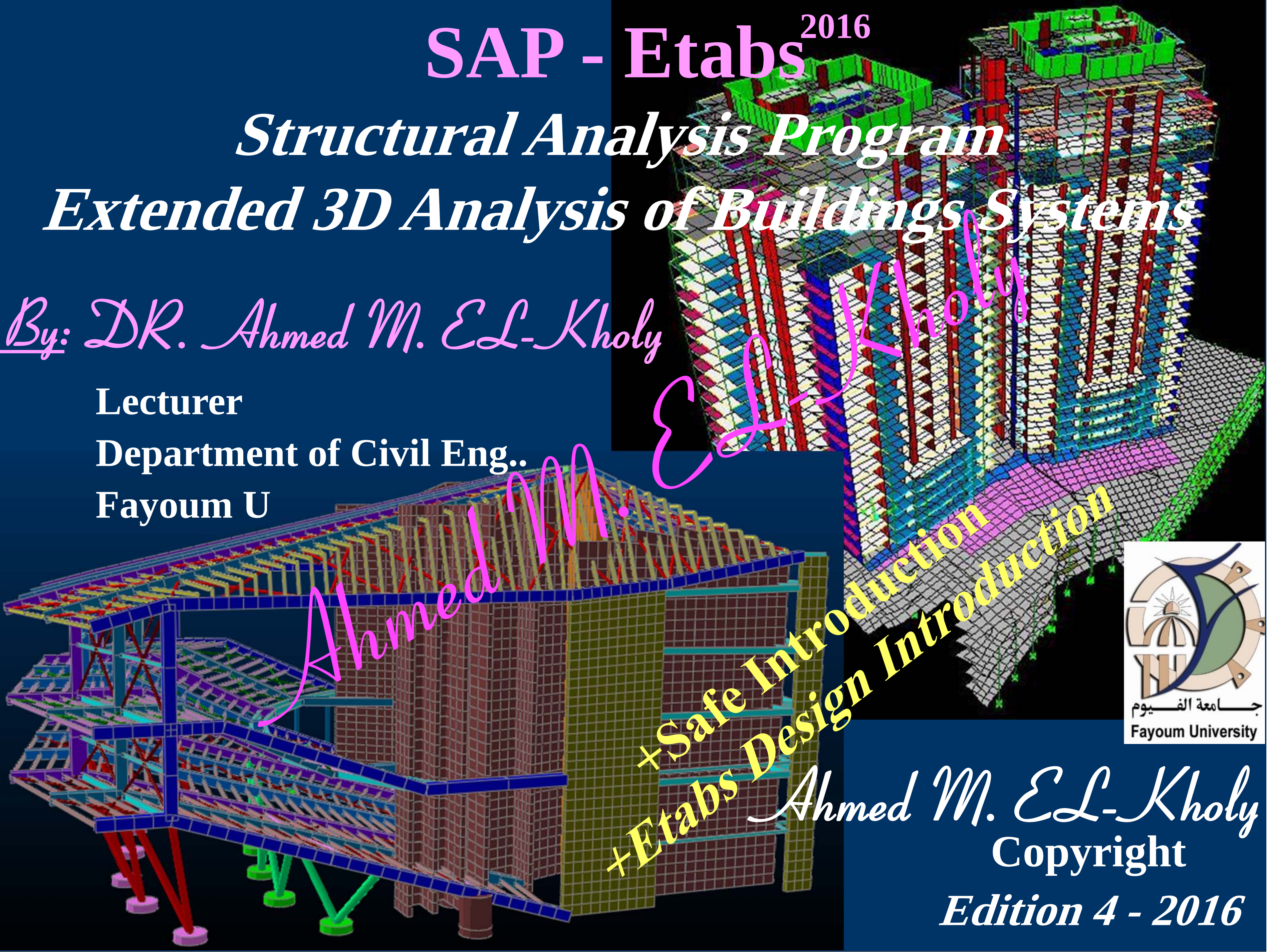
SAP - Etabs 2016

Structural Analysis Program
Extended 3D Analysis of Buildings Systems



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Fayoum U

+Safe Introduction
+Etabs Design Introduction

Edition 4 - 2016

جـــامعة الفـــيوم
Fayoum University

1- Schedule

2- SAP ??? Or Etabs ???

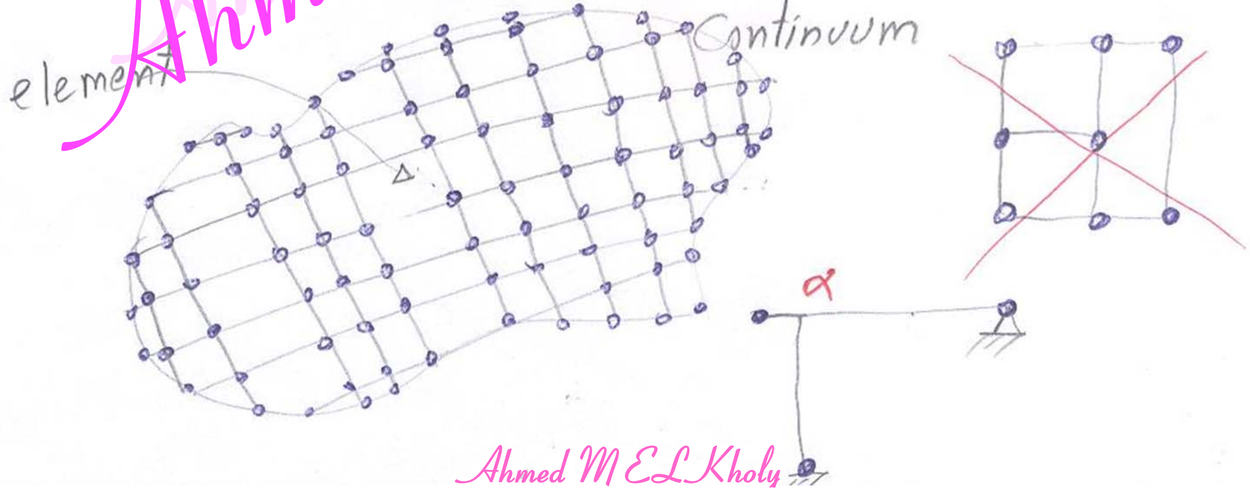
3- Examples

Important Brief
Introduction
to
Finite Element Method
“FEM”
Finite Element Analysis
“FEA”

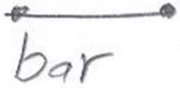
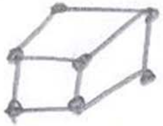
Finite Element Method

① FEM is widely Used in structural analysis. It is also Used in wide range of physical problems including heat transfer, speepage, flow of fluids and electrical and magnetic potential.

