



ADI CHUNCHANAGIRI UNIVERSITY
B G S INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING



LABORATORY MANUAL

SIXTH SEMESTER CIVIL ENGINEERING
SOFTWARE APPLICATION LAB
SUBJECT CODE –18CVL67

FACULTY INCHARGE:

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B G S INSTITUTE OF TECHNOLOGY

Vision

BGSIT is committed to the cause of creating tomorrow's engineers by providing quality education inculcating ethical values.

Mission

M1: Imparting quality technical education by nurturing a conducive learning environment.

M2: Offering professional training to meet industry requirements.

M3: Providing education with a moral - cultural base and spiritual touch.

DEPARTMENT OF CIVIL ENGINEERING

Vision

Producing technically competent and Environmental friendly Civil Engineering Professionals to cope with the societal challenges.

Mission

M1: Imparting quality education and professional ethics by proficient faculty.

M2: Providing infrastructure to meet the requirements of curriculum, research and consultancy.

M3: Motivating towards higher education and entrepreneurship.

M4: Promoting Interaction with design and construction industries.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Graduates will be pursuing successful career & higher education.

PEO 2: Graduates will be able to design safe, economical & sustainable civil engineering structures conforming to standards.

PEO 3: Graduates will display professional ethics to work in a team & lead the team by effectively communicating the ideas.

PEO 4: Graduates will practice lifelong learning.

PROGRAM OUTCOME

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Graduate will be able to analyze, design and execute the Civil Engineering structure Effectively for sustainable development.

PSO2: Graduate will acquire critical Thinking abilities and technical skills for the usage of modern tools in development of Civil Engineering structures.

PSO3: Graduate will able to get opportunities for their professional growth, demonstrate communication and aptitude skills to face the challenges and needs of our society

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MODULE 1

USE OF CIVIL ENGINEERING SOFTWARE

ACCU

MODULE-1

USE OF CIVIL ENGINEERING SOFTWARE

1.1 Software Available for the analysis

Most structural engineers use 3D integrated structural analysis and design software in their daily work. These software's make modeling geometries of structures and analyzing loads much more efficient, therefore decreasing the time and effort needed for finite element analysis. Many of these software's have integrated and diverse features, such as analyzing a diversified profile of structural elements (slabs, openings, foundations, columns, walls, bracings, beams, etc), modeling structures of different materials, checking for geometrical errors, and outputting analysis and graphical files. Although there are many software that have efficient features, we have listed the top 5 structural design and analysis software that we feel have crucial and special features for design and analysis.

There are various software available for analysis of the structure, the most commonly used software's in the consultancy firm are

1. STAAD. Pro
2. E-Tabs

1.1.1 STAAD.Pro 2005

STAAD.Pro is used for both linear static and non-linear analysis. STAAD.Pro is adept at analyzing time dependent effects, such as creep, shrinkage, and cracking of concrete. Other software's developed by the same company, Bentley, can be used in conjunction with STAAD.Pro. STAAD.Pro models can be imported to Open STAAD so that these models can be transferred to other third-party applications. STAAD.Pro models can also be integrated with Project Wise, in which the software can utilize the imported model for project collaboration and management. Not only can STAAD.Pro be integrated with software's developed by Bentley, their interface can import CAD models. STAAD.Pro is very user friendly since Bentley has also stated that 80 percent of their new customers can learn to operate STAAD. Pro 2005 efficiently

in under two hours. Bentley has also boasted that their programs can design structures using over 80 international codes and can generate structural design documents automatically.

1.1.2. E-Tabs

The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

A C U

ETABS

INTRODUCTION

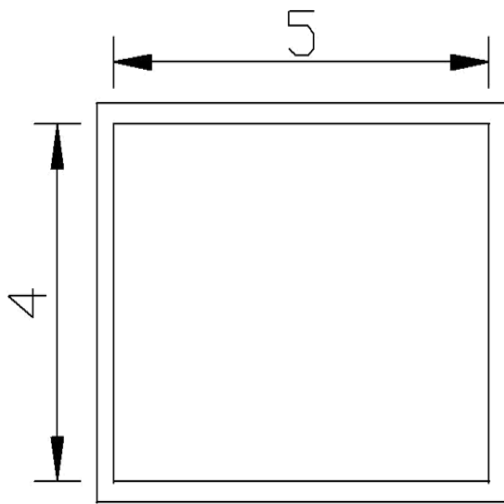
ETABS is a stand-alone finite-element-based structural analysis program with special purpose features for structural design and analysis of building systems. Embedded beneath the simple, intuitive user interface are very powerful numerical methods, design procedures and international 1 design codes that allow you to be versatile and productive, whether you are designing a simple 2-dimensional frame or performing a dynamic base isolation analysis of a complex high-rise.

ETABS works off of an integrated database. The basic concept is that you create only one model consisting of the floor systems and the vertical and lateral framing systems to analyse and design the whole building. Everything you need is integrated into one versatile analysis and design system with one user interface. There are no external modules to maintain and no worries about data transfer between modules. The effects on one part of the structure from changes in another part are instantaneous and automatic.

The analysis methods include a wide variety of Static and Dynamic Analysis Options. The integrated model can include, among others, complex Composite Floor Framing Systems with Openings and Overhangs, Steel Joist Systems, Moment Resisting Frames, Complex Shear Wall Systems, Rigid and Flexible Floors, Sloped Roofs, Ramps and Parking Structures, Mezzanine Floors, Trussed Systems, Multiple Tower Buildings and Stepped Diaphragm Systems.

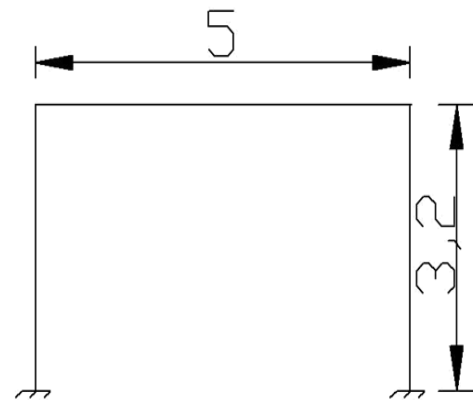
Vertical Dynamic Analysis options allow you to include the effects of vertical ground motion components in your earthquake analysis. It also allows you to perform detailed evaluations of vertical floor vibration problems in addition to the traditional empirical methods that are also built into the software.

Simple plan



Plan

plan and elevation is in meters



Elevation

Parameters

M20 grade concrete

FE415 grade Steel

Beam= 230mmx300mm

Column= 230mmx 230mm

Wall thickness= 230mm

Slab thickness= 150mm

Live load= 2kN/m²

Floor Finish= 1 kN/m²

1 ETABS 2013

Example 1.1 Linear static Analysis and design

1.11 MODELLING

1) File → New Model → Use built-in settings with:

Display units: Metric SI

Steel section database: Indian

Steel design code: IS800:2007

Concrete design code: IS 456:2000. For current plan and elevation, the details are modified as in fig 1.

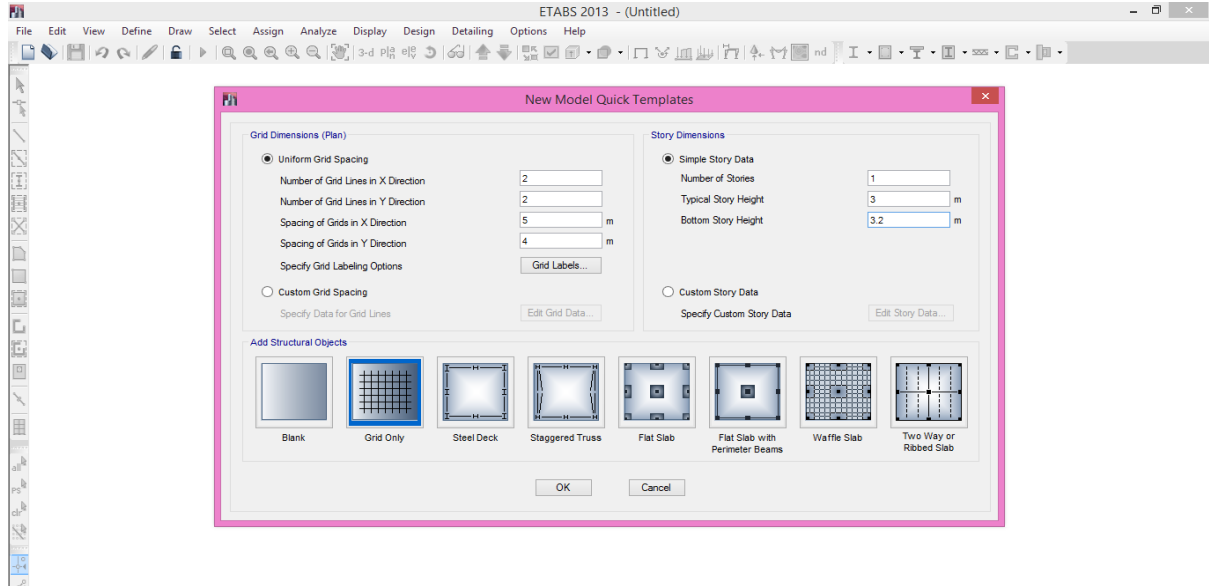


Fig 1

2) The grid system is displayed as in fig 2.

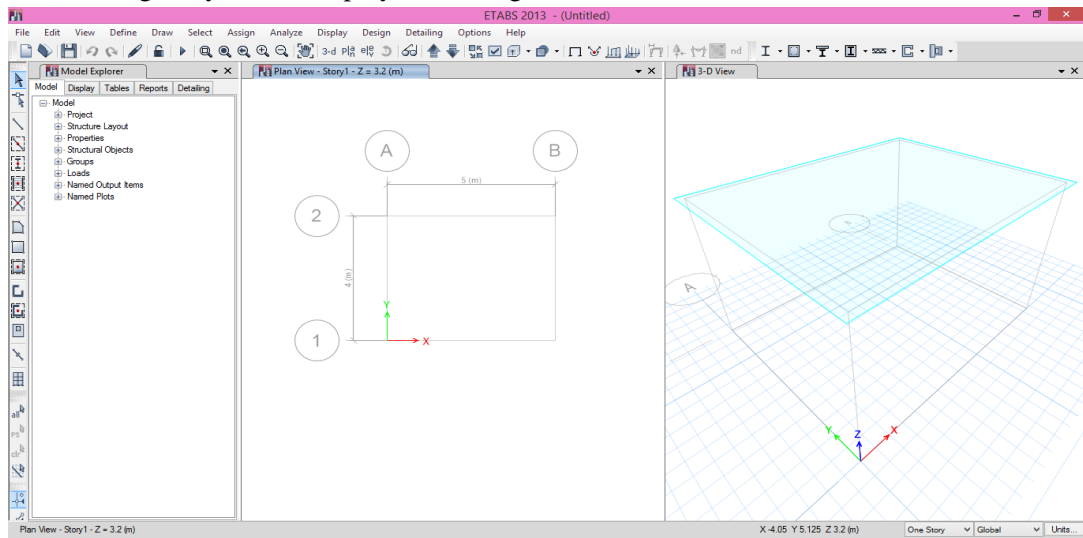


Fig 2

3) Define → Material properties → Add new material

a) For concrete

- i) Region :India
- ii) Material type: Concrete
- iii) Standard: Indian
- iv) Grade: M20 → OK

Changes are made as in fig 3.

The screenshot shows the 'Material Property Data' dialog box with the following settings:

- General Data:**
 - Material Name: M20
 - Material Type: Concrete
 - Directional Symmetry Type: Isotropic
 - Material Display Color: Yellow
 - Material Notes: (empty)
- 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: 22360.68 MPa
 - Poisson's Ratio, U: 0.2
 - Coefficient of Thermal Expansion, A: 0.0000055 1/C
 - Shear Modulus, G: 9316.95 MPa
- Design Property Data:**
 - Modify/Show Material Property Design Data...
- Advanced Material Property Data:**
 - Nonlinear Material Data...
 - Material Damping Properties...
 - Time Dependent Properties...

Buttons: OK, Cancel

Fig 3

b) For Rebar

- i) Region: India
- ii) Material type: Rebar
- iii) Standard: Indian
- iv) Grade: HYSD grade415 → OK

Changes are made as in fig 4.

The screenshot shows the 'Material Property Data' dialog box with the following settings:

- General Data:**
 - Material Name: HYSD415
 - Material Type: Rebar
 - Directional Symmetry Type: Uniaxial
 - Material Display Color: Grey
 - Material Notes: (empty)
- Material Weight and Mass:**
 - Specify Weight Density
 - Specify Mass Density
 - Weight per Unit Volume: 78.5 kN/m³
 - Mass per Unit Volume: 7849.047 kg/m³
- Mechanical Property Data:**
 - Modulus of Elasticity, E: 200000 MPa
 - Coefficient of Thermal Expansion, A: 0.0000117 1/C
- Design Property Data:**
 - Modify/Show Material Property Design Data...
- Advanced Material Property Data:**
 - Nonlinear Material Data...
 - Material Damping Properties...
 - Time Dependent Properties...

Buttons: OK, Cancel

Fig 4

C) For Masonry

- i) Region: India
- ii) Material type: Masonry → OK. Changes are made as in fig 5. OK → OK

Fig 5

- 4) Define → Section properties → Frame sections → Add new property
 - a) Column details
 - i) Section shape → Concrete Rectangular
 - ii) Concrete → [REDACTED]
 - iii) General data → Property name: Col230x230
Material: M20
 - iv) Section dimensions → Depth: 230 mm; Width: 230mm
 - v) Reinforcement → Modify/ Show Rebar
 - vi) Design Type: P-M2-M3 design (column)
 - vii) Rebar material → Longitudinal bar: HYSD 415 ; Confinement bar: HYSD 415

Changes are made as in fig 6. →OK

Fig 6

b) Beam details

- i) Section shape → Concrete Rectangular
- ii) Concrete → [REDACTED]
- iii) General data → Property Name: Beam230x230
Material: M20
- iv) Section dimensions → Depth=300mm; Width=230mm
- v) Reinforcement → Modify/ Show Rebar
- vi) Design Type: M3 design only (Beam)
- vii) Rebar material → Longitudinal bar: HYSD 415 ; Confinement bar: HYSD 415

Changes are made as shown in fig 7 → OK → OK → OK.

Fig 7

b) Slab details:

- i) Define → Section properties → Slab section → Add new property
- ii) General data → Property name: Slab
Slab material: M20
- iii) Property data → Thickness=150 mm

Changes are made as in fig 8. → OK→ OK

Fig 8

c) Wall details

- i) Define→ Section properties→ Wall section→ Add new property
- ii) General data→ Property name: Wall
Wall material: Masonry
Modelling type: Membrane
- iii) Property data→ Thickness: 230 mm→ OK→OK.

Changes are made as shown in fig 9.

Fig 9

1.2 Loading

- i) Define→ Load patterns
- ii) Load→ Floor finish
- iii) Type→ Super dead
- iv) Self-weight multiplier→0→ Add new load→ OK

Changes are made as in fig 10.

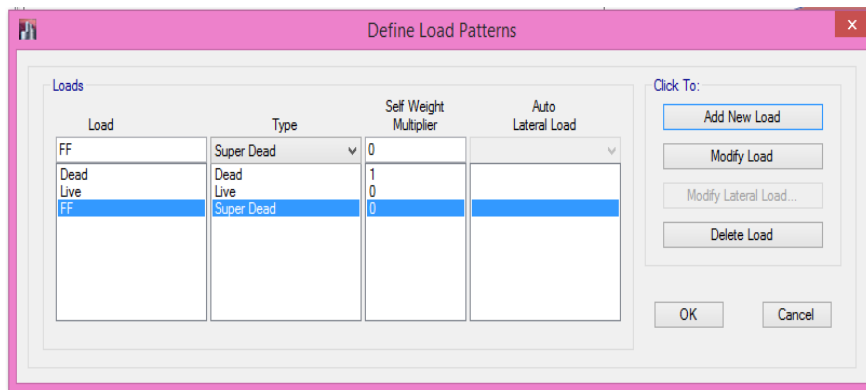


Fig 10

- 5) After all the defining of material, cross sections and load, allotment of these to the structure has to be done.
- 6) Draw → Draw Beam/ Column/Brace objects → Quick draw Column. The columns are to be placed in the grid points 1, 2, 3. (Corner points). Fig 11.

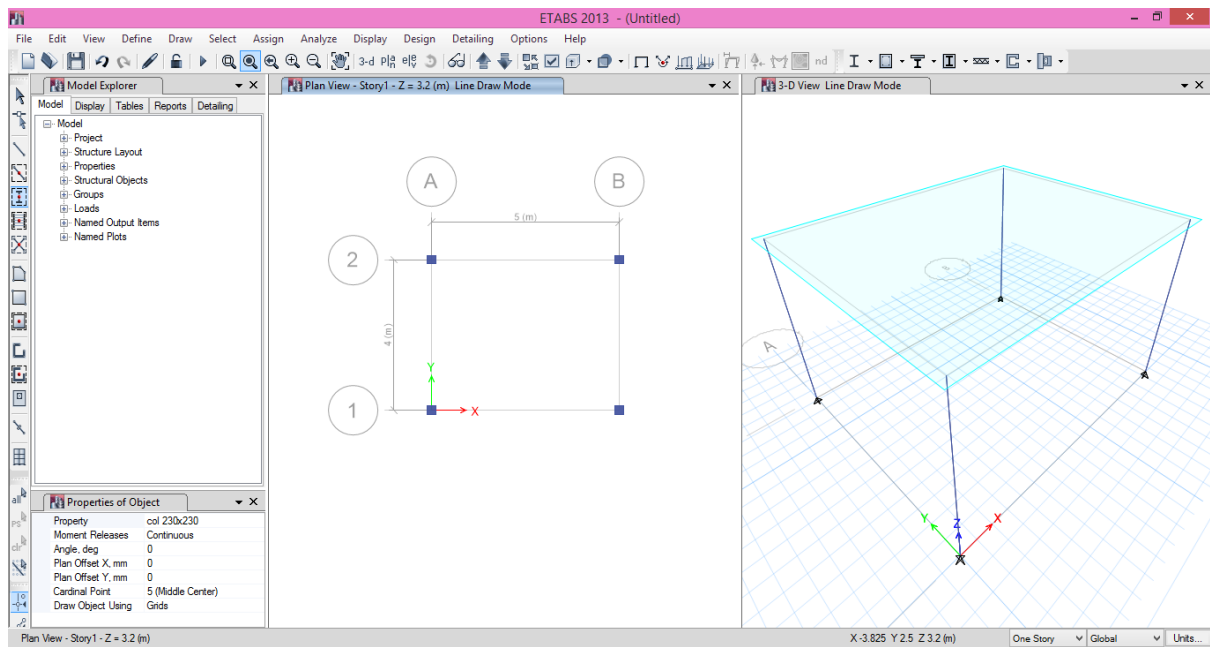


Fig 11

- 7) Draw → Draw Beam/ Column/ Brace Objects → Draw Beam/ Column/Brace. The beams are placed in between the columns as a straight line.
- 8) Draw → Draw Floor/ Wall objects → Draw rectangular Floor/Wall. The roof is placed on the storey.
- 9) Draw → Draw Floor/Wall Objects → Draw Walls. Start from grid point 1,2,3 and back to 1. Fig 12.

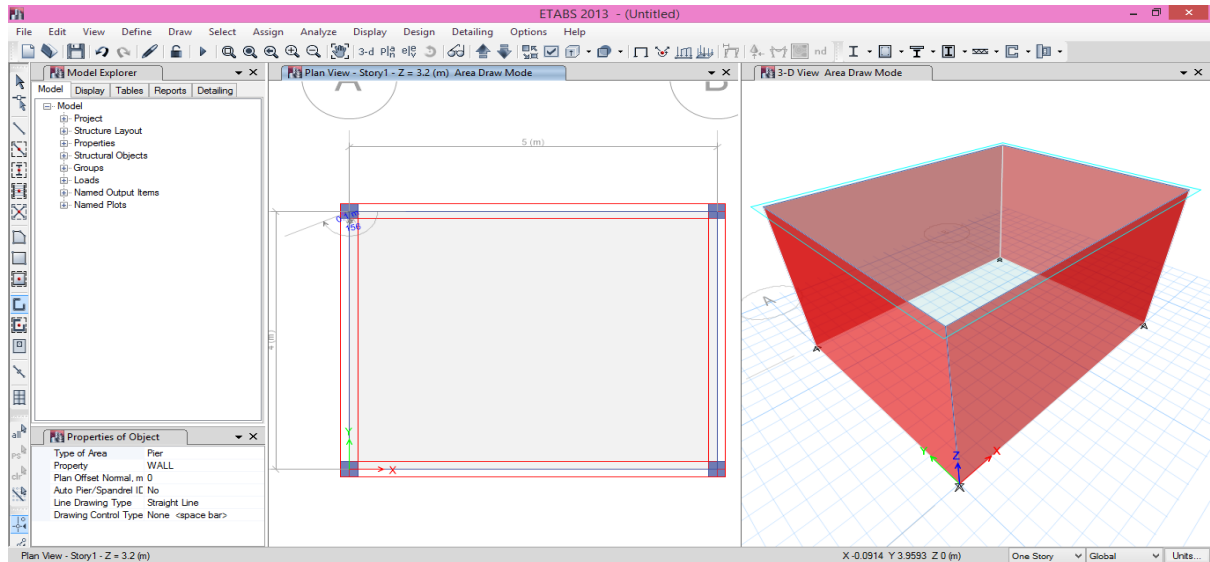


Fig 12

1.3 Support specification

Assign → Joint → Restraints → Select the nodes at the base and assign the supports. Fig 13

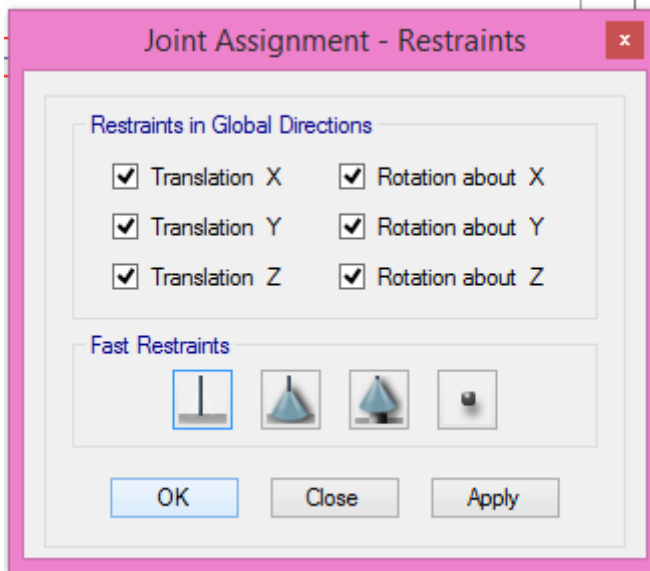


Fig 13

10) Select the slab → Assign → Shell loads → uniform → Live load and Floor Finish. Fig 14

This completes the modelling of the structure.

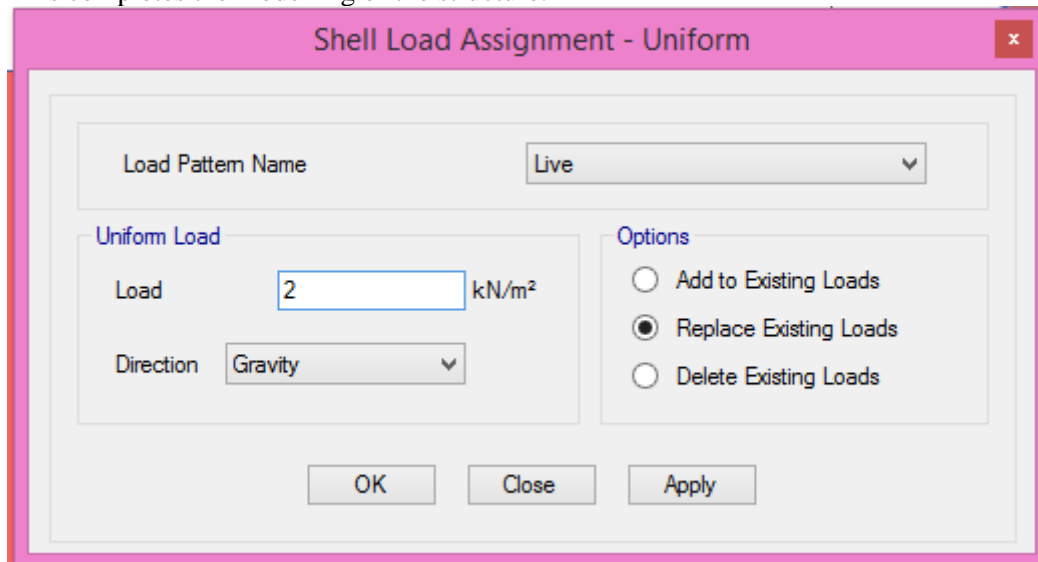


Fig 14

1.4 ANALYSIS

Before we start with analysis we have to save the file.

- 1) Analyze → Check model → Tick all the check boxes → OK
- 2) Analyze → Run Analysis.

A dialogue box opens intimating about the errors or warnings. Errors or warnings may appear if there are overlapping of the slabs or if any property assigning is not complete.

- 3) Display → Show tables → Analysis → Results → Structure results → Storey Forces → OK.
- 4) The results obtained can be imported to Excel sheet. Table 1

Any table can be imported to excel and design can be done.

TABLE: Story Forces								
Story	Load Case/Combo	Location	P	VX	VY	T	MX	MY
			kN	kN	kN	kN-m	kN-m	kN-m
Story1	Dead	Top	101.808	0	0	0	203.616	-254.52
Story1	Dead	Bottom	383.0189	0	0	0	766.0378	-957.5472
Story1	FF	Top	20	0	0	0	40	-50
Story1	FF	Bottom	77.6	0	0	0	155.2	-194
Story1	Live	Top	40	0	0	0	80	-100
Story1	Live	Bottom	155.2	0	0	0	310.4	-388

Table 1: Storey Forces

1.5 DESIGNING

- 1) Design → Concrete Frame design → Start design/Check.
- 2) Results are shown below as soon as the designing is complete. Fig 15 → Export all the files to excel. Table 2.

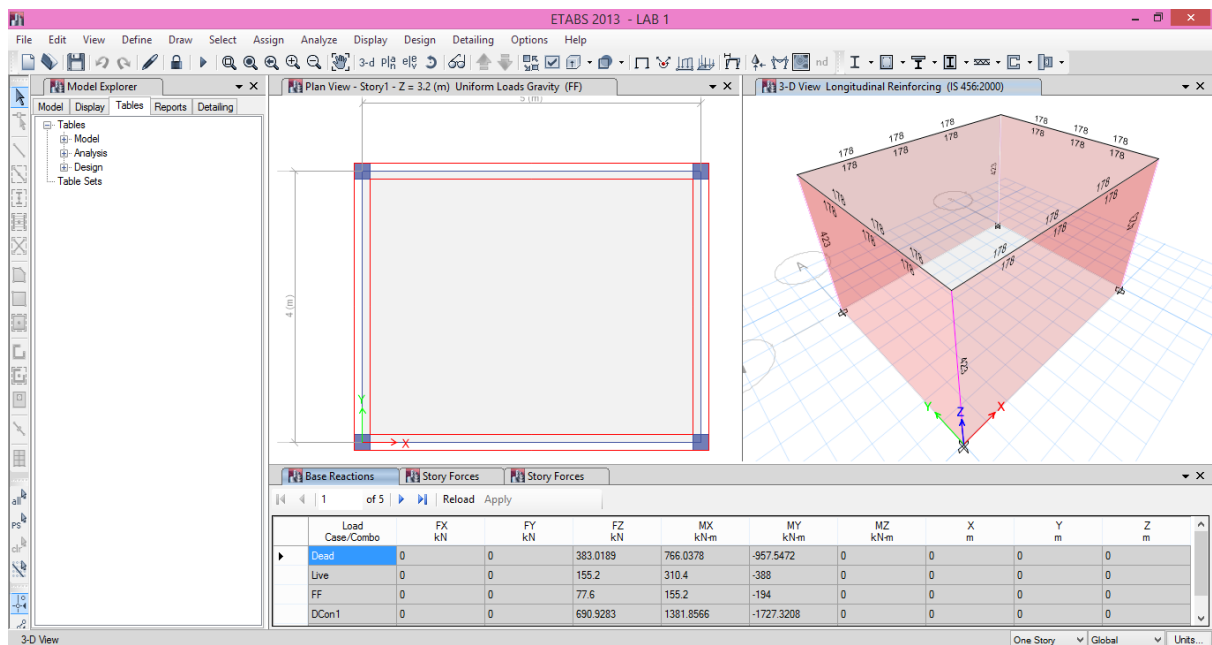


Fig 15

TABLE: Base Reactions									
Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kN	kN	kN	kN-m	kN-m	kN-m	m	m	m
Dead	0	0	383.0189	766.0378	-957.5472	0	0	0	0
Live	0	0	155.2	310.4	-388	0	0	0	0
FF	0	0	77.6	155.2	-194	0	0	0	0

Table 2: Base Reactions

3) Base reactions → Storey force are all shown in Table 3

TABLE: Story Forces									
Story	Load Case/Combo	Location	P	VX	VY	T	MX	MY	
			kN	kN	kN	kN-m	kN-m	kN-m	
Story1	DCon1	Top	182.712	0	0	0	365.424	-456.78	
Story1	DCon1	Bottom	690.9283	0	0	0	1381.8566	-1727.3208	
Story1	DCon2	Top	242.712	0	0	0	485.424	-606.78	
Story1	DCon2	Bottom	923.7283	0	0	0	1847.4566	-2309.3208	
Story1	Dead	Top	101.808	0	0	0	203.616	-254.52	
Story1	Dead	Bottom	383.0189	0	0	0	766.0378	-957.5472	
Story1	FF	Top	20	0	0	0	40	-50	
Story1	FF	Bottom	77.6	0	0	0	155.2	-194	
Story1	Live	Top	40	0	0	0	80	-100	
Story1	Live	Bottom	155.2	0	0	0	310.4	-388	

Table 3: Storey Forces

1.6 DETAILING

1) Detailing → Start detailing → All the necessary detailing is given in each of the tabs on the left hand side. Fig 16 & Fig 17

