COMPUTERS &
STRUCTURES
INC.

ETABS®

Examples Manual

Version 6.2
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Developed and written in U.S.A.

Table of Contents

Introduction

This manual presents a set of sample building systems that have been analyzed using the ETABS Version 6.1 computer program. The examples demonstrate some of the capabilities of the ETABS system. For purposes of verification, key results from some of the examples are compared with known results where available. The verification problems cover each type of element and include both static and dynamic analysis options.

For each example, this manual contains: a short description of the problem; a list of significant ETABS options activated; a comparison of key results with theoretical results or results from other computer programs, if available; and a listing of the input data. For some examples, selected output is also provided.

The input data files and selected output files associated with the sample problems are provided on the ETABS disk set. The input data filenames associated with a particular problem are identified in the section describing the corresponding example.

Example 1

Plane Frame with Beam Span Loads
Static Gravity Load Analysis

Description

This is a one story two-dimensional frame, subjected to vertical static loading.

The frame geometry and loading patterns are shown in Figure 1-1.

Significant Options of ETABS Activated

- Two-dimensional frame analysis
- Vertical beam span loading
- No rigid joint offsets on beams and columns
- Column pinned end connections

Computer Model

The frame is a 3-column line, 2-bay system. Kip-inch-second units are used. The modulus of elasticity is 3000 ksi. All columns are 12" x 24", all beams are 12" x 30".

To be able to compare ETABS results with theoretical results using prismatic members and elementary beam theory, rigid joint offsets on columns and beams are not modeled, and axial and shear deformations are neglected. This is done by not using the automatic property generation feature of ETABS; instead, the axial area and moment of inertia for each member are explicitly input.

The input data file for this example is EX1. A listing of this input data is given in Figure 1-2.

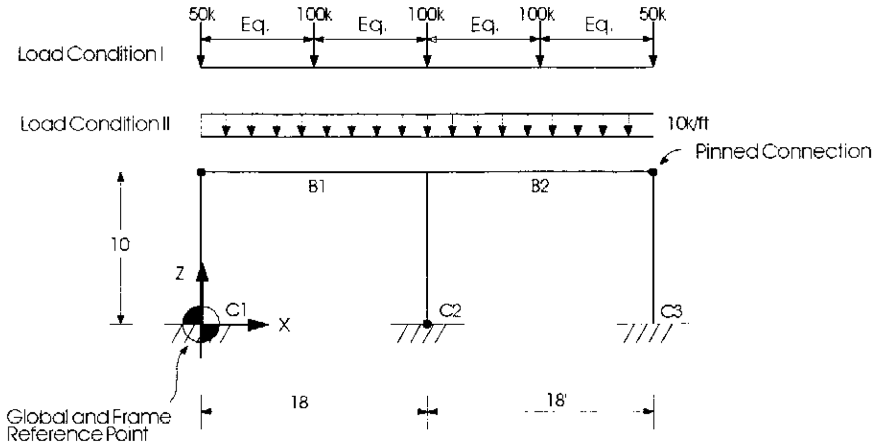
Comparison of Results

The theoretical results for bending moments and shear forces on beams B1 and B2 are easily obtained from tabulated values for propped cantilevers (see Reference [1]). These values for beam B1 are compared with ETABS results in Figure 1-3. As expected, the results are identical.

Selected output for frame member forces for this example is included in this manual.

References

1. **American Institute of Steel Construction**
Manual of Steel Construction-Allowable Stress Design, Chicago, Illinois, 1989.



Frame Elevation and Loads

Example 1
Plane Frame with Beam Span Loads
Figure 1-1

```
$ --------------------------- Heading
 ETABS 6.1
 Example 1 : Plane Frame With Beam Span Loads
             Static Gravity Load Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 1 1 1 1 0 2 0 1 1 1 0 0 0 0 0 0 1 0 0 0 1
 386.4
$ --------------------------- Story Data
 1st 10*12  0
$ --------------------------- Material Data
 1 c 3000
$ --------------------------- Column Properties
 1  user 1
 1e7 0 0 0 24P3*12/12
$ --------------------------- Beam Properties
 1  user 1
 0 0 0 0 30P3*12/12
$ --------------------------- Frame Data
 Two Bay Plane Frame in X-Z plane
 1 3 2 0 2 2 0 0 0 0 0 1
$ --------------------------- Column Line Location
 1 0
 2 18*12
 3 36*12
$ --------------------------- Bay Connectivity
 1 1 2
 2 2 3
$ --------------------------- Joint Loading Patterns
 1 50   0  0
 2 100 0   0
$ --------------------------- Beam Span Loading Patterns
 1 1
 9*12 100
 2 0 10/12
$ --------------------------- Column Assignments
 1 1 0 1st 1st 1 2 0
 2 2 0 1st 1st 1 1 0
 3 3 1
                             $ Leave a Blank Line
$ --------------------------- Beam Assignments
 1 2 0 1st 1st 1
                             $ Leave a Blank Line
$ --------------------------- Joint Load Assignments
 1 1 0 1st 1st 1 0 0
 2 2 0 1st 1st 2 0 0
 3 3 1
                             $ Leave a Blank Line
$ --------------------------- Beam Span Load Assignments
 1 2 0 1st 1st 1 2 0
                             $ Leave a Blank Line
$ --------------------------- Frame Location Data
 1 0 0 0 /Two Bay Frame
$ --------------------------- Load Case Data
 1 0 1
 2 0 0 1
$ ***** End of Input Data *****
```

Example 1
*Listing of Input Data (File: **EX1**)*
Figure 1-2

Quantity	Location	Load Case I (Concentrated Load)	
		ETABS	**Theoretical**
Bending Moments	End I	0.00	0.00
	1/4 Point	1687.50	1687.50
	1/2 Point	3375.00	3375.00
	3/4 Point	- 337.50	- 337.50
	End J	-4050.00	- 4050.00
Shear Forces	End I	- 31.25	- 31.25
	1/4 Point	- 31.25	- 31.25
	1/2 Point	68.75	68.75
	3/4 Point	68.75	68.75
	End J	68.75	68.75

Quantity	Location	Load Case II (Uniformly Distributed Load)	
		ETABS	**Theoretical**
Bending Moments	End I	0.00	0.00
	1/4 Point	2430.00	2430.00
	1/2 Point	2430.00	2430.00
	3/4 Point	0.00	0.00
	End J	- 4860.00	- 4860.00
Shear Forces	End I	- 67.50	- 67.50
	1/4 Point	- 22.50	- 22.50
	1/2 Point	22.50	22.50
	3/4 Point	67.50	67.50
	End J	112.50	112.50

Example 1
Comparison of Results for Beam B1
Figure 1-3

CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS PAGE 1
PROGRAM:ETABS/FILE:ex1.FRM

EXAMPLE 1 : PLANE FRAME WITH BEAM SPAN LOADS
STATIC GRAVITY LOAD ANALYSIS UNITS: KIP-INCH-SECOND

COLUMN FORCES AT LEVEL 1ST IN FRAME /TWO BAY FRAME

COL ID	OUTPUT ID	OUTPUT POINT	MAJOR MOMENT	MAJOR SHEAR	MINOR MOMENT	MINOR SHEAR	AXIAL FORCE	TORSIONAL MOMENT
1	CASE 1	TOP	.00	.00	.00	.00	-81.25	.00
		BOTTOM	.00		.00			
1	CASE 2	TOP	.00	.00	.00	.00	-67.50	.00
		BOTTOM	.00		.00			
2	CASE 1	TOP	.00	.00	.00	.00	-237.50	.00
		BOTTOM	.00		.00			
2	CASE 2	TOP	.00	.00	.00	.00	-225.00	.00
		BOTTOM	.00		.00			
3	CASE 1	TOP	.00	.00	.00	.00	-81.25	.00
		BOTTOM	.00		.00			
3	CASE 2	TOP	.00	.00	.00	.00	-67.50	.00
		BOTTOM	.00		.00			

BEAM FORCES AT LEVEL 1ST IN FRAME /TWO BAY FRAME

BAY ID	OUTPUT ID	OUTPUT POINT	MAJOR MOMENT	MAJOR SHEAR	MINOR MOMENT	MINOR SHEAR	AXIAL FORCE	TORSIONAL MOMENT
1	CASE 1	END-I	.00	-31.25	.00	.00	.00	.00
		1/4-PT	1687.50	-31.25	.00			
		1/2-PT	3375.00	68.75	.00			
		3/4-PT	-337.50	68.75	.00			
		END-J	-4050.00	68.75	.00			
1	CASE 2	END-I	.00	-67.50	.00	.00	.00	.00
		1/4-PT	2430.00	-22.50	.00			
		1/2-PT	2430.00	22.50	.00			
		3/4-PT	.00	67.50	.00			
		END-J	-4860.00	112.50	.00			
2	CASE 1	END-I	-4050.00	-68.75	.00	.00	.00	.00
		1/4-PT	-337.50	-68.75	.00			
		1/2-PT	3375.00	-68.75	.00			
		3/4-PT	1687.50	31.25	.00			
		END-J	.00	31.25	.00			
2	CASE 2	END-I	-4860.00	-112.50	.00	.00	.00	.00
		1/4-PT	.00	-67.50	.00			
		1/2-PT	2430.00	-22.50	.00			
		3/4-PT	2430.00	22.50	.00			
		END-J	.00	67.50	.00			

Example 1
Sample Output

Example 2

Three Story Plane Frame Dynamic Response Spectrum Analysis

Description

This is a three story plane frame subjected to the El Centro 1940 seismic response spectra, N-S component, 5 percent damping.

The frame geometry is shown in Figure 2-1.

Significant Options of ETABS Activated

- Two-dimensional frame analysis
- Rigid joint offsets on beams and columns automatically calculated
- Dynamic response spectrum analysis

Computer Model

The frame is modeled as a 2-column line, single bay system. Kip-inch-second units are used. Other parameters associated with the structure are as follows:

All columns are W14X90
All beams are infinitely rigid and 24" deep
Modulus of elasticity = 29500 ksi
Typical story mass = 0.4 kip-sec^2/in

The column is modeled to have infinite axial area, so that axial deformation is neglected. Also, zero column shear area is input to trigger the ETABS option of neglecting shear deformations. These deformations are neglected to be consistent with the hand-calculated model with which the results are compared.

The input data file for this example is EX2. The response spectrum file is ELCN-RS1. These files are listed in Figures 2-2 and 2-3.

Comparison of Results

Assuming the beams to be rigid and a rigid offset at the column top ends of 24 inches (i.e. equal to the depth of the beams), and neglecting both shear deformations and axial deformations, the story lateral stiffness for this example can be calculated (see Reference [1]).

The example then reduces to a three spring, three mass system with equal stiffnesses and masses. This can be analyzed using any exact method (see Reference [2]) to obtain the three natural periods and mass normalized mode shapes of the system.

The three theoretical natural periods and mass normalized mode shapes are compared in Figure 2-4 with ETABS results. As expected, the results are identical.

The spectral accelerations at the three natural periods can then be linearly interpolated from the response spectrum used.

The spectral accelerations can in turn be used with the mode shapes and story mass information to obtain the modal responses (see Reference [2]). The modal responses for story displacements and column moments can then be combined using the complete quadratic combination procedure (see Reference [3]).

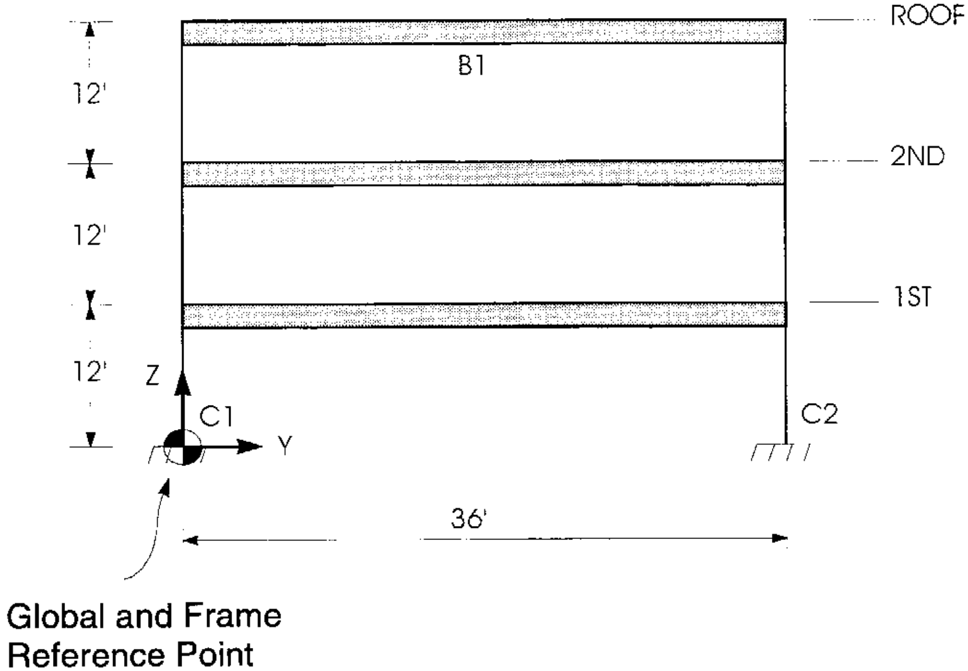
The story displacements and column moments thus obtained are compared in Figure 2-5 with ETABS results. As expected, the results are identical.

References

1. **Przemieniecki, J.S.**
   Theory of Matrix Structural Analysis, Mc-Graw-Hill, 1968.

2. **Paz, M.**
   Structural Dynamics, Theory and Computations, Van Nostrand Reinhold, 1985.

3. **Wilson, E.L., Kiureghian, A.D. and Bayo, E.P.**
   A Replacement for the SRSS Method in Seismic Analysis, Earthquake Engineering and Structural Dynamics, Vol. 9, 1981.



Example 2
Three-story Plane Frame
Figure 2-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 2 : Three Story Plane Frame
             Dynamic Response Spectrum Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 3 1 1 1 0 1 3 1 1 1 0 0 0 0 0 0 2 2 0 0 0 1
 386.4
$ -------------------------- Story Data
 roof 12*12 1
 1 0 0.4
 2nd 12*12 1
 1 0 0.4
 1st 12*12 1
 1 0 0.4
$ -------------------------- Material Data
 1 s 29500
$ -------------------------- Column Properties
 1 user 1
 1e7 0 0 0 999    $ W14x90 Neglecting Axial and Shear Deformations
$ -------------------------- Beam Properties
 1 user 1 24
 0 0 0 0 1e9
$ -------------------------- Frame Data
 Three Story Plane Frame in Y-Z Plane
 1 2 1
$ -------------------------- Column Line Location
 1 0 0 90
 2 0 36*12 90
$ -------------------------- Bay Connectivity
1 1 2
$ -------------------------- Column Assignments
 1 2 0 roof 1st 1

$ -------------------------- Beam Assignments
 1 1 0 roof 1st 1

$ -------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ -------------------------- Response Spectrum Data
 Spectrum Applied in Y Direction as L.C. D2
 0 CQC 0.05

 ELCN-RS1 386.4 1
$ --------------------------  Load Case Data
1 0 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 2
*Listing of Input Data (File: **EX2**)*
Figure 2-2

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLES EX2, EX4 AND EX19
$ DAMPING
    0.05
$ PERIOD     PSA
      .0    .3275
   .0263    .3299
   .0270    .3297
   .0278    .3429
   .0286    .3544
   .0294    .3626
   .0303    .3683
   .0313    .3676
   .0323    .3629
   .0333    .3604
   .0345    .3637
   .0357    .3632
   .0370    .3610
   .0385    .3585
   .0400    .3551
   .0417    .3458
   .0435    .3436
   .0455    .3465
   .0476    .3528
   .0500    .3542
   .0526    .3544
   .0556    .3546
   .0588    .3917
   .0625    .4305
   .0667    .4455
   .0714    .4784
   .0769    .5053
   .0833    .5181
   .0909    .4776
   .0966    .5526
   .1000    .5816
   .1015    .5846
   .1070    .5548
   .1130    .5292
   .1198    .5952
   .1274    .6373
   .1361    .6615
   .1460    .6885
   .1575    .8712
   .1709    .8167
   .1869    .9879
   .2062    .9697
   .2299    .7006
   .2597    .8576
   .2985    .7385
   .3509    .8705
   .4255    .9090
   .5405    .9824
   .7407    .4761
  1.1765    .2713
  2.8571    .1983
```

Example 2
*Listing of Input Data (File: **ELCN-RS1**)*
Figure 2-3

ETABS

Quantity	Mode 1	Mode 2	Mode 3
Period, secs.	0.4414	0.1575	0.1090
Mode Shape:			
Level,			
Roof	1.165	0.934	0.519
2nd	0.934	- 0.519	- 1.165
1st	0.519	- 1.165	0.934

Theoretical

Quantity	Mode 1	Mode 2	Mode 3
Period, secs.	0.4414	0.1575	0.1090
Mode Shape:			
Level,			
Roof	1.165	0.934	0.519
2nd	0.934	- 0.519	- 1.165
1st	0.519	- 1.165	0.934

Example 2
Comparison of Results for Periods and Mode Shapes
Figure 2-4

Quantity	ETABS	Theoretical
Displacement at Level		
Roof	2.139	2.139
2nd	1.716	1.719
1st	0.955	0.955
Base Moment Column C1	11730	11730

Example 2
Comparison of Results for Displacements and Column Moments
Figure 2-5

Example 3

Three Story Plane Frame Code Specified Static Lateral Load Analysis

Description

This is a three story plane frame which has been analyzed three times under the following code specified lateral load cases:

- UBC 1994 specified seismic loads (Reference [1])
- ATC 3-06 specified seismic loads (Reference [2])
- UBC 1994 specified wind loads (Reference [1])

The frame geometry is shown in Figure 3-1.

Significant Options of ETABS Activated

- Two-dimensional frame analysis
- Section properties automatically recovered from AISC data base
- Automatic generation of UBC 1994 seismic loads

- Automatic generation of ATC 3-06 seismic loads
- Automatic generation of UBC 1994 wind loads

Computer Model

The frame is modeled as a 2-column line, single bay system. Kip-inch-second units are used. Other parameters associated with the structure are as follows:

All columns are W14X90	
All beams are infinitely rigid and 24" deep	
Modulus of elasticity	= 29500 ksi
Poisson's ratio	= 0.3
Typical story mass	= 0.4 kip-sec^2/in

For the UBC94 seismic load analysis, the input data file is EX3a. A listing of the input data is given in Figure 3-2. Code parameters associated with the analysis are as follows:

UBC zone factor, Z	= 0.40
UBC Soil Profile Factor, S	= 1.2
UBC Importance factor, I	= 1.25
UBC Structural System coefficient, R_W	= 12
UBC Method A time period, T_a	= 0.5144 sec

For the ATC seismic load analysis, the input data file is EX3b. A listing of the input data is given in Figure 3-4. Code parameters associated with the analysis are as follows:

ATC coefficient, A_V	= 0.4 g
ATC coefficient, S	= 1.2
ATC coefficient, R	= 8
ATC time period, T_a	= 0.5144 sec

For the UBC94 wind load analysis, the input data file is EX3c. A listing of the input data is given in Figure 3-6. Exposure and code parameters associated with the analysis are as follows:

Width of structure supported by frame	= 20 ft
UBC Basic wind speed	= 100 mph

UBC Exposure type = C
UBC Importance factor, I = 1

Comparison of Results

For each of the static lateral load analyses, the story shears can be computed using the formulae given in the applicable references. For the seismic loads, the fundamental period computed by ETABS can be used in the formulae. From ETABS results, this fundamental period is 0.5203 seconds. (Note the difference between the calculated fundamental period for this example and Example 2, which neglects shear and axial deformations.)

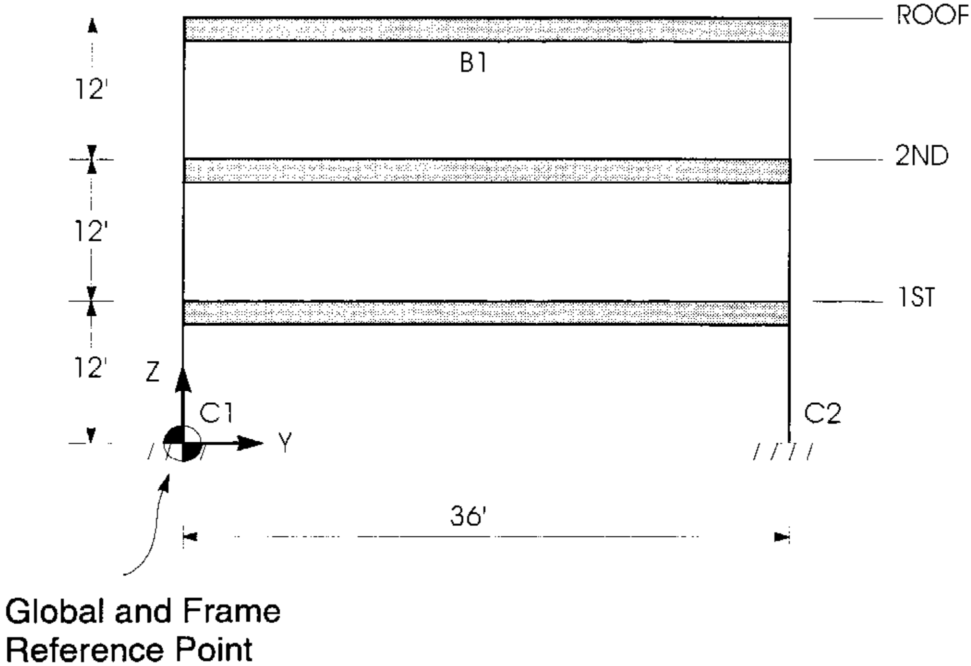
Hand-calculated story shears are compared with story shears produced by the ETABS program in Figure 3-3 for UBC seismic loads, Figure 3-5 for ATC seismic loads and Figure 3-7 for UBC wind loads. As expected, the values are identical.

Selected output for story displacements and shears for Example EX3c is included in this manual.

References

1. **International Conference of Building Officials**
Uniform Building Code, Whittier, California, 1994.

2. **Applied Technology Council**
Tentative Provisions for the development of Seismic Regulations for Buildings, ATC3-06, Palo Alto, California, 1978.



Example 3
Three-story Plane Frame
Figure 3-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 3a : Three Story Plane Frame
              UBC 1994, Seismic Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 3 1 1 1 0 1 3 1 1 1 0 0 0 0 11 1 2 0 0 0 1
 386.4
$ -------------------------- Story Data
 roof 12*12 1
 1 0 0.4
 2nd 12*12 1
 1 0 0.4
 1st 12*12 1
 1 0 0.4
$ -------------------------- Material Data
 1 s 29500 .3  .49/1728
$ -------------------------- Column Properties
 1  W14x90 1
$ -------------------------- Beam Properties
 1  user 1  24
 0 0 0 0 1e9
$ -------------------------- Frame Data
 Three Story Plane Frame
 1 2 1
$ -------------------------- Column Line Location
 1 0 0 90
 2 0 36*12 90
$ -------------------------- Bay Connectivity
1 1 2
$ -------------------------- Column Assignments
 1 2 0 roof 1st 1

$ -------------------------- Beam Assignments
 1 1 0 roof 1st 1

$ -------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ -------------------------- UBC '94 Seismic Data
 0.4 1.25 1.2
 0 0.514 12
 0 0.514 12
 0.0  0.0
 0.0  0.0
 0.0  0.0
$ -------------------------- Load Case Data
1 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 3a
*Listing of Input Data (File: **EX3a**)*
Figure 3-2

Level	ETABS (kips)	Theoretical (kips)
Roof	22.40	22.40
2nd	37.33	37.33
Ist	44.80	44.80

Example 3a
Comparison of Results for Story Shears
Figure 3-3

```
$ --------------------------- Heading
 ETABS 6.1
 Example 3b : Three Story Plane Frame
              ATC 3-06, Seismic Load Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 3 1 1 1 0 1 3 1 1 1 0 0 0 0 14 1 2 0 0 0 1
 386.4
$ --------------------------- Story Data
 roof 12*12 1
 1 0 0.4
 2nd 12*12 1
 1 0 0.4
 1st 12*12 1
 1 0 0.4
$ --------------------------- Material Data
 1 s 29500 .3 .49/1728
$ --------------------------- Column Properties
 1  W14x90 1
$ --------------------------- Beam Properties
 1  user 1 24
 0 0 0 0 1e9
$ --------------------------- Frame Data
 Three Story Plane Frame
 1 2 1
$ --------------------------- Column Line Location
 1 0 0 90
 2 0 36*12 90
$ --------------------------- Bay Connectivity
1 1 2
$ --------------------------- Column Assignments
 1 2 0 roof 1st 1

$ --------------------------- Beam Assignments
 1 1 0 roof 1st 1

$ --------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ --------------------------- ATC 3-06 Seismic Data
 0.40 0.40 1.2
 0 0.5144 8
 0 0.5144 8
 0.0  0.0
 0.0  0.0
 0.0  0.0
$ --------------------------- Load Case Data
1 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 3b
*Listing of Input Data (File:**EX3b**)*
Figure 3-4

Level	ETABS (kips)	Theoretical (kips)
Roof	25.89	25.89
2nd	43.08	43.08
Ist	51.61	51.61

Example 3b
Comparison of Results for Story Shears
Figure 3-5

```
$ -------------------------- Heading
 ETABS 6.1
 Example 3c : Three Story Plane Frame
              UBC 1994, Wind Load Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 3 1 1 1 0 1 0 1 1 1 0 0 0 0 21 0 2 0 0 0 1
 386.4
$ --------------------------- Story Data
 roof 12*12 1
 1 0 0.4
 2nd 12*12 1
 1 0 0.4
 1st 12*12 1
 1 0 0.4
$ --------------------------- Material Data
 1 s 29500
$ --------------------------- Column Properties
 1  W14x90 1
$ --------------------------- Beam Properties
 1  user 1 24
 0 0 0 0 1e9
$ --------------------------- Frame Data
 Three Story Plane Frame
 1 2 1
$ --------------------------- Column Line Location
 1 0 0 90
 2 0 36*12 90
$ --------------------------- Bay Connectivity
1 1 2
$ --------------------------- Column Assignments
 1 2 0 roof 1st 1

$ --------------------------- Beam Assignments
 1 1 0 roof 1st 1

$ --------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ --------------------------- UBC '94 Wind Data
 100 c 1
                             $ Wind Exposure Extend to Structural
                             $ Baseline in Both X and Y directions
 0 0 20*12
 0 0 20*12
 0 0 20*12
$ --------------------------- Load Case Data
1 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 3c
Listing of Input Data (File: ***EX3c****)*
Figure 3-6

Level	ETABS (kips)	Theoretical (kips)
Roof	5.15	5.15
2nd	14.74	14.75
1st	23.39	23.40

Example 3c
Comparison of Results for Story Shears
Figure 3-7

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    1
                                                  PROGRAM:ETABS/FILE:ex3c.STR
 EXAMPLE 3C : THREE STORY PLANE FRAME
 UBC 1994, WIND LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 STATIC LOAD CONDITION LATERAL DISPLACEMENTS FOR DIAPHRAGM     1

 VALUES ARE AT THE CENTER OF MASS OF THE
 CORRESPONDING DIAPHRAGM IN GLOBAL COORDINATES

                 /---------------------LOAD CONDITIONS---------------------/
 LEVEL     DIRN             I         II        III          A         B         C

 ROOF         Y     0.0000    0.0000    0.0000    0.0000    0.1388    0.0000

 2ND          Y     0.0000    0.0000    0.0000    0.0000    0.1208    0.0000

 1ST          Y     0.0000    0.0000    0.0000    0.0000    0.0734    0.0000
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    3
                                                  PROGRAM:ETABS/FILE:ex3c.STR
 EXAMPLE 3C : THREE STORY PLANE FRAME
 UBC 1994, WIND LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 STATIC LOAD CONDITION LATERAL STORY SHEARS FOR DIAPHRAGM     1

                 /---------------------LOAD CONDITIONS---------------------/
 LEVEL     DIRN             I         II        III          A         B         C

 ROOF         Y       0.00      0.00      0.00      0.00      5.15      0.00

 2ND          Y       0.00      0.00      0.00      0.00     14.74      0.00

 1ST          Y       0.00      0.00      0.00      0.00     23.40      0.00
```

Example 3c
Sample Output

Example 4

Single Story Three-Dimensional Frame Dynamic Response Spectrum Analysis

Description

This is a one story, four bay, three-dimensional frame. The frame is subjected to the El Centro 1940 N-S component seismic response spectrum, for 5 percent damping, in two orthogonal directions.

The frame geometry is shown in Figure 4-1.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Automatic story mass calculation
- Dynamic response spectrum analysis

Computer Model

The structure is modeled as a single frame with four column lines and four bays. Kip-inch-second units are used. Other parameters associated with the structure are as follows:

Columns on lines C1 and C2 24" x 24"
Columns on lines C3 and C4 18" x 18"
All beams infinitely rigid and 36" deep

Modulus of elasticity = 3000 ksi
Story weight = 150 psf

The columns are modeled to neglect shear and axial deformations to be consistent with the assumptions of hand calculations with which the results are compared below.

The input data file for this example is EX4. The response spectrum file is ELCN-RS1. These files are listed in Figures 4-2 and 4-3.

Comparison of Results

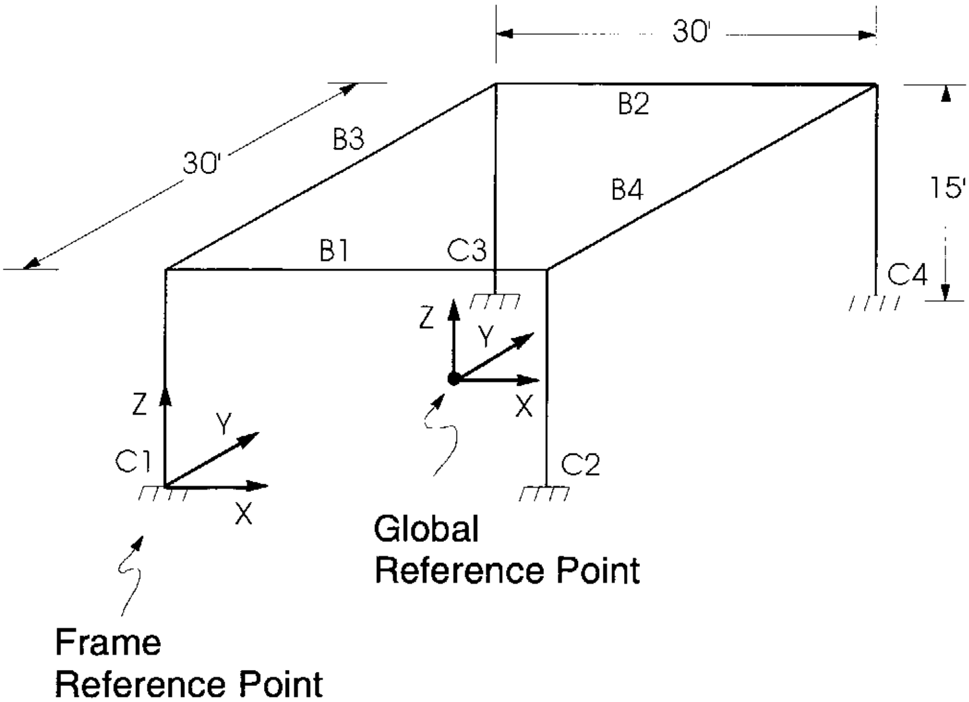
The example is a three degree of freedom system. From the individual column lateral stiffnesses assuming rigid beams and rigid offsets at column top ends equal to 36 inches (i.e. the depth of the beams), and neglecting both shear deformations and column axial deformations, the structural stiffness matrix can be assembled (see Reference [1]).

From the stiffness and mass matrices of the system, the three natural periods and mass normalized mode shapes of the system can be obtained (see Reference [2]). These are compared in Figure 4-4 with ETABS results. As expected, the results are identical.

References

1. **Przemieniecki, J.S.**
   Theory of Matrix Structural Analysis, McGraw-Hill, 1968.

2. **Paz, M.**
   Structural Dynamics, Theory and Computations, Van Nostrand Reinhold, 1985.



Example 4
Single Story Three-dimensional Frame
Figure 4-1

```
$ --------------------------- Heading
 ETABS 6.1
 Example 4 : Single Story Three-Dimensional Frame
             Dynamic Response Spectrum Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 1 1 1 1 1 2 3 1 2 1 0 0 0 0 0 2 0 0 0 0 1
 386.4
$ --------------------------- Mass Data
 1 1 1/386.4
 rect .15/144 0 0 30*12 30*12
$ --------------------------- Story Data
 1st 15*12 1
1 1
$ --------------------------- Material Data
 1 c 3000
$ --------------------------- Column Properties
 1  user 1
 1e7 0 0 0 24p4/12 24p4/12
 2  user 1
 1e7 0 0 0 18p4/12 18p4/12
$ --------------------------- Beam Properties
 1  user 1 36
 0 0 0 0 1e9
$ --------------------------- Frame Data
 Single Story Three-Dimensional Frame
 1 4 4
$ --------------------------- Column Line Location
 1
 2 30*12
 3 0 30*12
 4 30*12 30*12
$ --------------------------- Bay Connectivity
1 1 2
2 3 4
3 1 3
4 2 4
$ --------------------------- Column Assignments
 1 2 0 1st 1st 1
 3 4 0 1st 1st 2

$ --------------------------- Beam Assignments
 1 4 0 1st 1st 1

$ --------------------------- Frame Location
 1 -15*12 -15*12 0 /Single Story 3-D Frame
$ --------------------------- Response Spectrum Data
 Elcentro Response Spectrum is Used
 0 CQC 0.05
 ELCN-RS1 386.4 1
 ELCN-RS1 386.4 1
$ ---------------------------  Load Case Data
1 0 0 0 0 0 0 0 1
2 0 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 4
*Listing of Input Data (File: **EX4**)*
Figure 4-2

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLES EX2, EX4 AND EX19
$ DAMPING
    0.05
$ PERIOD      PSA
      .0     .3275
   .0263     .3299
   .0270     .3297
   .0278     .3429
   .0286     .3544
   .0294     .3626
   .0303     .3683
   .0313     .3676
   .0323     .3629
   .0333     .3604
   .0345     .3637
   .0357     .3632
   .0370     .3610
   .0385     .3585
   .0400     .3551
   .0417     .3458
   .0435     .3436
   .0455     .3465
   .0476     .3528
   .0500     .3542
   .0526     .3544
   .0556     .3546
   .0588     .3917
   .0625     .4305
   .0667     .4455
   .0714     .4784
   .0769     .5053
   .0833     .5181
   .0909     .4776
   .0966     .5526
   .1000     .5816
   .1015     .5846
   .1070     .5548
   .1130     .5292
   .1198     .5952
   .1274     .6373
   .1361     .6615
   .1460     .6885
   .1575     .8712
   .1709     .8167
   .1869     .9879
   .2062     .9697
   .2299     .7006
   .2597     .8576
   .2985     .7385
   .3509     .8705
   .4255     .9090
   .5405     .9824
   .7407     .4761
  1.1765     .2713
  2.8571     .1983
```

Example 4
*Listing of Input Data (File: **ELCN-RS1**)*
Figure 4-3

Mode	Quantity	ETABS	Theoretical
1	Period, sec.	0.1389	0.1389
	Mode Shape		
	X- Translation	- 1.6244	-1.6244
	Y- Translation	0.0000	0.0000
	Z- Rotation	0.0032	0.0032
2	Period, sec.	0.1254	0.1254
	Mode Shape		
	X- Translation	0.0000	0.0000
	Y- Translation	1.6918	1.6918
	Z- Rotation	0.0000	0.0000
3	Period, sec.	0.0703	0.0703
	Mode Shape		
	X- Translation	0.4728	0.4728
	Y- Translation	0.0000	0.0000
	Z- Rotation	0.0111	0.0111

Example 4
Comparison of results for Periods and Mode Shapes
Figure 4-4

Example 5

Three Story Three-Dimensional Braced Frame Dynamic Response Spectrum Analysis

Description

This is an L-shaped building structure with four identical braced frames. All members (columns and braces) carry only axial loads.

The structure is subject to the El Centro 1940 N-S component seismic response spectrum in the X-direction. The structural damping is 5 percent. The geometry of the structure and a typical frame are shown in Figure 5-1.

Significant Options of ETABS Activated

- Three-dimensional structure analysis using planar frames
- Brace (diagonal) and column members with no bending stiffness
- Dynamic response spectrum analysis

Computer Model

The structure is modeled by appropriately placing four identical planar frames. Each frame is modeled by three column lines. Kip-inch-second units are used. The modulus of elasticity is taken as 29500 ksi and the typical member axial area as 6 in^2. A story mass of 1.242 kip-sec^2/in and a mass moment of inertia of 174907.4 kip-sec^2-in are used.

The input data file is EX5. The response spectrum data file is ELCN-RS2. These files are listed in Figures 5-2 and 5-3.

