Seismic Analysis of Prefabricated Structures using ETABS

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Abstract:
This Thesis is about the comparative study of the analysis using software E-TABS and process of rehabilitating a shake table for use in seismic analysis of small-scale models in the School of Architecture. Lab view 8.0 Student Edition was used to write the controlling program for the shake table. Initially the frame was analyzed using the E-TABS Software.

In order to test seismic response of a prototype building, a 7-story reinforced concrete building was modeled in piano wire and plywood and tested on the shake table. The shake table recorded data from an accelerometer mounted on the model. The model was built to have the same resonant frequency as the prototype building.

Keywords: Shake Table, Labview 8.0, Seismic Analysis, Teaching Tool, Seismic Modeling.

1. INDRODUCTION

Seismology is the scientific study of earthquakes and the propagation of elastic waves through the Earth or through other planet-like bodies. The field also includes studies of earthquake environmental effects such as tsunamis as well as diverse seismic sources such as volcanic, tectonic, oceanic, atmospheric, and artificial processes such as explosions. A related field that uses geology to infer information regarding past earthquakes is paleo seismology. A recording of earth motion as a function of time is called a seismogram. A seismologist is a scientist who does research in seismology.

2. LITERATURE REVIEW

In the early work of Harrison [1], an equilateral triangular space steel frame subjected to proportional loads was tested. Yarimci [2] tested a full-size two-dimensional, twobay, three-story steel frame in which all members were bent about the strong axis. Wakabayashi and Matsui [3] tested two two-dimensional, one-bay, one- and two-story steel frames of quarter-scale subjected to proportional loads. Kanchanalai [4] tested a two-dimensional, two-bay, two-story steel frame of large scale to verify his plastic-zone analysis technique. Avery and Mahendran [5,6] performed large-scale testing of a two dimensional, one-bay, one-story steel frame comprising noncompact sections subjected to proportional loads. Recently, Kim and Kang [7] and Kim et al. [8] performed some ultimate strength large-scale testing for three-dimensional, onebay, two-story steel frames subjected to non-proportional and proportional loads, respectively. Kim and Kang [9] performed an ultimate strength large-scale testing to account for local buckling of a three-dimensional, one-bay, two-story steel frame.

3. STUCTURAL ANALYSIS BY E-TABS

ETABS is the present day leading design software in the market. Many design use this software companies for their project design purpose. So, this paper mainly deals with the comparative analysis of the results obtained from the analysis of a multi storey building structure when analyzed manually and using ETABS software separately. In this case, a 22.5m x 22.5m, 8 storey structure is modeled using ETABS software. The height of each storey is taken as 3meter making the total height of the structure 24 meter. Analysis of the structure is done and then the results generated by this software are compared with manual analysis of the structure using IS 1893:2002.

4. PROBLEM DEFINITION

A 22.5m x 22.5 m, 8 storey multi storey regular structure is considered for the study. Storey height is 3m. Modeling and analysis of the structure is done on ETABS software.

Preliminary Data

TABLE 4.1 Preliminary Data

LengthxWidth	22.5m x 22.5m
No. of Storey	8 (G+7)
Beam	250 mm x 400 mm
Columns	400 mm x 500 mm
Slab thickness	150 mm
Support Condition	Fixed
Thickness External Wall	120mm
Grade of Concrete and steel	M20 and Fe415
Length of each bay	7.5m

4.1 Loading Consideration

Loads acting on the structure are dead load (DL), Live Load(IL) and Earthquake Load (EL) DL: Self weight of the structure, Floor load and Wall loads
LL: Live load 3KN/m^2 is considered
Seismic: Zone: III
Zone Factor: 0.16
Soil type: II
Response reduction factor: R=3
Importance factor: 1
Damping: 5%
Time period: 0.427 sec (calculated as per IS 1893: 2002)