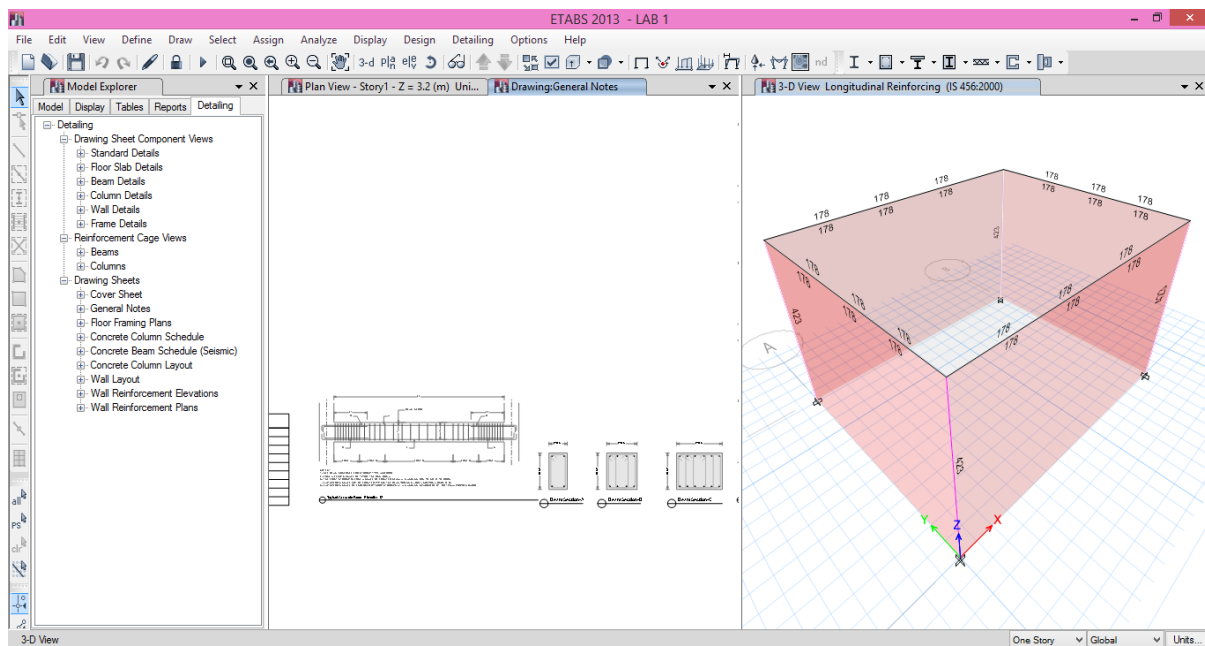


Fig 16

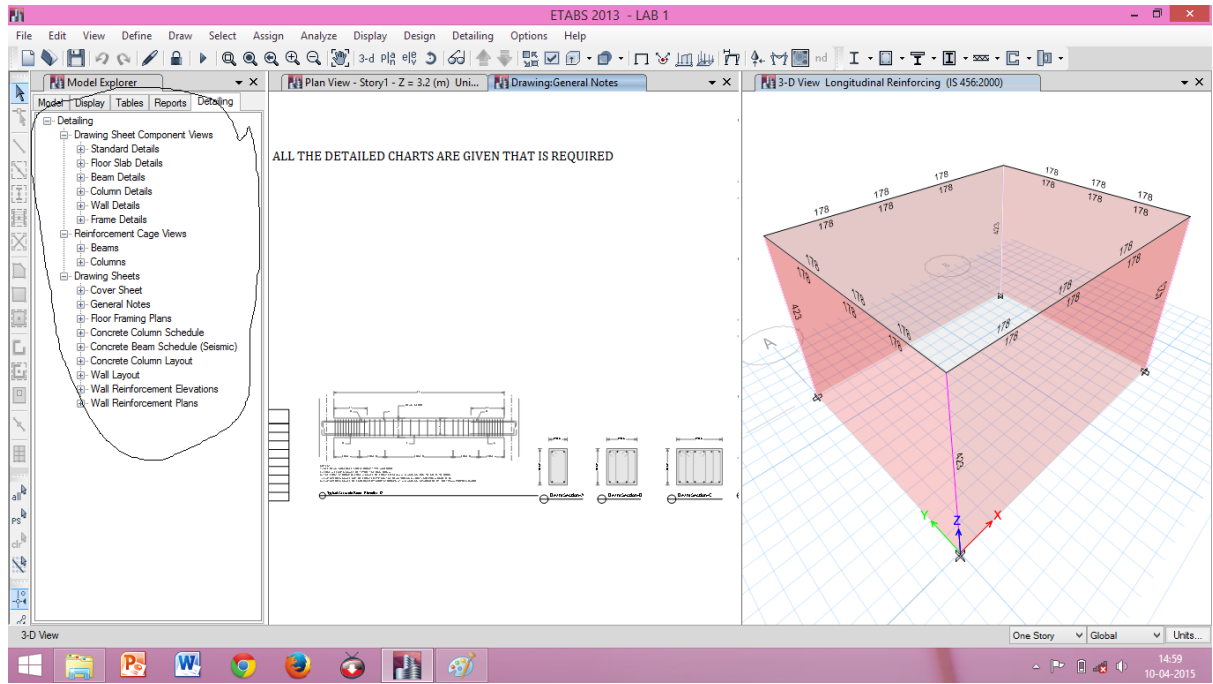
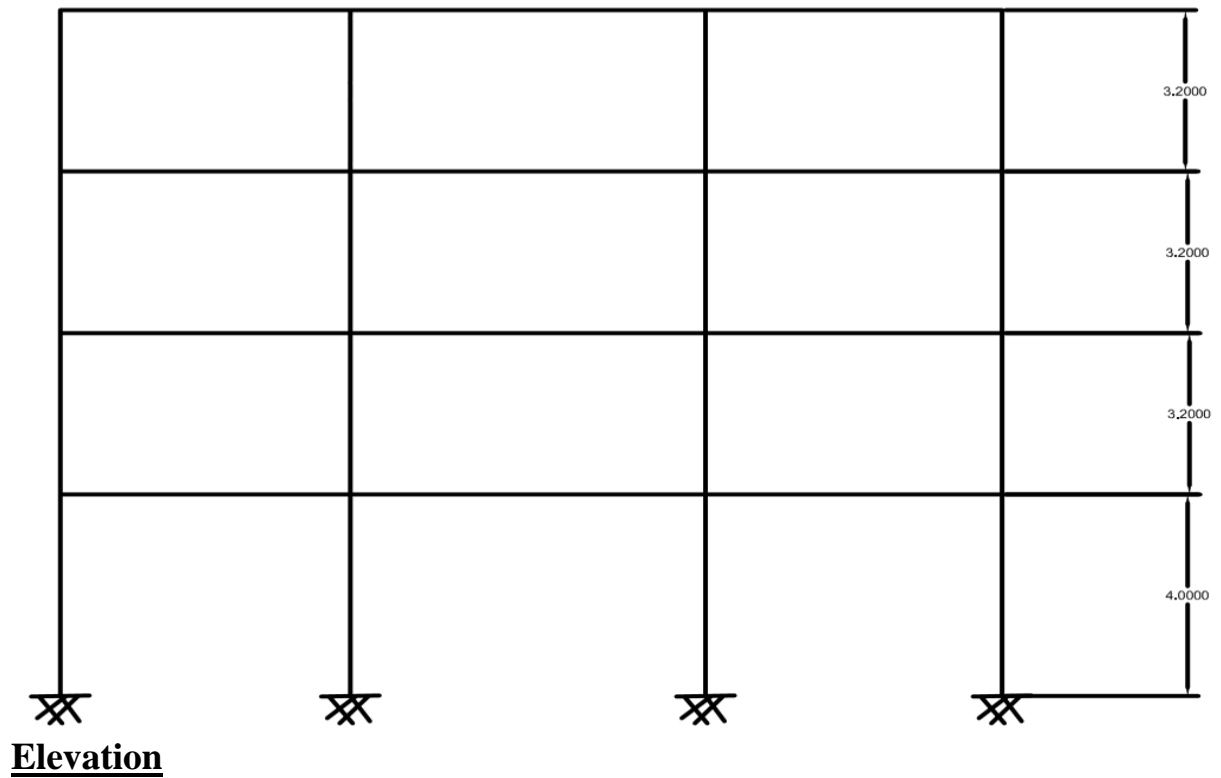
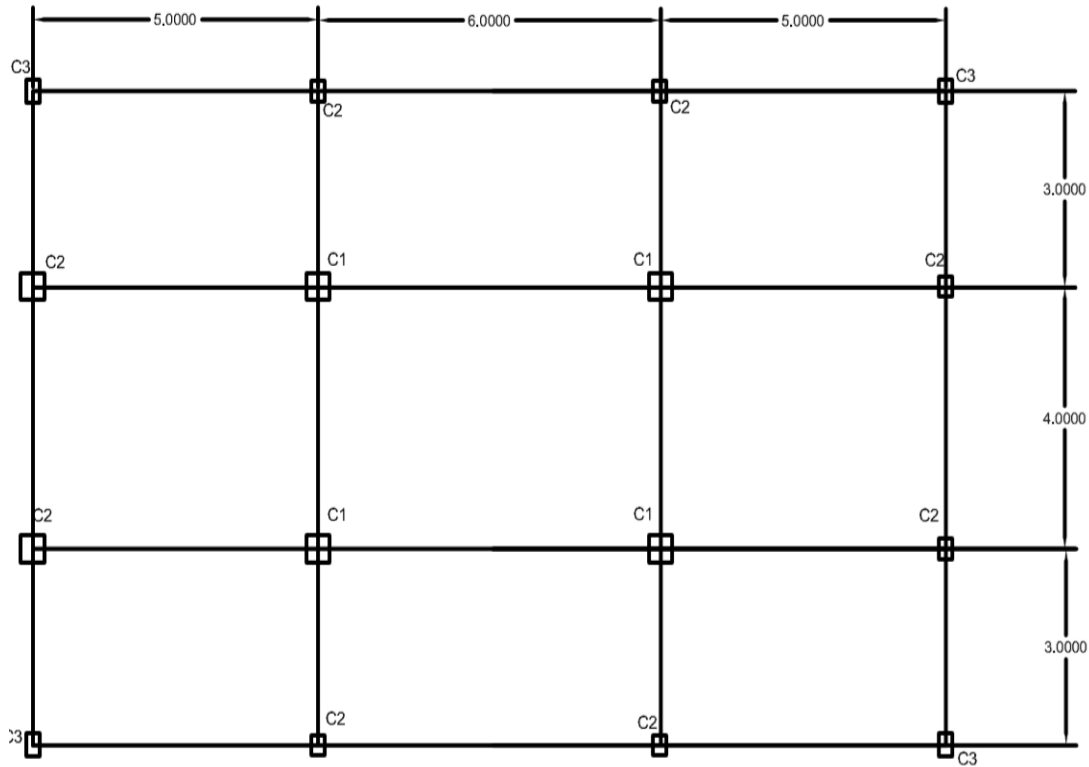


Fig 17

2. Example



Elevation



A plan of three story reinforced concrete (RC) frame structure is considered for modeling and analysis using ETABS.

Parameters

Beams

B1=230x350mm B2=230x300mm

Columns

C1=400x400mm C2=230x300mm C3=230x350mm

Slab= 150mm

Loads

live load =4 KN/m² floor finish=1.5 KN/m² wall load=13.11 KN/m²
concrete grade =M20 steel fe 415

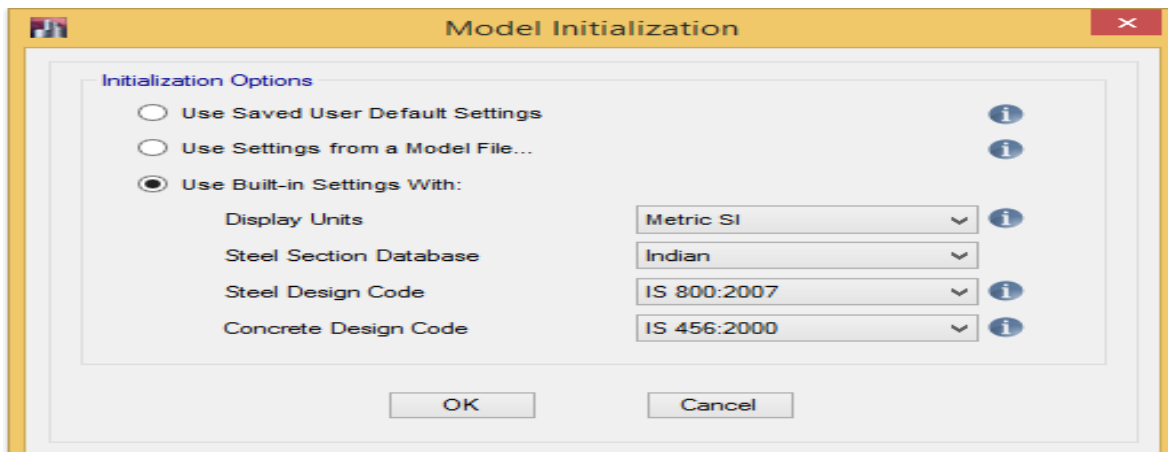
2.1 Modeling

1)file → new model → use built-in-settings with:

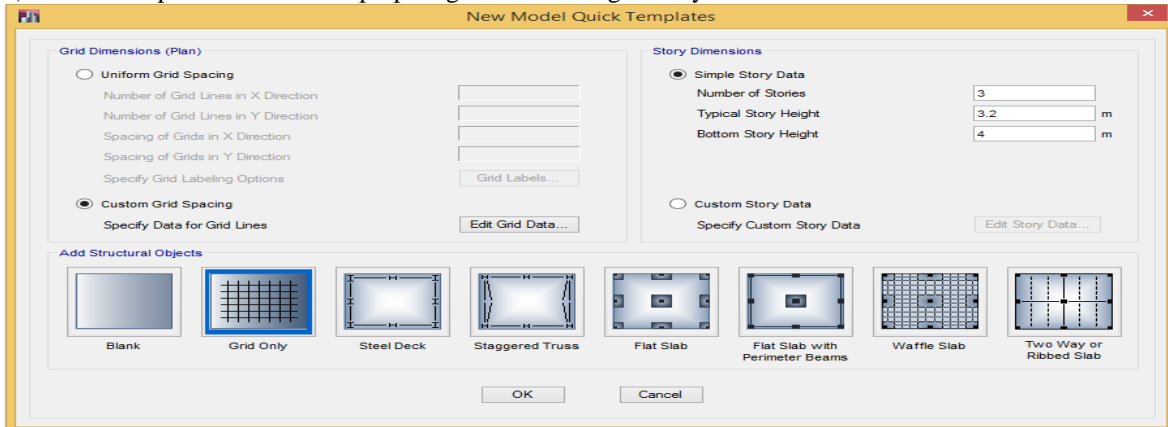
Display units: metric SI

Steel selection data base:indian

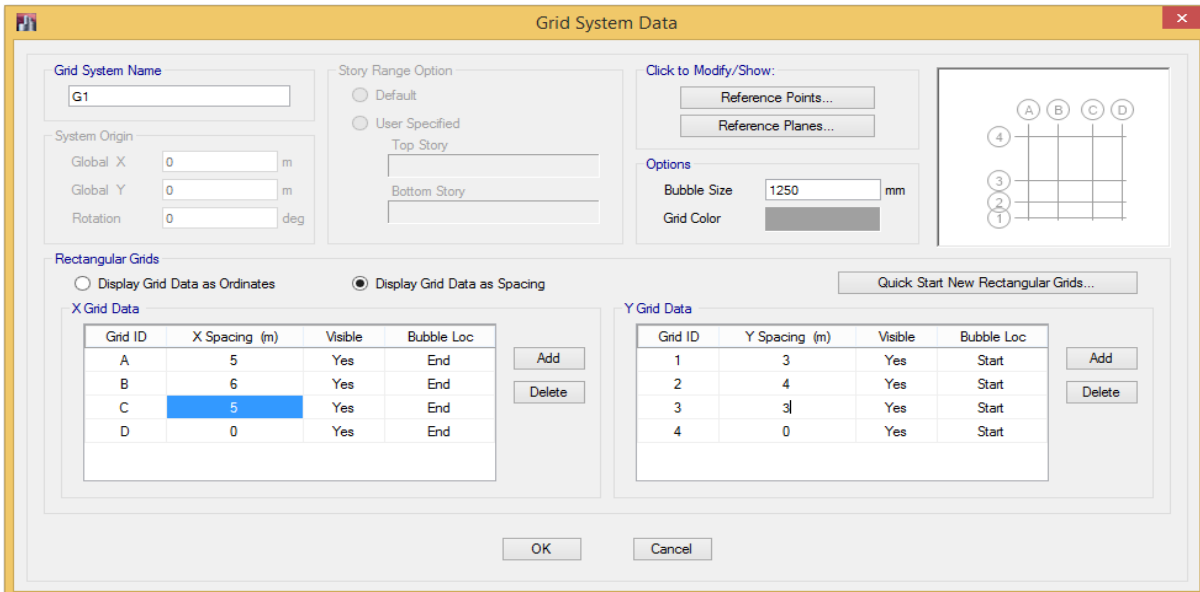
Concrete desing code:IS456:2000



2) For current plan and elevation prepare grid and select grid only



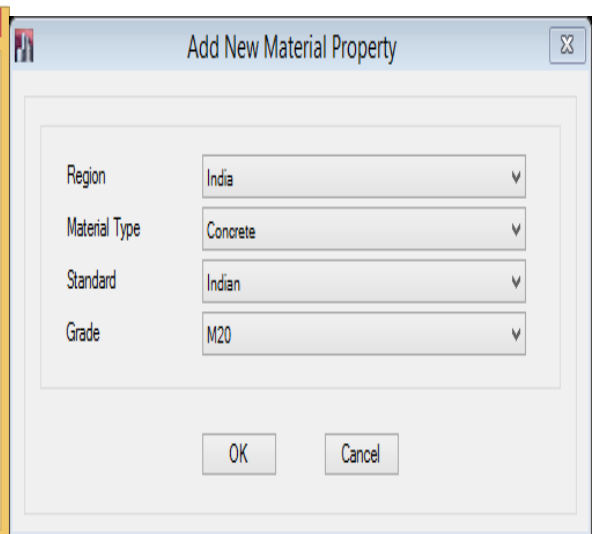
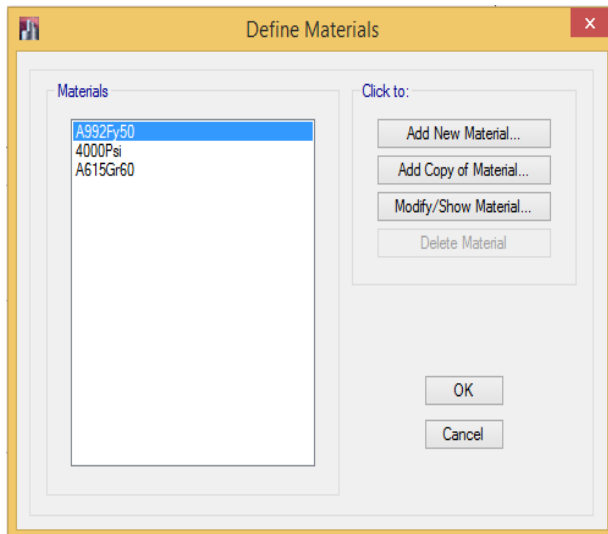
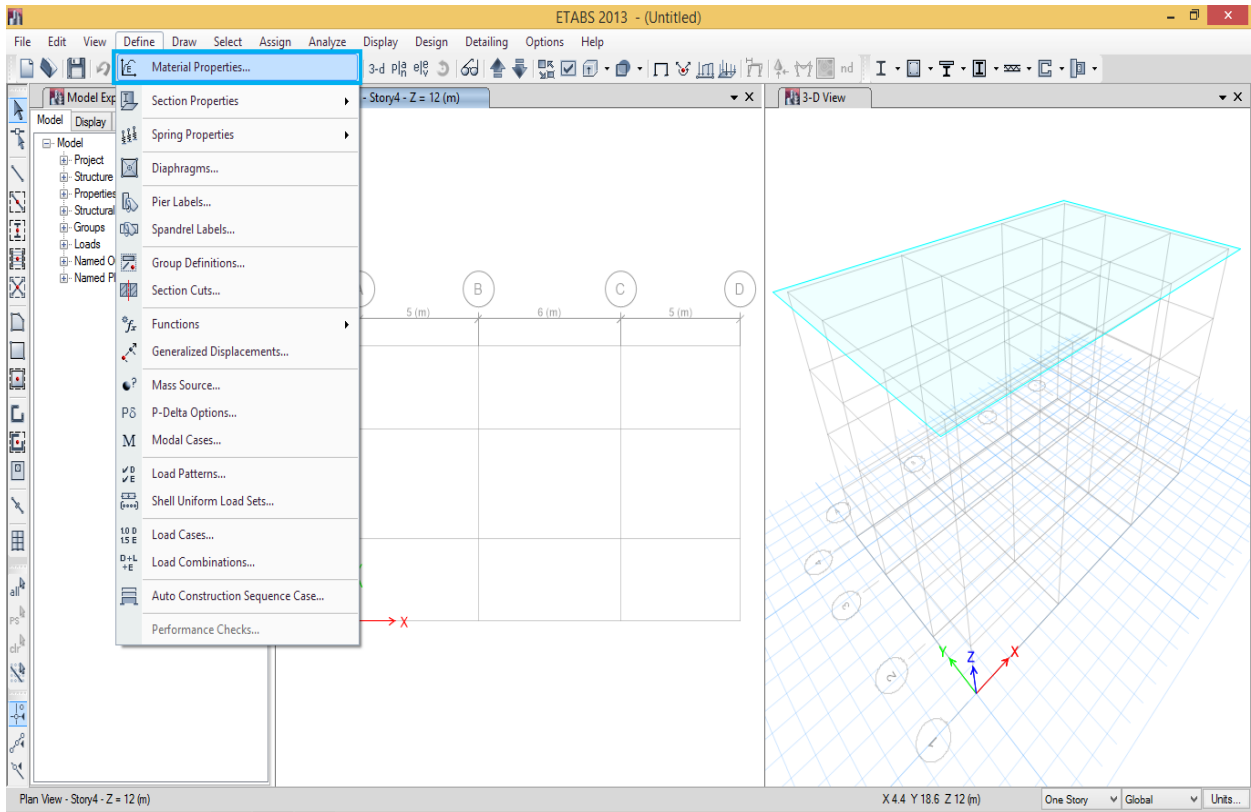
Set the grid line and spacing between two grid lines. Set the grid line spacing data using Edit grid Data command

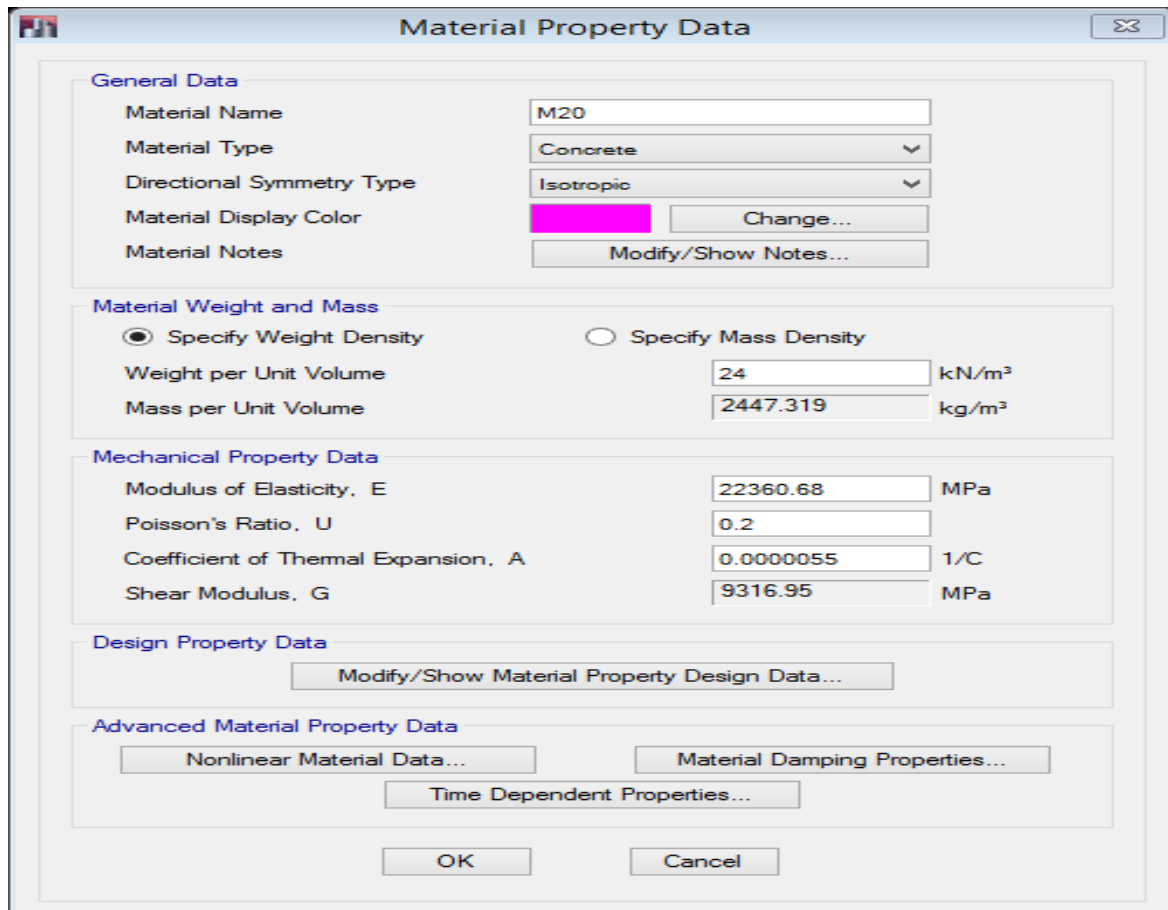


3) define → material property → add new material

a) for concrete

- i. Region :- India
- ii. Material type :-concrete
- iii. Standard :-India
- iv. Grade:-M20 → ok

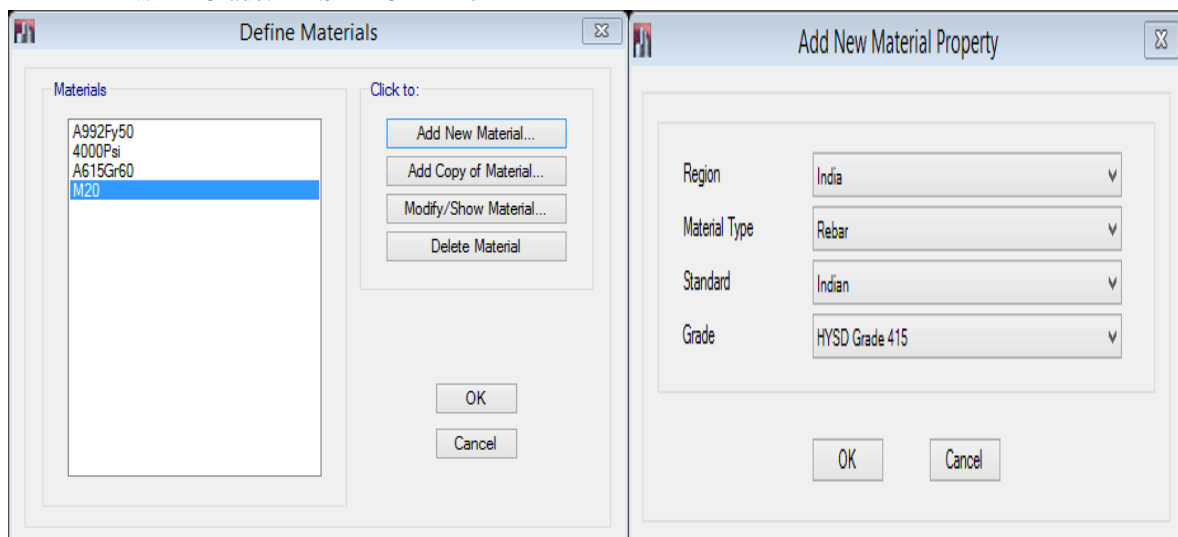




The image shows a 'Material Property Data' dialog box with the following sections and fields:

- General Data:**
 - Material Name: M20
 - Material Type: Concrete
 - Directional Symmetry Type: Isotropic
 - Material Display Color: (Color swatch) 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: 22360.68 MPa
 - Poisson's Ratio, U: 0.2
 - Coefficient of Thermal Expansion, A: 0.0000055 1/C
 - Shear Modulus, G: 9316.95 MPa
- Design Property Data:**
 - Modify/Show Material Property Design Data...
- Advanced Material Property Data:**
 - Nonlinear Material Data...
 - Material Damping Properties...
 - Time Dependent Properties...
- Buttons: OK, Cancel

- b) For rebar
- Region :-India
 - Material type:-rebar
 - Standard:-Indian
 - Grade:-HYSD 415 → ok



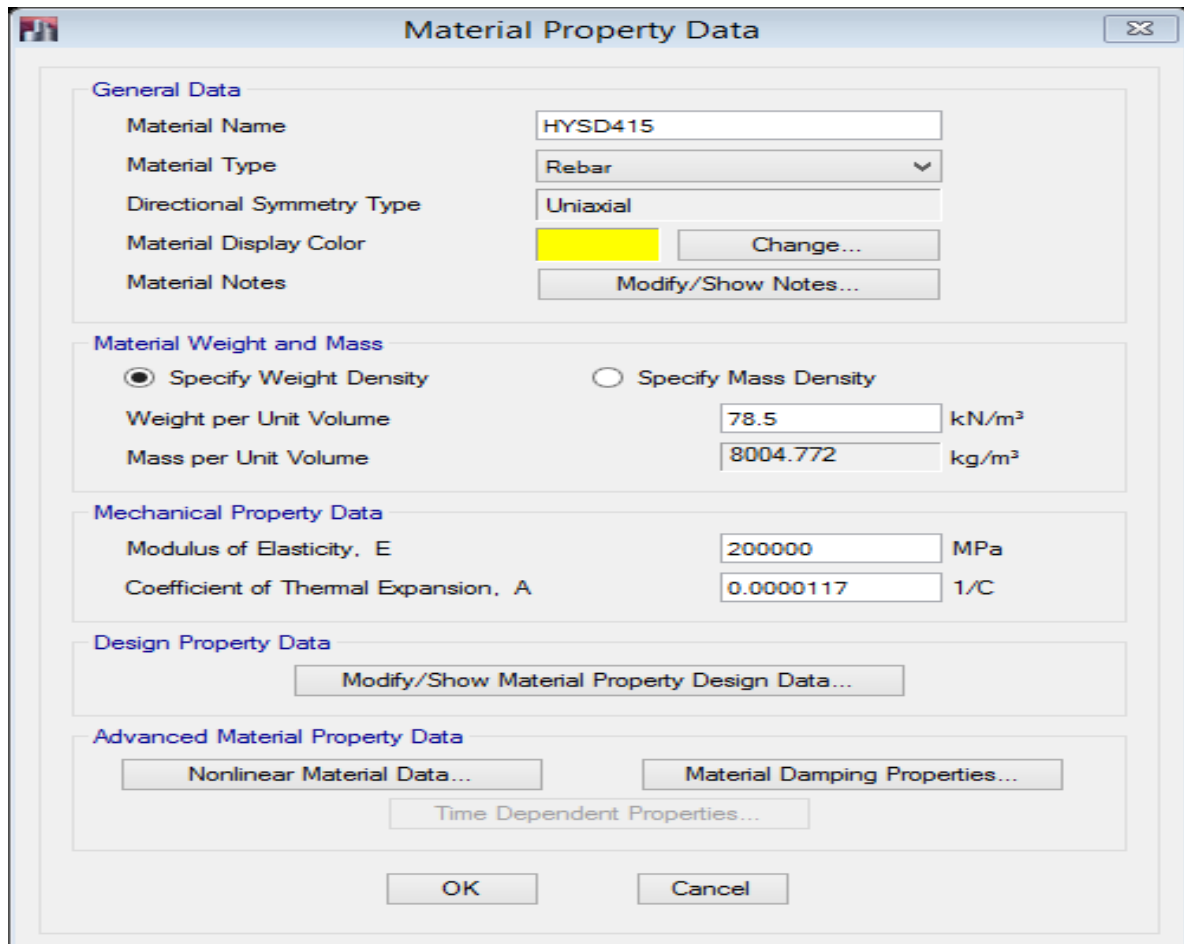
The image shows two dialog boxes side-by-side:

Define Materials:

- Materials list: A992Fy50, 4000Psi, A615Gr60, M20 (selected)
- Click to:
 - Add New Material...
 - Add Copy of Material...
 - Modify/Show Material...
 - Delete Material
- Buttons: OK, Cancel

Add New Material Property:

- Region: India
- Material Type: Rebar
- Standard: Indian
- Grade: HYSD Grade 415
- Buttons: OK, Cancel



The image shows a 'Material Property Data' dialog box with the following sections and fields:

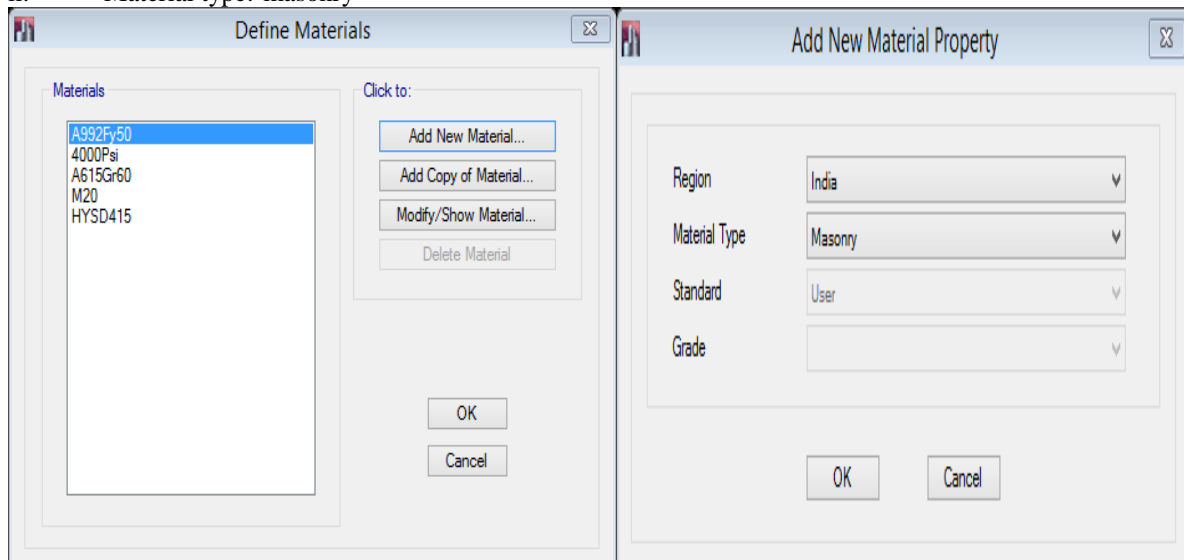
- General Data:**
 - Material Name: HYSD415
 - Material Type: Rebar
 - Directional Symmetry Type: Uniaxial
 - Material Display Color: Yellow (with 'Change...' button)
 - Material Notes: (with 'Modify/Show Notes...' button)
- Material Weight and Mass:**
 - Specify Weight Density Specify Mass Density
 - 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: 0.0000117 1/C
- Design Property Data:**
 - (with 'Modify/Show Material Property Design Data...' button)
- Advanced Material Property Data:**
 - (with 'Nonlinear Material Data...', 'Material Damping Properties...', and 'Time Dependent Properties...' buttons)

Buttons at the bottom: OK, Cancel.

c) for masonry

i. Region :-India

ii. Material type:-masonry



The image shows two dialog boxes side-by-side:

Define Materials:

- Materials list: A992Fy50, 4000Psi, A615Gr60, M20, HYSD415
- Click to: Add New Material..., Add Copy of Material..., Modify/Show Material..., Delete Material
- Buttons: OK, Cancel

Add New Material Property:

- Region: India
- Material Type: Masonry
- Standard: User
- Grade: (empty)
- Buttons: OK, Cancel

Material Property Data

General Data

Material Name: Masonry

Material Type: Masonry

Directional Symmetry Type: Isotropic

Material Display Color: [Red] Change...

Material Notes: Modify/Show Notes...

Material Weight and Mass

Specify Weight Density Specify Mass Density

Weight per Unit Volume: 21.2068 kN/m³

Mass per Unit Volume: 2162.493 kg/m³

Mechanical Property Data

Modulus of Elasticity, E: 3600000 MPa

Poisson's Ratio, U: 0.15

Coefficient of Thermal Expansion, A: 0.0000081 1/C

Shear Modulus, G: 1565217.39 MPa

Design Property Data

Modify/Show Material Property Design Data...

