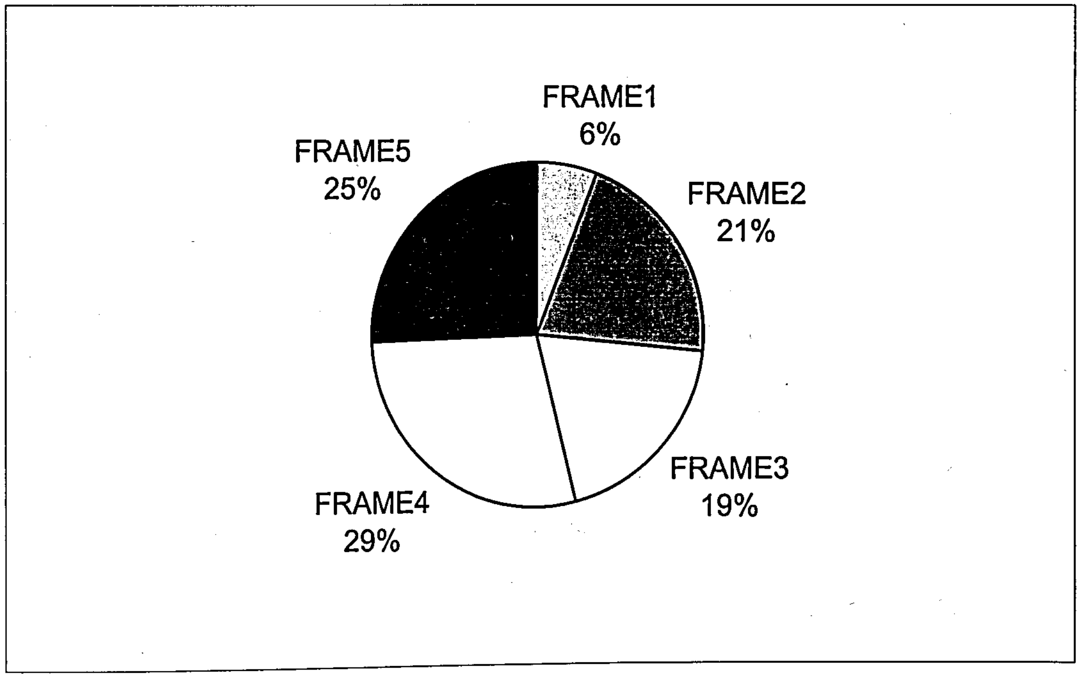

Figure 4.13. Percent sum of the displacements of the frames

4.2. Analysis of Maximum Storey Shears of the Frames

In the following 10 graphs the base shear of the buildings and all storey shears of the five differently configured frames are compared with each other. The considered shear is the maximum of the shears that the building experiences. The results are obtained from the section envelopes of the shear-time history analysis. The values may be both in positive and negative directions, but only positive absolute values are compared. Unlike to the drift analysis, in shear analysis different frames give best results for different storey shears. For the first three storeys no frame gives a clearly optimum result. For the fourth and fifth storeys Frame 5 gives the best results; for the sixth storey Frame 3, for the seventh and eighth storeys Frame 4 and for the ninth and tenth stories Frame 1 gives optimum results.