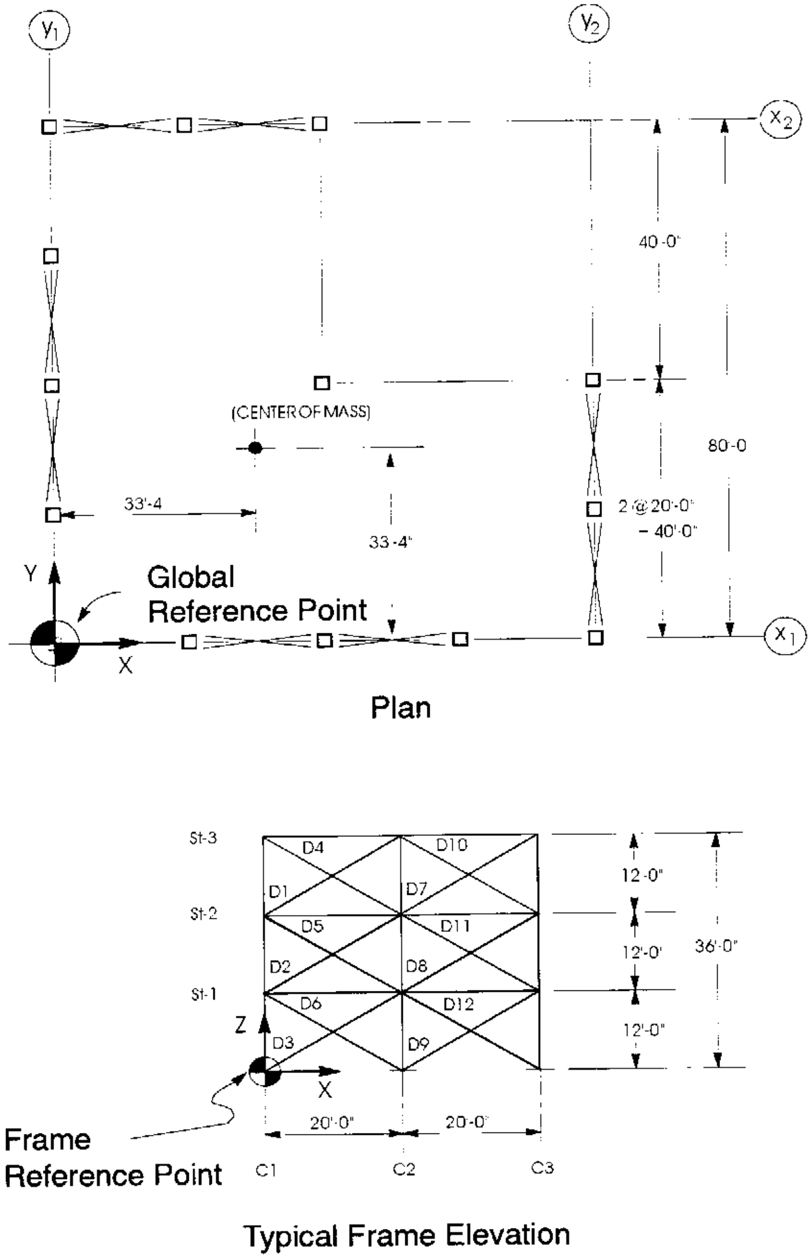
Comparison of Results

This example has been solved in References [1] and [2]. A comparison of ETABS results for natural periods and key member forces for one frame with References [1] and [2] is given in Figure 5-4. The agreement is excellent.

References

1. **Wilson, E.L. and Habibullah, A.**
   SAP90, Sample Example and Verification Manual, Computers and Structures, Inc., Berkeley, California, 1992.

2. **Peterson, F.E.**
   EASE2, Elastic Analysis for Structural Engineering - Example Problem Manual, Engineering Analysis Corporation, Berkeley, California, 1981.



Example 5
Three-story, Three-dimensional Braced Frame Building
Figure 5-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 5 : Three Story 3-D Braced Frame Building
 Dynamic Response Spectrum Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 3 1 1 4 0 1 2 1 1 0 0 1 0 0 0 2 0 0 0 0 1
 386.4
$ -------------------------- Story Data
 st-3 144 1
 1 0 1.242 174907.4 400 400
 st-2 144 1
 1 0 1.242 174907.4 400 400
 st-1 144 1
 1 0 1.242 174907.4 400 400
$ -------------------------- Material Data
 1 s 29500
$ -------------------------- Column Properties
 1  user 1
 6.0
$ -------------------------- Brace Properties
 1  user 1
 6.0
$ -------------------------- Frame Data
 Typical Braced Frame
 1 3 0 0 0 0 0 0 12
$ -------------------------- Column Line Location
 1 0
 2 240
 3 480
$ -------------------------- Column Assignments
 1 3 0 st-3 st-1 1

$ -------------------------- Brace Location and Assignments Data
 1 st-3 st-1 1 2 1
 4 st-3 st-1 2 1 1
 7 st-3 st-1 2 3 1
 10 st-3 st-1 3 2 1

$ -------------------------- Frame Location
 1 240 0  0 Frame on Global X-axis
 1 0 960  0 Frame Parallel to X-axis
 1 0 240 90 Frame on Global Y-axis
 1 960 0 90 Frame parallel to Y-axis
$ -------------------------- Response Spectrum Data
 Elcentro Response Spectrum is Used
 0 CQC 0.05
 ELCN-RS2 386.4 1

$ --------------------------  Load Case Data
 1 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 5
*Listing of Input Data (File: **EX5**)*
Figure 5-2

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLE EX5
$ DAMPING
    0.05
$ PERIOD      PSA
       0    .7385
   .2985    .7385
   .3509    .8705
       1    .8705
```

Example 5
Listing of Input Data (File: ***ELCN-RS2****)*
Figure 5-3

Quantity	ETABS	Reference 1	Reference 2
Period, Mode 1	0.32686	0.32689	0.32689
Period, Mode 2	0.32061	0.32064	0.32064
Axial Force Column C1, Story 1	279.39	279.47	279.48
Axial Force Brace D3	194.44	194.51	194.50
Axial Force Brace D9	120.49	120.53	120.52

Example 5
Comparison of Results
Figure 5-4

Example 6

Nine Story Ten Bay Plane Frame Eigenvalue Analysis

Description

This is a nine story, ten bay plane frame as shown in Figure 6-1.

An eigenvalue analysis is made.

Significant Options of ETABS Activated

- Two-dimensional frame analysis
- Eigenvalue analysis

Computer Model

The frame is modeled with eleven column lines and ten bays. Kip-ft-second units are used.

A modulus of elasticity of 432000 ksf is used. A typical member axial area of 3 ft^2 and moment of inertia of 1 ft^4 are used. A mass of 3 $kip\text{-}sec^2/ft/ft$ of member length is converted to story mass using tributary lengths and used for the analysis.

The input data filename for this example is EX6. A listing of the input data is given in Figure 6-2.

Comparison of Results

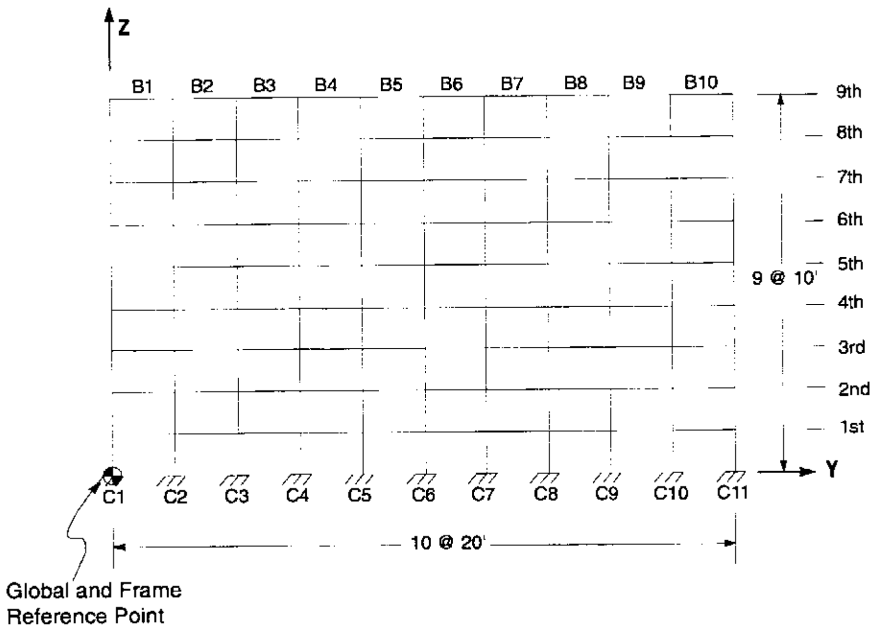
This example is also analyzed in References [1] and [2]. There are two differences between the ETABS analysis and the analyses of References [1] and [2]. The models of References [1] and [2] assign vertical and horizontal mass degrees of freedom to each joint in the structure. However, the ETABS model only assigns horizontal masses and additionally, only one horizontal mass is assigned for all the joints associated with any one floor level.

The eigenvalues obtained from ETABS are compared in Figure 6-3 with results from References [1] and [2]. Considering the differences in modeling enumerated above, the comparison is excellent.

References

1. **Wilson, E.L. and Habibullah, A.**
   SAP90, Sample Example and Verification Manual, Computers and Structures, Inc., Berkeley, California, 1992.

2. **Bathe, K.J. and Wilson, E.L.**
   Large Eigenvalue Problems in Dynamic Analysis, Journal of the Eng. Mech. Div., ASCE, Vol. 98, No. EM6, Proc. Paper 9433, December 1972.



Example 6
Nine-story, Ten-bay Plane Frame
Figure 6-1

```
$ --------------------------- Heading
 ETABS 6.1
 Example 6 : Nine Story Ten Bay Plane Frame
             Eigenvalue Analysis  Units: Kip-foot-second
$ --------------------------- Main Control Data
 9 1 1 1 0 0 8 1 1 1 0 0 0 0 0 1 2 0 4 0 5
 32.2
$ --------------------------- Story Data
 9th 10 1
 1 0 765
 8th 10 1
 1 0 930
 7th 10 1
 1 0 930
 6th 10 1
 1 0 930
 5th 10 1
 1 0 930
 4th 10 1
 1 0 930
 3rd 10 1
 1 0 930
 2nd 10 1
 1 0 930
 1st 10 1
 1 0 930
$ --------------------------- Material Data
 1 c 4.32e5
$ --------------------------- Column Properties
 1  user 1
 3.0 0 0 0 1.0
$ --------------------------- Beam Properties
 1  user 1
 3.0 0 0 0 1.0
$ --------------------------- Frame Data
 9-Story, 10-Bay Plane Frame
 1 11 10
$ --------------------------- Column Line Location
 1 0 0 90
 2 0 20 90
 3 0 40 90
 4 0 60 90
 5 0 80 90
 6 0 100 90
 7 0 120 90
 8 0 140 90
 9 0 160 90
 10 0 180 90
 11  0 200 90
$ --------------------------- Bay Connectivity
 1 1 2
 2 2 3
 3 3 4
 4 4 5
 5 5 6
 6 6 7
 7 7 8
 8 8 9
 9 9 10
 10 10 11
```

Example 6
*Listing of Input (File: **EX6**)*
Figure 6-2

```
$ --------------------------- Column Assignments
 1 11 0 9th 1st 1

$ --------------------------- Beam Assignments
 1 10 0 9th 1st 1

$ --------------------------- Frame Location
 1 0 0 0 2-D Frame
$ ***** End of Data Input *****
```

Example 6
*Listing of Input (File: **EX6**)*
Figure 6-2 (continued))

Mode	ETABS	Reference 1	Reference 2
1	0.58964	0.58954	0.58954
2	5.53195	5.52696	5.52695
3	16.5962	16.5879	16.5878

Example 6
Comparison of Results for Eigenvalues
Figure 6-3

Example 7

Seven Story Plane Frame Gravity and Lateral Loads Analysis

Description

This is a seven story plane frame. The gravity loads and the geometry of the frame are shown in Figure 7-1.

The frame is analyzed three times, subjected to the following lateral loads:

- Static lateral loads, shown in Figure 7-1
- Lateral loads resulting from the El Centro 1940 N-S component seismic response spectra, 5 percent damping
- Lateral loads resulting from the El Centro 1940 N-S component acceleration time history.

Significant Options of ETABS Activated

- Two-dimensional frame analysis
- User-specified section properties

- User-specified lateral loads
- Dynamic response spectrum analysis
- Dynamic time history analysis

Computer Model

The frame is modeled with three column lines and two bays. Kip-inch-second units are used. Since the wide flange members used in the frame are older sections, their properties are not available in the AISC section property data base included with the ETABS program, and the required properties therefore need to be explicitly provided in the input data.

The input data file for static lateral loads analysis is EX7a. A listing of this data file is given in Figure 7-2.

The input data file for dynamic response spectrum analysis is EX7b. The response spectrum file is ELCN-RS3. These files are listed in Figures 7-4 and 7-5.

The input data file for dynamic time history analysis is EX7c. The input history is ELCN-THU. These files are listed in Figures 7-8 and 7-9. Time history results are obtained for the first eight seconds of the excitation. This is consistent with Reference [2], with which the results are compared.

Comparison of Results

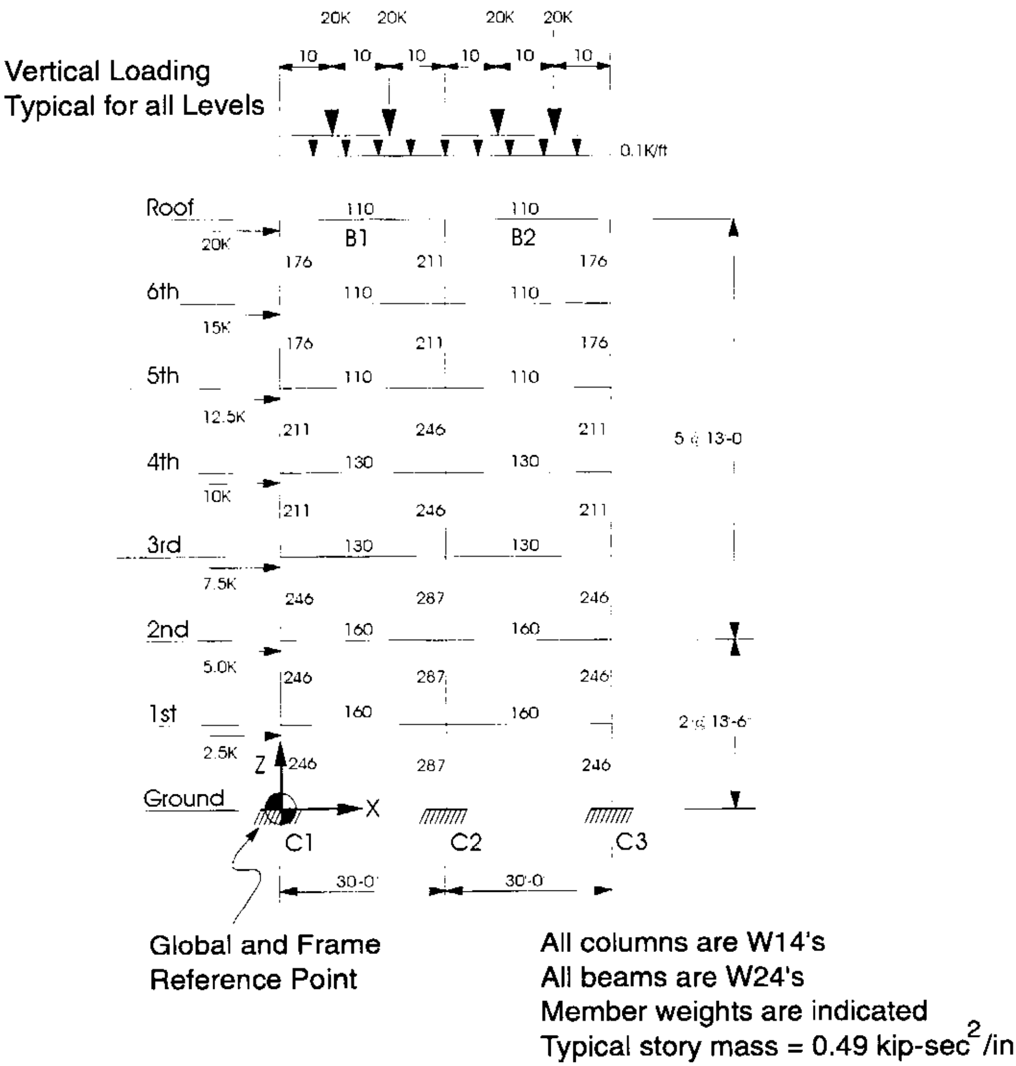
The example frame is analyzed in Reference [1] for gravity loads, static lateral loads and dynamic response spectrum loads. Reference [2] analyzes the example frame under static lateral loads and dynamic response spectrum and time history loads. A comparison of key ETABS results with Reference [1] and [2] results is presented in Figures 7-3, 7-6, 7-7 and 7-10. Note the difference in modal combination techniques between ETABS and Reference [1], which uses complete quadratic combination (CQC) and Reference [2], which uses square root of the sum of the squares combination (SRSS). The comparison of the results for all three analyses are excellent.

Selected output for story displacements, drifts and shears for Example EX7c is included in this manual.

References

1. **Wilson, E.L. and Habibullah, A.**
SAP90, Sample Example and Verification Manual, Computers and Structures, Inc., Berkeley, California, 1992.

2. *Static and Dynamic Analysis of Multistory Frame Structures Using DYNAMIC/EASE2*, Engineering Analysis Corporation and Computers and Structures, Inc. , Berkeley, California.



Example 7
Seven-story Plane Frame
Figure 7-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 7a : Seven Story Plane Frame
              Gravity and Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 7 1 1 1 0 2 0 1 4 3 0 0 0 0 1 0 1 0 4 0 1
 386.4
$ -------------------------- Story Data
 roof 156 1
 1 0
 6th 156 1
 1 0
 5th 156 1
 1 0
 4th 156 1
 1 0
 3rd 156 1
 1 0
 2nd 162 1
 1 0
 1st 162 1
 1 0
$ -------------------------- Material Data
 1 s 29500 .3 .49/1728
$ -------------------------- Column Properties
1  USER 1
 51.17  0  0  0  2150                    $W14X176
2  USER 1
 62.10  0  0  0  2670                    $W14X211
3  USER 1
 72.30  0  0  0  3230                    $W14X246
4  USER 1
 84.40  0  0  0  3910                    $W14X287
$ -------------------------- Beam Properties
1  USER 1
  0.0   0  0  0  3330                    $W24X110
2  USER 1
  0.0   0  0  0  4020                    $W24X130
3  USER 1
  0.0   0  0  0  5120                    $W24X160
$ -------------------------- Frame Data
 Seven Story Plane Frame
 1 3 2 0 0 1 0 0 0 0  0 2
$ -------------------------- Column Line Location
 1 0
 2 360
 3 720
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
$ -------------------------- Beam Span Loading Patterns
 1 2 .1/12
 120 20 240 20
$ -------------------------- Column Assignments
 1 1 0 roof 6th 1
 3 3 1
 1 1 0 5th 4th 2
 3 3 1
 1 1 0 3rd 1st 3
```

Example 7a
*Listing of Input Data (File: **EX7a**)*
Figure 7-2

```
 3 3 1
 2 2 0 roof 6th 2
 2 2 0 5th 4th 3
 2 2 0 3rd 1st 4
                                 $ Leave a Blank Line
$ -------------------------- Beam Assignments
 1 2 0 roof 5th 1
 1 2 0 4th 3rd 2
 1 2 0 2nd 1st 3
                                 $ Leave a Blank Line
$ -------------------------- Beam Span Load Assignments
 1 2 0 roof 1st 1
                                 $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 0 0 0 /7-Story Plane Frame
$ -------------------------- Lateral Loads Data
 roof 1 A 20
 6th  1 A 15
 5th  1 A 12.5
 4th  1 A 10
 3rd  1 A 7.5
 2nd  1 A 5
 1st  1 A 2.5
                                 $ Leave a Blank Line
$ -------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
$ ***** End of Input Data *****
```

Example 7a
Listing of Input Data (continued)
Figure 7-2

Quantity	ETABS	Reference 1	Reference 2
Lateral Displacement at Roof	1.4508	1.4508	1.4508
Axial Force Column C1 at Ground	69.99	69.99	69.99
Moment Column C1 at Ground	2324.68	2324.68	2324.68

Example 7a
Comparison of Results for Static Lateral Loads
Figure 7-3

```
$ -------------------------- Heading
 ETABS 6.1
 Example 7b : Seven Story Plane Frame
              Dynamic Response Spectrum Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 7 1 1 1 0 1 7 1 4 3 0 0 0 0 0 2 1 0 4 0 1
 386.4
$ -------------------------- Story Data
 roof 156 1
 1 0 .49
 6th 156 1
 1 0 .49
 5th 156 1
 1 0 .49
 4th 156 1
 1 0 .49
 3rd 156 1
 1 0 .49
 2nd 162 1
 1 0 .49
 1st 162 1
 1 0 .49
$ -------------------------- Material Data
 1 s 29500 .3 .49/1728
$ -------------------------- Column Properties
1  USER 1
 51.17  0   0   0   2150                    $W14X176
2  USER 1
 62.10  0   0   0   2670                    $W14X211
3  USER 1
 72.30  0   0   0   3230                    $W14X246
4  USER 1
 84.40  0   0   0   3910                    $W14X287
$ -------------------------- Beam Properties
1  USER 1
  0.0   0   0   0   3330                    $W24X110
2  USER 1
  0.0   0   0   0   4020                    $W24X130
3  USER 1
  0.0   0   0   0   5120                    $W24X160
$ -------------------------- Frame Data
 Seven Story Plane Frame
 1 3 2
$ -------------------------- Column Line Location
 1 0
 2 360
 3 720
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
$ -------------------------- Column Assignments
 1 1 0 roof 6th 1
 3 3 1
 1 1 0 5th 4th 2
 3 3 1
 1 1 0 3rd 1st 3
 3 3 1
 2 2 0 roof 6th 2
```

Example 7b
*Listing of Input Data (File: **EX7b**)*
Figure 7-4

```
 2 2 0 5th 4th 3
 2 2 0 3rd 1st 4
                              $ Leave a Blank Line
$ --------------------------- Beam Assignments
 1 2 0 roof 5th 1
 1 2 0 4th 3rd 2
 1 2 0 2nd 1st 3
                              $ Leave a Blank Line
$ --------------------------- Frame Location Data
 1 0 0 0 /7-Story Plane Frame
$ --------------------------- Response Spectrum Data
 Elcentro Response Spectrum
 0 cqc 0.05
 ELCN-RS3 386.4 1
                              $ No Y-direction input
$ --------------------------- Load Case Data
 1 0 0 0 0 0 0 0 1
$ ***** End of Input Data *****
```

Example 7b
Listing of Input Data (continued)
Figure 7-4

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLE EX7B
$ DAMPING
    0.05
$ PERIOD       PSA
   .0       .3275
   .0769   .505311
   .0795   .519598
   .08     .520045
   .0833   .518093
   .0870   .493366
   .0909   .477599
   .0951   .527825
   .0952   .530631
   .1000   .581609
   .1053   .564412
   .1111   .523663
   .1176   .572438
   .1190   .588211
   .1250   .627807
   .1333   .665413
   .1429   .636531
   .1538   .905796
   .1602   .804605
   .1667   .787220
   .1818   .943909
   .2000  1.005620
   .2222   .746135
   .2420   .704753
   .2500   .798052
   .2857   .718264
   .2985   .7385
   .3333   .880624
   .3509   .8705
   .4000   .882996
   .4313   .921167
   .5000  1.046620
   .6667   .641750
  1.0000   .482251
  1.2730   .258617
  2.0000   .160189
 10.0000   .0102
```

Example 7b
*Listing of Input Data (File: **ELCN-RS3**)*
Figure 7-5

Mode	ETABS	Reference 1	Reference 2
1	1.27321	1.27321	1.27321
2	0.43128	0.43128	0.43128
3	0.24204	0.24204	0.24204
4	0.16018	0.16018	0.16018
5	0.11899	0.11899	0.11899
6	0.09506	0.09506	0.09506
7	0.07951	0.07951	0.07951

Example 7b
Comparison of Results for Periods of Vibration
Figure 7-6

Quantity	ETABS CQC Combination	Reference 1 CQC Combination	Reference 2 SRSS Combination
Lateral Displacement at Roof	5.4314	5.4314	5.4378
Axial Force Column C1 at Ground	261.52	261.52	261.52
Moment Column C1 at Ground	9916.12	9916.12	9868.25

Example 7b
Comparison of Results for Response Spectrum Analysis
Figure 7-7

```
$ -------------------------- Heading
 ETABS 6.1
 Example 7c : Seven Story Plane Frame
              Dynamic Time History Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 7 1 1 1 0 1 7 1 4 3 0 0 0 0 0 3 1 0 4 0 1
 386.4
$ -------------------------- Story Data
 roof 156 1
 1 0 .49
 6th 156 1
 1 0 .49
 5th 156 1
 1 0 .49
 4th 156 1
 1 0 .49
 3rd 156 1
 1 0 .49
 2nd 162 1
 1 0 .49
 1st 162 1
 1 0 .49
$ -------------------------- Material Data
 1 s 29500 .3 .49/1728
$ -------------------------- Column Properties
1  USER 1
 51.17  0   0   0   2150                     $W14X176
2  USER 1
 62.10  0   0   0   2670                     $W14X211
3  USER 1
 72.30  0   0   0   3230                     $W14X246
4  USER 1
 84.40  0   0   0   3910                     $W14X287
$ -------------------------- Beam Properties
1  USER 1
  0.0   0   0   0   3330                     $W24X110
2  USER 1
  0.0   0   0   0   4020                     $W24X130
3  USER 1
  0.0   0   0   0   5120                     $W24X160
$ -------------------------- Frame Data
 Seven Story Plane Frame
 1 3 2
$ -------------------------- Column Line Location
 1 0
 2 360
 3 720
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
$ -------------------------- Column Assignments
 1 1 0 roof 6th 1
 3 3 1
 1 1 0 5th 4th 2
 3 3 1
 1 1 0 3rd 1st 3
 3 3 1
 2 2 0 roof 6th 2
```

Figure 7c
*Listing of Input Data (File: **EX7c**)*
Figure 7-8

```
 2 2 0 5th 4th 3
 2 2 0 3rd 1st 4
                               $ Leave a Blank Line
$ --------------------------- Beam Assignments
 1 2 0 roof 5th 1
 1 2 0 4th 3rd 2
 1 2 0 2nd 1st 3
                               $ Leave a Blank Line
$ --------------------------- Frame Location Data
 1 0 0 0 /7-Story Plane Frame
$ --------------------------- Seismic Time History Data
 Elcentro Time History
 0  400 .02 .05
 ELCN-THU 386.4 u 0 6 0
                               $ No Y-direction input
$ --------------------------- Load Case Data
 1 0 0 0 0 0 0 0 1
 ***** End of Input Data *****
```

Example 7c
Listing of Input Data (continued)
Figure 7-8

```
$ ELCENTRO TIME HISTORY IN G UNITS GIVEN IN UNEQUAL TIME STEPS
$ USED IN ETABS EXAMPLE EX7C
$     TIME        ACC        TIME        ACC        TIME        ACC
   0.00000     .01080     .04200     .00100     .09700     .01590
    .16100    -.00010     .22100     .01890     .26300     .00010
    .29100     .00590     .33200    -.00120     .37400     .02000
    .42900    -.02370     .47100     .00760     .58100     .04250
    .62300     .00940     .66500     .01380     .72000    -.00880
    .72010    -.02560     .78900    -.03870     .78910    -.05680
    .87200    -.02320     .87210    -.03430     .94100    -.04020
    .94110    -.06030     .99700    -.07890    1.06600    -.06660
   1.06610    -.03810    1.09400    -.04290    1.16800     .08970
   1.31500    -.16960    1.38400    -.08280    1.41200    -.08280
   1.44000    -.09450    1.48100    -.08850    1.50900    -.10800
   1.53700    -.12800    1.62800     .11440    1.70300     .23550
   1.80000     .14280    1.85500     .17770    1.92400    -.26100
   2.00700    -.31940    2.21500     .29520    2.27000     .26340
   2.32000    -.29840    2.39500     .00540    2.45000     .28650
   2.51900    -.04690    2.57500     .15160    2.65200     .20770
   2.70800     .10870    2.76900    -.03250    2.89300     .10330
   2.97600    -.08030    3.06800     .05200    3.12900    -.15470
   3.21200     .00650    3.25300    -.20600    3.38600     .19270
   3.41900    -.09370    3.53000     .17080    3.59900    -.03590
   3.66800     .03650    3.73800    -.07360    3.83500     .03110
   3.90400    -.18330    4.01400     .02270    4.05600    -.04350
   4.10600     .02160    4.22200    -.19720    4.31400    -.17620
   4.41600     .14600    4.47100    -.00470    4.61800     .25720
   4.66500    -.20450    4.75600     .06080    4.83100    -.27330
   4.97000     .17790    5.03900     .03010    5.10800     .21830
   5.19900     .02670    5.23300     .12520    5.30200     .12900
   5.33000     .10890    5.34300    -.02390    5.45400     .17230
   5.51000    -.10210    5.60600     .01410    5.69000    -.19490
   5.77300    -.02420    5.80000    -.00500    5.80900    -.02750
   5.86900    -.05730    5.88300    -.03270    5.92500     .02160
   5.98000     .01080    6.01300     .02350    6.08500    -.06650
   6.13200     .00140    6.17400     .04930    6.18800     .01490
   6.18810    -.02000    6.22900    -.03810    6.27900     .02070
   6.32600    -.00580    6.36800    -.06030    6.38200    -.01620
   6.40900     .02000    6.45900    -.01760    6.47800    -.00330
   6.52000     .00430    6.53400    -.00400    6.56200    -.00990
   6.57500    -.00170    6.60300    -.01700    6.64500     .03730
   6.68600     .04570    6.71400     .03850    6.72800     .00090
   6.76900    -.02880    6.76910     .00160    6.81100     .01130
   6.85200     .00220    6.90800     .00920    6.99100    -.09960
   7.07400     .03600    7.12100     .00780    7.14300    -.02770
   7.14900     .00260    7.17100     .02720    7.22600     .05760
   7.29500    -.04920    7.37000     .02970    7.40600     .01090
   7.42500     .01860    7.46100    -.02530    7.52500    -.03470
   7.57200     .00360    7.60000    -.06280    7.64100    -.02800
   7.66900    -.01960    7.69100     .00680    7.75200    -.00540
   7.79400    -.06030    7.83500    -.03570    7.87700    -.07160
   7.96000    -.01400    7.98700    -.00560    8.00100     .02220
   8.07000     .04680    8.12600     .02600    8.12610    -.03350
   8.19500    -.01280    8.22300     .06610    8.27800     .03050
   8.33400     .02460    8.40300     .03470    8.45800    -.03690
   8.53300    -.03440    8.59600    -.01040    8.63800    -.02600
   8.73500     .15340    8.81800    -.00280    8.86000     .02330
   8.88200    -.02610    8.91500    -.00220    8.95600    -.18490
   9.05300     .12600    9.09500     .03200    9.12300     .09550
```

Example 7c
Listing of Data File: ***ELCN-THU***
Figure 7-9

9.15000	.12460	9.25300	-.03280	9.28900	-.04510
9.42700	.13010	9.44100	-.16570	9.51000	.04190
9.63500	-.09360	9.70400	.08160	9.81500	-.08810
9.89800	.00640	9.93900	-.00060	9.99500	.05860
10.02200	-.07130	10.05000	-.04480	10.05010	-.02210
10.10500	.00930	10.10510	.00240	10.18800	.05100
10.27200	-.12430	10.38200	.05870	10.42400	.01330
10.45200	.03860	10.46500	.11640	10.50700	-.03740
10.53400	-.05720	10.64500	.03080	10.70100	.02230
10.71400	.05150	10.77000	.09030	10.83900	-.01940
10.92200	.04710	10.92210	-.06770	10.96400	-.07940
10.99100	-.01200	11.07400	.06080	11.08800	-.02690
11.11600	-.04160	11.20700	.02930	11.20710	.05520
11.22700	.07560	11.26800	.04310	11.32400	.02080
11.43400	.11800	11.57300	-.09990	11.65600	-.12470
11.72500	-.20940	11.72510	-.14180	11.78000	-.11630
11.80800	0.00000	11.87700	.07620	11.91900	.05700
11.98800	.13540	12.04300	.06730	12.11300	.08650

Example 7c
Listing of Input Data (continued)
Figure 7-9

Quantity	ETABS	Reference 2
Maximum Roof Displacement	5.49	5.48
Maximum Base Shear	285	284
Maximum Axial Force Column C1, at Ground	263	258
Maximum Moment Column C1, at Ground	9104	8740

Example 7c
Comparison of Results for Time History Analysis
Figure 7-10

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE     2
                                                      PROGRAM:ETABS/FILE:ex7c.STR
 EXAMPLE 7C : SEVEN STORY PLANE FRAME
 DYNAMIC TIME HISTORY ANALYSIS  UNITS: KIP-INCH-SECOND


 TIME HISTORY LATERAL DISPLACEMENTS FOR DIAPHRAGM     1

 VALUES ARE AT THE CENTER OF MASS OF THE
 CORRESPONDING DIAPHRAGM IN GLOBAL COORDINATES

                /--------LOAD CONDITION (DYN-1)--------/
                /------MAXIMUM-----//-----MINIMUM------/
 LEVEL     DIRN        VALUE      TIME      VALUE      TIME

 ROOF         X       5.4862    6.0400   -4.4613    6.7000

 6TH          X       5.0618    6.0600   -4.1164    6.7200

 5TH          X       4.3123    6.0800   -3.5456    6.7400

 4TH          X       3.4779    6.1000   -2.8909    6.7600

 3RD          X       2.5615    6.1400   -2.1482    6.7600

 2ND          X       1.6345    6.1400   -1.3843    5.5000

 1ST          X        .6500    6.1400    -.5695    5.4800


CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    3
                                                      PROGRAM:ETABS/FILE:ex7c.STR
 EXAMPLE 7C : SEVEN STORY PLANE FRAME
 DYNAMIC TIME HISTORY ANALYSIS  UNITS: KIP-INCH-SECOND


 TIME HISTORY LATERAL STORY INERTIA FORCES FOR DIAPHRAGM     1

 LOADS ARE AT THE CENTERS OF MASS OF THE RESPECTIVE STORY LEVELS

                /--------LOAD CONDITION (DYN-1)--------/
                /------MAXIMUM-----//-----MINIMUM------/
 LEVEL     DIRN        VALUE      TIME      VALUE      TIME

 ROOF         X       131.07      3.56   -119.91      2.96

 6TH          X        79.69      3.64    -84.74      2.06

 5TH          X        63.78      2.50    -74.95      3.10

 4TH          X        84.70      2.48    -64.39      3.14

 3RD          X        75.36      3.36    -96.01      2.72

 2ND          X        81.31      3.34    -95.77      2.74

 1ST          X        58.76      2.04    -69.50      2.24
```

Example 7c
Sample Output

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    5
                                                      PROGRAM:ETABS/FILE:ex7c.STR
 EXAMPLE 7C : SEVEN STORY PLANE FRAME
 DYNAMIC TIME HISTORY ANALYSIS  UNITS: KIP-INCH-SECOND


 TIME HISTORY LATERAL STORY SHEARS FOR DIAPHRAGM     1

                   /-------- LOAD CONDITION ( D1 )--------/
                   /------MAXIMUM-----//-----MINIMUM------/
 LEVEL     DIRN        VALUE      TIME     VALUE       TIME

 ROOF         X       131.07     3.560   -119.91      2.960

 6TH          X       179.08     3.560   -184.45      2.940

 5TH          X       206.36     6.040   -204.25      2.040

 4TH          X       223.20     6.040   -204.06      2.020

 3RD          X       249.04     6.120   -202.44      5.540

 2ND          X       274.64     6.140   -235.66      5.520

 1ST          X       284.70     6.160   -258.53      5.480
```

Example 7c
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    6
                                                    PROGRAM:ETABS/FILE:ex7c.STR
 EXAMPLE 7C : SEVEN STORY PLANE FRAME
 DYNAMIC TIME HISTORY ANALYSIS  UNITS: KIP-INCH-SECOND


 TIME HISTORY LATERAL FRAME DRIFT RATIOS  FOR DIAPHRAGM    1

 FRAME ID .... /7-STORY PLANE FRAME

 VALUES ARE AT THE FRAME ORIGIN IN THE FRAME LOCAL COORDINATES

                 /--------LOAD CONDITION (DYN-1)--------/
                 /------MAXIMUM-----//-----MINIMUM------/
 LEVEL     DIRN       VALUE      TIME      VALUE      TIME

 ROOF         X      .00422   3.56000   -.00400   2.96000
 ROOF         Y      .00000   8.00000    .00000   8.00000
 ROOF      ROTZ      .00000   8.00000    .00000   8.00000

 6TH          X      .00570   3.56000   -.00575   2.94000
 6TH          Y      .00000   8.00000    .00000   8.00000
 6TH       ROTZ      .00000   8.00000    .00000   8.00000

 5TH          X      .00602   6.04000   -.00580   2.04000
 5TH          Y      .00000   8.00000    .00000   8.00000
 5TH       ROTZ      .00000   8.00000    .00000   8.00000

 4TH          X      .00628   6.04000   -.00550   2.02000
 4TH          Y      .00000   8.00000    .00000   8.00000
 4TH       ROTZ      .00000   8.00000    .00000   8.00000

 3RD          X      .00607   6.10000   -.00496   6.74000
 3RD          Y      .00000   8.00000    .00000   8.00000
 3RD       ROTZ      .00000   8.00000    .00000   8.00000

 2ND          X      .00608   6.14000   -.00510   5.52000
 2ND          Y      .00000   8.00000    .00000   8.00000
 2ND       ROTZ      .00000   8.00000    .00000   8.00000

 1ST          X      .00401   6.14000   -.00352   5.48000
 1ST          Y      .00000   8.00000    .00000   8.00000
 1ST       ROTZ      .00000   8.00000    .00000   8.00000
```

Example 7c
Sample Output (continued)

Example 8

Two Story Three-Dimensional Frame Dynamic Response Spectrum Analysis

Description

This is a two story three-dimensional building frame subjected to a response spectrum of constant amplitude.

