

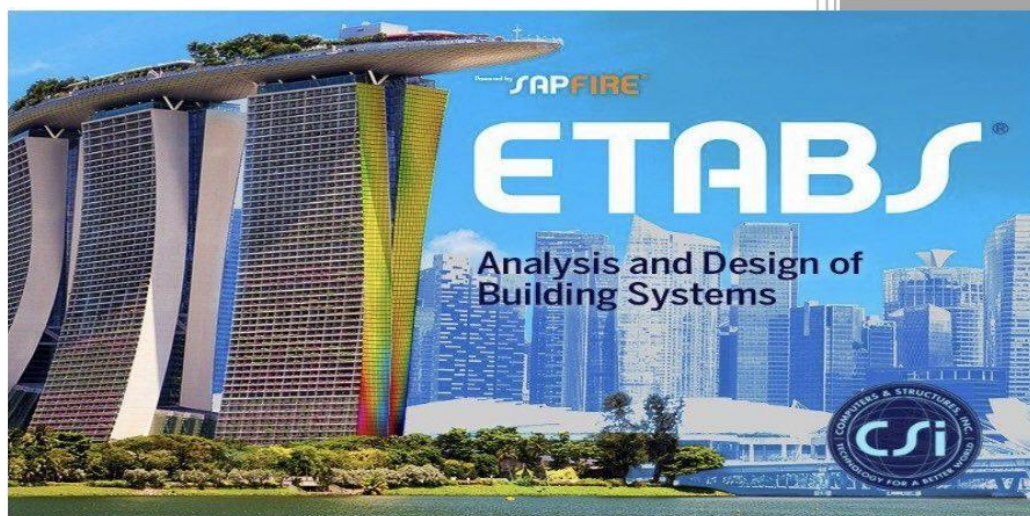
Salahaddin University
College of Engineering
Civil Engineering Department



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Part I

CAD Software



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Ex.1

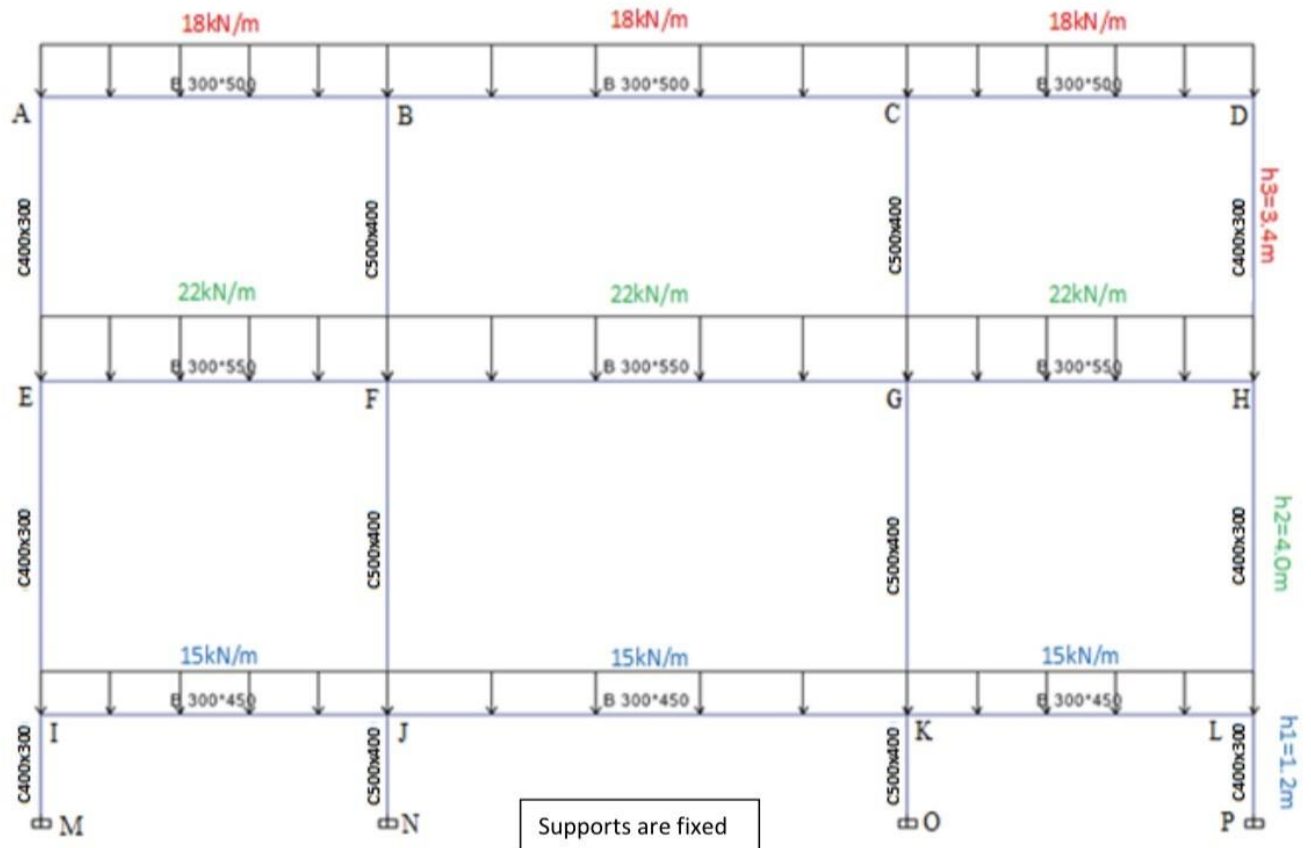
Analysis and Design of Multi-story Frame by (ETABS V19.1.0 Program) and (Hand calculation [Moment Distribution Method]); Comparison of results.

$f'_c=28$ MPa (for all structure) & $f_y=420$ MPa (for steel bars).