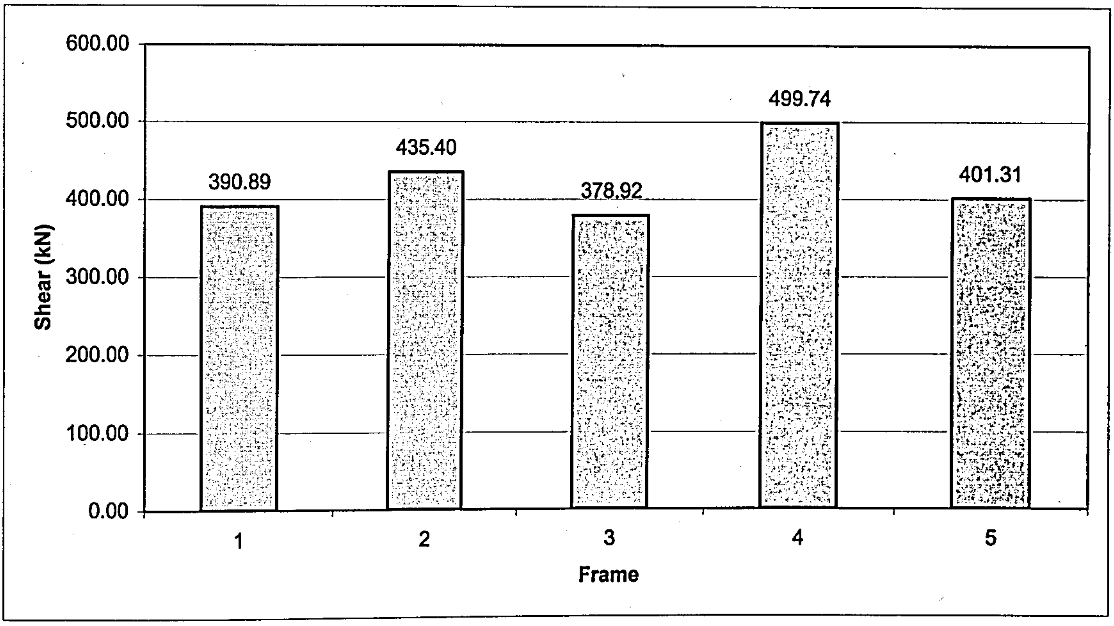

Figure 4.14. Comparison of maximum first storey shears

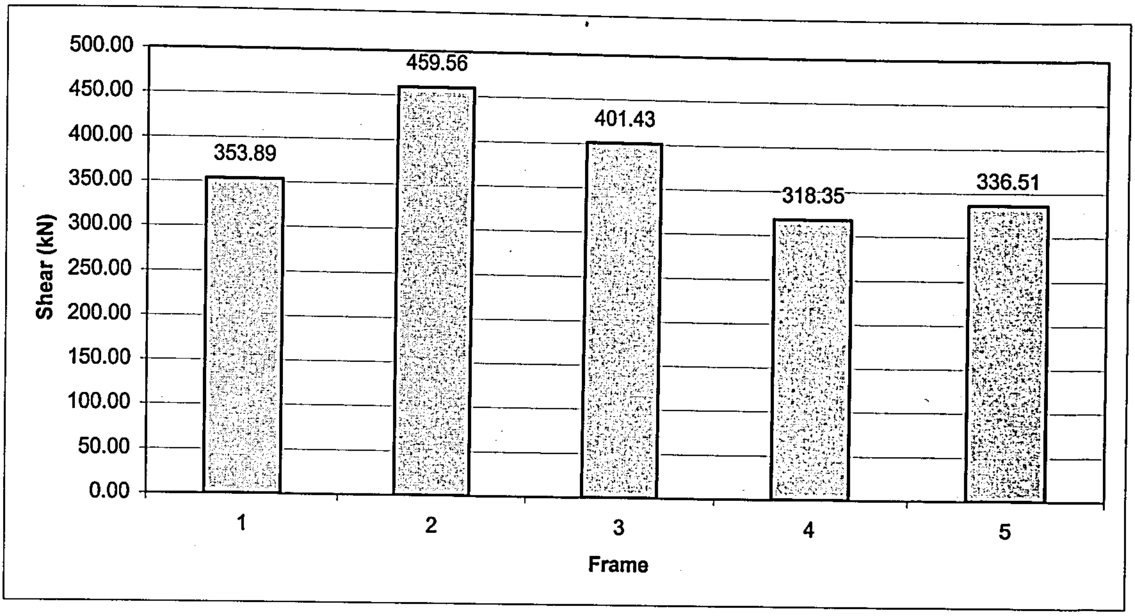

Figure 4.15. Comparison of maximum second storey shears

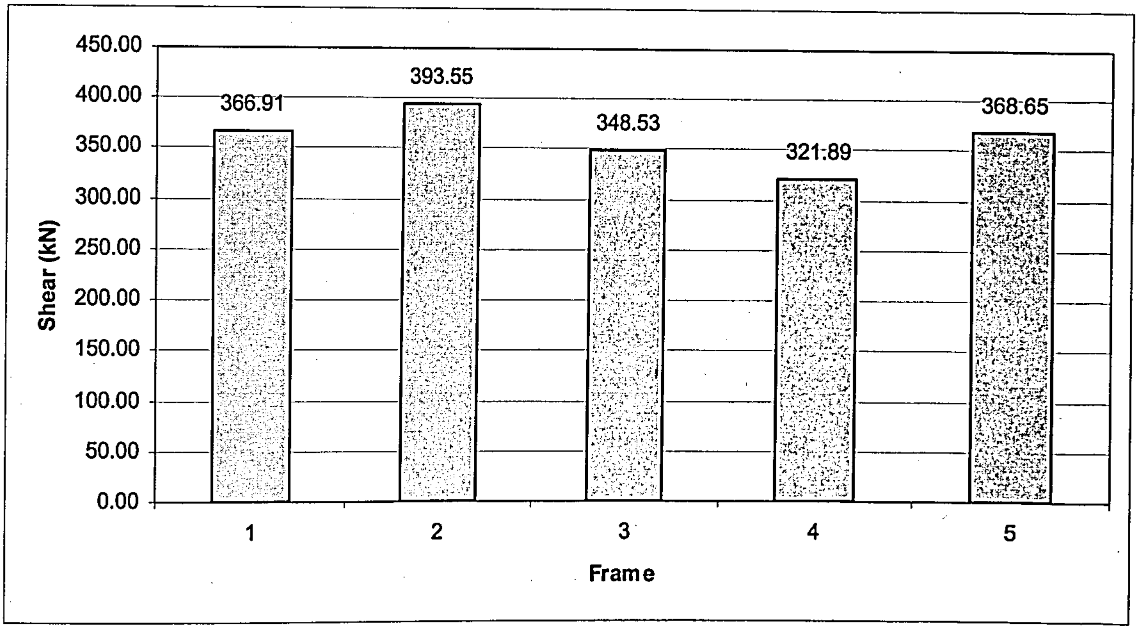

Figure 4.16. Comparison of maximum third storey shears

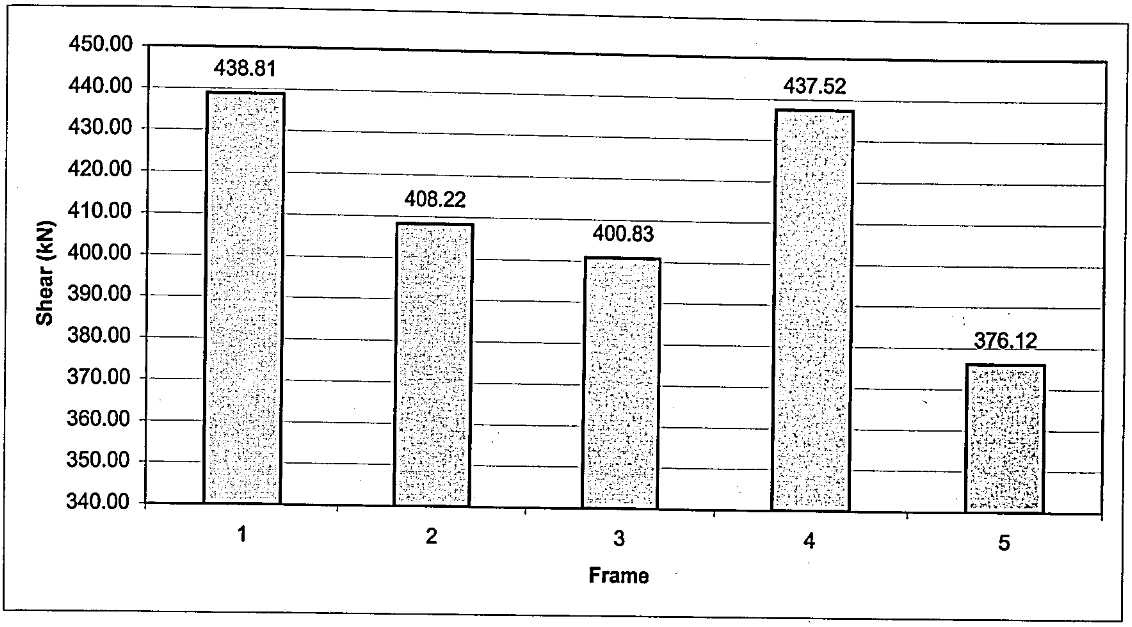

Figure 4.17. Comparison of maximum fourth storey shears

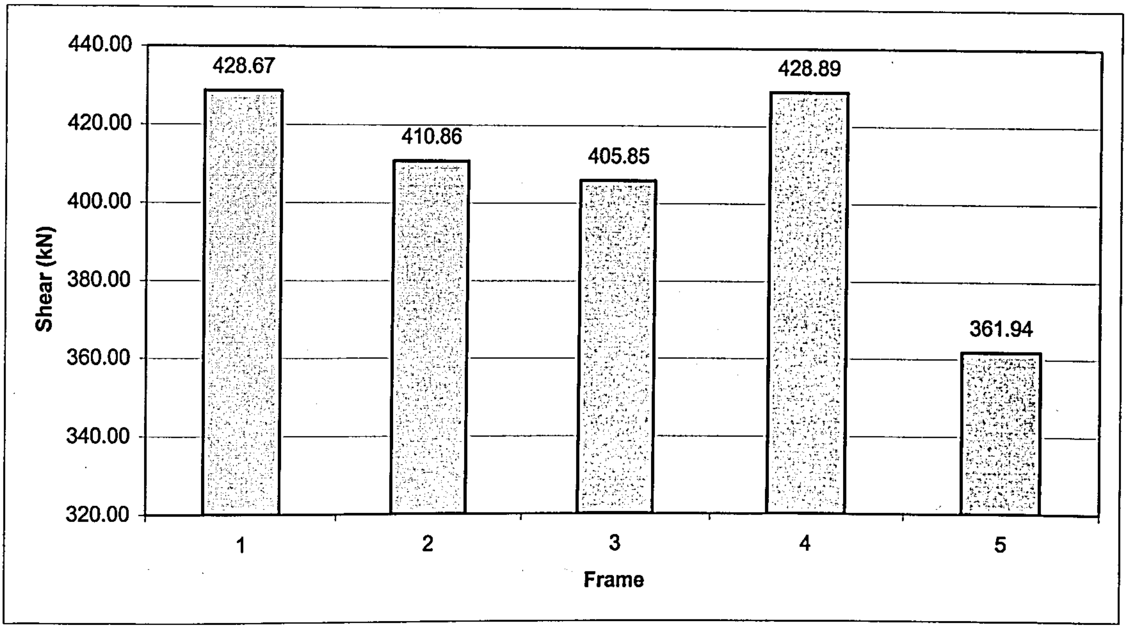

Figure 4.18. Comparison of maximum fifth storey shears

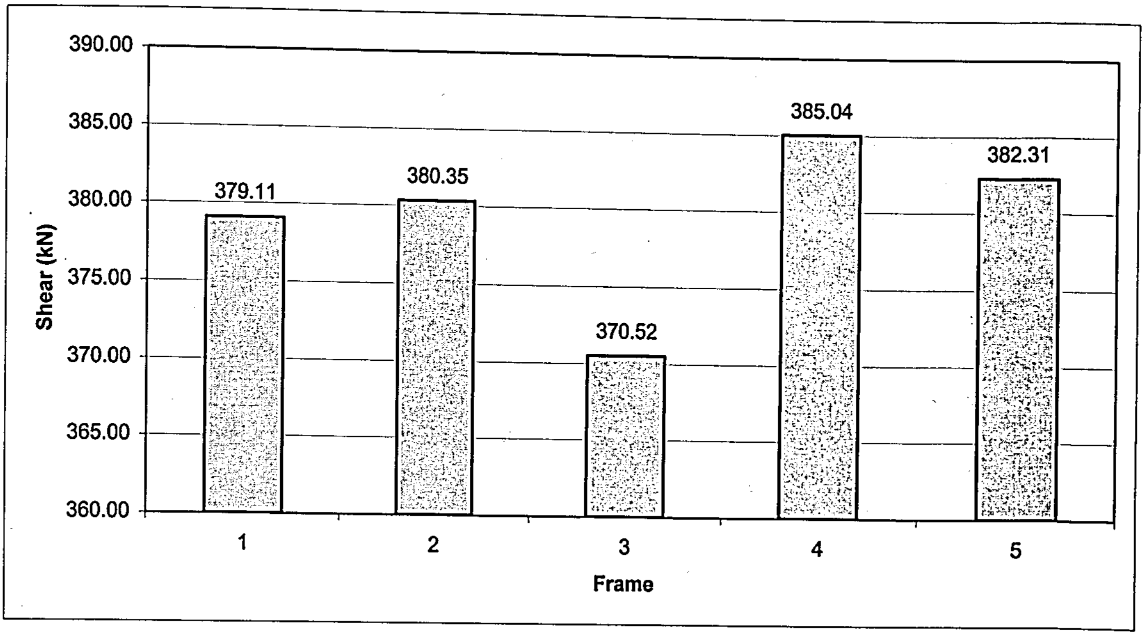

Figure 4.19. Comparison of maximum sixth storey shears

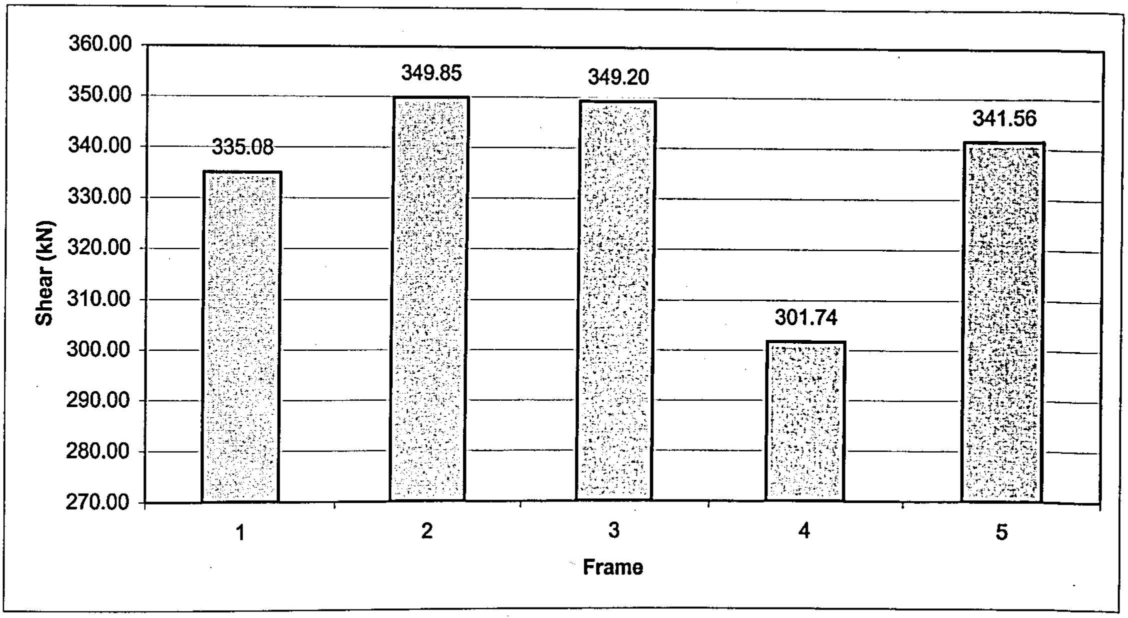

Figure 4.20. Comparison of maximum seventh storey shears

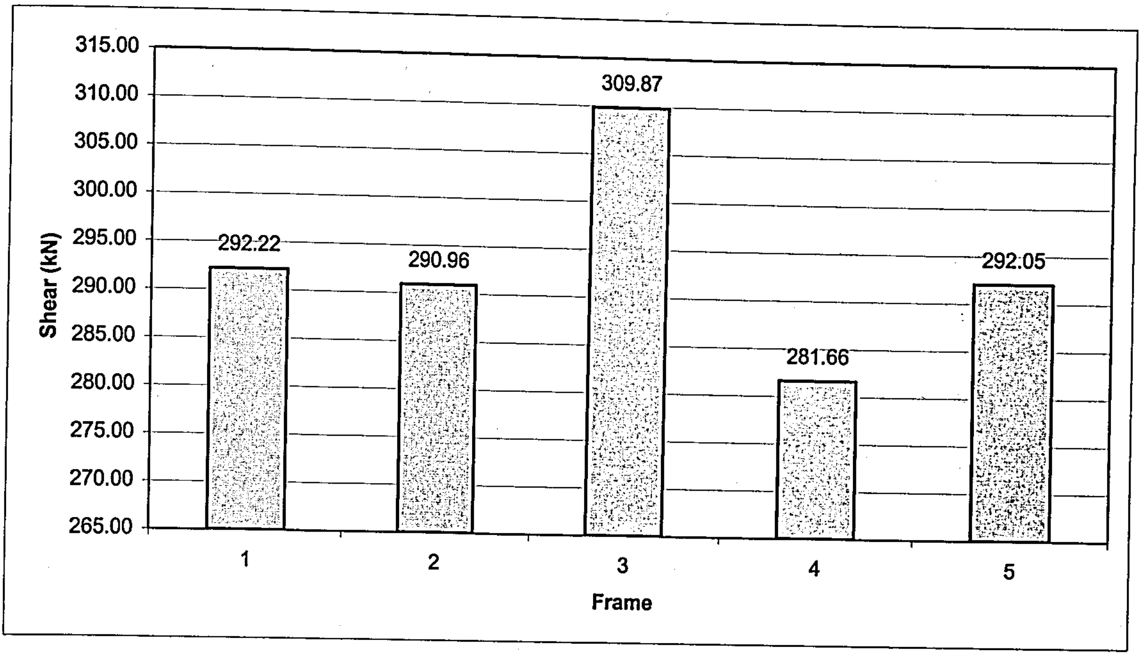

Figure 4.21. Comparison of maximum eighth storey shears

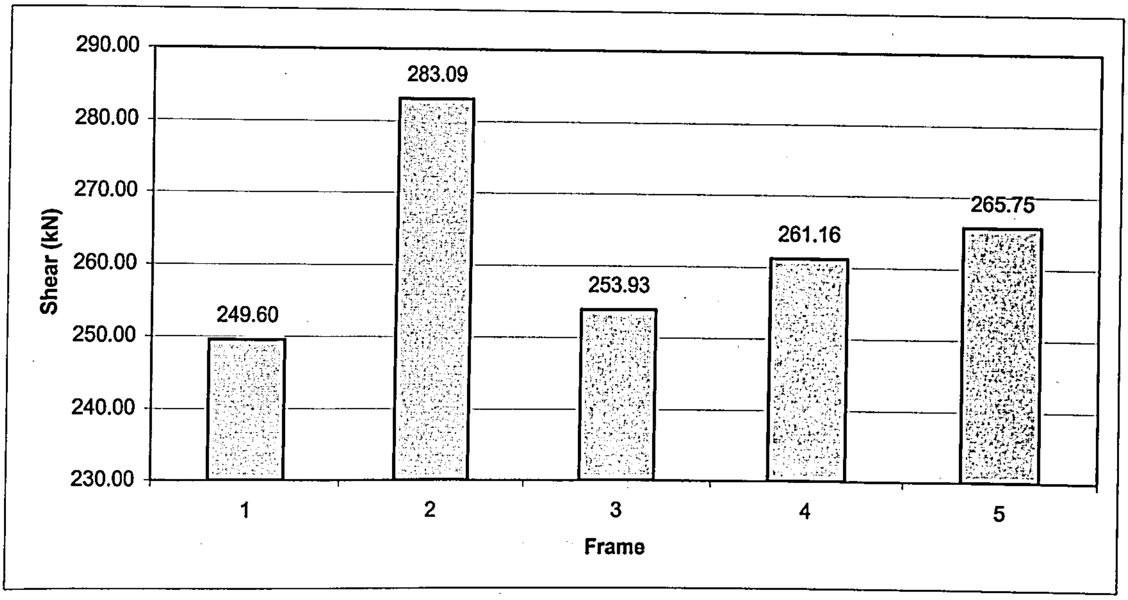

Figure 4.22. Comparison of maximum ninth storey shears

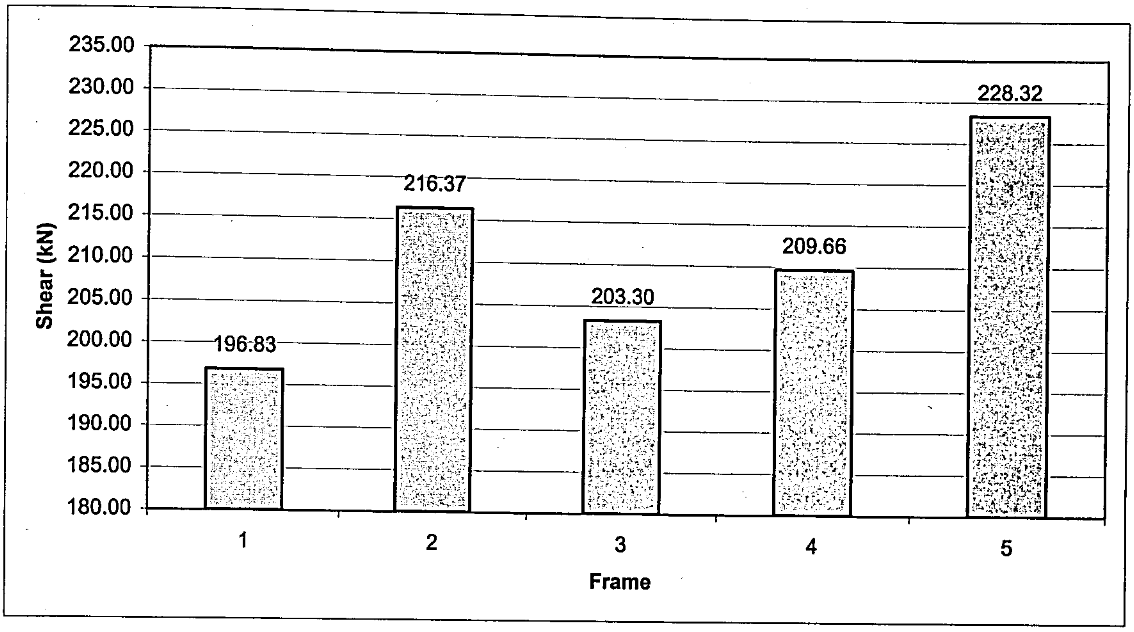

Figure 4.23. Comparison of maximum tenth storey shears

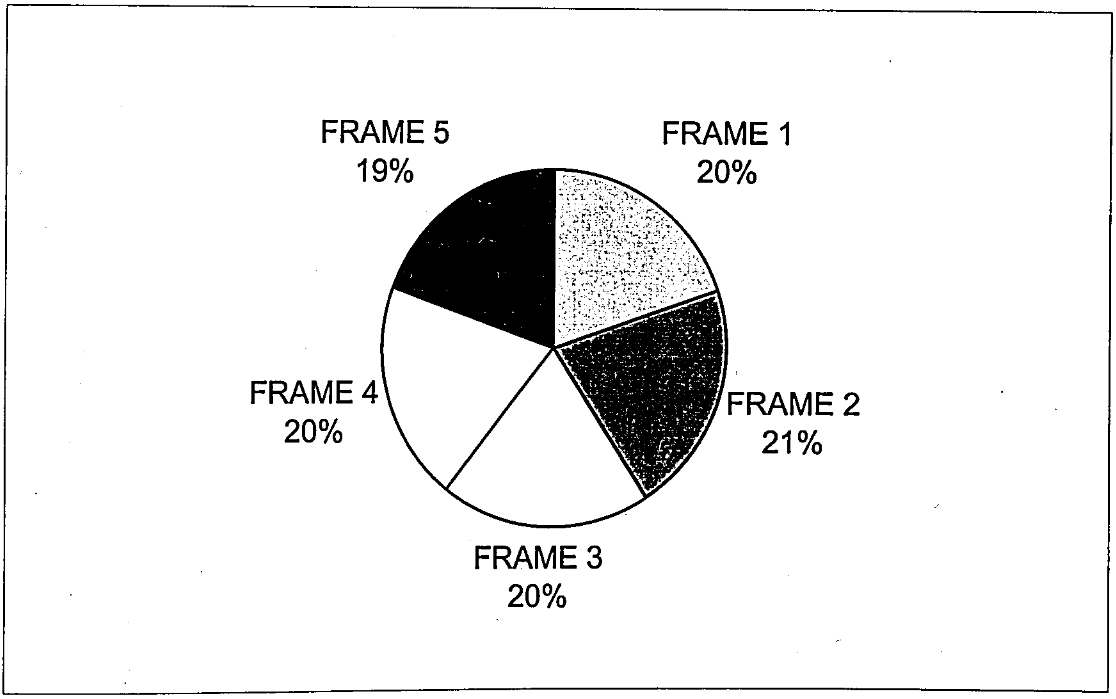

Figure 4.24. Percent sum of the maximum storey shears of the frames

4.3. Analysis of Mean Maximum Bending Moments of the Columns

In this section mean maximum moments of the columns of the frames are compared. The moments of five columns are added and divided by five. The considered moments may not exist at the same time step of the earthquake, but they are the maximum values obtained during the time history analysis.

From the results of the analysis a single frame type does not seem to give optimum solution to the columns having high internal moments. Vertically differently configured systems may give more safe solutions.

For the first storeys Frame 5, for the second and eighth storeys Frame 4, for the third, fifth and ninth storeys Frame 1, for the fourth storeys Frame 2, for the sixth, seventh and tenth storeys Frame 3, gives optimum solutions.

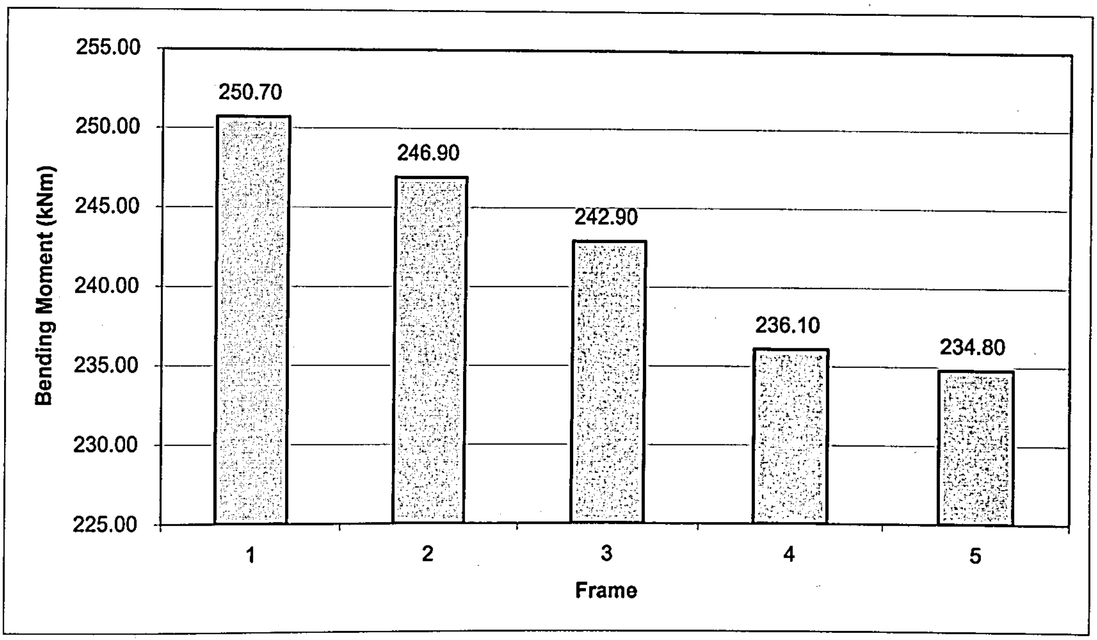

Figure 4.25. Comparison of mean maximum moments of the columns of the first storeys

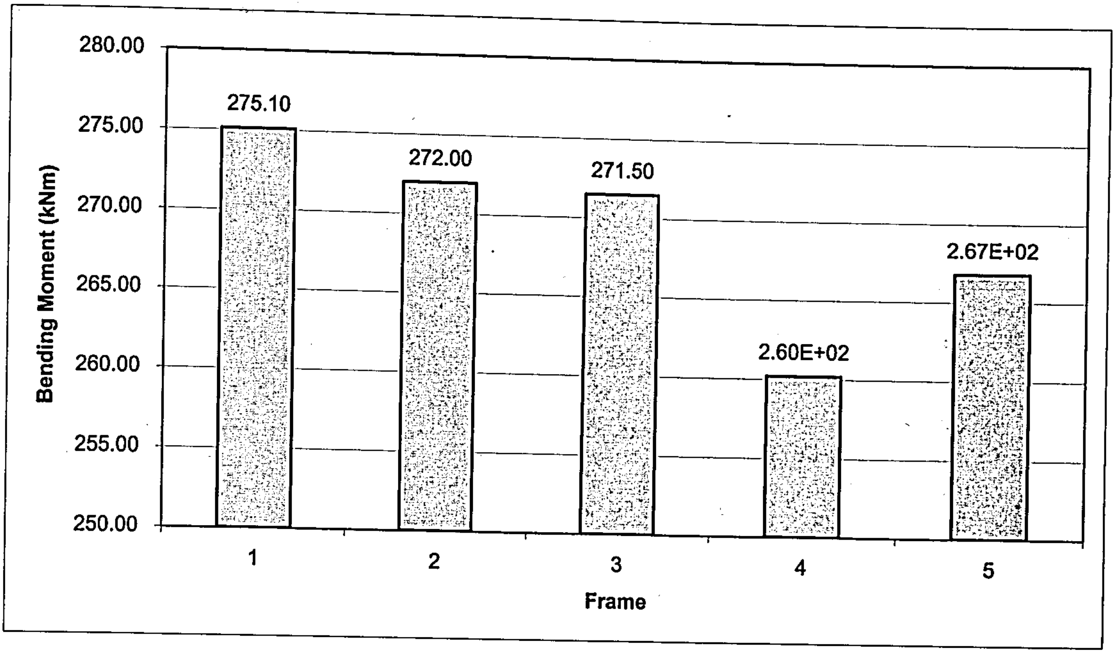

Figure 4.26. Comparison of mean maximum moments of the columns of the second storeys