The geometry of the structure is shown in Figure 8-1.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- User-specified section properties
- Dynamic response spectrum analysis

Computer Model

The three-dimensional structure is modeled as a single frame with nine column lines and twelve bays. Kip-foot-second units are used.

For consistency with models documented in other computer programs with which the ETABS results are to be compared below, no story mass moments of inertia are assigned in the ETABS model. A response spectrum with a constant value of 0.4 g is used. Other parameters associated with the structure are as follows:

	Columns	**Beams**
Axial area	4 ft^2	5 ft^2
Minor moment of inertia	1.25 ft^4	1.67 ft^4
Major moment of inertia	1.25 ft^4	2.61 ft^4
Modulus of elasticity	350000 ksf	500000 ksf

The input data file is EX8. The response spectrum file is CON-RS. These files are listed in Figures 8-2 and 8-3.

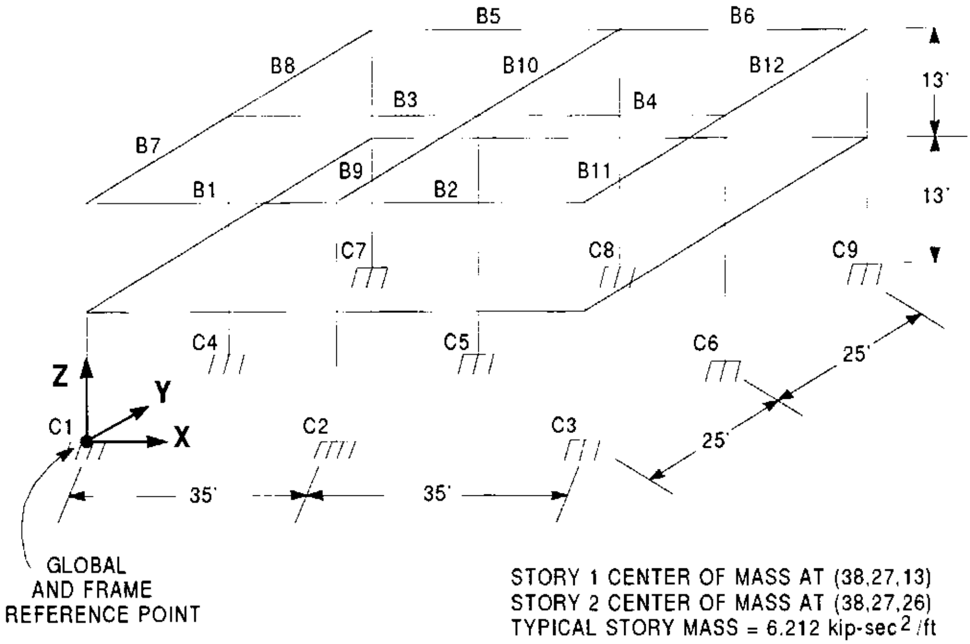
Comparison of Results

This example is also analyzed in References [1] and [2]. A comparison of the key ETABS results with References [1] and [2] is shown in Figure 8-4. The agreement is excellent.

References

1. **Wilson, E.L. and Habibullah, A.**
   SAP90, Sample Example and Verification Manual, Computers and Structures, Inc., Berkeley, California, 1992.

2. **Peterson, F.E.**
   EASE2, Elastic Analysis for Structural Engineering - Example Problem Manual, Engineering Analysis Corporation, Berkeley, California, 1981.



Example 8
Two-story Three-dimensional Frame
Figure 8-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 8 : Two Story Three Dimensional Building Frame
             Dynamic Response Spectrum Analysis  Units: Kip-foot-second
$ -------------------------- Main Control Data
 2 1 1 1 0 1 4 2 1 1 0 0 0 0 0 2 0 0 4 0 5
 32.2
$ -------------------------- Story Data
 2nd 13 1
 1 0 6.212 0. 38 27
 1st 13 1
 1 0 6.212 0. 38 27
$ -------------------------- Material Data
 1 c 3.5e5
 2 c 5.0e5
$ -------------------------- Column Properties
 1  user 1
 4.0 0. 0. 0. 1.25 1.25
$ -------------------------- Beam Properties
 1  user 2
 5.0 0. 0. 0. 2.61 1.67
$ -------------------------- Frame Data
 Three Dimensional Building Frame
 1 9 12
$ -------------------------- Column Line Location
 1 0 0
 2 35 0
 3 70 0
 4 0 25
 5 35 25
 6 70 25
 7 0 50
 8 35 50
 9 70 50
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
 3 4 5
 4 5 6
 5 7 8
 6 8 9
 7 1 4
 8 4 7
 9 2 5
 10 5 8
 11 3 6
 12 6 9
$ -------------------------- Column Assignments
 1 9 0 2nd 1st 1

$ -------------------------- Beam Assignments
 1 12 0 2nd 1st 1

$ -------------------------- Frame Location
 1 0 0 0  /3-D Frame
```

Example 8
*Listing of Input Data (File: **EX8**)*
Figure 8-2

```
$ -------------------------- Response Spectrum Data
 Constant 0.4g Spectrum
 0 CQC 0.04
 CON-RS  32.2 1
                             $ No Y-direction input
$ --------------------------  Load Case Data
1 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 8
Listing of Input Data (continued)
Figure 8-2

```
$ CONSTANT RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLE EX8
$ DAMPING
    0.04
$ PERIOD     PSA
       0       .4
     100       .4
```

Example 8
*Listing of Input Data (File: **CON-RS**)*
Figure 8-3

Quantity	ETABS	Reference 1	Reference 2
Period, Mode 1	0.22708	0.22706	0.22706
Period, Mode 2	0.21565	0.21563	0.21563
Period, Mode 3	0.07335	0.07335	0.07335
Period, Mode 4	0.07201	0.07201	0.07201
X-Displacement Center of Mass, Roof	0.0201	0.0201	0.0201

Example 8
Comparison of Results
Figure 8-4

Example 9

Two Story Three-Dimensional Unsymmetrical Building Frame Dynamic Response Spectrum Analysis

Description

This is a two story three-dimensional unsymmetrical building frame. The structure is subjected to a seismic response spectrum along two horizontal axes which are at a 30 degree angle to the building axes.

The geometry of the structure is shown in Figure 9-1.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Dynamic response spectrum analysis

Computer Model

The three-dimensional structure is modeled as a single frame with six column lines and five bays. Kip-foot-second units are used. The seismic excitation is identical to the one used in Reference [1]. Typical columns are 18" x 18" and beams are 12" x 24". The modulus of elasticity is taken as 432000 ksf.

The input data file is EX9. The response spectrum file is ELCN-RS4. These files are listed in Figures 9-2 and 9-3.

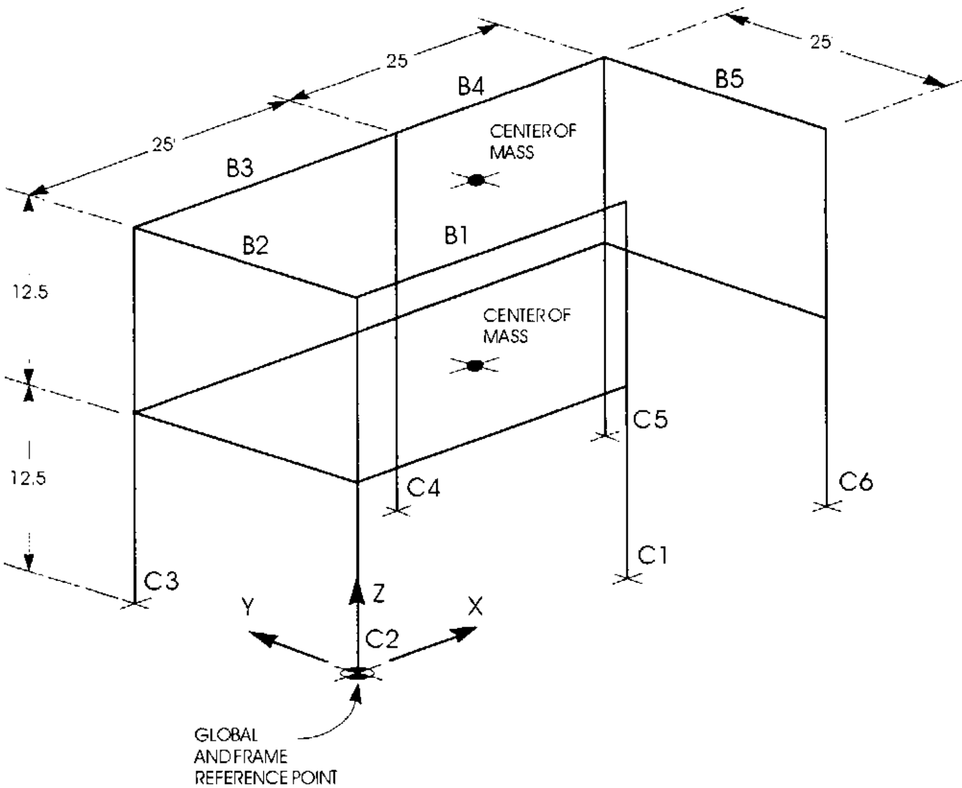
Comparison of Results

The structure is also analyzed in Reference [1]. Key ETABS results are compared in Figure 9-4. The comparison is excellent.

Sample ETABS output for this example is included in this manual.

Reference

1. **Wilson, E.L. and Habibullah, A.**
SAP90, Sample Example and Verification Manual, Computers and Structures, Inc., Berkeley, California, 1992.



Example 9
Two-story Three-dimensional Unsymmetrical Building Frame
Figure 9-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example 9 : Two Story 3-D Unsymmetrical Building Frame
             Dynamic Response Spectrum Analysis  Units: Kip-foot-second
$ -------------------------- Main Control Data
 2 1 1 1 0 2 6 1 1 1 0 0 0 0 0 2 0 0 4 0 5
 386.4
$ -------------------------- Story Data
 2nd 12.5 1
 1 0 3.88 1011 25 12.5
 1st 12.5 1
 1 0 3.88 1011 25 12.5
$ -------------------------- Material Data
 1 c 432000
$ -------------------------- Column Properties
 1  user 1
 2.25 0 0 0 .4219 .4219
$ -------------------------- Beam Properties
 1  user 1
 2. 0 0 0 .6667 .1667
$ -------------------------- Frame Data
 Three Dimensional Building Frame
 1 6 5
$ -------------------------- Column Line Location
 1 25 0
 2 0 0
 3 0 25
 4 25 25
 5 50 25
 6 50 0
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
 3 3 4
 4 4 5
 5 5 6
$ -------------------------- Column Assignments
 1 6 0  2nd 1st 1

$ -------------------------- Beam Assignments
 1 5 0  2nd 1st 1

$ -------------------------- Frame Location
 1 0 0 0  /3-D Frame
$ -------------------------- Response Spectrum Data
 El Centro 1940 Spectra
30 CQC 0.05
ELCN-RS4 32.2 1
ELCN-RS4 32.2 1
$ --------------------------  Load Case Data
1 0 0 0 0 0 0 0 1
2 0 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 9
*Listing of Input Data (File: **EX9**)*
Figure 9-2

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLE EX9
$ DAMPING
    0.05
$ PERIOD       PSA
   0.000     .4000
   0.100     .5810
   0.125     .6280
   0.167     .7870
   0.182     .9439
   0.200    1.0056
   0.250    0.7980
   0.333    0.8806
   0.431    0.9212
   0.500    1.0466
   0.667     .6418
   1.000     .4822
   1.273     .2586
   2.000     .1602
  10.000     .0102
```

Example 9
Listing of Input Data (File: ***ELCN-RS4****)*
Figure 9-3

QUANTITY	ETABS	REFERENCE 1
Period, Mode 1	0.4146	0.4146
Period, Mode 2	0.3753	0.3753
Period, Mode 3	0.2436	0.2436
Period, Mode 4	0.1148	0.1148
Period, Mode 5	0.1103	0.1103
Period, Mode 6	0.0729	0.0729
X-Displacement, Center of Mass, at Roof for:		
Seismic at 30° to X	0.1062	0.1062
Seismic at 120° to X	0.0617	0.0617

Example 9
Comparison Of Results
Figure 9-4

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    1
                                                  PROGRAM:ETABS/FILE:EX9.EKO
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 J O B   C O N T R O L   I N F O R M A T I O N


 NUMBER OF STORIES---------------------------   2
 NUMBER OF FLOOR DIAPHRAGMS ON EACH LEVEL-----   1
 NUMBER OF DIFFERENT FRAMES-------------------   1
 NUMBER OF TOTAL FRAMES----------------------   1
 NUMBER OF MASS TYPES------------------------   0
 NUMBER OF LOAD CASES------------------------   2
 NUMBER OF STRUCTURAL PERIODS----------------   6

 NUMBER OF MATERIAL PROPERTIES---------------   1

 NUMBER OF PROPERTIES FOR COLUMNS------------   1
 NUMBER OF PROPERTIES FOR BEAMS--------------   1
 NUMBER OF PROPERTIES FOR FLOORS-------------   0
 NUMBER OF PROPERTIES FOR BRACES-------------   0
 NUMBER OF PROPERTIES FOR PANELS-------------   0
 NUMBER OF PROPERTIES FOR SUPPORTS/LINKS------   0

 CODE FOR STATIC LATERAL ANALYSIS------------   0
 CODE FOR DYNAMIC LATERAL ANALYSIS-----------   2
 CODE FOR STRUCTURE TYPE--------------------   0
 CODE FOR P-DELTA ANALYSIS ------------------   0
 CODE FOR FRAME JOINT STIFFNESS MODIFICATION--   4
 CODE FOR FRAME SELF WEIGHT LOAD CONDITION----   0
 CODE FOR TYPE OF UNITS---------------------   5



 GRAVITATIONAL ACCELERATION----------------   0.3864E+03
 EIGEN CONVERGENCE TOLERANCE---------------   0.1000E-03
 EIGEN CUTOFF TIME PERIOD------------------   0.0000E+00
 P-DELTA FACTOR----------------------------   0.1000E+01
```

Example 9
Sample Output

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE    2
                                                   PROGRAM:ETABS/FILE:EX9.EKO
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 STRUCTURAL STORY DATA . . .

 STORY         STORY  NUMBER OF
 LEVEL        HEIGHT DIAPHRAGMS
 2ND           12.50          1
 1ST           12.50          1




CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE    3
                                                   PROGRAM:ETABS/FILE:EX9.EKO
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 DIAPHRAGM MASS DATA

 STORY     DIAPHRAGM        MASS  DIAPHRAGM   DIAPHRAGM   DIAPHRAGM  DIAPHRAGM
 LEVEL        NUMBER        TYPE       MASS         MMI         X-M        Y-M
 2ND
                   1           0      3.880  0.1011E+04      25.000     12.500
 1ST
                   1           0      3.880  0.1011E+04      25.000     12.500




CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE    4
                                                   PROGRAM:ETABS/FILE:EX9.EKO
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 DIAPHRAGM EXTERNAL STIFFNESS DATA

 STORY     DIAPHRAGM  DIAPHRAGM   DIAPHRAGM   DIAPHRAGM
 LEVEL        NUMBER        K-X         K-Y         K-R
 2ND
                   1 0.0000E+00  0.0000E+00  0.0000E+00
 1ST
                   1 0.0000E+00  0.0000E+00  0.0000E+00
```

Example 9
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    3
                                                      PROGRAM:ETABS/FILE:EX9.STR
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 DYNAMIC RESPONSE SPECTRUM BASE SHEARS

   MODE    /-------------D1-------------//-------------D2-------------/
     NO        DIRECTION-X    DIRECTION-Y    DIRECTION-X    DIRECTION-Y
      1              0.652        100.016          1.112        170.656
      2            168.372         -1.127        -98.718          0.661
      3              2.128          0.010         -1.215         -0.006
      4              0.048         10.295          0.083         17.640
      5             15.329         -0.065         -8.937          0.038
      6              0.011          0.000         -0.006          0.000

    CQC            169.654        100.059         98.709        172.036
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    4
                                                      PROGRAM:ETABS/FILE:EX9.STR
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND


 RESPONSE SPECTRUM LATERAL DISPLACEMENTS FOR DIAPHRAGM     1

 VALUES ARE AT THE CENTER OF MASS OF THE
 CORRESPONDING DIAPHRAGM IN GLOBAL COORDINATES

                     /-LOAD  CONDITIONS-/
 LEVEL      DIRN             D1         D2

 2ND           X       0.1062     0.0617
 2ND           Y       0.0779     0.1337
 2ND        ROTZ   7.851E-04  4.525E-04

 1ST           X       0.0491     0.0285
 1ST           Y       0.0339     0.0582
 1ST        ROTZ   3.173E-04  1.830E-04
```

Example 9
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     5
                                                        PROGRAM:ETABS/FILE:EX9.STR
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS   UNITS: KIP-FOOT-SECOND


 RESPONSE SPECTRUM LATERAL STORY INERTIA FORCES FOR DIAPHRAGM     1

 LOADS ARE AT THE CENTERS OF MASS OF THE RESPECTIVE STORY LEVELS

                      /-LOAD  CONDITIONS-/
 LEVEL      DIRN              D1         D2

 2ND           X       116.19      67.59
 2ND           Y        69.71     119.83
 2ND        ROTZ    2.825E+02 1.625E+02

 1ST           X        60.71      35.27
 1ST           Y        35.28      60.75
 1ST        ROTZ    1.255E+02 7.213E+01
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     6
                                                        PROGRAM:ETABS/FILE:EX9.STR
 EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
 DYNAMIC RESPONSE SPECTRUM ANALYSIS   UNITS: KIP-FOOT-SECOND


 RESPONSE SPECTRUM LATERAL STORY SHEARS FOR DIAPHRAGM      1

                      /-LOAD  CONDITIONS-/
 LEVEL      DIRN              D1         D2

 2ND           X       116.19      67.59
 2ND           Y        69.71     119.83

 1ST           X       169.65      98.71
 1ST           Y       100.06     172.04
```

Example 9
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    2
                                                  PROGRAM:ETABS/FILE:EX9.DSP
EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
DYNAMIC RESPONSE SPECTRUM ANALYSIS  UNITS: KIP-FOOT-SECOND

DISPLACEMENTS AT LEVEL 2ND      IN FRAME /3-D FRAME

 COL OUTPUT     LOCAL      LOCAL      LOCAL      LOCAL      LOCAL     LOCAL
  ID     ID    X-TRAN     Y-TRAN     Z-TRAN    XX-ROTN    YY-ROTN   ZZ-ROTN
   1 CASE 1   0.11538    0.07787    0.00064    0.00338    0.00258   0.00079
   1 CASE 2   0.06697    0.13367    0.00037    0.00579    0.00149   0.00045

   2 CASE 1   0.11538    0.07099    0.00084    0.00166    0.00258   0.00079
   2 CASE 2   0.06697    0.13910    0.00066    0.00328    0.00149   0.00045

   3 CASE 1   0.09725    0.07099    0.00051    0.00166    0.00224   0.00079
   3 CASE 2   0.05651    0.13910    0.00096    0.00328    0.00131   0.00045

   4 CASE 1   0.09725    0.07787    0.00000    0.00338    0.00130   0.00079
   4 CASE 2   0.05651    0.13367    0.00001    0.00579    0.00075   0.00045

   5 CASE 1   0.09725    0.08864    0.00087    0.00212    0.00225   0.00079
   5 CASE 2   0.05651    0.12900    0.00066    0.00302    0.00129   0.00045

   6 CASE 1   0.11538    0.08864    0.00051    0.00212    0.00468   0.00079
   6 CASE 2   0.06697    0.12900    0.00073    0.00302    0.00271   0.00045
```

Example 9
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE   2
                                              PROGRAM:ETABS/FILE:EX9.FRM
EXAMPLE 9 : TWO STORY 3-D UNSYMMETRICAL BUILDING FRAME
DYNAMIC RESPONSE SPECTRUM ANALYSIS   UNITS: KIP-FOOT-SECOND


COLUMN FORCES AT LEVEL 2ND       IN FRAME /3-D FRAME

 COL OUTPUT OUTPUT      MAJOR      MAJOR      MINOR      MINOR     AXIAL TORSIONAL
  ID     ID  POINT     MOMENT      SHEAR     MOMENT      SHEAR     FORCE    MOMENT
   1 CASE 1    TOP     174.49      24.74       0.00       1.31     13.96      0.00
            BOTTOM     134.84                 16.39
   1 CASE 2    TOP     101.88      14.43       0.00       2.27      8.15      0.00
            BOTTOM      78.63                 28.32

   2 CASE 1    TOP     174.49      24.74     112.11      16.16     18.46      0.00
            BOTTOM     134.84                 90.02
   2 CASE 2    TOP     101.88      14.43     222.69      32.26     14.84      0.00
            BOTTOM      78.63                180.63

   3 CASE 1    TOP     131.91      18.29     112.11      16.16     11.23      0.00
            BOTTOM      96.95                 90.02
   3 CASE 2    TOP      75.79      10.51     222.69      32.26     21.33      0.00
            BOTTOM      55.67                180.63

   4 CASE 1    TOP     219.58      32.74       0.00       1.31      0.13      0.00
            BOTTOM     189.74                 16.39
   4 CASE 2    TOP     127.51      19.01       0.00       2.27      0.23      0.00
            BOTTOM     110.15                 28.32

   5 CASE 1    TOP     131.20      18.19     142.89      20.78     19.12      0.00
            BOTTOM      96.45                116.90
   5 CASE 2    TOP      77.00      10.67     205.02      29.61     14.79      0.00
            BOTTOM      56.52                165.23

   6 CASE 1    TOP       0.00       2.80     142.89      20.78     11.43      0.00
            BOTTOM      35.05                116.90
   6 CASE 2    TOP       0.00       1.64     205.02      29.61     16.40      0.00
            BOTTOM      20.44                165.23
```

Example 9
Sample Output (continued)

Example 10

Three Story Plane Frame with ADAS Elements Nonlinear Time History Analysis

Description

This is a single-bay, three story, plane frame subjected to ground motion as shown in Figure 10-1. El Centro 1940 (N-S) record is used in the nonlinear time history analysis. Three elements that absorb energy through hysteresis (ADAS elements as described in References [1] and [2]) are used to connect the chevron braces to the frame. Two models are investigated; in the first model the ADAS elements are intended to produce about 5% damping in the fundamental mode. In the second model damping is increased to 25%. The properties of ADAS elements were supplied by the manufacturer.

Significant Options of ETABS Activated

- Two dimensional frame analysis
- Use of multiple diaphragms
- Use of uniaxial hysteretic link elements
- Joint assignments

- Nonlinear time history analysis

Computer Model

The frame is modeled as a 4-column line, 2-bay system. Kip-inch-second units are used. The modulus of elasticity is taken as 29000 ksi. Column, beam and brace section properties are user-defined.

ETABS uniaxial hysteretic spring properties (**PLASTIC1**) are used to model the ADAS elements. These are assigned as zero length links under shear deformation (IDIR = 2).

Two diaphragms are allocated to each floor level. Column lines 2 and 3 are defined at the same location. Joint assignment data is used to connect Column line 2 to Diaphragm 2. In contrast, all other column lines remain connected to Diaphragm 1 by default. At each story level links are located between column lines 2 and 3 and the top of the chevrons are connected to column line 2. Under this arrangement displacements are transferred between the chevrons and the frame via the link elements undergoing shear deformation.

To capture a mode which contains the deformation of the chevrons, a small percentage of the total story mass (1%) is assigned to Diaphragm 2 to represent the mass of the ADAS elements and the braces. In both models Diaphragm 1 carries 99% of the total story mass.

In both models the value of post yield stiffness ratio is taken as 5% and the time increment for output sampling is specified as .02 seconds.

The input data for this example is EX10 which is listed in Figure 10-2. The time history file is ELCN-THE. Both these files are available to the user on a disk as part of the ETABS package.

Comparison of Results

Sample results are compared in Figure 10-3 with results from the nonlinear analysis program DRAIN-2DX (Reference [3]) for both 5% and 25% damping cases. The agreement is good to excellent in spite the fact that in the ETABS models the distribution of the total story mass between the two diaphragms is done intuitively.

The load-deformation response of a typical link showing the hysteretic behavior is reproduced in Figure 10-4.

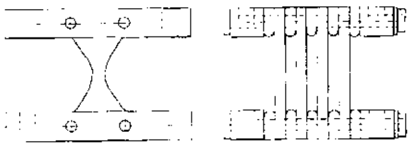
Figure 10-5 shows the energy calculations graphically which include variations of the kinetic, damping, potential, input and nonlinear energies as well as the error. The latter remains zero over the time range considered, implying the accuracy in energy balance over the successive time steps.

References

1. **Scholl, Roger E.**
   Design Criteria for Yielding and Friction Energy Dissipators, Proceedings of ATC-17-1 Seminar on Seismic Isolation, Passive Energy Dissipation, and Active Control, San Francisco, California, Vol. 2, 485-495, Applied Technology Council, Redwood City, California, 1993.

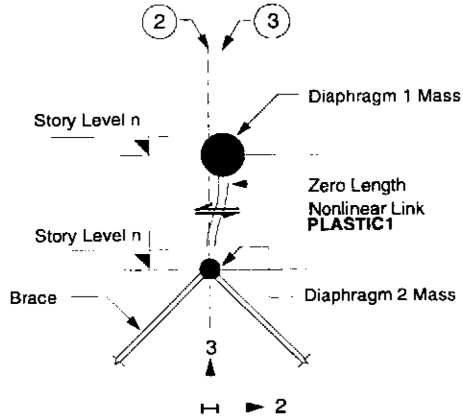
2. **Tsai, K.H., Chen, H.W., Hong, C.P., Su, Y.F.**
   Design of Steel Triangular Plate Energy Absorbers for Seismic-Resistant Construction, Earthquake Spectra, Vol. 9, Number 3, 505-528, 1993.

3. **Prakash, V., Powell, G.A. and Campbell, S.**
   DRAIN-2DX Base Program Description and User Guide, Department of Civil Engineering, University of California, Berkeley, California, 1993.

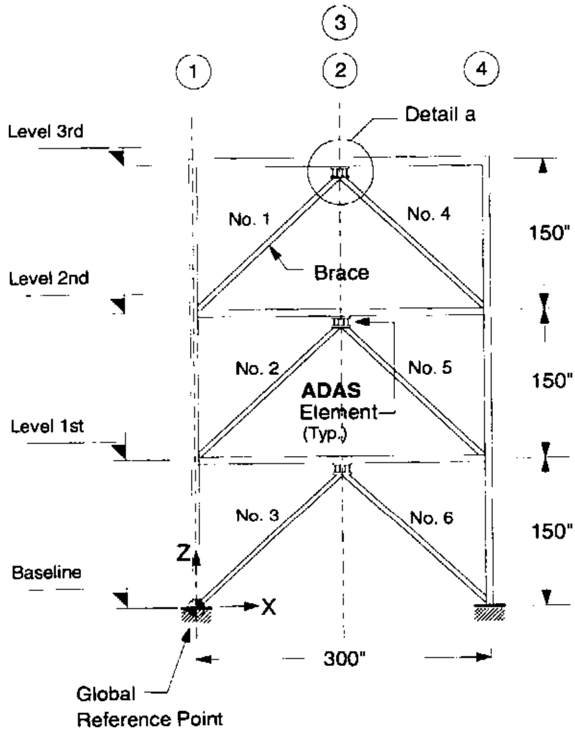


Detail 'a'

Typical ADAS Element



Schematic View of ETABS Model of ADAS Element



Frame Elevation

Example 10
Planar Frame with ADAS Elements
Figure 10-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example EX10      :Three Story Plane Frame With ADAS Elements
 Nonlinear Time History Analysis       Units: Kip-inch-second
$ -------------------------- Main Control Data
 3 2 1 1 0 1 6 1 3 1 0 1 0 3 0 4 1 0 0 0 1
 386.2
$ -------------------------- Story Data
 3rd 150 2
 1 0 64.4/386.2*.99  $ Diaphragm no. 1 carries 99% of the mass
 2 0 64.4/386.2*.01  $ Diaphragm no. 2 carries 1%  of the mass
 2nd 150 2
 1 0 96.6/386.2*.99
 2 0 96.6/386.2*.01
 1st 150 2
 1 0 96.6/386.2*.99
 2 0 96.6/386.2*.01
$ -------------------------- Material Data
 1 s 29000
$ -------------------------- Column Properties
 1 user 1
 999 0 0 0 404.08
 2 user 1
 999 0 0 0 323.29
 3 user 1
 999 0 0 0 242.46
$ -------------------------- Beam Properties
 1  user 1
 99.54 0 0 0 999921.70
$ -------------------------- Brace Properties
 1 user 1
 9910.54
$ -------------------------- Spring Properties Approximating 5% Damping
 1 plastic1 2 2*41.67         $ Spring is active in shear (direction 2)
 2*41.67 2*5.47 .05  2  .5    $ Strain Hardening Ratio = 5%
 2 plastic1 2 2*33.33
 2*33.33 2*4.11 .05  2  .5
 3 plastic1 2 2*25
 2*25    2*2.16 .05  2  .5
$ -------------------------- Spring Properties Approximating 25% Damping
$ 1 plastic1 2 2*125          $ Spring is active in shear (direction 2)
$ 2*125    2*19.1  .05 2  .5   $ Strain Hardening Ratio = 5%
$ 2 plastic1 2 2*100
$ 2*100    2*15.1  .05 2  .5
$ 3 plastic1 2 2*75
$ 2*75     2*7.15  .05 2  .5
$ -------------------------- Frame Data
 Three Story Plane Frame
 1  4 2 0 0 0 0 1 6 0 3
$ -------------------------- Column Line Location
 1
 2 150
 3 150
 4 300
$ -------------------------- Bay Connectivity
 1 1 3
 2 3 4
```

Example 10
*Listing of Input Data (File: **EX10**)*
Figure 10-2

```
$ -------------------------- Joint Assignments
 2 2 0 3rd 1st 2             $ Connect column line 2 to
                             $ diaphragm no. 2
$ -------------------------- Column Assignments
 1 1 0 3rd 3rd 3
 1 1 0 2nd 2nd 2
 1 1 0 1st 1st 1
 4 4 1

$ -------------------------- Beam Assignments
 1 2 0 3rd 1st 1

$ -------------------------- Brace Location/Assignment
 1 3rd 1st 1 2 1 3 3 1
 4 3rd 1st 4 2 1 3 3 1

$ -------------------------- Link Location/Assignment
 1 3rd 3rd 2 3 3 0 0 0       $ Nonlinear links are of zero
 2 2nd 2nd 2 3 2 0 0 0       $ length, connecting column lines
 3 1st 1st 2 3 1 0 0 0       $ 2 and 3 and deforming in shear.

$ -------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ -------------------------- Elcentro 1940 N-S Time History
 Elcentro Time History
 0 960 .02
 ELCN-THE 386.2 E .02 6 0
                           $ No Y-direction input
                           $ Use defaults for iteration control
                           $ No initial load (default)
$ -------------------------- Load Case Data
1 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 10
Listings of Input Data (continued)
Figure 10-2

Level	5% Damping		25% Damping	
	ETABS	**DRAIN-2DX**	**ETABS**	**DRAIN-2DX**
3rd	4.61	4.57	2.12	1.92
2nd	3.50	3.51	1.69	1.55
1st	1.83	1.82	0.93	0.86

Comparison of Maximum Story Deflections

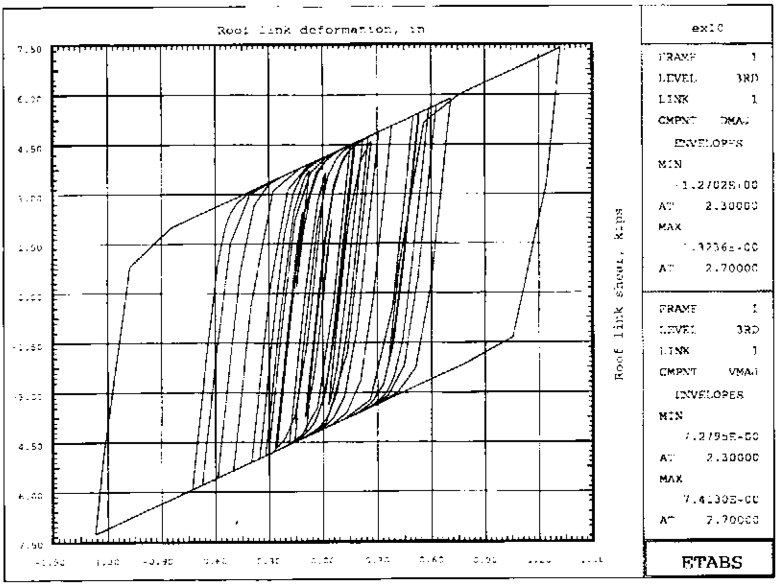
Level	5% Damping		25% Damping	
	ETABS	**DRAIN-2DX**	**ETABS**	**DRAIN-2DX**
3rd	7.41	7.31	17.82	17.40
2nd	14.00	13.92	36.90	36.20
1st	18.01	18.00	47.90	47.10

Comparison of Maximum Link Shear Force

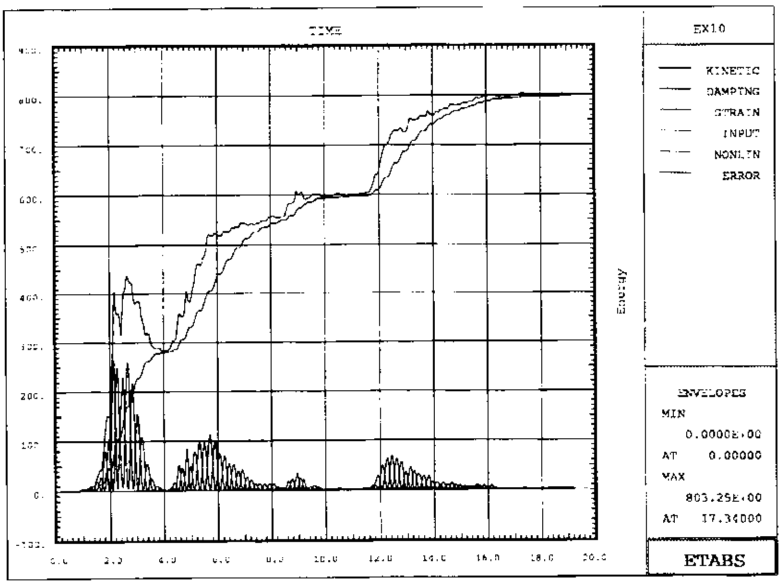
Brace	5% Damping		25% Damping	
	ETABS	**DRAIN-2DX**	**ETABS**	**DRAIN-2DX**
No. 1	5.42	5.17	12.70	12.30
No. 5	9.93	9.84	26.13	25.60
No. 3	12.76	12.70	33.70	33.28

Comparison of Maximum Brace Axial Force

Example 10
Figure 10-3



Example 10
Load-Deformation Response of a Typical Link
Figure 10-4



Example 10
Energy Variations
Figure 10-5

Example 11

Three Story Plane Frame with Viscous Damper Elements Nonlinear Time History Analysis

Description

This is a single-bay, three story, plane frame subjected to ground motion as shown in Figure 11-1. El Centro 1940 (N-S) record is used in the nonlinear time history analysis. Three viscous damper elements of the type discussed in Reference [1] are used to connect the chevron braces to the frame. Two models are investigated; in the first model the damper elements are intended to produce about 5% damping in the fundamental mode. In the second model damping is increased to 25%.

The ETABS viscous damper element (**DAMPER**) is a uniaxial damping device with a linear or nonlinear force-velocity relationship given by $F = C\,V^{\alpha}$.

Significant Options of ETABS Activated

- Two dimensional frame analysis
- Use of multiple diaphragms
- Use of uniaxial damper elements

- Joint assignments
- Nonlinear time history analysis

Computer Model

The frame is modeled as a 4-column line, 2-bay system. Kip-inch-second units are used. The modulus of elasticity is taken as 29000 ksi. Column, beam and brace section properties are user-defined.

ETABS uniaxial damper properties (**DAMPER**) are used to model the viscous dampers. These are assigned as zero length links under shear deformation (IDIR = 2).

Two diaphragms are allocated to each floor level. Column lines 2 and 3 are defined at the same location. Joint assignment data is used to connect Column line 2 to Diaphragm 2. In contrast, all other column lines remain connected to Diaphragm 1 by default. At each story level links are located between Column lines 2 and 3 and the top of the chevrons are connected to Column line 2. Under this arrangement displacements are transferred between the chevrons and the frame via the link elements undergoing shear deformation.

To capture a mode which contains the deformation of the chevrons, a small percentage of the total story mass (1%) is assigned to Diaphragm 2 to represent the mass of the viscous elements and the braces. In both models Diaphragm 1 carries 99% of the total story mass.

The time increment for output sampling is specified as .02 seconds.

The input data for this example is EX11 which is listed in Figure 11-2. The time history file is ELCN-THE. Both these files are available to the user on a disk as part of the ETABS package.

Comparison of Results

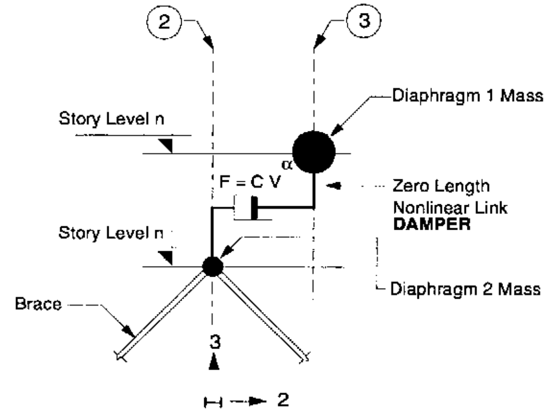
Sample results for $\alpha = 1$ are compared in Figure 11-3 with results from the nonlinear analysis program DRAIN-2DX (Reference [2]) for both 5% and 25% damping cases. The agreement is excellent. The user should recognize that if Diaphragm 2 were to be completely excluded in the model the overall results would remain unaffected. The reason for the inclusion of this extra diaphragm in the model is to enable the computation of local effects, i.e. the chevron forces (deformations). The load-deformation response of a typical link showing the energy absorption behavior of the damper is reproduced in Figure 11-4.

Figure 11-5 shows the energy calculations graphically which include variations of the kinetic, damping, potential, input and nonlinear energies as well as the error. The latter remains zero over the time range considered, implying the accuracy in energy balance over the successive time steps.

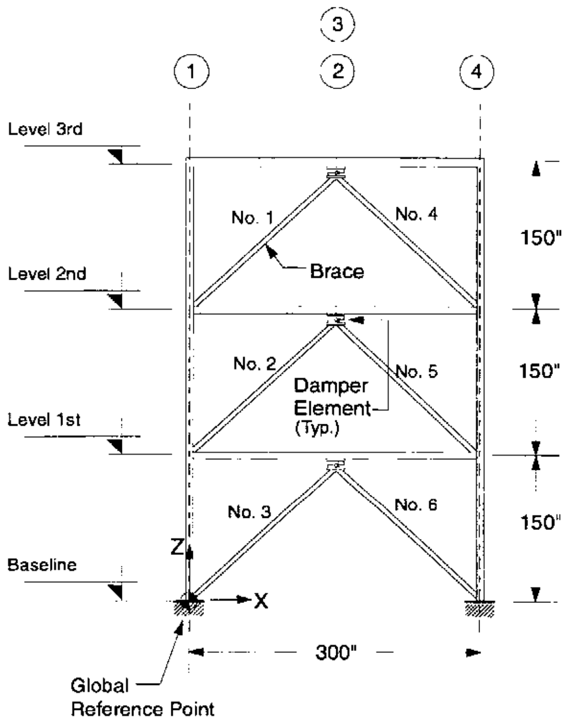
References

1. **Hanson, R.D.**
   Supplemental Damping for Improved Seismic Performance, Earthquake Spectra, Vol. 9, Number 3, 319-334, 1993.

2. **Prakash, V., Powell, G.A. and Campbell, S.**
   DRAIN-2DX Base Program Description and User Guide, Department of Civil Engineering, University of California, Berkeley, California, 1993.



Schematic View of ETABS Model of Damper Element



Frame Elevation

Example 11
Planar Frame with ADAS Elements
Figure 11-1

```
$ --------------------------- Heading
 ETABS 6.1
 Example EX11    :Three Story Plane Frame With DAMPER Elements
 Nonlinear Time History Analysis        Units: Kip-inch-second
$ --------------------------- Main Control Data
 3 2 1 1 0 1 6 1 3 1 0 1 0 3 0 4 1 0 0 0 1
 386.2
$ --------------------------- Story Data
 3rd 150 2
 1 0 64.4/386.2*.99  $ Diaphragm no. 1 carries 99% of the mass
 2 0 64.4/386.2*.01  $ Diaphragm no. 2 carries 1%  of the mass
 2nd 150 2
 1 0 96.6/386.2*.99
 2 0 96.6/386.2*.01
 1st 150 2
 1 0 96.6/386.2*.99
 2 0 96.6/386.2*.01
$ --------------------------- Material Data
 1 s 29000
$ --------------------------- Column Properties
 1 user 1
 999 0 0 0 404.08
 2 user 1
 999 0 0 0 323.29
 3 user 1
 999 0 0 0 242.46
$ --------------------------- Beam Properties
 1  user 1
 99.54 0 0 0 999921.70
$ --------------------------- Brace Properties
 1 user 1
 9910.54
$ --------------------------- Spring Properties Approximating 5% Damping
 1 Damper 2
 2*.4975 1
 2 Damper 2
 2*.3980 1
 3 Damper 2
 2*.2985 1
$ --------------------------- Spring Properties Approximating 25% Damping
$ 1 Damper 2
$ 2*.4975*5 1
$ 2 Damper 2
$ 2*.3980*5 1
$ 3 Damper 2
$ 2*.2985*5 1
$ --------------------------- Frame Data
 Three Story Plane Frame
 1  4 2 0 0 0 0 1 6 0 3
$ --------------------------- Column Line Location
 1
 2 150
 3 150
 4 300
$ --------------------------- Bay Connectivity
 1 1 3
 2 3 4
```

Example 11
Listing of Input Data (File: ***EX11****)*
Figure 11-2

```
$ --------------------------- Joint Assignments
 2 2 0 3rd 1st 2             $ Connect column line 2 to
                             $ diaphragm no. 2
$ --------------------------- Column Assignments
 1 1 0 3rd 3rd 3
 1 1 0 2nd 2nd 2
 1 1 0 1st 1st 1
 4 4 1

$ --------------------------- Beam Assignments
 1 2 0 3rd 1st 1

$ --------------------------- Brace Location/Assignment
 1 3rd 1st 1 2 1 3 3 1
 4 3rd 1st 4 2 1 3 3 1

$ --------------------------- Link Location/Assignment
 1 3rd 3rd 2 3 3 0 0 0       $ Nonlinear links are of zero
 2 2nd 2nd 2 3 2 0 0 0       $ length, connecting column lines
 3 1st 1st 2 3 1 0 0 0       $ 2 and 3 and deforming in shear.