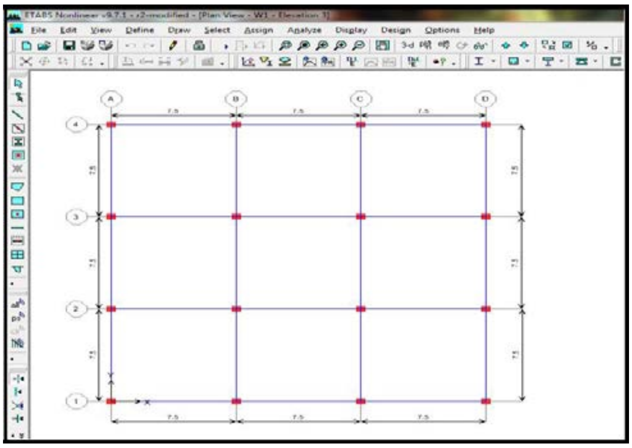


Fig.4.1 Plan of the structure

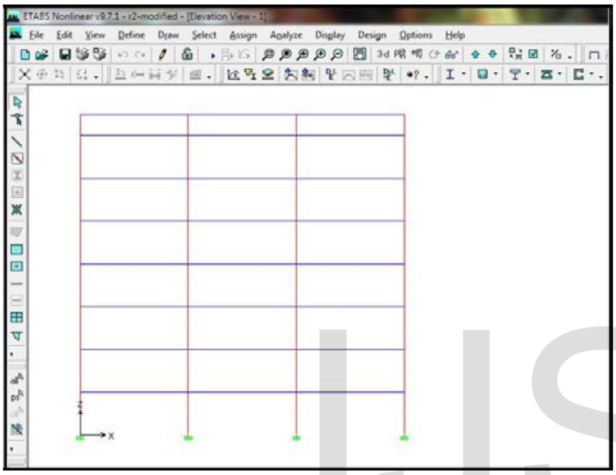


Fig.4.2 Assigning Frame Sections

Dead Load (D. L.) per floor

TABLE 4.2 Dead Load Calulation

Items	Size (LBH) m^3	No.	Density (kN/m^3)	Dead Load
Beam	0.25 x 0.4 x 0.75	24	24	432
Column	0.5 x 0.4 x 7.5	16	24	230.4
Slab	22.5 x 22.5 x 0.15	1	24	1822.5
Wall	22.5 x 0.12 x 3	4	20	648
			UM	3132.9