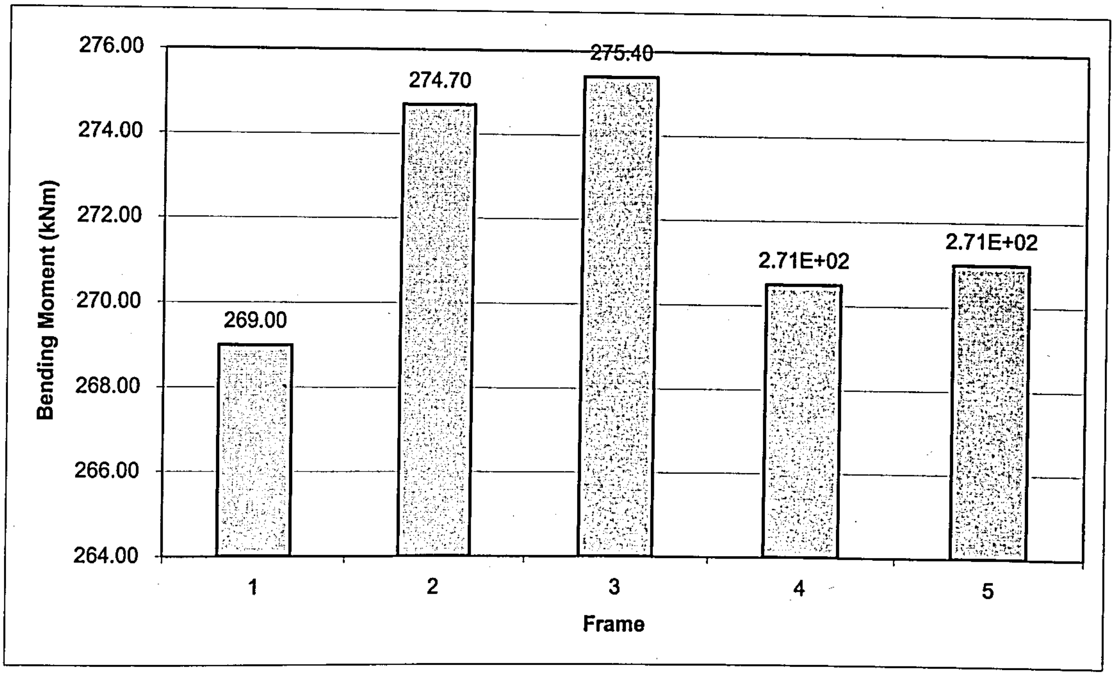

Figure 4.27. Comparison of mean maximum moments of the columns of the third storeys

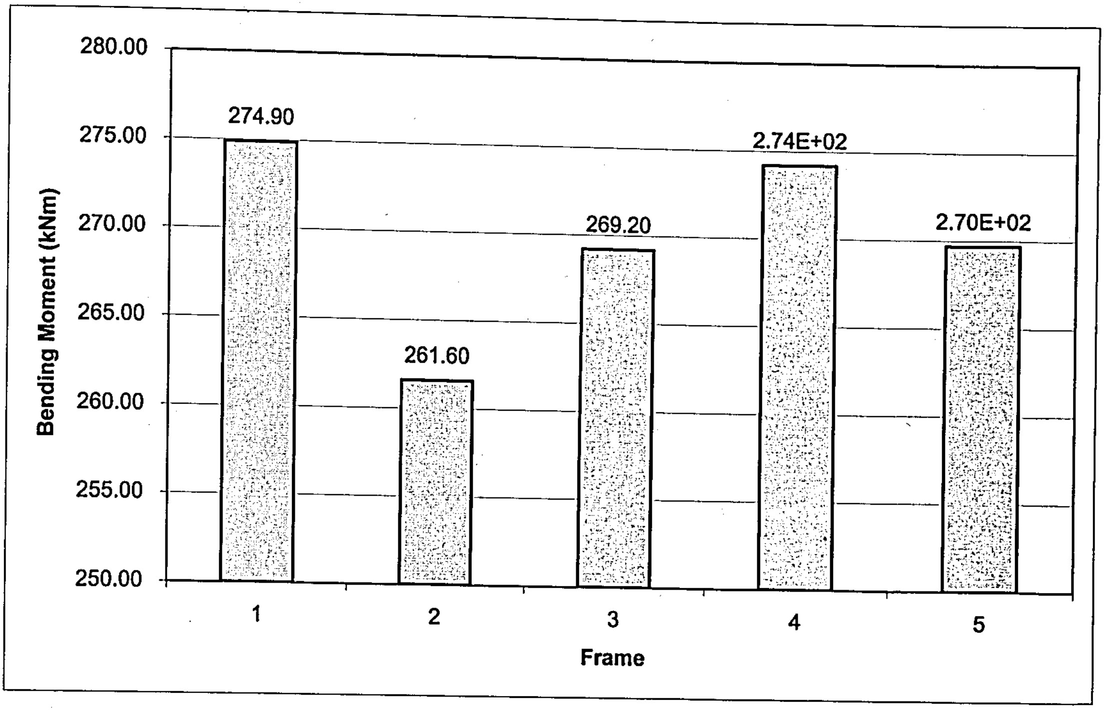

Figure 4.28. Comparison of mean maximum moments of the columns of the fourth storeys

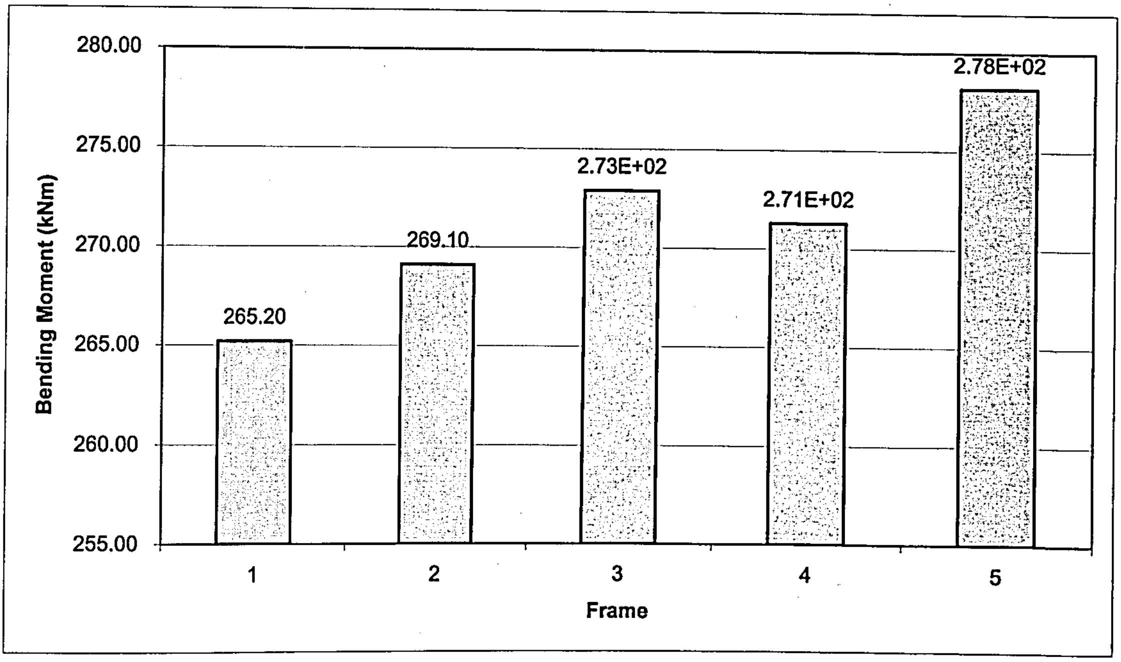

Figure 4.29. Comparison of mean maximum moments of the columns of the fifth storeys

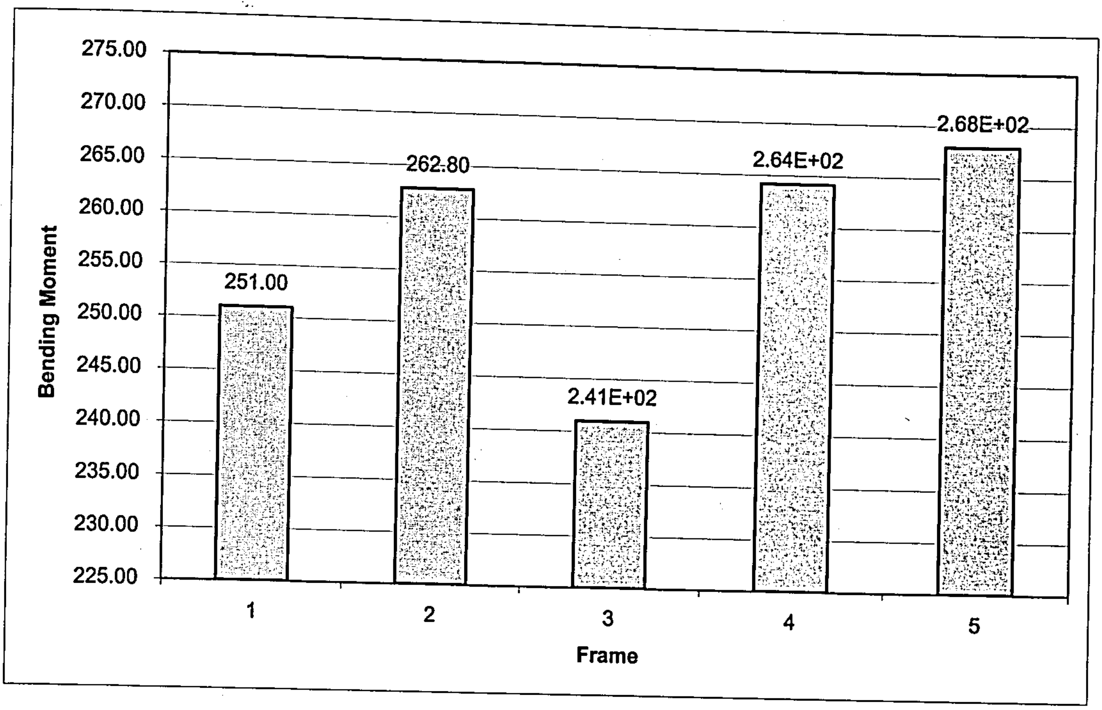

Figure 4.30. Comparison of mean maximum moments of the columns of the sixth storeys

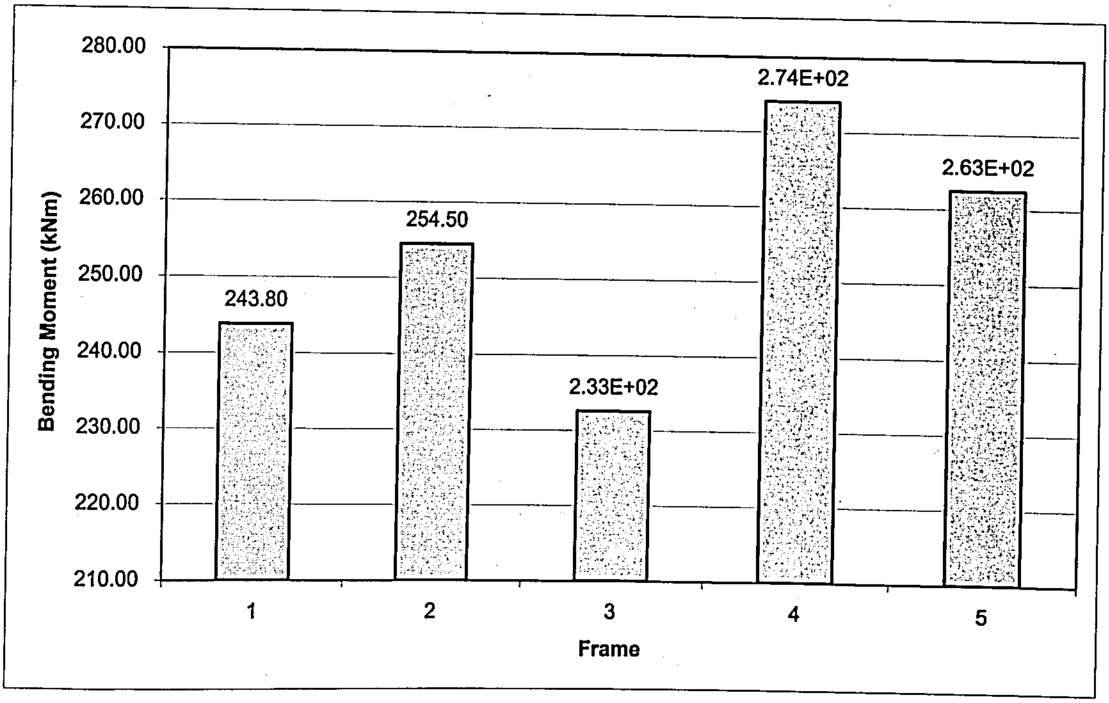

Figure 4.31. Comparison of mean maximum moments of the columns of the seventh storeys

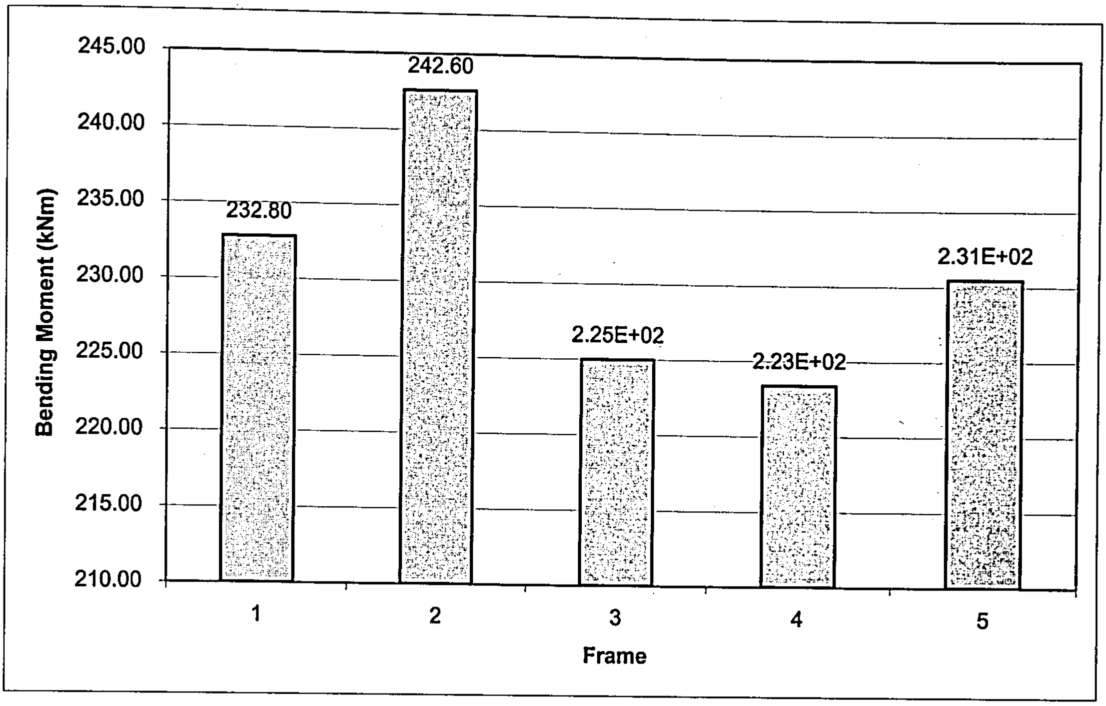

Figure 4.32. Comparison of mean maximum moments of the columns of the eighth storeys

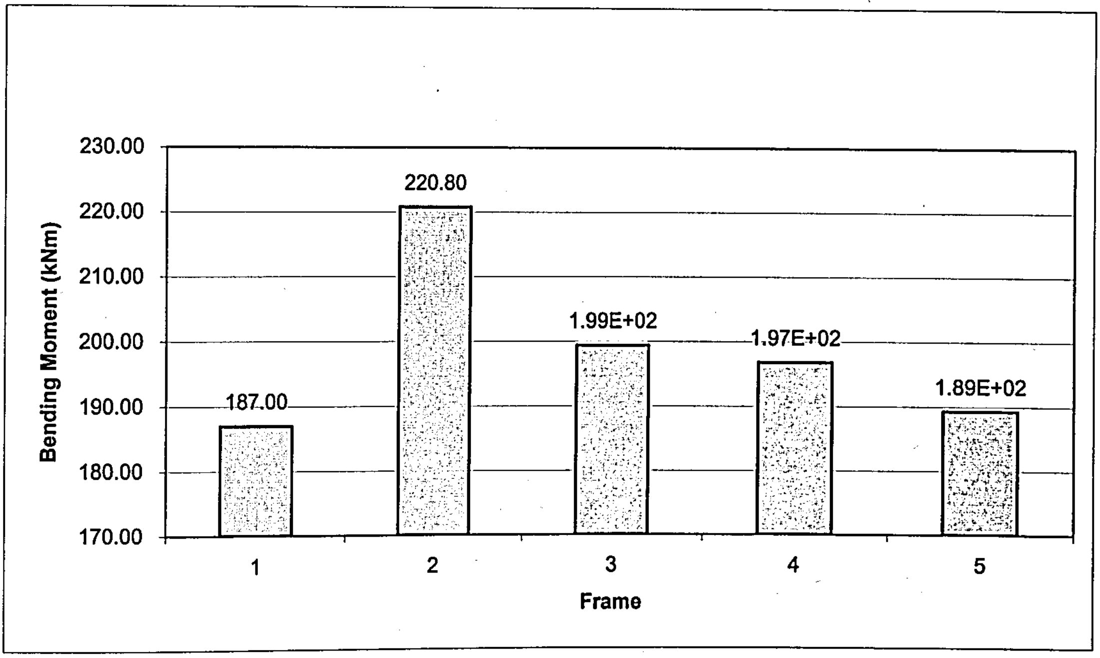

Figure 4.33. Comparison of mean maximum moments of the columns of the ninth storeys