$ --------------------------- Frame Location
 1 0 0 0  /Plane Frame
$ --------------------------- Elcentro 1940 N-S Time History
 Elcentro Time History
 0 960 .02
 ELCN-THE 386.2 E .02 6 0
                            $ No Y-direction input
                            $ Use defaults for iteration control
                            $ No initial load (default)
$ --------------------------- Load Case Data
1 0 0 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 11
Listings of Input Data (continued)
Figure 11-2

Level	5% Damping		25% Damping	
	ETABS	DRAIN-2DX	ETABS	DRAIN-2DX
3rd	4.12	4.11	2.24	2.24
2nd	3.15	3.14	1.72	1.71
1st	1.64	1.63	0.88	0.87

Comparison of Maximum Story Deflections

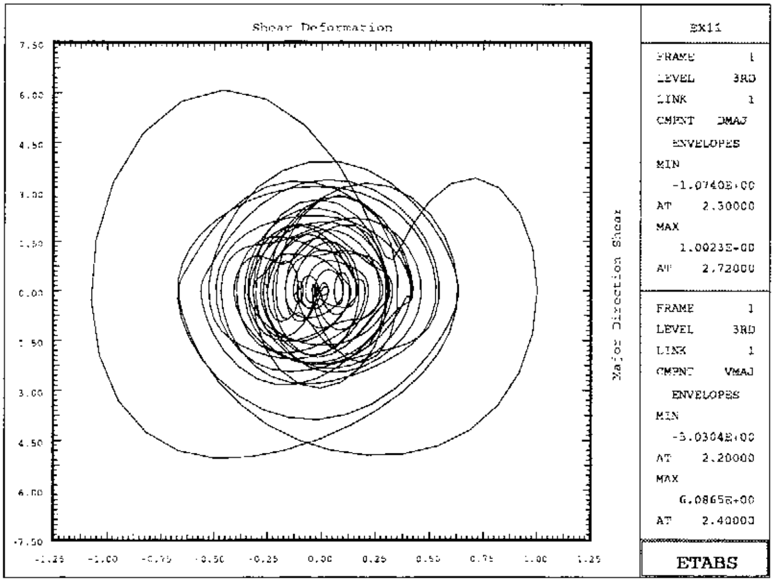
Level	5% Damping		25% Damping	
	ETABS	DRAIN-2DX	ETABS	DRAIN-2DX
3rd	6.09	5.98	14.65	14.75
2nd	10.79	10.80	32.72	32.84
1st	15.13	15.02	44.91	44.97

Comparison of Maximum Link Shear Force

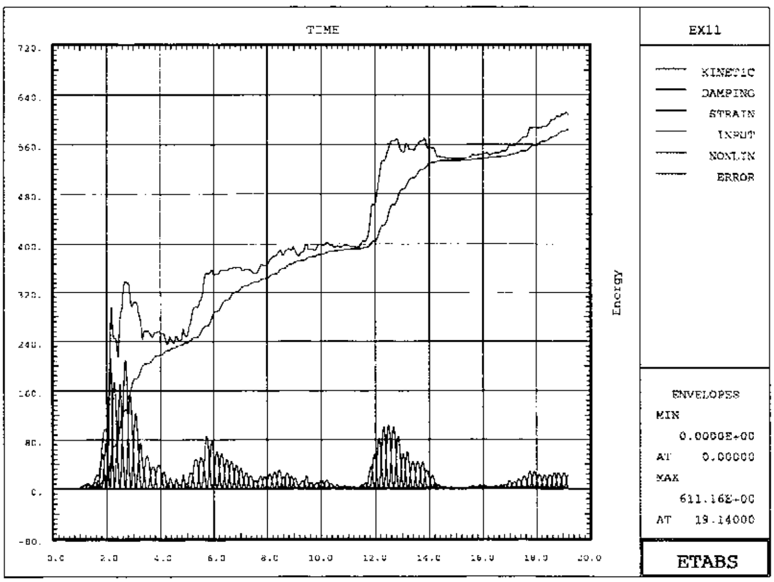
Brace	5% Damping		25% Damping	
	ETABS	DRAIN-2DX	ETABS	DRAIN-2DX
No. 1	4.19	4.23	10.53	10.43
No. 5	7.84	7.63	23.37	23.22
No. 3	10.77	10.62	32.01	31.80

Comparison Of Maximum Brace Axial Force

Example 11
Figure 11-3



Example 11
Load-Deformation Response of a Typical Damper
Figure 11-4



Example 11
Energy Variations
Figure 11-5

Example 12

Pounding of Two Planar Frames Nonlinear Time History Analysis

Description

A two bay seven story plane frame is linked to a one bay four story plane frame using ETABS **GAP** elements. The structure experiences pounding due to ground motion. El Centro 1940 (N-S) record is used in the nonlinear time history analysis.

The geometry of the structure is shown in Figure 12-1.

Significant Options of ETABS Activated

- Two dimensional frame analysis
- Use of uniaxial gap elements
- Joint assignments
- Nonlinear time history analysis
- Use of multiple diaphragms

Computer Model

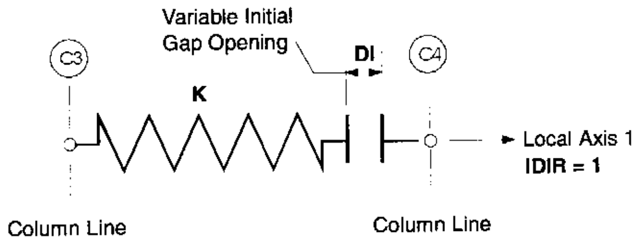
This example illustrates the use of gap elements to model pounding between buildings. The combined structure is modeled as a single frame with five column lines and three beam bays.

Through the joint assignment option Column lines 4 and 5 are connected to Diaphragm 2. Column lines 1 to 3 remain connected to Diaphragm 1 by default. This arrangement physically divides the structure into two parts. The interaction is provided via the gap elements which are used as links spanning Column lines 3 and 4. The local axis 1 of these links is in the global X-direction.

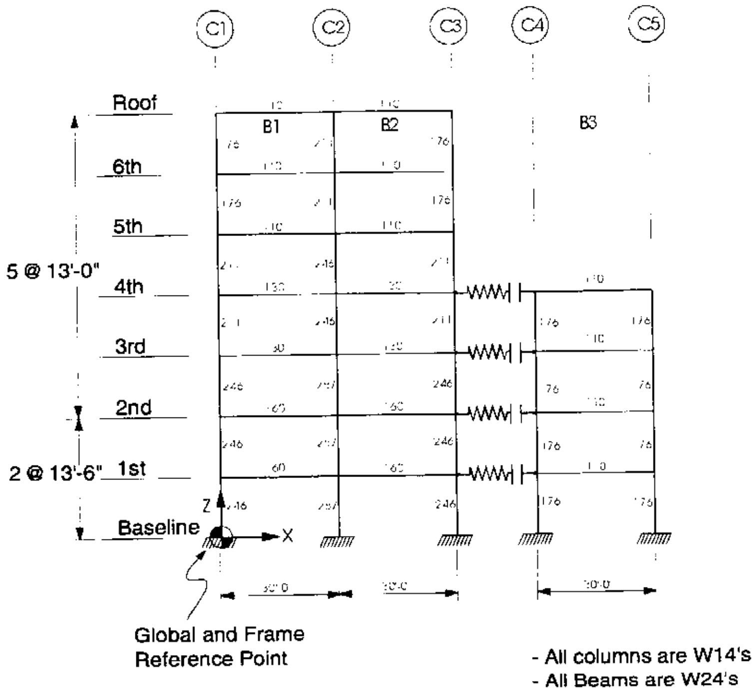
The input data for this example is EX12 which is listed in Figure 12-2. The time history file is ELCN-THU. Both these files are available to the user on a disk as part of the ETABS package.

Comparison of Results

This example is included as a sample only. A typical output produced by the program TIMER is shown in Figure 12-3. It shows the variations of displacement of Column lines 3 and 4 and the link force at Story level 4. It can be clearly seen that the link force is generated whenever the two column lines move in phase and their separation is less than the specified initial opening or if they move towards each other out of phase. For most part the pounding has the effect of keeping the buildings in phase. For display purposes the displacements are scaled up by a factor of 100.



Gap Element Used as a Link



Frame Elevation

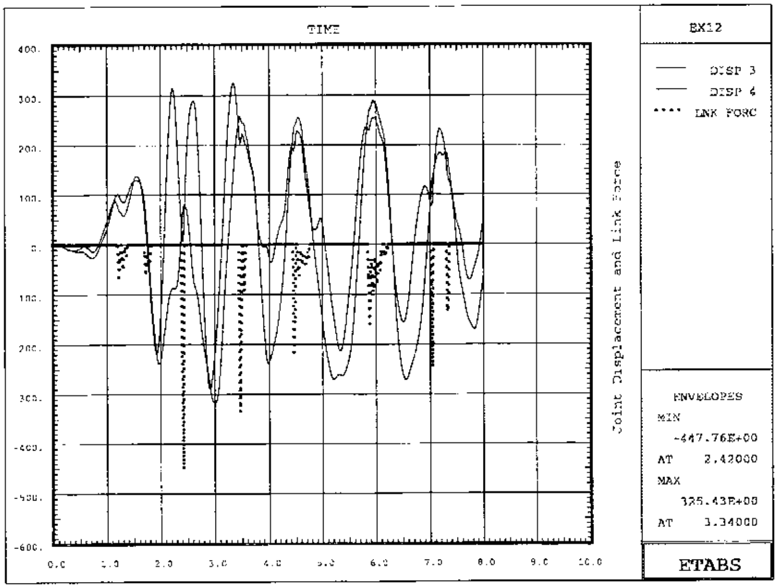
Example 12
Planar Frame Structure
Figure 12-1

```
$ -------------------------- Heading
 ETABS 6.1
 Example ex12 : Seven and Four Story Frames Linked by a Gap Element
 Nonlinear Dynamic Time History Analysis     Units: Kip-inch-second
$ -------------------------- Main Control Data
 7 2 1 1 0 1 11 1 4 3 0 0 0 1 0 4 1 0 0 0 1
 386.4
$ -------------------------- Story Data
 roof 156 1
 1 0 .49
 6th 156  1
 1 0 .49
 5th 156  1
 1 0 .49
 4th 156  2
 1 0 .49
 2 0 .49/2
 3rd 156  2
 1 0 .49
 2 0 .49/2
 2nd 162  2
 1 0 .49
 2 0 .49/2
 1st 162  2
 1 0 .49
 2 0 .49/2
$ -------------------------- Material Data
 1 s 29500 .3
$ -------------------------- Column Properties
1  USER 1
 51.17  0  0  0  2150                     $W14X176
2  USER 1
 62.10  0  0  0  2670                     $W14X211
3  USER 1
 72.30  0  0  0  3230                     $W14X246
4  USER 1
 84.40  0  0  0  3910                     $W14X287
$ -------------------------- Beam Properties
1  USER 1
  0.0   0  0  0  3330                     $W24X110
2  USER 1
  0.0   0  0  0  4020                     $W24X130
3  USER 1
  0.0   0  0  0  5120                     $W24X160
$ -------------------------- Spring Properties
1 Gap 1
1e3 .25
$ -------------------------- Frame Data
 Seven Story Plane Frame
 1 5 3 0 0 0 0 1 0 0 4
$ -------------------------- Column Line Location
 1 0
 2 360
 3 720
 4 732
 5 1092
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
 3 4 5
```

Example 12
*Listing of Input Data (File: **EX12**)*
Figure 12-2

```
$ -------------------------- Joint Assignments
 4 5 0 4th 1st 2
                              $ Leave a Blank Line
$ -------------------------- Column Assignments
 1 1 0 roof 6th  1
 3 3 1
 1 1 0 5th 4th   2
 3 3 1
 1 1 0 3rd 1st   3
 3 3 1
 2 2 0 roof 6th  2
 2 2 0 5th 4th   3
 2 2 0 3rd 1st   4
 4 5 0 4th 1st   1
                              $ Leave a Blank Line
$ -------------------------- Beam Assignments
 1 2 0 roof 5th 1
 1 2 0 4th 3rd  2
 1 2 0 2nd 1st  3
 3 3 0 4th 1st  1
                              $ Leave a Blank Line
$ -------------------------- Link Assignments
 1 4th 1st 3 4 1

$ -------------------------- Frame Location Data
 1 0 0 0 /Compound Frame
$ -------------------------- Seismic Time History Data
 Elcentro Time History
 0  400 .02 .05
 ELCN-THU  386.4 u 0 6 0
                           $ No Y-direction input
                           $ Use default iteration controls
                           $ No initial load (default)
$ -------------------------- Load Case Data
 1 0 0 0 0 0 0 0 1
$ ***** End of Input Data *****
```

Example 12
Listing of Input Data (continued))
Figure 12-2



Variations of Displacement of Column Lines 3 and 4
and Link Force at Story Level 4
Figure 12-3

Example 13

Base-Isolated Two Story 3D Frame Nonlinear Time History Analysis

Description

This is a two story three-dimensional frame with base isolation. The structure is subjected to earthquake motion in two perpendicular directions using the Loma Prieta acceleration records.

The geometry of the structure is shown in Figure 13-1.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Use of floor elements
- Use of biaxial hysteretic elements
- Joint assignments
- Nonlinear time history analysis

Computer Model

The structure is modeled as a single reinforced concrete frame with 9 column lines and 12 bays. The floor slab is is taken to be 8" thick covering all the specified floor bays at the base and the 1st story levels. At the second story level the corner column as well as the two edge beams are eliminated together with the floor slab to render this particular level unsymmetric as depicted in Figure 13-1.

Hysteretic base isolators of the type described in Reference [1] are modeled using the ETABS **ISOLATOR1** elements which show biaxial hysteretic characteristics.

A modulus of elasticity of 3000 ksi is used. The self-weight of concrete is taken as 150 pcf. Kip-inch-second units are used.

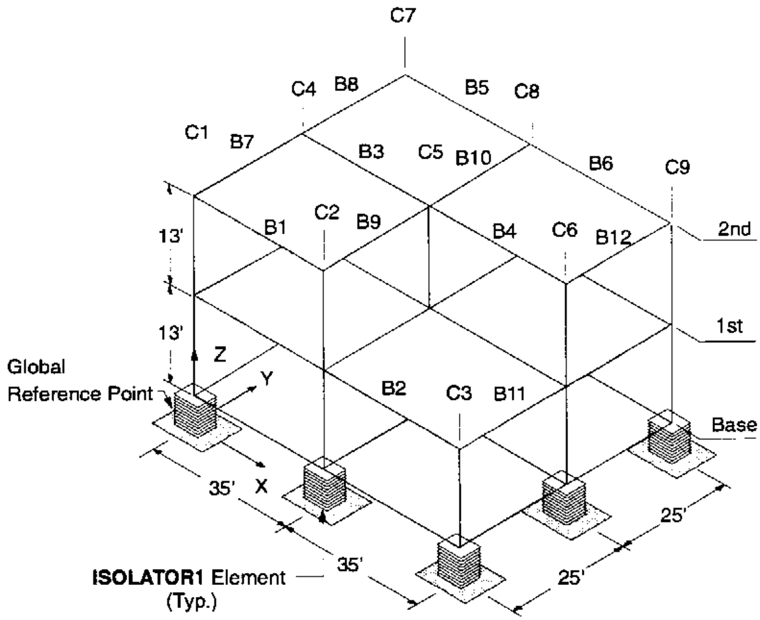
The input data file for this example is EX13 which is listed in Figure 13-2. The time history files are LP-TH0 and LP-TH90. All these files are available to the user on a disk as part of the ETABS package.

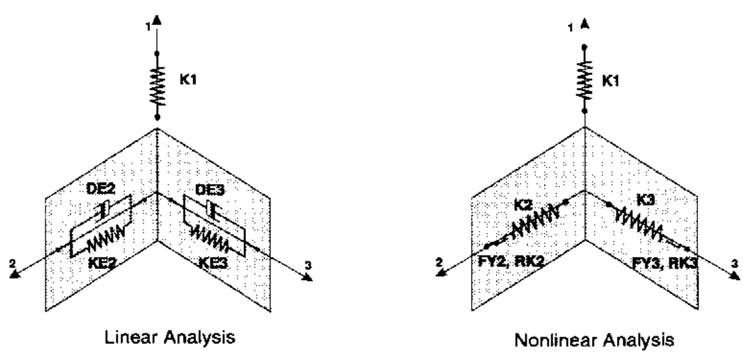
Comparison of Results

This example is included as a sample only. Typical outputs from the TIMER program are given in Figures 13-3 to 13-5. Figure 13-4 shows the shear force interaction diagram of a typical isolator element, identifying the failure surface. Figure 13-5 shows the load-deformation relationship in the major direction; the effect of minor direction shear is evident.

References

1. **Nagarajaiah, S., Reinhorn, A.M. and Constantinou, M.C.**
   3D-Basis: Nonlinear Dynamic Analysis of Three-Dimensional Base Isolated Structures: Part II, Technical Report NCEER-91-0005, National Center for Earthquake Engineering Research, State University of New York at Buffalo, Buffalo, New York, 1991.





ISOLATOR1 Element
(Biaxial Hysteretic)

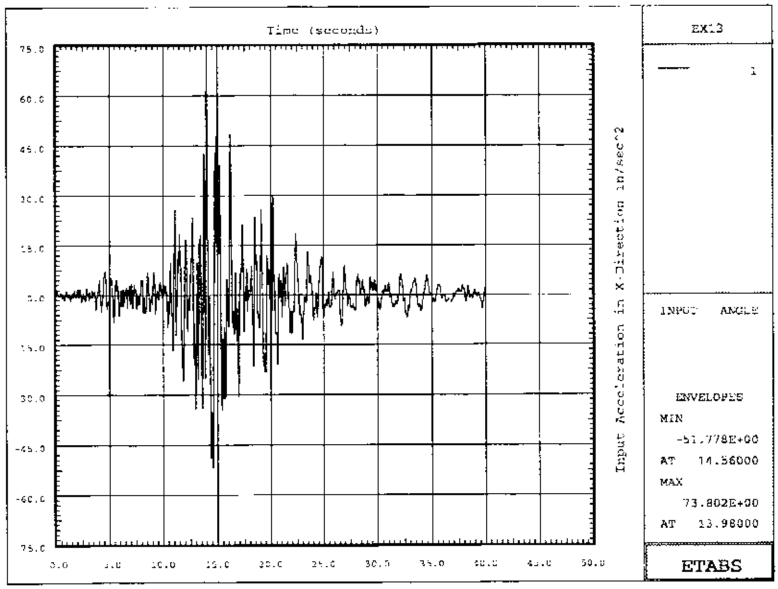
Example 13
Base-Isolated Three-Dimensional Frame
Figure 13-1

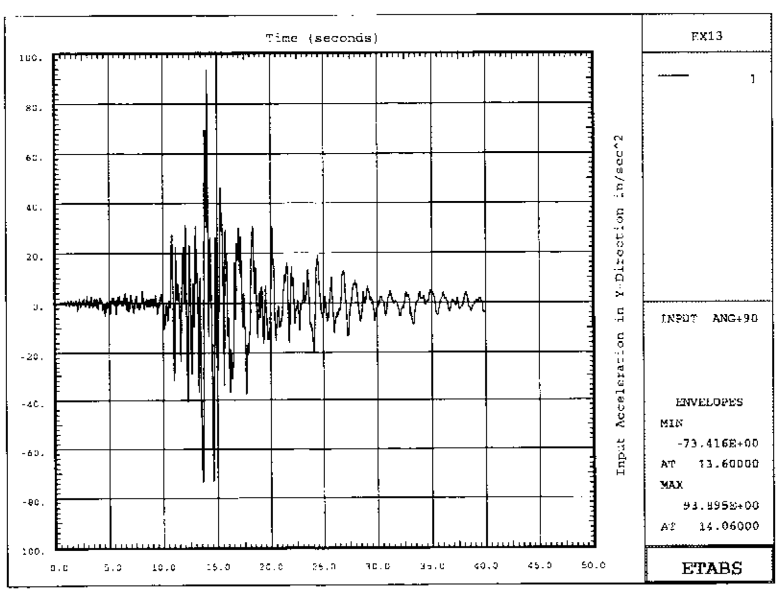
```
$ --------------------------- Heading
 ETABS 6.1
 Example 13 : Two Story 3D Building Frame With Hysteretic Base Isolators
 Nonlinear Time History Analysis       Units: Kip-inch-second
$ --------------------------- Main Control Data
 3 1 1 1 0 1 9 1 1 1 1 0 0 1 0 4 0 0 2 1 1
 386.4
$ --------------------------- Story Data
 2nd 13*12
 1st 13*12
 base 1*12
$ --------------------------- Material Data
 1  c 3000 .2 .150/1728 .150/1728/386.4
$ --------------------------- Column Properties
 1  rect 1 24 24
$ --------------------------- Beam Properties
 1  rect 1 36 0 24
$ --------------------------- Floor Properties
 1 memb 1 8 8 8
$ --------------------------- Isolator Properties
 1 isolator1 50 50 0 0
 1e3 50 50 10 10 .01 .01
$ --------------------------- Frame Data
 Three Dimensional Building Frame
 1 9 12 4 0 0 0 1
$ --------------------------- Column Line Location
 1      0      0
 2 35*12      0
 3 70*12      0
 4      0 25*12
 5 35*12 25*12
 6 70*12 25*12
 7      0 50*12
 8 35*12 50*12
 9 70*12 50*12
$ --------------------------- Beam Bay Connectivity
 1 1 2
 2 2 3
 3 4 5
 4 5 6
 5 7 8
 6 8 9
 7 1 4
 8 4 7
 9 2 5
 10 5 8
 11 3 6
 12 6 9
$ --------------------------- Floor Bay Connectivity
 1 3 6 2 5
 2 6 9 5 8
 3 2 5 1 4
 4 5 8 4 7
$ --------------------------- Joint Assignments
 1 9 0 base base 1 1
```

Example 13
*Listing of Input Data (File: **EX13**)*
Figure 13-2

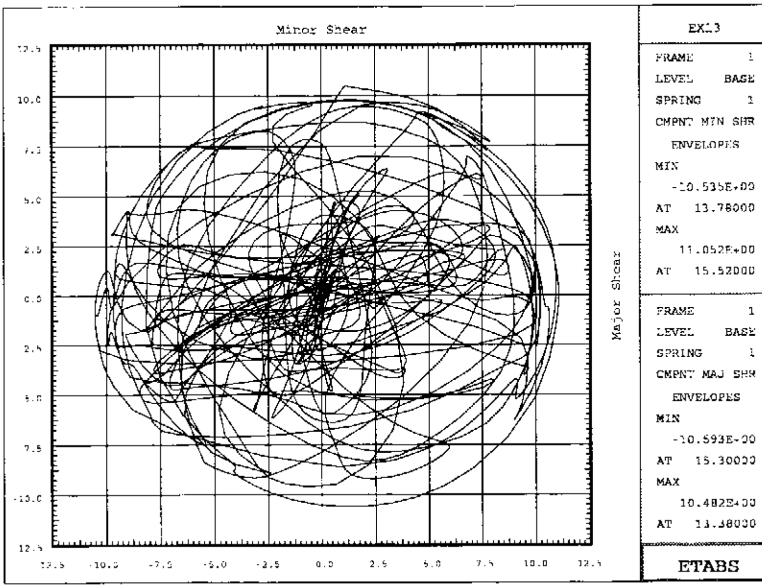
```
$ --------------------------- Column Assignments
 1 1 0 2nd 1st 1
 2 2 1
 3 3 0 1st 1st 1
 4 9 1

$ --------------------------- Beam Assignments
 1 1 0 2nd base 1
 2 2 0 1st base 1
 3 10 1
 11 11 2
 12 12 1

$ --------------------------- Floor Assignments
 2 4 0 2nd base 1
 1 1 0 1st base 1

$ --------------------------- Frame Location
 1 0 0 0  /3-D Frame
$ --------------------------- Loma Prieta Time History
 Loma Prieta Time History
 0  2000 .02
 LP-TH0  386.4  E .02 5 0
 LP-TH90 386.4  E .02 5 0
 .005 1e-6 0.0 5             $ Iteration control parameters
 1 0 0 0 0 0                 $ Preload with self weight
$ ---------------------------  Load Case Data
1 0 1 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 13
Listing of Input Data (continued)
Figure 13-2

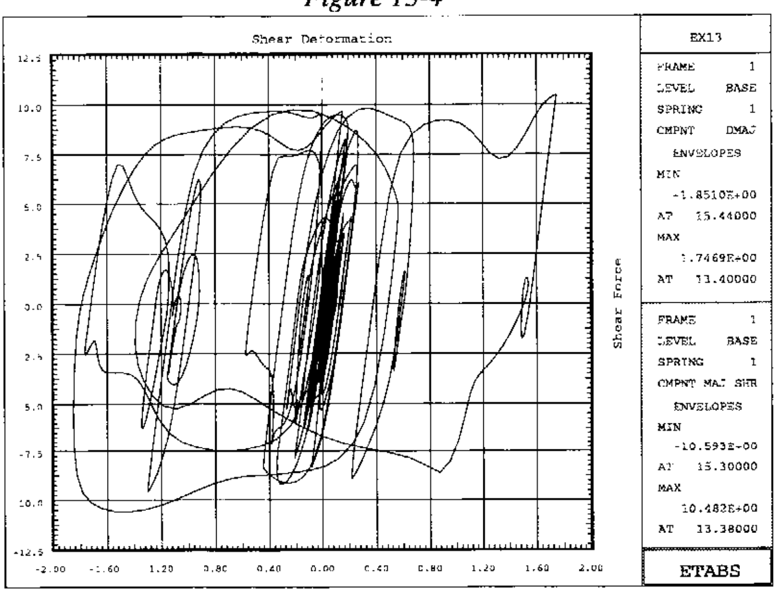




Example 13
Input Acceleration Records
Figure 13-3



Example 13
Shear force Interaction Diagram
Figure 13-4



Example 13
Load-Deformation Diagram
Figure 13-5

Example 14

Friction Pendulum Base-Isolated 3D Frame Nonlinear Time History Analysis

Description

This is a two story three-dimensional frame with base isolation using friction pendulum base isolators. The structure is subjected to earthquake motion in two perpendicular directions using the Loma Prieta acceleration records.

The geometry of the structure is shown in Figure 14-1.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Use of floor elements
- Use of biaxial friction pendulum elements
- Joint assignments
- Nonlinear time history analysis

Computer Model

The structure is modeled as a single reinforced concrete frame with 9 column lines and 12 bays. The floor slab is is taken to be 8" thick covering all the specified floor bays at the base and the 1st story levels. At the second story level the corner column as well as the two edge beams are eliminated together with the floor slab to render this particular level anti-symmetric as depicted in Figure 14-1.

Friction pendulum type base isolators of the type described in Reference [1] are modeled using the ETABS **ISOLATOR2** elements.

The isolator properties are defined as follows:

Stiffness in direction 1	1E3
Stiffness in directions 2 and 3	1E2
Coefficient of friction at fast speed	.04
Coefficient of friction at slow speed	.03
Parameter determining the variation of the coefficient of friction with velocity	20
Radius of contact surface in directions 2 and 3	60

In the time history data block the following control parameters are activated:

Maximum time step for integration	.005
Force tolerance for convergence	1E-6
Under-relaxation factor	0.0
Maximum number of iterations before automatic subdivision is invoked by the program	5

A modulus of elasticity of 3000 ksi is used. The self-weight of concrete is taken as 150 pcf. Kip-inch-second units are used.

It is important for these isolator elements that the axial load from other loads be modeled before starting the nonlinear analysis. This is achieved by using a factor of unity on the dead load (self weight) on the structure in the nonlinear analysis initial conditions data.

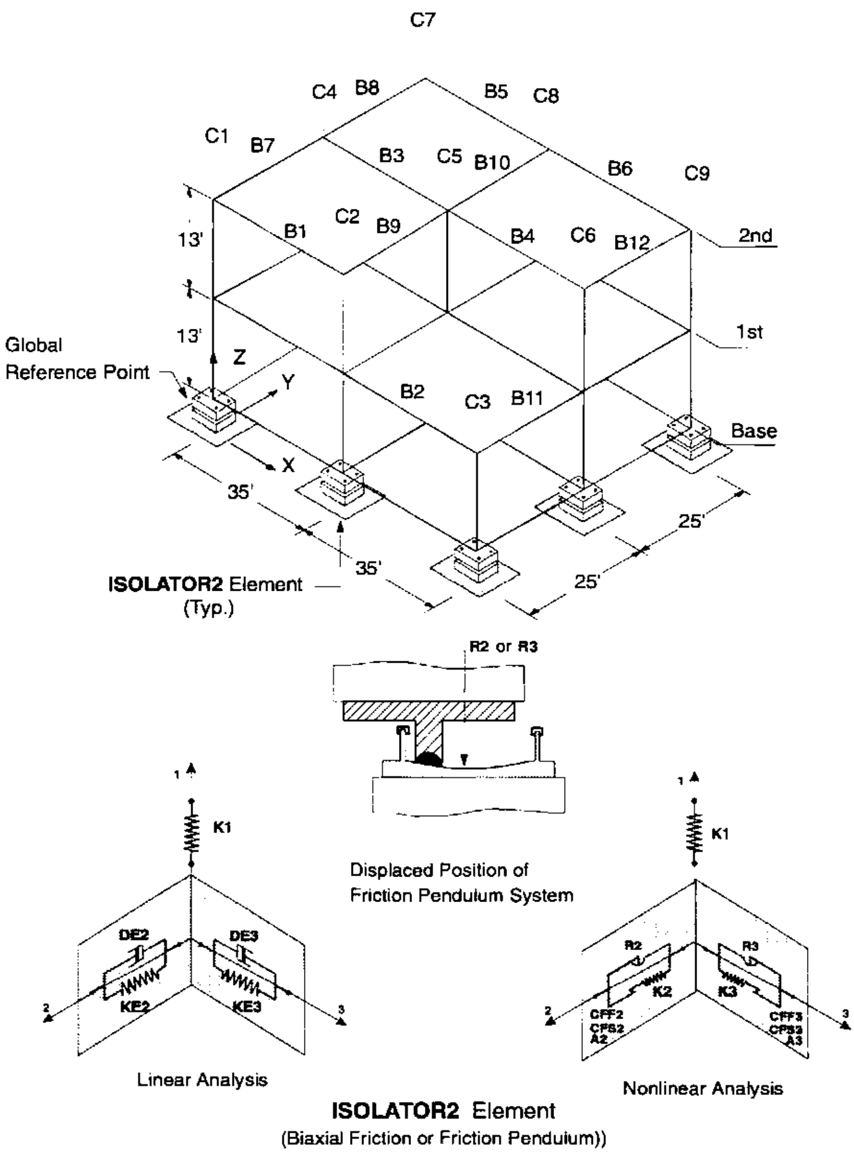
The input data file for this example is EX14 which is listed in Figure 14-2. The time history files are LP-TH0 and LP-TH90. All these files are available to the user on a disk as part of the ETABS package.

Comparison of Results

This example is included as a sample only. Typical outputs from the TIMER program are given in Figures 14-3 and 14-4. Figure 14-3 shows the variation of energy. The variation of the displacement of the second floor at Column line 1 is depicted in Figure 14-4.

References

1. **Zayas, V. and Low, S.**
   A Simple Pendulum Technique for Achieving Seismic Isolation, Earthquake Spectra, Vol. 6, No. 2, Earthquake Engineering Research Institute, Oakland, California,1990.



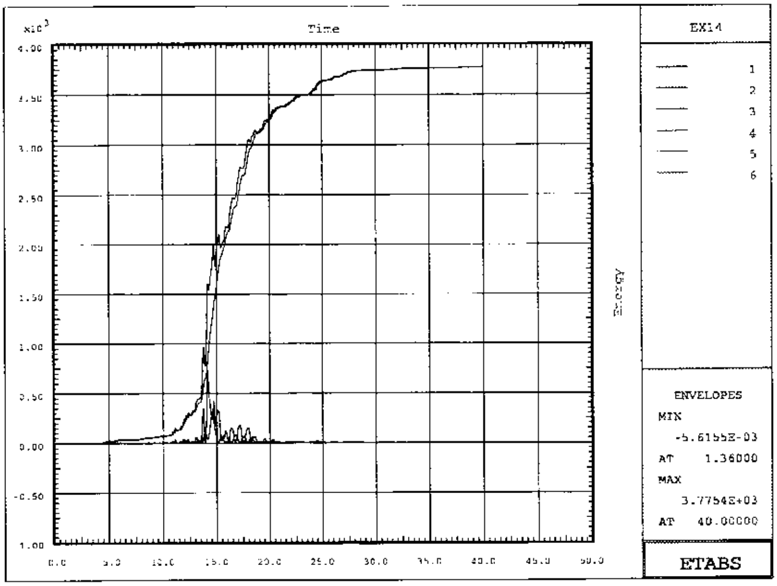
Example 14
Base-Isolated Three-Dimensional Frame
Figure 14-1