The multi-story frame plan and elevation are as in following:



Plan of the multi-story frame

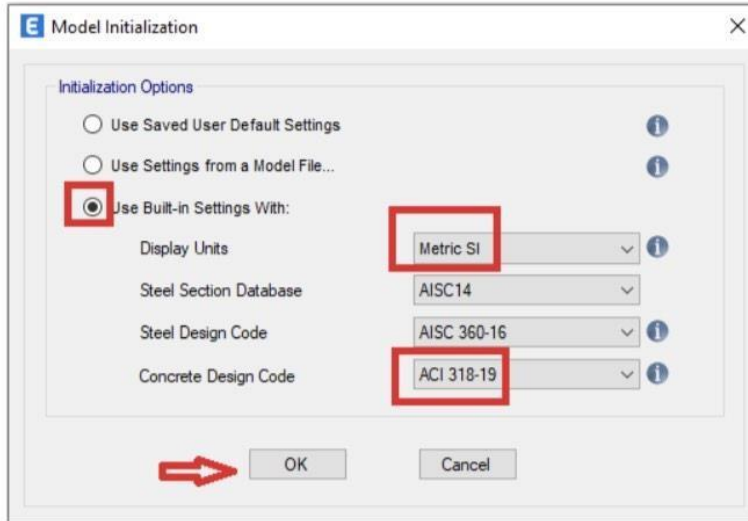


Elevation view of the multi-story frame along (Grid 1).

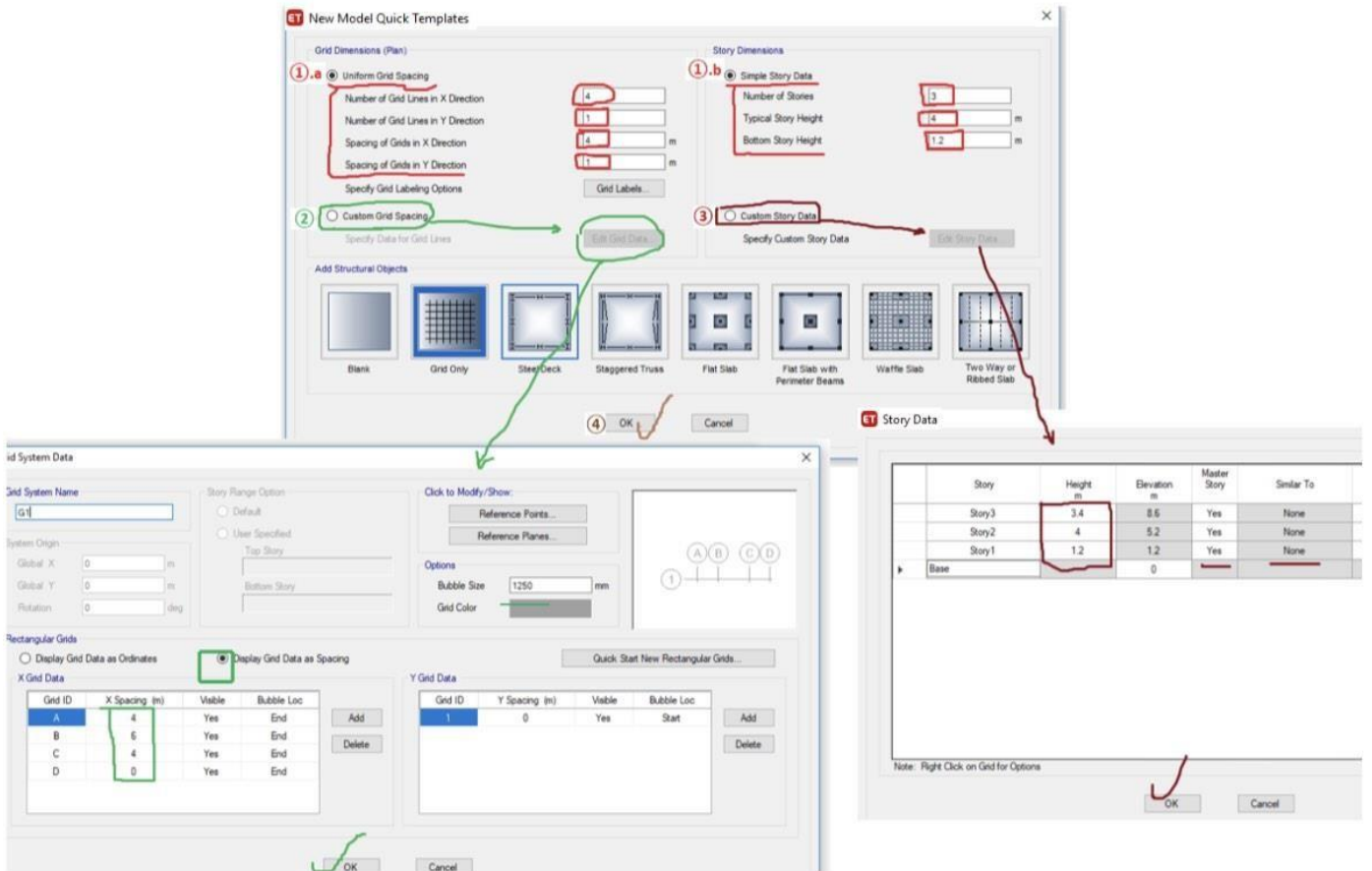
a. Create the Structural multi-story frames


Step 1: To define unit and design codes & Grid dimensions and height of stories.

File menu → New model → Select (Built-in setting with:) → Display units (Metric SI), (Concrete design code) ACI 318-19 → Ok



Following window is display → 1. The grids in x- and y-directions, 2. Spacing between x and y grids, 3. Number of stories.



Step 2: Define Materials: Define menu → Material properties  Material Properties...

- $f'_c = 28 \text{ MPa}$ (for all structure):

Define Materials

Materials: A992Fy50, 4000Psi, A615Gr60, A416Gr270

Click to:

1. Modify/Show Material...

Material Property Design Data

Material Name and Type

Material Name: Fc=28MPa

Material Type: Concrete, Isotropic

Grade: Fc 28MPa

Design Properties for Concrete Materials

Specified Concrete Compressive Strength, f'_c : 28 MPa

Lightweight Concrete

Shear Strength Reduction Factor

4. OK

Material Property Data

General Data

Material Name: fc=28MPa

Material Type: Concrete

Directional Symmetry Type: Isotropic

Material Display Color: Change...

Material Notes: Modify/Show Notes...