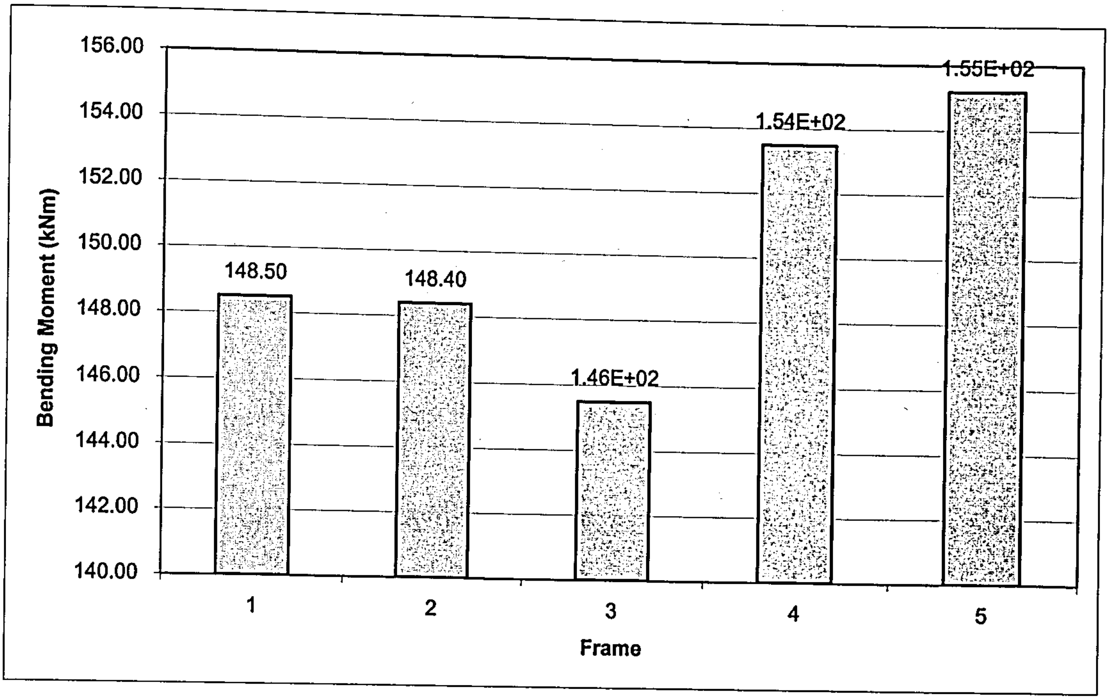

Figure 4.34. Comparison of mean maximum moments of the columns of the tenth storeys

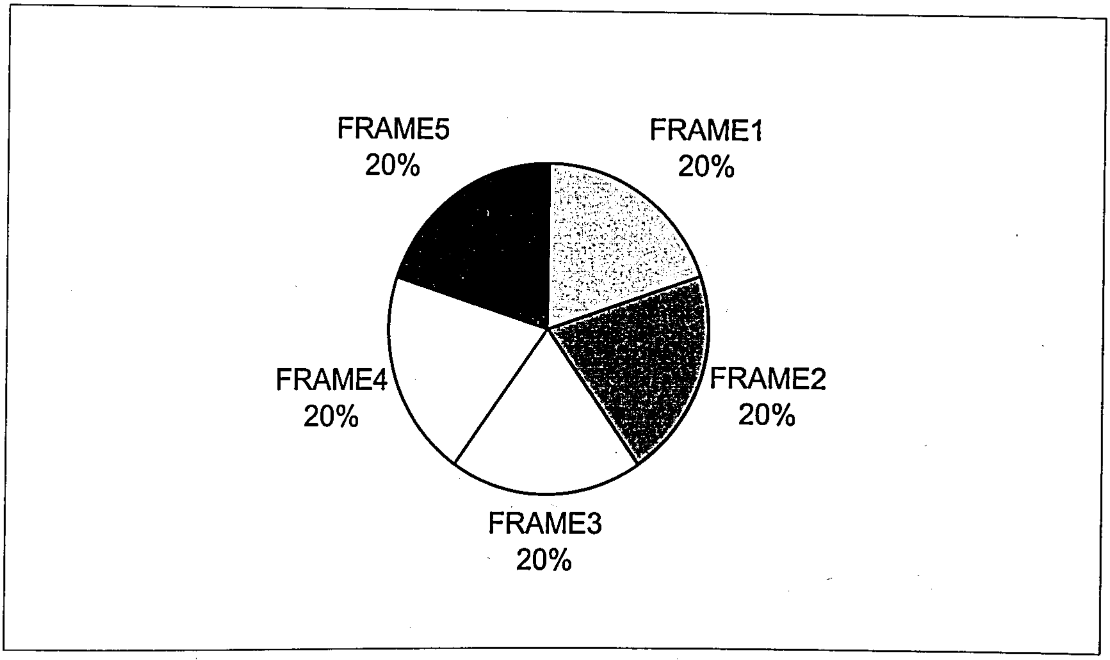

Figure 4.35. Percent sum of the maximum bending moments of columns of frames

4.4. Analysis of Axial Force versus Displacement History of the Braces of Frame 1

In this part of the study the seismic response of braces is emphasized in vertical direction. In all of the frames braces are designed in a way that their configuration is vertically the same. By monitoring the axial force-displacement history of the braces it will be easier to see whether it is necessary to design unchanging vertical distribution or not. Looking at the graphs it is seen that it is not a must, because at the upper storeys the braces even do not reach the yielding level.

The bilinear hysteretic behavior of the diagonals of Frame 1 corresponding to all storeys subjected to the Duzce earthquake accelerogram, are presented in the following 10 figures. The graph does not represent all the braces of a storey, but only a single brace. Braces of the first three storeys pass to the plastic level, while the upper ones remain in the elastic range. The area enclosed by the hysteretic loops directly refers to the energy absorbed by the brace because of the plastic behavior. The area over the 0 force level is much more greater than the area below 0 level, which results from the buckling property of the brace model. During compression the model does not yield, it buckles. By these graphs it is clearly seen that the braces of lower storeys works more than the upper ones. In this frame the braces of the upper 7 storeys do not yield.

Only structures with energy dissipating devices along the full height are studied in this thesis; however, arrangements including dissipators distributed only in the lower part of the buildings may be an acceptable structural solution for the type of the frames covered in this study [10]. But in the high vibration modes the response may change [11].