② In FEM, a Continuum is idealized as an assemblage of finite elements with specified nodes. The ∞ number of DOF of Continuum is replaced by specified unknowns at the nodes.

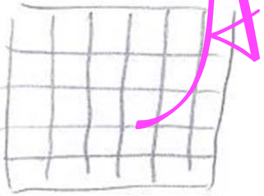


③ The use of PC is essential in FEM because of the large N of DOF commonly involved.

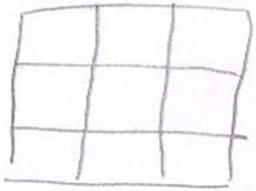
④ Elements: 1D  bar, 2D  , 3D 

⑤ For finite elements other than bars, "exact" element matrices can not be generated and "exact" solution can not achieved.

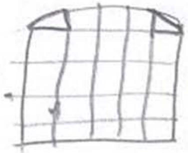
⑥ For finite elements other than bars, the more elements you use the higher accuracy you achieve.

⑦ 

fine mesh
high accuracy



Coarse mesh $\propto$
low accuracy

⑧ Avoid triangular element as much as possible. 

⑨ Aspect raito (a/b) Should be close to 1 as much as possible.

Preferable → $a/b \not> 4$

Should not → $a/b \not> 10$

Best $\theta = 90$

Must $\theta \not> 180$

Preferable $45 < \theta < 135$

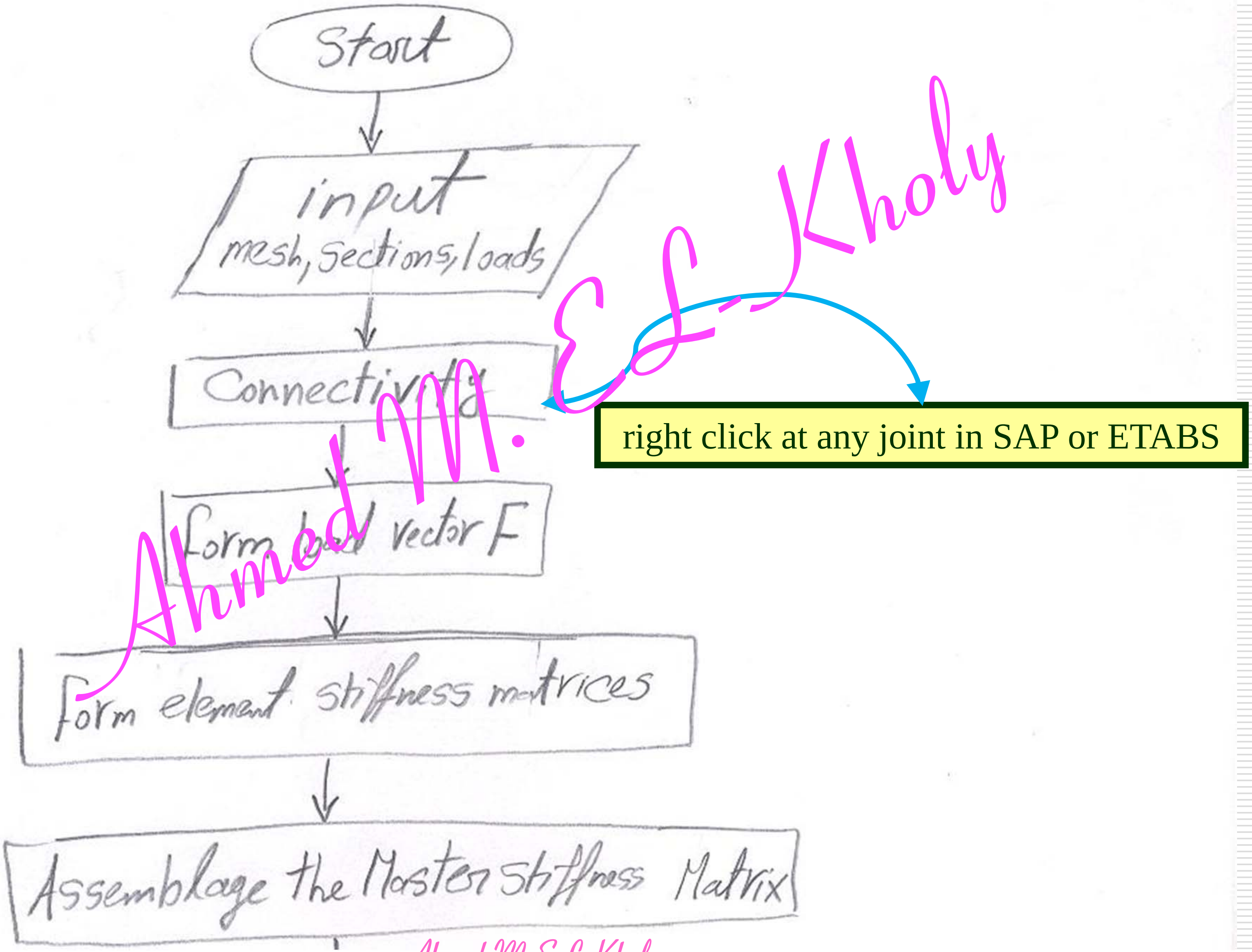
~~Whole approach~~

⑩ FEA is an application of the Matrix-Stiffness (Displacement) Method.