Material Weight and Mass

Specify Weight Density Specify Mass Density

Weight per Unit Volume: 24 kN/m³

Mass per Unit Volume: 2447.319 kg/m³

Mechanical Property Data

Modulus of Elasticity, E: 24870 MPa

Poisson's Ratio, ν : 0.2

Coefficient of Thermal Expansion, A: 0.0000099 1/C

Shear Modulus, G: 10362.5 MPa

Design Property Data

Modify/Show Material Property Design Data...

Advanced Material Property Data

Nonlinear Material Data... Material Damping Properties... Time Dependent Properties...

5. OK

- $f_y = 420 \text{ MPa}$ (for steel bars):

Define Materials

Materials: A992Fy50, 4000Psi, A615Gr60, A416Gr270

Click to:

1. Modify/Show Material...

Material Property Design Data

Material Name and Type

Material Name: fy=420MPa

Material Type: Rebar, Uniaxial

Grade: fy=420MPa

Design Properties for Rebar Materials

Minimum Yield Strength, F_y : 420 MPa

Minimum Tensile Strength, F_u : 630 MPa

Expected Yield Strength, F_{ye} : 462 MPa

Expected Tensile Strength, F_{ue} : 693 MPa

4. OK

Material Property Data

General Data

Material Name: fy=420

Material Type: Rebar

Directional Symmetry Type: Uniaxial

Material Display Color: Change...

Material Notes: Modify/Show Notes...

Material Weight and Mass

Specify Weight Density Specify Mass Density

Weight per Unit Volume: 78.5 kN/m³

Mass per Unit Volume: 8004.772 kg/m³

Mechanical Property Data

Modulus of Elasticity, E: 200000 MPa

Coefficient of Thermal Expansion, A: 0.000117 1/C

Design Property Data

Modify/Show Material Property Design Data...

Advanced Material Property Data

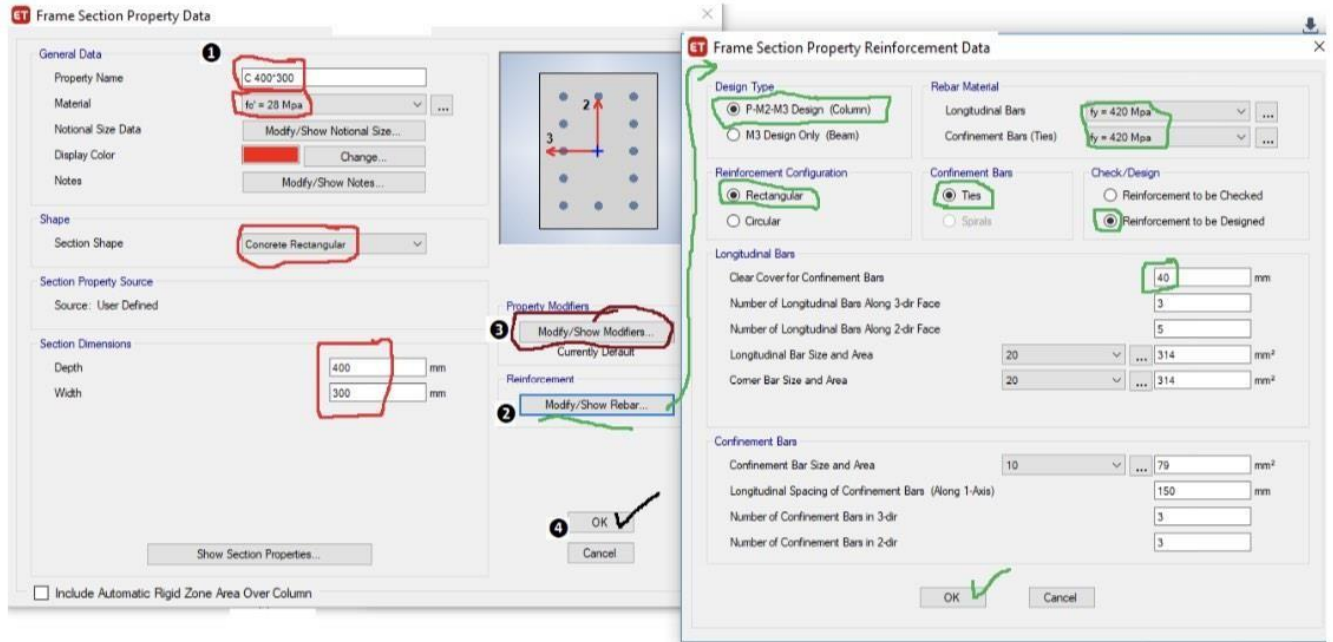
Nonlinear Material Data... Material Damping Properties... Time Dependent Properties...