Advanced Material Property Data

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

OK Cancel

4) Define → Section properties → Frame sections → Add new property

a) Column details

i) Section shape → Concrete Rectangular

ii) shape type → concrete → ok

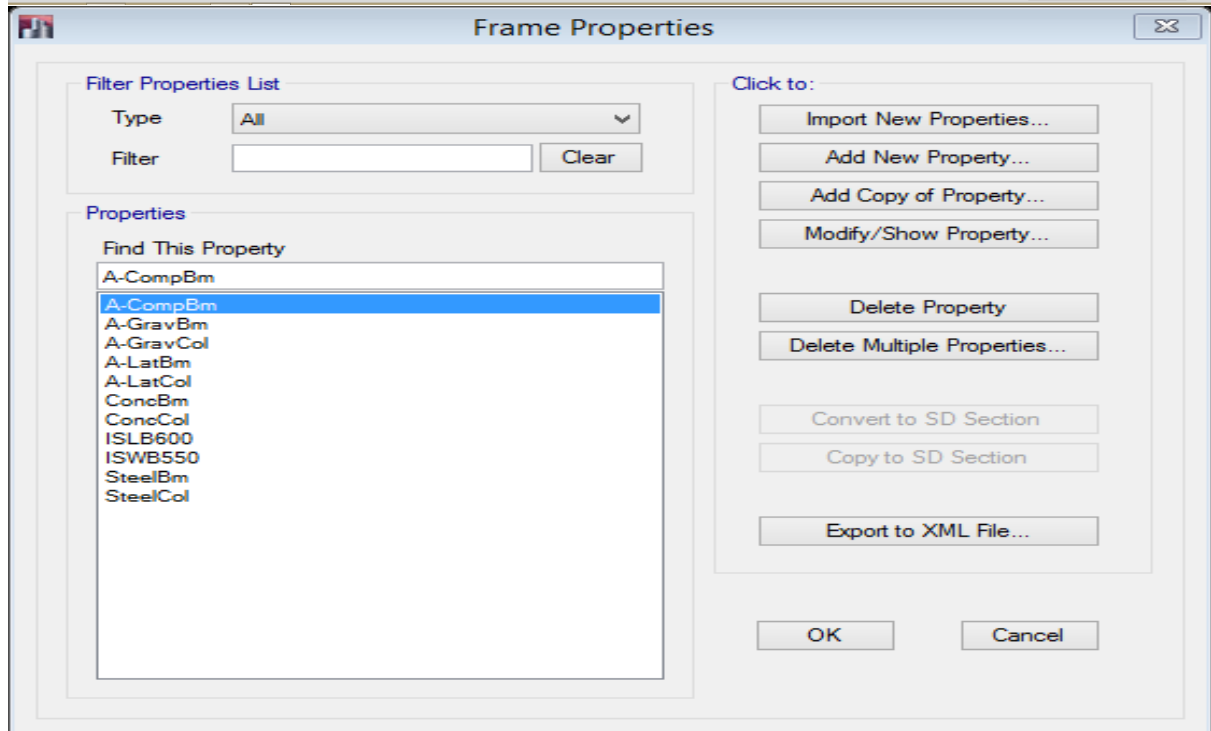
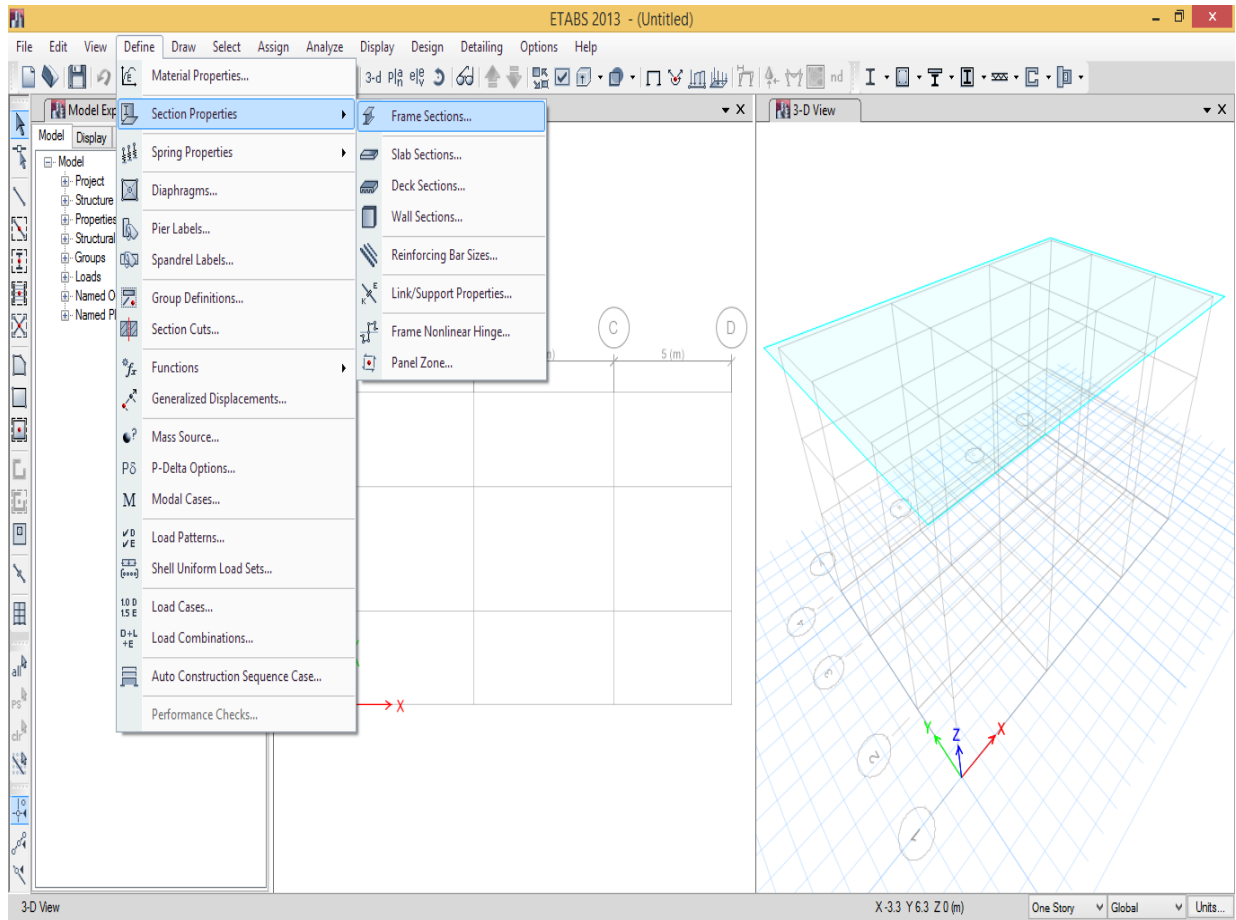
iii) General data → Property name: C400x400
Material: M20

iv) Section dimensions → Depth:400 mm; Width: 400mm

v) Reinforcement → Modify/ Show Rebar

vi) Design Type: P-M2-M3 design (column)

vii) Rebar material → Longitudinal bar: HYSD 415 ; Confinement bar: HYSD 415



Frame Property Shape Type

Shape Type
Section Shape: Concrete Rectangular

Frequently Used Shape Types

Concrete

Steel

Special

Steel Composite

OK Cancel

Frame Section Property Data

General Data

Property Name: C400X400
Material: M20
Display Color: Change...
Notes: Modify/Show Notes...

Shape

Section Shape: Concrete Rectangular

Section Property Source

Source: User Defined

Section Dimensions

Depth: 400 mm
Width: 400 mm

Property Modifiers

Modify/Show Modifiers...
Currently Default

Reinforcement

Modify/Show Rebar...

OK Cancel

Show Section Properties...

Frame Section Property Reinforcement Data

Design Type

P-M2-M3 Design (Column)
 M3 Design Only (Beam)

Rebar Material

Longitudinal Bars: HYSD415
Confinement Bars (Ties): HYSD415

Reinforcement Configuration

Rectangular
 Circular

Confinement Bars

Ties
 Spirals

Check/Design

Reinforcement to be Checked
 Reinforcement to be Designed

Longitudinal Bars

Clear Cover for Confinement Bars: 40 mm
Number of Longitudinal Bars Along 3-dir Face: 3
Number of Longitudinal Bars Along 2-dir Face: 5
Longitudinal Bar Size and Area: 20 3.1 cm²
Corner Bar Size and Area: 20 3.1 cm²

Confinement Bars

Confinement Bar Size and Area: 10 0.8 cm²
Longitudinal Spacing of Confinement Bars (Along 1-Axis): 150 mm
Number of Confinement Bars in 3-dir: 3
Number of Confinement Bars in 2-dir: 3

OK Cancel

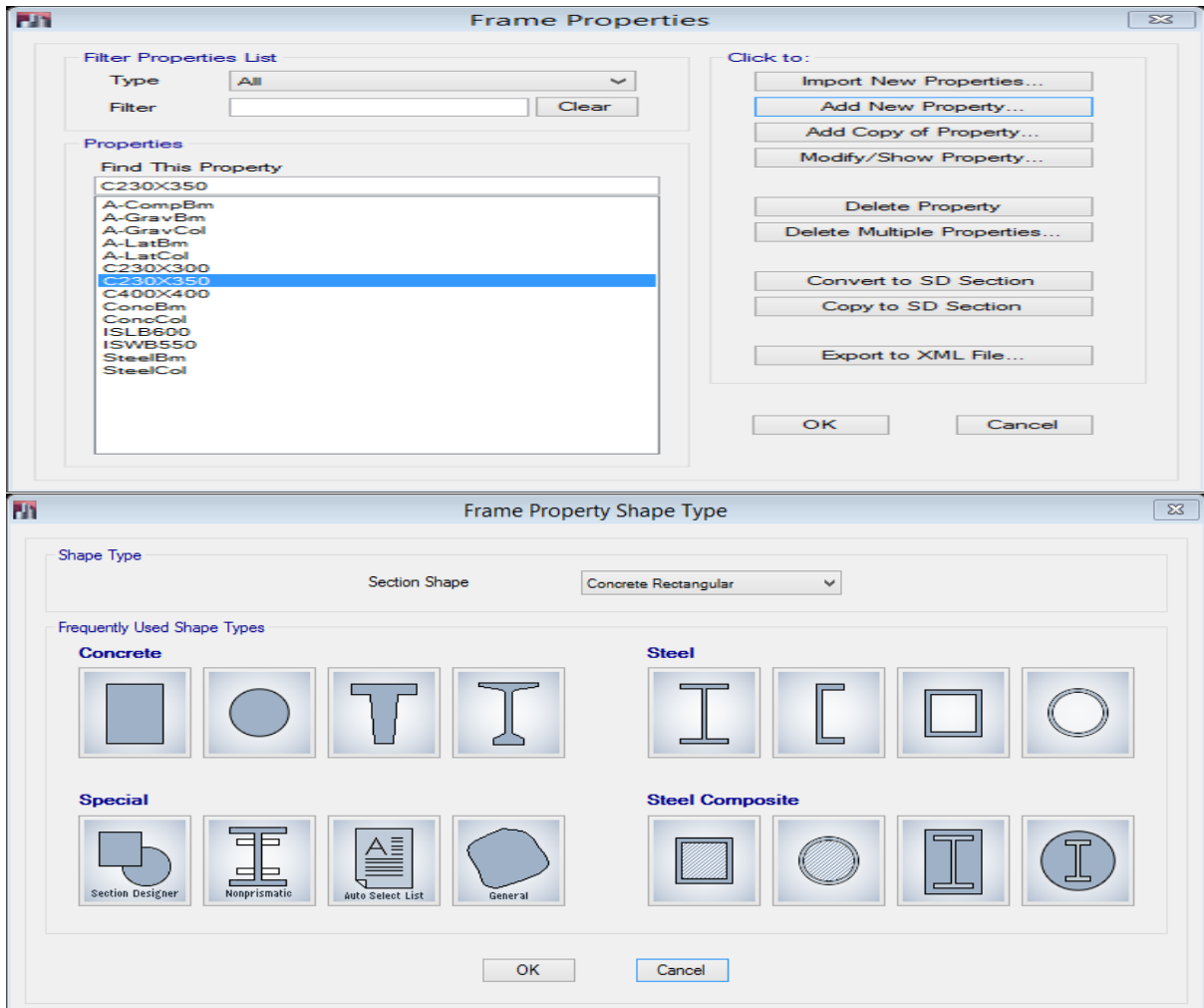
Similarly C2 and C3 is defined

b) Beam details

i) Section shape → Concrete Rectangular

ii) shape type → concrete

- iii) General data → Property Name: Beam230x350
Material: M20
- iv) Section dimensions → Depth=350mm; Width=230mm
- v) Reinforcement → Modify/ Show Rebar
- vi) Design Type: M3 design only (Beam)
- vii) Rebar material → Longitudinal bar: HYSD 415 ; Confinement bar: HYSD 415



The image shows two screenshots of software dialog boxes. The top dialog is titled "Frame Section Property Data" and contains the following fields and options:

- General Data:** Property Name (B230X350), Material (M20), Display Color (blue), Notes (Modify/Show Notes...).
- Shape:** Section Shape (Concrete Rectangular).
- Section Property Source:** Source: User Defined.
- Section Dimensions:** Depth (350 mm), Width (230 mm).
- Property Modifiers:** Modify/Show Modifiers... (Currently Default).
- Reinforcement:** Modify/Show Rebar....
- Buttons: OK, Cancel, Show Section Properties...

The bottom dialog is titled "Frame Section Property Reinforcement Data" and contains the following fields and options:

- Design Type:** P-M2-M3 Design (Column) (unselected), M3 Design Only (Beam) (selected).
- Rebar Material:** Longitudinal Bars (HYSD415), Confinement Bars (Ties) (HYSD415).
- Cover to Longitudinal Rebar Group Centroid:** Top Bars (60 mm), Bottom Bars (60 mm).
- Reinforcement Area Overwrites for Ductile Beams:** Top Bars at I-End (0 cm²), Top Bars at J-End (0 cm²), Bottom Bars at I-End (0 cm²), Bottom Bars at J-End (0 cm²).
- Buttons: OK, Cancel.

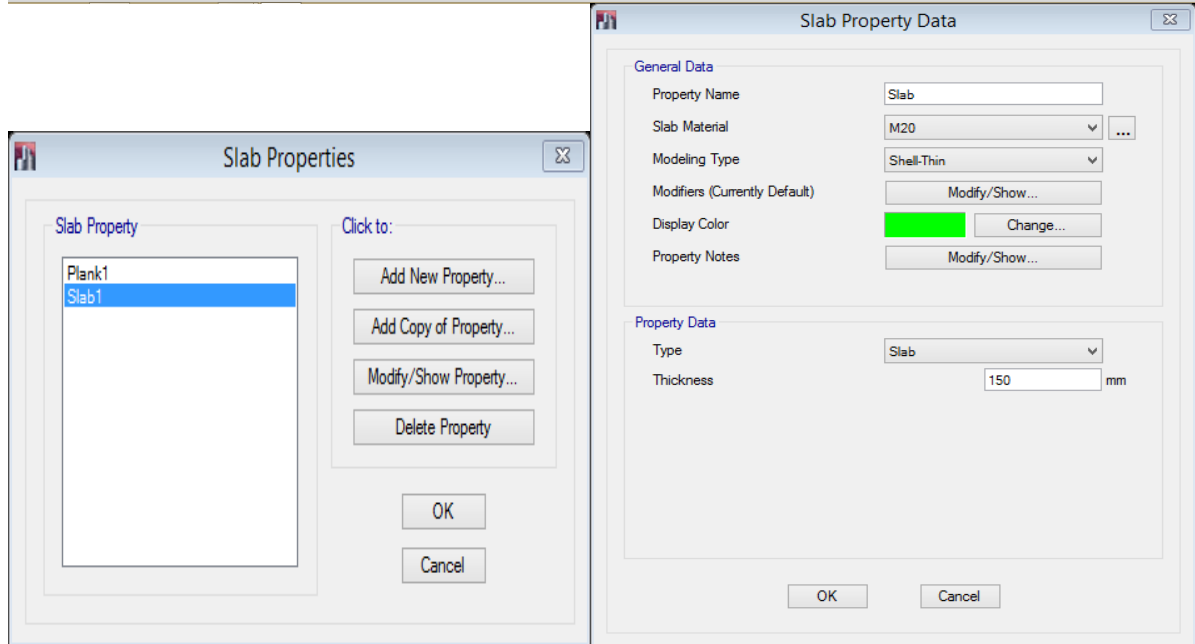
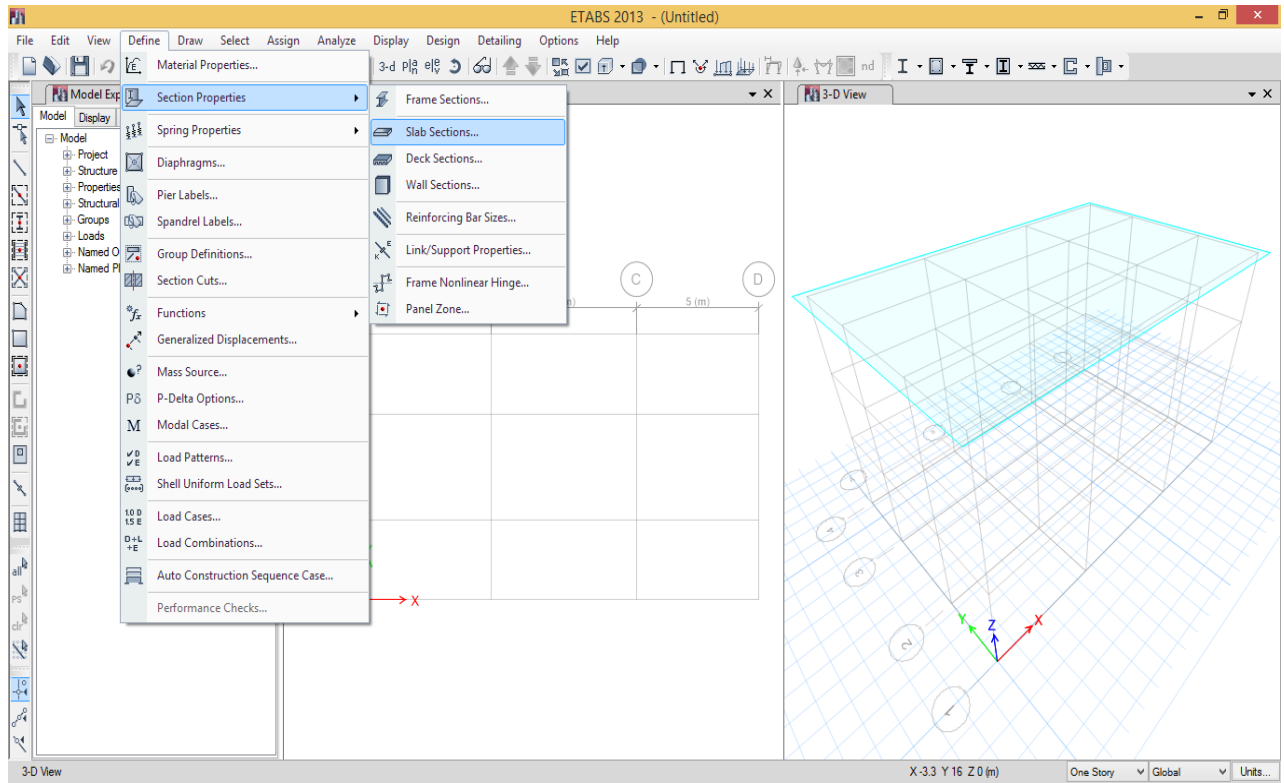
Similarly B2=230x300mm is defined

c) Slab details:

i) Define → Section properties → Slab section → Add new property

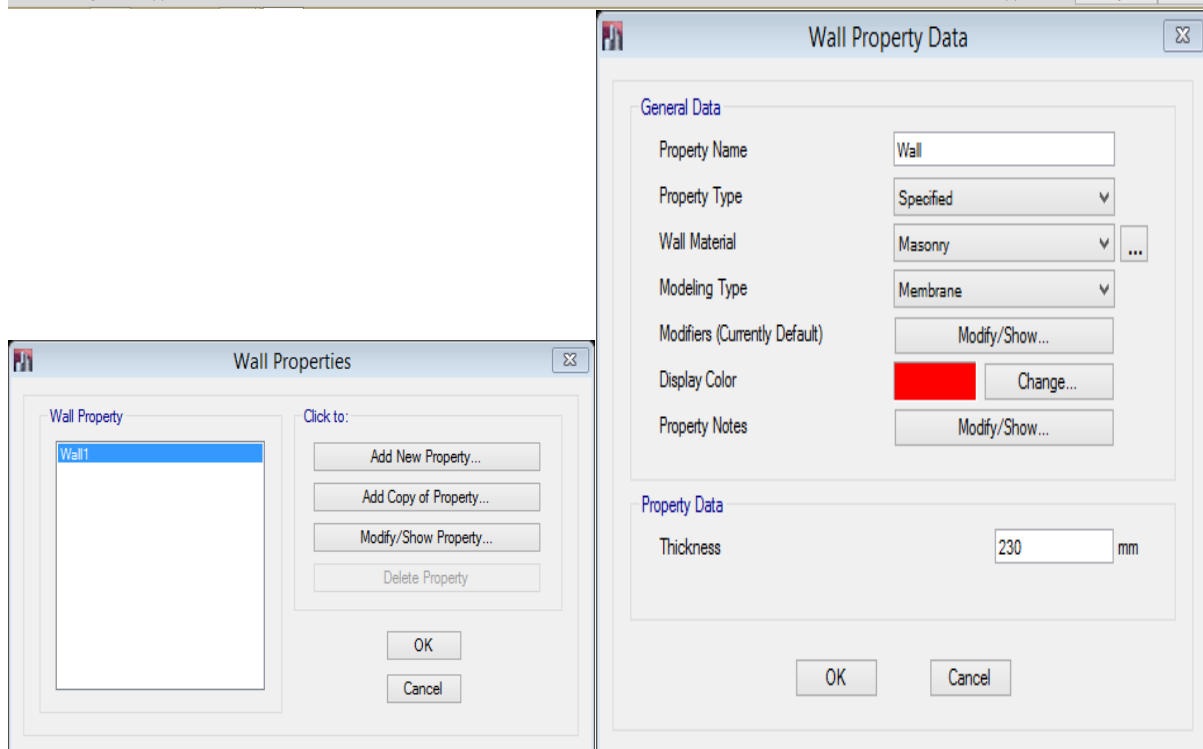
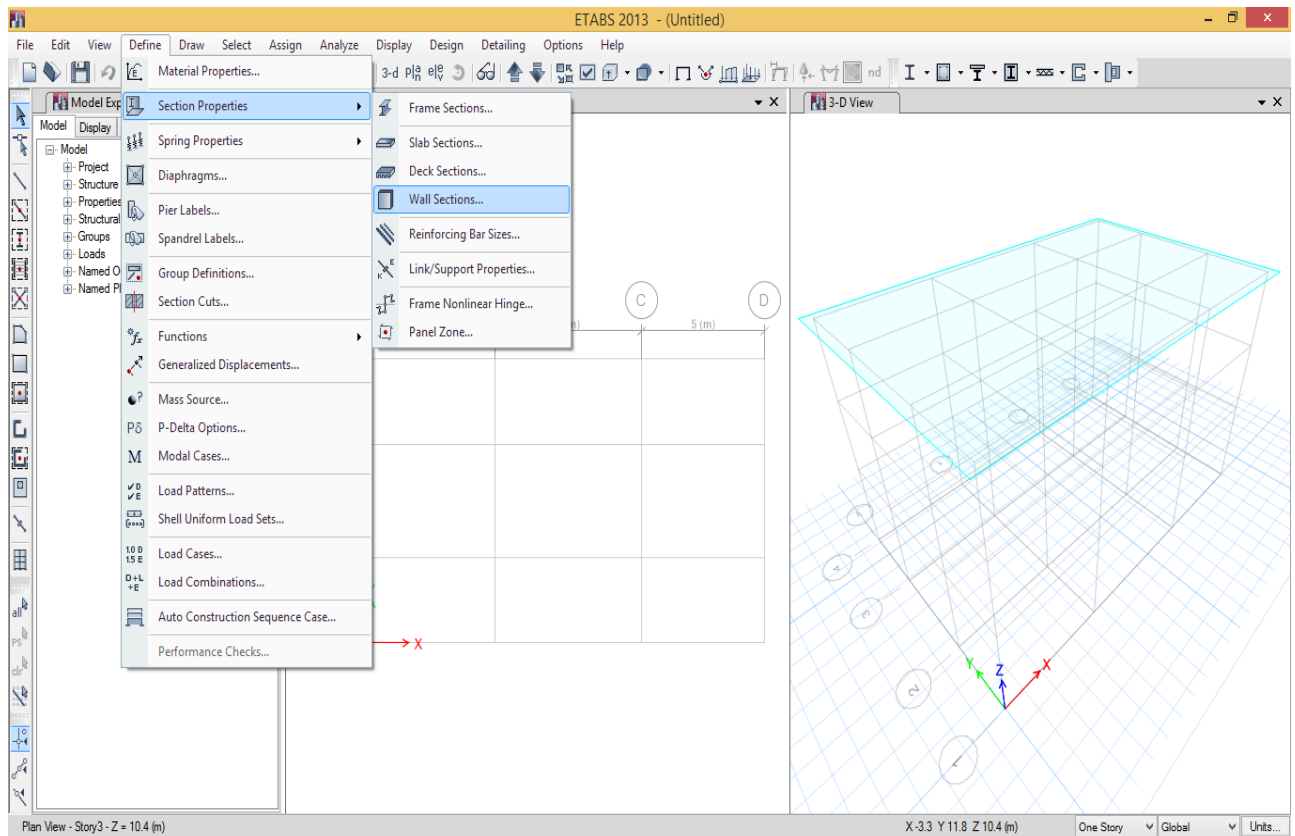
ii) General data → Property name: Slab
Slab material: M20

iii) Property data → Thickness=150 mm



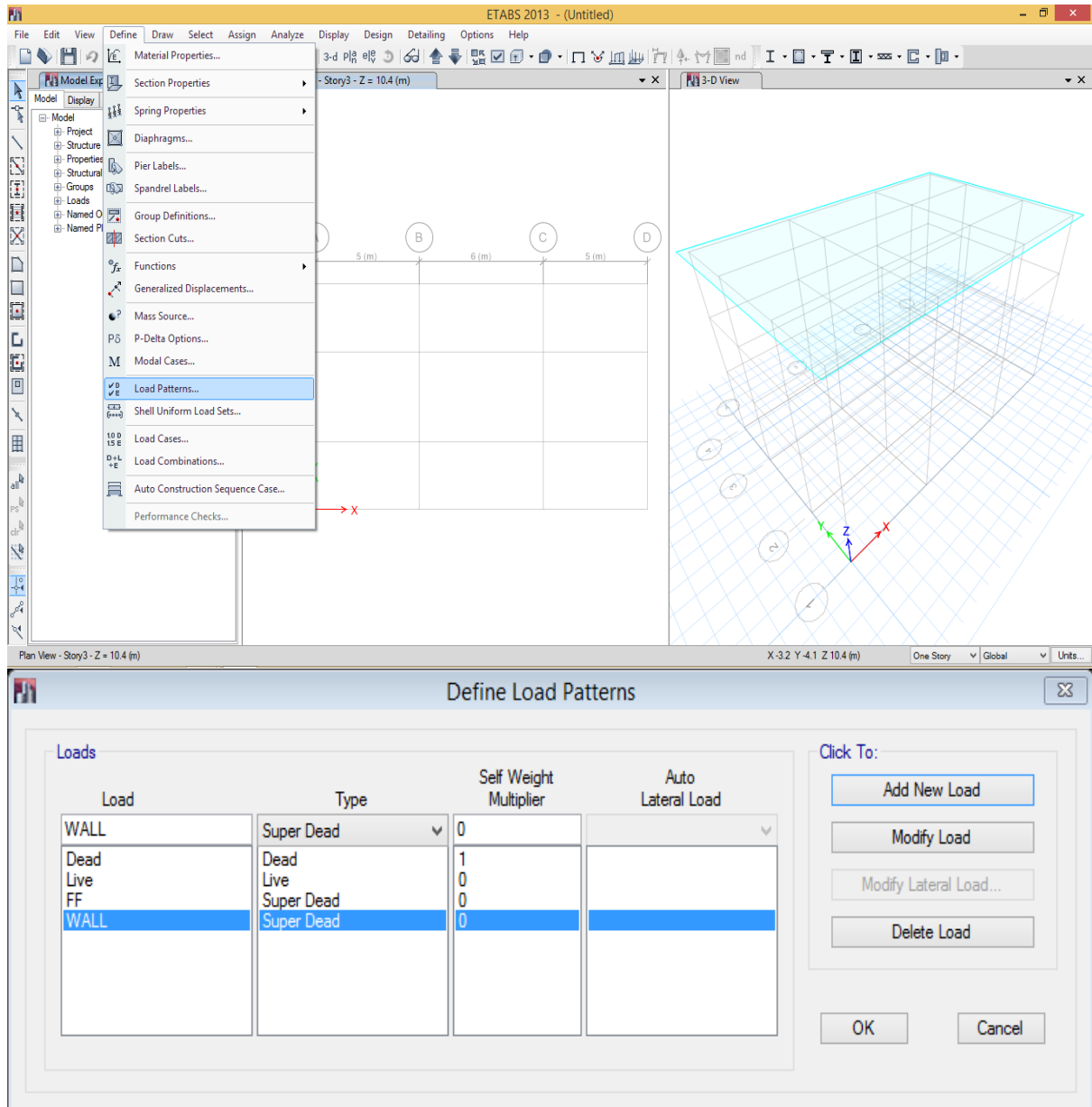
c) wall details:

- i) Define → Section properties → wall section → Add new property
- ii) General data → Property name: wall
Slab material: masonry
- iii) Property data → member → thickness=230mm



2.2) Loads

- i) Define → Load patterns
 - ii) Load → Floor finish
 - iii) Type → Super dead
 - iv) Self-weight multiplier → 0 → Add new load → OK
- similarly define the wall load also

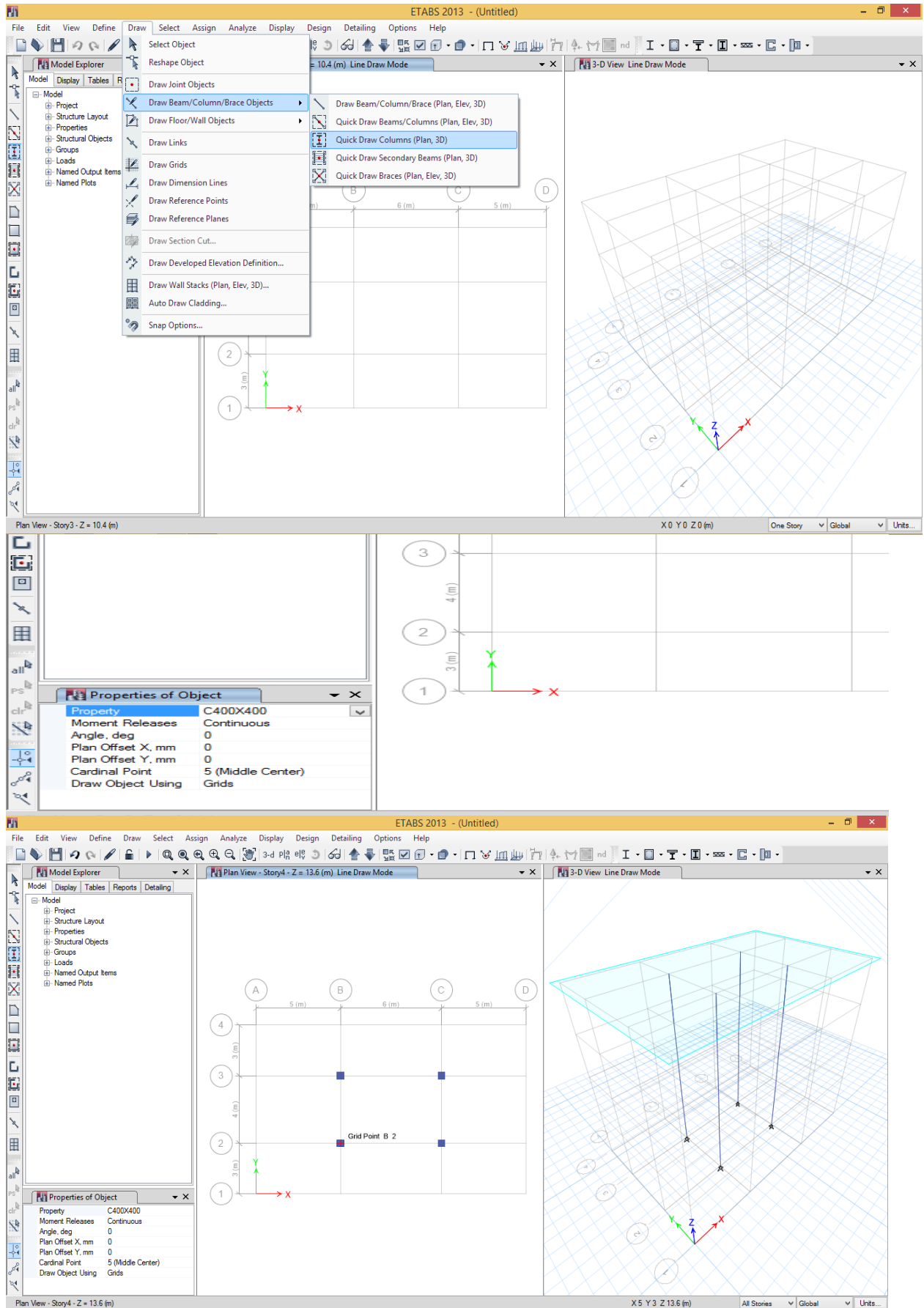


5) After all the defining of material, cross sections and load, allotment of these to the structure has to be done.