```
$ --------------------------- Heading
ETABS 6.1
Example 14 : Two Story 3D Building Frame With Sliding Base Isolators
Nonlinear Time History Analysis       Units: Kip-inch-second
$ --------------------------- Main Control Data
3 1 1 1 0 1 9 1 1 1 1 0 0 1 0 4 0 0 2 1 1
386.4
$ --------------------------- Story Data
2nd 13*12
1st 13*12
base 1*12
$ --------------------------- Material Data
1  c 3000 .2 .150/1728 .150/1728/386.4
$ --------------------------- Column Properties
1  rect 1 24 24
$ --------------------------- Beam Properties
1  rect 1 36 0 24
$ --------------------------- Floor Properties
1 memb 1 8 8 8
$ --------------------------- Isolator Properties
1 isolator2 4 4 0 0
1e3 1E2 1E2 .04 .04 .03 .03 20 20 60 60
$ --------------------------- Frame Data
Three Dimensional Building Frame
1 9 12 4 0 0 0 1
$ --------------------------- Column Line Location
1     0     0
2 35*12     0
3 70*12     0
4     0 25*12
5 35*12 25*12
6 70*12 25*12
7     0 50*12
8 35*12 50*12
9 70*12 50*12
$ --------------------------- Beam Bay Connectivity
1 1 2
2 2 3
3 4 5
4 5 6
5 7 8
6 8 9
7 1 4
8 4 7
9 2 5
10 5 8
11 3 6
12 6 9
$ --------------------------- Floor Bay Connectivity
1 3 6 2 5
2 6 9 5 8
3 2 5 1 4
4 5 8 4 7
$ --------------------------- Joint Assignments
1 9 0 base base 1 1
```

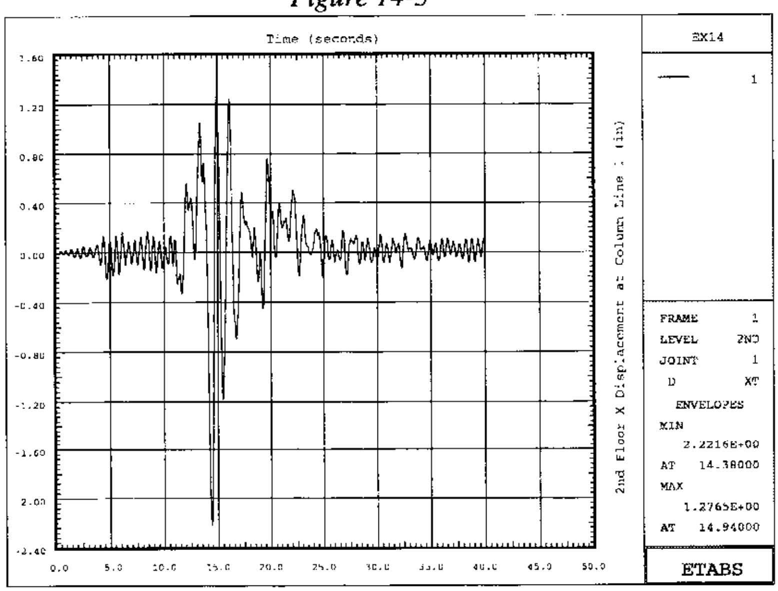
Example 14
*Listing of Input Data (File: **EX14**)*
Figure 14-2

```
$ --------------------------- Column Assignments
 1 1 0 2nd 1st 1
 2 2 1
 3 3 0 1st 1st 1
 4 9 1

$ --------------------------- Beam Assignments
 1 1 0 2nd base 1
 2 2 0 1st base 1
 3 10 1
 11 11 2
 12 12 1

$ --------------------------- Floor Assignments
 2 4 0 2nd base 1
 1 1 0 1st base 1

$ --------------------------- Frame Location
 1 0 0 0  /3-D Frame
$ --------------------------- Loma Prieta Time History
 Loma Prieta Time History
 0  2000 .02
 LP-TH0  386.4  E .02 5 0
 LP-TH90 386.4  E .02 5 0
 .005 1e-6 0.0 5             $ Iteration control parameters
 1 0 0 0 0 0                 $ Preload with self weight
$ ---------------------------  Load Case Data
1 0 1 0 0 0 0 0 1
$ ***** End of Data Input *****
```

Example 14
Listing of Input Data (continued)
Figure 14-2



Example 14
Variation of Energy
Figure 14-3



Example 14
Variation of Displacement
Figure 14-4

Example 15

Panel Element Behavior Static Lateral Loads Analysis

Description

This example analyzes a series of wall configurations to evaluate the behavior of the ETABS panel element. All walls are subjected to a static lateral load applied at the top of the wall.

The following walls are included:

- Planar shear wall, shown in Figure 15-1
- Wall supported on columns, shown in Figure 15-5
- Wall-spandrel system, shown in Figure 15-9
- C-shaped wall section, shown in Figure 15-13
- Wall with edges thickened, shown in Figure 15-17
- E-shaped wall section, shown in Figure 15-21

Significant Options of ETABS Activated

- Use of panel elements
- Two-dimensional and three-dimensional shear wall systems
- Static lateral loads analysis

Computer Model

A modulus of elasticity of 3000 ksi and a Poisson's ratio of 0.2 are used for all walls. Kip-inch-second units are used throughout.

The following sections describe the models for the different walls:

Planar Shear Wall

This shear wall is modeled with one panel per story. Three different wall lengths of 120", 360" and 720" are analyzed. Also, one-story and three-story walls are analyzed, together with the six-story wall shown in Figure 15-1. A wall thickness of 12" is used.

The input data for the six-story wall with a wall length of 360" is included as file EX15a. A listing of this input data is given in Figure 15-2.

Wall Supported on Columns

This wall is modeled with two column lines. Columns are used for the first story and one panel, with end piers, per story is used for the top two stories as shown in Figure 15-5. End piers are 40" by 12" in cross section and panels are 12" thick. Columns are 40" by 20" in cross section.

The input data for this wall is EX15b. A listing of this input data is given in Figure 15-6.

Wall-Spandrel System

This wall is modeled with four column lines. The spandrels are modeled as beams. Two different spandrel lengths of 60" and 240" are analyzed. Each wall is modeled with one panel per story. Three-story walls are also analyzed together with the six-story wall shown in Figure 15-9. A wall and spandrel thickness of 12" is used.

The input data for the six-story wall with 240" long spandrel beam is included as file EX15c. A listing of this input data is given in Figure 15-10.

C-Shaped Wall Section

This wall is modeled with six column lines and five panels per story, to model the shape of the wall. All five panels at a particular story have the same wall ID number so the member forces that are produced will be for the whole wall, at a particular level corresponding to the centroid of the C-section. A three-story wall was also analyzed together with the six-story wall, as shown in Figure 15-13. A wall thickness of 6" is used.

The input data for the six-story wall is included as file EX15d. A listing of this input data is given in Figure 15-14.

Wall with Edges Thickened

This wall is modeled with two column lines and one panel, with end piers, per story as shown in Figure 15-17. A three-story wall was also analyzed together with the six-story wall shown in Figure 15-17.

The input data for the six-story wall is included as file EX15e. A listing of this input data is given in Figure 15-18.

E-Shaped Wall Section

This wall is modeled with six column lines and five panels per story to model the shape of the wall. All five panels at a particular story have the same wall ID number so the member forces that are produced will be for the whole E-shaped wall, at a particular level, corresponding to the centroid of the E-section. A three-story wall was also analyzed together with the six-story wall, as shown in Figure 15-21. A wall thickness of 6" is used.

The input data for the six-story wall is included as file EX15f. A listing of this input data is given in Figure 15-22.

Comparison of Results

All walls analyzed in this example using ETABS were also analyzed using the general structural analysis program SAP90 (Reference [1]), using refined meshes of the membrane/shell element of that program. The SAP90 meshes utilized are shown in Figures 15-3, 15-7, 15-11, 15-15, 15-19 and 15-23. For the SAP90 analysis, the rigid diaphragms at the floor levels were modeled by either constraining all wall nodes at the floor to have the same lateral displacement for planar walls, or by adding rigid members in the plane of the floor for three-dimensional walls.

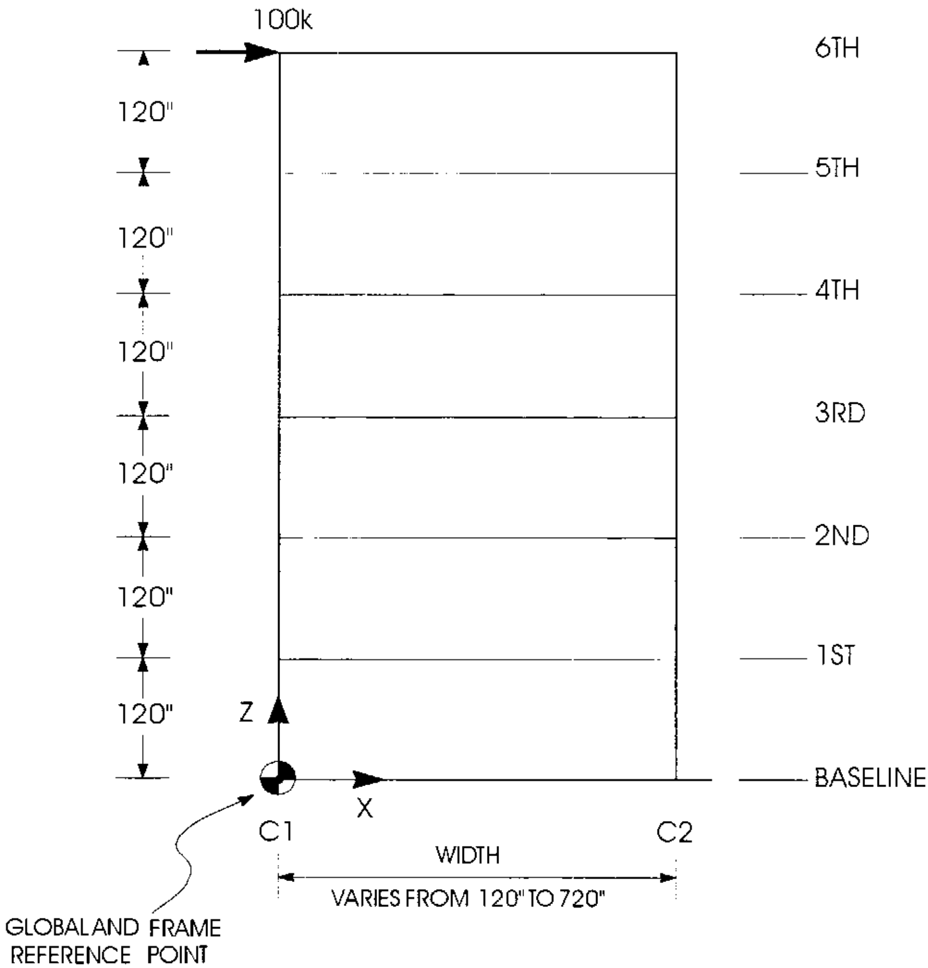
The lateral displacements from the ETABS and SAP90 analyses are compared in Figures 15-4, 15-8, 15-12, 15-16, 15-20 and 15-24 for the various walls. The agreement is good to excellent. In general, the comparisons become better as the number of stories is increased.

It should be noted here that most of the above walls were also analyzed with ETABS using additional column lines and panels (i.e. finer meshes of smaller panels). No significant differences in the displacements and member forces were discovered. Therefore, with the ETABS panel element the user need not be concerned with mesh refinement for more accurate results. Only the number of column lines and panel elements that are needed for the definition of the wall geometry need be defined.

Sample ETABS output for Example 15f is included in this manual.

References

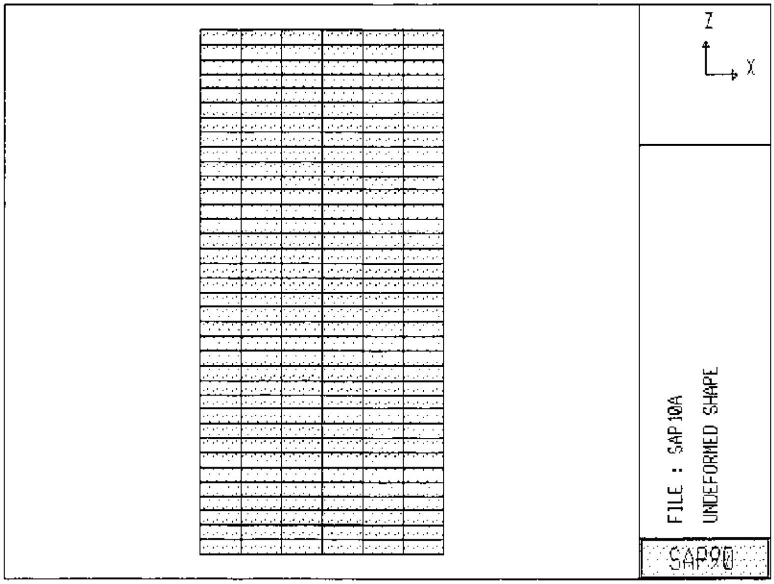
1. **Wilson, E.L. and Habibullah, A.**
SAP90, Technical Reference Manual, Computers and Structures, Inc., Berkeley, California, 1988.



Example 15a
Planar Shear Wall
Figure 15-1

```
$ --------------------------Heading
 ETABS 6.1
 Example 15a : Panel Behavior - Six Story Planar Shear Wall
               Static Lateral Load Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 6 1 1 1 0 2 0 1 0 0 0 0 1 0 1 0 1 0 0 1 1
 386.4
$ --------------------------- Story Data
 6th 120
 5th 120
 4th 120
 3rd 120
 2nd 120
 1st 120
$ --------------------------- Material Data
 1 c 3000 .2 .15/1728
$ --------------------------- Panel Properties
 1 MEMB 1 12 12 12
$ --------------------------- Frame Data
 Planar Shear Wall
 1 2 0 0 0 0 0 0 0 6
$ --------------------------- Column Line Location
 1 0
 2 360
$ --------------------------- Column Assignments
                              $ Leave a Blank Line
$ --------------------------- Panel Assignments
 1 6th 1st 1 2 1
                              $ Leave a Blank Line
$ --------------------------- Frame Location Data
 1 0 0 0 /Shear Wall
$ --------------------------- Lateral Loads Data
 6th 1 A 100
                              $ Leave a Blank Line
$ --------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
$ ***** End of Input Data *****
```

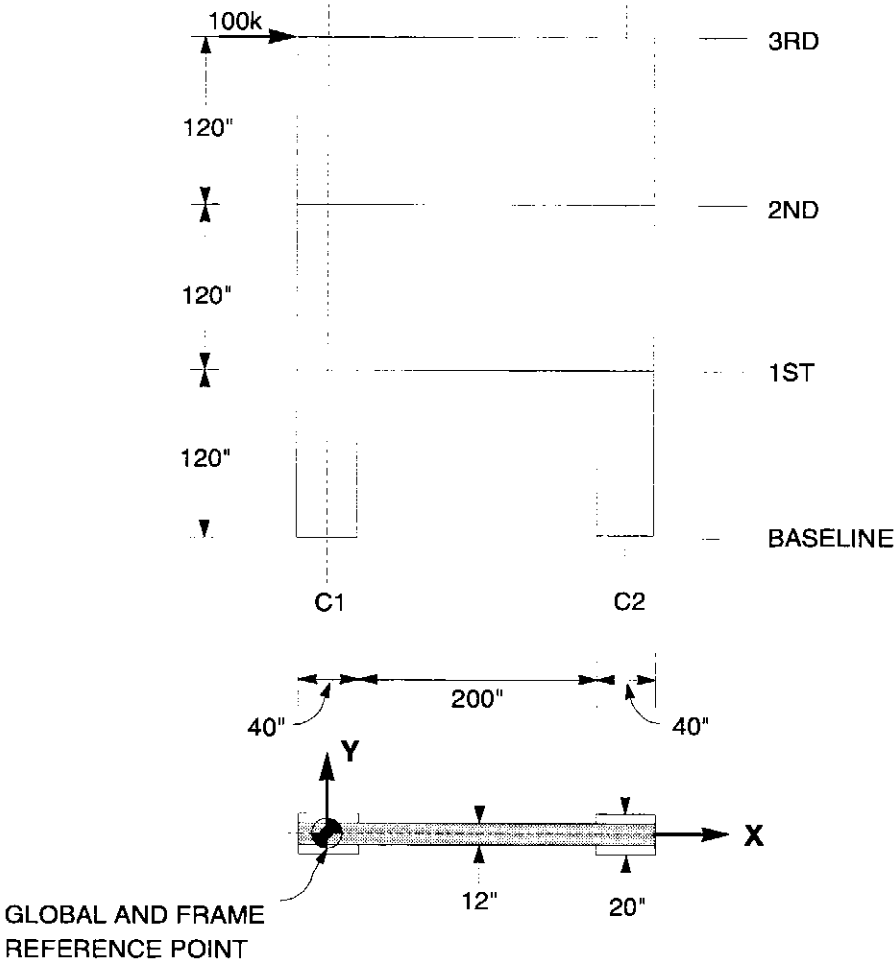
Example 15a
*Listing of Input Data (File: **EX15a**)*
Figure 15-2



Example 15a
SAP90 Mesh Used for Comparison
Figure 15-3

Number of Stories	Wall Height (inches)	Wall Length (inches)	ETABS	SAP90
6	720	120	2.4358	2.4338
		360	0.1021	0.1033
		720	0.0178	0.0187
3	360	120	0.3179	0.3218
		360	0.0177	0.0187
		720	0.0047	0.0052
1	120	120	0.0171	0.0187
		360	0.0026	0.0029
		720	0.0012	0.0013

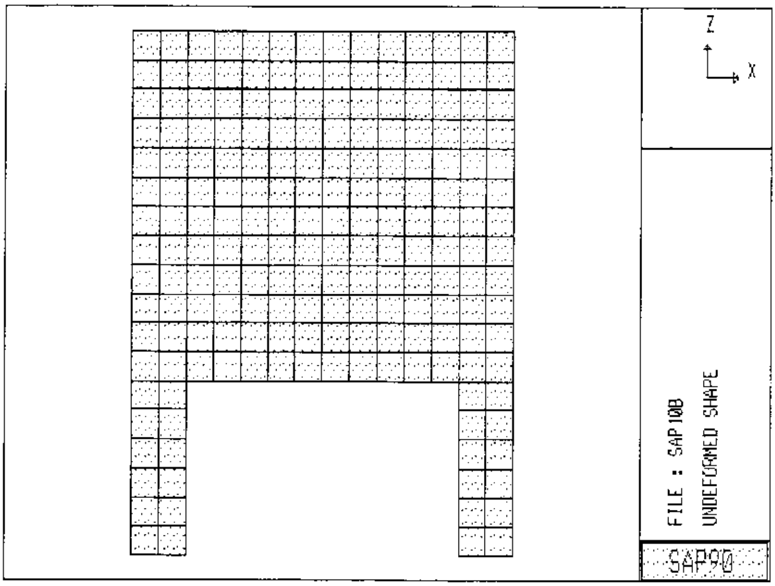
Example 15a
Comparison of Results for Top Displacements (inches)
Figure 15-4



Example 15b
Wall Supported on Columns
Figure 15-5

```
$ --------------------------Heading
 ETABS 6.1
 Example 15b : Panel Behavior - Wall Supported on Columns
               Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 3 1 1 1 0 2 0 1 1 0 0 0 1 0 1 0 1 0 0 1 1
 386.4
$ -------------------------- Story Data
 3rd 120
 2nd 120
 1st 120
$ -------------------------- Material Data
 1 c 3000 .2 .15/1728
$ -------------------------- Column Properties
 1 rect 1 40 20
$ -------------------------- Panel Properties
 1 MEMB 1 12 12 12 40 12 40 12
$ -------------------------- Frame Data
 Planar Shear Wall
 1 2 0 0 0 0 0 0 0 2
$ -------------------------- Column Line Location
 1 240
 2 0
$ -------------------------- Column Assignments
 1 2 0 1st  1st 1
                              $ Leave a Blank Line
$ -------------------------- Panel Assignments
 1 3rd 2nd  2 1 1
                              $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 0 0 0 /Shear Wall
$ -------------------------- Lateral Loads Data
 3rd 1 A 100
                              $ Leave a Blank Line
$ -------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
$ ***** End of Input Data *****
```

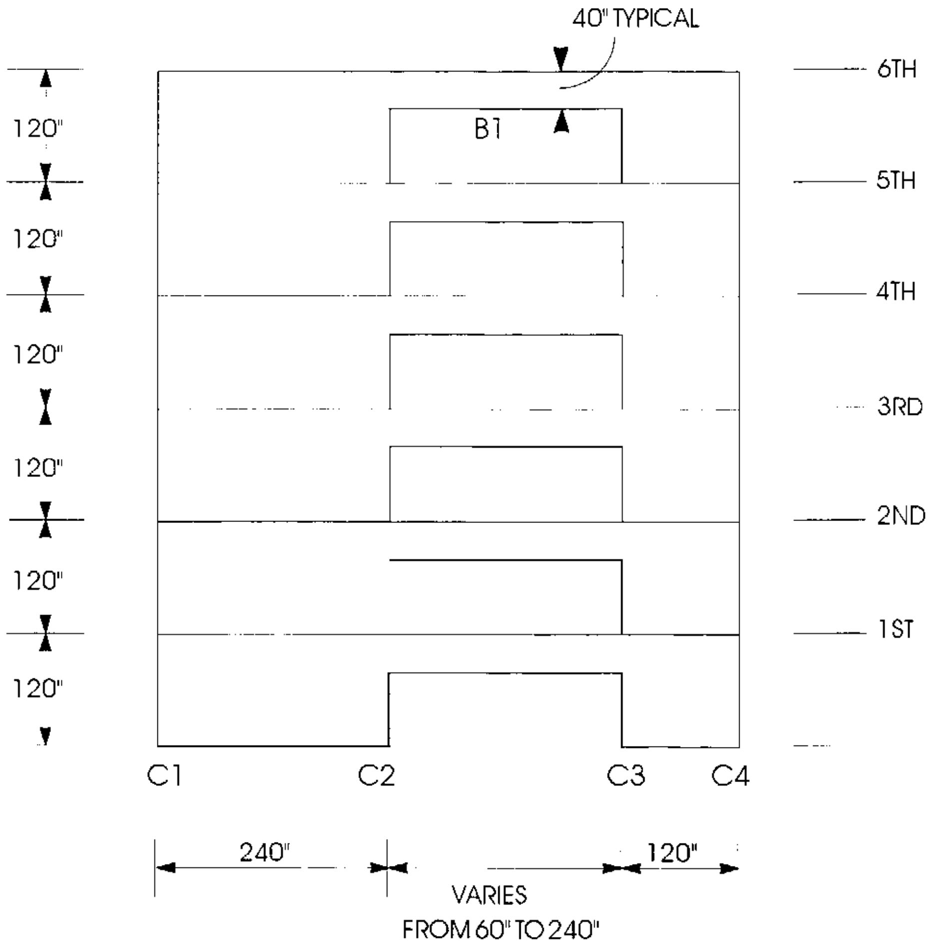
Example 15b
*Listing of Input Data (File: **EX15b**)*
Figure 15-6



Example 15b
SAP90 Mesh Used for Comparison
Figure 15-7

Location	ETABS	SAP90
Story 3	0.0606	0.0662
Story 2	0.0468	0.0521
Story 1	0.0358	0.0403

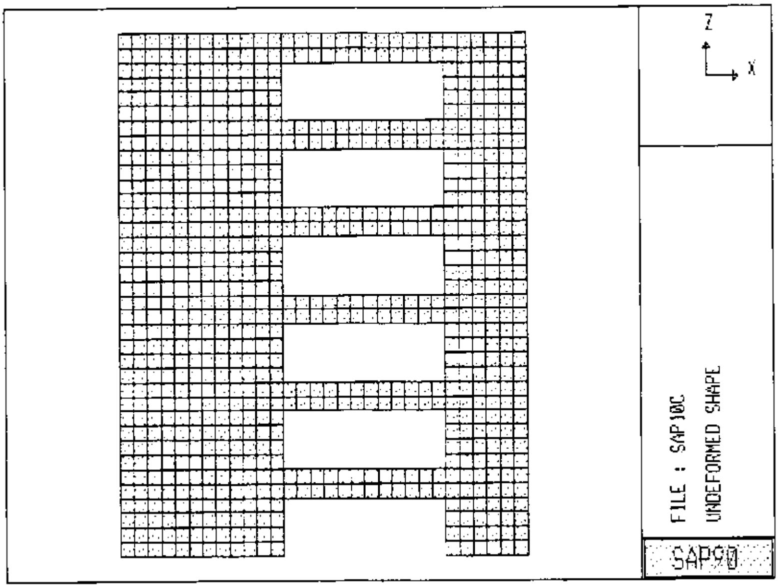
Example 15b
Comparison of Results for Displacements (inches)
Figure 15-8



Example 15c
Wall-spandrel System
Figure 15-9

```
$ -------------------------- Heading
ETABS 6.1
Example 15c   Panel Behavior: Wall-Spandrel System
              Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
6 1 1 1 0 2 0 1 0 1 0 0 1 0 1 0 1 0 0 1 1
386.4
$ -------------------------- Story Data
6th 120
5th 120
4th 120
3rd 120
2nd 120
1st 120
$ -------------------------- Material Data
1 c 3000 .2 .15/1728
$ -------------------------- Beam Properties
1 RECT 1  40 0.0 12.0
$ -------------------------- Panel Properties
1 MEMB 1 12
$ -------------------------- Frame Data
Six Story Wall-Spandrel Plane Frame
1 4 1 0 0 0 0 0 0 12
$ -------------------------- Column Line Location
1 0
2 240
3 480
4 600
$ -------------------------- Bay Connectivity
1 2 3
$ -------------------------- Column Assignments
                             $ Leave a Blank Line
$ -------------------------- Beam Assignments
1 1 0  6th 1st 1
                             $ Leave a Blank Line
$ -------------------------- Panel Assignments
1 6th 1st 1 2 1
2 6th 1st 3 4 1
                             $ Leave a Blank Line
$ -------------------------- Frame Location Data
1 0 0 0 /Wall-Spandrel Frame
$ -------------------------- Lateral Loads Data
6th 1 A 100
                             $ Leave a Blank Line
$ -------------------------- Load Case Data
1 0 1
2 0 0 0 0 1
$ ***** End of Input Data *****
```

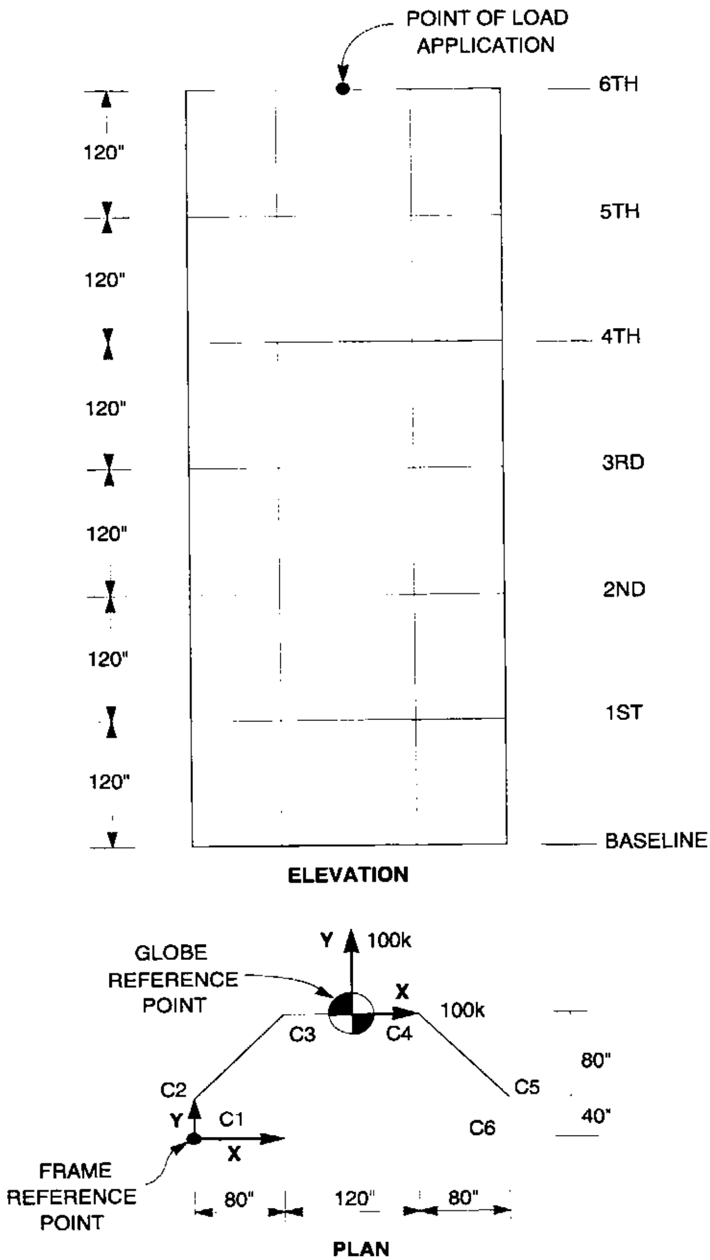
Example 15c
*Listing of Input Data (File: **EX15c**)*
Figure 15-10



Example 15c
SAP90 Mesh Used for Comparison
Figure 15-11

Number of Stories	Beam Length (inches)	ETABS	SAP90
6	60	0.0886	0.0876
	240	0.1482	0.1539
3	60	0.0202	0.0205
	240	0.0327	0.0344

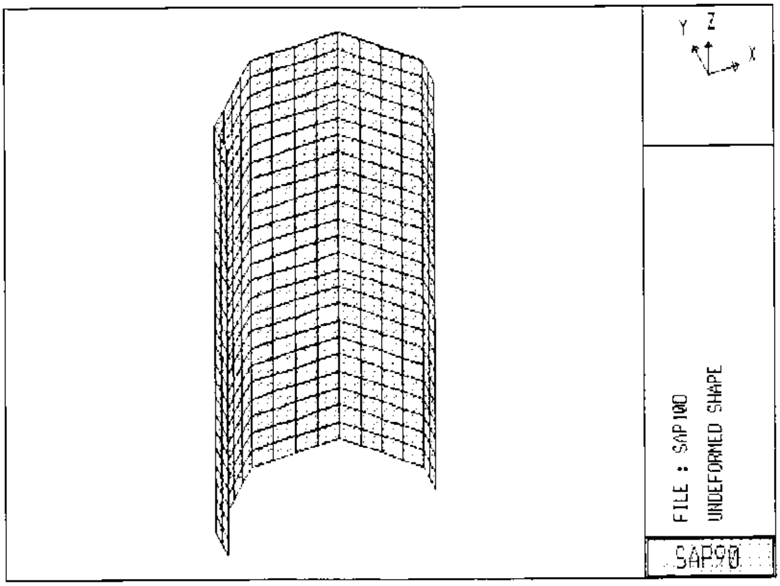
Example 15c
Comparison of Results for Top Displacements (inches)
Figure 15-12



Example 15d
C-Shaped Wall Section
Figure 15-13

```
$ -------------------------- Heading
 ETABS 6.1
 Example 15d   Panel Behavior: Wall-Spandrel System
               Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 6 1 1 1 0 3 0 1 0 0 0 0 1 0 1 0 0 0 0 1 1
 386.4
$ -------------------------- Story Data
 6th 120
 5th 120
 4th 120
 3rd 120
 2nd 120
 1st 120
$ -------------------------- Material Data
 1 c 3000 .2 .15/1728
$ -------------------------- Panel Properties
 1 MEMB 1 6
$ -------------------------- Frame Data
 C-Section Frame
 1 6 0 0 0 0 0 0 0 30
$ -------------------------- Column Line Location
 1 0
 2 0 40
 3 80 120
 4 200 120
 5 280 40
 6 280 0
$ -------------------------- Column Assignments

$ -------------------------- Panel Assignments
 1 6th 1st 1 2 1
 1 6th 1st 2 3 1
 1 6th 1st 3 4 1
 1 6th 1st 4 5 1
 1 6th 1st 5 6 1
                             $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 -140 -120 0 /C-Section
$ -------------------------- Lateral Load Data
 6th 1 A 100
 6th 1 B   0 100

$ -------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
 3 0 0 0 0 0 1
$ ***** End of Input Data *****
```

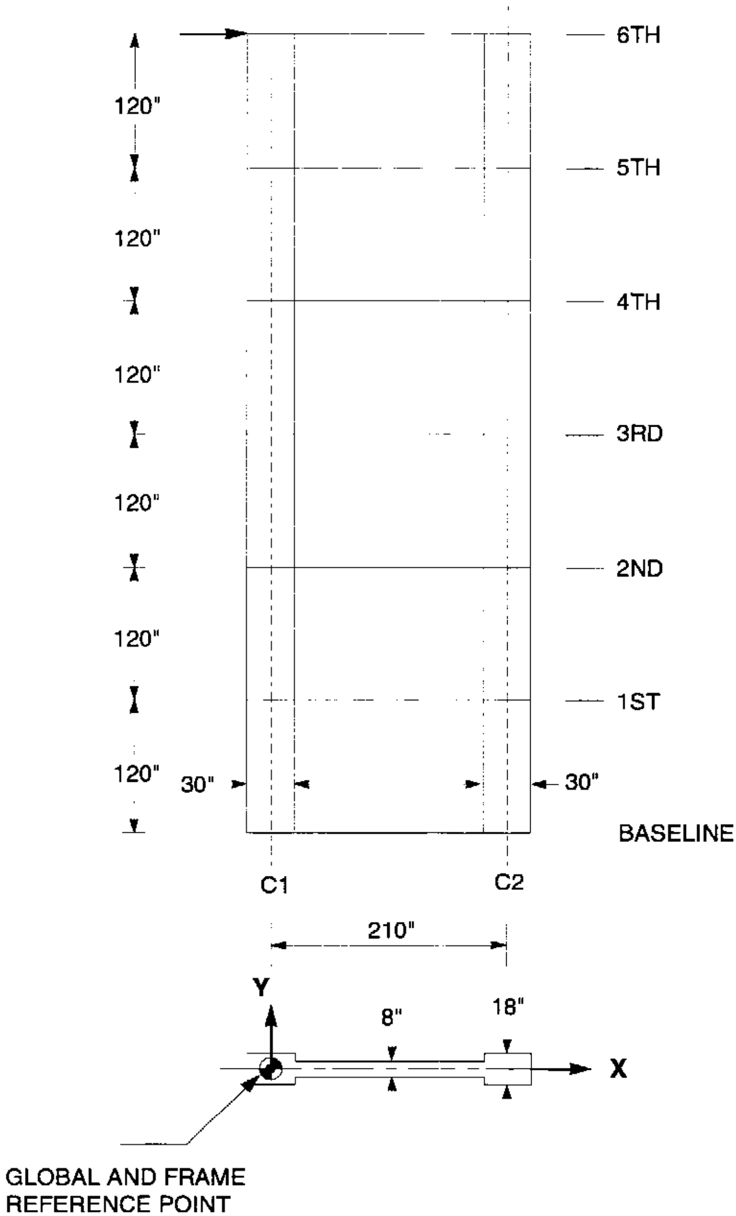
Example 15d
Listing of Input Data (File: ***EX15d****)*
Figure 15-14



Example 15d
SAP90 Mesh Used for Comparison
Figure 15-15

Number of Stories	Load Direction	Displacement Direction	ETABS	SAP90
6	X	X	0.8900"	0.8939"
	X	Z-rotation	0.0187	0.0191
	Y	Y	1.2057"	1.1884"
3	X	X	0.1370"	0.1338"
	X	Z-rotation	0.0025	0.0025
	Y	Y	0.1823"	0.1735"

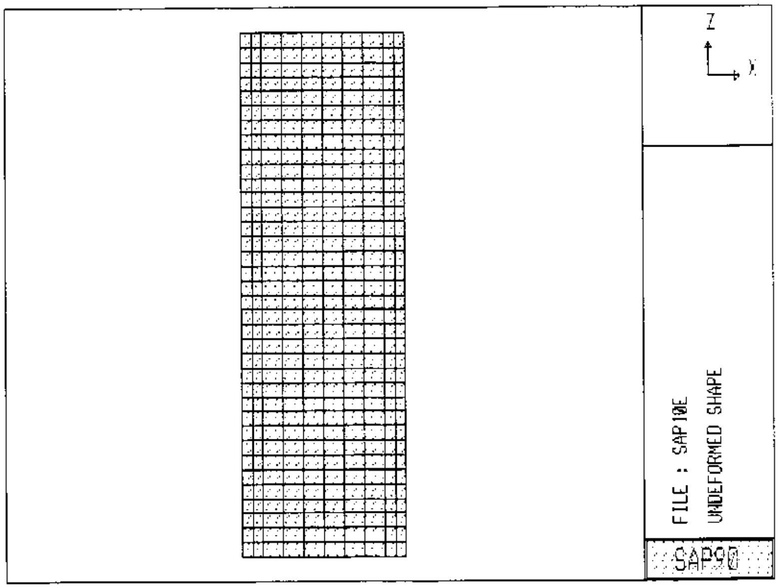
Example 15d
Comparison of Results for Displacements at Load Application Point
Figure 15-16



Example 15e
Wall with Edges Thickened
Figure 15-17