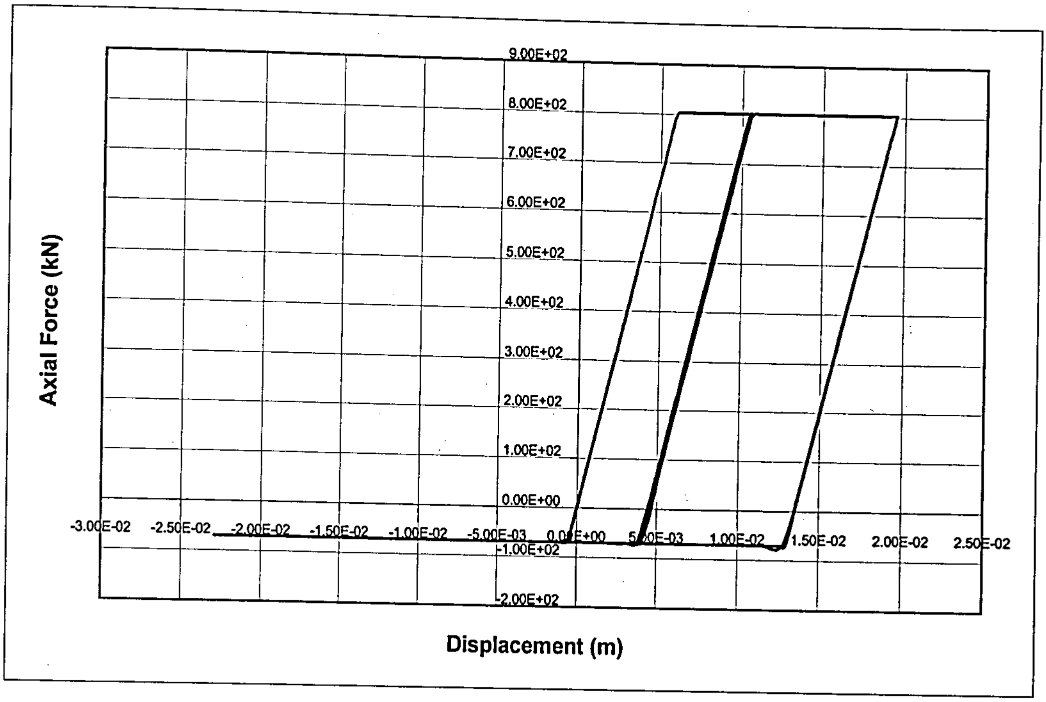

Figure 4.36. Bilinear behavior of the braces of the first storey

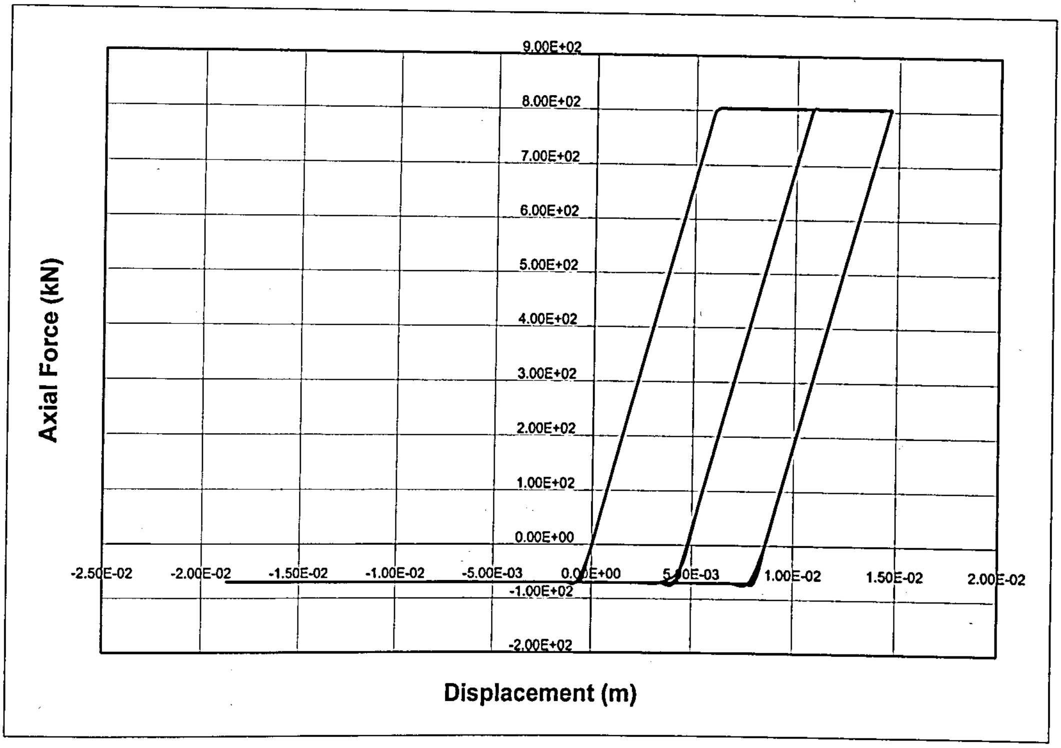

Figure 4.37. Bilinear behavior of the braces of the second storey

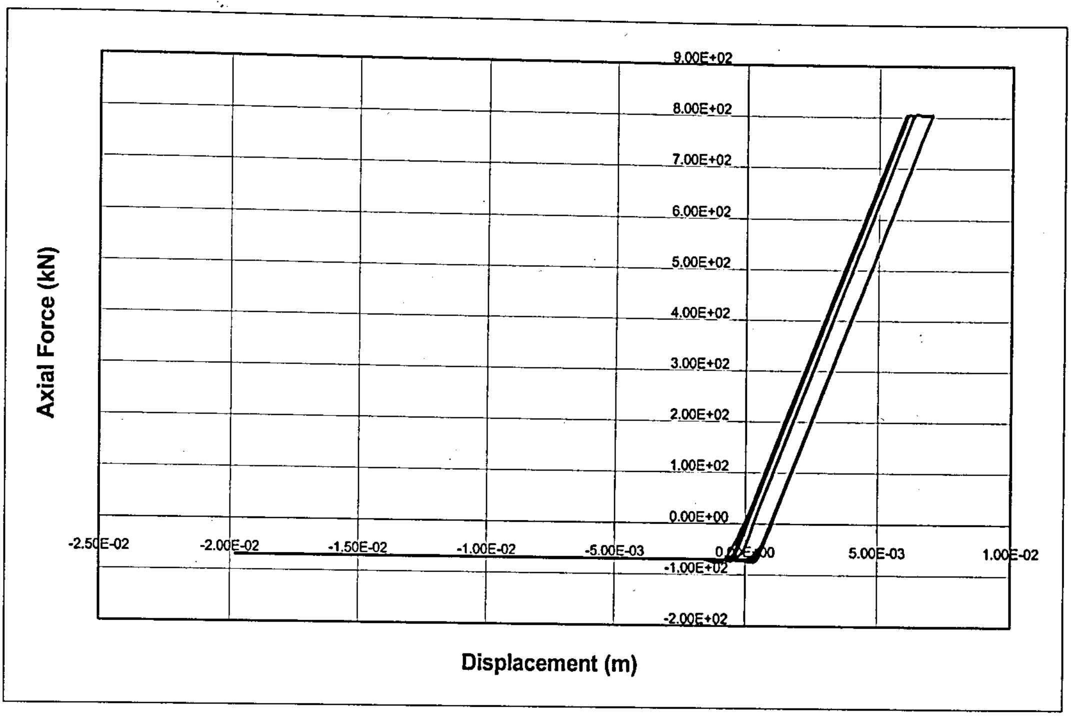

Figure 4.38. Bilinear behavior of the braces of the third storey

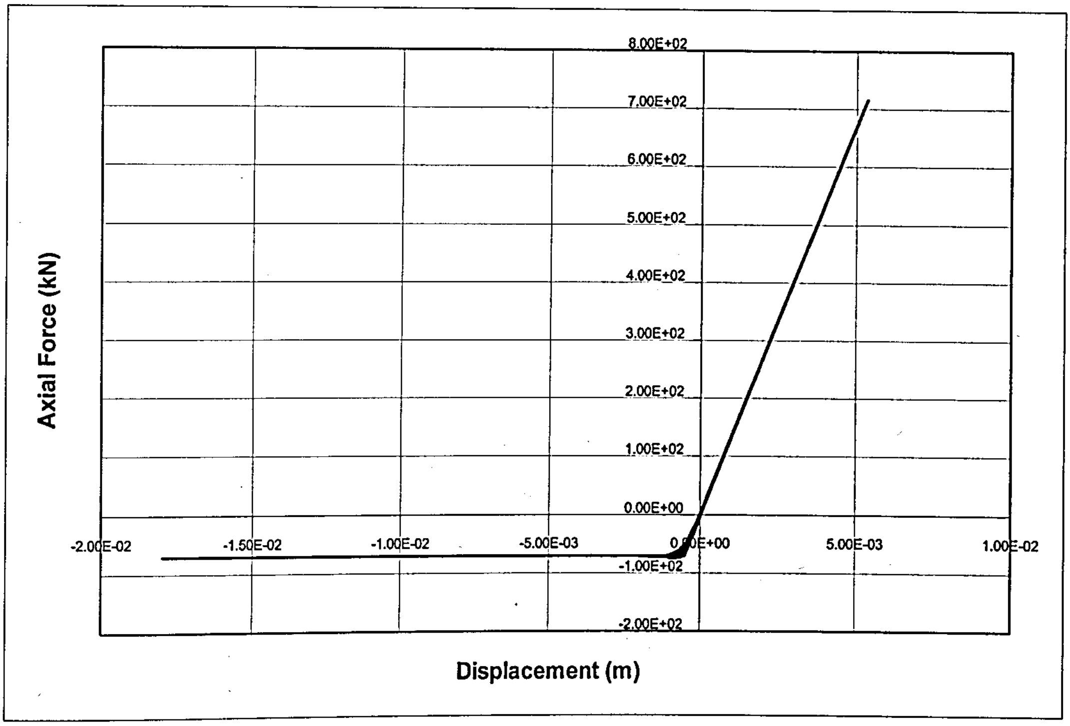

Figure 4.39. Bilinear behavior of the braces of the fourth storey

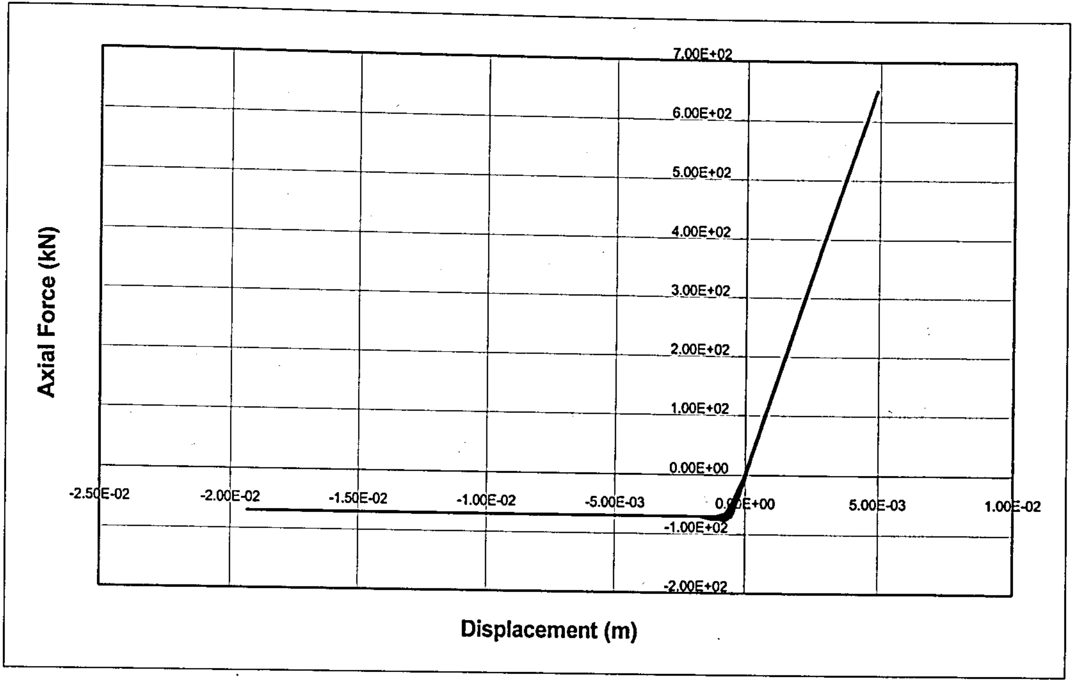

Figure 4.40. Bilinear behavior of the braces of the fifth storey

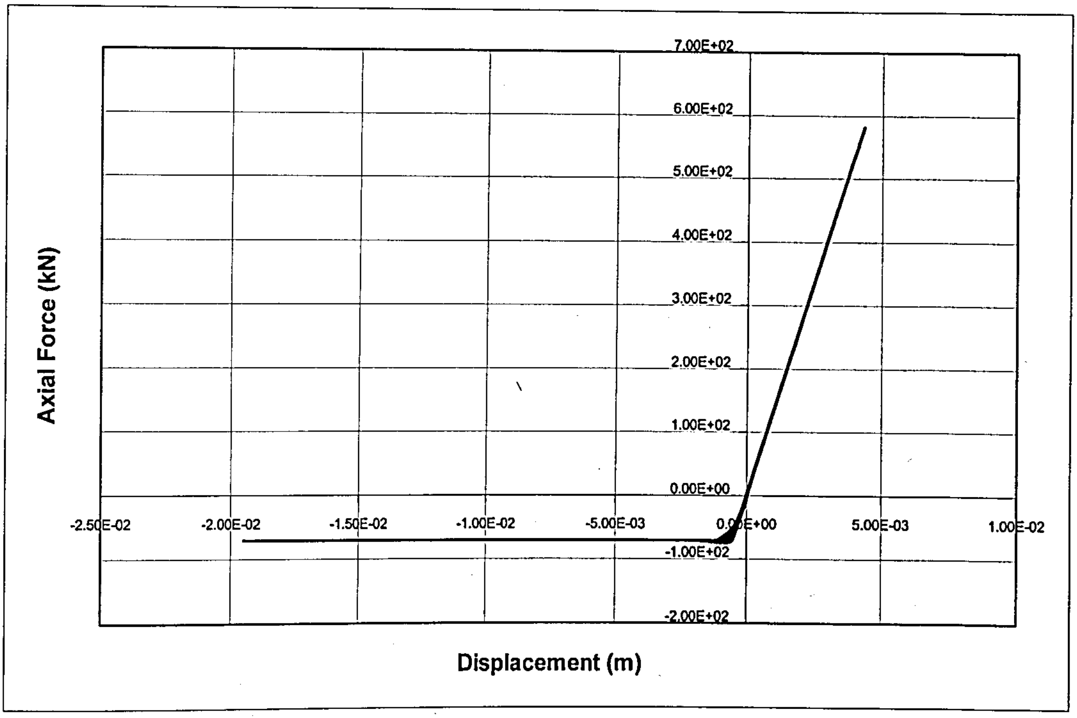

Figure 4.41. Bilinear behavior of the braces of the sixth storey

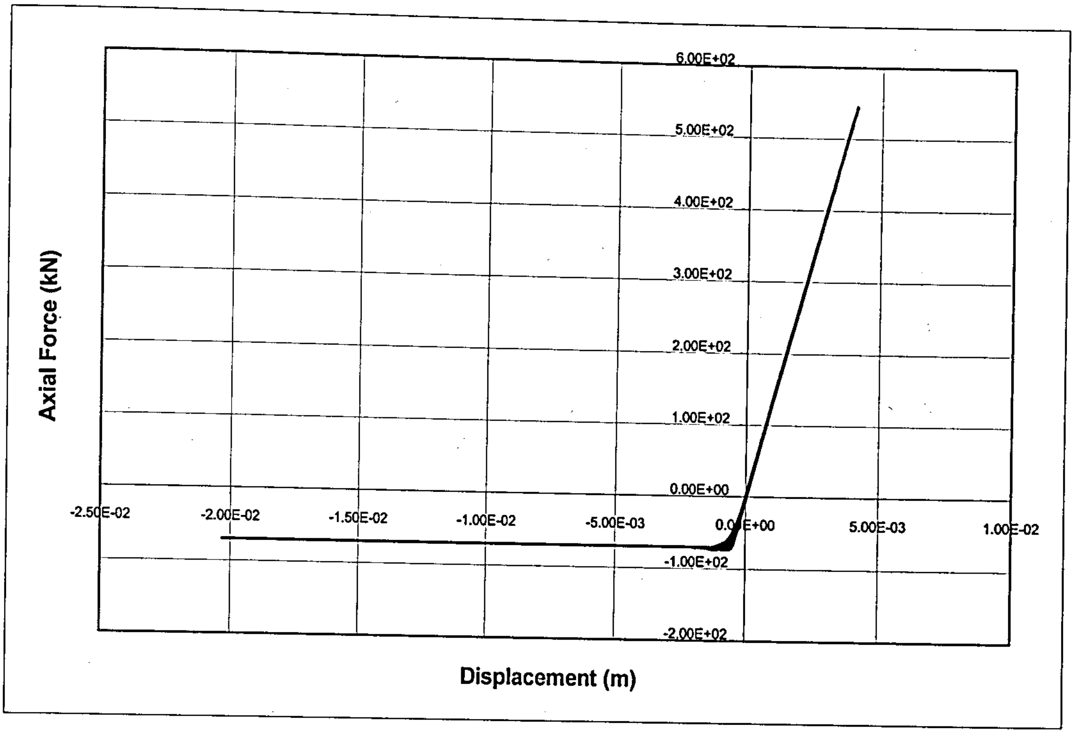

Figure 4.42. Bilinear behavior of the braces of the seventh storey

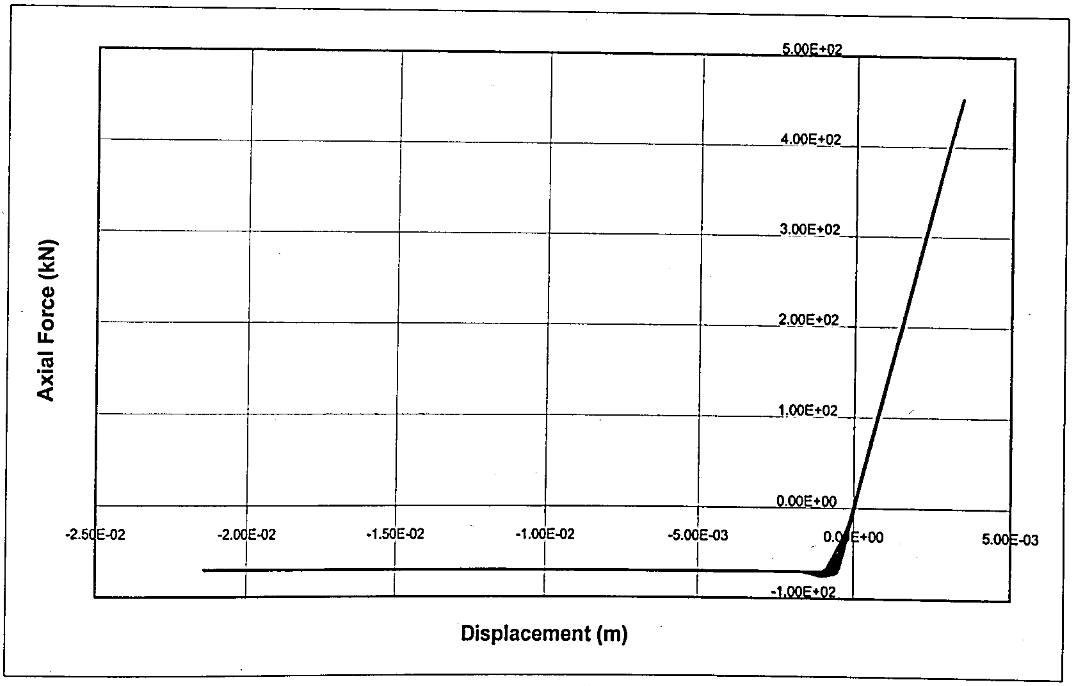

Figure 4.43. Bilinear behavior of the braces of the eighth storey

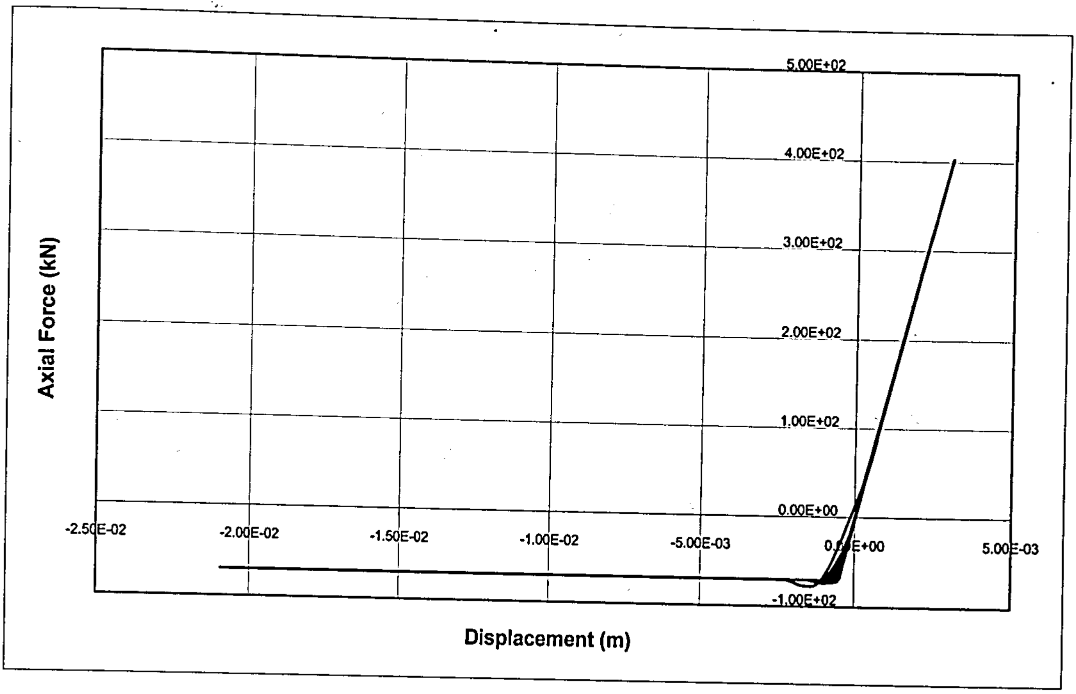

Figure 4.44. Bilinear behavior of the braces of the ninth storey

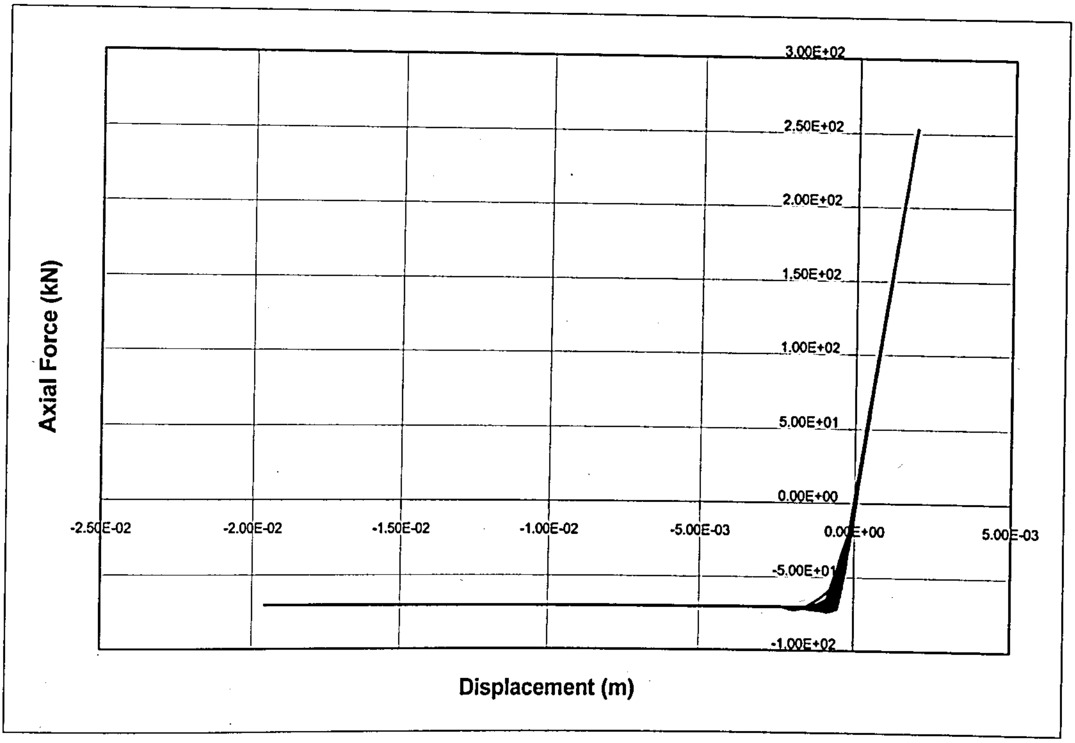

Figure 4.45. Bilinear behavior of the braces of the tenth storey

5. CONCLUSIONS

From the results of the analysis done in this study the following results may be obtained.

- Properly designed energy dissipating devices can control the seismic response of the frames.

- A single type of design does not give better results for controlling every type of structural deficiencies.

- For drift control the better performing frame was the one with bracing-dissipator distribution over the full frame width (Frame 1). Less satisfactory performance was shown by Frame 4, which is braced only in outer bays.

- For shear control; different types of bracing systems performed better for different storeys, but considering the average Frame 5 gave better results. Frame 2 was the worst working system. Frame 5 performed 8.2 per cent better than Frame 2.

- For control of moments of columns; different types of bracing systems performed better for different storeys. In the average Frame 3 which was braced as a core in the mid bays obtained better results and Frame 2 which has bracings in two bays next to each other on the edge of the frame obtained the worst results. Performance of Frame 3 is 3.3 per cent better than Frame 2.

- Starting from the bottom storey the energy absorbed by the braces is significantly decreasing at every upper storey. Therefore vertically full height distribution of energy dissipating devices is not a must. Acceptable structural solutions may be obtained by arranging the dissipators only in the lower storeys.