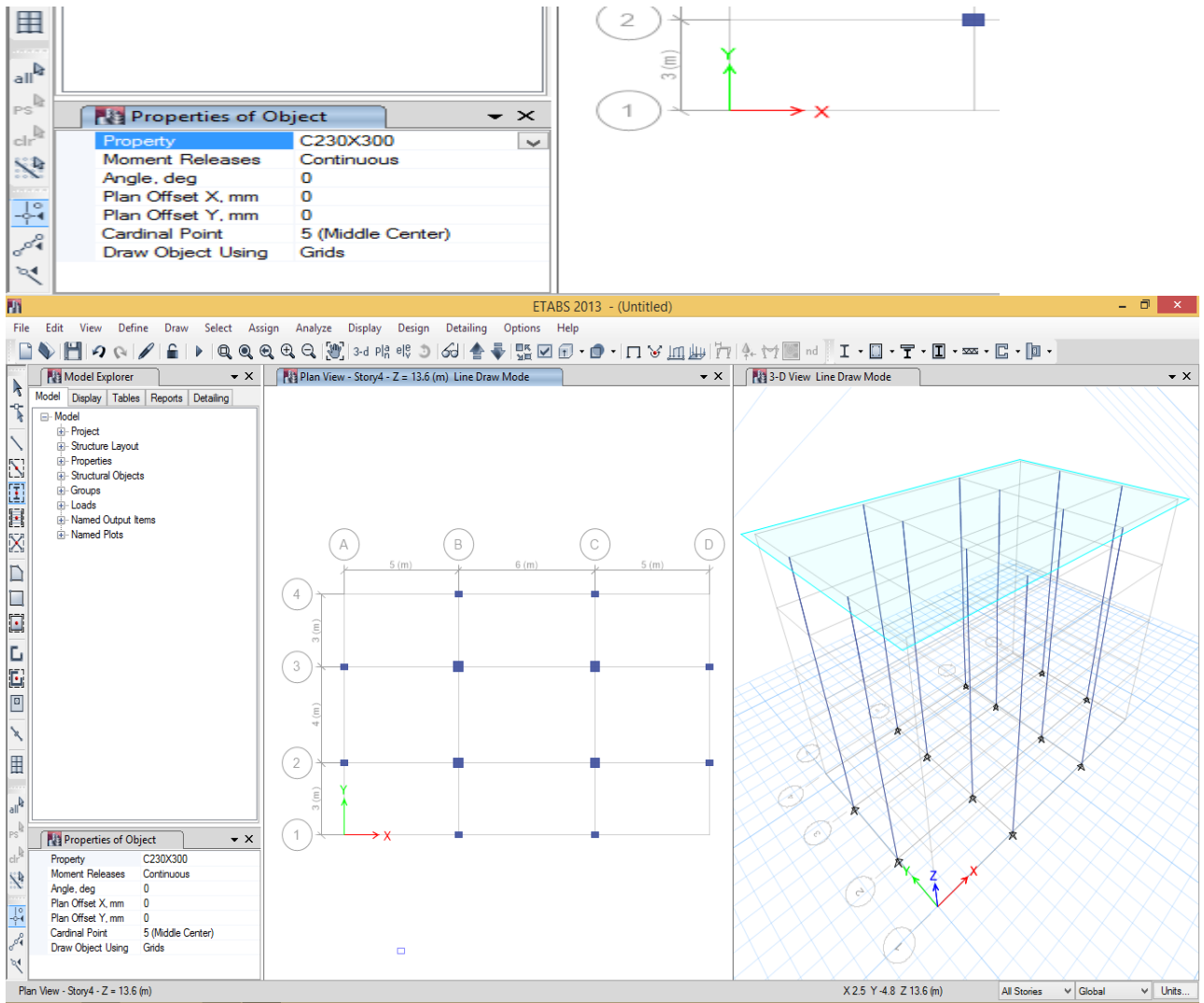
6) Draw the all columns and beams as for fig shows

Draw → Draw Beam/Column/Brace object → Quick draw column

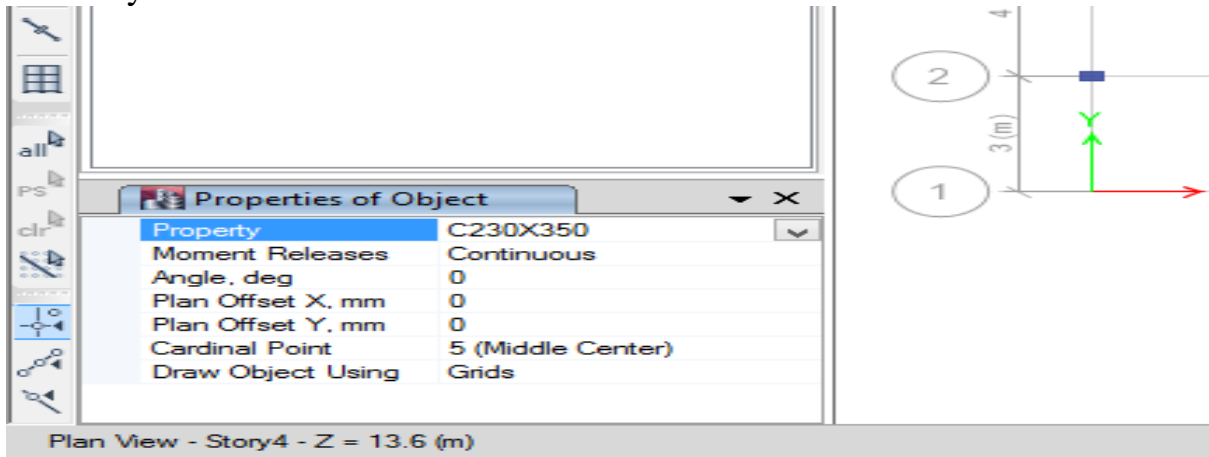
Draw the C400x400 columns at corner of the grid plan

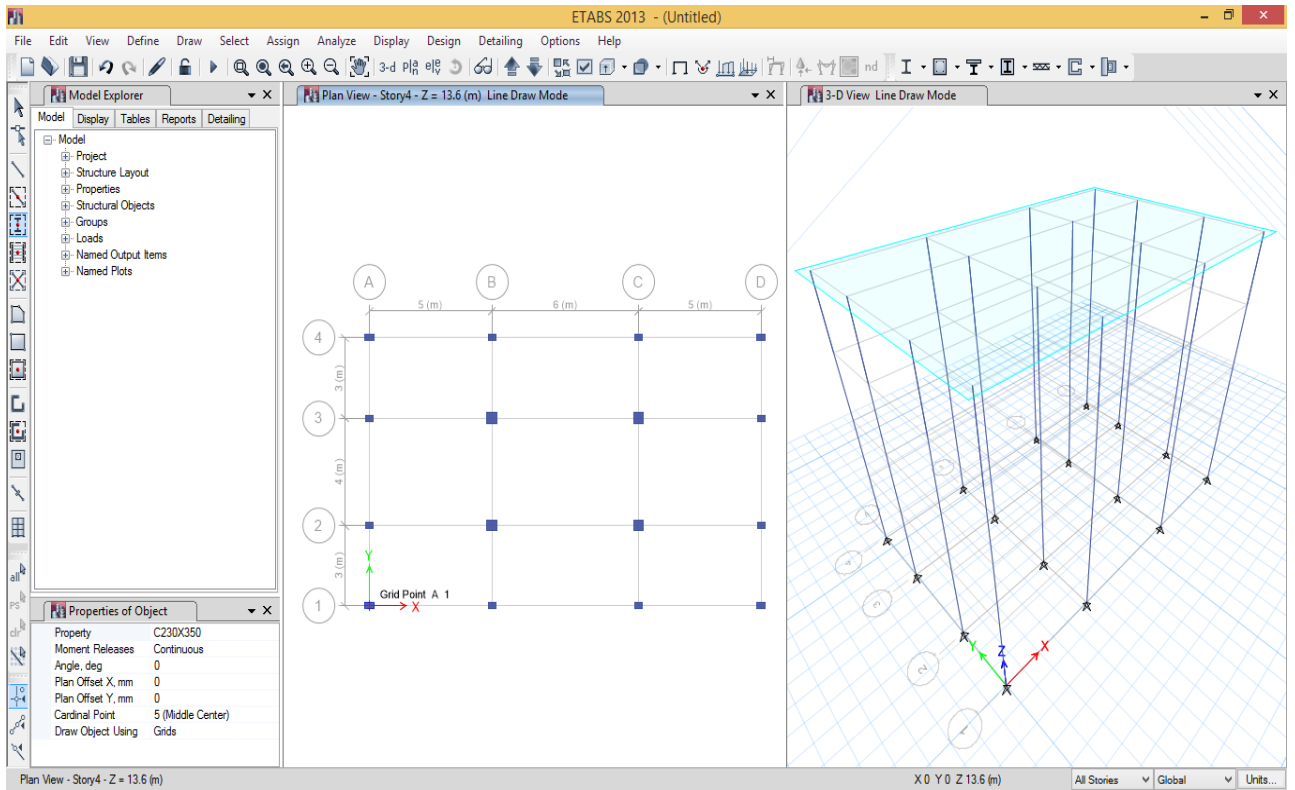


Select the property columns as C230X300 to draw

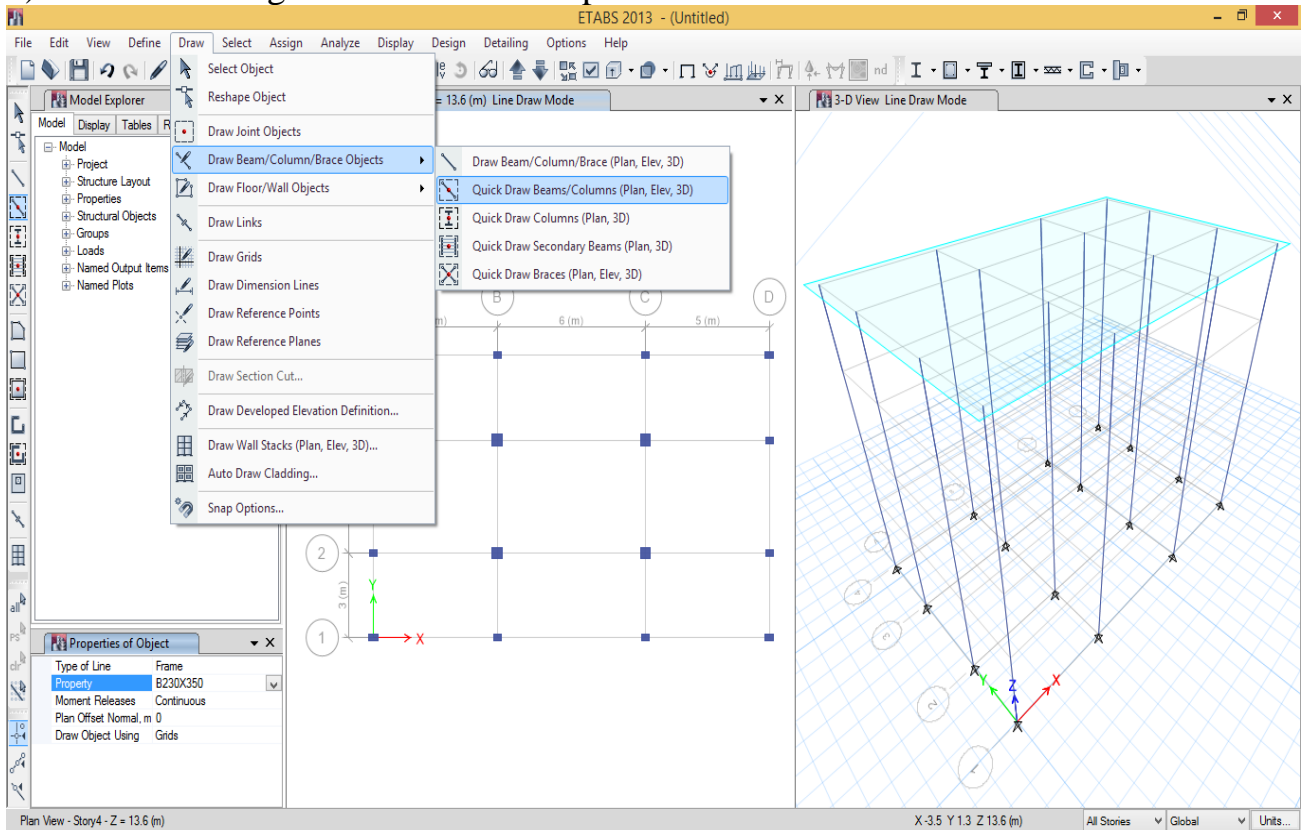


Similarly C230x350





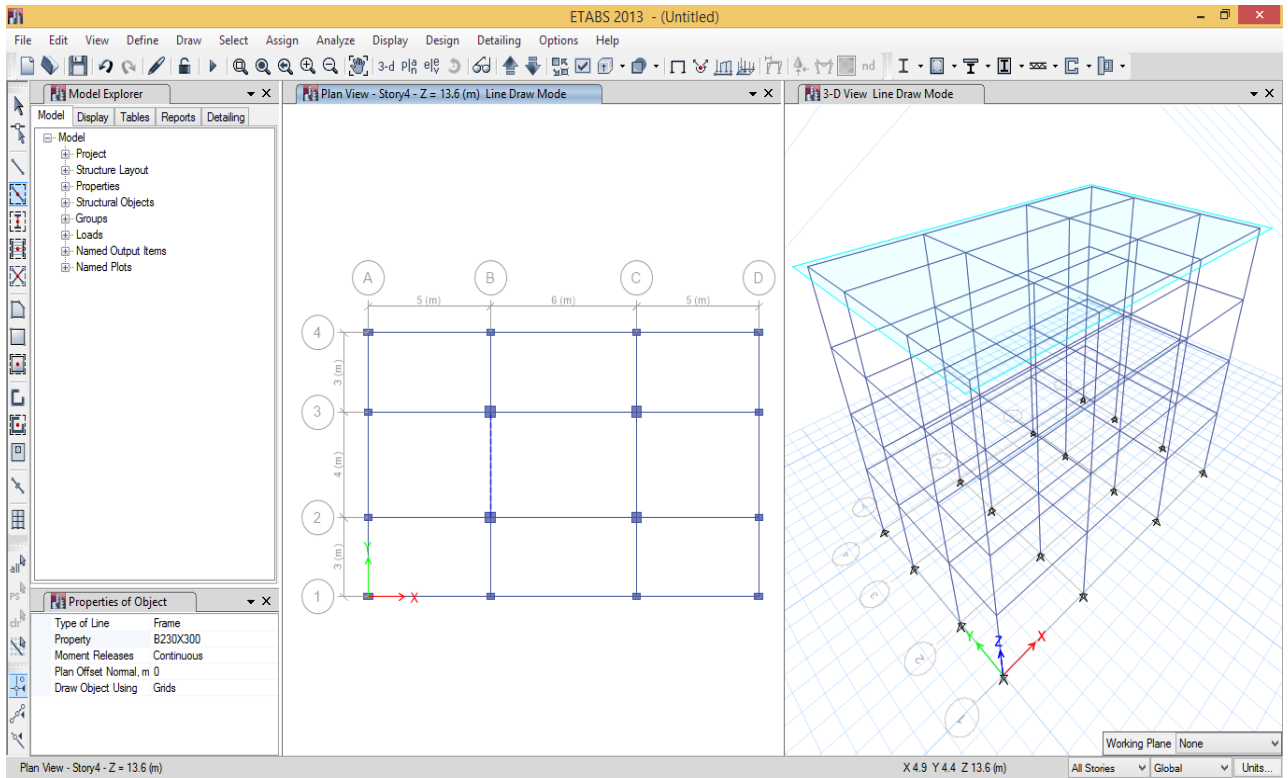
7) Draw beam in grid as mentioned in plan



The screenshot displays the ETABS 2013 software interface for a structural model. The main window shows the Plan View of Story 4 at Z = 13.6 (m). The model consists of a grid with columns labeled A, B, C, and D, and levels labeled 1, 2, 3, and 4. The horizontal dimensions are 5 (m) between A and B, 6 (m) between B and C, and 5 (m) between C and D. The vertical dimensions are 3 (m) between levels 1 and 2, 4 (m) between levels 2 and 3, and 3 (m) between levels 3 and 4. A 3-D View window shows the model in perspective, with a coordinate system (X, Y, Z) and a Working Plane set to None. The Properties of Object window shows the following details:

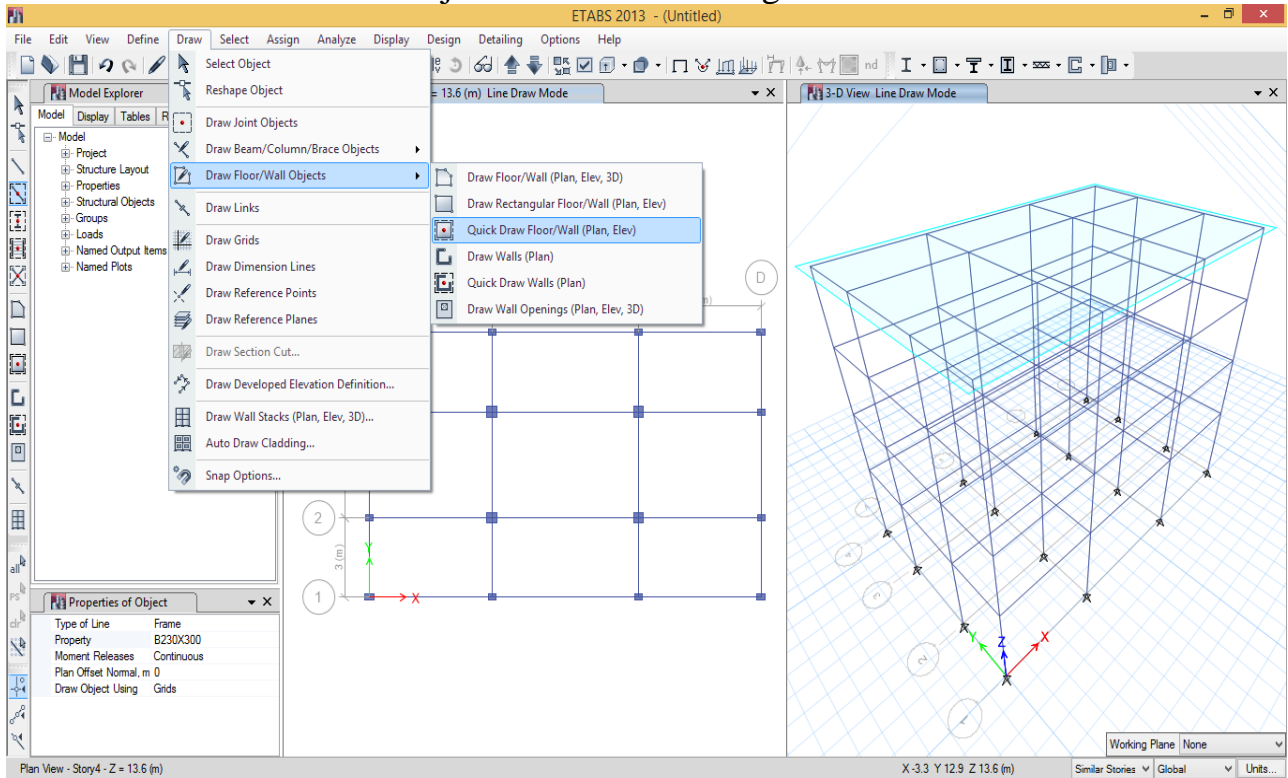
Property	Value
Type of Line	Frame
Property	B230X350
Moment Releases	Continuous
Plan Offset Normal, m	0
Draw Object Using	Grids

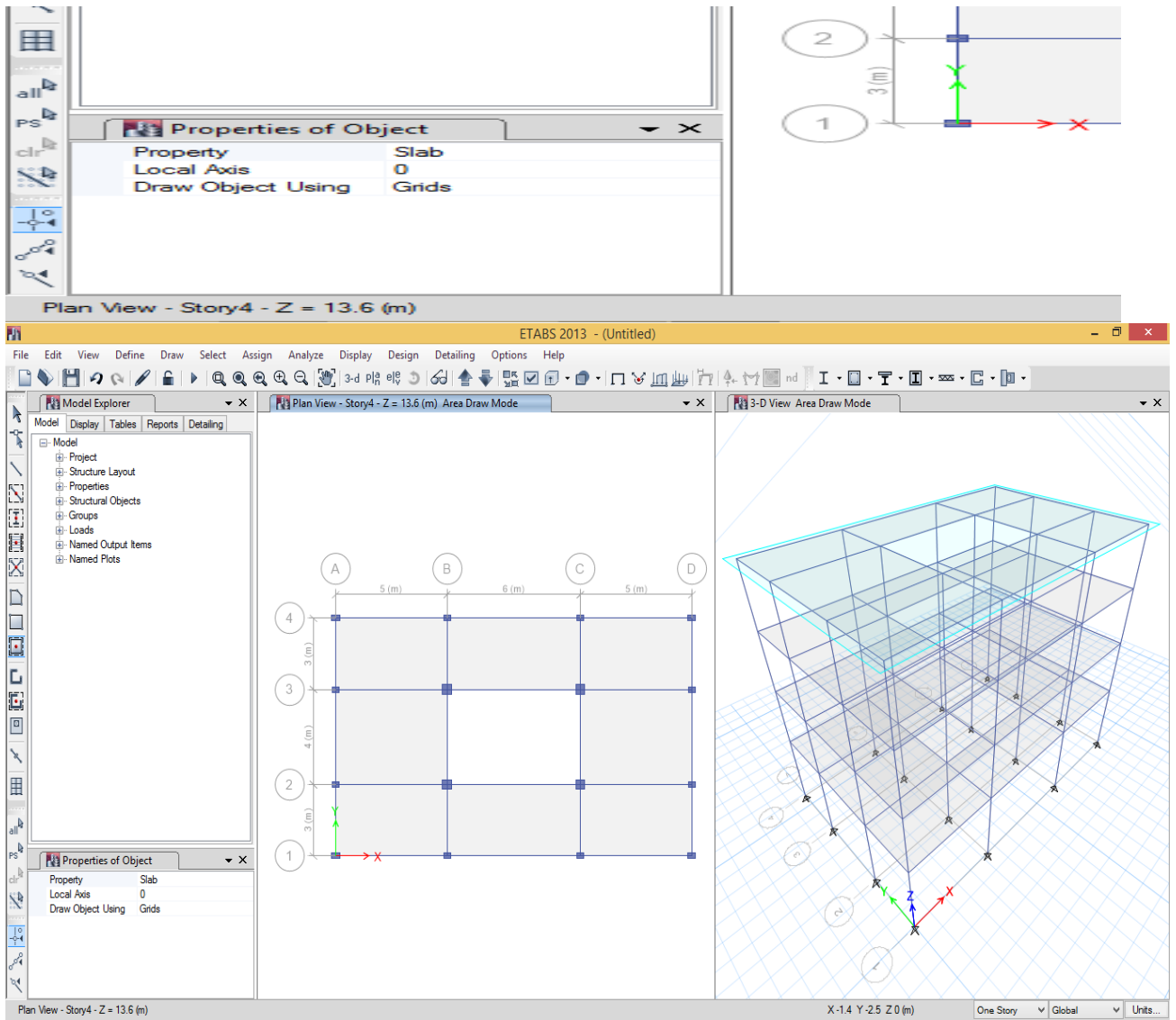
The 3-D View window shows the model in perspective, with a coordinate system (X, Y, Z) and a Working Plane set to None. The status bar indicates the current view is X 2.3 Y 10 Z 13.6 (m) and the units are Global.



8) Draw slab in grid as mentioned in plan:

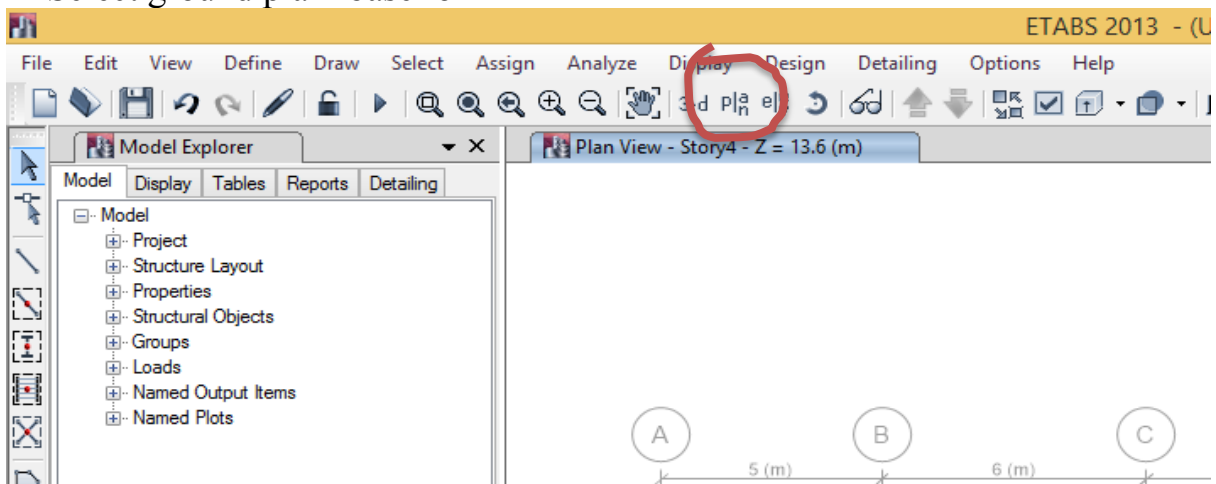
Draw → draw floor/wall objects → draw rectangular floor/wall

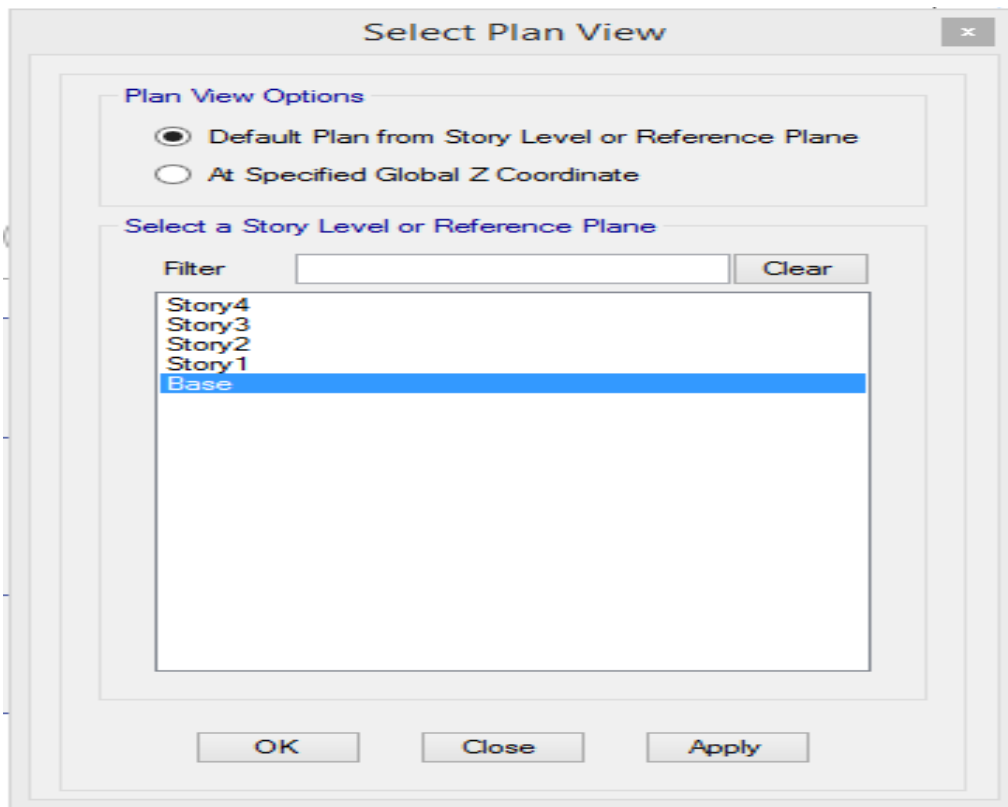




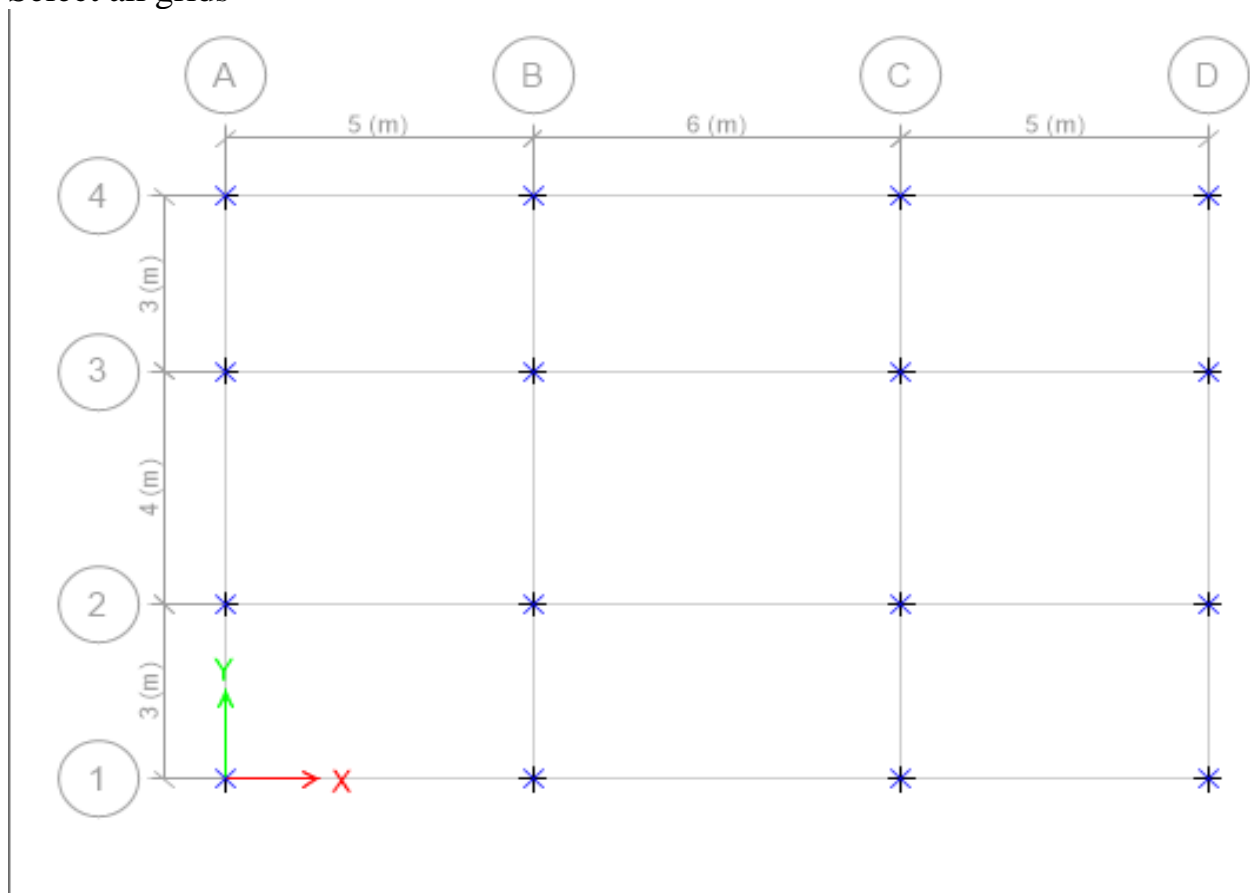
2.2) Support specification

- Select ground plan>base>ok

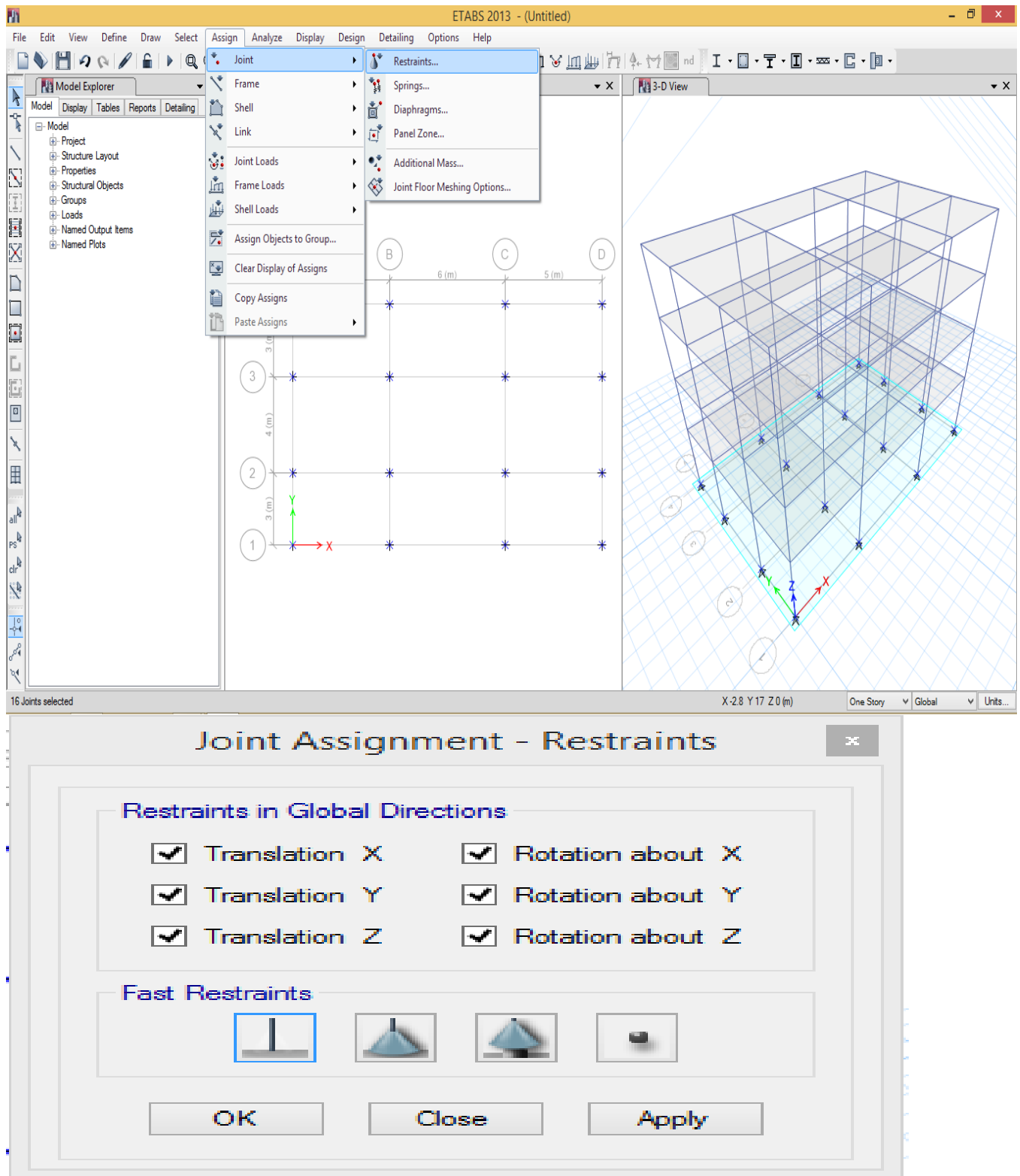




Select all grids

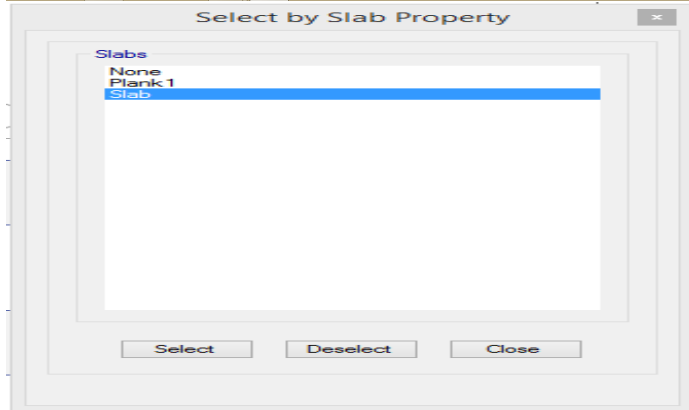
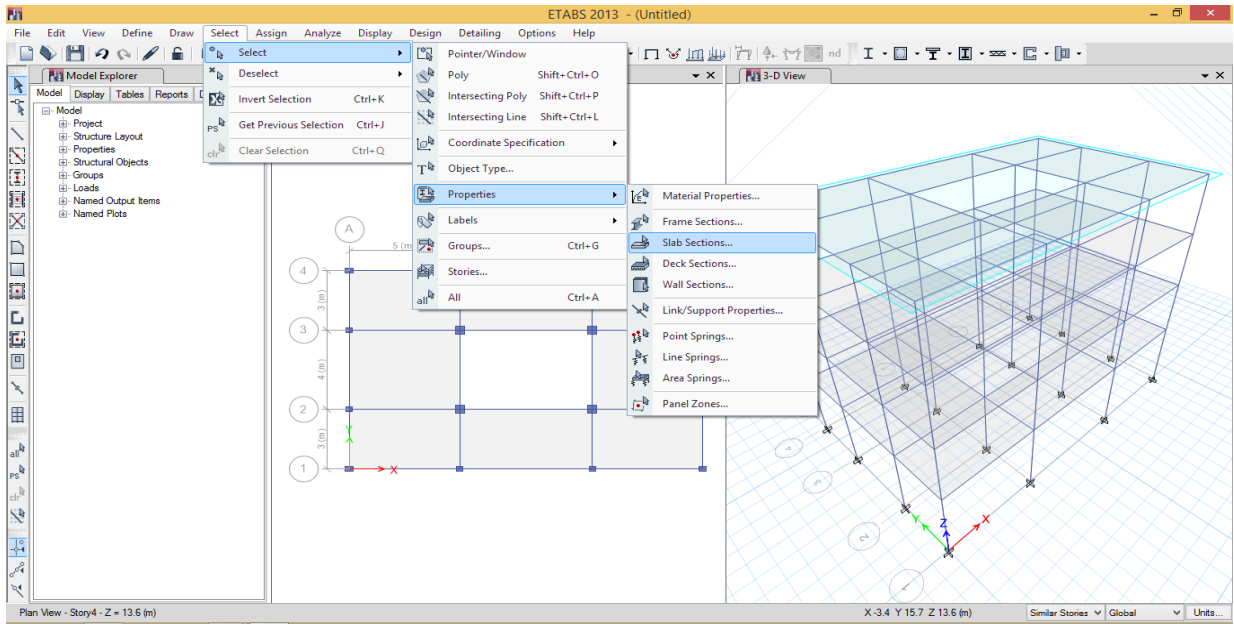