```
$ --------------------------Heading
 ETABS 6.1
 Example 15e : Panel Behavior - Six Story Wall With Thickened Edges
               Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 6 1 1 1 0 2 0 1 0 0 0 0 1 0 1 0 1 0 0 1 1
 386.4
$ -------------------------- Story Data
 6th 120
 5th 120
 4th 120
 3rd 120
 2nd 120
 1st 120
$ -------------------------- Material Data
 1 c 3000 .2 .15/1728
$ -------------------------- Panel Properties
 1 MEMB 1 8  8  8  30  18  30  18
$ -------------------------- Frame Data
 Planar Shear Wall
 1 2 0 0 0 0 0 0 0 6
$ -------------------------- Column Line Location
 1 0
 2 210
$ -------------------------- Column Assignments

$ -------------------------- Panel Assignments
 1 6th 1st 1 2 1
                             $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 0 0 0 /Shear Wall
$ -------------------------- Lateral Loads Data
 6th 1 A 100
                              $ Leave a Blank Line
$ -------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
$ ***** End of Input Data *****
```

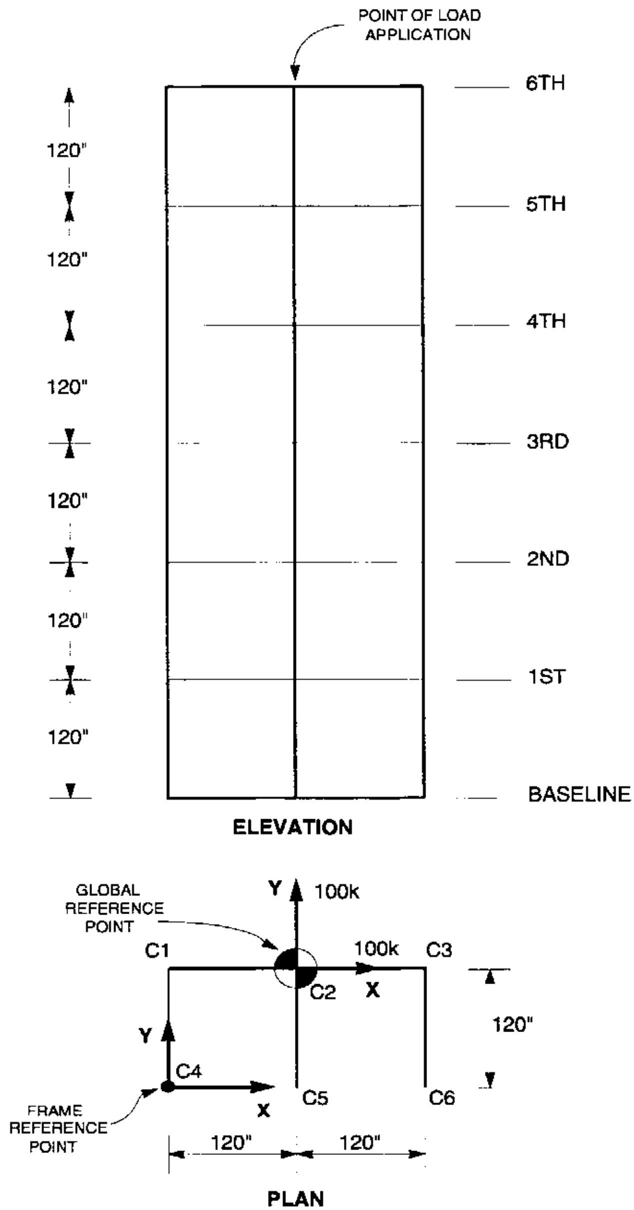
Example 15e
*Listing of Input Data (File: **EX15e**)*
Figure 15-18



Example 15e
SAP90 Mesh Used for Comparison
Figure 15-19

Number of Stories	ETABS	SAP90
6	0.2925	0.2909
3	0.0480	0.0483

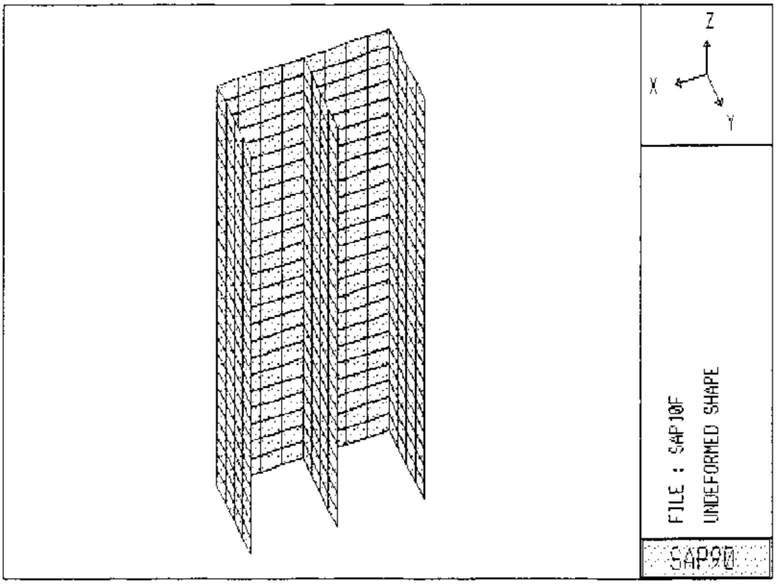
Example 15e
Comparison of Results for Top Displacements (inches)
Figure 15-20



Example 15f
E-Shaped Wall Section
Figure 15-21

```
$ -------------------------- Heading
 ETABS 6.1
 Example 15f   Panel Behavior: E-Shaped Wall Section
               Static Lateral Load Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
 6 1 1 1 0 3 0 1 0 0 0 0 1 0 1 0 0 0 0 1 1
 386.4
$ -------------------------- Story Data
 6th 120
 5th 120
 4th 120
 3rd 120
 2nd 120
 1st 120
$ -------------------------- Material Data
 1 c 3000 .2 .15/1728
$ -------------------------- Panel Properties
 1 MEMB 1 6
$ -------------------------- Frame Data
 E-Section Frame
 1 6 0 0 0 0 0 0 0 30
$ -------------------------- Column Line Location
 1 0 120
 2 120 120
 3 240 120
 4 0
 5 120
 6 240
$ -------------------------- Column Assignments

$ -------------------------- Panel Assignments
 1 6th 1st 1 2 1
 1 6th 1st 2 3 1
 1 6th 1st 1 4 1
 1 6th 1st 2 5 1
 1 6th 1st 3 6 1
                            $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 -120 -120 0 /E-Shaped Wall
$ -------------------------- Lateral Load Data
 6th 1 A 100
 6th 1 B   0  100

$ -------------------------- Load Case Data
 1 0 1
 2 0 0 0 0 1
 3 0 0 0 0 0 1
$ ***** End of Input Data *****
```

Example 15f
*Listing of Input Data (File:**EX15f**)*
Figure 15-22



Example 15f
SAP90 Mesh Used for Comparison
Figure 15-23

Number of Stories	Load Direction	Displacement Direction	ETABS	SAP90
6	X	X	0.3904"	0.3822"
	X	Z-rotation	0.0042	0.0043
	Y	Y	0.7540"	0.7512"
3	X	X	0.0676"	0.0639"
	X	Z-rotation	0.0005	0.0005
	Y	Y	0.1057"	0.1065"

Example 15f
Comparison of Results for Displacements at Load Application Point
Figure 15-24

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    1
                                                       PROGRAM:ETABS/FILE:ex15f.EKO
 EXAMPLE 15F    PANEL BEHAVIOR: E-SHAPED WALL SECTION
 STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 J O B   C O N T R O L   I N F O R M A T I O N


 NUMBER OF STORIES---------------------------   6
 NUMBER OF FLOOR DIAPHRAGMS ON EACH LEVEL-----   1
 NUMBER OF DIFFERENT FRAMES------------------   1
 NUMBER OF TOTAL FRAMES----------------------   1
 NUMBER OF MASS TYPES------------------------   0
 NUMBER OF LOAD CASES------------------------   3
 NUMBER OF STRUCTURAL PERIODS----------------   0

 NUMBER OF MATERIAL PROPERTIES---------------   1

 NUMBER OF PROPERTIES FOR COLUMNS------------   0
 NUMBER OF PROPERTIES FOR BEAMS--------------   0
 NUMBER OF PROPERTIES FOR FLOORS-------------   0
 NUMBER OF PROPERTIES FOR BRACES-------------   0
 NUMBER OF PROPERTIES FOR PANELS-------------   1
 NUMBER OF PROPERTIES FOR SUPPORTS/LINKS------   0

 CODE FOR STATIC LATERAL ANALYSIS------------   1
 CODE FOR DYNAMIC LATERAL ANALYSIS-----------   0
 CODE FOR STRUCTURE TYPE---------------------   0
 CODE FOR P-DELTA ANALYSIS ------------------   0
 CODE FOR FRAME JOINT STIFFNESS MODIFICATION--   0
 CODE FOR FRAME SELF WEIGHT LOAD CONDITION----   1
 CODE FOR TYPE OF UNITS----------------------   1



 GRAVITATIONAL ACCELERATION----------------   0.3864E+03
 EIGEN CONVERGENCE TOLERANCE---------------   0.1000E-03
 EIGEN CUTOFF TIME PERIOD------------------   0.0000E+00
 P-DELTA FACTOR----------------------------   0.1000E+01
```

Example 15f
Sample Output

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     2
                                                  PROGRAM:ETABS/FILE:ex15f.EKO
 EXAMPLE 15F   PANEL BEHAVIOR: E-SHAPED WALL SECTION
 STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 STRUCTURAL STORY DATA . . .

 STORY          STORY  NUMBER OF
 LEVEL         HEIGHT DIAPHRAGMS
 6TH           120.00          0
 5TH           120.00          0
 4TH           120.00          0
 3RD           120.00          0
 2ND           120.00          0
 1ST           120.00          0
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     3
                                                  PROGRAM:ETABS/FILE:ex15f.EKO
 EXAMPLE 15F   PANEL BEHAVIOR: E-SHAPED WALL SECTION
 STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 MATERIAL PROPERTIES

  ID TYPE      ELASTIC     POISSONS        UNIT         UNIT     COEFF OF
               MODULUS        RATIO      WEIGHT         MASS    EXPANSION
   1    C   0.3000E+04       0.2000  0.8681E-04   0.0000E+00   0.0000E+00


 MATERIAL PROPERTIES FOR DESIGN

  ID TYPE           FY           FC         FYS          FCS      FBMAJ      FBMIN
   1    C    0.000E+00    0.000E+00   0.000E+00    0.000E+00
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     4
                                                  PROGRAM:ETABS/FILE:ex15f.EKO
 EXAMPLE 15F   PANEL BEHAVIOR: E-SHAPED WALL SECTION
 STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 SECTION PROPERTIES FOR   PANELS

      ELEMENT   MAT     PANEL     PANEL     PANEL    PANEL    PANEL   PANEL    PANEL
   ID TYPE       ID        TV        TH      TSHR       BI       DI      BJ       DJ
    1 MEMB        1     6.000     6.000     6.000     0.00     0.00    0.00     0.00
```

Example 15f
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    2
                                                   PROGRAM:ETABS/FILE:ex15f.STR
 EXAMPLE 15F   PANEL BEHAVIOR: E-SHAPED WALL SECTION
 STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND


 STATIC LOAD CONDITION LATERAL DISPLACEMENTS FOR DIAPHRAGM     1

 VALUES ARE AT THE CENTER OF MASS OF THE
 CORRESPONDING DIAPHRAGM IN GLOBAL COORDINATES

                /---------------------LOAD CONDITIONS---------------------/
 LEVEL     DIRN         I         II        III          A         B          C

 6TH          X     0.0000     0.0000     0.0000    0.3904    0.0000    0.0000
 6TH          Y     0.0000     0.0000     0.0000    0.0000    0.7540    0.0000
 6TH       ROTZ  -1.957E-18 0.000E+00 0.000E+00 4.228E-03-4.953E-16 0.000E+00

 5TH          X     0.0000     0.0000     0.0000    0.2978    0.0000    0.0000
 5TH          Y     0.0000     0.0000     0.0000    0.0000    0.5697    0.0000
 5TH       ROTZ  -1.531E-18 0.000E+00 0.000E+00 3.179E-03-3.954E-16 0.000E+00

 4TH          X     0.0000     0.0000     0.0000    0.2099    0.0000    0.0000
 4TH          Y     0.0000     0.0000     0.0000    0.0000    0.3955    0.0000
 4TH       ROTZ  -1.099E-18 0.000E+00 0.000E+00 2.188E-03-2.926E-16 0.000E+00

 3RD          X     0.0000     0.0000     0.0000    0.1314    0.0000    0.0000
 3RD          Y     0.0000     0.0000     0.0000    0.0000    0.2413    0.0000
 3RD       ROTZ  -6.965E-19 0.000E+00 0.000E+00 1.316E-03-1.914E-16 0.000E+00

 2ND          X     0.0000     0.0000     0.0000    0.0671    0.0000    0.0000
 2ND          Y     0.0000     0.0000     0.0000    0.0000    0.1173    0.0000
 2ND       ROTZ  -3.532E-19 0.000E+00 0.000E+00 6.211E-04-9.969E-17 0.000E+00

 1ST          X     0.0000     0.0000     0.0000    0.0217    0.0000    0.0000
 1ST          Y     0.0000     0.0000     0.0000    0.0000    0.0335    0.0000
 1ST       ROTZ  -1.038E-19 0.000E+00 0.000E+00 1.627E-04-3.061E-17 0.000E+00
```

Example 15f
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS  PAGE    2
                                                    PROGRAM:ETABS/FILE:ex15f.DSP
EXAMPLE 15F   PANEL BEHAVIOR: E-SHAPED WALL SECTION
STATIC LATERAL LOAD ANALYSIS  UNITS: KIP-INCH-SECOND

DISPLACEMENTS AT LEVEL 6TH      IN FRAME /E-SHAPED WALL
```

COL ID	OUTPUT ID	LOCAL X-TRAN	LOCAL Y-TRAN	LOCAL Z-TRAN	LOCAL XX-ROTN	LOCAL YY-ROTN	LOCAL ZZ-ROTN
1	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
1	CASE 2	0.39042	-0.50739	0.08507	0.00106	0.00071	0.00423
1	CASE 3	0.00000	0.75398	-0.05462	-0.00151	-0.00001	0.00000
2	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
2	CASE 2	0.39042	0.00000	0.00000	0.00000	0.00071	0.00423
2	CASE 3	0.00000	0.75398	-0.05379	-0.00151	0.00000	0.00000
3	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
3	CASE 2	0.39042	0.50739	-0.08507	-0.00106	0.00071	0.00423
3	CASE 3	0.00000	0.75398	-0.05462	-0.00151	0.00001	0.00000
4	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
4	CASE 2	0.89781	-0.50739	-0.04266	0.00106	0.00181	0.00423
4	CASE 3	0.00000	0.75398	0.12634	-0.00151	0.00000	0.00000
5	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
5	CASE 2	0.89781	0.00000	0.00000	0.00000	0.00181	0.00423
5	CASE 3	0.00000	0.75398	0.12716	-0.00151	0.00000	0.00000
6	CASE 1	0.00000	0.00000	-0.00743	0.00000	0.00000	0.00000
6	CASE 2	0.89781	0.50739	0.04266	-0.00106	0.00181	0.00423
6	CASE 3	0.00000	0.75398	0.12634	-0.00151	0.00000	0.00000

Example 15f
Sample Output (continued)

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     2
                                                PROGRAM:ETABS/FILE:ex15f.FRM
EXAMPLE 15F    PANEL BEHAVIOR: E-SHAPED WALL SECTION
STATIC LATERAL LOAD ANALYSIS   UNITS: KIP-INCH-SECOND


WALL FORCES AT LEVEL 6TH       IN FRAME /E-SHAPED WALL

WALL OUTPUT OUTPUT      MAJOR      MAJOR      MINOR      MINOR     AXIAL TORSIONAL
  ID     ID  POINT     MOMENT      SHEAR     MOMENT      SHEAR     FORCE    MOMENT
   1 CASE 1    TOP       0.00       0.00       0.00       0.00    -18.75      0.00
            BOTTOM       0.00                  0.00
   1 CASE 2    TOP       0.00     100.00       0.00       0.00      0.00  -3600.00
            BOTTOM   12000.00                  0.00
   1 CASE 3    TOP       0.00       0.00       0.00     100.00      0.00      0.00
            BOTTOM       0.00              12000.00
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     3
                                                PROGRAM:ETABS/FILE:ex15f.FRM
EXAMPLE 15F    PANEL BEHAVIOR: E-SHAPED WALL SECTION
STATIC LATERAL LOAD ANALYSIS   UNITS: KIP-INCH-SECOND


WALL FORCES AT LEVEL 5TH       IN FRAME /E-SHAPED WALL

WALL OUTPUT OUTPUT      MAJOR      MAJOR      MINOR      MINOR     AXIAL TORSIONAL
  ID     ID  POINT     MOMENT      SHEAR     MOMENT      SHEAR     FORCE    MOMENT
   1 CASE 1    TOP       0.00       0.00       0.00       0.00    -56.25      0.00
            BOTTOM       0.00                  0.00
   1 CASE 2    TOP   12000.00     100.00       0.00       0.00      0.00  -3600.00
            BOTTOM   24000.00                  0.00
   1 CASE 3    TOP       0.00       0.00   12000.00     100.00      0.00      0.00
            BOTTOM       0.00              24000.00
```

```
CSI/ETABS - EXTENDED THREE DIMENSIONAL ANALYSIS OF BUILDING SYSTEMS   PAGE     4
                                                PROGRAM:ETABS/FILE:ex15f.FRM
EXAMPLE 15F    PANEL BEHAVIOR: E-SHAPED WALL SECTION
STATIC LATERAL LOAD ANALYSIS   UNITS: KIP-INCH-SECOND


WALL FORCES AT LEVEL 4TH       IN FRAME /E-SHAPED WALL

WALL OUTPUT OUTPUT      MAJOR      MAJOR      MINOR      MINOR     AXIAL TORSIONAL
  ID     ID  POINT     MOMENT      SHEAR     MOMENT      SHEAR     FORCE    MOMENT
   1 CASE 1    TOP       0.00       0.00       0.00       0.00    -93.75      0.00
            BOTTOM       0.00                  0.00
   1 CASE 2    TOP   24000.00     100.00       0.00       0.00      0.00  -3600.00
            BOTTOM   36000.00                  0.00
   1 CASE 3    TOP       0.00       0.00   24000.00     100.00      0.00      0.00
            BOTTOM       0.00              36000.00
```

Example 15f
Sample Output (continued)

Example 16

Six Story Shear Wall/Frame Building Gravity and UBC 1994 Seismic Load Analysis

Description

This is a six story structure consisting of a ductile steel frame, concrete elevator core shear walls and basement shear walls.

The structure is analyzed for vertical dead and live loads and for lateral static seismic UBC 1994 (Reference [1]), loads acting in the longitudinal and transverse directions of the structure.

The geometry and the gravity loads are shown in Figures 16-1 and 16-2.

Significant Options of ETABS Activated

- Mass properties calculated automatically
- AISC data base of section properties used
- Vertical loading options activated
- UBC 1994 seismic loads calculated automatically

- Pin base conditions for steel frame

Computer Model

This example is a typical shear wall/frame interaction problem. Vertical loading has only been applied to the steel frame. A typical story weight density of 100 psf is used to obtain mass properties. Kip-inch-second units are used.

The following UBC94 factors are input to automatically generate seismic loads:

Z = 0.4
I = 1.0
S = 1.0
R_W = 12
T_a = 0.44 sec.

and the lateral load distribution is stopped above the basement walls.

This model consists of three different frames, as follows:

Frame 1: Ductile steel frame
Frame 2: Elevator core walls
Frame 3: Basement walls

The ductile steel frame is modeled with twelve column lines and eleven bays. A modulus of elasticity of 29500 ksi is used for steel. The box columns are assumed to be 16" x 16" with 1" thickness in the 1st and 2nd stories, 3/4" thickness in the 3rd and 4th stories, and 1/2" thickness in the 5th and 6th stories.

The elevator core walls are modeled with twelve column lines and eight panels per story. The eight panels are grouped into four walls, two planar and two C-sections. It should be noted that because of vertical isolation of the four walls, each could have been modeled as a separate frame. A modulus of elasticity of 3000 ksi is used for concrete. A wall thickness of 12" is used.

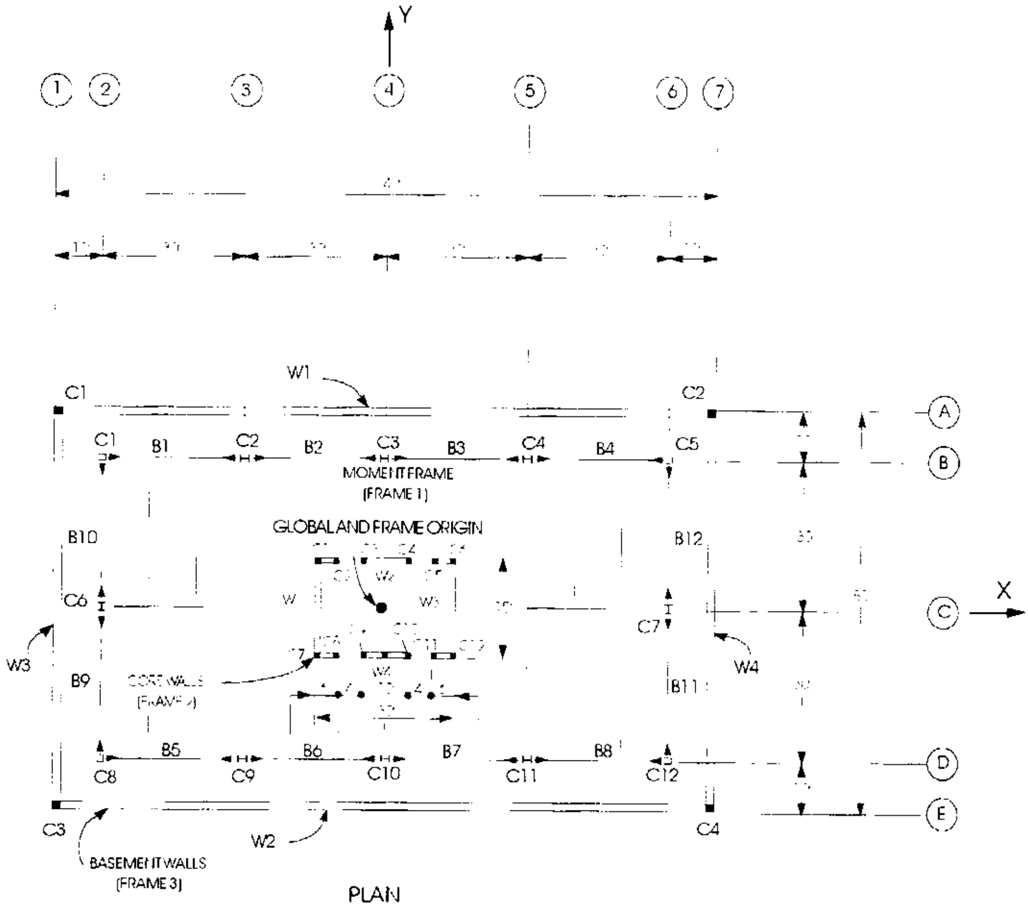
The basement walls are modeled with four column lines and four panels per story, each identified with a different wall ID number. A wall thickness of 12" is used.

The input data file for this example is EX16. A listing of the input data is given in Figure 16-3.

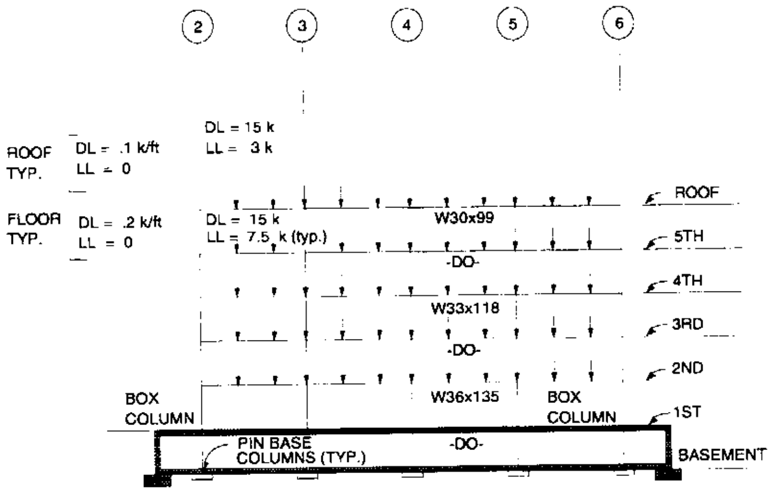
References

1. **International Conference of Building Officials**

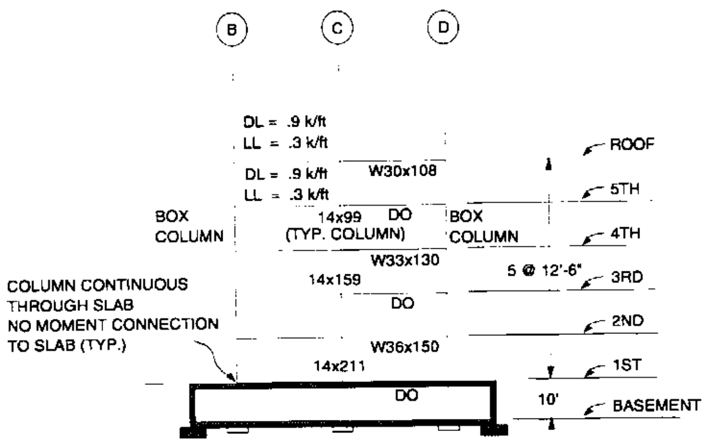
   Uniform Building Code, Whittier, California, 1994.



Example 16
Six-story Shear Wall / Frame Building
Figure 16-1



TYPICAL LONGITUDINAL FRAMING



TYPICAL TRANSVERSE FRAMING

Example 16
Six-story Shear Wall / Frame Building
Figure 16-2

```
$ ---------------------------Heading
 ETABS 6.1
 Example 16 :Six Story Shear Wall/frame Building
 Gravity and UBC 1994 Seismic Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 6 1 3 3 1 4 9 2 6 6 0 0 1 0 11 1 0 0 2 0 1
 386.4
$ --------------------------- Mass Data
 1 1 1/386.4
 rect  .1/144 0 0 720 1440
$ --------------------------- Story Data
 roof 150 1
 1 1
 5th 150 1
 1 1
 4th 150 1
 1 1
 3rd 150 1
 1 1
 2nd 150 1
 1 1
 1st 120 0
$ --------------------------- Material Data
 1 s 29500 .3 .49/1728
 2 c 3000  .3 .15/1728
$ --------------------------- Column Properties
 1  W14x99  1
 2  W14x159  1
 3  W14x211  1
 4  Box 1 16 16 .5  .5
 5  Box 1 16 16 .75 .75
 6  Box 1 16 16 1.  1.
$ --------------------------- Beam Properties
 1  W30x99    1
 2  W33x118   1
 3  W36x135   1
 4  W30x108   1
 5  W33x130   1
 6  W36x150   1
$ --------------------------- Panel Properties
 1  memb 2  12
$ --------------------------- Data for Frame 1
 /Steel Frame 3-Dimensional
 1 12 12 0 3 6 0 0 0 0 0 2
$ --------------------------- Column Line Location
 1 -720  360
 2 -360  360
 3  0    360
 4  360  360
 5  720  360
 6 -720  0  90
 7  720  0  90
 8 -720 -360
 9 -360 -360
 10 0   -360
 11 360 -360
 12 720 -360
```

Example 16
*Listing of Input Data (File: **EX16**)*
Figure 16-3

```
$ -------------------------- Bay Connectivity
 1 1 2
 2 2 3
 3 3 4
 4 4 5
 5 8 9
 6 9 10
 7 10 11
 8 11 12
 9 8 6
 10 6 1
 11 12 7
 12 7 5
$ -------------------------- Joint Load Patterns
 1 15.
 2 3.
 3 7.5
$ -------------------------- Beam Span Loading Patterns
 1 2 .1/12
 -.33 15 -.67 15
 2 2 0
 -.33 3 -.67 3
 3 2 .2/12
 -.33 15 -.67 15
 4 2 0
 -.33 7.5 -.67 7.5
 5 0 .9/12
 6 0 .3/12
$ -------------------------- Column Assignments
 1 1 0 roof 5th 4
 1 1 0 4th 3rd 5
 1 1 0 2nd 2nd 6
 1 1 0 1st 1st 6 1 1
 5 5 1
 8 8 1
 12 12 1
 2 2 0 roof 5th 1
 2 2 0 4th 3rd 2
 2 2 0 2nd 2nd 3
 2 2 0 1st 1st 3 1 1
 3 3 2
 4 4 2
 6 6 2
 7 7 2
 9 9 2
 10 10 2
 11 11 2
                                          $ Leave a Blank Line
$ -------------------------- Beam Assignments
 1 8 0 roof 5th 1
 1 8 0 4th 3rd 2
 1 8 0 2nd 2nd 3
 9 12 0 roof 5th 4
 9 12 0 4th 3rd 5
 9 12 0 2nd 2nd 6
                                          $ Leave a Blank Line
```

Example 16
Listing of Input Data (continued)
Figure 16-3

```
$ -------------------------- Joint Load Assignments
 2 4 0 roof roof 1 2
 2 4 0 5th 2nd 1 3
 9 11 2
                               $ Leave a Blank Line
$ -------------------------- Beam Span Load Assignments
 1 8 0 roof roof 1 2
 1 8 0 5th 2nd 3 4
 9 12 0 roof 2nd 5 6
                               $ Leave a Blank Line
$ -------------------------- Data for Frame 2
 /Core Walls
 2 12 0 0 0 0 0 0 0 48
$ -------------------------- Column Line Location
 1 -180   90
 2 -108   90
 3 -60    90
 4  60    90
 5  108   90
 6  180   90
 7 -180  -90
 8 -108  -90
 9 -60   -90
 10 60   -90
 11 108  -90
 12 180  -90
$ -------------------------- Column Assignments

$ -------------------------- Panel Assignments
 1 roof 1st 2  1  1
 1 roof 1st 1  7  1
 1 roof 1st 7  8  1
 2 roof 1st 3  4  1
 3 roof 1st 5  6  1
 3 roof 1st 6  12 1
 3 roof 1st 12 11 1
 4 roof 1st 9  10 1

$ -------------------------- Data for Frame 3
 /Basement Walls
 3 4 0 0 0 0 0 0 0 4
$ -------------------------- Column Line Location
 1 -70*12  40*12
 2  70*12  40*12
 3 -70*12 -40*12
 4  70*12 -40*12
$ -------------------------- Column Assignments

$ -------------------------- Panel Assignments
 1 1st 1st 1 2 1
 2 1st 1st 3 4 1
 3 1st 1st 1 3 1
 4 1st 1st 4 2 1
                               $ Leave a Blank Line
$ -------------------------- Frame Location Data
 1 0 0 0 /Main Frame
 2 0 0 0 /Core Walls
 3 0 0 0 /Basement Walls
```

Example 16
Listing of Input Data (continued)
Figure 16-3

```
$ --------------------------- UBC '94 Seismic Load Data
 .4 1. 1.
 0 .44 12 roof 1st
 0 .44 12 roof 1st
 36 72
 36 72
 36 72
 36 72
 36 72

$ --------------------------- Load Case Data
 1 0 1
 2 0 0 1
 3 0 0 0 0 1
 4 0 0 0 0 0 1
$ ***** End of Input Data *****
```

Example 16
Listing of Input Data (continued)
Figure 16-3

Example 17

Stepped Diaphragm Parking Structure ATC Seismic Load Analysis

Description

This is a five story split-level parking structure consisting of concrete beams, ramps and columns. Lateral loads are resisted by a three-dimensional moment frame. The structure is analyzed for lateral static seismic loads acting in the longitudinal and transverse directions of the structure. The geometry of the structure is shown in Figure 17-1.

Significant Options of ETABS Activated

- Joint diaphragm assignments and disconnections
- Use of floor elements to model the inter-connecting ramps
- Use of slopting beam elements
- Automatic calculation of ATC lateral loads

Computer Model

This example demonstrates the diaphragm disconnect feature of ETABS. This feature enables the user to model discontinuous diaphragms making the joint displacements at a particular level independent of the diaphragm displacements at that level. Kip-inch-second units are used. A story weight density of 120 psf is assumed.

The whole structure is modeled as a single frame with ten stories, 27 column lines and 42 beam bays. No columns exist on column lines C9, C15, C18 and C19. These column lines are included only to model the beams. All column lines on grid lines A and B in Figure 17-1 are disconnected from floor diaphragms of the stories bearing the story identification with the H suffix. Similarly, all column lines on grid lines D and E are disconnected from floor diaphragms of the stories bearing story identifications without the H suffix.

Floor elements are used to model the ramps with in-plane flexibility. Beam bays 39, 40, 41 and 42 are used to assign sloping edge beams to the ramps in the longitudinal direction.

Linear spring supports are used under story 1STH for columns on grid lines D and E.

The following ATC factors are input to automatically generate ATC seismic loads (Reference [1]):

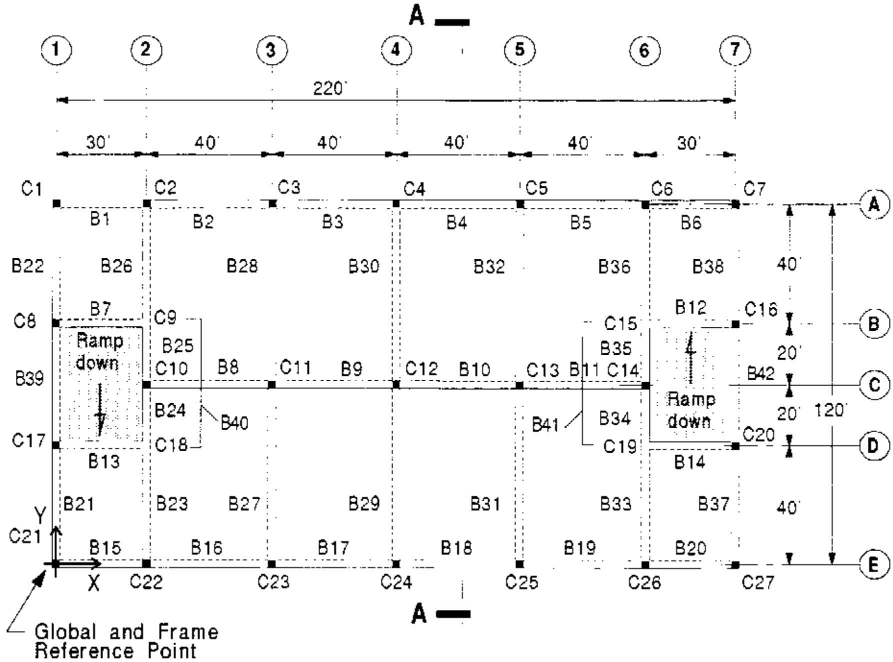
A_v = 0.4 g
S = 1.2
R = 7
T_a = 0.4344 secs.

The input data file for this example is EX17. A listing of the input data is given in Figure 17-2.

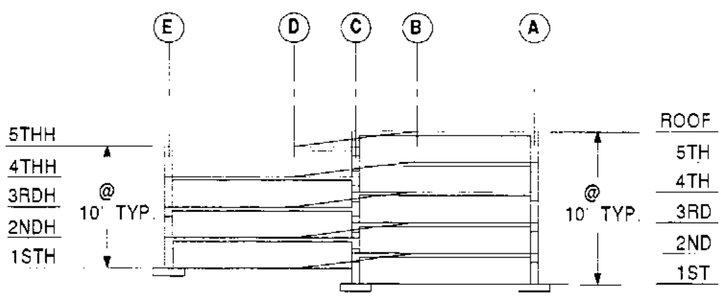
References

1. **Applied Technology Council**

Tentative Provisions for the Development of Seismic Regulations for Buildings, ATC 3-06, Palo Alto, California, 1978.