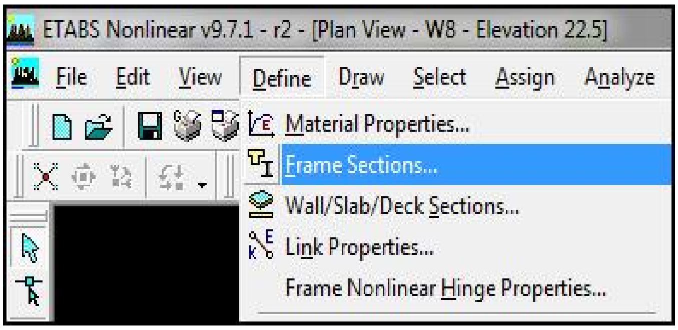


Fig.4.3 Assigning Frame Sections

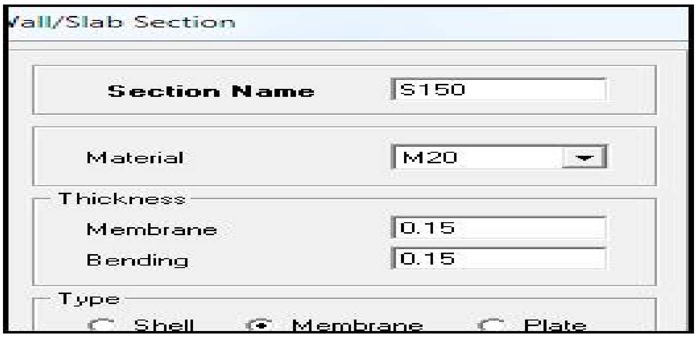


Fig.4.4 Assigning Material Properties

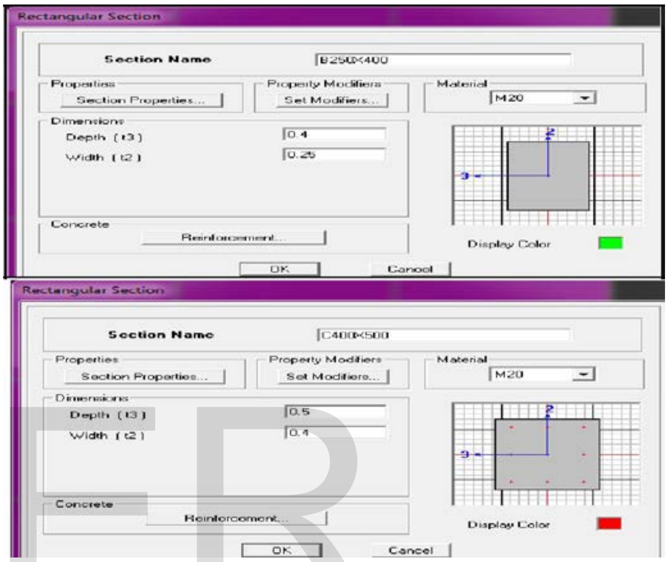


Fig.4.5 Assigning Section Properties

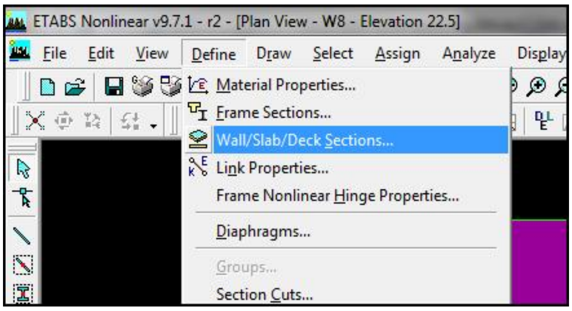


Fig.4.6 Procedure to model slab

4.2. UDL due to wall:

Wall is not modulated only UDL is due to wall on beam is considered.

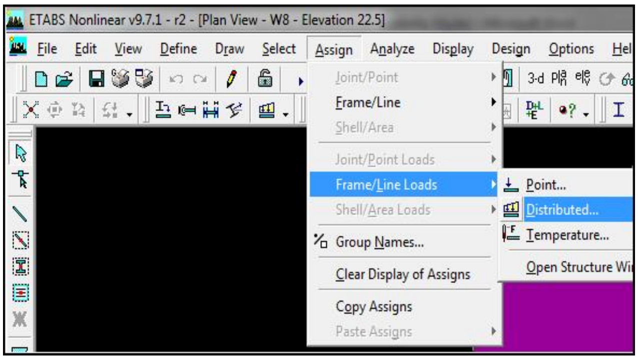
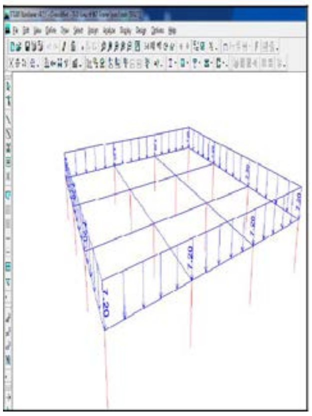


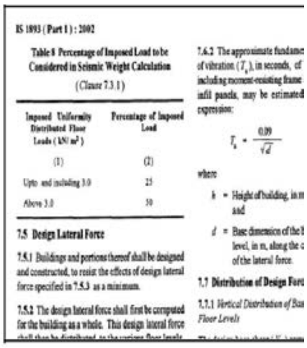
Fig.4.7 Procedure to assign UDL to beam

UDL OF WALL = 0.12(thickness) × 3(height of wall) ×20 (Brick density) = 7.2 kN/m

4.3 . Live load on floor area

As mentioned in II.C, Live load is considered 3kN/m2 on each floor.
Each floor has dimension 22.5m x 22.5m.
Live load on each floor is
3x22.5x22.5 = 1518.75 KN
As per IS 1893:2002 (pg no. 24) Clause no. 7.3.1, Table no.8,
Only 25% live load is considered in seismic weight calculations.
25% of live load = 0.25x 1518.75 = 379.6875 KN.