- assign > Joint/Point>Restrain (Support) command

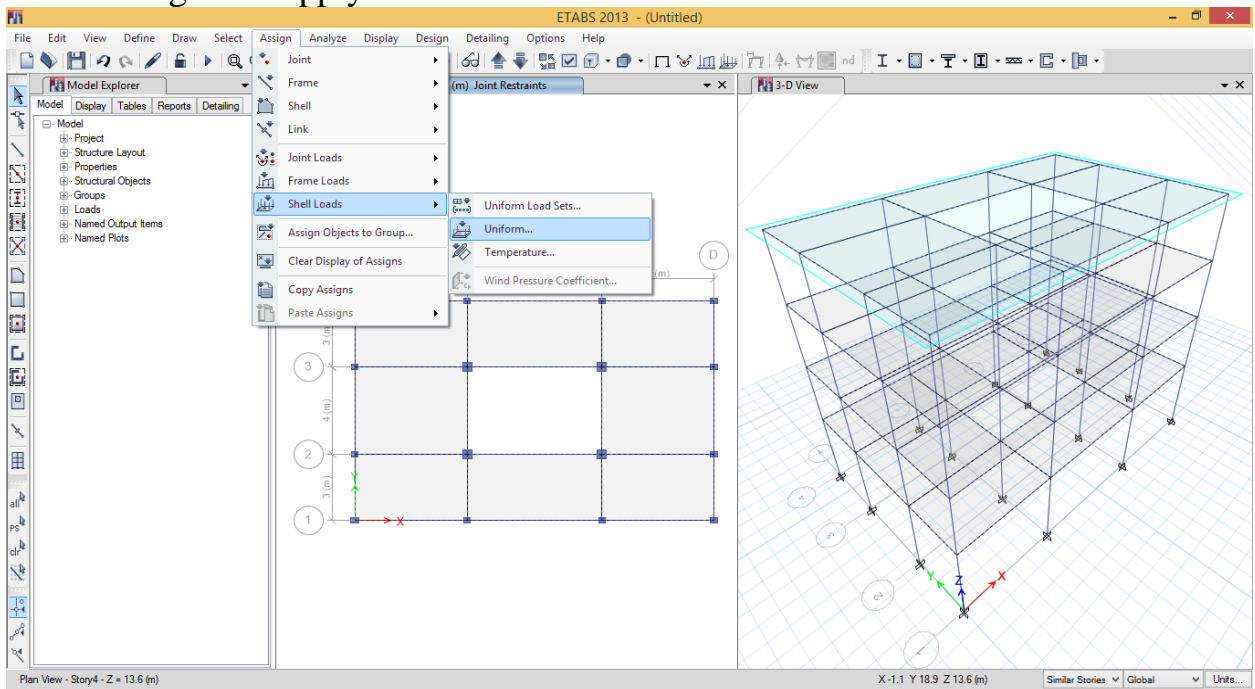


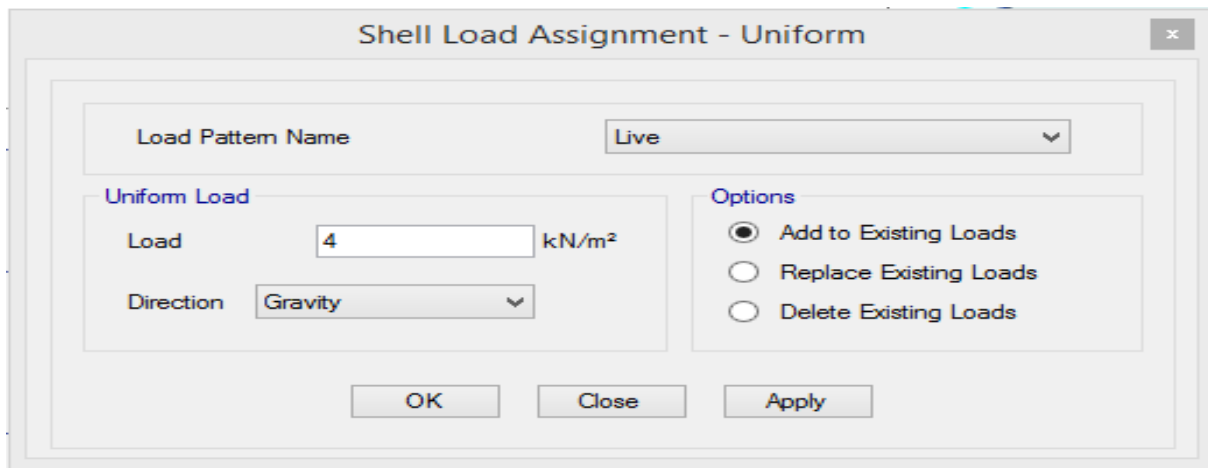
2.3) Loading :

- Select slab
select>select>properties>slab sections>slab>select>close

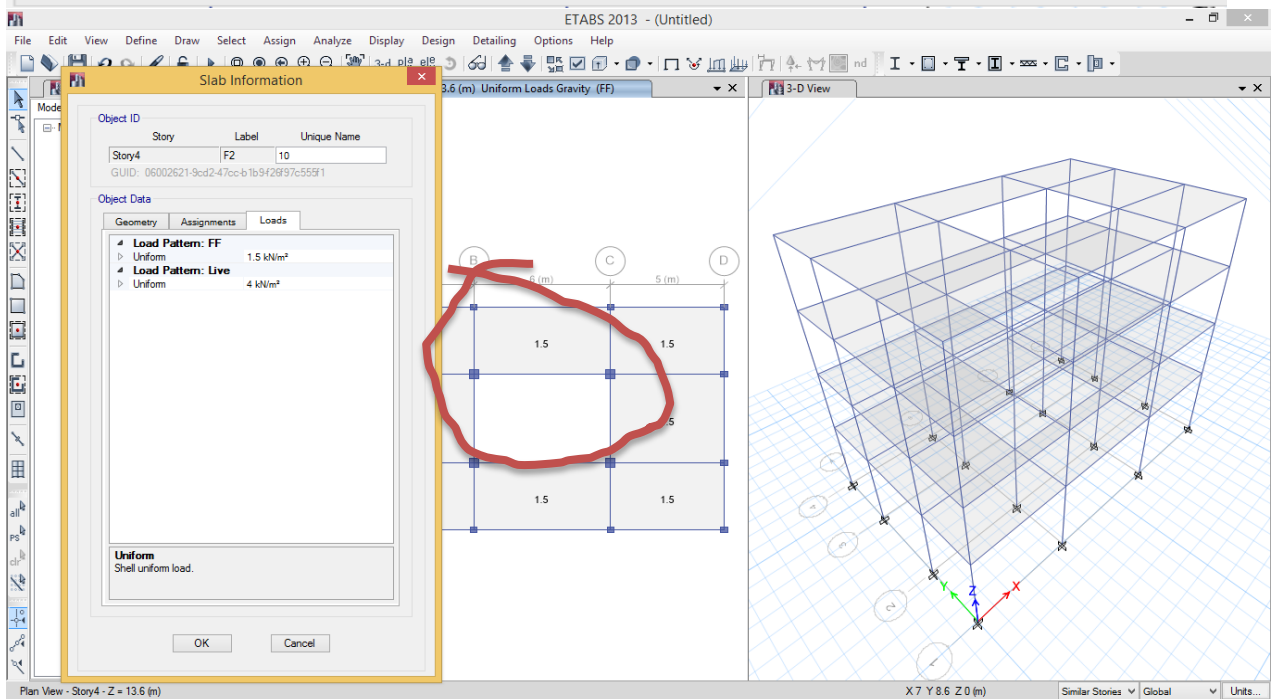
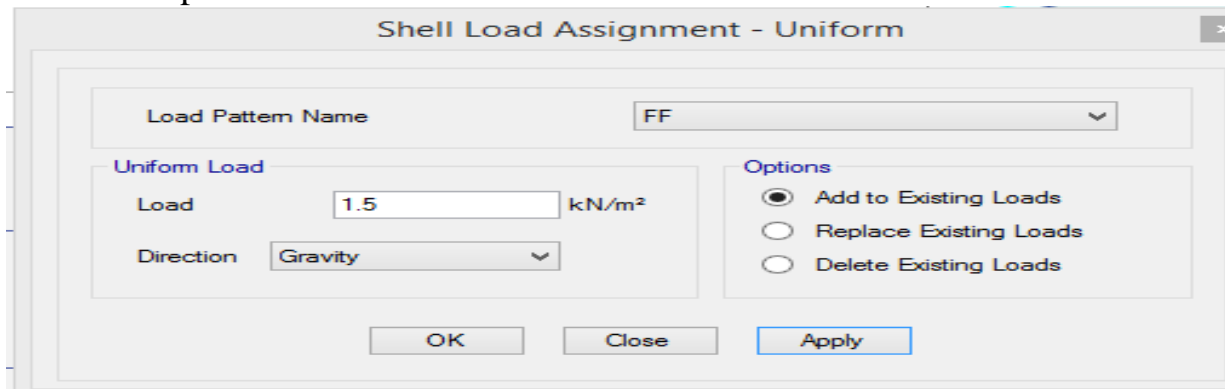


- Assign load>shell load>uniform>select load pattern live load> load 4kn/m2> add existing load>apply



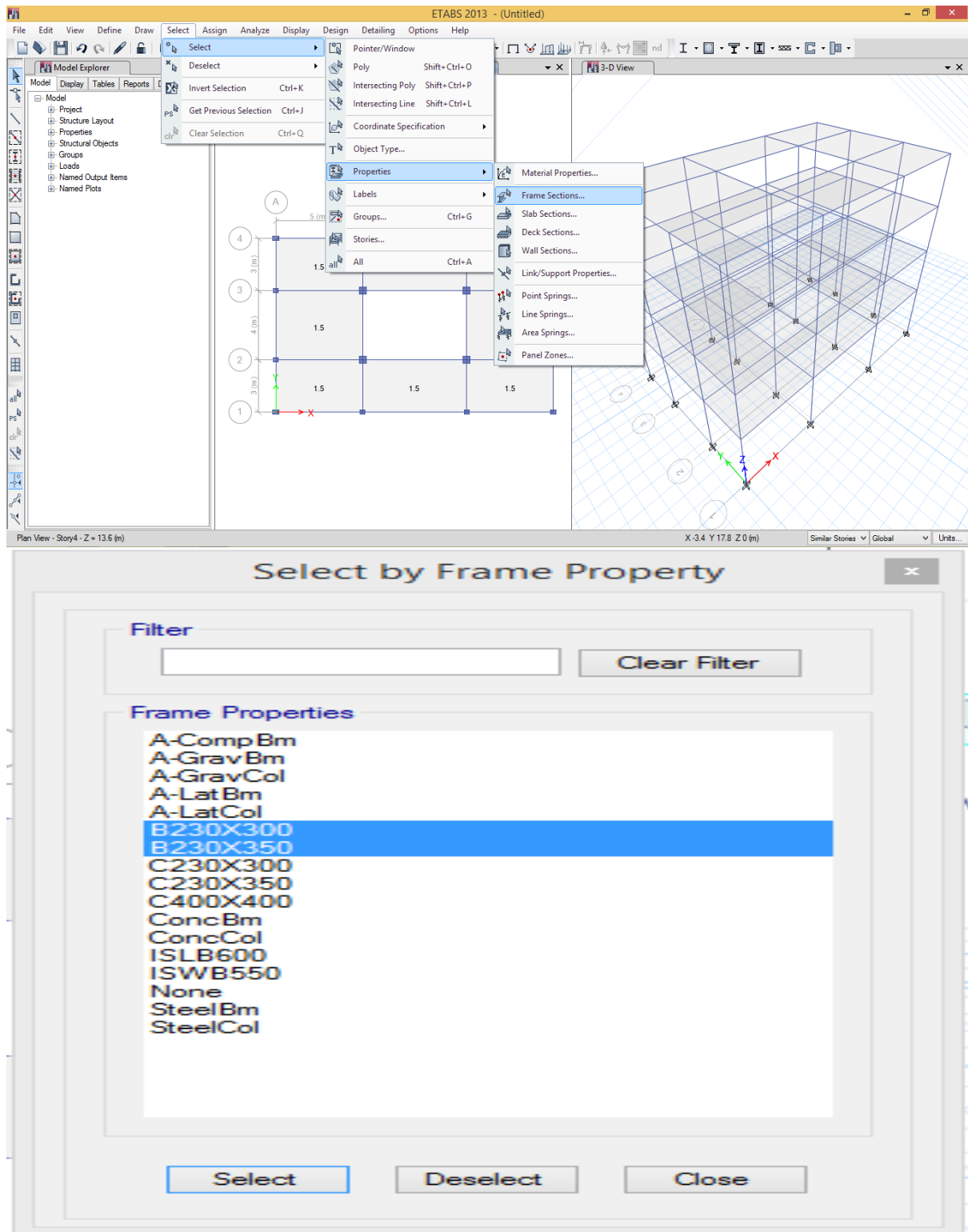


Select load pattern as FF>load 1.5kn/m2>ok

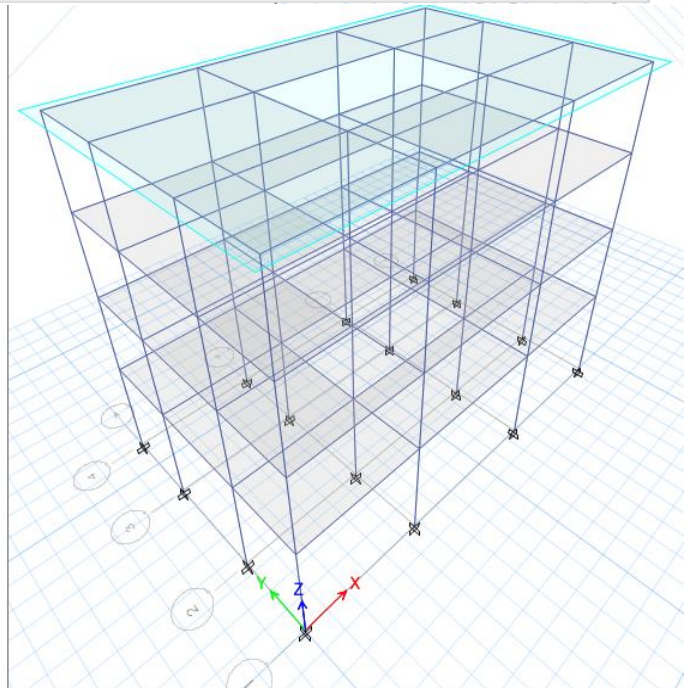
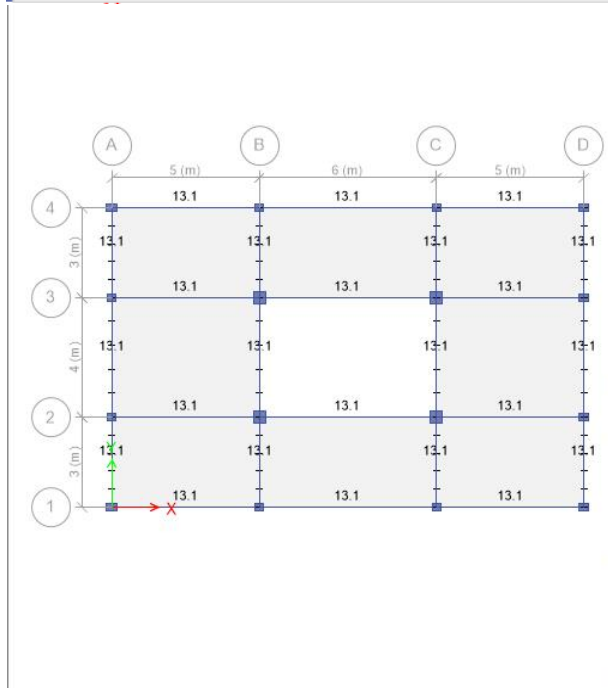
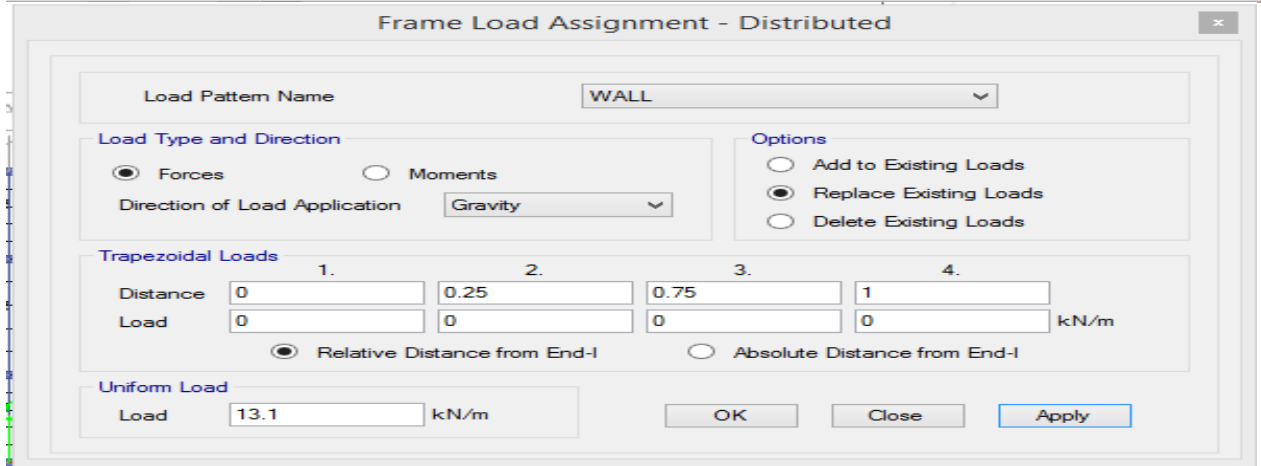
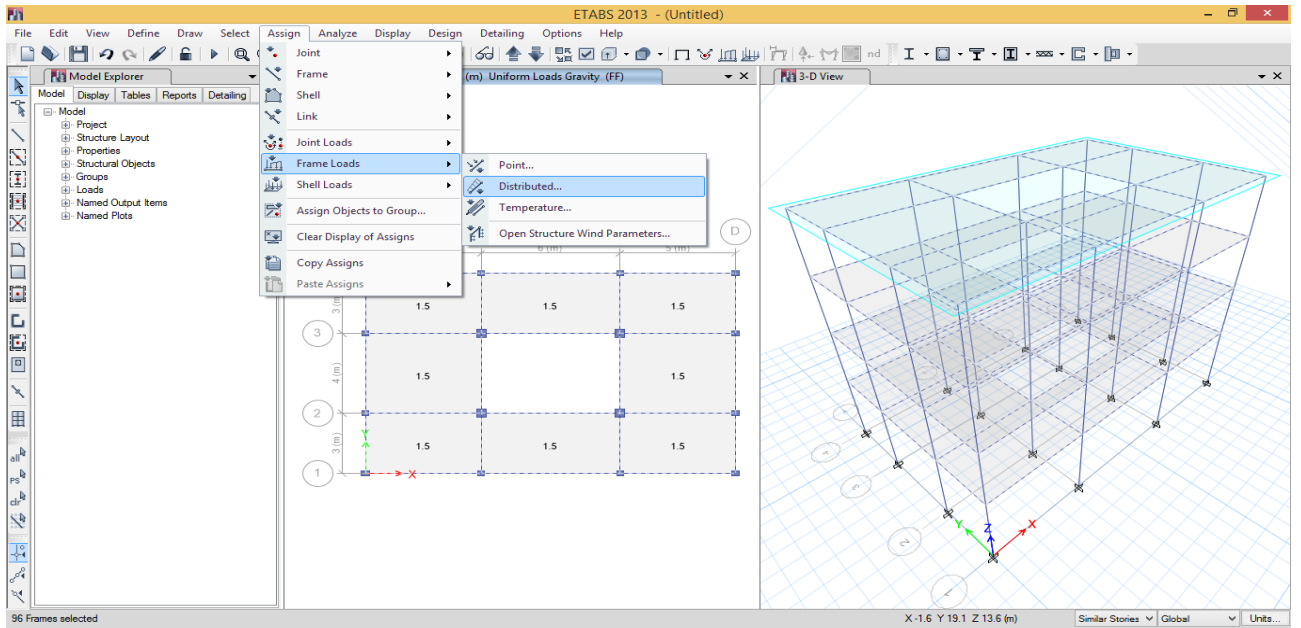


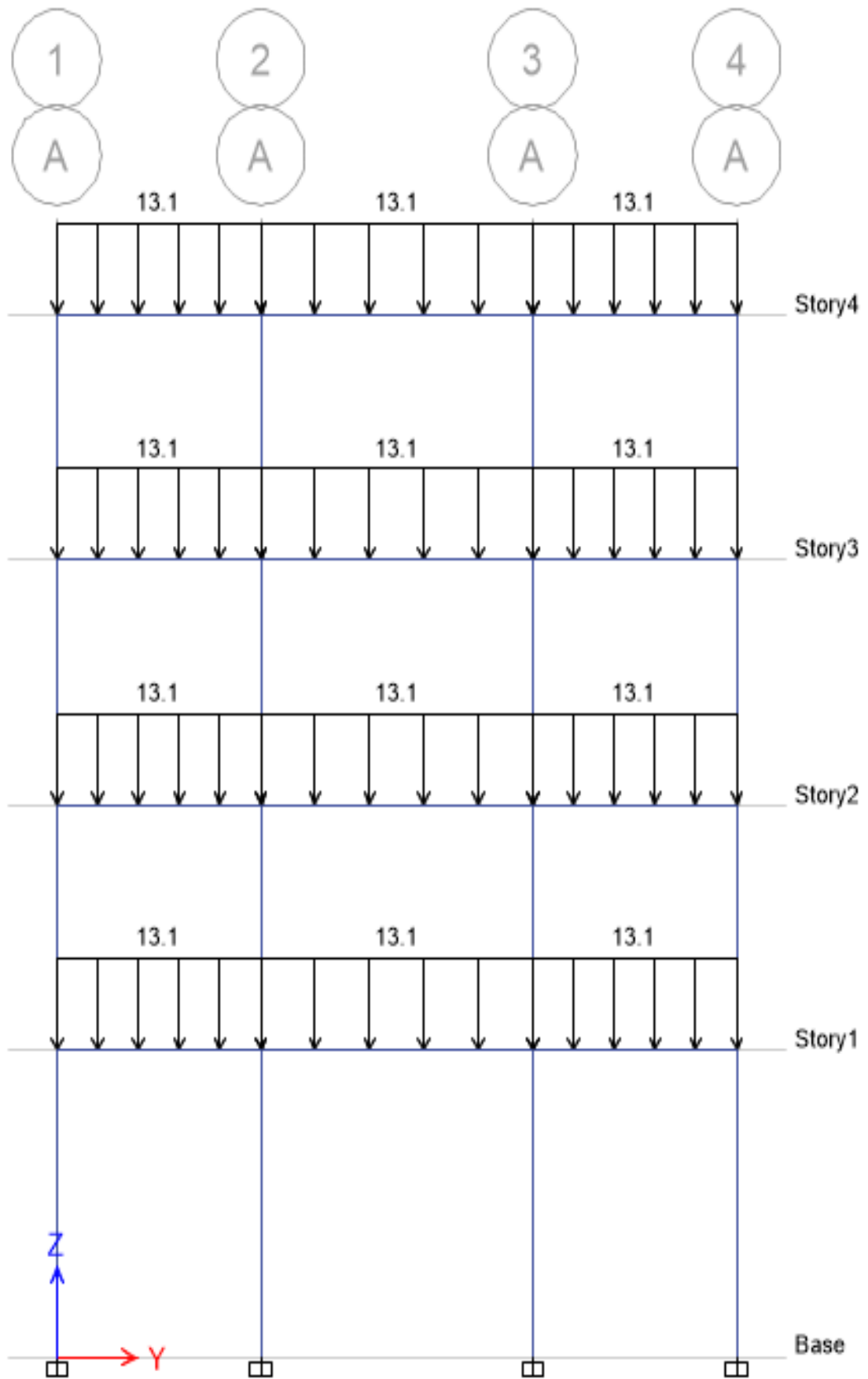
Assign Wall load covert to udl acting on beam section

Select>properties>frame sections>select beams >click select>close



Assign wall load>frame load>distributed> select load patter as wall>load 13.1kn/m²>apply

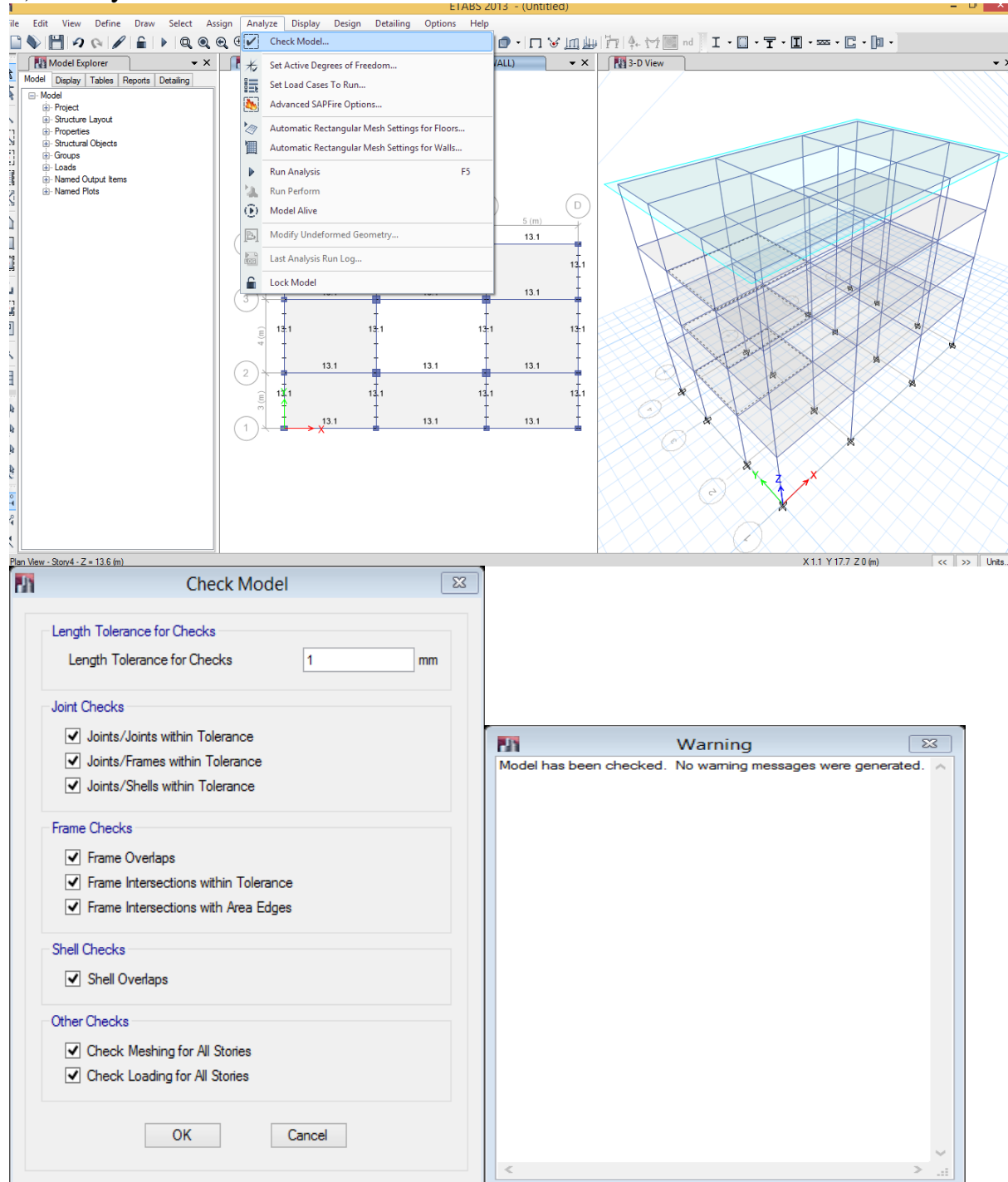




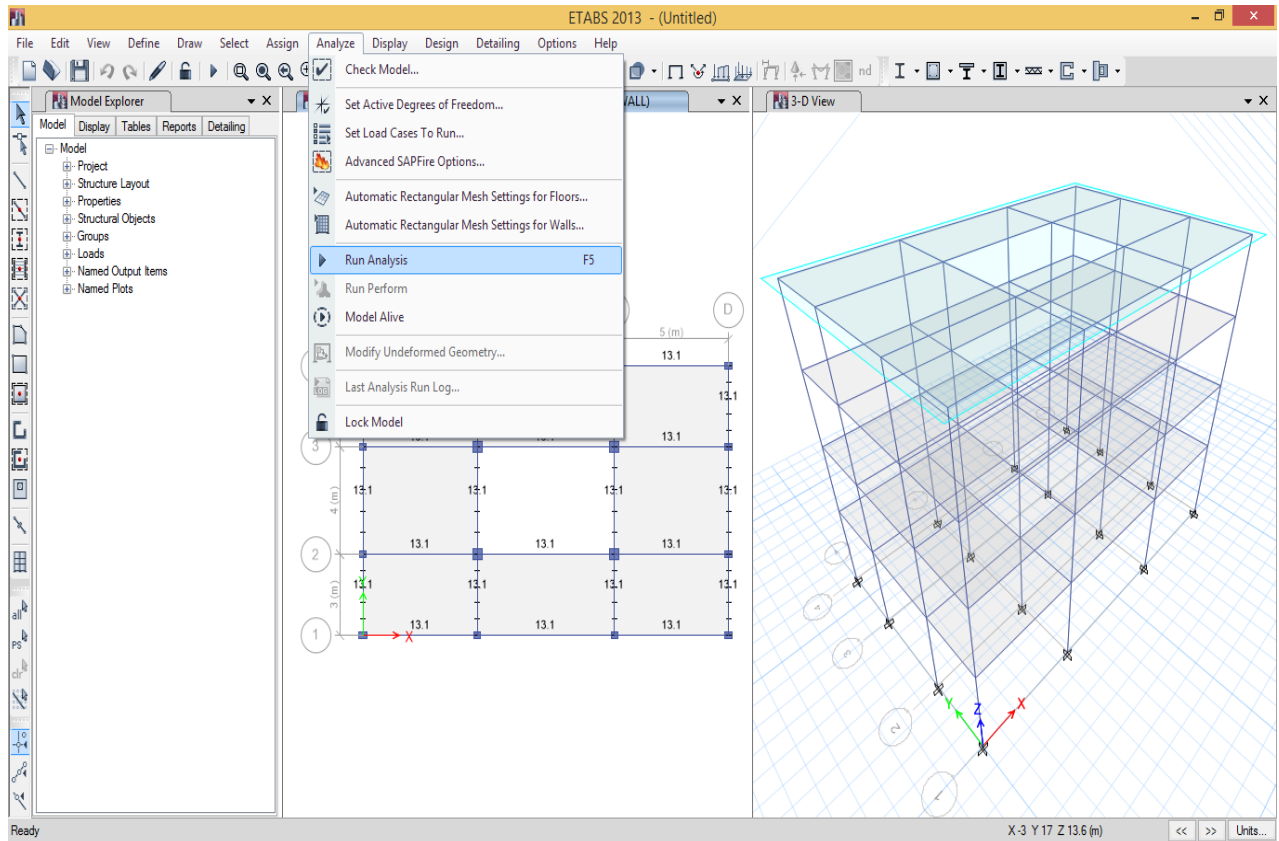
2.4) ANALYSIS

Before we start with analysis we have to save the file.