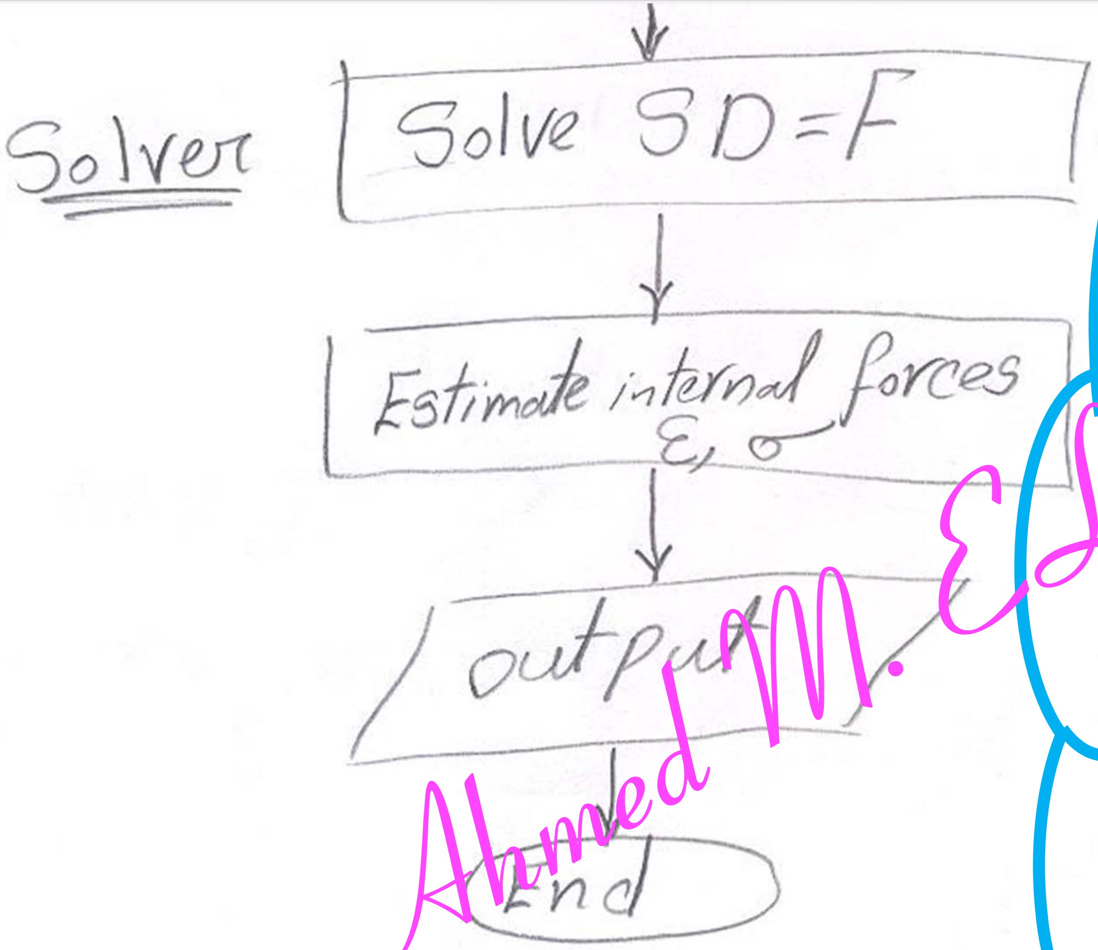
$$SD = F$$ at node, away of node

however S is different, S is exact for bars and approximate for 2D & 3D elements

Linear Static FEA



right click at any joint in SAP or ETABS



$D = S^{-1}F$

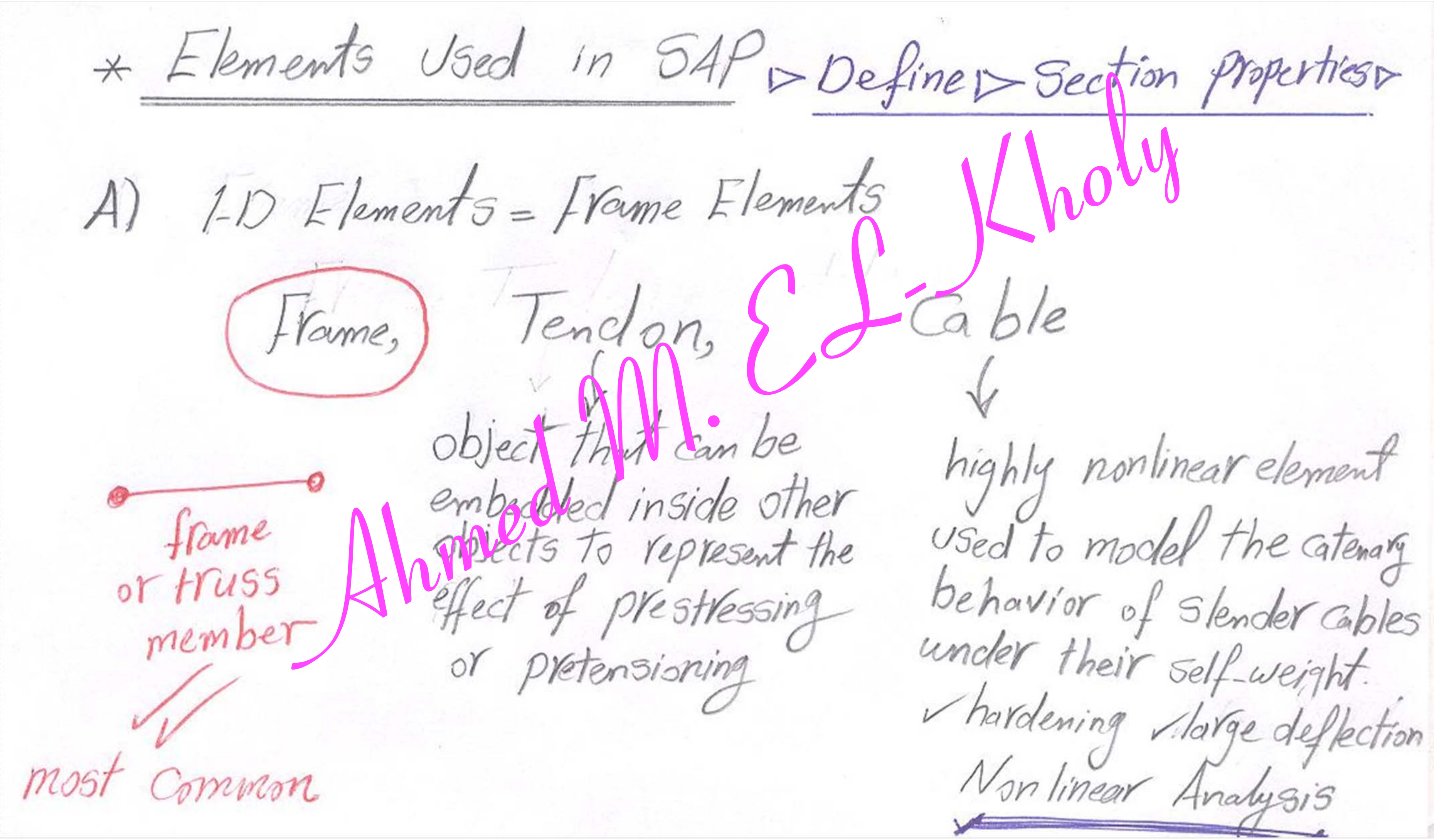
Displacement

First of all, You have to check the deformed shape on SAP or Etabs before reading any Straining actions or Reaction, ...