IS 1893 (Part 1) : 2002

Table 8 Percentage of Imposed Load to be Considered in Seismic Weight Calculation
(Clause 7.3.1)

Imposed Uniformity Distributed Floor Loads (kN/m²)	Percentage of Imposed Load
(1)	(2)
Upto and including 3.0	25
Above 3.0	50

Fig.4.8 7.2kN/m UDL applied to beam on each floor

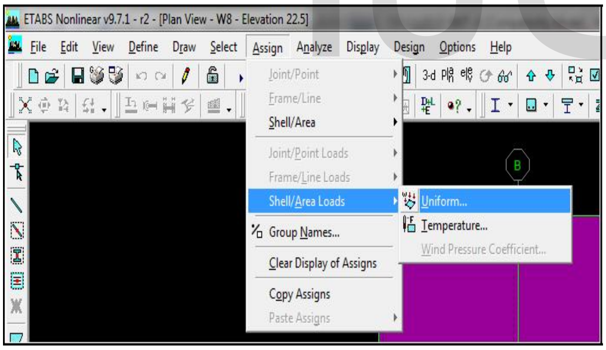


Fig.4.9 Procedure to assign live load on floor

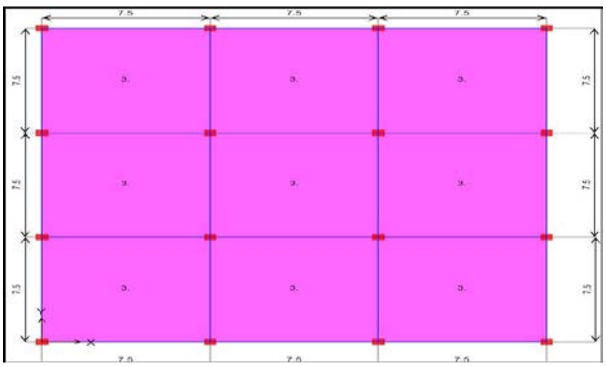


Fig.4.10 Applied live load on each floor

As per IS 1893:2000, the load combination Dead load + Fig 6: 7.2kN/m UDL applied to beam on each floor Live Load becomes DL + 25% LL.

DL = 3132.9, 25% LL = 379.687

DL+ 25% LL = 3572.5875 kN per each floor.

This live load reduction is defined by a command mass source in ETABS 7.1.