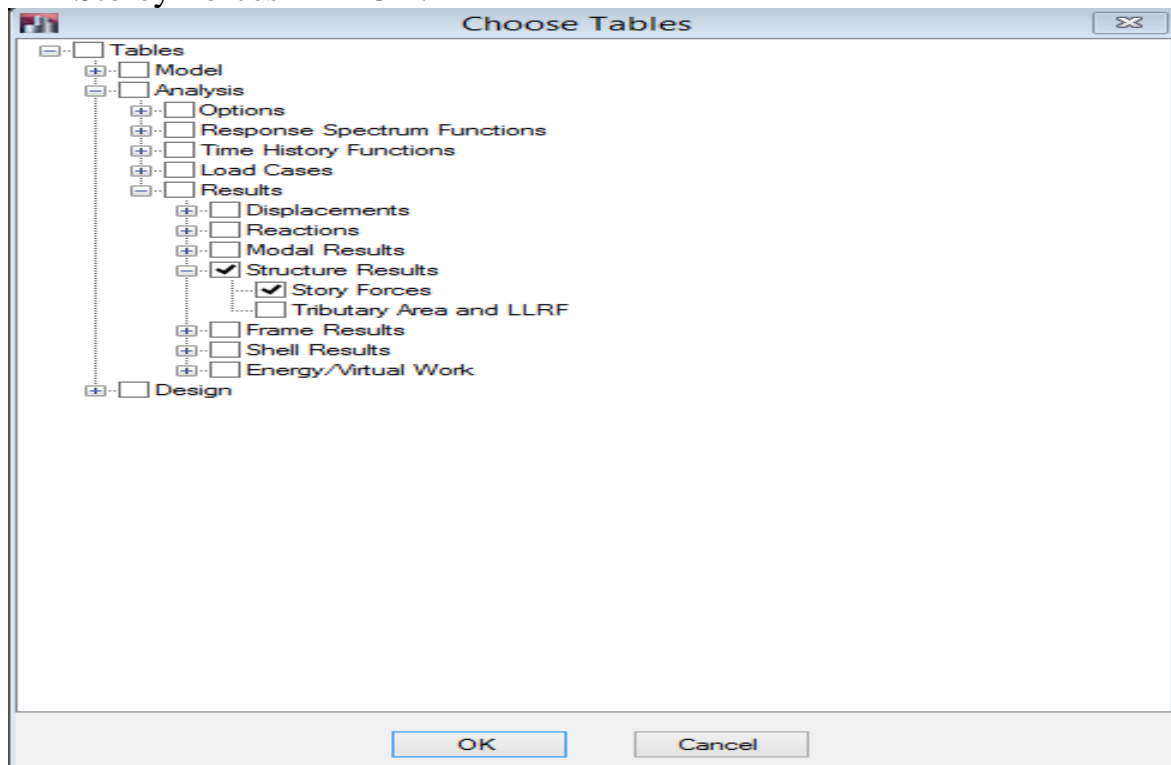
1) Analyze → Check model → Tick all the check boxes → OK



- A dialogue box opens intimating about the errors or warnings. Errors or warnings may appear if there are overlapping of the slabs or if any properties assigning is not complete.
- Run analysis

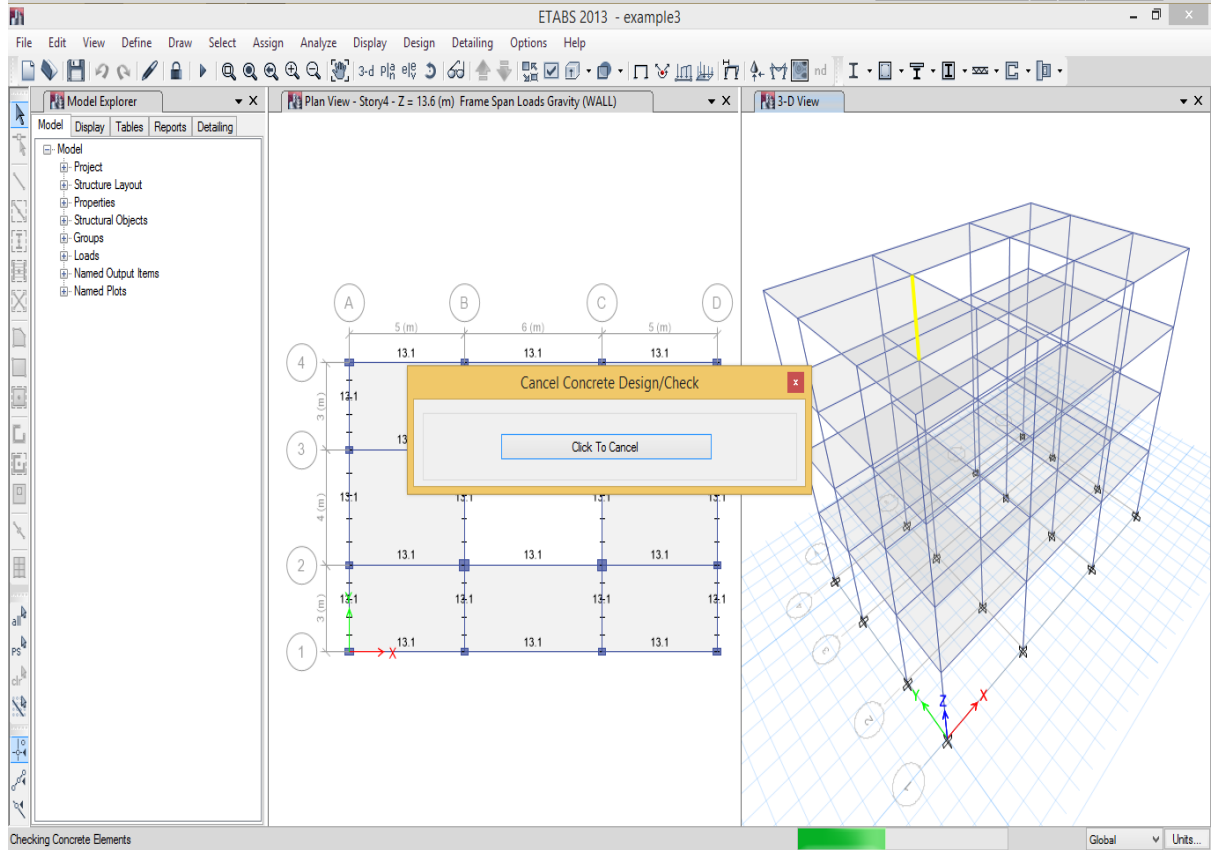
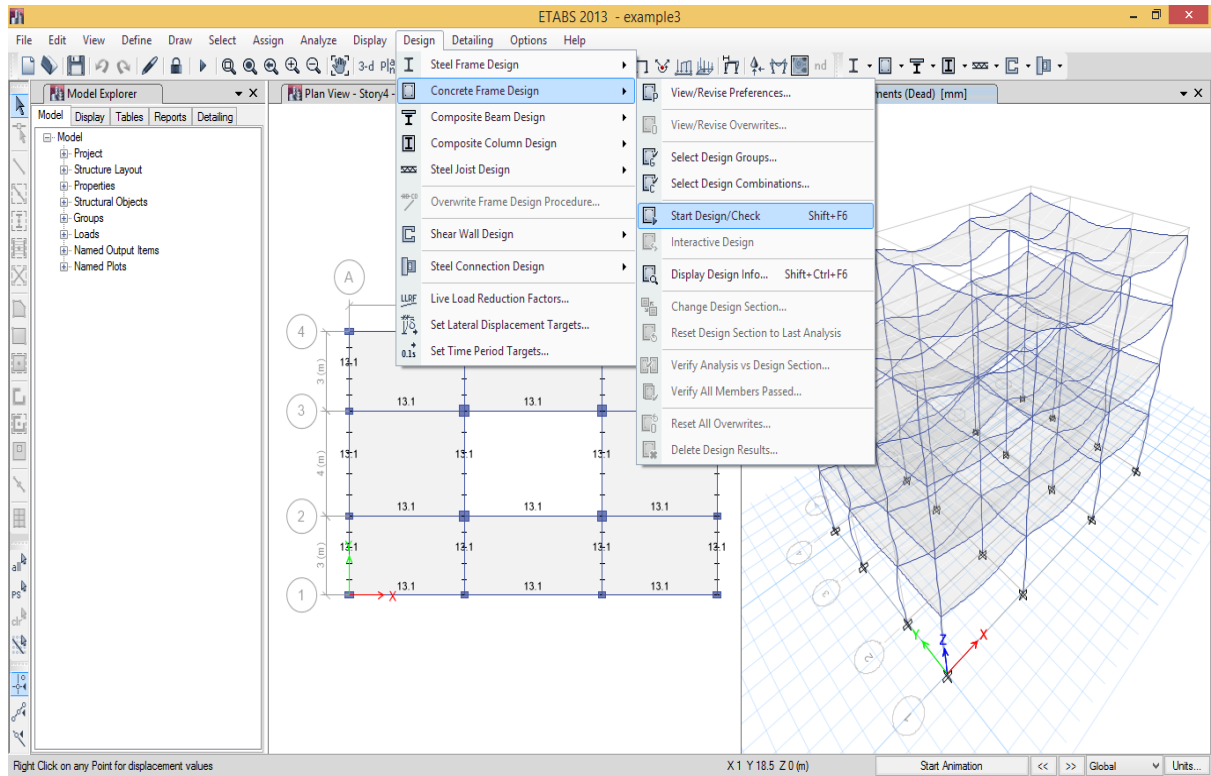


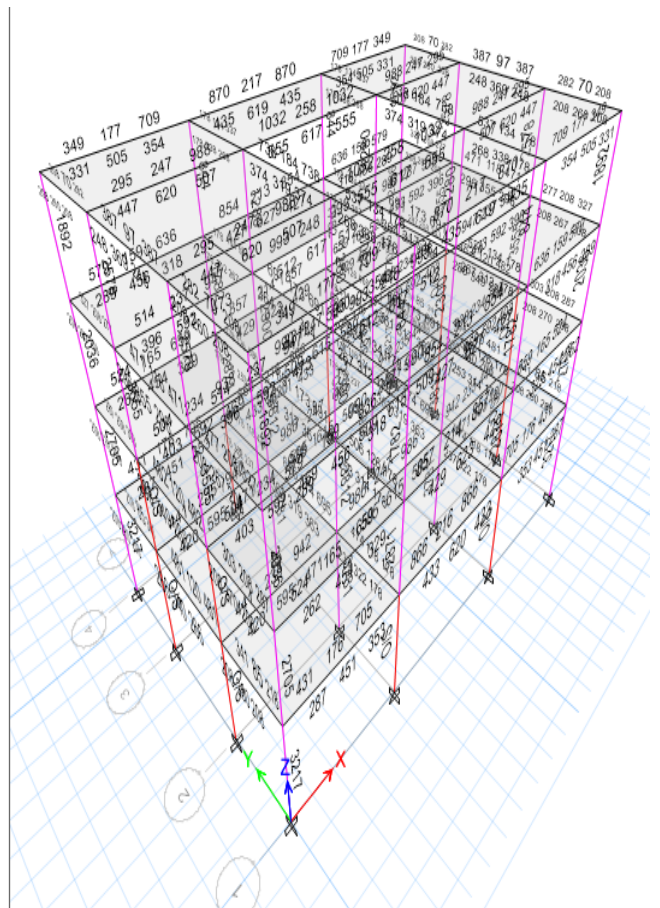
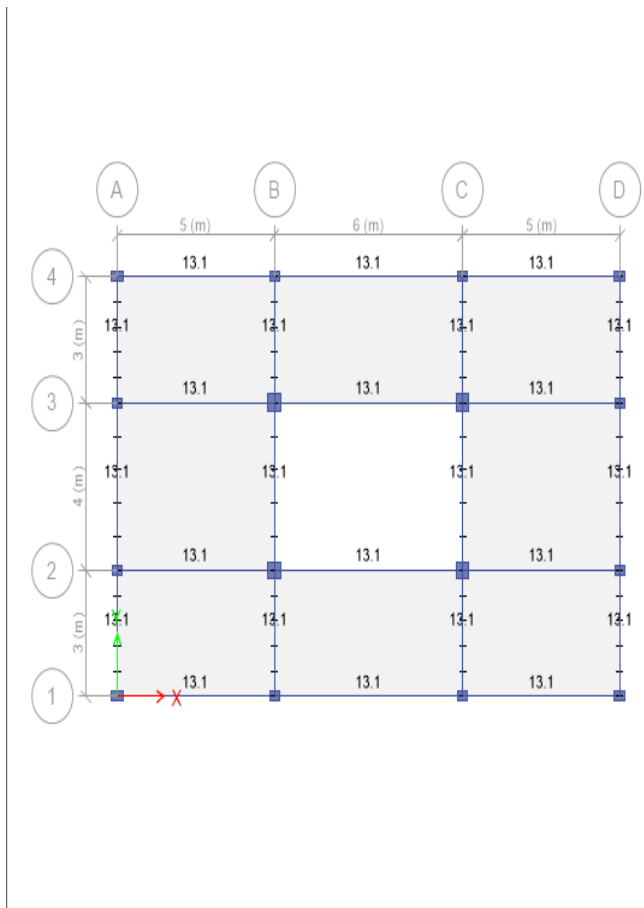
- Display → Show tables → Analysis → Results → Structure results → Storey Forces → OK.



2.5) DESIGNING

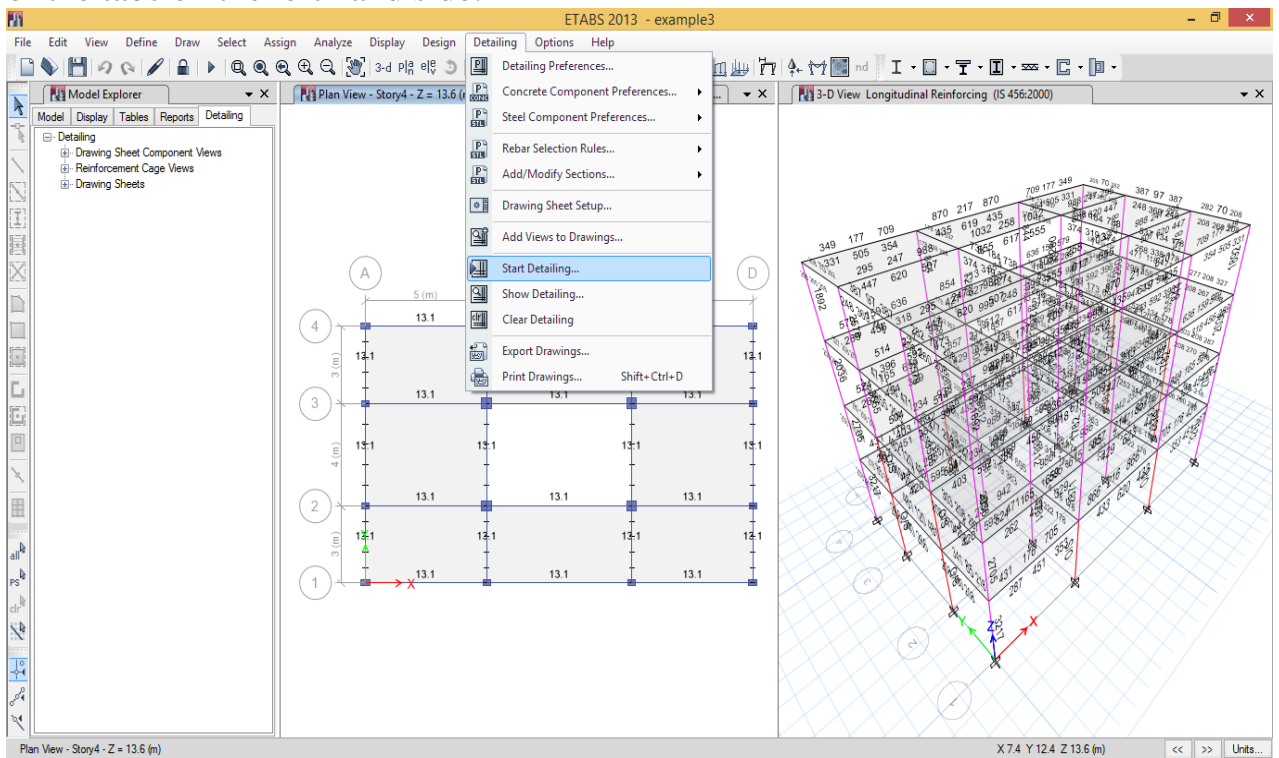
- Design → Concrete Frame design → Start design/Check. • Results are shown below as soon as the designing is complete • Or shift+F6

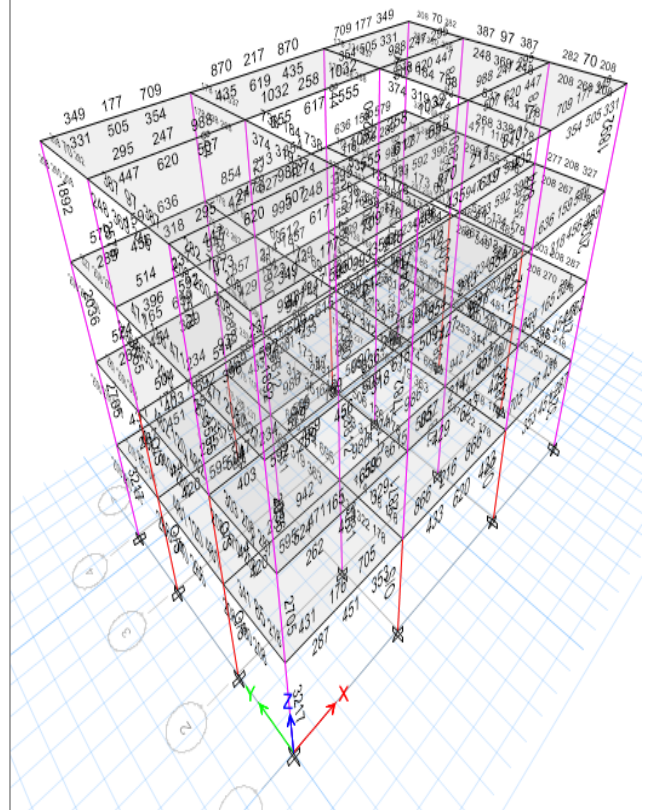
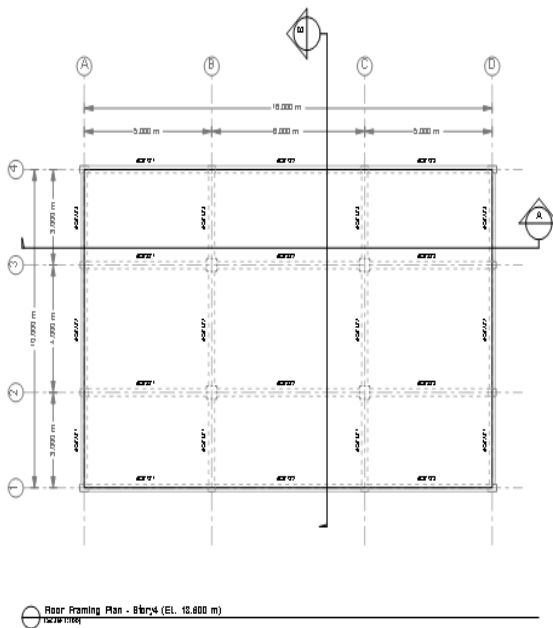
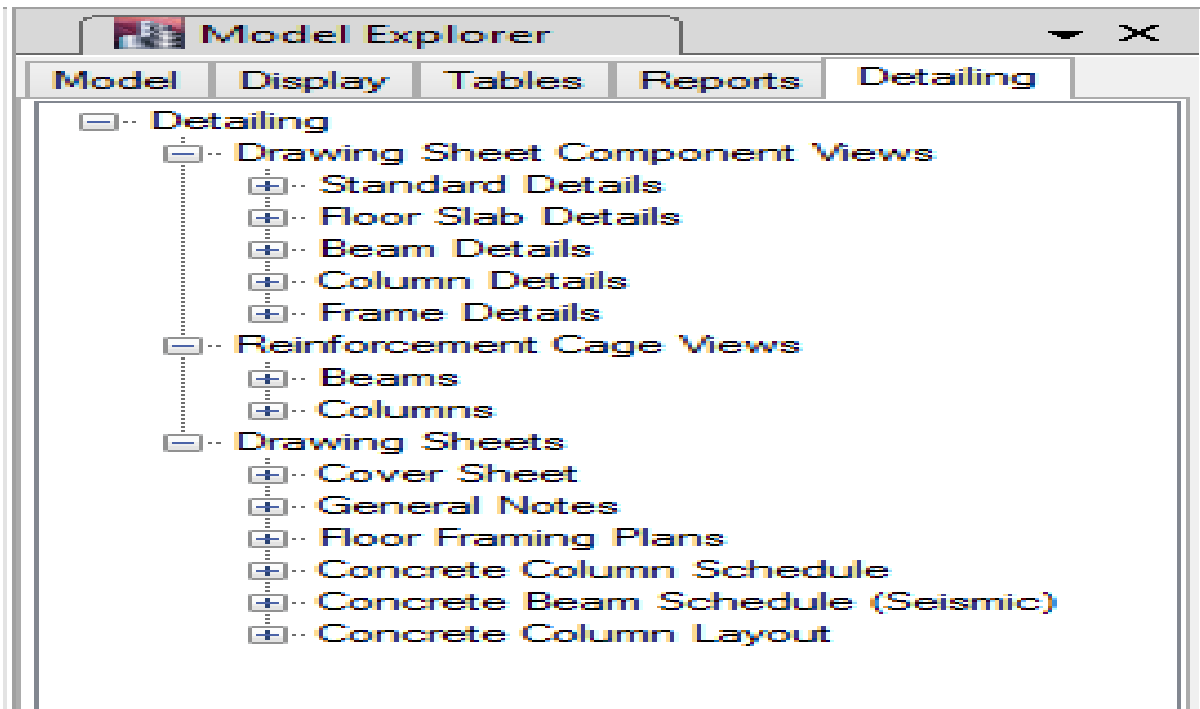


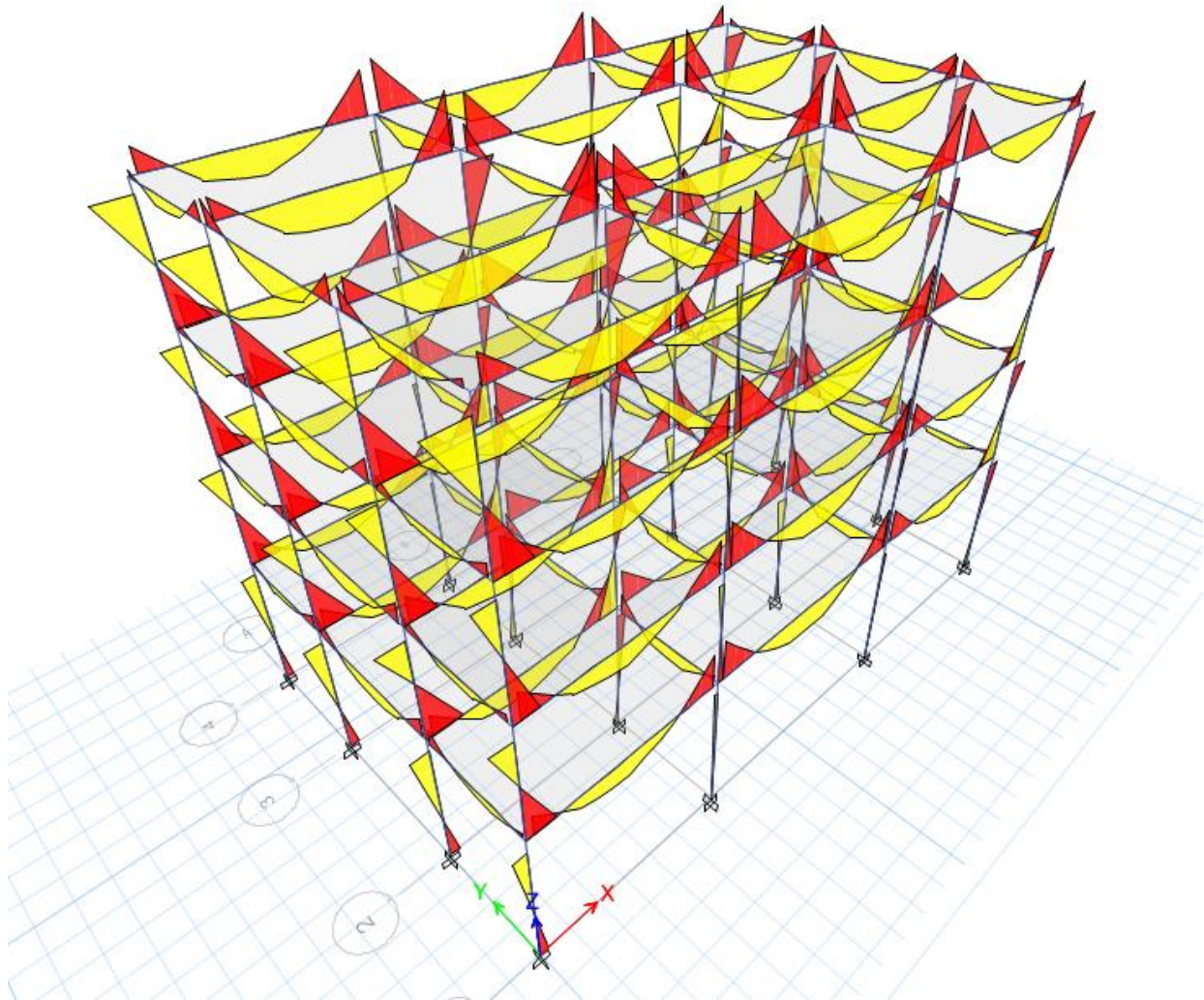


2.6) DETAILING

- Detailing → Start detailing → All the necessary detailing is given in each of the tabs on the left hand side.







Bending moment diagram for dead load

3. Linear dynamic analysis

The modelling, assigning the material and section properties, drawing of beams, columns and slab, assigning the static loads (Dead loads and Live loads) have been discussed in the linear static analysis. Linear dynamic analysis deals with analyzing the structure for dynamic forces such as wind loads and earthquake forces.

Example 1. Linear dynamic analysis of a multi-storey building (G+3)

Parameters:

Column **C1 = 230x300 mm**

C2 = 230x230 mm

Beam **B1 = 230x400 mm**

B2 = 230x300 mm

Slab thickness = 150 mm

Live load = 4 kN/m²

Floor finish = 1.5 kN/m²

Storey height = 3 m

Bottom storey height = 3.2 m

Structure is subjected to

- i. Wind load at 50m/s
- ii. Take Windward coefficient of 0.8
- iii. Leeward coefficient of 0.5
- iv. Earth quake forces in X and Y directions.
- v. Take, Seismic Zone factor as 0.36
- vi. Importance factor as 1
- vii. Response reduction factor of 0.50

The plan of the building is given in the figure below.

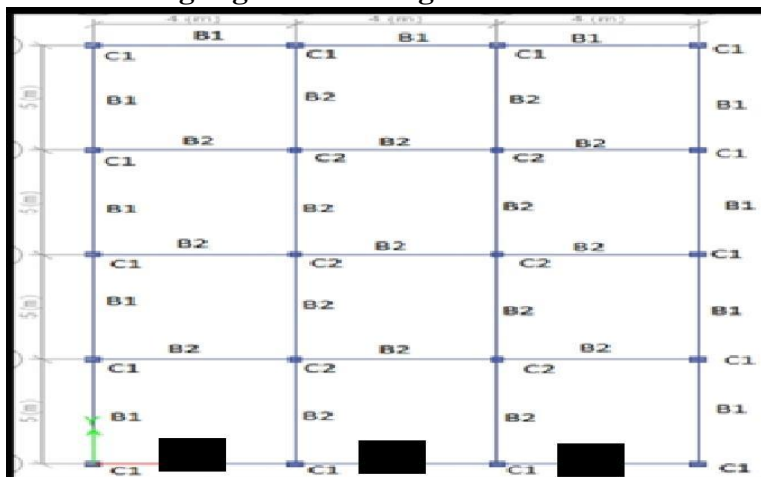
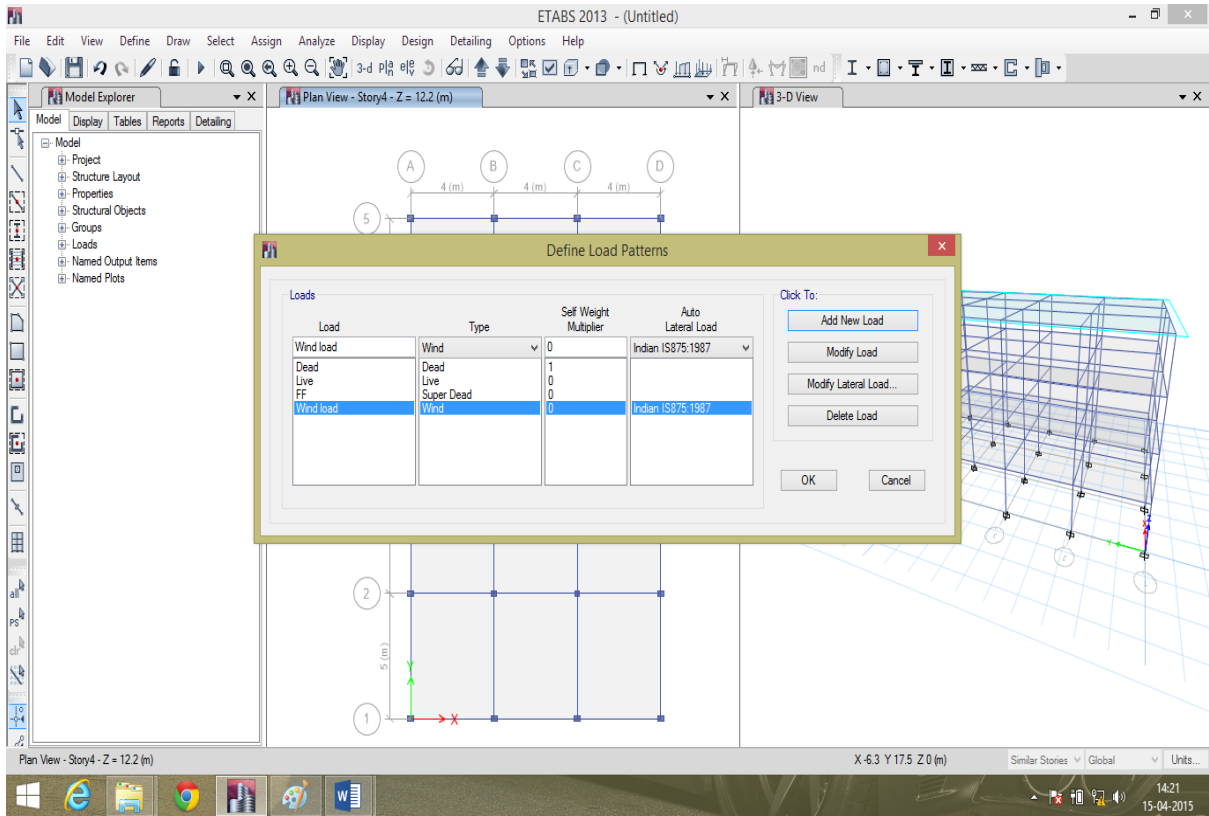
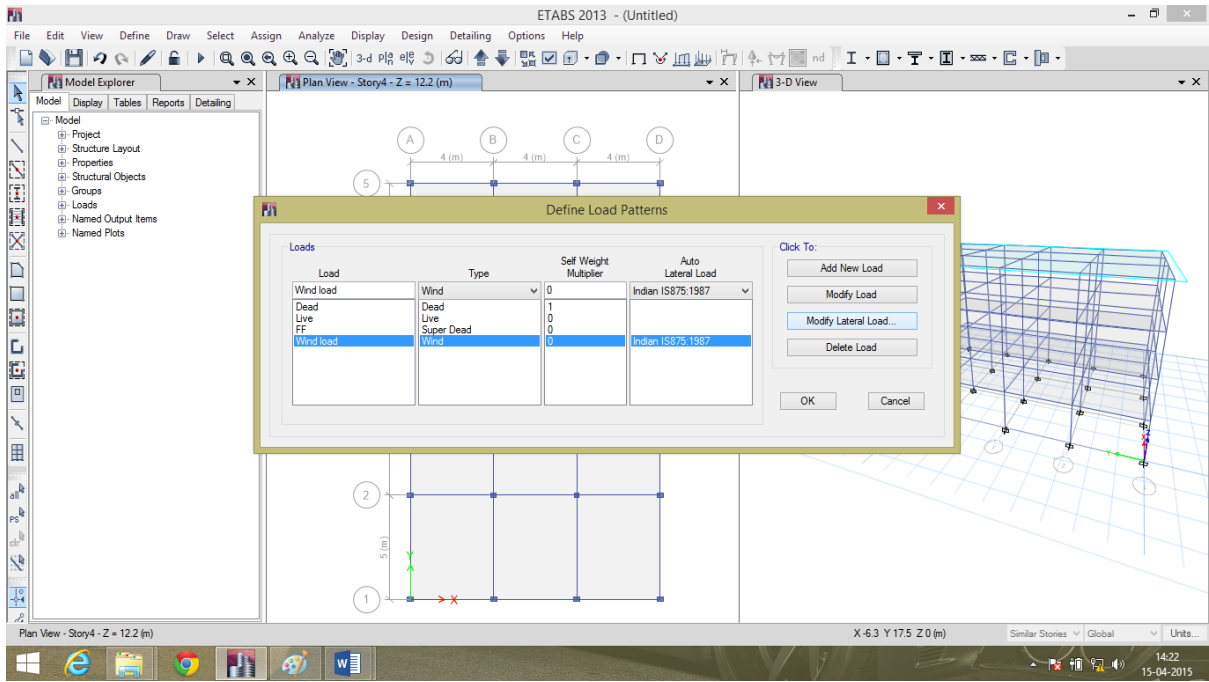