SAP

Structural Analysis Program

Important Brief Introduction to **SAP**



* Elements Used in SAP ▷ Define ▷ Section properties ▷

A) 1-D Elements = Frame Elements

Frame, Tendon, Cable

frame or truss member

✓✓ most common

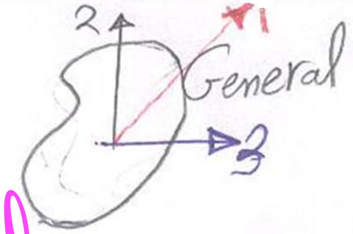
object that can be embedded inside other objects to represent the effect of prestressing or pretensioning

highly nonlinear element used to model the catenary behavior of slender cables under their self-weight.

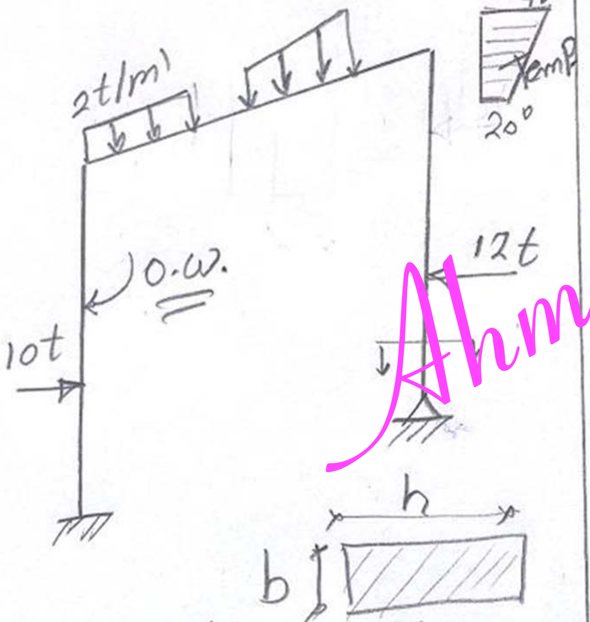
✓hardening ✓large deflection

Nonlinear Analysis

Frame element



- Inertia >>
- Area <<



A<< , I>>

Examples

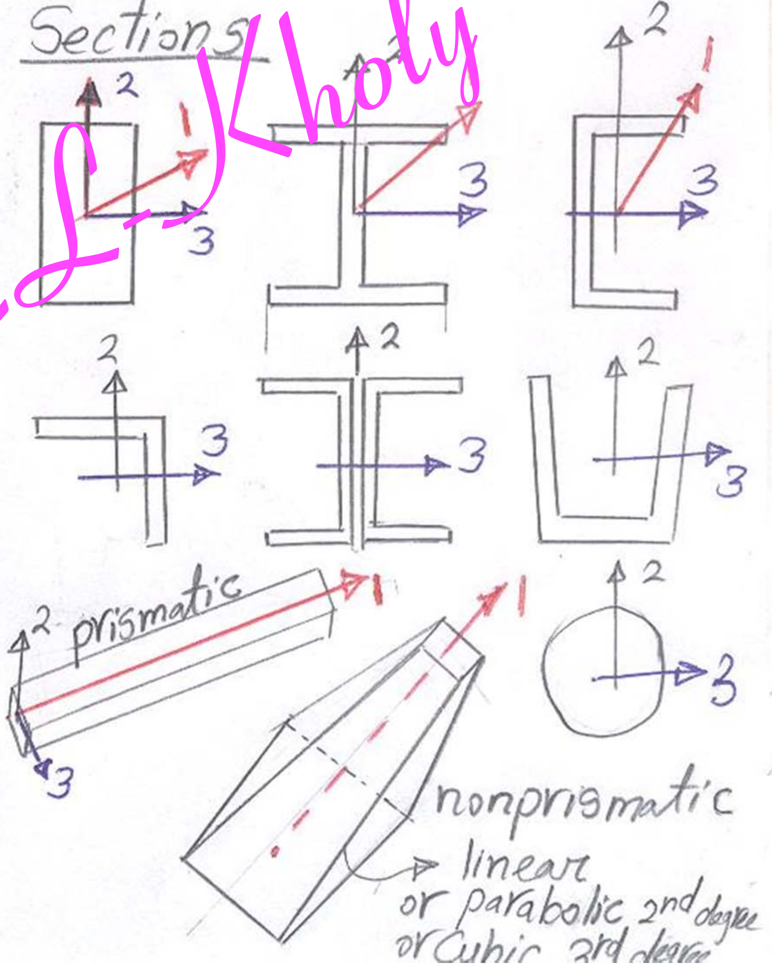
* Beam

* Column

* Frame
2D, 3D

* Truss
2D, 3D

Sections



linear
or parabolic 2nd degree
or Cubic 3rd degree

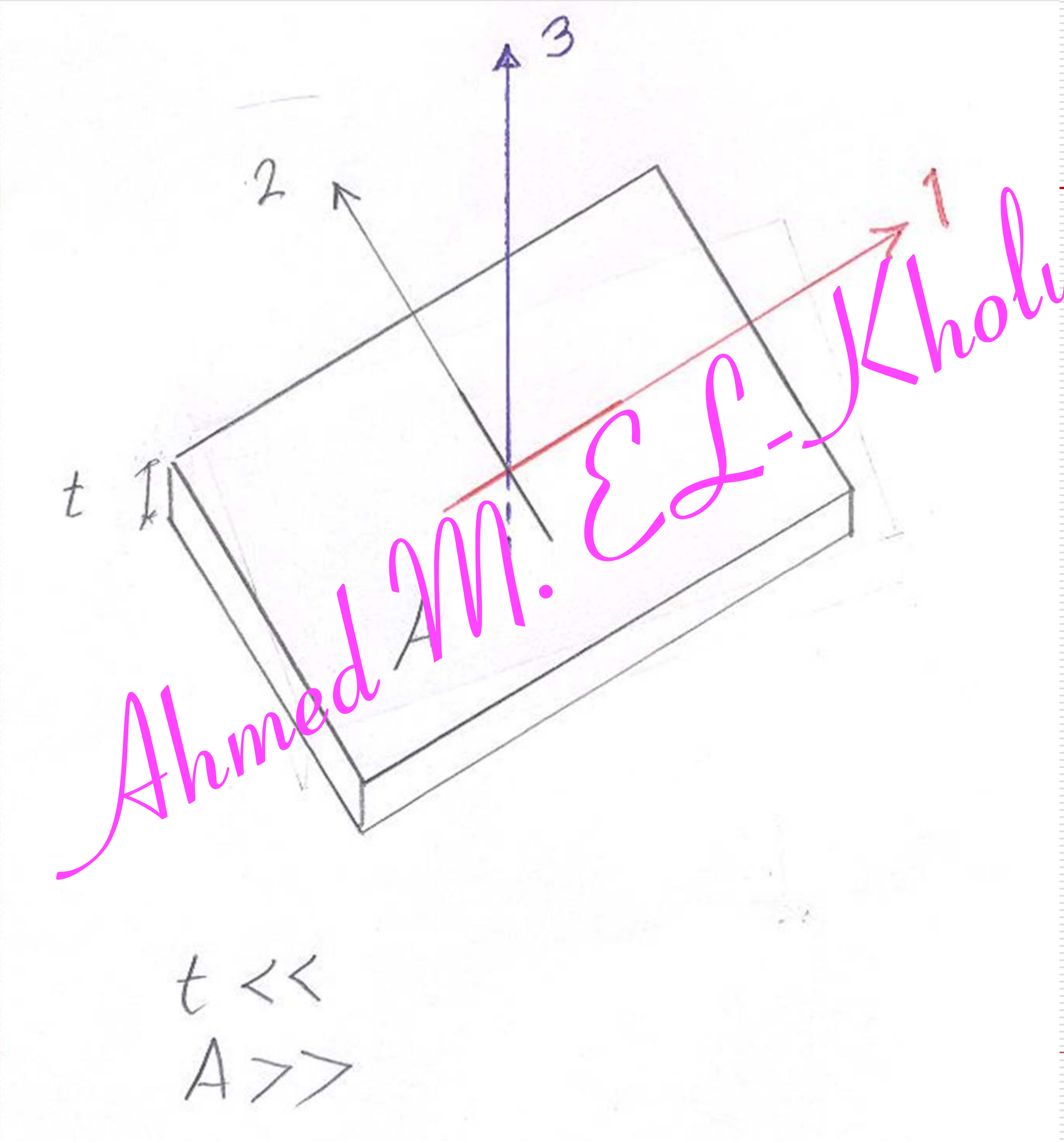
B) 2-D Elements = Area Elements

▷ Define ▷ Section properties ▷ Area Sections

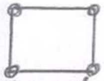
plane , Asolid , shell

three types available in SAP.

? Area Element	Examples	Loads
• Inertia ≪	• Slabs	• O.W.