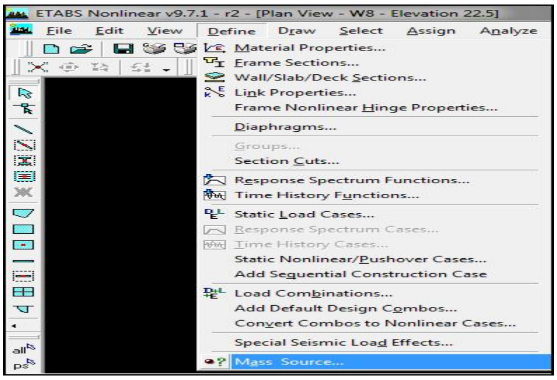


Fig.4.11 Procedure to define Mass Source

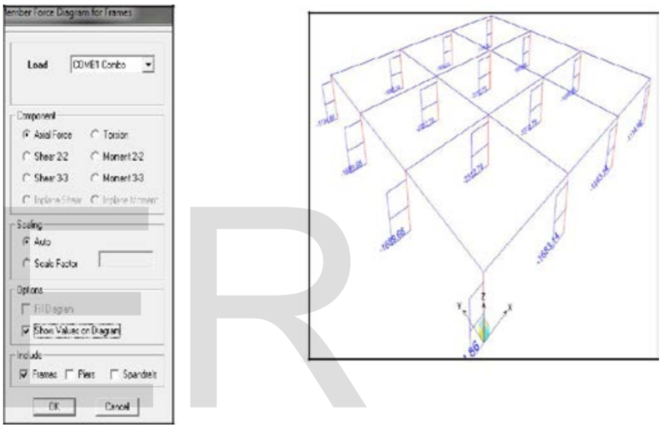


Fig.4.12 Actual Mass Source window in ETABS and Axial load in each column

4.4. Seismic weight calculation of building

As per III, C
W1=W2=W3=W4=W5=W6=W7= 3512.5875 kN. Lumped mass at roof floor.
In the calculation of seismic weight, for the terrace floor 50% of the weight is considered for walls and columns.
W8 = 432 + (230.4 / 2) + 1822.5 + (648 / 2)= 2693.7 kN.
Total weight (W) = (3512.587 x 7) + 2693.7= 27281.8125 kN.
Now the seismic weight obtain in ETABS software is as shown below.

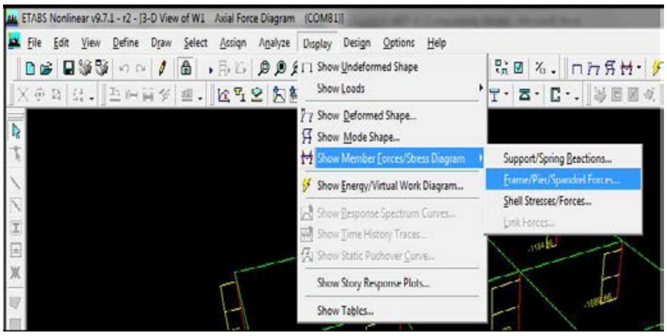
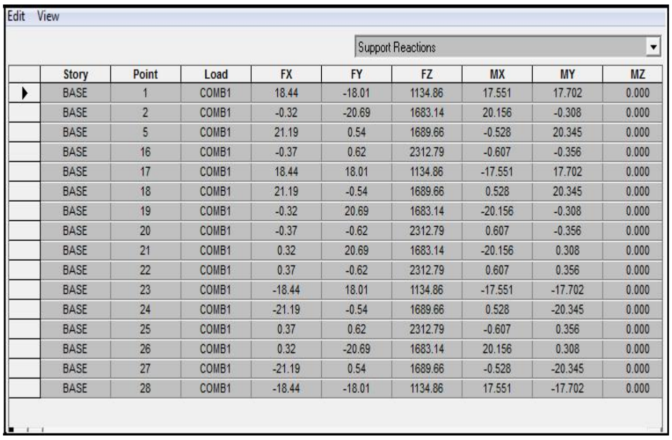


Fig.4.13 Procedure to display axial loads in

columns

Now the algebraic sum of all the axial forces gives seismic weight of the complete building. The same values can be obtained in the table form and facility of exporting these values in excel is available in ETABS that algebraic sum and other any mathematical calculations can be simplified in excel. The procedure of exporting these values in ETABS is explained as below in four steps.



Story	Point	Load	FX	FY	FZ	MX	MY	MZ
BASE	1	COMB1	18.44	-18.01	1134.86	17.551	17.702	0.000
BASE	2	COMB1	-0.32	-20.69	1683.14	20.156	-0.308	0.000
BASE	5	COMB1	21.19	0.54	1689.66	-0.528	20.345	0.000
BASE	16	COMB1	-0.37	0.62	2312.79	-0.607	-0.356	0.000
BASE	17	COMB1	18.44	18.01	1134.86	-17.551	17.702	0.000
BASE	18	COMB1	21.19	-0.54	1689.66	0.528	20.345	0.000
BASE	19	COMB1	-0.32	20.69	1683.14	-20.156	-0.308	0.000
BASE	20	COMB1	-0.37	-0.62	2312.79	0.607	-0.356	0.000
BASE	21	COMB1	0.32	20.69	1683.14	-20.156	0.308	0.000
BASE	22	COMB1	0.37	-0.62	2312.79	0.607	0.356	0.000
BASE	23	COMB1	-18.44	18.01	1134.86	-17.551	-17.702	0.000
BASE	24	COMB1	-21.19	-0.54	1689.66	0.528	-20.345	0.000
BASE	25	COMB1	0.37	0.62	2312.79	-0.607	0.356	0.000
BASE	26	COMB1	0.32	-20.69	1683.14	20.156	0.308	0.000
BASE	27	COMB1	-21.19	0.54	1689.66	-0.528	-20.345	0.000
BASE	28	COMB1	-18.44	-18.01	1134.86	17.551	-17.702	0.000