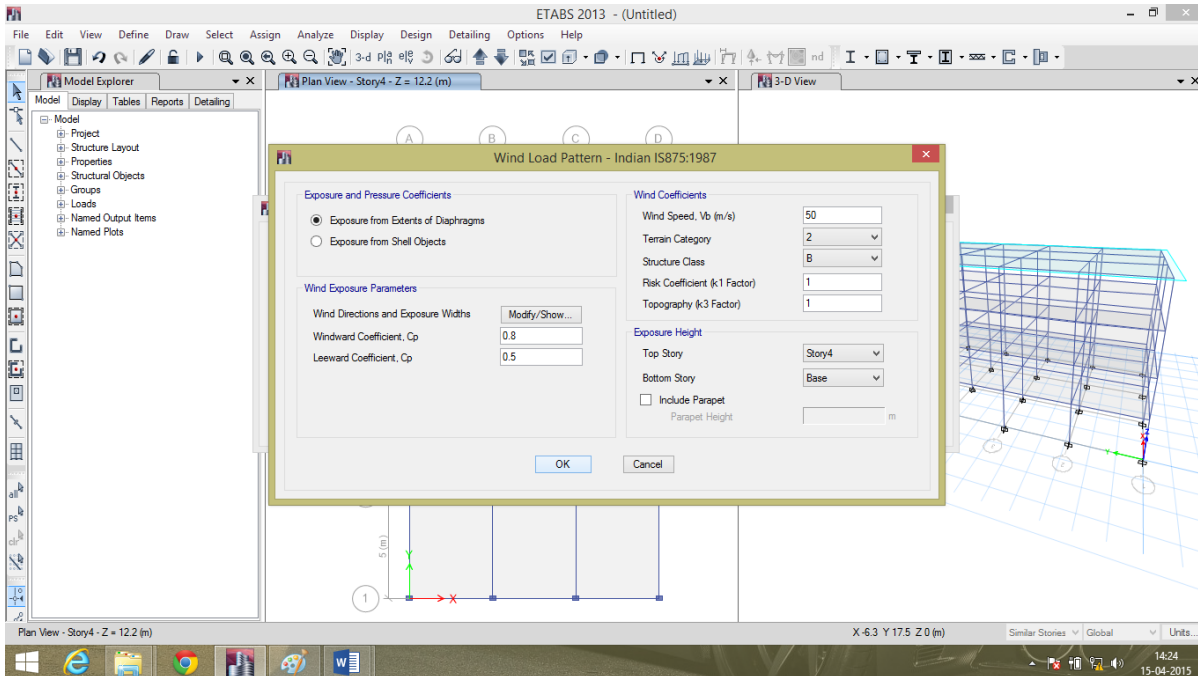
Fig. 1 Plan of a G+3 building

Similar to how we define Dead and Live loads in load patterns, define wind load which conforms to IS875:1987 and Earth quake loads in X and Y directions which conforms to IS1893:2000

3.21) To define wind load

Type→ Wind→ Self weight multiplier (Software takes it by default) → Auto lateral load (Code provision) → Add new load→ Modify lateral load→ Windward coefficient→ Leeward coefficient→ Wind speed→ OK

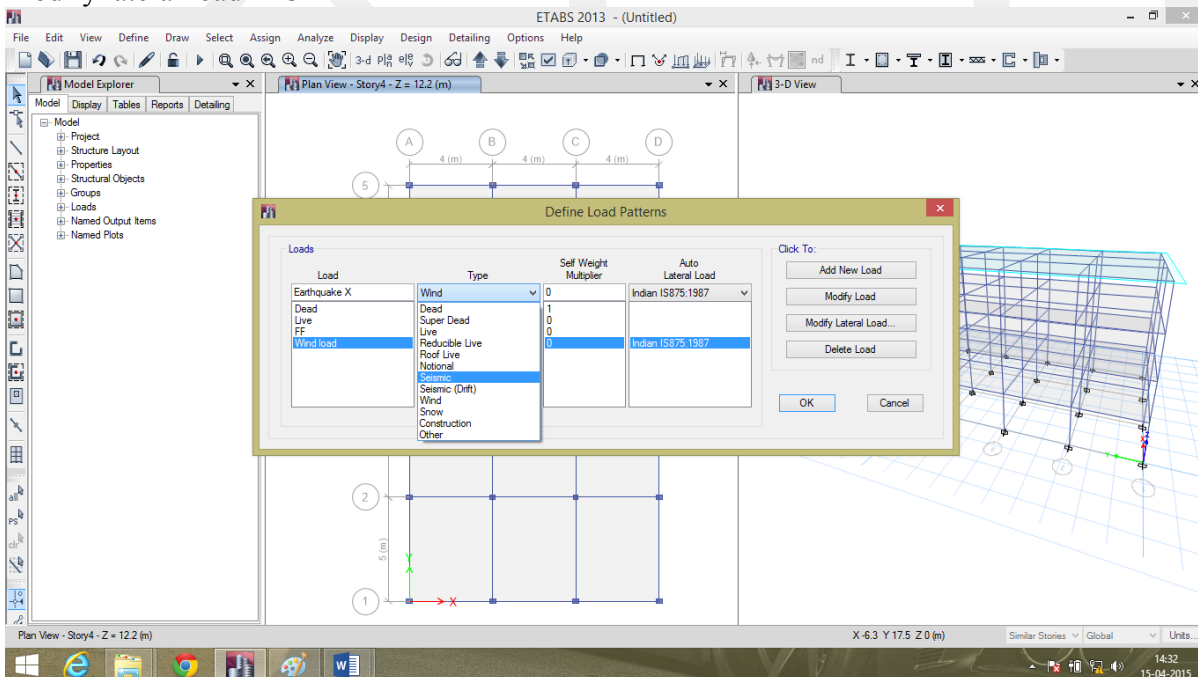


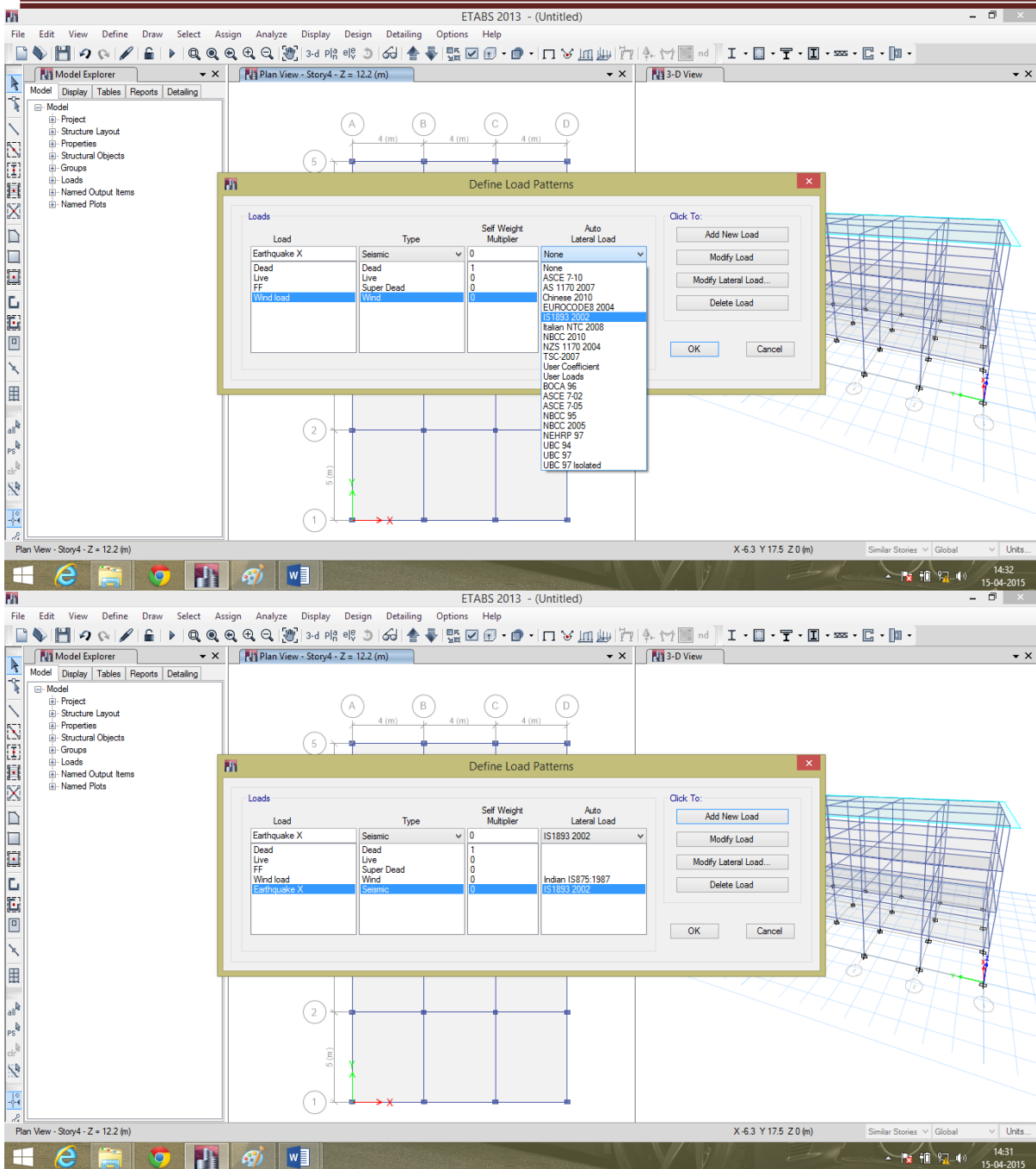


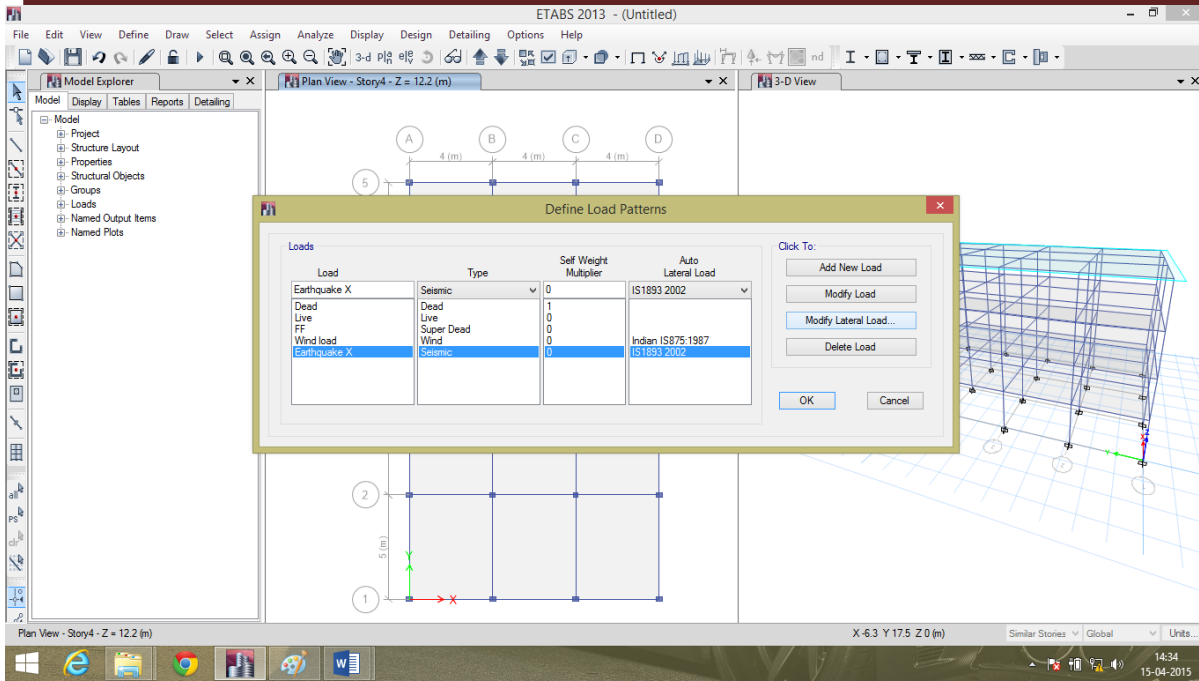
3.22) To define Earthquake load

In X direction

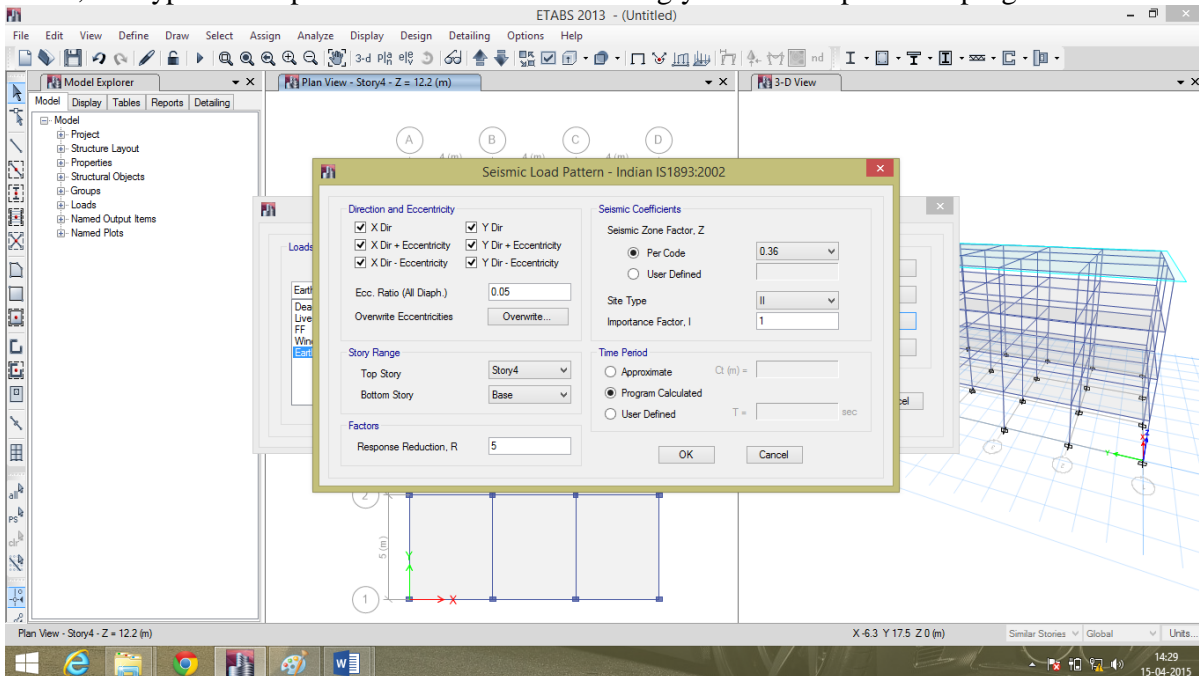
Load → Type → Seismic → Self weight (by default) → Auto lateral load (IS1893:2000) → Add new load → Modify lateral load → OK

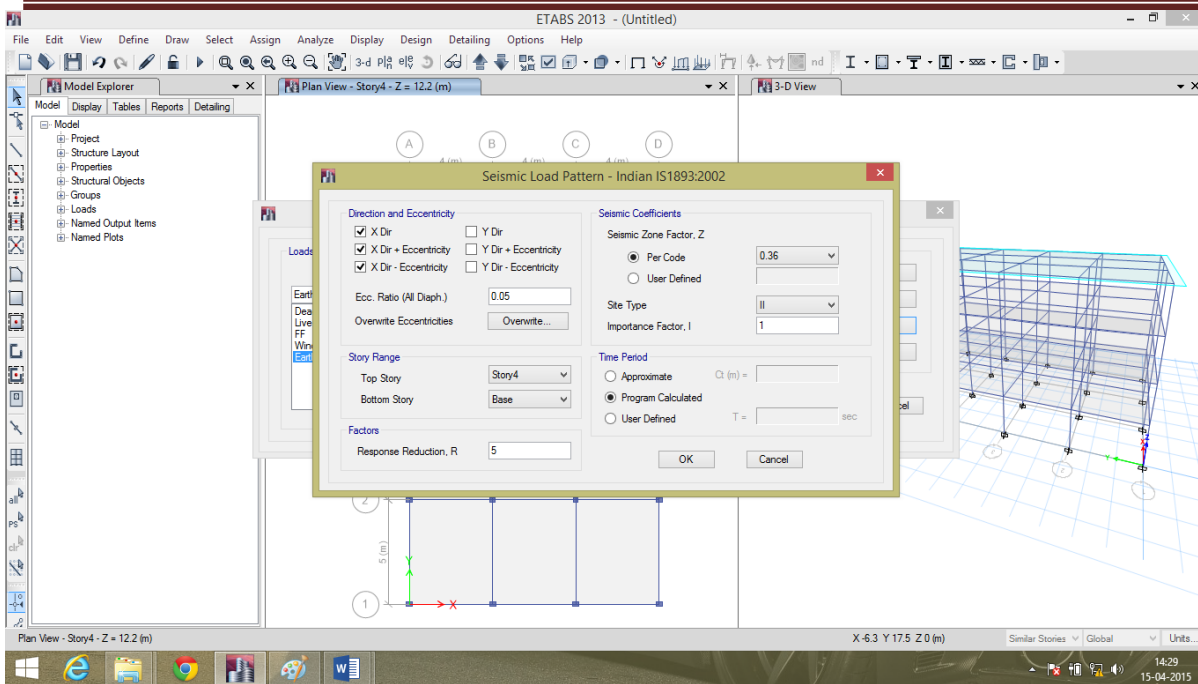






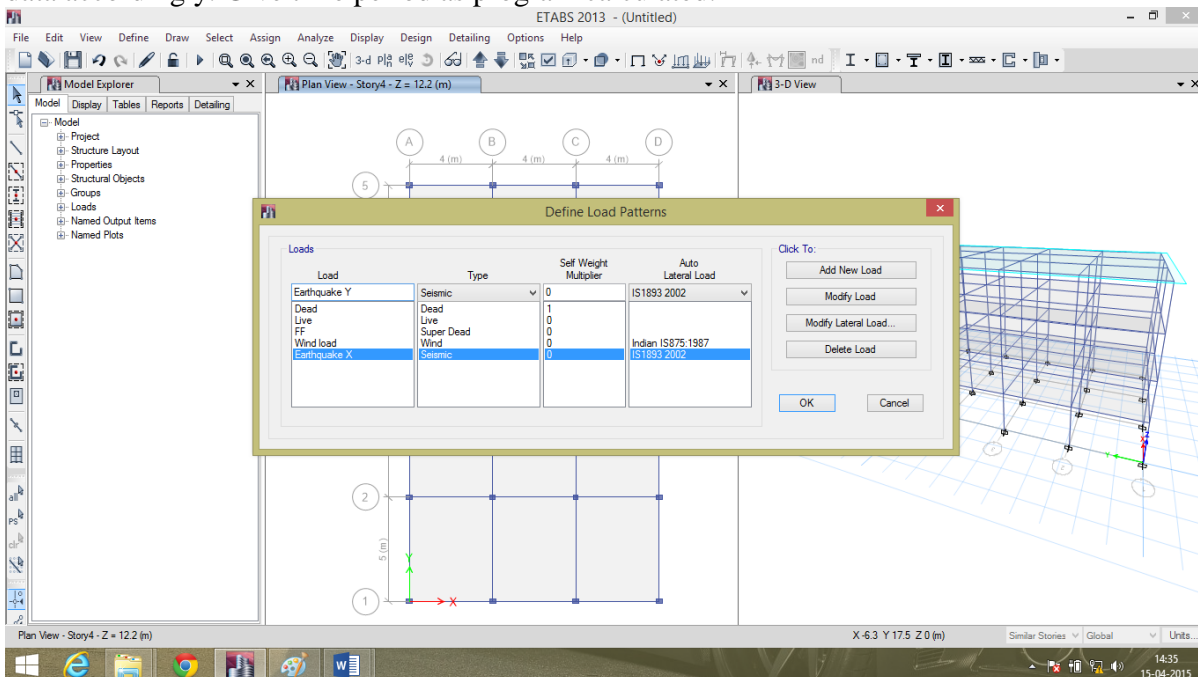
A dialogue box appears, deselect Y direction forces to assign earthquake load in X direction. Modify Zone factor, site type and response reduction data accordingly. Give time period as program calculated.

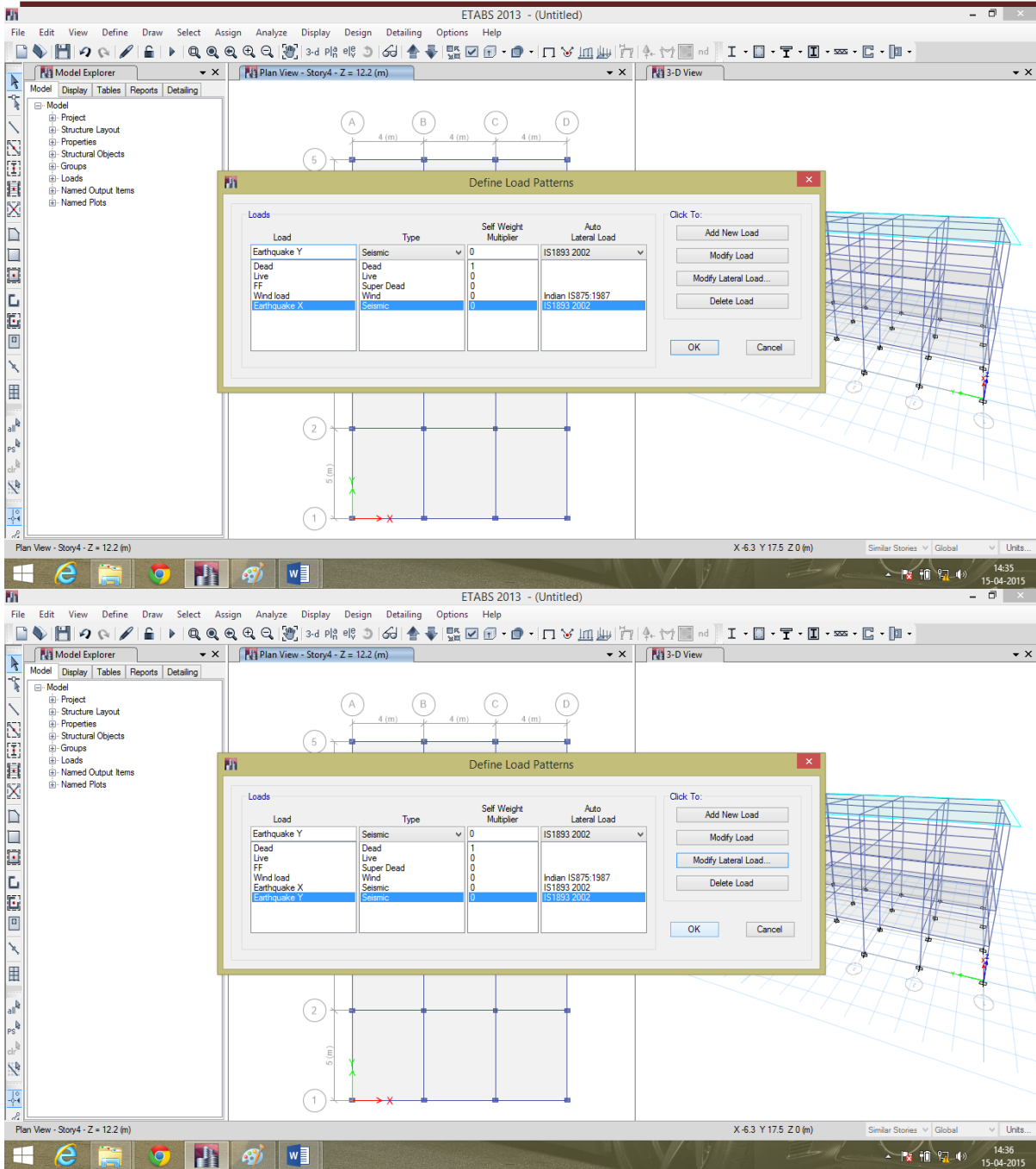




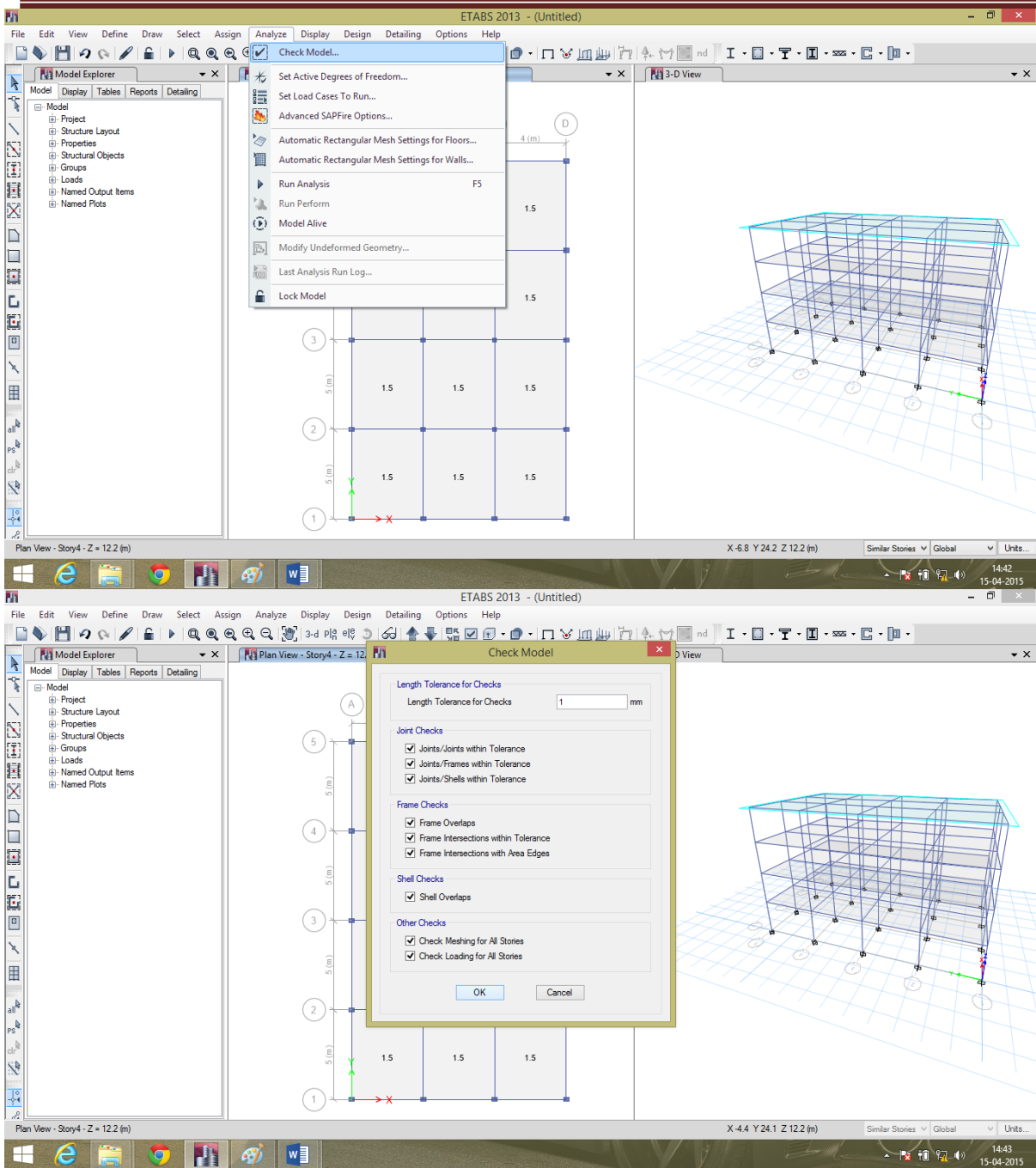
In Y direction

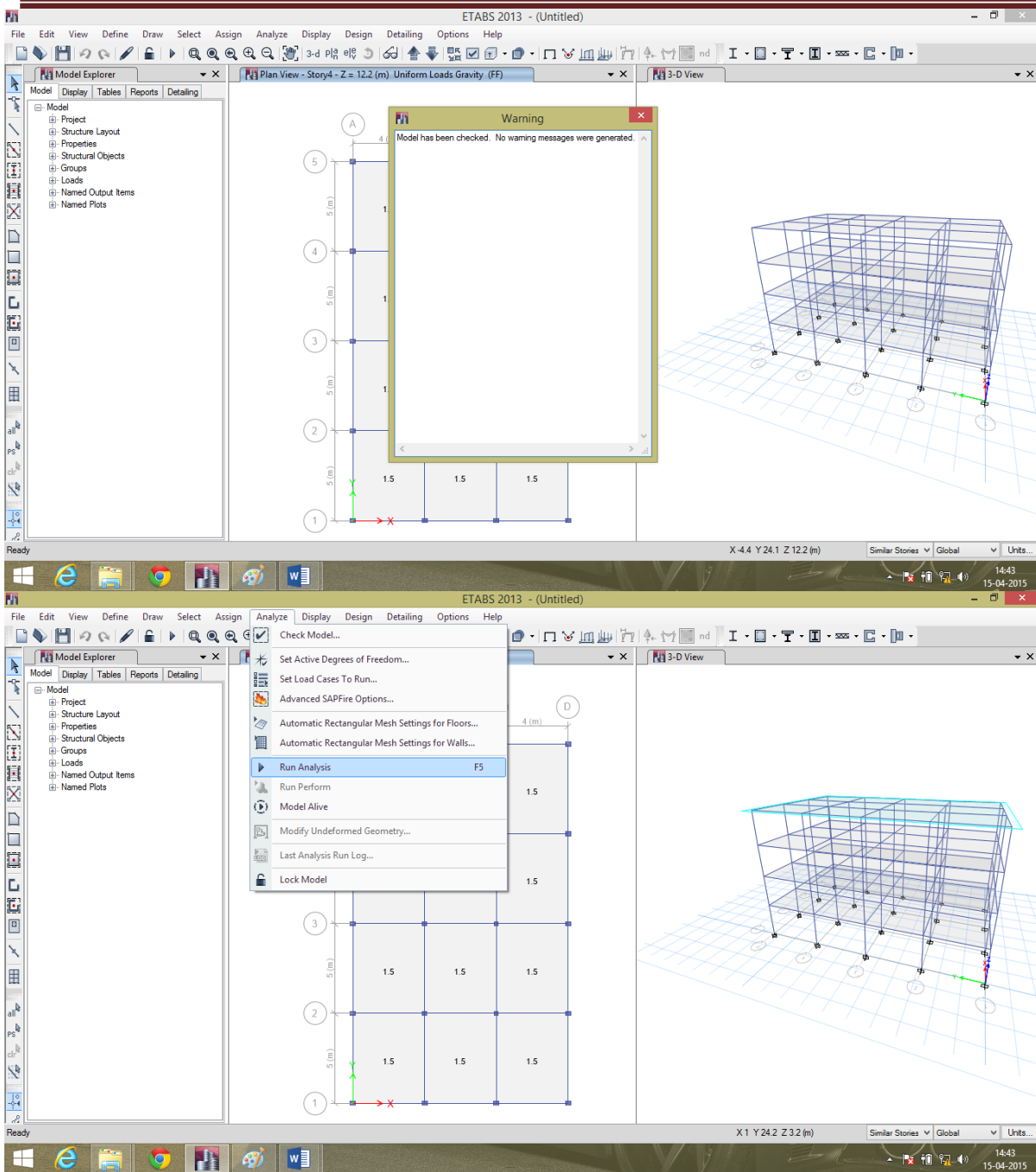
Similar to defining the Earthquake load in X direction, define the force in Y direction also by deselecting X direction forces to assign earthquake load in Y direction. Modify Zone factor, site type and response reduction data accordingly. Give time period as program calculated.



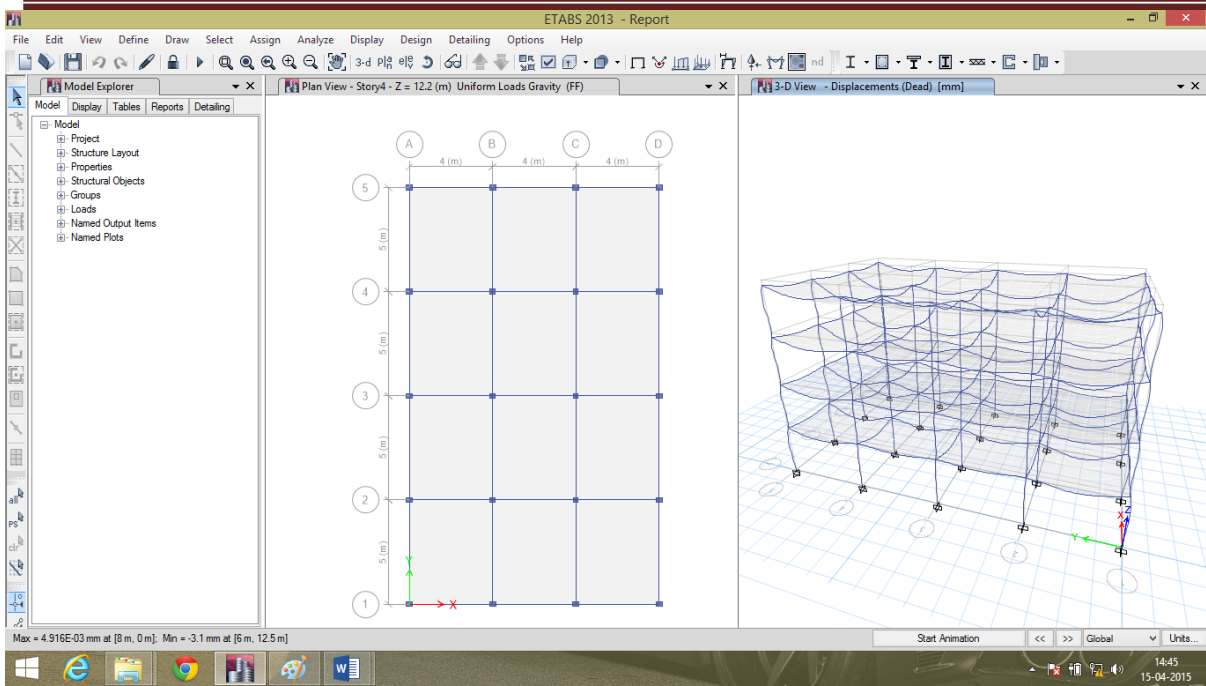


After assigning the dead loads, live loads, floor finish, wind load, earthquake forces in X and Y directions, Check the model for analysis. If no warning messages occur then go for running the analysis.