APPENDIX A: DRAIN-2DX INPUT FILE OF FRAME 1

```
!---PROGRAM BY SEYIT CERIBASI, BU CIVIL ENGINEERING DEPARTMENT---!
!---10 STOREY-WITH STEEL BRACINGS---!
!---WITH P-DELTA EFFECT---!
*STARTXX
!234567890123456789012345678901234567890123456789012345678901234567890
  brace1           0 1 1 1              BRACED FRAME-1
*NODECOORDS
!---LEFT COLUMN,FROM BASE
!---MASTER JOINTS:1,2,3,4,5,6,7,8
C        1        8.        3.
C        2        8.        6.
C        3        8.        9.
C        4        8.       12.
C        5        8.       15.
C        6        8.       18.
C        7        8.       21.
C        8        8.       24.
C        9        8.       27.
C       10        8.       30.
!---Other Joints:
C       11        0.        0.
C      111        0.       30.
C      211        4.        0.
C      311        4.       30.
C      411        8.        0.
C      511        8.       30.
C      611       12.        0.
C      711       12.       30.
C      811       16.        0.
C      911       16.       30.
L       11       111         10
L      211       311         10
L      411       511         10
L      611       711         10
L      811       911         10
*RESTRAINTS
!---FIXED BASE---
!---MASTER JOINTS ARE RESTRAINT TO Y DIRECTION AND TO ROTATION---
!234567890123456789012345678901234567890123456789012345678901234567890
S 111        11       811       200
S 011         1        10         1
*SLAVING
S 100         1        21       621      200
S 100         2        31       631      200
S 100         3        41       641      200
S 100         4        51       651      200
S 100         5        61       661      200
S 100         6        71       671      200
S 100         7        81       681      200
S 100         8        91       691      200
S 100         9       101       701      200
S 100        10       111       711      200
*MASSES
!---Mass=80 tons/per level
!234567890123456789012345678901234567890123456789012345678901234567890
S 100       80.         1        10        1
!---ELEMENTS OF BEAMS-COLUMNS---TYPE-02
*ELEMENTGROUP
!234567890123456789012345678901234567890123456789012345678901234567890
```

```
   02    0    2
    2    0    2
!---1==Columns: Concerete=with yield
!---2==Beams:   Concerete=with yield
!    Young Modules    poison     Area       I
    1 2.080E+07      0.       0.15   3125E-6   4.   4.   2.
    2 2.080E+07      0.      0.125  2.604E-2   4.   4.   2.
!---YIELD ALLOWED FOR COLUMNS
!---YIELD ALLOWED FOR BEAM
!234567890123456789012345678901234567890123456789012345678901234567890
!---YIELD Surface Data:
    1    3    65.830    65.830  2459.120   438.247 2.71 0.47 2.71 0.47
    2    3    44.200    44.200  1964.660   280.600 3.09 0.35 3.09 0.35
!---COLUMNS
!234567890123456789012345678901234567890123456789012345678901234567890
    1        11        21        10    1    0    1    1
   11       211       221        10    1    0    1    1
   21       411       421        10    1    0    1    1
   31       611       621        10    1    0    1    1
   41       811       821        10    1    0    1    1
!---BEAMS
   51        21       221        10    2    0    2    2
   61       221       421        10    2    0    2    2
   71       421       621        10    2    0    2    2
   81       621       821        10    2    0    2    2
   90       711       911         1    2    0    2    2
!---ELEMENTS OF INELASTIC TRUSS BAR ELEMENT---TYPE-01
!2345678901234567890123456789012345678901234567890123456789012345678990
*ELEMENTGROUP
   01    0    2     1
    1
!234567890123456789012345678901234567890123456789012345678901234567890
!---YIELD ALLOWED FOR BRACINGS, YIELD AT TENSION AND BUCKLES IN
COMPRESSION
!---NOTE THAT VALUES BELOW ARE STRESS (KN/m2)
!     Elasticity     SHR     Area  Tension Yield Compression Buckling
!234567890123456789012345678901234567890123456789012345678901234567890
    1  2.00E+08        0.   33.5E-4    2.4e+5    2.1e+4     1        0.
!---BRACES
    1        11       221        10    1
   11       221       411        10    1
   21       411       621        10    1
   31       621       811        10    1
   40       711       901         1    1
*SECTION
!..
! ---------------------------------------------------------------------
! DEFINE FIRST FLOOR STRUCTURAL SECTION TO MONITOR BASE SHEAR
! INCLINATION ANGLE
      0.0                               BASE SHEAR
! ---------------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    1        8.0    0
!    TRANSFORMATION MATRIX
      1.0       0.0       0.0
      0.0       1.0       0.0
      0.0       0.0       1.0
      0.0       0.0       0.0
      0.0       0.0       0.0
```

```
      0.0        0.0        0.0
   1   11        4.0    1
   1   21        0.0    1
   1   31       -4.0    1
   1   41       -8.0    1
*SECTION
!..
! -------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 2ND FLOOR SHEAR
! INCLINATION ANGLE
      0.0                                   2ND FLOOR SHEAR
! -------------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567 8
   1    2       8.0    0
!    TRANSFORMATION MATRIX
      1.0        0.0        0.0
      0.0        1.0        0.0
      0.0        0.0        1.0
      0.0        0.0        0.0
      0.0        0.0        0.0
      0.0        0.0        0.0
   1   12        4.0    1
   1   22        0.0    1
   1   32       -4.0    1
   1   42       -8.0    1
*SECTION
!..
! -------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 3RD FLOOR SHEAR
! INCLINATION ANGLE
      0.0                                   3RD FLOOR SHEAR
! -------------------------------------------------------------------
! CUTTING ELEMENTS
!2345678901234567890123456789012345678901234567890123456789012345678 90
   1    3       8.0    0
!    TRANSFORMATION MATRIX
      1.0        0.0        0.0
      0.0        1.0        0.0
      0.0        0.0        1.0
      0.0        0.0        0.0
      0.0        0.0        0.0
      0.0        0.0        0.0
   1   13        4.0    1
   1   23        0.0    1
   1   33       -4.0    1
   1   43       -8.0    1
*SECTION
!..
! -------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 4TH FLOOR SHEAR
! INCLINATION ANGLE
      0.0                                   4TH FLOOR SHEAR
! -------------------------------------------------------------------
! CUTTING ELEMENTS
!2345678901234567890123456789012345678901234567890123456789012345678 90
   1    4       8.0    0
!    TRANSFORMATION MATRIX
      1.0        0.0        0.0
      0.0        1.0        0.0
```

```
       0.0       0.0       1.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
    1   14       4.0    1
    1   24       0.0    1
    1   34      -4.0    1
    1   44      -8.0    1
*SECTION
!..
! --------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 5TH FLOOR SHEAR
! INCLINATION ANGLE
       0.0                              5TH FLOOR SHEAR
! --------------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    5       8.0    0
!    TRANSFORMATION MATRIX
       1.0       0.0       0.0
       0.0       1.0       0.0
       0.0       0.0       1.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
    1   15       4.0    1
    1   25       0.0    1
    1   35      -4.0    1
    1   45      -8.0    1
*SECTION
!..
! --------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 6TH FLOOR SHEAR
! INCLINATION ANGLE
       0.0                              6TH FLOOR SHEAR
! --------------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    6       8.0    0
!    TRANSFORMATION MATRIX
       1.0       0.0       0.0
       0.0       1.0       0.0
       0.0       0.0       1.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
    1   16       4.0    1
    1   26       0.0    1
    1   36      -4.0    1
    1   46      -8.0    1
*SECTION
!..
! --------------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 7TH FLOOR SHEAR
! INCLINATION ANGLE
       0.0                              7TH FLOOR SHEAR
! --------------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    7       8.0    0
```

```
!    TRANSFORMATION MATRIX
        1.0        0.0        0.0
        0.0        1.0        0.0
        0.0        0.0        1.0
        0.0        0.0        0.0
        0.0        0.0        0.0
        0.0        0.0        0.0
    1   17         4.0     1
    1   27         0.0     1
    1   37        -4.0     1
    1   47        -8.0     1
*SECTION
!..
! ----------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 8TH FLOOR SHEAR
! INCLINATION ANGLE
        0.0                             8TH FLOOR SHEAR
! ----------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    8        8.0     0
!    TRANSFORMATION MATRIX
        1.0        0.0        0.0
        0.0        1.0        0.0
        0.0        0.0        1.0
        0.0        0.0        0.0
        0.0        0.0        0.0
        0.0        0.0        0.0
    1   18         4.0     1
    1   28         0.0     1
    1   38        -4.0     1
    1   48        -8.0     1
*SECTION
!..
! ----------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 9TH FLOOR SHEAR
! INCLINATION ANGLE
        0.0                             9TH FLOOR SHEAR
! ----------------------------------------------------------------
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1    9        8.0     0
!    TRANSFORMATION MATRIX
        1.0        0.0        0.0
        0.0        1.0        0.0
        0.0        0.0        1.0
        0.0        0.0        0.0
        0.0        0.0        0.0
        0.0        0.0        0.0
    1   19         4.0     1
    1   29         0.0     1
    1   39        -4.0     1
    1   49        -8.0     1
*SECTION
!..
! ----------------------------------------------------------------
! DEFINE A STRUCTURAL SECTION TO MONITOR 10TH FLOOR SHEAR
! INCLINATION ANGLE
        0.0                             10TH FLOOR SHEAR
! ----------------------------------------------------------------
```

```
! CUTTING ELEMENTS
!234567890123456789012345678901234567890123456789012345678901234567890
    1   10         8.0    0
!     TRANSFORMATION MATRIX
        1.0        0.0        0.0
        0.0        1.0        0.0
        0.0        0.0        1.0
        0.0        0.0        0.0
        0.0        0.0        0.0
        0.0        0.0        0.0
    1    20        4.0    1
    1    30        0.0    1
    1    40       -4.0    1
    1    50       -8.0    1
!
! *******************************************************************
! DEFINE INTERSTORY DRIFT RATIOS AS GENERALIZED DISPLACEMENTS
!     STORY HEIGHT = 300 CM ; 1/1=1
! -------------------------------------------------------------------
*GENDISP
        21     1  1                      FIRST STORY DRIFT
        11     1 -1
! -------------------------------------------------------------------
*GENDISP
        31     1  1                      SECOND STORY DRIFT
        21     1 -1
! -------------------------------------------------------------------
*GENDISP
        41     1  1                      THIRD STORY DRIFT
        31     1 -1
! -------------------------------------------------------------------
*GENDISP
        51     1  1                      FOURTH STORY DRIFT
        41     1 -1
! -------------------------------------------------------------------
*GENDISP
        61     1  1                      FIFTH STORY DRIFT
        51     1 -1
! -------------------------------------------------------------------
*GENDISP
        71     1  1                      SIXTH STORY DRIFT
        61     1 -1
! -------------------------------------------------------------------
*GENDISP
        81     1  1                      SEVENTH STORY DRIFT
        71     1 -1
! -------------------------------------------------------------------
*GENDISP
        91     1  1                      EIGHTH STORY DRIFT
        81     1 -1
! -------------------------------------------------------------------
*GENDISP
       101     1  1                      NINTH STORY DRIFT
        91     1 -1
! -------------------------------------------------------------------
*GENDISP
       111     1  1                      TENTH STORY DRIFT
       101     1 -1
! -------------------------------------------------------------------
*GENDISP
```

```
        111    1  1                        TIP DISPLACEMENT
         11    1 -1
*RESULTS
!---All storey drifts will be needed
!---NODE 21
!23456789012345678901234567890123456789012345678901234567890
!                 Node #
NSD    111         111
!---NOT ALL ELEMENTS-ONLY SELECTED, only braced element selected...
!          Element 1.Node 2.Node
!          Group #  #      #
E      111    2     1   10
!E      111    1    1    1
*NODALOAD
 LOAD
!---LOADS THAT WILL BE APPLIED
!        X        Y       Moment
!23456789012345678901234567890123456789012345678901234567890
S        0.   -100.000   83.3333         21
S        0.   -100.000   83.3333         31
S        0.   -100.000   83.3333         41
S        0.   -100.000   83.3333         51
S        0.   -100.000   83.3333         61
S        0.   -100.000   83.3333         71
S        0.   -100.000   83.3333         81
S        0.   -100.000   83.3333         91
S        0.   -100.000   83.3333        101
S        0.   -100.000   83.3333        111
S        0.   -200.000       0.0        221
S        0.   -200.000       0.0        231
S        0.   -200.000       0.0        241
S        0.   -200.000       0.0        251
S        0.   -200.000       0.0        261
S        0.   -200.000       0.0        271
S        0.   -200.000       0.0        281
S        0.   -200.000       0.0        291
S        0.   -200.000       0.0        301
S        0.   -200.000       0.0        311
S        0.   -200.000       0.0        421
S        0.   -200.000       0.0        431
S        0.   -200.000       0.0        441
S        0.   -200.000       0.0        451
S        0.   -200.000       0.0        461
S        0.   -200.000       0.0        471
S        0.   -200.000       0.0        481
S        0.   -200.000       0.0        491
S        0.   -200.000       0.0        501
S        0.   -200.000       0.0        511
S        0.   -200.000       0.0        621
S        0.   -200.000       0.0        631
S        0.   -200.000       0.0        641
S        0.   -200.000       0.0        651
S        0.   -200.000       0.0        661
S        0.   -200.000       0.0        671
S        0.   -200.000       0.0        681
S        0.   -200.000       0.0        691
S        0.   -200.000       0.0        701
S        0.   -200.000       0.0        711
S        0.   -100.000  -83.3333        821
S        0.   -100.000  -83.3333        831
```

```
S        0.  -100.000  -83.3333        841
S        0.  -100.000  -83.3333        851
S        0.  -100.000  -83.3333        861
S        0.  -100.000  -83.3333        871
S        0.  -100.000  -83.3333        881
S        0.  -100.000  -83.3333        891
S        0.  -100.000  -83.3333        901
S        0.  -100.000  -83.3333        911
*ACCNREC
!2345678901234567890123456789012345678901234567890123456789012345678901234567890
!---EARTHQUAKE INFORMATION:
 duzt    duztduz.txt                    *                               Duzce
Trans
 5179    1    0    0                 0.01      0.005        0.
*PARAMETERS
! ==================================================================
! STRUCTURE VISCOUS DAMPING SCALE FACTORS
!   define alpha and beta to achieve 3% damping in first two modes.
!   note: this assumes that damping has not been set in an earlier
analysis.
!   from mode analysis=> T1= 0.76 sec, T2= 0.235 sec
!   C= a*M+b*K
!   from Chopra,
!               b= df*2/(w1+w2)      = 0.00285
!               (w= 2*pi/T)
! ------------------------------------------------------------------
!         sfac_alpha sfac_beta
VS                     0.00285
OS       0    0   -1    0   20
OD       0        0.    0        0.    1              0         0. 9999
0.
DC  1    0    0 9999
DT   0.005
!2345678901234567890123456789012345678901234567890123456789012345678901234567890
*MODE
!2345678901234567890123456789012345678901234567890123456789012345678901234567890
                                            MODE SHAPE ANALYSIS
    1             0
*STAT
N     LOAD
L      1.              1
*ACCN
!2345678901234567890123456789012345678901234567890123456789012345678901234567890
!   Total   Max          Time
!    time time step     interval
    25.895 6000    1     0.005                                    Duzce
Trans
1     duzt
*STOP
```