Fig.4.14 Base Shear in each Storey

5. ANALYSIS FOR BASE SHEAR

A. Design Seismic Base Shear

As per IS 1893:2002, Page No. 24, The total design lateral force or design seismic base Shear (VB) along any principal direction shall be determined by the following expression:

VB = Ah x w

Where,

Ah = Design horizontal acceleration spectrum Value as per

Clause 6.4.2, using the fundamental natural period T, as per

Clause 7.6 in the considered direction of vibration, and

w = Seismic weight of the building as per Clause 7.4.2. As per IS 1893:2002, Clause 6.4.2, Page No. 14,

Where,

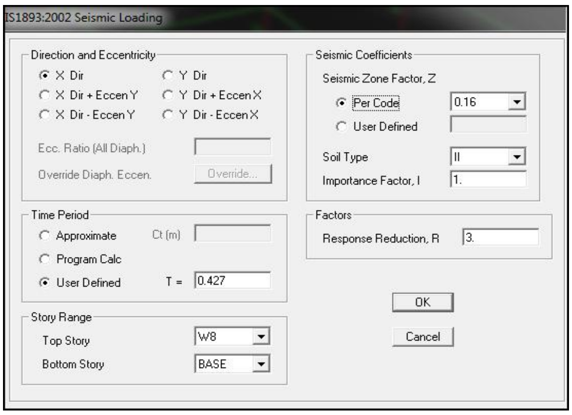
Z =0.16, As per IS 1893:2002, Table No.2 and ANNEX E, Zone Factor for IIIrd zone.

I= 1, As per IS 1893:2002, Table No.6, Importance factor, It is depends on the functional use of the structure.

R= 3, As per IS 1893:2002, Table No.7, Response reduction factor.

Sa/g = Average response acceleration coefficient.

The value of average response acceleration coefficient is determined from the graph given on page no.16 of IS 1893:2002.



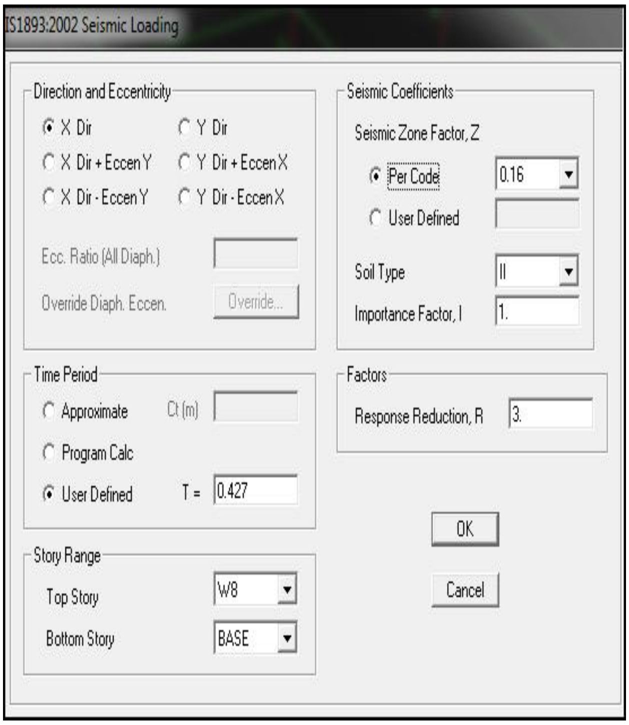


Fig.4.15 Seismic loading

For determination of average response acceleration coefficient, it is required to calculate time period.