5. OK

Step 3: Defines: Columns, beams

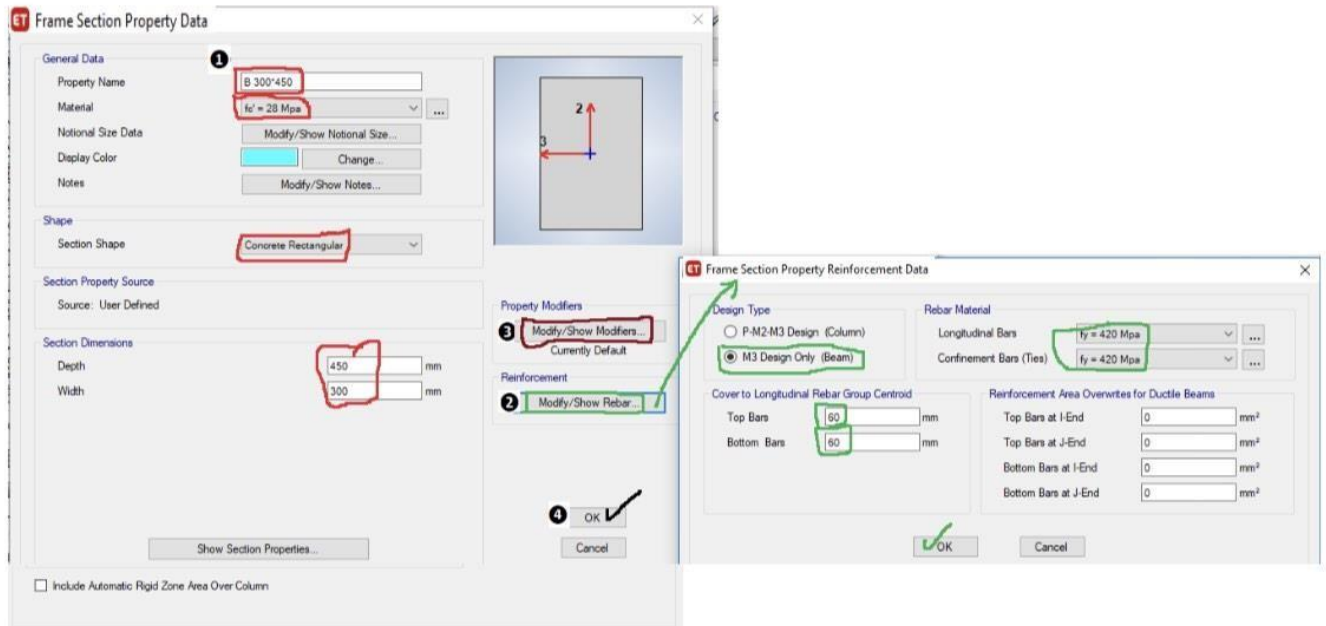
Columns

Define menu → section properties → frame sections → **ConcCol** → add copy of property... (Modify the property of the columns) & (Modify/Show Rebar...) → ... Ok






Beams:

Define menu → section properties → frame sections → **ConcBm** → add copy of property... (Modify the property of the beams) & (Modify/Show Rebar...) → ... Ok




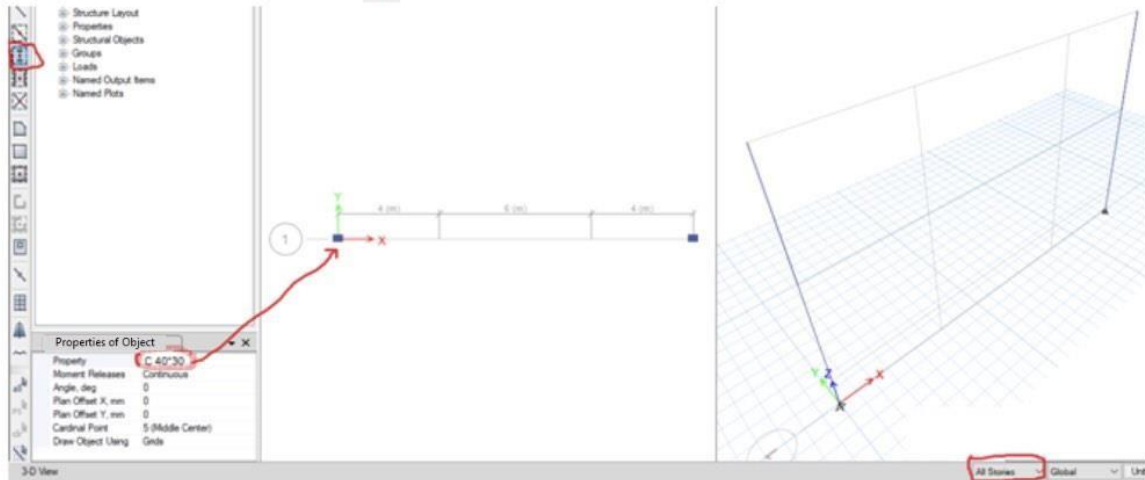
Step 4: Draw Columns and Beams:

-  Draw Beam/Column (Plan, Elev. , 3D).
-  Quick Draw Beams/Columns (Plan, Elev. , 3D).
-  Quick Draw Columns (Plan).


- To Draw Columns:**

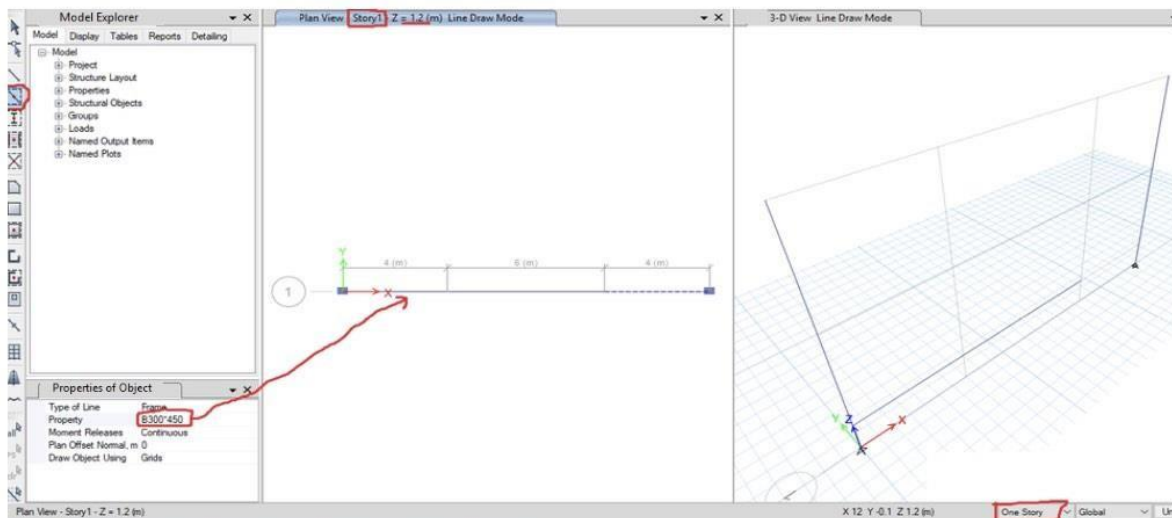
On Plan View → go to story 3 → select (All Stories),

Click on quick draw column icon  → choose (Property: C) → & draw columns.