• Area ≫	• Raft	• Pressure
• Covers an area with relatively small thickness.	• Tanks	• Temperature
	• Tunnels	
	• Pools	


3
2
1
t
A
t <<
A >>

Area Element Types

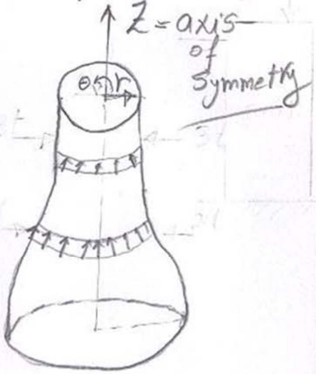

4 nodes

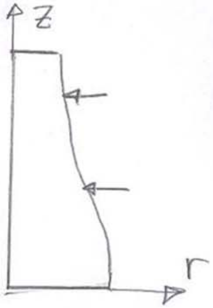

3 nodes

more general ?

Asolid Axisymmetric

- 2D Analysis
- In plane forces





thickness = θ = 360 ?

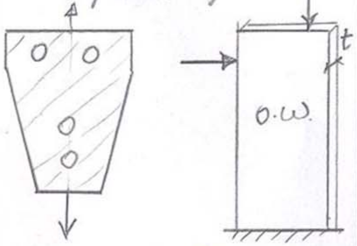
if θ = 0°

Sap puts θ = 1 rad

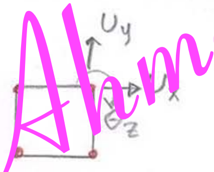
Plane (memberane)

plane stress

- 2D Analysis
- In plane forces



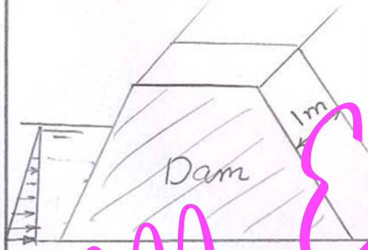
- Small t ?
- $\sigma_{out\text{-}plane} = 0$
- Gusset plate, Shear wall



- 3Dof at node

plane strain

- 2D Analysis
- In plane forces



- Large t, take unit t ?
- $\varepsilon_{out\text{-}plane} = 0$
- Dam, Culvert
- 3Dof at node

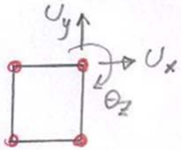
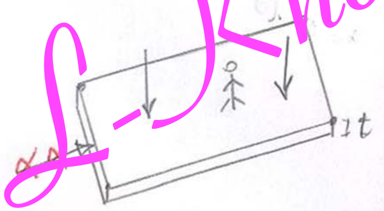
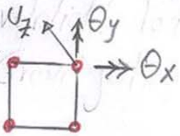


plate (bending)

- 2D Analysis
- Out of plane forces



- Small t ?
- No in-plane forces
- Slabs under vertical loads.