As per IS 1893:2002, Page No.7, time period T is given by

H= Height of the building in meter. = 24 m

Note: As per IS 1893:2002 for the terrace floor, half of the total load is considered for walls and columns. So while modeling in ETABS, top story height is modeled 1.5m while height of other stories is 3m. So in ETABS model H = 22.5m d=Base dimension of the building in meter = 22.4 m

Ta = 0.455 sec.

Ta = 0.427 sec.(In case of ETABS)

Sa/g = 2.5.

Now Design horizontal acceleration spectrum Value cans be calculated.

Fig 17: Window of ETABS base shear value Vb (1797.28 kN) in ETABS. (Ref.6)

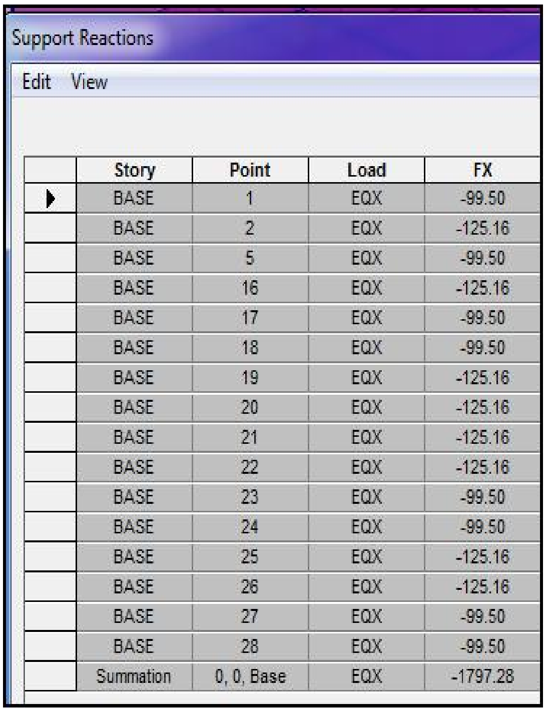
B. Vertical Distribution of Base Shear to Different Floor Levels:

The design base shear VB shall be distributed long the height of the building as per following equation

Now base shear

VB = Ah x w = 0.0667 x 27281.8125

VB = 1819.696 kN.


Support Reactions
Edit View

	Story	Point	Load	FX
▶	BASE	1	EQX	-99.50
	BASE	2	EQX	-125.16
	BASE	5	EQX	-99.50
	BASE	16	EQX	-125.16
	BASE	17	EQX	-99.50
	BASE	18	EQX	-99.50
	BASE	19	EQX	-125.16
	BASE	20	EQX	-125.16
	BASE	21	EQX	-125.16
	BASE	22	EQX	-125.16
	BASE	23	EQX	-99.50
	BASE	24	EQX	-99.50
	BASE	25	EQX	-125.16
	BASE	26	EQX	-125.16
	BASE	27	EQX	-99.50
	BASE	28	EQX	-99.50
	Summation	0, 0, Base	EQX	-1797.28

Fig.4.16 Window of ETABS base shear value

5.1. Vertical Distribution of Base Shear to Different Floor Levels:

The design base shear V_B shall be distributed long the height of the building as per following equation

Where,
Qi = Design lateral force at floor i,
Wi = Seismic weight of floor i,
hi = Height of floor i measured from base

Floor	Height	Wi hi^2	Q(KN)	Base Shear in KN
1	3	31613.29	9.624	1819.69
2	6	126453.15	38.5	1810.07
3	9	284519.59	86.62	1771.57
4	12	505812.6	153.98	1684.95
5	15	790332.19	240.6	1530.97
6	18	1138078.3	346.46	1290.37
7	21	1549051	471.57	943.91
8	24	1551571.2	472.34	472.34
		5977431.9		

n = Number of stories in the building is the number of levels at which the masses are located.