- To Draw Beams** On Plan View → go to story → select (One Story),

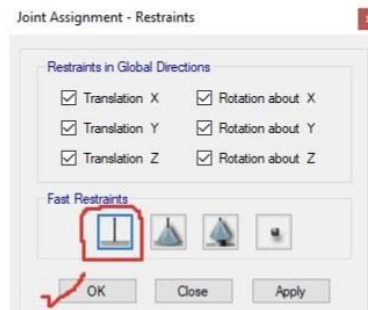
Click on quick draw beam icon  → choose (Property: B) → and draw beams.



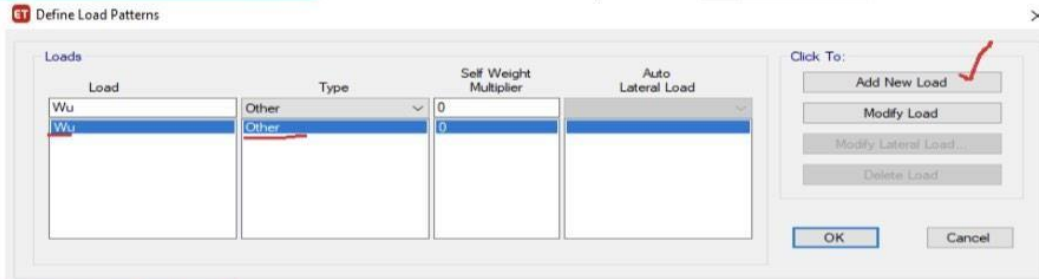
Step 5: Fixing the Ground Floor Joints(Columns):

Select (One Story) → Select ground floor (Base) joints,

And click on assign → Joints  Joint → restrains  Restraints... → Ok



Step 6: Define Static Load Patterns: Define menu → Load patterns Load Patterns...

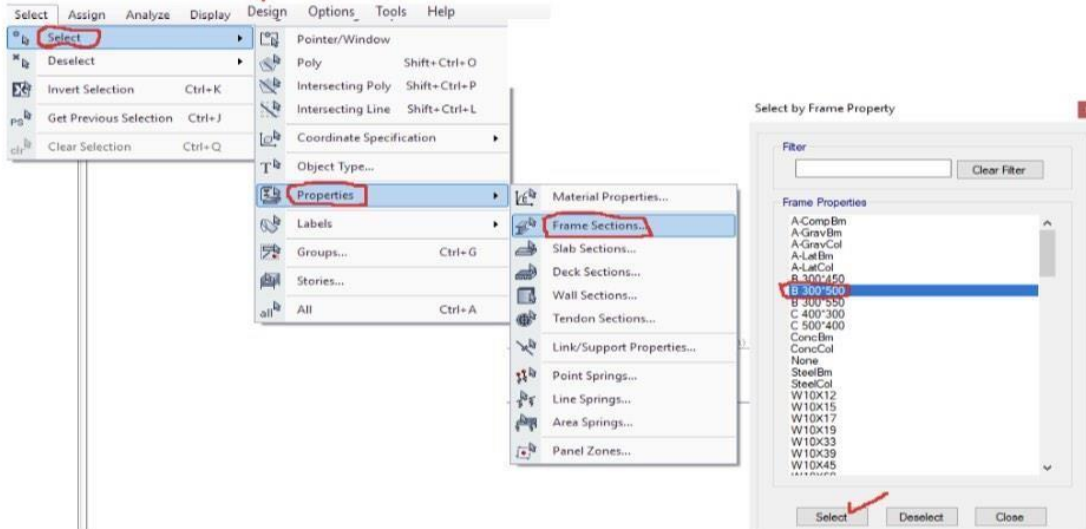


Step 7: Assign Gravity Loads:

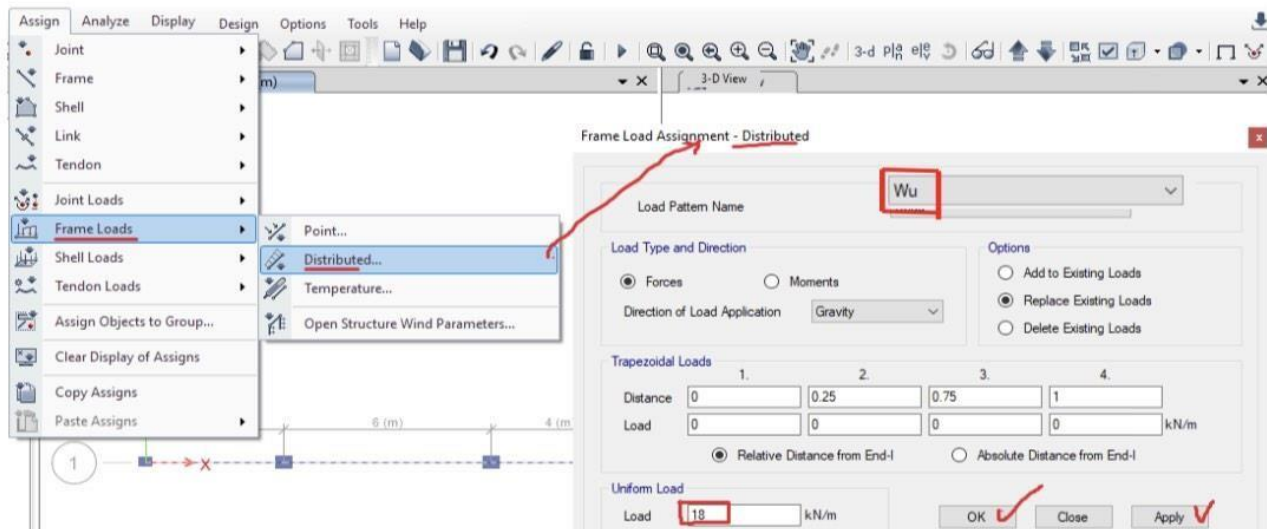
In this Step, the Line loads will be applied to the model. Make sure that the **(One story)** feature is enabled and that the plan View is active.