Typical Floor Framing Plan



All Columns 18" x 18"
All Beams 18" x 30"
Ramps Are 8" Thick Concrete

Section A-A

Example 17
*Listing of Input Data (File: **EX17**)*
Figure 17-1

```
$ ---------------------------Heading
 ETABS 6.1
 Example 17 : Stepped Diaphragm Parking Structure
              ATC 3-06 Seismic Load Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 10 2 1 1 2 2 27 1 1 1 1 0 0 1 14 1 0 0 0 0 1
 386.4
$ --------------------------- Mass Data
 1 1 1/386.4
 rect .12/144 1320 1080 720 2640
 2 1 1/386.4
 rect .12/144 1320  360 720 2640
$ --------------------------- Story Data
 roof 60 1
 1 1
 5thh  60 1
 2 2
 5th  60 1
 1 1
 4thh 60 1
 2 2
 4th  60 1
 1 1
 3rdh 60 1
 2 2
 3rd  60 1
 1 1
 2ndh 60 1
 2 2
 2nd  60 1
 1 1
 1sth 60 0
$ --------------------------- Material Data
 1 c 3000 .2 .15/1728
$ --------------------------- Column Properties
 1  rect 1 18 18
$ --------------------------- Beam Properties
 1  rect 1 30  0 18
$ --------------------------- Floor Properties
 1  memb 1 8  8  8
$ --------------------------- Spring Properties
 1  Linear
 1e6 1e6 1e6 1e6 1e6 1e6
$ --------------------------- Frame Data
 /Main Frame
 1 27 42 2 0 0 0 1
$ --------------------------- Column Line Location
 1     0 1440
 2   360 1440
 3   840 1440
 4  1320 1440
 5  1800 1440
 6  2280 1440
 7  2640 1440
 8     0  960
 9   360  960
 10  360  720
 11  840  720
 12 1320  720
 13 1800  720
 14 2280  720
 15 2280  960
```

Example 17
*Listing of Input Data (File: **EX17**)*
Figure 17-2

```
 16 2640  960
 17    0  480
 18  360  480
 19 2280  480
 20 2640  480
 21    0    0
 22  360    0
 23  840    0
 24 1320    0
 25 1800    0
 26 2280    0
 27 2640    0
$ --------------------------- Bay Connectivity
 1   1   2
 2   2   3
 3   3   4
 4   4   5
 5   5   6
 6   6   7
 7   8   9
 8  10  11
 9  11  12
 10 12  13
 11 13  14
 12 15  16
 13 17  18
 14 19  20
 15 21  22
 16 22  23
 17 23  24
 18 24  25
 19 25  26
 20 26  27
 21 21  17
 22  8   1
 23 22  18
 24 18  10
 25 10   9
 26  9   2
 27 23  11
 28 11   3
 29 24  12
 30 12   4
 31 25  13
 32 13   5
 33 26  19
 34 19  14
 35 14  15
 36 15   6
 37 27  20
 38 16   7
 39 17   8   1
 40 18   9   1
 41 19  15  -1
 42 20  16  -1
$ --------------------------- Floor Bay Connectivity
  1 17  18  8  9  1
  2 19  20 15 16 -1
```

Example 17
Listing of Input Data (continued)
Figure 17-2

```
$ --------------------------- Joint Assignments
 1  27  0  roof 1sth  0       $ Disconnect Diaphragm all floors
 1  16  0  roof roof  1
 1  16  0   5th  5th  1
 1  16  0   4th  4th  1
 1  16  0   3rd  3rd  1
 1  16  0   2nd  2nd  1
 10 14  0  5thh 5thh  2
 10 14  0  4thh 4thh  2
 10 14  0  3rdh 3rdh  2
 10 14  0  2ndh 2ndh  2
 10 14  0  1sth 1sth  0
 17 27  0  5thh 5thh  2
 17 27  0  4thh 4thh  2
 17 27  0  3rdh 3rdh  2
 17 27  0  2ndh 2ndh  2
 17 17  0  1sth 1sth  2 1
 18 19  0  1sth 1sth  2
 20 27  0  1sth 1sth  2 1

$ --------------------------- Column Assignments
 1   8  0 roof 1sth 1
 10 14  1
 16 16  1
 20 27  0  5thh 2nd  1
 17 17 20
                               $ Leave a Blank Line
$ --------------------------- Beam Assignments
 1  7  0 roof roof 1
 1  7  0  5th  5th 1
 1  7  0  4th  4th 1
 1  7  0  3rd  3rd 1
 1  7  0  2nd  2nd 1
 22 22 1
 26 26 1
 28 28 1
 30 30 1
 32 32 1
 36 36 1
 38 38 1
 25 25 1
 35 35 1
 12 12 1
 8  11 0  roof 2nd 1
 13 20 0  5thh 5thh 1
 13 20 0  4thh 4thh 1
 13 20 0  3rdh 3rdh 1
 13 20 0  2ndh 2ndh 1
 24 24 13
 34 34 13
 21 21 13
 23 23 13
 27 27 13
 29 29 13
 31 31 13
 33 33 13
 37 37 13
 39 40  1
 41 42 13
                               $ Leave a Blank Line
```

Example 17
Listing of Input Data (continued)
Figure 17-2

```
$ --------------------------- Floor Assignments
 1  1  0  roof  roof  1
 1  1  0  5th   5th   1
 1  1  0  4th   4th   1
 1  1  0  3rd   3rd   1
 1  1  0  2nd   2nd   1
 2  2  0  5thh  5thh  1
 2  2  0  4thh  4thh  1
 2  2  0  3rdh  3rdh  1
 2  2  0  2ndh  2ndh  1
                             $ Leave a Blank Line
$ --------------------------- Frame Location Data
 1 0 0 0 /Main Frame
$ --------------------------- ATC 3-06 Seismic Load Data
 .4 .4 1.2
 0. .4344 7 roof 2nd
 0. .4344 7 roof 2nd
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0
$ --------------------------- Load Case Data
 1 0  0 0 0 1
 2 0  0 0 0 0 1
$ ***** End of Input Data *****
```

Example 17
Listing of Input Data (continued)
Figure 17-2

Example 18

Pyramid Building Static Lateral Loads and Eigenvalue Analysis

Description

This is a five-level pyramid-type steel structure subjected to lateral static loads.

The lateral loads are applied in the global X-direction (Load Condition A) and in a direction inclined at 45 degrees to thc global X-direction (Load Condition B).

The geometry and loads of the structure are shown in Figures 18-1 and 18-2.

Significant Options of ETABS Activated

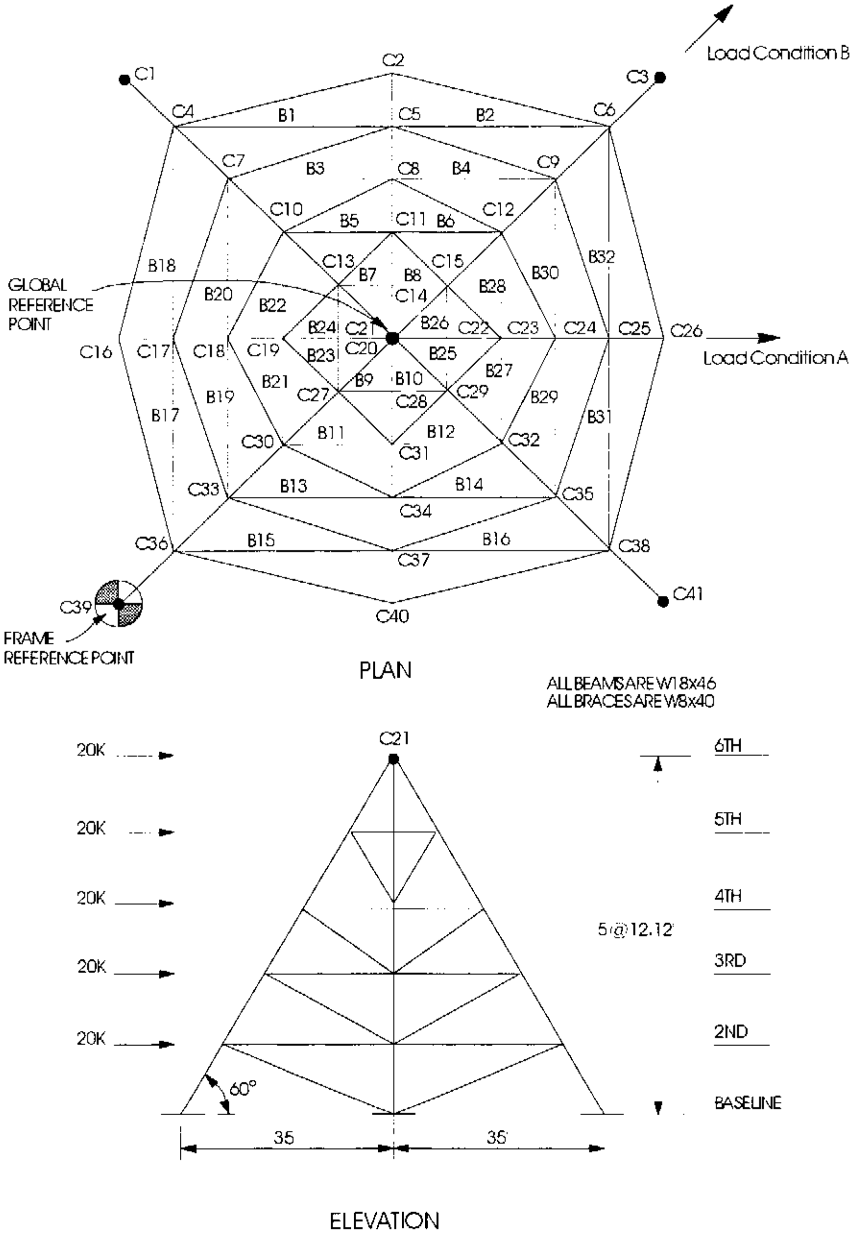
- Use of bracing elements
- Automatic AISC section property selection
- User-specified static lateral loads
- Calculation of structural time periods and mode shapes

Computer Model

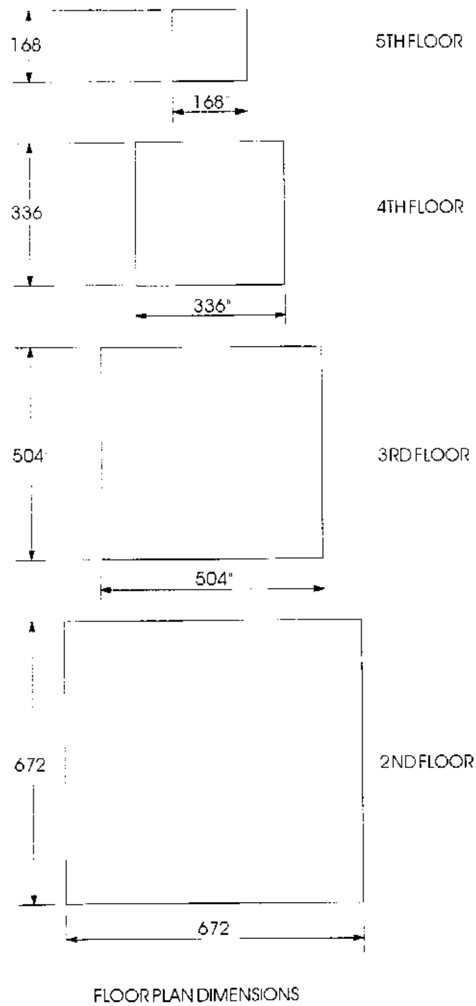
The structure is modeled as a single frame with 41 column lines and 32 bays. Note that this model has no vertical column elements. The column lines are used purely for the purpose of locating the beam and brace elements.

A modulus of elasticity of 29500 ksi is used. The story weight is taken as 100 psf. Kip-inch-second units are used.

The input data file for this example is EX18. A listing of the input data is given in Figure 18-3.



Example 18
Pyramid Building
Figure 18-1



Example 18
Pyramid Building
Figure 18-2

```
$ --------------------------Heading
ETABS 6.1
Example 18 : Pyramid Building
Static Lateral Load and Eigenvalue Analysis  Units: Kip-inch-second
$ -------------------------- Main Control Data
5 1 1 1 4 2 9 1 0 1 0 1 0 0 1 1 0 0 0 0 1
386.4
$ -------------------------- Mass Data
1 1 1/386.4
rect .1/144 0 0 168 168
2 1 1/386.4
rect .1/144 0 0 336 336
3 1 1/386.4
rect .1/144 0 0 504 504
4 1 1/386.4
rect .1/144 0 0 672 672
$ -------------------------- Story Data
6th 145.5 1
1 0
5th 145.5 1
1 1
4th 145.5 1
1 2
3rd 145.5 1
1 3
2nd 145.5 1
1 4
$ -------------------------- Material Data
1 s 29500 .3 .49/1728  0 36
$ -------------------------- Beam Properties
1  W18x46 1
$ -------------------------- Brace Properties
1  W8x40  1
$ -------------------------- Frame Data
/Main Frame
1 41 32 0 0 0 0 0 72
$ -------------------------- Column Line Location
1    0  840
2  420  840
3  840  840
4   84  756
5  420  756
6  756  756
7  168  672
8  420  672
9  672  672
10 252  588
11 420  588
12 588  588
13 336  504
14 420  504
15 504  504
16   0  420
17  84  420
18 168  420
19 252  420
20 336  420
21 420  420
22 504  420
```

Example 18
*Listing Of Input Data (File: **EX18**)*
Figure 18-3

```
23 588  420
24 672  420
25 756  420
26 840  420
27 336  336
28 420  336
29 504  336
30 252  252
31 420  252
32 588  252
33 168  168
34 420  168
35 672  168
36  84   84
37 420   84
38 756   84
39   0    0
40 420    0
41 840    0
$ -------------------------- Bay Connectivity
1   4   5
2   5   6
3   7   8
4   8   9
5  10  11
6  11  12
7  13  14
8  14  15
9  27  28
10 28  29
11 30  31
12 31  32
13 33  34
14 34  35
15 36  37
16 37  38
17 36  17
18 17   4
19 33  18
20 18   7
21 30  19
22 19  10
23 27  20
24 20  13
25 29  22
26 22  15
27 32  23
28 23  12
29 35  24
30 24   9
31 38  25
32 25   6
```

Example 18
Listing Of Input Data (continued)
Figure 18-3

```
$ -------------------------- Column Assignments

$ -------------------------- Beam Assignments
 1 2 0 2nd 2nd 1
 3 4 0 3rd 3rd 1
 5 6 0 4th 4th 1
 7 8 0 5th 5th 1
 9 10 7
11 12 5
13 14 3
15 16 1
17 18 1
19 20 3
21 22 5
23 24 7
25 26 7
27 28 5
29 30 3
31 32 1
                                $ Leave a Blank Line
$ -------------------------- Brace Assignments
101 2ND 2ND  2  4  1
102 3RD 3RD  5  7  1
103 4TH 4TH  8 10  1
104 5TH 5TH 11 13  1
105 2ND 2ND  2  6  1
106 3RD 3RD  5  9  1
107 4TH 4TH  8 12  1
108 5TH 5TH 11 15  1
109 2ND 2ND  2  5  1
110 3RD 3RD  5  8  1
111 4TH 4TH  8 11  1
112 5TH 5TH 11 14  1
113 6TH 6TH 14 21  1
114 2ND 2ND  3  6  1
115 3RD 3RD  6  9  1
116 4TH 4TH  9 12  1
117 5TH 5TH 12 15  1
118 6TH 6TH 15 21  1
201 2ND 2ND 26  6  1
202 3RD 3RD 25  9  1
203 4TH 4TH 24 12  1
204 5TH 5TH 23 15  1
205 2ND 2ND 26 38  1
206 3RD 3RD 25 35  1
207 4TH 4TH 24 32  1
208 5TH 5TH 23 29  1
209 2ND 2ND 26 25  1
210 3RD 3RD 25 24  1
211 4TH 4TH 24 23  1
212 5TH 5TH 23 22  1
213 6TH 6TH 22 21  1
214 2ND 2ND 41 38  1
215 3RD 3RD 38 35  1
216 4TH 4TH 35 32  1
217 5TH 5TH 32 29  1
218 6TH 6TH 29 21  1
301 2ND 2ND 40 38  1
302 3RD 3RD 37 35  1
```

Example 18
Listing Of Input Data (continued)
Figure 18-3

```
303 4TH 4TH 34 32  1
304 5TH 5TH 31 29  1
305 2ND 2ND 40 36  1
306 3RD 3RD 37 33  1
307 4TH 4TH 34 30  1
308 5TH 5TH 31 27  1
309 2ND 2ND 40 37  1
310 3RD 3RD 37 34  1
311 4TH 4TH 34 31  1
312 5TH 5TH 31 28  1
313 6TH 6TH 28 21  1
314 2ND 2ND 39 36  1
315 3RD 3RD 36 33  1
316 4TH 4TH 33 30  1
317 5TH 5TH 30 27  1
318 6TH 6TH 27 21  1
401 2ND 2ND 16 36  1
402 3RD 3RD 17 33  1
403 4TH 4TH 18 30  1
404 5TH 5TH 19 27  1
405 2ND 2ND 16  4  1
406 3RD 3RD 17  7  1
407 4TH 4TH 18 10  1
408 5TH 5TH 19 13  1
409 2ND 2ND 16 17  1
410 3RD 3RD 17 18  1
411 4TH 4TH 18 19  1
412 5TH 5TH 19 20  1
413 6TH 6TH 20 21  1
414 2ND 2ND  1  4  1
415 3RD 3RD  4  7  1
416 4TH 4TH  7 10  1
417 5TH 5TH 10 13  1
418 6TH 6TH 13 21  1

$ --------------------------- Frame Location Data
 1 -420 -420 0 /Main Frame
$ --------------------------- User Specified lateral Loads
 6th 1 A 20
 5th 1 A 20
 4th 1 A 20
 3rd 1 A 20
 2nd 1 A 20
 6th 1 B 2p.5*20/2 2p.5*20/2
 5th 1 B 2p.5*20/2 2p.5*20/2
 4th 1 B 2p.5*20/2 2p.5*20/2
 3rd 1 B 2p.5*20/2 2p.5*20/2
 2nd 1 B 2p.5*20/2 2p.5*20/2

$                                          LOAD CASE DATA
1 0 0 0 0 1
2 0 0 0 0 0 1
$   END OF INPUT DATA
```

Example 18
Listing Of Input Data (continued)
Figure 18-3

Example 19

Twenty Five Story Triple Tower Building Dynamic Response Spectrum Analysis

Description

This is a 25-story structure consisting of three identical three-dimensional circular towers connected by horizontal floor diaphragms. The geometry of the structure is shown in Figures 19-1 and 19-2. A dynamic response spectrum analysis is performed. The dynamic excitation corresponds to the El Centro earthquake of 1940, N-S component, 5 percent damping, response spectra in two orthogonal horizontal directions.

Significant Options of ETABS Activated

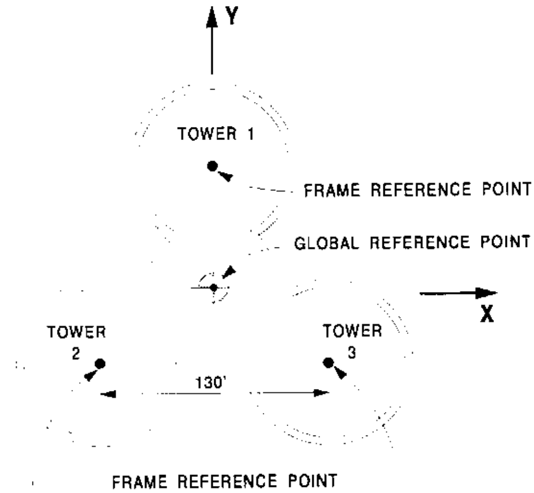
- Large capacity dynamic response spectrum analysis
- Arithmetic operations for coordinate calculation
- Automatic AISC section property selection
- Automatic section property calculation

Computer Model

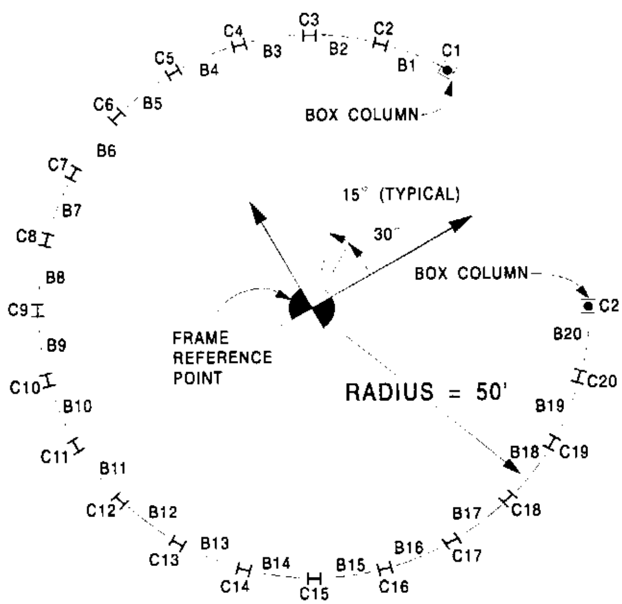
This structure is modeled with three identical frames. Each frame is modeled with 21 column lines and 20 bays. Kip-inch-second units are used. A modulus of elasticity of 29500 ksi is used. The story weight is taken as 1087 kips. The story mass moment of inertia is taken as 6254000 kip-sec^2-in.

Fifteen modes are used in the dynamic analysis.

The input data file for this example is EX19. The response spectrum data file is ELCN-RS1. These files are listed in Figures 19-3 and 19-4.

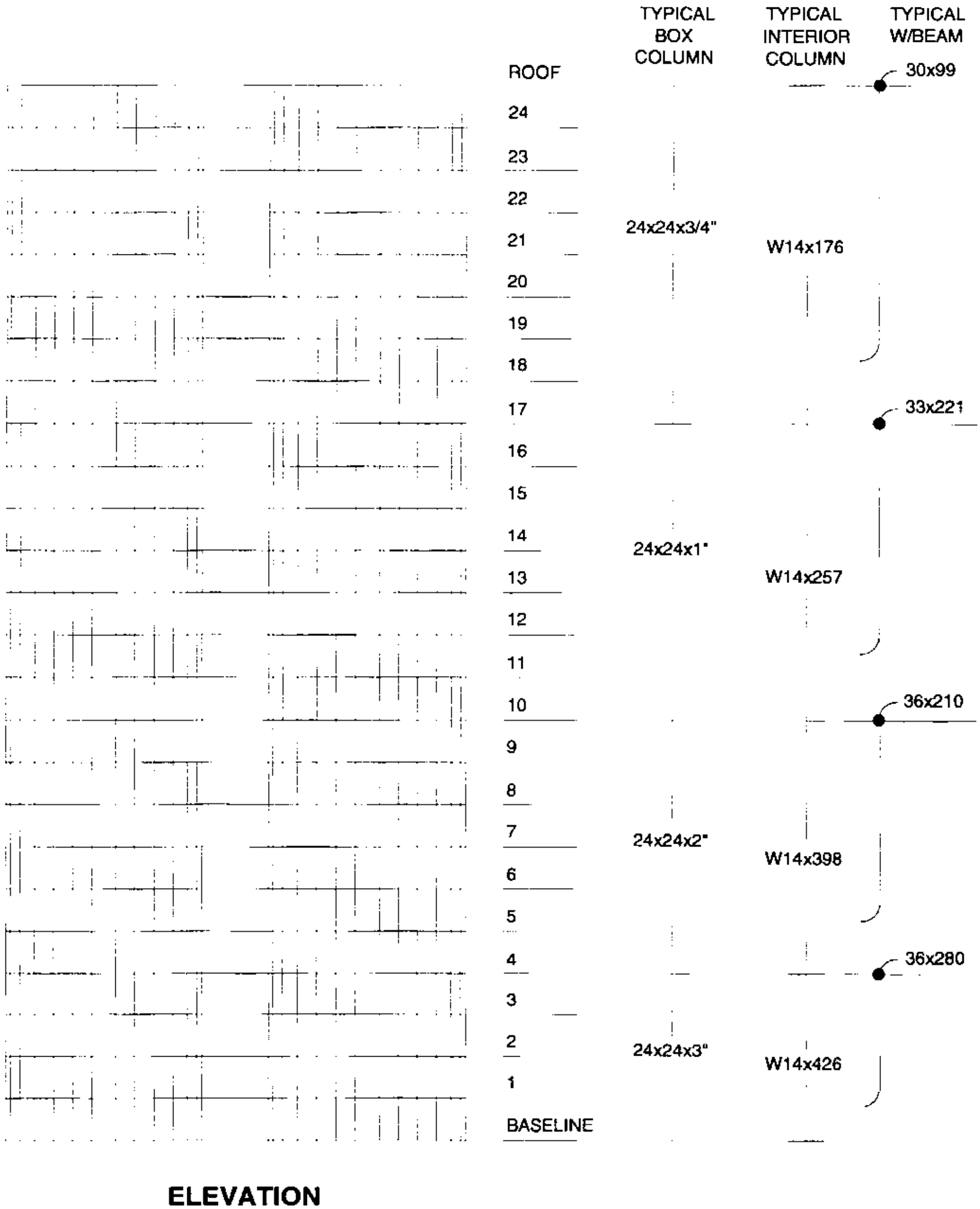


PLAN



TYPICAL TOWER PLAN

Example 19
Twenty-five Story Triple Tower Building
Figure 19-1



Example 19
Twenty-five Story Triple Tower Building
Figure 19-2

```
$ -------------------------- Heading
 ETABS 6.1
 Example 19 : Twenty Five Story Triple Tower Building
 Dynamic Response Spectrum Analysis  Units: Kip-inch-second
$ -------------------------- Control Data
 25 1 1 3 0 2 15 1 8 4 0 0 0 0 0 2 0 0 2 0 1
 386.4
$ -------------------------- Story Data
ROOF    12.5*12   1
        1 0 1087/386.4 6254000
24TH    12.5*12   1
        1 0 1087/386.4 6254000
23RD    12.5*12   1
        1 0 1087/386.4 6254000
22ND    12.5*12   1
        1 0 1087/386.4 6254000
21ST    12.5*12   1
        1 0 1087/386.4 6254000
20TH    12.5*12   1
        1 0 1087/386.4 6254000
19TH    12.5*12   1
        1 0 1087/386.4 6254000
18TH    12.5*12   1
        1 0 1087/386.4 6254000
17TH    12.5*12   1
        1 0 1087/386.4 6254000
16TH    12.5*12   1
        1 0 1087/386.4 6254000
15TH    12.5*12   1
        1 0 1087/386.4 6254000
14TH    12.5*12   1
        1 0 1087/386.4 6254000
13TH    12.5*12   1
        1 0 1087/386.4 6254000
12TH    12.5*12   1
        1 0 1087/386.4 6254000
11TH    12.5*12   1
        1 0 1087/386.4 6254000
10TH    12.5*12   1
        1 0 1087/386.4 6254000
 9TH    12.5*12   1
        1 0 1087/386.4 6254000
 8TH    12.5*12   1
        1 0 1087/386.4 6254000
 7TH    12.5*12   1
        1 0 1087/386.4 6254000
 6TH    12.5*12   1
        1 0 1087/386.4 6254000
 5TH    12.5*12   1
        1 0 1087/386.4 6254000
 4TH    12.5*12   1
        1 0 1087/386.4 6254000
 3RD    12.5*12   1
        1 0 1087/386.4 6254000
 2ND    12.5*12   1
        1 0 1087/386.4 6254000
 1ST    20.0*12   1
        1 0 1087/386.4 6254000
```

Example 19
*Listing of Input Data (File: **EX19**)*
Figure 19-3

```
$ -------------------------- Material Data
 1 S 29500 .25 .490/1728 0  36
$ -------------------------- Column Properties
 1    BOX  1  24 24   3    3
 2    BOX  1  24 24   2    2
 3    BOX  1  24 24   1    1
 4    BOX  1  24 24   .75  .75
 5    W14X426 1
 6    W14X398 1
 7    W14X257 1
 8    W14X176 1
$ -------------------------- Beam Properties
 1  W36X280   1
 2  W36X210   1
 3  W33X221   1
 4  W30X99    1
$ -------------------------- Typical Frame Data
 /TYPICAL ROUND TOWER
 1 21 20
$   COLUMN LINE COORDINATES
 1    3P.5/2*50*12            50*12/2                  120
 2    2P-.5*50*12             2P-.5*50*12              135
 3    50*12/2                 3P.5/2*50*12             150
 4    3P.5-2*-1P.5/2*50*12  3P.5+2P.5/2*50*12          165
 5    0                       50*12                    180
 6    3P.5-2*-1P.5/2*-50*12 3P.5+2P.5/2*50*12          195
 7    -50*12/2                3P.5/2*50*12             210
 8    2P-.5*-50*12            2P-.5*50*12              225
 9    3P.5/2*-50*12           50*12/2                  240
 10   3P.5+2P.5/2*-50*12   3P.5-2*-1P.5/2*50*12        255
 11   -50*12                  0                        270
 12   3P.5+2P.5/2*-50*12   3P.5-2*-1P.5/2*-50*12       285
 13   3P.5/2*-50*12           -50*12/2                 300
 14   2P-.5*-50*12            2P-.5*-50*12             315
 15   -50*12/2                3P.5/2*-50*12            330
 16   3P.5-2*-1P.5/2*-50*12 3P.5+2P.5/2*-50*12         345
 17   0                       -50*12                   360
 18   3P.5-2*-1P.5/2*50*12  3P.5+2P.5/2*-50*12          15
 19   50*12/2                 3P.5/2*-50*12             30
 20   2P-.5*50*12             2P-.5*-50*12              45
 21   3P.5/2*50*12            -50*12/2                  60
$ -------------------------- Bay Connectivity
 1  1  2
 2  2  3
 3  3  4
 4  4  5
 5  5  6
 6  6  7
 7  7  8
 8  8  9
 9  9  10
 10  10  11
 11  11  12
 12  12  13
 13  13  14
 14  14  15
 15  15  16
```

Example 19
Listing of Input Data (continued)
Figure 19-3

```
 16  16  17
 17  17  18
 18  18  19
 19  19  20
 20  20  21
$ -------------------------- Column Assignments
 1 1 0 roof 18th 4
 1 1 0 17th 11th 3
 1 1 0 10th  5th 2
 1 1 0  4th  1st 1
 21 21 1
 2 20 0  roof 18th 8
 2 20 0  17th 11th 7
 2 20 0  10th  5th 6
 2 20 0   4th  1st 5

$ -------------------------- Beam Assignments
 1 20 0 roof 18th 4
 1 20 0 17th 11th 3
 1 20 0 10th  5th 2
 1 20 0  4th  1st 1

$ -------------------------- Frame Locations
 1       0  3P.5*2/3*65*12 270 /TOWER 1
 1 -65*12  3P.5*-65*12/3   30 /TOWER 2
 1  65*12  3P.5*-65*12/3  150 /TOWER 3
$ -------------------------- Response Spectrum Data
 /Elcentro Response Spectrum
 0 CQC .05
 ELCN-RS1 386.4 1
 ELCN-RS1 386.4 1
$ -------------------------- Load Case Data
 1 0    0 0 0   0 0 0  1
 2 0    0 0 0   0 0 0  0 1
$ *****End of Input Data *****
```

Example 19
Listing of Input Data (continued)
Figure 19-3

```
$ ELCENTRO RESPONSE SPECTRUM IN G UNITS
$ USED IN ETABS EXAMPLES EX2, EX4 AND EX19
$ DAMPING
    0.05
$ PERIOD     PSA
      .0   .3275
   .0263   .3299
   .0270   .3297
   .0278   .3429
   .0286   .3544
   .0294   .3626
   .0303   .3683
   .0313   .3676
   .0323   .3629
   .0333   .3604
   .0345   .3637
   .0357   .3632
   .0370   .3610
   .0385   .3585
   .0400   .3551
   .0417   .3458
   .0435   .3436
   .0455   .3465
   .0476   .3528
   .0500   .3542
   .0526   .3544
   .0556   .3546
   .0588   .3917
   .0625   .4305
   .0667   .4455
   .0714   .4784
   .0769   .5053
   .0833   .5181
   .0909   .4776
   .0966   .5526
   .1000   .5816
   .1015   .5846
   .1070   .5548
   .1130   .5292
   .1198   .5952
   .1274   .6373
   .1361   .6615
   .1460   .6885
   .1575   .8712
   .1709   .8167
   .1869   .9879
   .2062   .9697
   .2299   .7006
   .2597   .8576
   .2985   .7385
   .3509   .8705
   .4255   .9090
   .5405   .9824
   .7407   .4761
  1.1765   .2713
  2.8571   .1983
```

Example 19
Listing of Input Data (File: ***ELCN-RS1****)*
Figure 19-4

Example 20

Fourteen Story Shear Wall/Frame Tower BOCA 1993 Wind Load Analysis

Description

This is a 14-story shear wall/frame tower as shown in Figures 20-1 and 20-2.

The structure is analyzed for BOCA 1993 wind loading (Reference [1]).

Significant Options of ETABS Activated

- Pierced shear wall modeling
- Automated BOCA 1993 wind loading
- Three-dimensional curved frame modeling

Computer Model

The structure is modeled with a total of six frames. Three identical curved steel frames and three identical checkerboard shear wall frames are used. Kip-inch-second units are used.

The following parameters are used to generate the wind loading:

Basic Wind Speed	=	90 MPH
Exposure Type	=	C
Importance Factor	=	1.0
Building Aspect Ratio	=	1.0 (conservative)
Exposure Width	=	400 ft (assumed)

The steel frames are modeled with eleven column lines and ten bays. The modulus of elasticity of steel is taken as 29500 ksi.

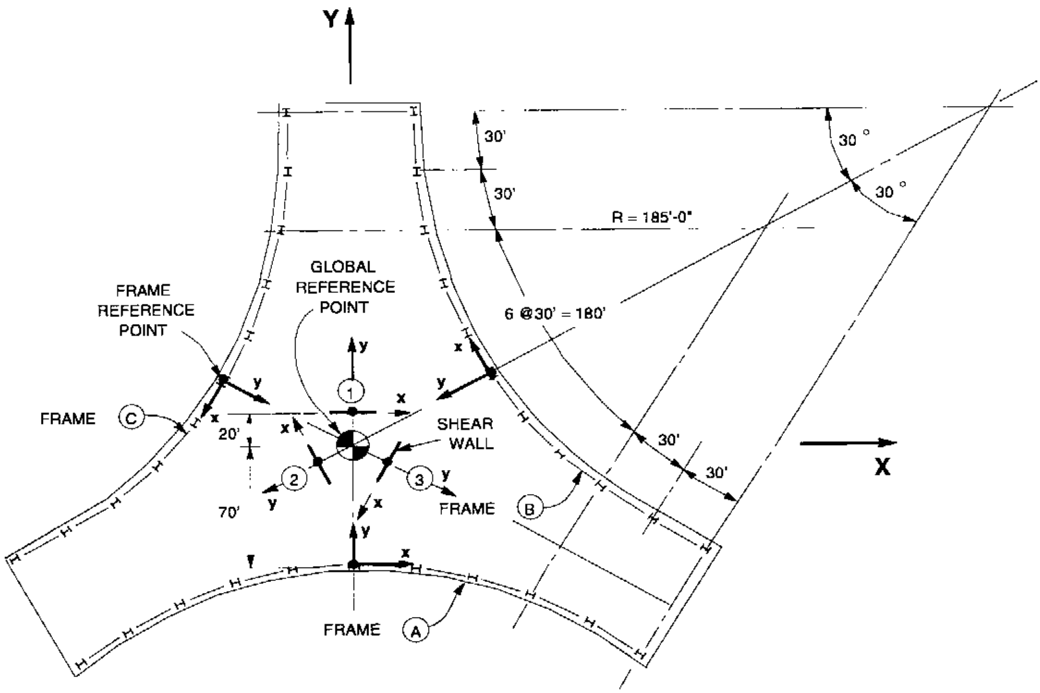
The shear wall frame is modeled with four column lines, two bays and 21 panel elements. Two beam elements are used at the top story. A finer mesh can also be used to better define the geometry, but is not considered necessary.

The input data file for this example is EX20. A listing of the input data is given in Figure 20-3.

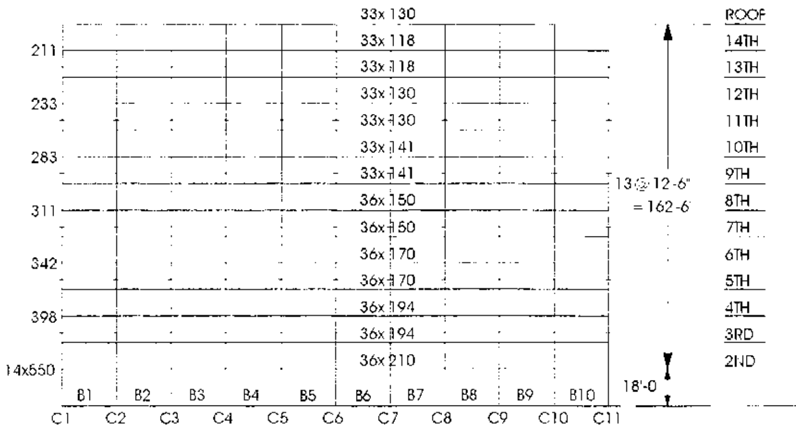
References

1. **Building Officials and Code Administrators International, Inc.**

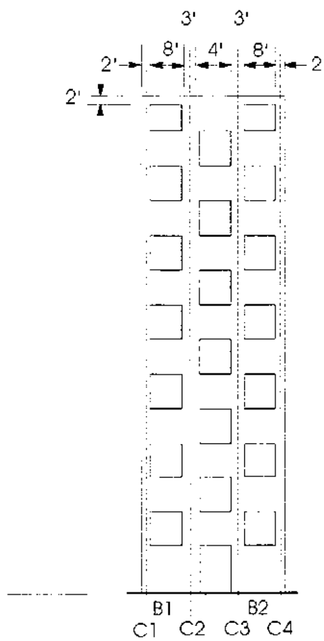
The BOCA National Building Code, Country Club Hills, Illinois, 1993.