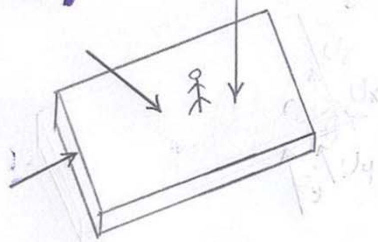
- Thin: Neglect transverse shear deformation ?
- Thick: Include transverse shear deformation ?
- Thick: $t \geqslant \frac{1}{10} \sim \frac{1}{5}$ Span

* transfer Slab → Use thick

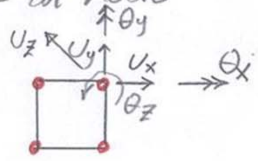
Shell

- 3D Analysis
- In + out of plane forces

? Shell ?
=
Plane (Memberane) + plate
t? t?



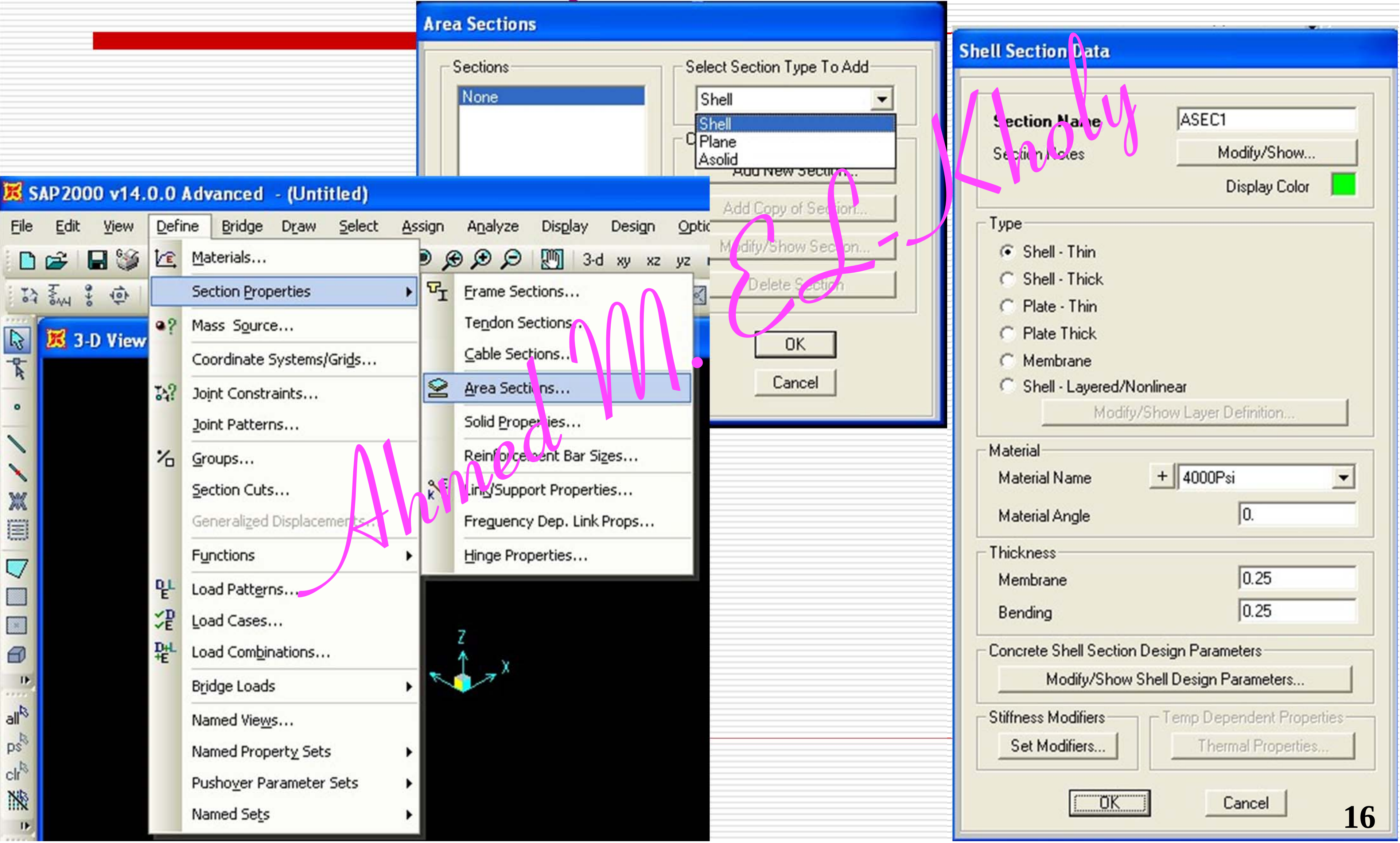
- Slabs under gravity loads and horizontal (Wind or EQ) loads
- 6Dof at node



Define Section properties Area Sections

Area Sections

..Define… Section Properties…Area Sections…



Area Sections

Sections: None

Select Section Type To Add: Shell

Shell Section Data

Section Name: ASEC1

Section Notes

Display Color: 🟩

Type

- ● Shell - Thin
- ○ Shell - Thick
- ○ Plate - Thin
- ○ Plate Thick
- ○ Membrane
- ○ Shell - Layered/Nonlinear

Material

Material Name: 4000Psi

Material Angle: 0.