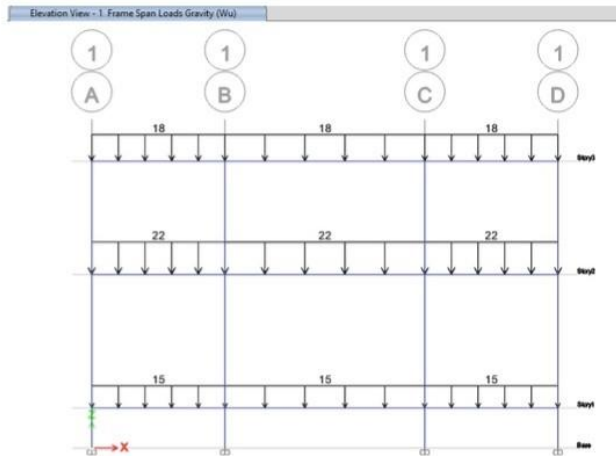
Now we will assign the line loads to the beams.

Select menu → **Select** → **Properties** → **Frame section** → **Ok**



After that; **Assign menu** → **frame loads** **Frame Loads** → **distributed** **Distributed...** → **Ok**.

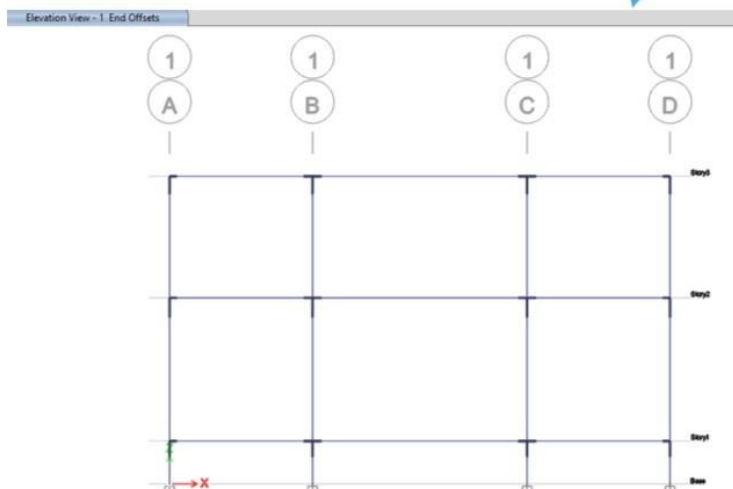




Step 8: Moments @ the face of supports (Columns):

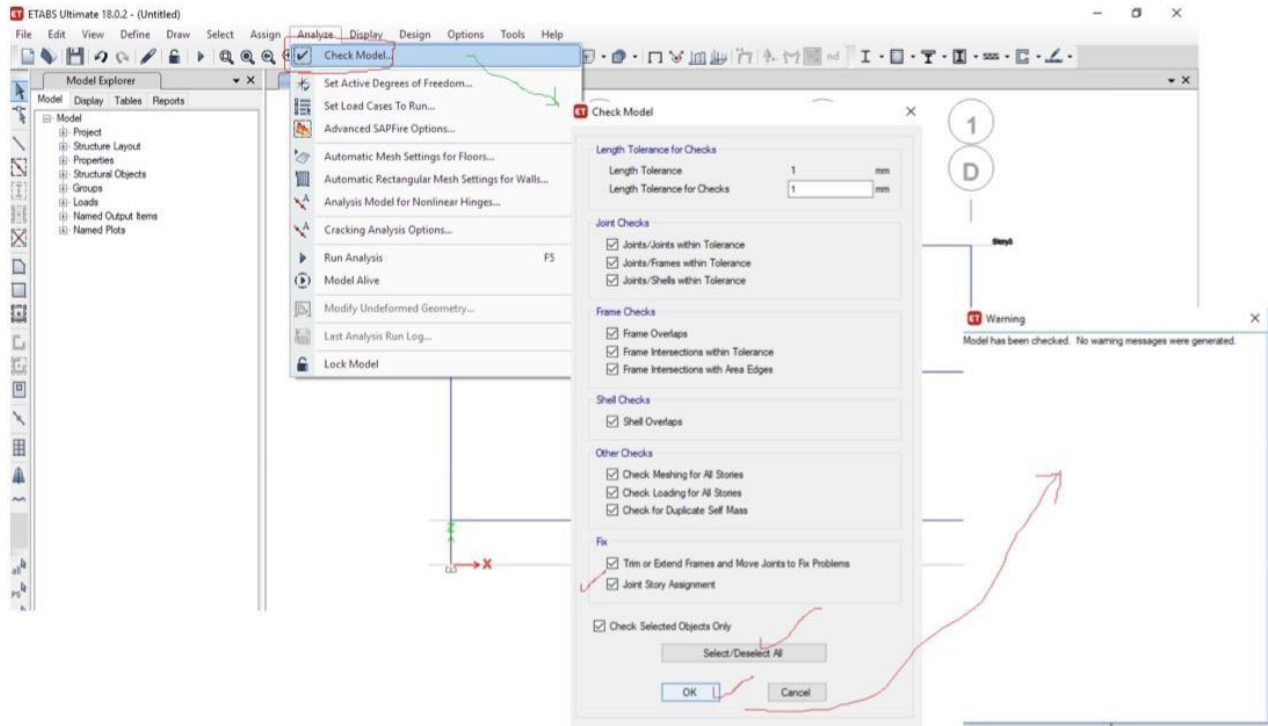
Elevation view (Gride 1) or 3D → select multi-story frame,

Assign menu → Frame → End length offsets → End Length Offsets... ↓




Step 9: Check the Model:

To check the Model: Analyze menu → check model Check Model... → select all items ... → Ok.

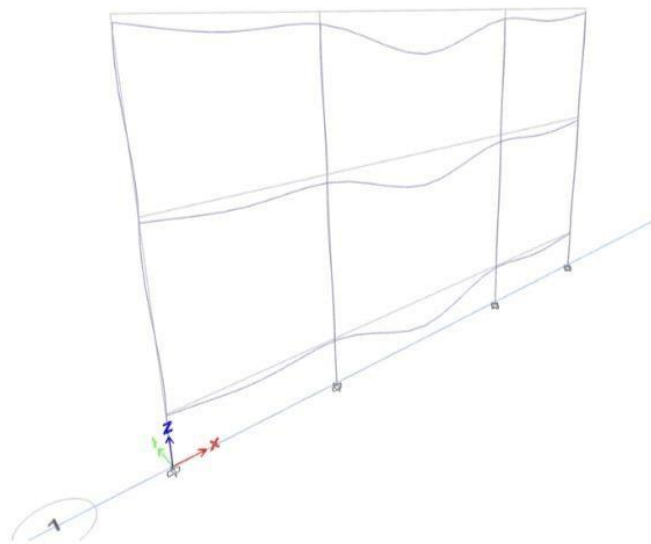


Step 10: Run the Analysis: In this step, the analysis will be Run.