After running the analysis, we get an output as shown in the figure below. 3D model shows the deflected shape of the structure.



A C U

MODULE 2

PROJECT

MANAGEMENT

MODULE 2

Project Management

2.1: Basic features of Project Management

Project: Project is a temporary endeavor undertaken to create a unique product, service or result.

Project Management: It is the application of knowledge, skills, tools and techniques to execute projects effectively and efficiently. Project management is the process and activity of planning, organizing, motivating and controlling resources, procedures and protocols to achieve specific goals in scientific or daily problems.

Project management helps in following tasks:

- ✓ How long the project will take.
- ✓ The input on the overall project if a task is delayed
- ✓ Which tasks are critical
- ✓ Are sufficient resources allocated to the project to complete on time??
- ✓ The resource costs of the project
- ✓ Is the project on schedule?

Project management can be broken down into three phases:

- Creating the project plan: Identifying the tasks to be completed and organizing the resources available to complete the tasks.
- Managing the project: Ensuring that the allocated resources complete the defined tasks on schedule and within budget.
- Progress Reporting: Procuring reports on project progress.
- The steps involved in setting up of a project:
 - a. Set a schedule: create a workday and holiday schedule.
 - b. Define the project goals and determine what needs to be done.
 - Break the project into phases and subdivide phases into tasks.
 - Identity project milestones
 - Estimate the duration of each task.
 - c. Determine the sequence of tasks:
 - Which tasks can be completed at the before others?
 - Which tasks can be completed at the same time?
 - Define task constraints.

- d. Assign resources:
 - Who is needed for each task?
 - What equipment is needed for each task?
 - What facilities are necessary?
- e. Review the Plan
- f. Review the plan:
 - Verify the accuracy and completeness
 - Circulate the plan for review.
- g. Additional planning issues:
 - Budget and cost constraints
 - Who else needs project status information?
 - What are the consequences of missing deadlines?

Critical Path Method (CPM):

This refers to a mathematical model that takes into account the relationship between tasks, their duration and any constraints regarding the availability of resources to identify which tasks are critical. A task is critical when its delay could affect the end date of the project.

Program Evaluation Review Technique (PERT):

A PERT chart, sometimes called a network chart, refers to the graphic representation of how the tasks are lined to one another. This chart is useful when it is more important to focus on the relationships between tasks rather than the time schedule.

Gantt chart:

Henry L Gantt developed a graphic charting system to depict activities across a time scale. The Gantt chart can be used in Microsoft project to build a project as well as track and report it.

Views:

A view is a format in which you enter and display information. The gantt chart view is the default view. It is made up of the entry table on the left, used to enter task information and the Gantt chart on the right.

Views fall into three categories:

- Sheet views
- Chart and graph views
- Form views

Changing views:

Project comes with 24 predefined views. You can use the view menu to change views or the view bar located on the left side of the project window. The view bar lists 8 of the most commonly used views which are described below:

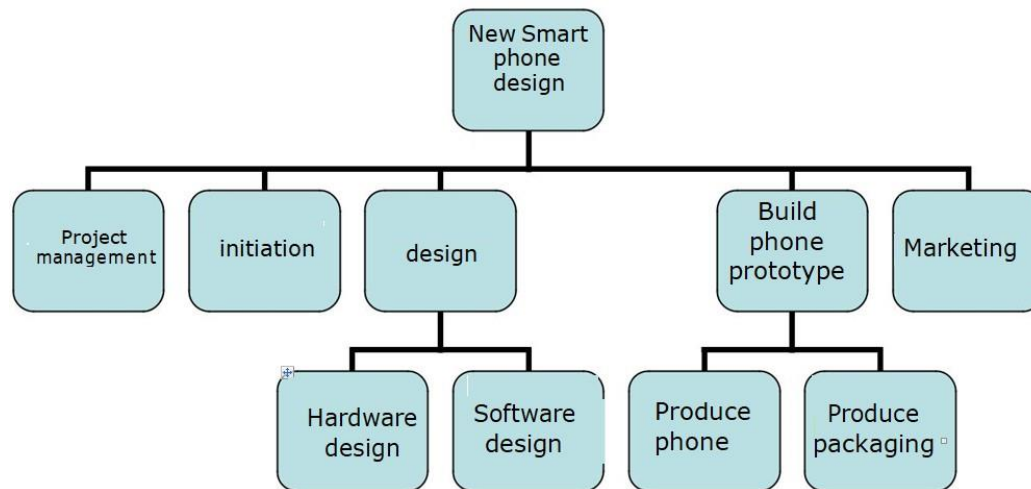
- 1) **Calendar:** a monthly calendar showing tasks and their durations. Use this view to show the tasks scheduled in a specific week or range of months.
- 2) **Gantt chart:** A list of tasks and related information and a chart showing tasks and their durations over time. This is the most commonly used view to enter and schedule a list of tasks.
- 3) **Network Diagram:** A network diagram showing all tasks and task dependencies. Use this chart to create and fine tune your schedule in a flowchart format.
- 4) **Task Usage:** A list of tasks showing assigned resources grouped under each task. Use this view to see which resources are assigned to specific tasks and to view resource work contours.
- 5) **Tracking Gantt:** A list of task and related information and a chart showing baseline and scheduled Gantt bars for each task. Use this view to compare the baseline and schedule with the actual schedule.
- 6) **Resource Graph:** A graph showing resource allocation cost or work. Use this view to display information about a single resource or group of resources over time.
- 7) **Resource Sheet:** A list of resources and related information. Use this view to enter and edit resource information in a spread sheet like format.
- 8) **Resource Usage:** A list of resources showing task assignments grouped under each resource. Use this view to show cost or work allocation information over time for each resource per assignment and to set resources work contours.
- 9) **More view:** Opens the more view dialogue box which displays a list of every view available.

2.2: Construction of Project

Aim: To start with new project in software, create a new project and explore the project guide & create a new calendar.

Theory: Development of a project need all basic data regarding the project which includes project start date, end date, resources, budget etc. Work Breakdown Structure (WBS) is the hierarchical arrangement of all activities involved in a project by linking with one another.

A work breakdown structure (WBS), in project management is a deliverable-oriented decomposition of a project into smaller components. A WBS may be a product, service, data, service or any combination of above. WBS is a hierarchical and incremental decomposition of the project into phases, deliverables and work packages. WBS is also called as an organized method of dividing a product into sub products at lower level details. Hierarchical decomposition of work is called work breakdown structure.



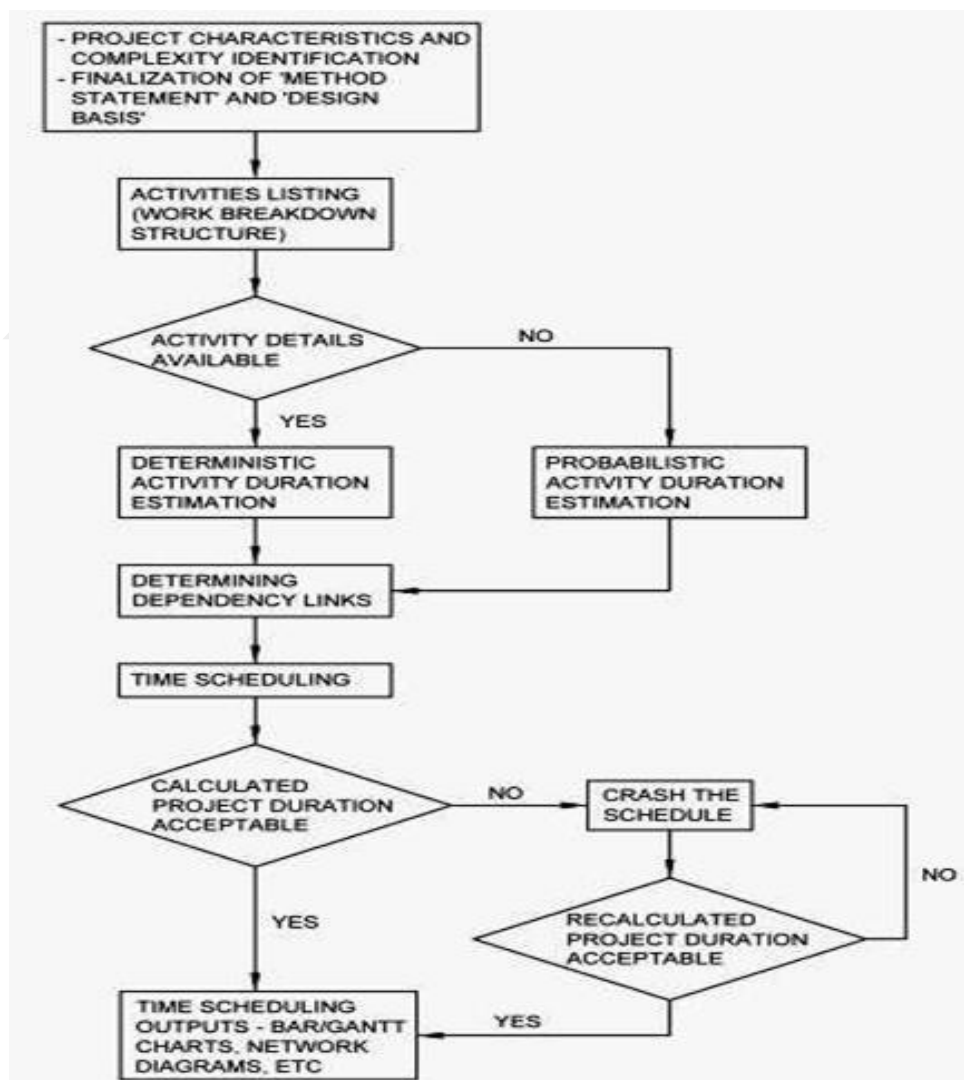
Sample of Work Breakdown Structure

Defining Project Activities: An activity is an identifiable, quantifiable, measurable and costable lowest element of work, which must be performed during the course of a project for achieving the project mission.

Principles of Project Planning

Planning is a process of preparing the proper commitments for resources in the most effective and efficient manner. In every organization, for planning, separate will be present which should follow certain basic principles to form an effective plan for the project.

- Information provided by the plan should be in readily understanding manner however complex the situation it may describe.
- Plan should be realistic and easily deliverable.
- Flexibility should be maintained while planning.
- Plan should be comprehensive



Steps involved in Project Planning

A project planning involves following steps:

- Define the scope of work
- Prepare a detailed list of activities to be performed
- Prepare a network diagram or a logic to establish relationship among different activities
- Analyze the network diagram to determine project duration, critical and noncritical activities in a project
- Identify the critical path with the help of critical activities
- Establish standards for the resources (men, material, machinery and money)
- Allocate the resources
- Forecasting budget allocation to achieve the target
- Organization of project information
- Recording the status report of every activity

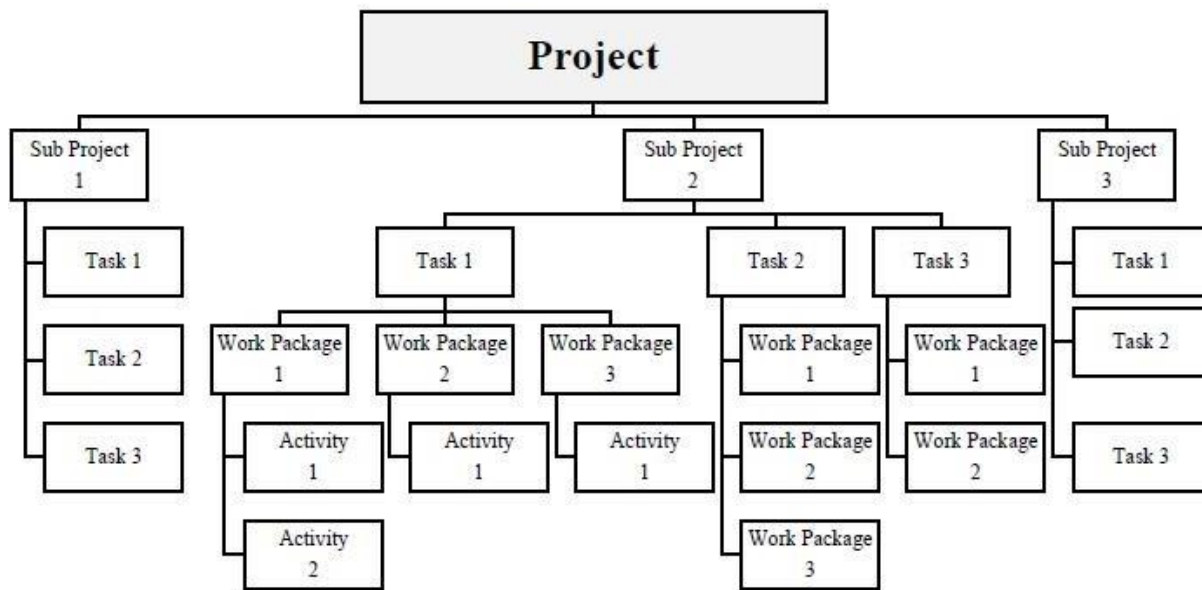
Project work scope can be broken down into manageable parts in a proper hierarchical order into levels of sub-projects, tasks, work packages and activities. Each descending level of WBS signifies a detailed description of the elements in preceding project level.

Sub-project level: It is an independent deliverable end product containing multi task which will be having large volume of work.

Task level: It is an identifiable major work containing one or more work packages.

Work-package level: It is a sizable, identifiable, cost-able and controllable work or item with package of activities.

Activity level: It is identifiable lower level job or operation which consumes time and resources.



Typical WBS format

Construction Planning Techniques

LOB Technique

This technique can be effectively used where repetitive works carried out or structure of similar types built. This method is best suited for repetitive operations, such as pipe lines, tunnels, highways and housing colony. LOB technique is very simple to understand and optimum resource allocation is possible.

Matrix Schedule

This technique is good for high rise buildings with successive floors of repeating floor plan. This method is easy to understand and need no explanation. Logical relationship among various sub-contractors can be shown by this technique very effectively.

Graphical Evaluation and Review Technique

This method involves concept of CPM and PERT. Here an activity can start only after the completion of previous depended activity. It is very advanced technique where complex projects can be handled very effectively.

Project Scheduling

Construction Project Scheduling is a graphical representation which shows the proper phasing of construction activities with their starting and completion dates and sequence of relationship

among various activities or operations in a project so that work can be carried out in an orderly and effective manner.

In construction field, every project is time bound. Every project defines clear objectives which specifies the completion time of project. Cost and time are correlated in every project. Schedule must be always proper, well defined. Because, improper scheduling lead to create delay and loss in project.

Objectives of Scheduling

Scheduling is a process of putting the construction plan on calendar basis. Schedule with proper network diagram shows the sequence and interdependencies of activities, their time duration and their earliest and latest completion time with optimum allocation of budget and resources. Success of any project depends on three main parameters:

- **Time:** It is important factor on which the schedule is worked out, until there exist any constraints such as resource or site specific conditions.
- **Budget:** All resources of project are planned and then cost of the project estimated which forms the budget of project.
- **Quality:** Obtaining required quality is up most important factor in any project.

The work should fulfill owner's requirements within given budget. Quality can be maintained by milestone activities which help to check the required quality before continuing with the next activity.

Milestones

Milestones in project schedule, defines point of time indicating start or finish a group of activity. In WBS, milestone can be any component. Project scheduling depends on these milestones by setting their planned dates of start and finish as intermediate project targets. These milestones help during assessment of project status at senior management level and to take proper decisions for the project. Highlighting these milestones in network of activities helps in project management.

Scheduling Procedure

Every project needs proper scheduling of activities and all scheduling techniques use time scale along the horizontal axis. Schedules are best presented in bar chart form for better

communication. Scheduling need work experience for proper plan. It gives an exact time table for construction activities. Several steps involved in project scheduling:

- Estimating the time duration required for every activity on the network.
- Assign and arrange the activities by logical sequencing, so that simultaneous activities at a time are made possible to minimize time consumption.
- Using these estimates and sequences of time, compute the total duration of the project.
- Estimation of time intervals within which every single activity must start and finish with respect to completion date requirement.
- Estimation of quantity of work for every individual activity involved in the project.
- Identifying the critical activities in the network by means of CPM.
- If project completion date is fluctuating then shorten the project duration as much as possible for least possible cost.
- Utilize the float in network for activities by adjusting the start and end dates and minimize the resource conflicts by smoothening and leveling the resources.
- Finally make up a working project schedule which shows anticipated calendar dates for activities.

Project Scheduling Techniques

Commonly used project scheduling techniques are:

- Gantt Chart / Bar Chart
- Milestone Chart
- Logic / Network Analysis

2.3: Identification of Predecessor & Successor activities

Aim: Identify predecessor and successor activities by linking the activities in sequence.

Theory: Activities in a project are arranged in an order and linked with each other by proper sequence and overlapping. There are different logical sequences followed for linking the activities.

Logical Sequencing of Activities

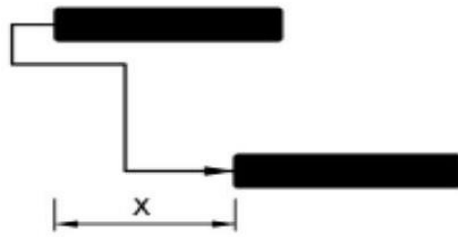
Sequencing of activities is a very critical task in scheduling. The dependency between activities classified into four types:

- **Finish to Start (FS):** Successor activity will start after the completion of predecessor activity.
- **Start to Start (SS):** Successor activity has to start when the predecessor activity already started and partially completed. For some duration, both the activities will take place simultaneously.
- **Finish to Finish (FF):** Successor activity has to finish only after the completion of predecessor activity. Here also both activities will take place simultaneously for certain period of time.
- **Start to Finish (SF):** There will be a relationship between the start of predecessor activity and finish of successor activity.

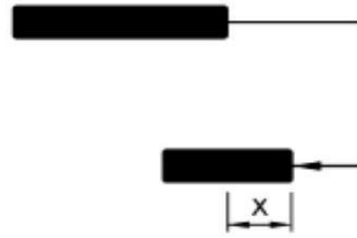
Lead and Lags show time differences between two components of dependent link. Lead shows the acceleration of successor activity with respect to predecessor one and Lag shows the Delay between dependent components of successor activity with respect to predecessor one.

By identifying the predecessors and successors, Gantt chart is developed which shows the activities on a bar chart.

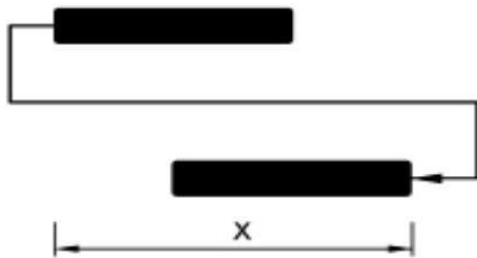




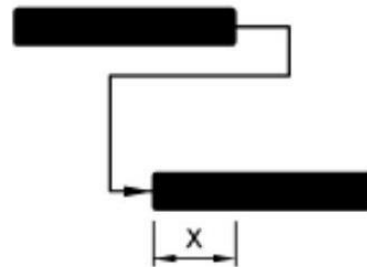
START TO START WITH X DAYS LAG
(SS + X DAYS)



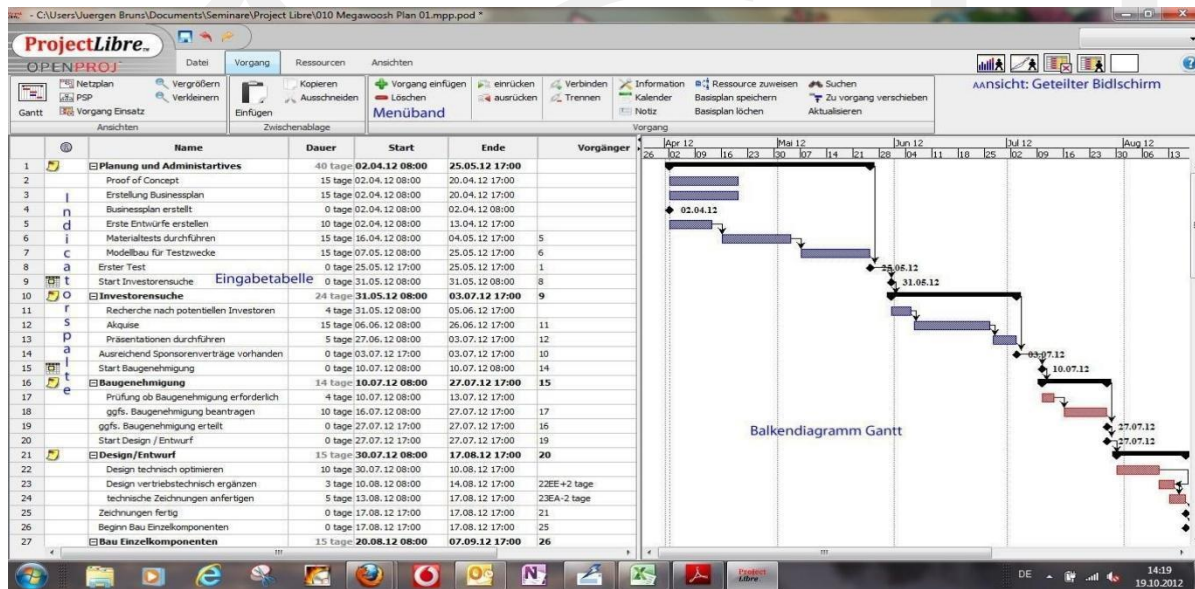
FINISH TO FINISH WITH X DAYS LAG
(FF + X DAYS)

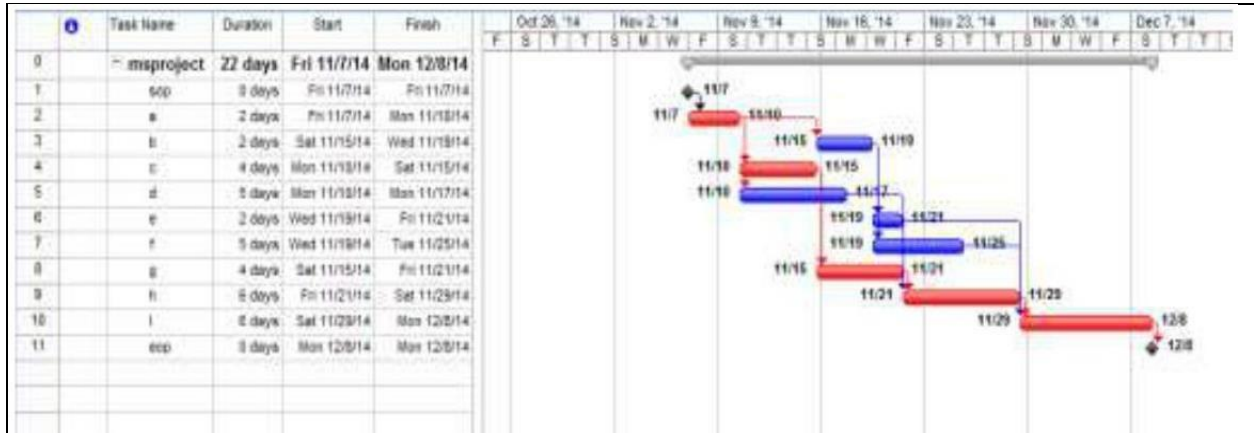


START TO FINISH WITH X DAYS LAG
(SF + X DAYS)



FINISH TO START WITH X DAYS LEAD
(FS - X DAYS)





Typical Example of Gantt Chart

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2.4: Constructing Network Diagram & Analyzing Critical path

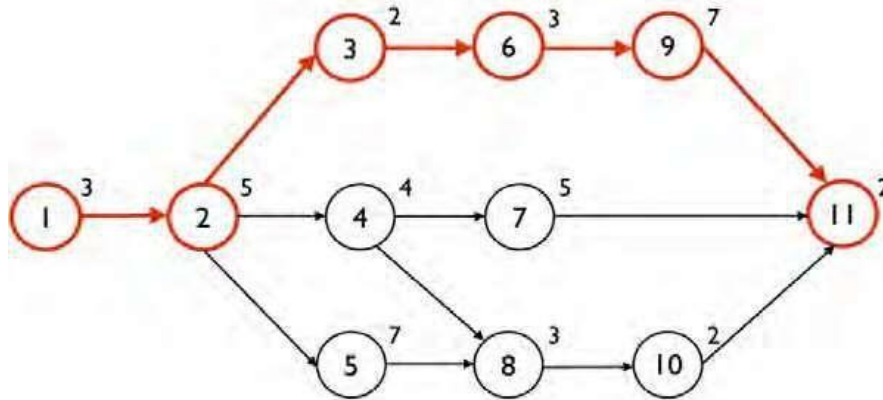
Aim: Formation of network diagram and identifying the critical path and critical activities for the project and also calculating the project duration.

Theory: Network Analysis is a name given to certain techniques of project management planning, managing and controlling of activities. It involves development of network which indicates the logical sequence of all the activities present in a project. First job should be defined and then should integrate the elements of particular job in a logical sequence and should control the process as per plan. CPM and PERT are the most popular methods of network analysis.

Critical Path Method (CPM)

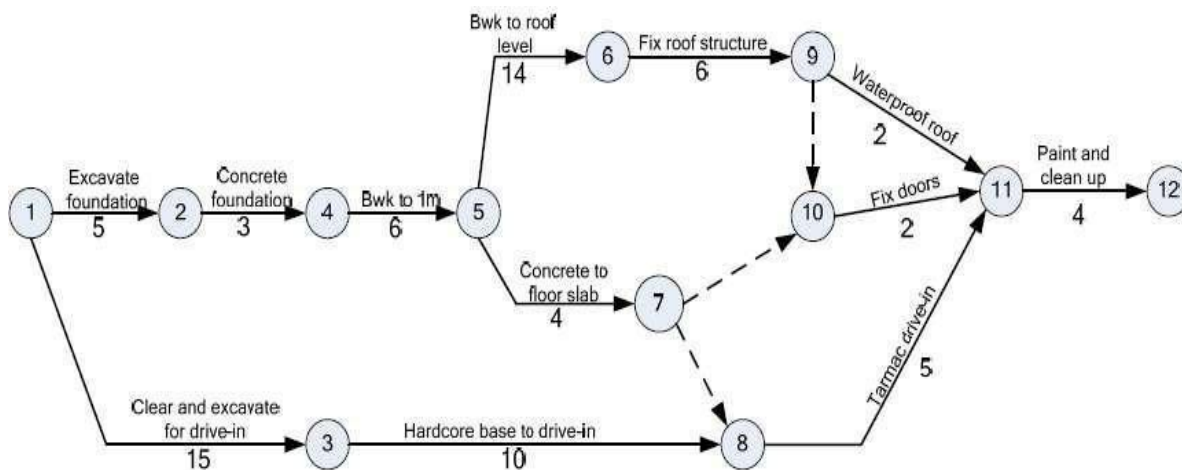
Critical Path Method is a process of planning, scheduling and controlling the activities of a project. It is a mathematically based algorithm for scheduling the project activities. CPM developed in the late 1950s by *Morgan R. Walker of Dupont* and *James E. Kelley, Jr. of Remington Rand*. Researches were going on how best to utilize project time and to reduce gaps. To determine how best to reduce time needed to perform routine plan maintenance; many researchers tried and finally developed CPM as an effective method. CPM networks are used for usually repetitive type of projects where accurate estimates of time can be made for the project related activities. Very small amount of variations are possible in this method; hence this method is not suitable for research and development type of projects.

CPM is a network which is based on activities; which are planned and monitored. Events are milestones in this network which represent start or end of certain activity or group of activities. It follows a proper deterministic approach, where it carries out only one time estimate; without considering any uncertainties. In CPM, activities and events form a model where each event is followed by an arrow.



Typical example of Critical path network diagram

Critical Path: Longest path in a network diagram which represent maximum time duration is called as “Critical Path”. The duration obtained by critical path is considered as the total project duration. In this critical path, a set of events will be present whose slack value will be zero. In fig example for a CPM given, where red colored path shows the critical path and the events lying in this path are known as “Critical Activities” and the circles lying in this path known as “Critical Events”. If there is any delay in non-critical activity, then it will not affect the total project duration in any manner; but if there is any delay in critical activities, then it would definitely affect the total project duration. Hence, a top most focus must be given to these critical activities to avoid delay in project completion. If the time duration obtained by such network analysis is not accepted by project authorities, then such critical activities will have to be crashed by involving additional direct cost and resources are then diverted from non-critical activities to critical activities to avoid delay in project completion and to meet the requirement.



Program Evaluation and Review Technique (PERT)

PERT developed in the late 1950's for the U. S. Navy. In this, time and cost both can be checked. This technique commonly used in conjunction with CPM for a given project. PERT helps in managing the multiple tasks which are occurring simultaneously. It can be used also in non-repetitive type projects where time and cost are quiet uncertain.

Comparison between CPM and PERT

- CPM is activity oriented network system where as PERT is an event oriented network system.
- CPM provides a fair degree of accuracy in estimation but in PERT, estimation of time is not much precise.
- Cost is the main governing factor in CPM, but time is governing factor in PERT.
- CPM follows a proper deterministic approach but whereas PERT follows probabilistic approach.
- Non-repetitive projects cannot be handled by CPM, whereas PERT can handle such type of projects.

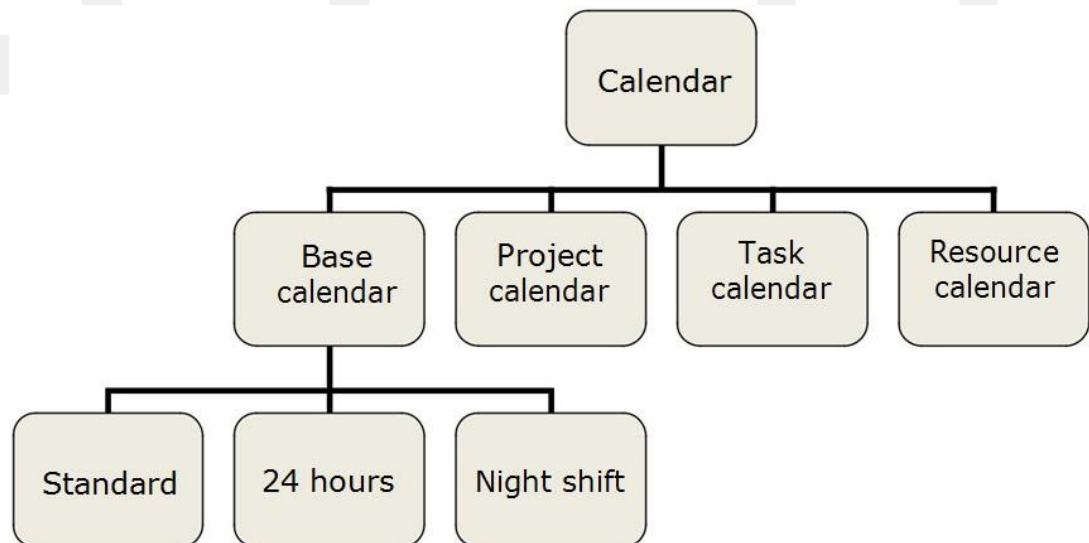
2.5: Study on various options in project management

Aim: Study of various options available in project management

Theory: Different options can be viewed in project management software's. Some of the main tools are discussed below:

1. **Lead & Lag Time:** If a task can start four days before the previous one is finished, a lead time of four days gets that successor tasks to start early. The start slack field contains the duration representing the difference between the early start and late start dates. The finish slack field contains the duration representing the difference between the early finish and late finish dates.
2. **Constraints:** Restriction set on the start or finish date of a task. You can specify that a task must start on or finish no later than a particular date. Constraints can be flexible or inflexible. With this, we can impose MSP to calculate the start and finish dates of task.
3. **Calendar:** Calendars are used to set project and resource working times to accurately reflect resource availability information. Calendar is the primary means by which we can control when each task and resource can be scheduled for work in a project.

Calendar types:



We can also provide work week by only selecting working days and work times. Also project management software gives opportunity to add exceptions and holidays in the work week to exactly calculate project duration.

4. Network Diagram: A standard project management has a various views, tracking form that indicates the detail workflow among the tasks in a project is the network diagram.
5. Resources: Resources are the people, supplies and equipments that enable us to complete the task in project. We can add quantity of resource required for every single task and calculate the budget required for resources.

2.6: Resource Creation & Allocation

Aim: To create resources in project and allotting them for different activities

Theory: There are different types of resources in a project. Namely,

- a) Work resources: indicates the people or equipment that consumes time when working on a task.
- b) Material Resource: These are the consumables required to proceed the activities in a project.
- c) Cost resource: it represents financial cost associated with a task that is needed to account for. For example, traveling expense, contractor bill, stationary for office etc.

The resources will be defined on a resource sheet and then each activity will be assigned with required resources from sheet.

2.7: Splitting, linking, merging of activities and creating baseline project

Aim: To split, link, merge the activities in a project

Theory: A relationship establishes the dependency between any two tasks. Tasks with dependency relationships are linked. A task that must occur before another task is a

“Predecessor Task” and that which must occur later in the relationship is a “Successor Task”.

In project management software, we can split an activity by giving different start and finish dates. Same way, linking of activities done by logical sequences, where network is generated. Sometimes different activities start together, and such activities can be merged with each other to get project duration within the critical schedule

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