Thickness

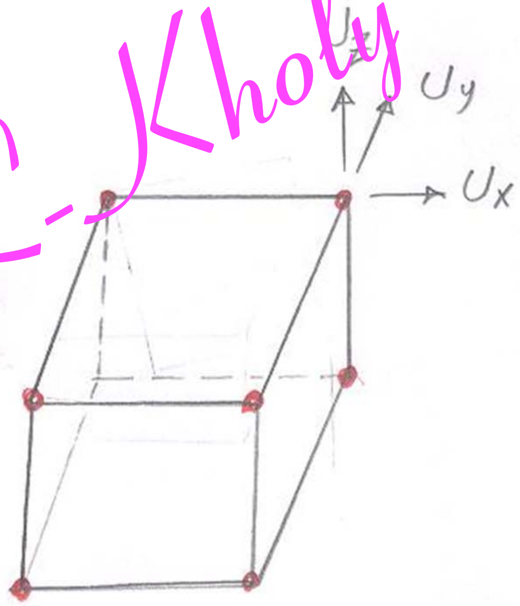
Membrane: 0.25

Bending: 0.25

C) 3-D Elements = Solid elements

▷ Define ▷ Section properties ▷ Solid properties

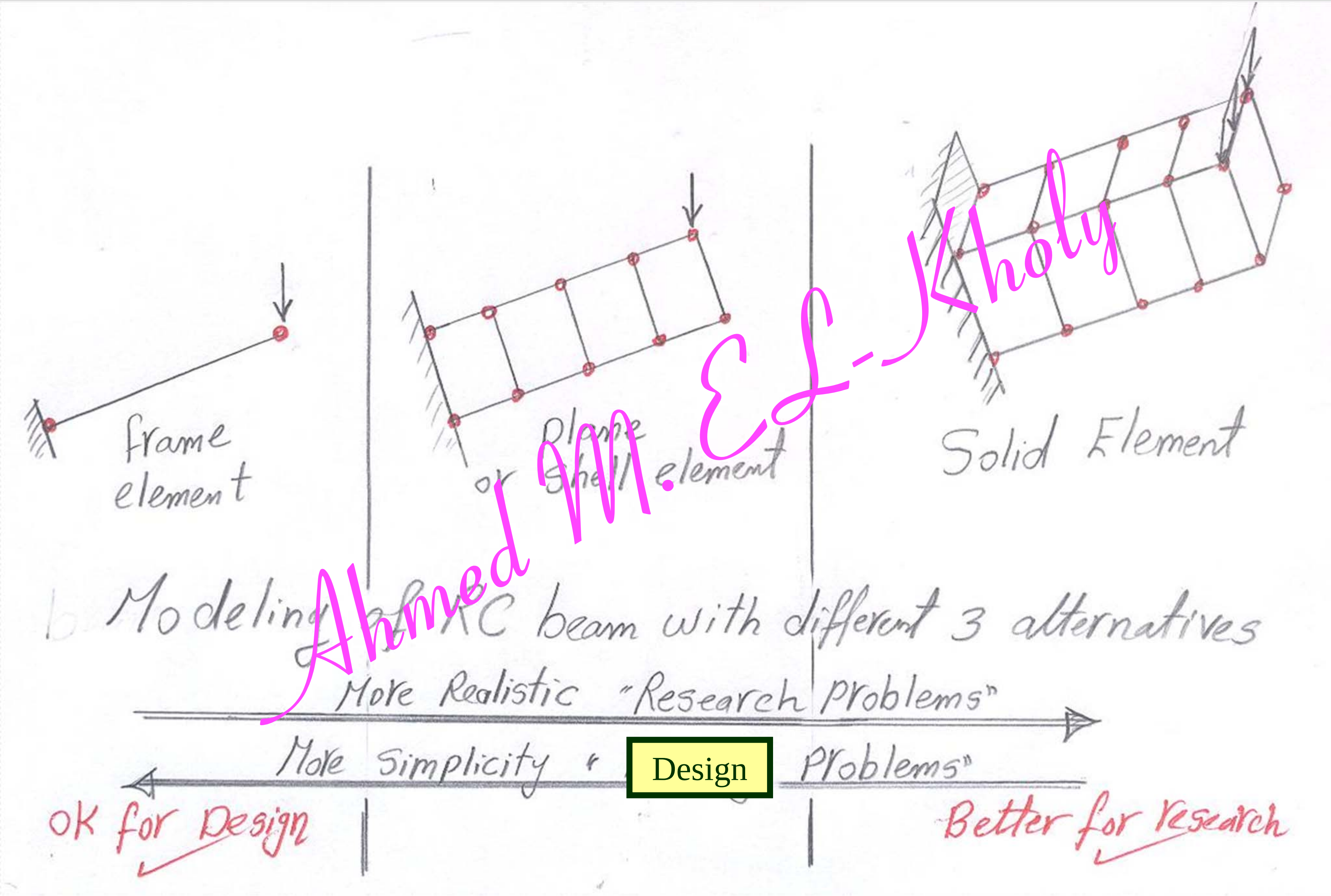
- 3-D Analysis
- Volume Structures
- Footing
- Research Concrete beam
- High Computation time



8 nodes

3 DoF at node

Typical Solid Element



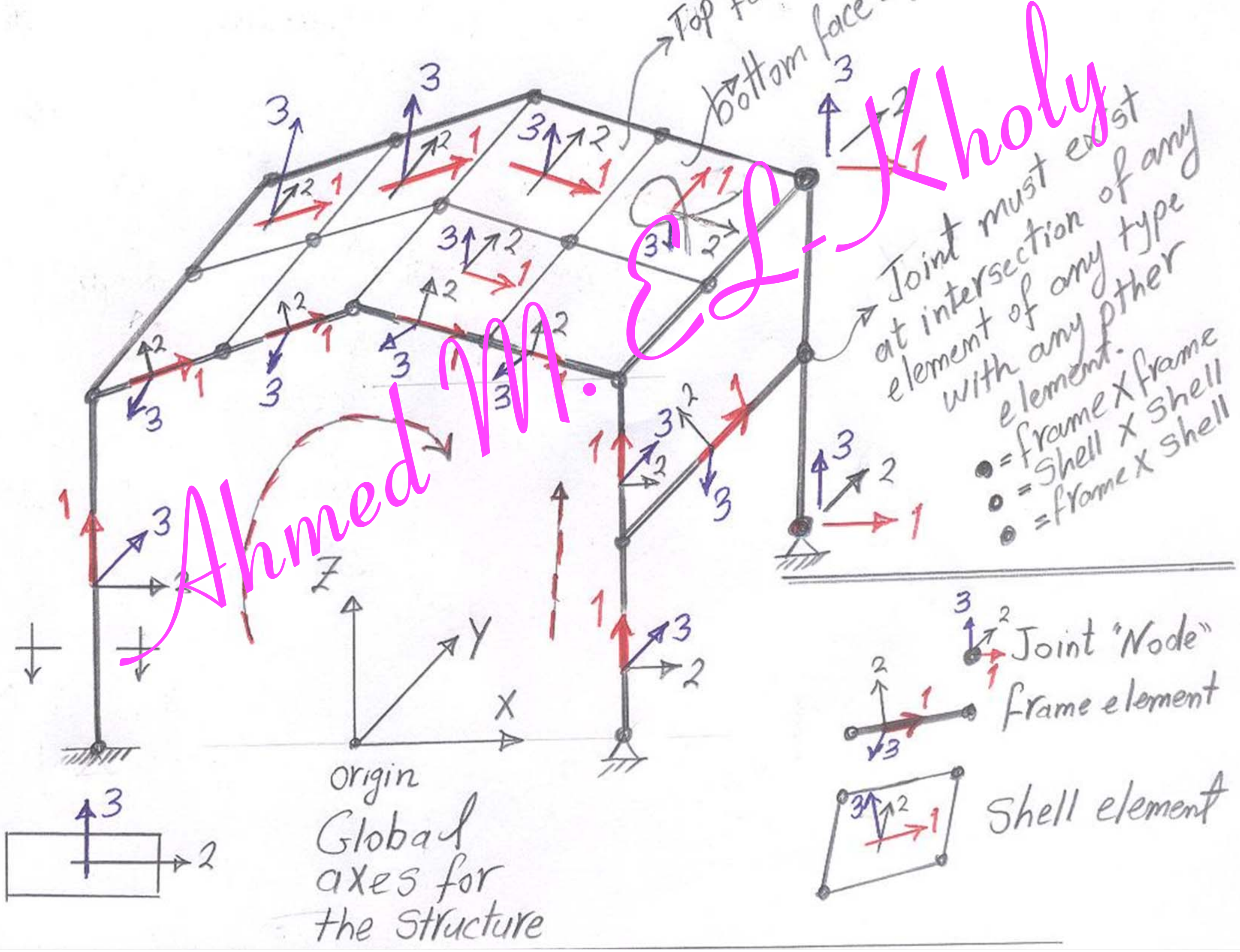
b- Modeling of RC beam with different 3 alternatives