APPENDIX B: DRAIN-2DX BRACE1.ECH FILE OF FRAME 1

```
------------------------------------------------------------------------------
                               DRAIN-2DX

                     PROGRAM VERSION 1.10,  NOV. 1993
------------------------------------------------------------------------------


*------------------------*
*START : Problem Initiation
*------------------------*
PROBLEM NAME   = brace1
PROBLEM TITLE  = BRACED FRAME-1

Execution code            = 0  (execute)
Input echo code           = 1
(Echo input lines and show analysis progress)
P-delta analysis code     = 1  (Yes)
Energy calculation code = 1  (Yes)
User output file type     =    (no file)

*---------------------------*
*NODECOORDS : Node Coordinates
*---------------------------*

Spec        Node     X Coord     Y Coord       Offset
Type      Number   or Offset   or Offset         Node

   C           1  8.0000E+00  3.0000E+00            0
   C           2  8.0000E+00  6.0000E+00            0
   C           3  8.0000E+00  9.0000E+00            0
   C           4  8.0000E+00  1.2000E+01            0
   C           5  8.0000E+00  1.5000E+01            0
   C           6  8.0000E+00  1.8000E+01            0
   C           7  8.0000E+00  2.1000E+01            0
   C           8  8.0000E+00  2.4000E+01            0
   C           9  8.0000E+00  2.7000E+01            0
   C          10  8.0000E+00  3.0000E+01            0
   C          11  0.0000E+00  0.0000E+00            0
   C         111  0.0000E+00  3.0000E+01            0
   C         211  4.0000E+00  0.0000E+00            0
   C         311  4.0000E+00  3.0000E+01            0
   C         411  8.0000E+00  0.0000E+00            0
   C         511  8.0000E+00  3.0000E+01            0
   C         611  1.2000E+01  0.0000E+00            0
   C         711  1.2000E+01  3.0000E+01            0
   C         811  1.6000E+01  0.0000E+00            0
   C         911  1.6000E+01  3.0000E+01            0

Spec        Node        Node     Incrm Number      Spacing
Type          NB          NE       ND      NG           SP

   L          11         111       10       9   0.0000E+00
   L         211         311       10       9   0.0000E+00
   L         411         511       10       9   0.0000E+00
   L         611         711       10       9   0.0000E+00
   L         811         911       10       9   0.0000E+00
```

```
*---------------*
NODAL COORDINATES
*---------------*

       Node        X            Y
      Number   Coordinate   Coordinate

         1   8.00000E+00  3.00000E+00
         2   8.00000E+00  6.00000E+00
         3   8.00000E+00  9.00000E+00
         4   8.00000E+00  1.20000E+01
         5   8.00000E+00  1.50000E+01
         6   8.00000E+00  1.80000E+01
         7   8.00000E+00  2.10000E+01
         8   8.00000E+00  2.40000E+01
         9   8.00000E+00  2.70000E+01
        10   8.00000E+00  3.00000E+01
        11   0.00000E+00  0.00000E+00
        21   0.00000E+00  3.00000E+00
        31   0.00000E+00  6.00000E+00
        41   0.00000E+00  9.00000E+00
        51   0.00000E+00  1.20000E+01
        61   0.00000E+00  1.50000E+01
        71   0.00000E+00  1.80000E+01
        81   0.00000E+00  2.10000E+01
        91   0.00000E+00  2.40000E+01
       101   0.00000E+00  2.70000E+01
       111   0.00000E+00  3.00000E+01
       211   4.00000E+00  0.00000E+00
       221   4.00000E+00  3.00000E+00
       231   4.00000E+00  6.00000E+00
       241   4.00000E+00  9.00000E+00
       251   4.00000E+00  1.20000E+01
       261   4.00000E+00  1.50000E+01
       271   4.00000E+00  1.80000E+01
       281   4.00000E+00  2.10000E+01
       291   4.00000E+00  2.40000E+01
       301   4.00000E+00  2.70000E+01
       311   4.00000E+00  3.00000E+01
       411   8.00000E+00  0.00000E+00
       421   8.00000E+00  3.00000E+00
       431   8.00000E+00  6.00000E+00
       441   8.00000E+00  9.00000E+00
       451   8.00000E+00  1.20000E+01
       461   8.00000E+00  1.50000E+01
       471   8.00000E+00  1.80000E+01
       481   8.00000E+00  2.10000E+01
       491   8.00000E+00  2.40000E+01
       501   8.00000E+00  2.70000E+01
       511   8.00000E+00  3.00000E+01
       611   1.20000E+01  0.00000E+00
       621   1.20000E+01  3.00000E+00
       631   1.20000E+01  6.00000E+00
       641   1.20000E+01  9.00000E+00
       651   1.20000E+01  1.20000E+01
       661   1.20000E+01  1.50000E+01
       671   1.20000E+01  1.80000E+01
       681   1.20000E+01  2.10000E+01
       691   1.20000E+01  2.40000E+01
       701   1.20000E+01  2.70000E+01
```

```
        711   1.20000E+01  3.00000E+01
        811   1.60000E+01  0.00000E+00
        821   1.60000E+01  3.00000E+00
        831   1.60000E+01  6.00000E+00
        841   1.60000E+01  9.00000E+00
        851   1.60000E+01  1.20000E+01
        861   1.60000E+01  1.50000E+01
        871   1.60000E+01  1.80000E+01
        881   1.60000E+01  2.10000E+01
        891   1.60000E+01  2.40000E+01
        901   1.60000E+01  2.70000E+01
        911   1.60000E+01  3.00000E+01

 *----------------------------*
 *RESTRAINTS : Restrained Nodes
 *----------------------------*

 Spec Restraint Codes       Node       Node      Incrm       Node
Incrm
 Type       X    Y    R      NF/NB      NL/NE1     ND/ND1       /NE2
/ND2

    S       1    1    1         11        811        200
    S       0    1    1          1         10          1

 *------------------------------------*
 *SLAVING : Nodal Slaving Constraints
 *------------------------------------*

 Spec  Slaving Codes     Master       Node       Node      Incrm       Node
Incrm
 Type     X     Y     R      Node      NF/NB     NL/NE1    ND/ND1        /NE2
/ND2

    S     1     0     0         1         21        621       200
    S     1     0     0         2         31        631       200
    S     1     0     0         3         41        641       200
    S     1     0     0         4         51        651       200
    S     1     0     0         5         61        661       200
    S     1     0     0         6         71        671       200
    S     1     0     0         7         81        681       200
    S     1     0     0         8         91        691       200
    S     1     0     0         9        101        701       200
    S     1     0     0        10        111        711       200

  *--------------------------*
  STRUCTURE DEGREES OF FREEDOM
  *--------------------------*

   Seq        Node     DOF No. (Seq. No. of Master Node if Negative)
   No.       Number          X        Y        R

     1           1           1        0        0
     2           2           2        0        0
     3           3           3        0        0
     4           4           4        0        0
     5           5           5        0        0
     6           6           6        0        0
     7           7           7        0        0
     8           8           8        0        0
     9           9           9        0        0
    10          10          10        0        0
```

```
11            11        0      0      0
12            21       -1     11     12
13            31       -2     13     14
14            41       -3     15     16
15            51       -4     17     18
16            61       -5     19     20
17            71       -6     21     22
18            81       -7     23     24
19            91       -8     25     26
20           101       -9     27     28
21           111      -10     29     30
22           211        0      0      0
23           221       -1     31     32
24           231       -2     33     34
25           241       -3     35     36
26           251       -4     37     38
27           261       -5     39     40
28           271       -6     41     42
29           281       -7     43     44
30           291       -8     45     46
31           301       -9     47     48
32           311      -10     49     50
33           411        0      0      0
34           421       -1     51     52
35           431       -2     53     54
36           441       -3     55     56
37           451       -4     57     58
38           461       -5     59     60
39           471       -6     61     62
40           481       -7     63     64
41           491       -8     65     66
42           501       -9     67     68
43           511      -10     69     70
44           611        0      0      0
45           621       -1     71     72
46           631       -2     73     74
47           641       -3     75     76
48           651       -4     77     78
49           661       -5     79     80
50           671       -6     81     82
51           681       -7     83     84
52           691       -8     85     86
53           701       -9     87     88
54           711      -10     89     90
55           811        0      0      0
56           821       91     92     93
57           831       94     95     96
58           841       97     98     99
59           851      100    101    102
60           861      103    104    105
61           871      106    107    108
62           881      109    110    111
63           891      112    113    114
64           901      115    116    117
65           911      118    119    120

*--------------------*
*MASSES : Nodal Masses
*--------------------*
```

```
 Spec  Mass Codes.       Mass      Node       Node      Incrm       Node
Incrm   Modifying      Damping
 Type   X    Y   R       Value     NF/NB      NL/NE1    ND/ND1       /NE2
/ND2       Factor      Factor

    S 1-Y 0-N 0-N  8.0000E+01        1         10         1
1.0000E+00  0.0000E+00

 *-----------------*
 TOTAL NODAL MASSES
 *-----------------*

      Node Translational Translational    Rotational
    Number        X-mass        Y-mass        R-mass

         1   8.00000E+01   0.00000E+00   0.00000E+00
         2   8.00000E+01   0.00000E+00   0.00000E+00
         3   8.00000E+01   0.00000E+00   0.00000E+00
         4   8.00000E+01   0.00000E+00   0.00000E+00
         5   8.00000E+01   0.00000E+00   0.00000E+00
         6   8.00000E+01   0.00000E+00   0.00000E+00
         7   8.00000E+01   0.00000E+00   0.00000E+00
         8   8.00000E+01   0.00000E+00   0.00000E+00
         9   8.00000E+01   0.00000E+00   0.00000E+00
        10   8.00000E+01   0.00000E+00   0.00000E+00
 -------------------------------------
   Total =   8.00000E+02   0.00000E+00
 -------------------------------------

 *-----------------------------------------------------*
 *ELEMENTGROUP : Element Group Definition, Group No.  1
 *-----------------------------------------------------*

 Group Information

   Element type no.        =    2
   Event code              =    0  (suppress)
   P-delta analysis code =      2  (include; variable Kg in dynamic)
   Damping factor (beta) =  0.0000E+00
   Group title             =

 BEAM COLUMN ELEMENTS (TYPE 02) VERSION 1.10

 Control Information
    No. of stiffness types     =   2
    No. of rigid zone types    =   0
    No. of yield surface types =   2


 Stiffness Types

     Type      Youngs  Hardening     Section  Reference     Flex.Stif.Fac.
Shear  Poisn  Overshoot
      No.    Modulus     Ratio        Area     Inertia      ii     jj     ij
Area   Ratio  Tolerance

          1  2.080E+07  1.000E-06  1.500E-01  3.125E-03  4.00   4.00   2.00
0.000E+00    .00   1.000E-05
```

```
         2  2.080E+07  1.000E-06  1.250E-01  2.604E-02  4.00  4.00  2.00
0.000E+00     .00   1.000E-05


 Yield Surface Types

      Type Shape      Yield Moments          Yield Forces         Coordinates
of A       Coordinates of B
       No.  Code  Positive   Negative  Compression  Tension     Moment
Force       Moment       Force

         1   3    6.583E+01  6.583E+01  2.459E+03  4.382E+02  2.710E+00
4.700E-01  2.710E+00  4.700E-01
  ***WARNING - odd shape - check A and B
         2   3    4.420E+01  4.420E+01  1.965E+03  2.806E+02  3.090E+00
3.500E-01  3.090E+00  3.500E-01
  ***WARNING - odd shape - check A and B


 Element Generation Commands

      Elem        Node       Node       Node  Stif  Rigd  Yield Surfaces
      No.          I          J         Diff  Type  Type  End I   End J

         1        11         21          10     1     0     1       1
   *     2        21         31          10     1     0     1       1
   *     3        31         41          10     1     0     1       1
   *     4        41         51          10     1     0     1       1
   *     5        51         61          10     1     0     1       1
   *     6        61         71          10     1     0     1       1
   *     7        71         81          10     1     0     1       1
   *     8        81         91          10     1     0     1       1
   *     9        91        101          10     1     0     1       1
   *    10       101        111          10     1     0     1       1
        11       211        221          10     1     0     1       1
   *    12       221        231          10     1     0     1       1
   *    13       231        241          10     1     0     1       1
   *    14       241        251          10     1     0     1       1
   *    15       251        261          10     1     0     1       1
   *    16       261        271          10     1     0     1       1
   *    17       271        281          10     1     0     1       1
   *    18       281        291          10     1     0     1       1
   *    19       291        301          10     1     0     1       1
   *    20       301        311          10     1     0     1       1
        21       411        421          10     1     0     1       1
   *    22       421        431          10     1     0     1       1
   *    23       431        441          10     1     0     1       1
   *    24       441        451          10     1     0     1       1
   *    25       451        461          10     1     0     1       1
   *    26       461        471          10     1     0     1       1
   *    27       471        481          10     1     0     1       1
   *    28       481        491          10     1     0     1       1
   *    29       491        501          10     1     0     1       1
   *    30       501        511          10     1     0     1       1
        31       611        621          10     1     0     1       1
   *    32       621        631          10     1     0     1       1
   *    33       631        641          10     1     0     1       1
   *    34       641        651          10     1     0     1       1
   *    35       651        661          10     1     0     1       1
```

```
*   36      661      671      10    1    0    1    1
*   37      671      681      10    1    0    1    1
*   38      681      691      10    1    0    1    1
*   39      691      701      10    1    0    1    1
*   40      701      711      10    1    0    1    1
    41      811      821      10    1    0    1    1
*   42      821      831      10    1    0    1    1
*   43      831      841      10    1    0    1    1
*   44      841      851      10    1    0    1    1
*   45      851      861      10    1    0    1    1
*   46      861      871      10    1    0    1    1
*   47      871      881      10    1    0    1    1
*   48      881      891      10    1    0    1    1
*   49      891      901      10    1    0    1    1
*   50      901      911      10    1    0    1    1
    51       21      221      10    2    0    2    2
*   52       31      231      10    2    0    2    2
*   53       41      241      10    2    0    2    2
*   54       51      251      10    2    0    2    2
*   55       61      261      10    2    0    2    2
*   56       71      271      10    2    0    2    2
*   57       81      281      10    2    0    2    2
*   58       91      291      10    2    0    2    2
*   59      101      301      10    2    0    2    2
*   60      111      311      10    2    0    2    2
    61      221      421      10    2    0    2    2
*   62      231      431      10    2    0    2    2
*   63      241      441      10    2    0    2    2
*   64      251      451      10    2    0    2    2
*   65      261      461      10    2    0    2    2
*   66      271      471      10    2    0    2    2
*   67      281      481      10    2    0    2    2
*   68      291      491      10    2    0    2    2
*   69      301      501      10    2    0    2    2
*   70      311      511      10    2    0    2    2
    71      421      621      10    2    0    2    2
*   72      431      631      10    2    0    2    2
*   73      441      641      10    2    0    2    2
*   74      451      651      10    2    0    2    2
*   75      461      661      10    2    0    2    2
*   76      471      671      10    2    0    2    2
*   77      481      681      10    2    0    2    2
*   78      491      691      10    2    0    2    2
*   79      501      701      10    2    0    2    2
*   80      511      711      10    2    0    2    2
    81      621      821      10    2    0    2    2
*   82      631      831      10    2    0    2    2
*   83      641      841      10    2    0    2    2
*   84      651      851      10    2    0    2    2
*   85      661      861      10    2    0    2    2
*   86      671      871      10    2    0    2    2
*   87      681      881      10    2    0    2    2
*   88      691      891      10    2    0    2    2
*   89      701      901      10    2    0    2    2
    90      711      911       1    2    0    2    2

*-------------------------------------------------------*
*ELEMENTGROUP : Element Group Definition, Group No.   2
*-------------------------------------------------------*
```

```
 Group Information

   Element type no.      =    1
   Event code            =    0  (suppress)
   P-delta analysis code =    2  (include; variable Kg in dynamic)
   Damping factor (beta) =  1.0000E+00
   Group title           =

 TRUSS ELEMENTS (TYPE 01) VERSION 1.10

 Control Information
     No. of property types =    1

 Property Types

     Type      Youngs    Hardening     Section   Tens Yield  Comp Yield
Buck   Overshoot
       No.     Modulus       Ratio        Area      Stress      Stress
Code   Tolerance

          1  2.0000E+08  1.0000E-05  3.3500E-03  2.4000E+05  2.1000E+04
1  1.0000E-05

 Element Generation Commands

     Elem        Node        Node       Node Prop
      No.         I           J         Diff Type

        1         11         221         10    1
   *    2         21         231         10    1
   *    3         31         241         10    1
   *    4         41         251         10    1
   *    5         51         261         10    1
   *    6         61         271         10    1
   *    7         71         281         10    1
   *    8         81         291         10    1
   *    9         91         301         10    1
   *   10        101         311         10    1
       11        221         411         10    1
   *   12        231         421         10    1
   *   13        241         431         10    1
   *   14        251         441         10    1
   *   15        261         451         10    1
   *   16        271         461         10    1
   *   17        281         471         10    1
   *   18        291         481         10    1
   *   19        301         491         10    1
   *   20        311         501         10    1
       21        411         621         10    1
   *   22        421         631         10    1
   *   23        431         641         10    1
   *   24        441         651         10    1
   *   25        451         661         10    1
   *   26        461         671         10    1
   *   27        471         681         10    1
   *   28        481         691         10    1
   *   29        491         701         10    1
   *   30        501         711         10    1
       31        621         811         10    1
   *   32        631         821         10    1
```

```
  *   33         641        831         10    1
  *   34         651        841         10    1
  *   35         661        851         10    1
  *   36         671        861         10    1
  *   37         681        871         10    1
  *   38         691        881         10    1
  *   39         701        891         10    1
      40         711        901          1    1

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   1
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = BASE SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X           Y           R

    1   1    1  8.0000E+00    0    1  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   11  4.0000E+00    1    1
    3   1   21  0.0000E+00    1    1
    4   1   31 -4.0000E+00    1    1
    5   1   41 -8.0000E+00    1    1

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   2
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 2ND FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X           Y           R

    1   1    2  8.0000E+00    0    2  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00

    2   1   12  4.0000E+00    1    2
    3   1   22  0.0000E+00    1    2
    4   1   32 -4.0000E+00    1    2
    5   1   42 -8.0000E+00    1    2

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   3
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 3RD FLOOR SHEAR

Cut Elements
```

```
  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X            Y            R

    1   1    3  8.0000E+00    0    3  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   13  4.0000E+00    1    3
    3   1   23  0.0000E+00    1    3
    4   1   33 -4.0000E+00    1    3
    5   1   43 -8.0000E+00    1    3

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.    4
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 4TH FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X            Y            R

    1   1    4  8.0000E+00    0    4  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   14  4.0000E+00    1    4
    3   1   24  0.0000E+00    1    4
    4   1   34 -4.0000E+00    1    4
    5   1   44 -8.0000E+00    1    4

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.    5
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 5TH FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X            Y            R

    1   1    5  8.0000E+00    0    5  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   15  4.0000E+00    1    5
    3   1   25  0.0000E+00    1    5
    4   1   35 -4.0000E+00    1    5