Example 20
Fourteen-story Shear Wall/frame Tower
Figure 20-1



Typical Frame Elevation



Typical Shear Wall
(Not to Scale)

Example 20
Fourteen-story Shear Wall/frame Tower
Figure 20-2

```
$ -------------------------- Heading
 ETABS 6.1
 Example 20 : Fourteen Story Shear Wall/Frame Tower
 BOCA 1993 Wind Load Analysis  Units: Kip-inch-second
$ -------------------------- Control Data
 14 1 2 6 0 2 15 2 8 8 0 0 3 0 22 0 0 0 2 0 1
 386.4
$                                         STORY DATA
 ROOF  150
 14TH  150
 13TH  150
 12TH  150
 11TH  150
 10TH  150
  9TH  150
  8TH  150
  7TH  150
  6TH  150
  5TH  150
  4TH  150
  3RD  150
  2ND  216
$ -------------------------- Material Data
 1  S  29500  .3 .49/1728
 2  C   3000  .3 .15/1728
$ -------------------------- Column Properties
 1      W14X550  1
 2      W14X398  1
 3      W14X342  1
 4      W14X311  1
 5      W14X283  1
 6      W14X233  1
 7      W14X211  1
 8 rect 2 24 18
$ -------------------------- Beam Properties
 1      W33X130  1
 2      W33X118  1
 3      W33X141  1
 4      W36X150  1
 5      W36X170  1
 6      W36X194  1
 7      W36X210  1
 8      RECT 2  24  0  18
$ -------------------------- Panel Properties
 1  memb 2 18 18 18 24 18 36 18
 2  memb 2 18 18 18 36 18 36 18
 3  memb 2 18 18 18 36 18 24 18
$ -------------------------- Frame Data
$                            Data for Typical Steel Frame
 /Typical Steel Frame
 1  11  10
$ -------------------------- Column Line Location
 1   -1661.42  -617.56   30.00
 2   -1349.65  -437.56   30.00
 3   -1037.90  -257.56   27.87
 4    -707.44  -115.74   18.58
 5    -358.42   -29.13    9.29
 6       0.00     0.00    0.00
 7     358.42   -29.13   -9.29
 8     707.44  -115.74  -18.58
```

Example 20
*Listing Of Input Data (File: **EX20**)*
Figure 20-3

```
 9    1037.90  -257.56  -27.87
 10   1349.65  -437.56  -30.00
 11   1661.42  -617.56  -30.00
$ -------------------------- Bay Connectivity
 1  1  2
 2  2  3
 3  3  4
 4  4  5
 5  5  6
 6  6  7
 7  7  8
 8  8  9
 9  9  10
 10 10 11
$ -------------------------- Column Assignments
 1 11 0  roof 14th 7
 1 11 0  13th 12th 6
 1 11 0  11th 10th 5
 1 11 0   9th  8th 4
 1 11 0   7th  6th 3
 1 11 0   5th  4th 2
 1 11 0   3rd  2nd 1

$ -------------------------- Beam Assignments
 1 10  0  roof roof 1
 1 10  0  14th 13th 2
 1 10  0  12th 11th 1
 1 10  0  10th  9th 3
 1 10  0   8th  7th 4
 1 10  0   6th  5th 5
 1 10  0   4th  3rd 6
 1 10  0   2nd  2nd 7

$ -------------------------- Data For typical Shear Wall Frame
 /Typical Shear Wall Frame
 2  4  2  0   0  0  0  0  0  21
$ -------------------------- Column Line Location
 1 -168
 2  -42
 3   42
 4  168
$ -------------------------- Bay Connectivity
 1  1 2
 2  3 4
$ -------------------------- Column Assignments
 1 1 0 roof roof 8
 1 1 0 13th 13th 8
 1 1 0 11th 11th 8
 1 1 0  9th  9th 8
 1 1 0  7th  7th 8
 1 1 0  5th  5th 8
 1 1 0  3rd  3rd 8
 4 4 1

$ -------------------------- Beam Assignments
 1 2 0 roof roof 8
                              $ Leave a Blank Line
```

Example 20
Listing of Input Data (continued)
Figure 20-3

```
$ -------------------------- $ Panel Locations and Assignments
 101   2nd   2nd  1 2 1
 102   2nd   2nd  3 4 3
 201   3rd   3rd  2 3 2
 301   4th   4th  1 2 1
 302   4th   4th  3 4 3
 401   5th   5th  2 3 2
 501   6th   6th  1 2 1
 502   6th   6th  3 4 3
 601   7th   7th  2 3 2
 701   8th   8th  1 2 1
 702   8th   8th  3 4 3
 801   9th   9th  2 3 2
 901  10th  10th  1 2 1
 902  10th  10th  3 4 3
 1001 11th  11th  2 3 2
 1101 12th  12th  1 2 1
 1102 12th  12th  3 4 3
 1201 13th  13th  2 3 2
 1301 14th  14th  1 2 1
 1302 14th  14th  3 4 3
 1401 roof  roof  2 3 2

$ -------------------------- Frame Locations
 1     0.0           -840.0     0.0  /FRAME  A
 1     3P.5/2*70*12  420.0  120.0  /FRAME  B
 1     3P.5/2*-70*12 420.0  240.0  /FRAME  C
 2     0.0              240.0      0.0  /SHEAR  WALL  1
 2     3P.5/2*-20*12   -120.0    120.0  /SHEAR  WALL  2
 2     3P.5/2*20*12    -120.0    240.0  /SHEAR  WALL  3
$ -------------------------- BOCA 1992 Wind Load Data
 90 C 1 1


 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
 4800  0        4800  0
$                               LOAD CASE DATA
 1  0  0  0  0  1
 2  0  0  0  0  0  1
$   END OF INPUT DATA
```

Example 20
Listing of Input Data (continued)
Figure 20-3

Example 21

Flexible Diaphragm Building Response Spectrum Analysis

Description

This is a two story three-dimensional structure with concrete filled metal deck at the second floor and unfilled metal deck on the roof. The geometry of the structure is shown in shown in Figure 21-1. The structure is analyzed for seismic loads specified as response spectra and gravity dead and live loads which are applied as floor loads.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Flexible diaphragm modeling
- Use of floor elements and floor load patterns
- Joint diaphragm assignments
- Dynamic response spectrum analysis

Computer Model

The building is modeled using a single frame with 21 column lines, 32 beam bays, and 12 floor bays. Floor elements are used in the model to apply gravity loads and to model diaphragm flexibility. Kip-inch-second units are used.

Wide flange (W) sections are used to model the beams. Figure 21-2 shows the section properties assigned to each beam element. The beams ends are all pinned in both the major and minor directions as depicted in this figure. Square tube sections are used for columns and braces. All column bases as well as the brace ends are pinned. The flexibility of the floor is accounted for by using an equivalent concrete thickness. The flexibility of the roof deck is modeled using a modified modulus of elasticity.

The model uses seven diaphragms. Each transverse line of three column lines is associated with a separate diaphragm. For example, column lines C1, C2 and C3 are part of Diaphragm No. 1, column lines C4, C5 and C6 are part of Diaphragm No. 2, etc. Diaphragm connectivity is specified in the Joint Assignments data block. Column lines C3, C6, C9, C12, C15, C18 and C21 only contribute mass to their respective diaphragms without being rigidly connected to them. Lumping of masses this way models the flexibility of the diaphragm for Y- direction dynamic loading.

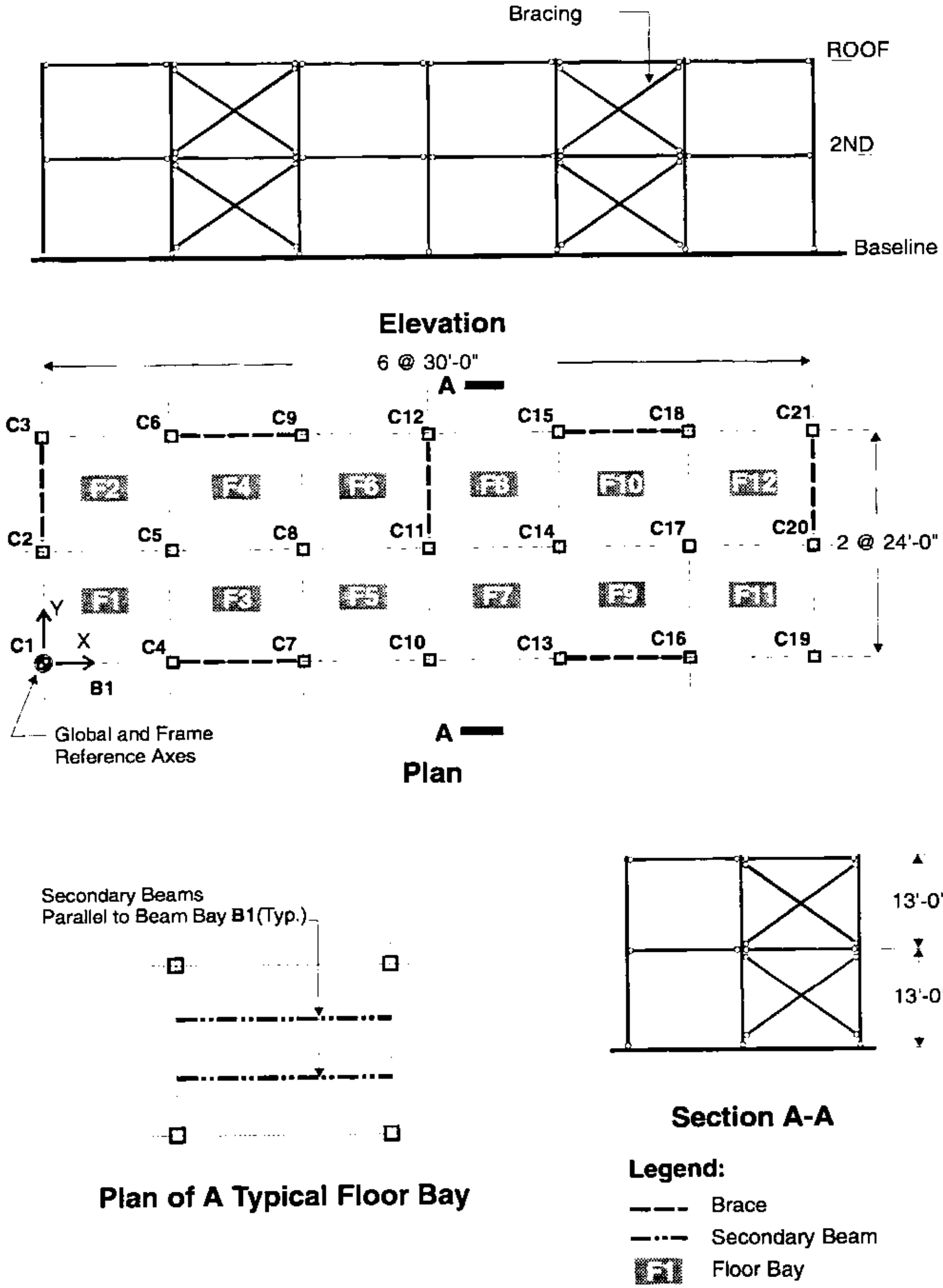
For completeness, all forty two mode shapes are requested in the analysis.

Four load conditions are considered in the analysis. Load condition I is the gravity dead load applied as floor bay loads. The roof dead load is assumed to be 15 psf. The floor dead load is taken as 75 psf. The roof and the floor live loads are 20 psf and 80 psf respectively. The dynamic load conditions D1 and D2 refer to the base excitation in the global X- and Y- directions. A 5% damping ratio is used for all the modes with CQC modal combinations.

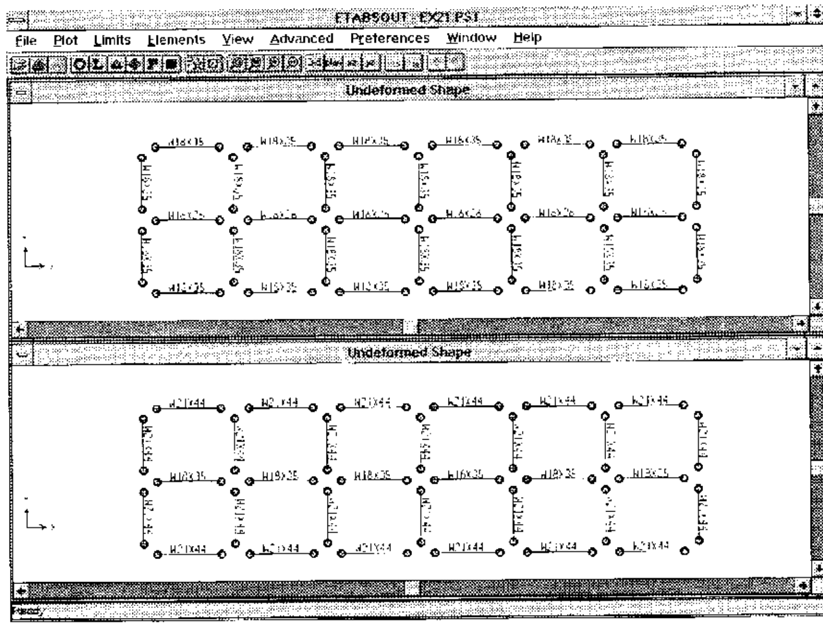
The input data file is EX21 which is listed in Figure 21-4. The response spectrum data file is ELCN-RS1. These files are available to the user on a disk as part of the ETABS package.

Diaphragm Flexibility Study

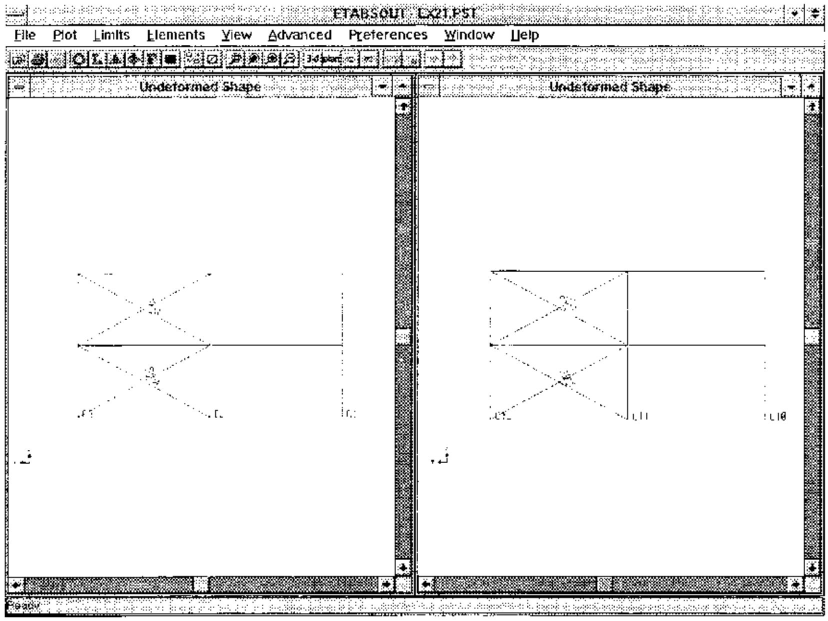
This example and two variations were used to demonstrate the effect of floor flexibility on the dynamic response of the structure. Three flexibility cases are considered. In the first case both the roof and the floor diaphragms are assumed flexible. The second case models a flexible roof but considers the floor rigid. The third case models both the roof and the floor as rigid. The variation of axial force in sample braces for the dynamic load condition D2 are shown in Figure 21-3. For this structure and this response spectra the total forces are higher when diaphragm flexibility is considered. Also the distribution of load to the middle braces is higher when diaphragm flexibility is considered. However, even for this very flexible diaphragm system a tributary area approach would over estimate the middle brace force and under estimate the end brace force.



Example 21
Flexible Diaphragm Building
Figure 21-1



Example 21
Roof and Floor Beam Section Properties
Figure 21-2



Model	Axial Force in Braces (kips)			
	Upper Story Braces		Lower Story Braces	
	End Brace (D1)	Middle Brace (D5)	End Brace (D2)	Middle Brace (D6)
Flexible Roof & Flexible Floor	10.95	13.72	117.01	168.18
Flexible Roof & Rigid Floor	8.97	15.24	134.80	133.92
Rigid Roof & Rigid Floor	9.12	9.12	133.47	133.47

Example 21
Effect of Diaphragm Flexibility on Brace Forces
Figure 21-3

```
$ --------------------------Heading
 ETABS 6.1
 Example 21 : Flexible Diaphragm Building
 Gravity and Response Spectrum Analysis  Units: Kip-inch-second
$ --------------------------- Main Control Data
 2 7 1 1 0 4 42 3 1 3 2 1 0 0 0 2 0 0 0 1 1
 386.4
$ --------------------------- Story Data
 ROOF   156
 2ND    156
$ --------------------------- Material Data
 1 s 29500 .3 .49/1728     .49/1728/386.4
 2 c 3000  .2 .075/3.5/144 .075/3.5/144/386.4
 3 o 162.5 .3
$ --------------------------- Column Properties
 1  TS8x8x1/4    1
$ --------------------------- Beam Properties
 1  W16x26  1
 2  W18x35  1
 3  W21x44  1
$ --------------------------- Floor Properties
 1  memb 2  3.5 3.5 3.5
 2  memb 3  1   1   1
$ --------------------------- Brace Properties
 1  TS8x8x3/16 1
$ --------------------------- Data for Frame 1
 /2 Story Steel Frame
 1 21 32 12 0 0 4 1 28
$ --------------------------- Column Line Location
 1       0    0
 2       0  288
 3       0  576
 4     360    0
 5     360  288
 6     360  576
 7     720    0
 8     720  288
 9     720  576
 10   1080    0
 11   1080  288
 12   1080  576
 13   1440    0
 14   1440  288
 15   1440  576
 16   1800    0
 17   1800  288
 18   1800  576
 19   2160    0
 20   2160  288
 21   2160  576
$ --------------------------- Beam Bay Connectivity
 1   1   4
 2   2   5
 3   3   6
 4   4   7
 5   5   8
 6   6   9
 7   7  10
 8   8  11
 9   9  12
 10 10  13
```

Example 21
*Listing of Input Data (File: **EX21**)*
Figure 21-4

```
 11 11  14 12 12  15
 13 13  16
 14 14  17
 15 15  18
 16 16  19
 17 17  20
 18 18  21
 19  1   2
 20  2   3
 21  4   5
 22  5   6
 23  7   8
 24  8   9
 25 10  11
 26 11  12
 27 13  14
 28 14  15
 29 16  17
 30 17  18
 31 19  20
 32 20  21
$ -------------------------- Floor Bay Connectivity
 1   1  4  2  5  0  2  1
 2   2  5  3  6  0  2  1
 3   4  7  5  8  0  2  1
 4   5  8  6  9  0  2  1
 5   7 10  8 11  0  2  1
 6   8 11  9 12  0  2  1
 7  10 13 11 14  0  2  1
 8  11 14 12 15  0  2  1
 9  13 16 14 17  0  2  1
 10 14 17 15 18  0  2  1
 11 16 19 17 20  0  2  1
 12 17 20 18 21  0  2  1
$ -------------------------- Floor Load Patterns
 1  .015/144
 2  .020/144
 3  .075/144
 4  .080/144
$ -------------------------- Joint Assignments
 1   21  0  ROOF  2ND   0     $ Disconnect All Diaphragms
 1    2  0  ROOF  2ND   1
 3    3  0  ROOF  2ND  -1
 4    5  0  ROOF  2ND   2
 6    6  0  ROOF  2ND  -2
 7    8  0  ROOF  2ND   3
 9    9  0  ROOF  2ND  -3
 10  11  0  ROOF  2ND   4
 12  12  0  ROOF  2ND  -4
 13  14  0  ROOF  2ND   5
 15  15  0  ROOF  2ND  -5
 16  17  0  ROOF  2ND   6
 18  18  0  ROOF  2ND  -6
 19  20  0  ROOF  2ND   7
 21  21  0  ROOF  2ND  -7

$ -------------------------- Column Assignments
 1  21  0  ROOF  ROOF  1
 1  21  0  2ND   2ND   1  1  1
                              $ Leave a Blank Line
```

Example 21
Listing of Input Data (continued)
Figure 21-4

```
$ -------------------------- Beam Assignments
1   1  0  ROOF  ROOF  2  3  3
3   4  1
6   7  1
9  10  1
12 13  1
15 16  1
18 18  1
1   1  0  2ND   2ND   3  3  3
3   4  1
6   7  1
9  10  1
12 13  1
15 16  1
18 18  1
2   2  0  ROOF  ROOF  1  3  3
5   5  2
8   8  2
11 11  2
14 14  2
17 17  2
2   2  0  2ND   2ND   2  3  3
5   5  2
8   8  2
11 11  2
14 14  2
17 17  2
19 32  0  ROOF  ROOF  2  3  3
19 32  0  2ND   2ND   3  3  3
                                 $ Leave a Blank Line
$ -------------------------- Floor Assignments
 1  12  0  ROOF   ROOF  2
 1  12  0  2ND    2ND   1

$ -------------------------- Brace Location and Assignments
 1   ROOF   2ND   3   2  1  3   3
 3   ROOF   2ND   2   3  1  3   3
 5   ROOF   2ND  12  11  1  3   3
 7   ROOF   2ND  11  12  1  3   3
 9   ROOF   2ND  21  20  1  3   3
 11  ROOF   2ND  20  21  1  3   3
 13  ROOF   2ND   6   9  1  3   3
 15  ROOF   2ND   9   6  1  3   3
 17  ROOF   2ND  15  18  1  3   3
 19  ROOF   2ND  18  15  1  3   3
 21  ROOF   2ND   4   7  1  3   3
 23  ROOF   2ND   7   4  1  3   3
 25  ROOF   2ND  13  16  1  3   3
 27  ROOF   2ND  16  13  1  3   3
                                 $ Leave a Blank Line
$ -------------------------- Floor Load Assignments
 1  12   0  ROOF  ROOF  1  2
 1  12   0  2ND   2ND   3  4
                                 $ Leave a Blank Line
$ -------------------------- Frame Location
 1 0 0 0 / Steel Frame
```

Example 21
Listing of Input Data (continued)
Figure 21-4

```
$ -------------------------- Response Spectrum Data
 Elcentro Response Spectrum
 0  CQC  0.05
 ELCN-RS1  386.4  1
 ELCN-RS1  386.4  1
$ -------------------------- Load case Data
 1 0 1
 2 0 0 1
 3 0 0 0 0 0 0 0 0 1
 4 0 0 0 0 0 0 0 0 0 1
```

Example 21
Listing of Input Data (continued)
Figure 21-4

Example 22

Multiple Diaphragm Structure Time History Analysis

Description

This example is designed to illustrate many of the program's features. It uses several different types of elements and multiple diaphragms.

The model consists of a four story and a two story structure with a combined base as shown in Figure 22-1.

The structure is analyzed for gravity loads applied as floor loads. The static lateral loads are user-defined wind loads based on the UBC 1994. The time history analysis uses the Loma Prieta acceleration records.

Significant Options of ETABS Activated

- Three-dimensional frame analysis
- Use of multiple diaphragms to model separate structures
- Use of floor elements for floor loads
- Joint diaphragm assignments

- User-defined static lateral load
- Time history analysis

Computer Model

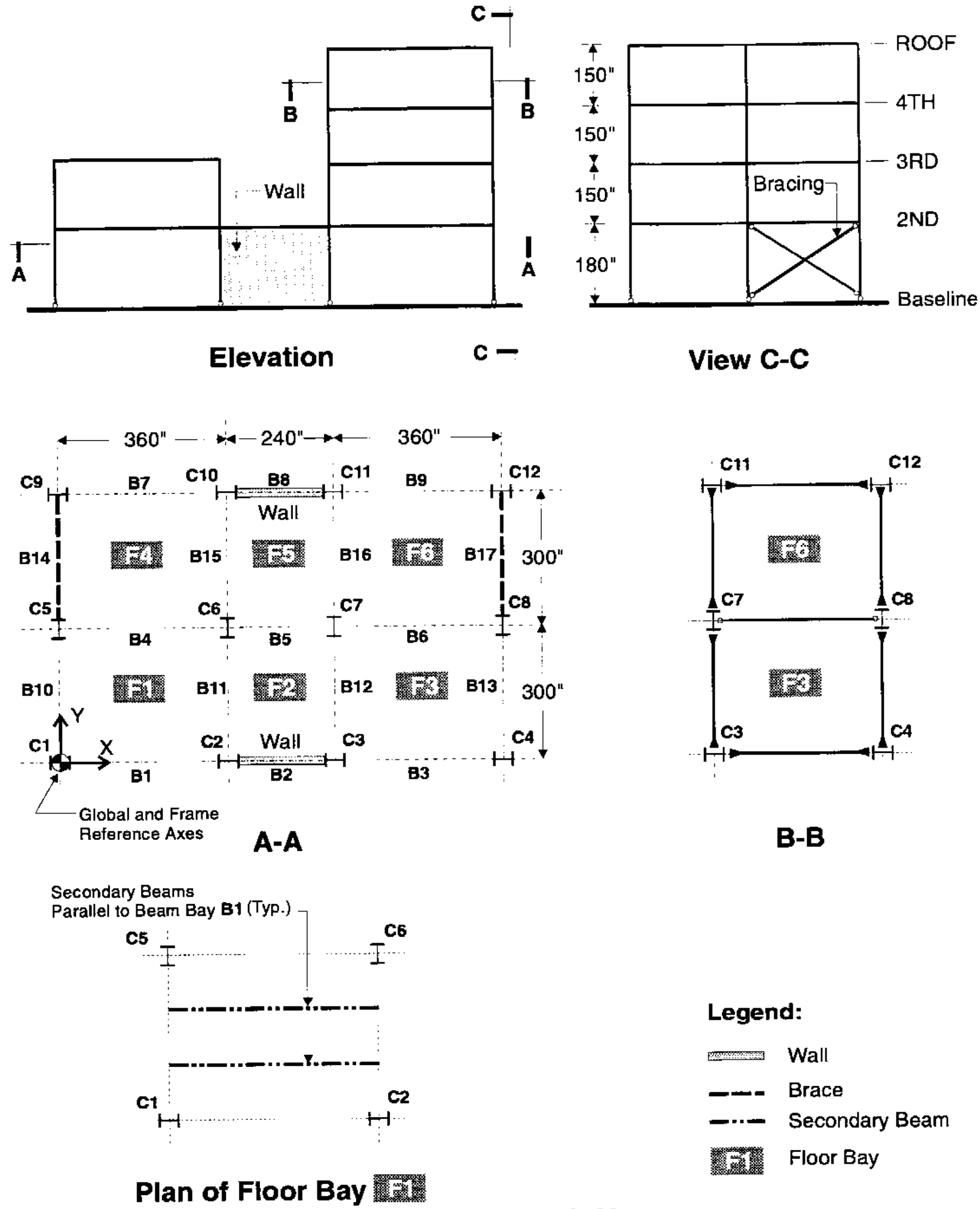
The ETABS model used for the design of the structure consists of a single frame with 12 column lines, 17 beam bays, and 6 floor bays. Floor elements are used in the model to apply the gravity loads. Panel elements are used to model the structural wall system. Kip-inch-second units are used.

Wide flange (W) sections are used to model the columns, the beams and the braces. Figure 22-2 shows the section properties assigned to the column and beam elements making up the frame. Member pin end conditions are also shown.

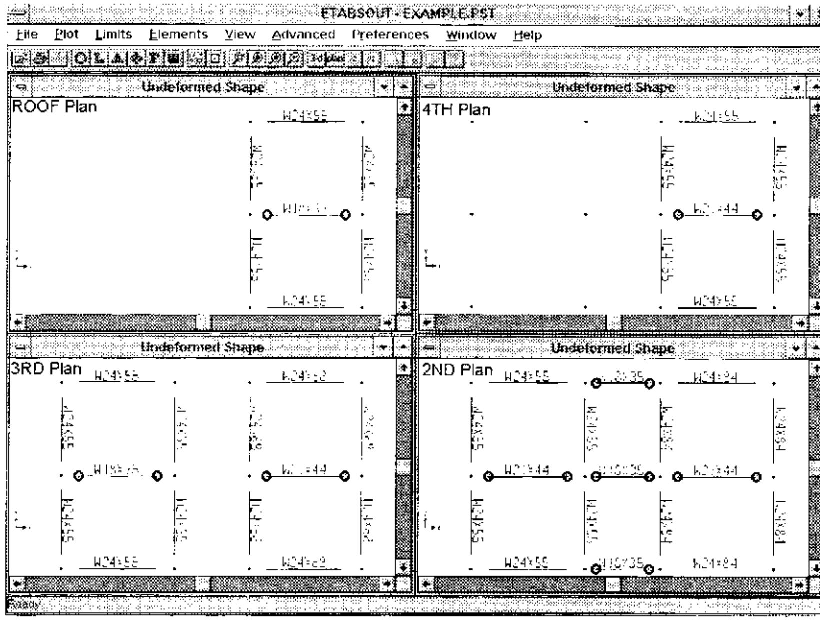
Three diaphragms are used in the model. In the four-story part of the structure all column lines are connected to Diaphragm No.1 (the default) for the top three stories. In the two-story part of the structure all column lines are connected to Diaphragm No. 2 at story level 3RD. At the common story level all the column lines for both structures are connected to Diaphragm No. 3. Diaphragm connectivity is specified in the Joint Assignments data block.

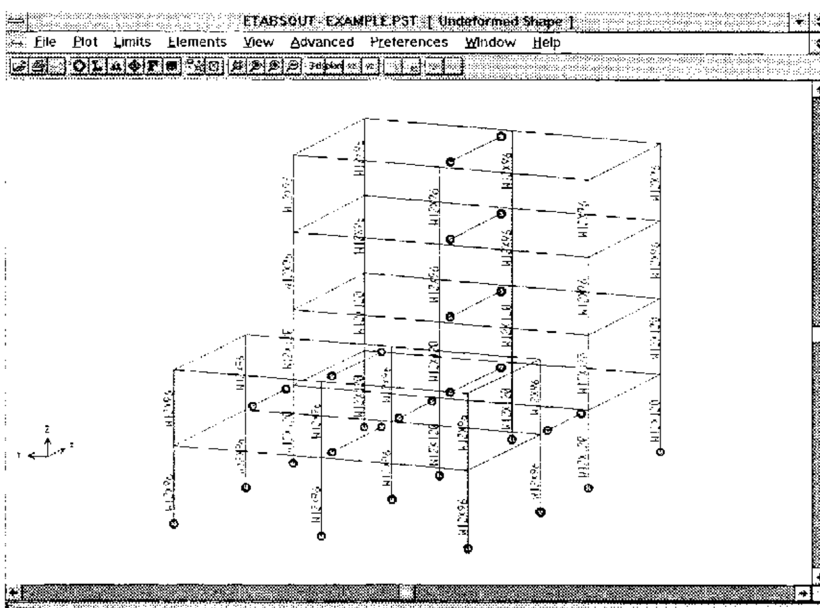
Five load conditions are considered in the analysis. Load condition I is the gravity dead load applied as a floor bay load. Load condition II is the gravity live load which is applied in a similar manner. Load conditions A and B are user-defined lateral static wind loads applied in the global X- and Y- directions. These are calculated based on the requirements of the UBC94 wind loads and are applied to the corresponding levels. Load condition D1 is the linear time history analysis using the Loma Prieta records. These are scaled down to the UBC94 lateral static seismic load requirements.

The input data file for this example is EXAMPLE which is listed in Figure 22-3. The time history files are LP-TH0 and LP-TH90. These files are available to the user on a disk as part of the ETABS package.



Example 22
Multiple Diaphragm Structure
Figure 22-1





Example 22
Beam and Column Section Properties
Figure 22-2

```
$ ----------------------------------------------- Control Data
ETABS 6.1
Example 22 : Multiple Diaphragm Structure
             Lateral Load Analysis    Units: Kip-inch-second
 4 3 1 1 0 5 15 4 2 5 2 1 1 0 1 3 0 0 2 0 1
 386.4 0.0001 0 1
$ ----------------------------------------------- Story Data
 ROOF  150  0
 4TH   150  0
 3RD   150  0
 2ND   180  0
$ ----------------------------------------------- Material Data
 1 S 29000 0.3 0.000283  7.324016E-07 0.0000065 36 0 0  0
 2 S 29000 0.3 0.000283  7.324016E-07 0.0000065 50 0 0  0
 3 W 3600  0.2 0.0000868*8/0.1 2.246377E-07*8/0.1 0.0000055 60 4 40 4
 4 C 3600  0.2 0.0000868 2.246377E-07 0.0000055 60 4 40 4
$ ----------------------------------------------- Column Properties
 1 W12X96  2
 2 W12X120 2
$ ----------------------------------------------- Beam Properties
 1 W24X55  1
 2 W24X68  1
 3 W24X84  1
 4 W18X35  1
 5 W21X44  1
$ ----------------------------------------------- Floor Properties
 1 MEMB 4 6
 2 MEMB 4 5.2
$ ----------------------------------------------- Brace Properties
 1 W12X65  1
$ ----------------------------------------------- Panel Properties
 1 MEMB 3 0.1 0.1 8   $ Only shear stiffness being modeled for infill panel
$ ----------------------------------------------- Frame Data
 / Steel Frame
 1 12 17 6 0 0 4 1 4 2 0 0 1
$ ----------------------------------------------- Column Line Location
 1     0   0  0
 2   360   0  0
 3   600   0  0
 4   960   0  0
 5     0 300 90
 6   360 300 90
 7   600 300 90
 8   960 300 90
 9     0 600  0
 10  360 600  0
 11  600 600  0
 12  960 600  0
$ ----------------------------------------------- Beam Bay Connectivity
 1   1 2  0
 2   2 3  0
 3   3 4  0
 4   5 6  0
 5   6 7  0
 6   7 8  0
 7   9 10 0
 8 10 11 0
 9 11 12 0
 10 1 5  0
 11 2 6  0
 12 3 7  0
 13 4 8  0
 14 5 9  0
 15 6 10 0
```

Example 22
*Listing of Input Data (File: **EXAMPLE**)*
Figure 22-3

```
 16 7 11 0
 17 8 12 0
$ ------------------------------------------ Floor Bay Connectivity
 1 1 2  5  6 0 2 1
 2 2 3  6  7 0 2 1
 3 3 4  7  8 0 2 1
 4 5 6  9 10 0 2 1
 5 6 7 10 11 0 2 1
 6 7 8 11 12 0 2 1
$ ------------------------------------------ Floor Load Patterns
 1 4.513889E-04 0 0
 2 1.388889E-04 0 0
 3 5.208334E-04 0 0
 4 5.555556E-04 0 0
$ ------------------------------------------ Joint Assignments
  3  4  0 ROOF 3RD  1  0     $ Higher portion connected to Diaphragm 1
  7  8  3
 11 12  3
  1  2  0 3RD  3RD  2  0      $ Lower portion connected to Diaphragm 2
  5  6  1
  9 10  1
  1 12  0 2ND  2ND  3  0      $ Base connected to Diaphragm 3

$ ------------------------------------------ Column Assignments
  3  4  0 ROOF 4TH  1
  3  4  0 3RD  3RD  2
  3  4  0 2ND  2ND  2  1  1
  7  8  3
 11 12  3
  1  2  0 3RD  3RD  1
  1  2  0 2ND  2ND  1  1  1
  5  6  1
  9 10  1

$ ------------------------------------------ Beam Assignments
  3  3  0 ROOF 4TH  1
  3  3  0 3RD  3RD  2
  3  3  0 2ND  2ND  3
  9  9  3
 12 13  3
 16 17  3
  6  6  0 ROOF ROOF 4 3 3
  6  6  0 4TH  2ND  5 3 3
  1  1  0 3RD  2ND  1
  7  7  1
 10 11  1
 14 15  1
  4  4  0 3RD  3RD  4 3 3
  4  4  0 2ND  2ND  5 3 3
  2  2  0 2ND  2ND  4 3 3 0 0
  5  5  2
  8  8  2

$ ------------------------------------------ Floor Assignments
 3 3 0 ROOF ROOF 2
 3 3 0 4TH  3RD  1
 6 6 3
 1 1 0 3RD  3RD  2
 4 4 1
 1 6 0 2ND  2ND  1
```

Example 22
Listing of Input Data (continued)
Figure 22-3

```
$ ------------------------------------------- Brace Assignments
 1 2ND 2ND  5  9 1 3 3 1
 2 2ND 2ND  9  5 1 3 3 1
 3 2ND 2ND  8 12 1 3 3 1
 4 2ND 2ND 12  8 1 3 3 1

$ ------------------------------------------- Panel Assignments
 1 2ND 2ND  2  3 1
 2 2ND 2ND 10 11 1

$ ------------------------------------------- Floor Load Assignments
 3 3 0 ROOF ROOF 1 2
 3 3 0 4TH  2ND  3 4
 6 6 3
 1 1 0 3RD  3RD  1 2
 1 1 0 2ND  2ND  3 4
 4 4 1
 2 2 0 2ND  2ND  3 4
 5 5 2

$ Frame Location Data
 1 0 0 0   //Example Frame//
$ User Static Lateral Load Data
$ Based on UBC Wind 70MPH, C Exposure
 ROOF 1 A  7.88     0 780 300
 ROOF 1 B     0  4.73 780 300
 4TH  1 A 15.09     0 780 300
 4TH  1 B    0   9.05 780 300
 3RD  1 A 13.65     0 780 300
 3RD  1 B     0  8.19 780 300
 3RD  2 A  6.83     0 180 300
 3RD  2 B     0  4.09 180 300
 2ND  3 A 13.37     0 480 300
 2ND  3 B     0 18.96 480 300

$ Time History Data
 Loma Prieta Records Scaled to UBC Static Seismic
$ Static based on Z=0.4, S=1.2, RW=8, TA=0.39
 0  240 .10 0.05
 LP-TH0  386.4*0.48  E .02 5 0
 LP-TH90 386.4*0.48  E .02 5 0
$ Load Case Data
 1 0 1 0 0 0 0 0 0 0
 2 0 0 1 0 0 0 0 0 0
 3 0 0 0 0 1 0 0 0 0
 4 0 0 0 0 0 1 0 0 0
 5 0 0 0 0 0 0 0 1 0
$ *****End of Input******
```

Example 22
Listing of Input Data (continued)
Figure 22-3