Click the **Analyze** menu → **Run Analysis** command or **The Run Analysis** button, .

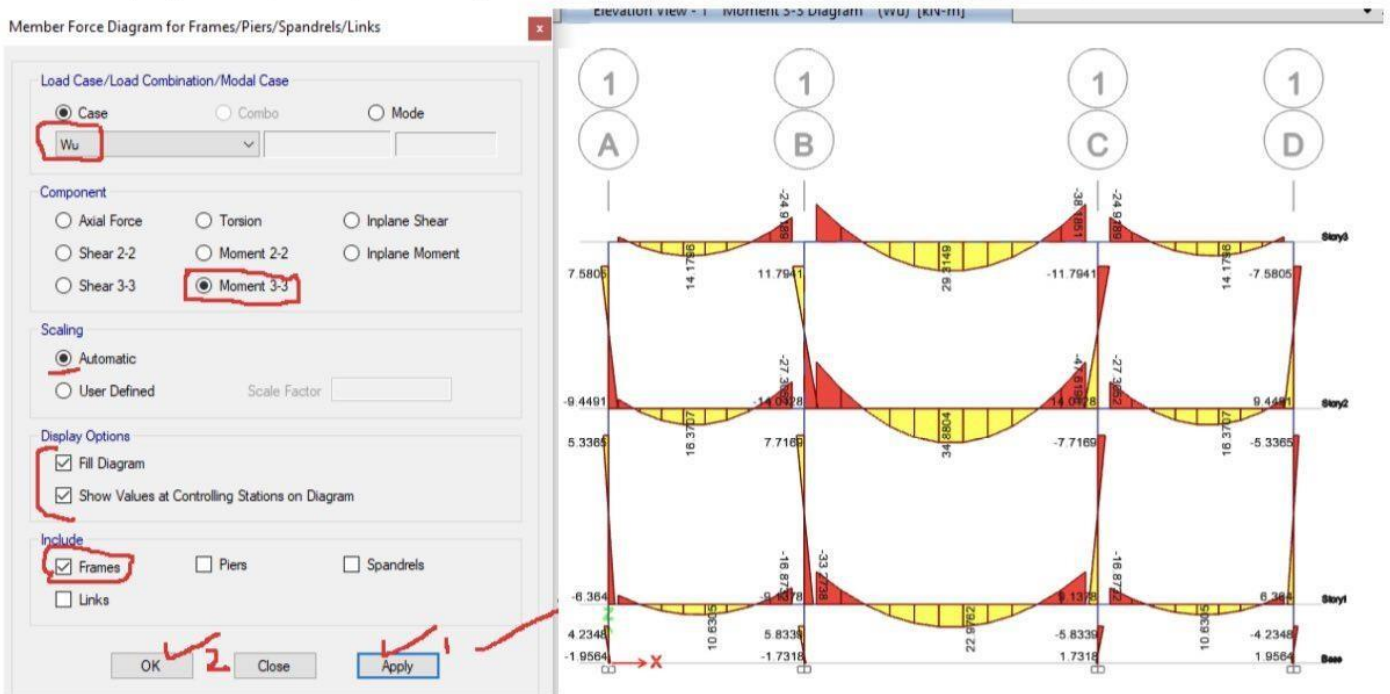
When the **entire analysis process has been completed**, the model automatically **displays a deformed shape view of the model**, and the model is locked. The model is locked when the **Lock/Unlock Model** button, , Appears locked.

Locking the model **prevents any changes to the model** that would invalidate the analysis results.

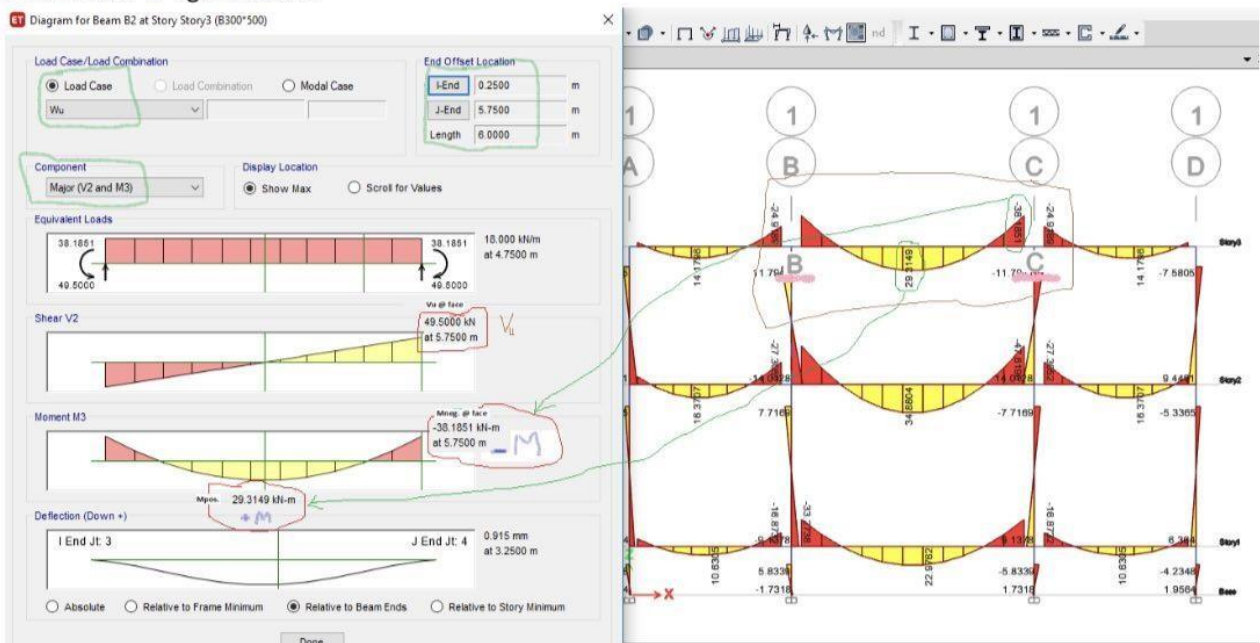


Step 11: Display the Results:

- Make sure that the elevation view (Grid 1) is active.
Display menu → Force/stress diagrams → Frame/pier/Spandrel/Link force **M** | → Ok



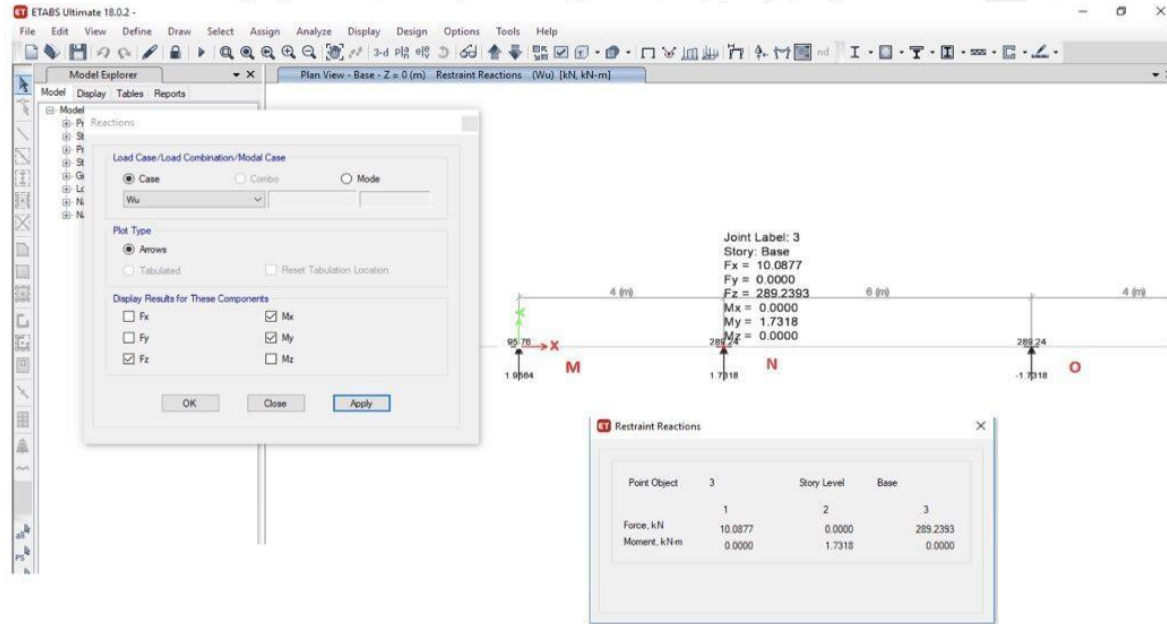
- Right click on the beam or column between any grid lines to access the diagram for beams and columns from shown in figure below.



• **Find reactions:**

Elevation view (**Plan/Base**) or **3D** or **Grid 1** active,

To find reactions: Display menu → Force/stress diagrams → Support/spring reactions... → Ok



b. Moment Distribution Method for multi-story frame by (hand calculation)

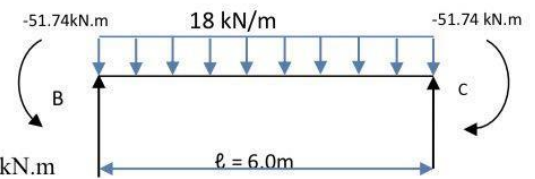
Joint	A		B		F		E					
member	AE	AB	BA	BC	BF	FB	FG	FJ	FE	EF	EA	EI
D.F	0.376	0.624	0.345	0.115	0.54	0.335	0.095	0.285	0.285	0.545	0.24	0.209
F.E.M		-24	24	-54			-66		29	-29		
D.M	9.024	14.976	10.35	3.45	16.2	12.40	3.52	10.55	10.55	15.81	6.96	6.06
C.O.F	3.48	5.18	7.49		6.20	8.1		2.48	7.90	5.27	4.51	1.74
D.M	-3.25	-5.40	-4.72	-1.57	-7.39	-6.19	-1.76	-5.27	-5.27	-6.28	-2.77	-2.41
C.O.F	-1.38	-2.36	-2.70		-3.09	-3.70		-0.77	-3.14	-2.63	-1.63	-0.38
D.M	1.41	2.34	2.00	0.67	3.13	2.55	0.72	2.17	2.17	1.09	0.48	0.42
C.O.F	0.24	1.00	1.17		1.27	1.56		0.31	0.55	1.08	0.70	0.14
D.M	-0.47	-0.77	-0.84	-0.28	-1.32	-0.81	-0.23	-0.69	-0.69	-1.05	-0.46	-0.40
	9.05	-9.05	36.74	-51.74	15.00	13.91	-63.75	8.78	41.06	-15.71	7.80	5.17

Calculate positive moments for interior spans as follows: for interior panel, $M_{pos} = 18 \times 6^2 / 8 - 51.74 = 29.26$ kN.m

*To find reactions, take moments about point B (@center of column);

$$6 R_c - 18 \times 6 \times 3 = 0 \quad \rightarrow \quad R_B = R_c = 54 \text{ kN}$$

M_{neg} at face of support B, C = $51.74 - 54 \times 0.25 + (18 \times 0.25^2 / 2) \approx 38.80$ kN.m



Check $M_{pos} + (M_{neg})_{average \text{ at face}} \leq M_o = 18 \times (6-0.5)^2 / 8 = 68.06$ kN.m $\rightarrow 29.26 + 38.8 = 68.06 = M_o = 68.06$ kN.m **OK**

*To find reactions, take moments about point B' (@face of column);

$$5.5 R_{c'} - 18 \times 5.5 \times 2.75 = 0 \quad \rightarrow \quad R_{B'} = R_{C'} = 49.5 \text{ kN} \quad (@\text{face of column})$$