    5   1   45 -8.0000E+00    1    5

*-------------------------------------------------------*
```

```
*SECTION : Structure Section Definition, Section No.   6
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 6TH FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X           Y           R

    1   1    6  8.0000E+00    0    6  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   16  4.0000E+00    1    6
    3   1   26  0.0000E+00    1    6
    4   1   36 -4.0000E+00    1    6
    5   1   46 -8.0000E+00    1    6

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   7
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 7TH FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X           Y           R

    1   1    7  8.0000E+00    0    7  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
    2   1   17  4.0000E+00    1    7
    3   1   27  0.0000E+00    1    7
    4   1   37 -4.0000E+00    1    7
    5   1   47 -8.0000E+00    1    7

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   8
*-------------------------------------------------------*
 Section inclination angle =  0.0000E+00
 Section title             = 8TH FLOOR SHEAR

Cut Elements

  Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
  No. No.  No. Sect Center Code  No.            X           Y           R

    1   1    8  8.0000E+00    0    8  1.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  1.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  1.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
                                      0.0000E+00  0.0000E+00  0.0000E+00
```

```
     2    1    18  4.0000E+00     1     8
     3    1    28  0.0000E+00     1     8
     4    1    38 -4.0000E+00     1     8
     5    1    48 -8.0000E+00     1     8

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.   9
*-------------------------------------------------------*
  Section inclination angle =  0.0000E+00
  Section title             = 9TH FLOOR SHEAR

Cut Elements

   Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
   No. No.  No. Sect Center Code  No.           X           Y           R

     1    1     9  8.0000E+00     0     9  1.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  1.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  1.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
     2    1    19  4.0000E+00     1     9
     3    1    29  0.0000E+00     1     9
     4    1    39 -4.0000E+00     1     9
     5    1    49 -8.0000E+00     1     9

*-------------------------------------------------------*
*SECTION : Structure Section Definition, Section No.  10
*-------------------------------------------------------*
  Section inclination angle =  0.0000E+00
  Section title             = 10TH FLOOR SHEAR

Cut Elements

   Cut Grp Elem  Dist from  Tran Tran  Transformation Matrix
   No. No.  No. Sect Center Code  No.           X           Y           R

     1    1    10  8.0000E+00     0    10  1.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  1.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  1.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
                                           0.0000E+00  0.0000E+00  0.0000E+00
     2    1    20  4.0000E+00     1    10
     3    1    30  0.0000E+00     1    10
     4    1    40 -4.0000E+00     1    10
     5    1    50 -8.0000E+00     1    10

*--------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.    1
*--------------------------------------------------------------------*
TITLE = FIRST STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          21 1=X    1.000E+00
   2          11 1=X   -1.000E+00
```

```
*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   2
*-----------------------------------------------------------------------*
TITLE = SECOND STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          31 1=X   1.000E+00
   2          21 1=X  -1.000E+00

*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   3
*-----------------------------------------------------------------------*
TITLE = THIRD STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          41 1=X   1.000E+00
   2          31 1=X  -1.000E+00

*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   4
*-----------------------------------------------------------------------*
TITLE = FOURTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          51 1=X   1.000E+00
   2          41 1=X  -1.000E+00

*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   5
*-----------------------------------------------------------------------*
TITLE = FIFTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          61 1=X   1.000E+00
   2          51 1=X  -1.000E+00

*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   6
*-----------------------------------------------------------------------*
TITLE = SIXTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          71 1=X   1.000E+00
   2          61 1=X  -1.000E+00

*-----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   7
*-----------------------------------------------------------------------*
TITLE = SEVENTH STORY DRIFT
```

```
Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          81 1=X   1.000E+00
   2          71 1=X  -1.000E+00

*----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.    8
*----------------------------------------------------------------------*
TITLE = EIGHTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1          91 1=X   1.000E+00
   2          81 1=X  -1.000E+00

*----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.    9
*----------------------------------------------------------------------*
TITLE = NINTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1         101 1=X   1.000E+00
   2          91 1=X  -1.000E+00

*----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   10
*----------------------------------------------------------------------*
TITLE = TENTH STORY DRIFT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1         111 1=X   1.000E+00
   2         101 1=X  -1.000E+00

*----------------------------------------------------------------------*
*GENDISP : Generalized Displacement Definition, Displacement No.   11
*----------------------------------------------------------------------*
TITLE = TIP DISPLACEMENT

Disp        Node Disp  Participn
 No.      Number Dirn     Factor

   1         111 1=X   1.000E+00
   2          11 1=X  -1.000E+00

*--------------------------------------*
*RESULTS : Results Output Specification
*--------------------------------------*

 Nodes

   Spec Rslt User Post Prnt       Node       Node       Incrm        Node
Incrm
   Type Type Outp Proc Code      NF/NB     NL/NE1      ND/ND1        /NE2
/ND2
```

```
      S Disp    1    1    1       111        111          1

   Elements

     User Post Prnt  Elem First  Last  Elem
     Outp Proc Code Group  Elem  Elem  Diff

        1    1    1     2     1    10     1

   *----------------------------------*
   *NODALOAD : Static Nodal Load Pattern
   *----------------------------------*
   PATTERN NAME  = LOAD
   PATTERN TITLE =

   Nodal Loads

     Spec           X           Y           R         Node        Node
  Incrm          Node       Incrm
     Type          Load        Load        Load       NF/NB       NL/NE1
  ND/ND1          /NE2        /ND2

        S  0.0000E+00 -1.0000E+02  8.3333E+01          21          21
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          31          31
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          41          41
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          51          51
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          61          61
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          71          71
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          81          81
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01          91          91
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01         101         101
  1
        S  0.0000E+00 -1.0000E+02  8.3333E+01         111         111
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         221         221
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         231         231
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         241         241
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         251         251
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         261         261
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         271         271
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         281         281
  1
        S  0.0000E+00 -2.0000E+02  0.0000E+00         291         291
  1
```

```
      S  0.0000E+00 -2.0000E+02  0.0000E+00        301        301
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        311        311
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        421        421
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        431        431
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        441        441
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        451        451
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        461        461
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        471        471
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        481        481
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        491        491
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        501        501
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        511        511
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        621        621
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        631        631
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        641        641
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        651        651
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        661        661
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        671        671
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        681        681
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        691        691
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        701        701
 1
      S  0.0000E+00 -2.0000E+02  0.0000E+00        711        711
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        821        821
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        831        831
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        841        841
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        851        851
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        861        861
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        871        871
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        881        881
 1
      S  0.0000E+00 -1.0000E+02 -8.3333E+01        891        891
 1
```

```
          S  0.0000E+00 -1.0000E+02 -8.3333E+01          901           901
1
          S  0.0000E+00 -1.0000E+02 -8.3333E+01          911           911
1

    *-------------------------*
    NODAL LOADS FOR THIS PATTERN
    *-------------------------*

         Node          X           Y            R
       Number        Force       Force        Moment

           21  0.0000E+00 -1.0000E+02  8.3333E+01
           31  0.0000E+00 -1.0000E+02  8.3333E+01
           41  0.0000E+00 -1.0000E+02  8.3333E+01
           51  0.0000E+00 -1.0000E+02  8.3333E+01
           61  0.0000E+00 -1.0000E+02  8.3333E+01
           71  0.0000E+00 -1.0000E+02  8.3333E+01
           81  0.0000E+00 -1.0000E+02  8.3333E+01
           91  0.0000E+00 -1.0000E+02  8.3333E+01
          101  0.0000E+00 -1.0000E+02  8.3333E+01
          111  0.0000E+00 -1.0000E+02  8.3333E+01
          221  0.0000E+00 -2.0000E+02  0.0000E+00
          231  0.0000E+00 -2.0000E+02  0.0000E+00
          241  0.0000E+00 -2.0000E+02  0.0000E+00
          251  0.0000E+00 -2.0000E+02  0.0000E+00
          261  0.0000E+00 -2.0000E+02  0.0000E+00
          271  0.0000E+00 -2.0000E+02  0.0000E+00
          281  0.0000E+00 -2.0000E+02  0.0000E+00
          291  0.0000E+00 -2.0000E+02  0.0000E+00
          301  0.0000E+00 -2.0000E+02  0.0000E+00
          311  0.0000E+00 -2.0000E+02  0.0000E+00
          421  0.0000E+00 -2.0000E+02  0.0000E+00
          431  0.0000E+00 -2.0000E+02  0.0000E+00
          441  0.0000E+00 -2.0000E+02  0.0000E+00
          451  0.0000E+00 -2.0000E+02  0.0000E+00
          461  0.0000E+00 -2.0000E+02  0.0000E+00
          471  0.0000E+00 -2.0000E+02  0.0000E+00
          481  0.0000E+00 -2.0000E+02  0.0000E+00
          491  0.0000E+00 -2.0000E+02  0.0000E+00
          501  0.0000E+00 -2.0000E+02  0.0000E+00
          511  0.0000E+00 -2.0000E+02  0.0000E+00
          621  0.0000E+00 -2.0000E+02  0.0000E+00
          631  0.0000E+00 -2.0000E+02  0.0000E+00
          641  0.0000E+00 -2.0000E+02  0.0000E+00
          651  0.0000E+00 -2.0000E+02  0.0000E+00
          661  0.0000E+00 -2.0000E+02  0.0000E+00
          671  0.0000E+00 -2.0000E+02  0.0000E+00
          681  0.0000E+00 -2.0000E+02  0.0000E+00
          691  0.0000E+00 -2.0000E+02  0.0000E+00
          701  0.0000E+00 -2.0000E+02  0.0000E+00
          711  0.0000E+00 -2.0000E+02  0.0000E+00
          821  0.0000E+00 -1.0000E+02 -8.3333E+01
          831  0.0000E+00 -1.0000E+02 -8.3333E+01
          841  0.0000E+00 -1.0000E+02 -8.3333E+01
          851  0.0000E+00 -1.0000E+02 -8.3333E+01
          861  0.0000E+00 -1.0000E+02 -8.3333E+01
          871  0.0000E+00 -1.0000E+02 -8.3333E+01
          881  0.0000E+00 -1.0000E+02 -8.3333E+01
          891  0.0000E+00 -1.0000E+02 -8.3333E+01
```

```
      901  0.0000E+00 -1.0000E+02 -8.3333E+01
      911  0.0000E+00 -1.0000E+02 -8.3333E+01

*-----------------------------------*
*ACCNREC : Ground Acceleration Record
*-----------------------------------*
RECORD NAME  = duzt
RECORD TITLE =                              Duzce Trans
Record file name (formatted)    = duztduz.txt
Input format                    = (*)

Control Information

  Number of Acceleration values         = 5179
  No. of Acceleration values per line   =    1
  Data code  = 0 Acceleration values only
  Print code = 0 (as input)
  Time scale factor                     =  1.0000E+00
  Acceleration scale factor             =  1.0000E-02
  Time interval                         =  5.0000E-03
  Start Time                            =  0.0000E+00

  Acceleration Record  (as input) (REMOVED)

*-----------------*
MEMORY REQUIREMENTS
*-----------------*

Excluding element data            =    57510
Minimum required                  =    57794
Total if only one element block   =    85950
Total with duplicate stiffness
      and unbalance load vector   =    99794
Total to be entirely in memory    =   128234

Total available                   =  1000000
Number of element blocks          =        1

*------------------------------*
*PARAMETERS : Analysis Parameters
*------------------------------*

Structure Viscous Damping Scale Factors

  Scale factor for alpha damping =  0.0000E+00
  Scale factor for beta damping  =  2.8500E-03

Output Intervals for Static Analysis

  Load step interval for :
    Saving structure state                  =     0 (do not save)
    Saving results for post-processing      =     0 (do not save)
    Results printout                        =    -1 (every event)
    Saving envelope for post-processing     =     0 (do not save)
    Envelope printout                       =    20

Output Intervals for Dynamic Analysis

  Time step and time intervals for :
    Saving structure state : step                  =     0 (do not save)
```

```
                          time                        =   0.0000E+00
    Saving results for post-processing : step   =      0 (do not save)
                                       : time   =   0.0000E+00
    Results printout : step                     =      1
                       time                     =   0.0000E+00
    Saving envelope for post-processing : step =       0 (do not save)
                                        : time =    0.0000E+00
    Envelope printout : step                    =   9999
                      : time                    =   0.0000E+00

Control Parameters for Dynamic Analysis

  Event calculation code                      = 0 (ignore)
  Velocity correction code                    = 0 (do not modify)
  Acceleration correction code                = 0 (do not modify)
  Max. number of events allowed in any step =     0 (no limit)

Time Step Parameters for Dynamic Analysis

  For constant time step solution scheme :
    Time step (constant throughout) =  5.0000E-03

  For variable time step solution scheme :
    Initial Time step                =  1.0000E+00
    Maximum allowable time step      =  1.0000E+10
    Minimum allowable time step      =  0.0000E+00

*--------------------------------------------------------------------
-*
*MODE : Mode Shapes and Periods -
*--------------------------------------------------------------------
-*

Control Information

  Maximum number of mode shapes     =  10
  Shortest significant period       =  0.0000E+00
  Code for printing mode shapes     = 0
    (print displacements for all nodes)
  Code for saving mode shapes       = 0 (save)
  Code for printing damping ratios = 0 (print)

*------------------------------*
SUCCESSFUL COMPLETION OF ANALYSIS
*------------------------------*

*-------------------------------------------------------------*
*STAT : Static Analysis -
*-------------------------------------------------------------*

Nodal Loads

  Patt       Scale
  Name       Factor

  LOAD  1.0000E+00

Load Control

  Load factor increment per analysis step    =  1.0000E+00
```

```
  Load factor increment for analysis segment =  1.0000E+00
  Maximum number of events in any step       =     1

  Maximum number of steps                     =     2

*-----------------------------------*
BEGIN STATIC ANALYSIS, SEGMENT NO.   1
*-----------------------------------*

*---------------------------------------*
NODAL LOAD INCREMENTS FOR UNIT LOAD FACTOR
*---------------------------------------*


      Node         X-Force      Y-Force     R-Moment

        21      0.0000E+00 -1.0000E+02  8.3333E+01
        31      0.0000E+00 -1.0000E+02  8.3333E+01
        41      0.0000E+00 -1.0000E+02  8.3333E+01
        51      0.0000E+00 -1.0000E+02  8.3333E+01
        61      0.0000E+00 -1.0000E+02  8.3333E+01
        71      0.0000E+00 -1.0000E+02  8.3333E+01
        81      0.0000E+00 -1.0000E+02  8.3333E+01
        91      0.0000E+00 -1.0000E+02  8.3333E+01
       101      0.0000E+00 -1.0000E+02  8.3333E+01
       111      0.0000E+00 -1.0000E+02  8.3333E+01
       221      0.0000E+00 -2.0000E+02  0.0000E+00
       231      0.0000E+00 -2.0000E+02  0.0000E+00
       241      0.0000E+00 -2.0000E+02  0.0000E+00
       251      0.0000E+00 -2.0000E+02  0.0000E+00
       261      0.0000E+00 -2.0000E+02  0.0000E+00
       271      0.0000E+00 -2.0000E+02  0.0000E+00
       281      0.0000E+00 -2.0000E+02  0.0000E+00
       291      0.0000E+00 -2.0000E+02  0.0000E+00
       301      0.0000E+00 -2.0000E+02  0.0000E+00
       311      0.0000E+00 -2.0000E+02  0.0000E+00
       421      0.0000E+00 -2.0000E+02  0.0000E+00
       431      0.0000E+00 -2.0000E+02  0.0000E+00
       441      0.0000E+00 -2.0000E+02  0.0000E+00
       451      0.0000E+00 -2.0000E+02  0.0000E+00
       461      0.0000E+00 -2.0000E+02  0.0000E+00
       471      0.0000E+00 -2.0000E+02  0.0000E+00
       481      0.0000E+00 -2.0000E+02  0.0000E+00
       491      0.0000E+00 -2.0000E+02  0.0000E+00
       501      0.0000E+00 -2.0000E+02  0.0000E+00
       511      0.0000E+00 -2.0000E+02  0.0000E+00
       621      0.0000E+00 -2.0000E+02  0.0000E+00
       631      0.0000E+00 -2.0000E+02  0.0000E+00
       641      0.0000E+00 -2.0000E+02  0.0000E+00
       651      0.0000E+00 -2.0000E+02  0.0000E+00
       661      0.0000E+00 -2.0000E+02  0.0000E+00
       671      0.0000E+00 -2.0000E+02  0.0000E+00
       681      0.0000E+00 -2.0000E+02  0.0000E+00
       691      0.0000E+00 -2.0000E+02  0.0000E+00
       701      0.0000E+00 -2.0000E+02  0.0000E+00
       711      0.0000E+00 -2.0000E+02  0.0000E+00
       821      0.0000E+00 -1.0000E+02 -8.3333E+01
       831      0.0000E+00 -1.0000E+02 -8.3333E+01
       841      0.0000E+00 -1.0000E+02 -8.3333E+01
       851      0.0000E+00 -1.0000E+02 -8.3333E+01
```

```
       861     0.0000E+00 -1.0000E+02 -8.3333E+01
       871     0.0000E+00 -1.0000E+02 -8.3333E+01
       881     0.0000E+00 -1.0000E+02 -8.3333E+01
       891     0.0000E+00 -1.0000E+02 -8.3333E+01
       901     0.0000E+00 -1.0000E+02 -8.3333E+01
       911     0.0000E+00 -1.0000E+02 -8.3333E+01

 *----------*
 ANALYSIS LOG
 *----------*

   Step         Load Event Event        Event Group Elem Event    Max
Force  Max Moment
    No.       Factor   No.  Type        Factor   No.  No.  Code
Unbalance   Unbalance

      1  1.0000E+00     1     5  1.0000E+00
5.5434E+01  3.3308E+01

 COMPLETED : SEGMENT LOAD FACTOR INCREMENT

 *------------------------------*
 SUCCESSFUL COMPLETION OF ANALYSIS
 *------------------------------*

 *----------------------------------------------------------------------
----------*
 *ACCN : New Ground Acceleration Analysis -
 *----------------------------------------------------------------------
----------*

 Control Information

   Time increment for analysis segment =  2.5895E+01
   Maximum number of time steps        =  6000
   Time step code                      = 1 (constant)
   Time step                           =  5.0000E-03
   X coordinate of center of rotation  =  0.0000E+00
   Y coordinate of center of rotation  =  0.0000E+00

 Ground Acceleration Records

   Dirn Record Acceleration     Time
   Code   Name Scale Factor Scale Factor

      1   duzt  1.00000E+00  1.00000E+00

 *-----------------------------------------------*
 BEGIN GROUND ACCELERATION ANALYSIS, SEGMENT NO.   2
 *-----------------------------------------------*

 *----------*
 ANALYSIS LOG   (REMOVED)
 *----------*

 COMPLETED : MAXIMUM TIME FOR RESPONSE

 *------------------------------*
 SUCCESSFUL COMPLETION OF ANALYSIS
```

```
*--------------------------------*

*------------------------------*
*STOP : END OF ANALYSIS SESSION
*------------------------------*
No data errors found
```

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