Design

* Local axes and global axes

Top face = face6 = +3face = red color

bottom face = face5 = -3face = pink color



Joint must exist at intersection of any element of any type with any other element.

● = frame X frame
● = Shell X shell
● = frame X shell

Global axes for the Structure

* for joint, default 1, 2, 3 // x, y, Z

* for frame, 1 // axis of member, 2 ⊥ axis of member

* for shell, 1 & 2 in the plane of area, 3 ⊥ area

---

* for frames, Use  to get BMD ← مطلبه طاقر

---

* for shells, 1 axes have to be parallel to each other

2 axes " " " " " " "

3 axes " " " " (all upward or all downward)

to get readable moment

Frame output

$M_{33}, M_{22}, V_{22}, V_{33}, P, M_t$

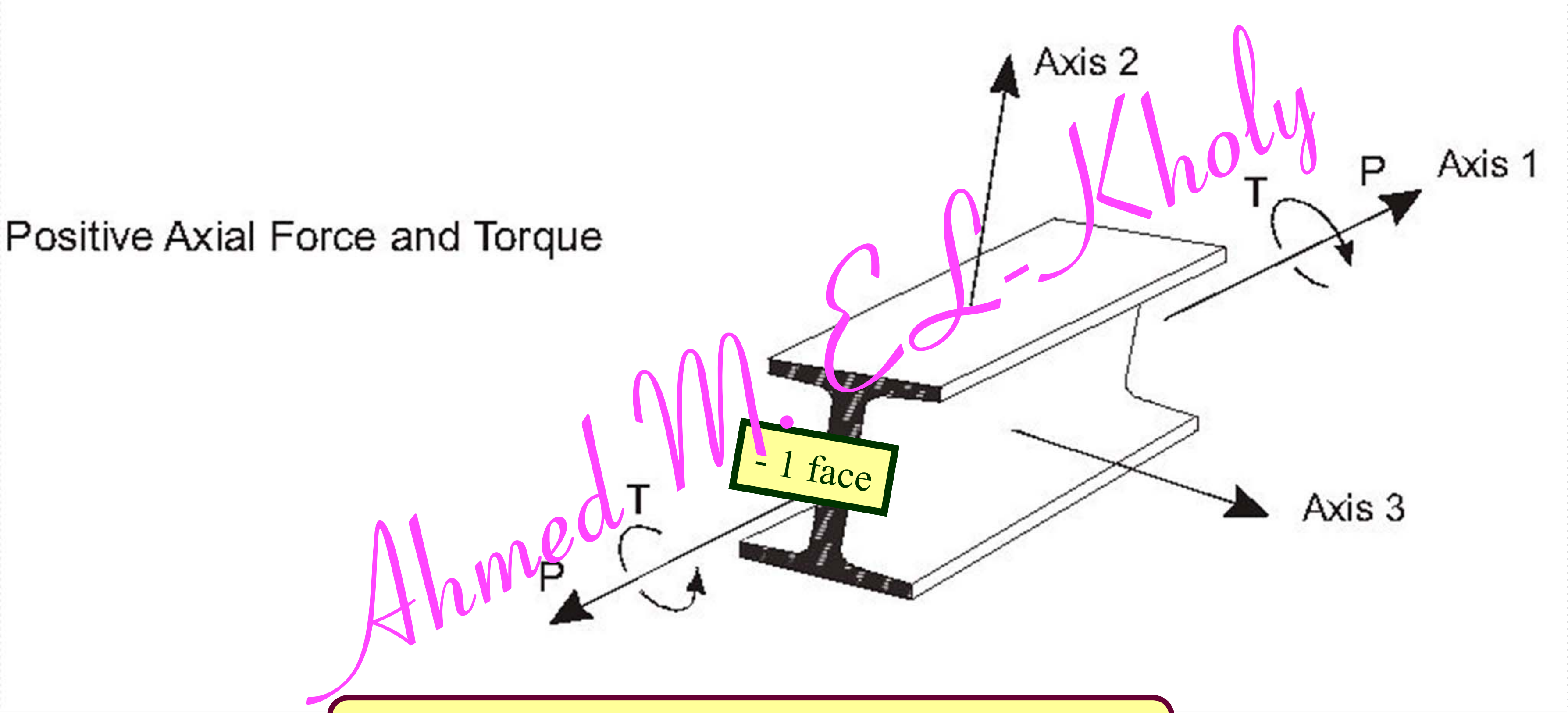
Shell output

$M_{11}, M_{22}, M_{12}, F_{11}, F_{22}, F_{12}, V_{13}, V_{23}$

Sign Convention

Accessing the Help

Frame Sign Convention

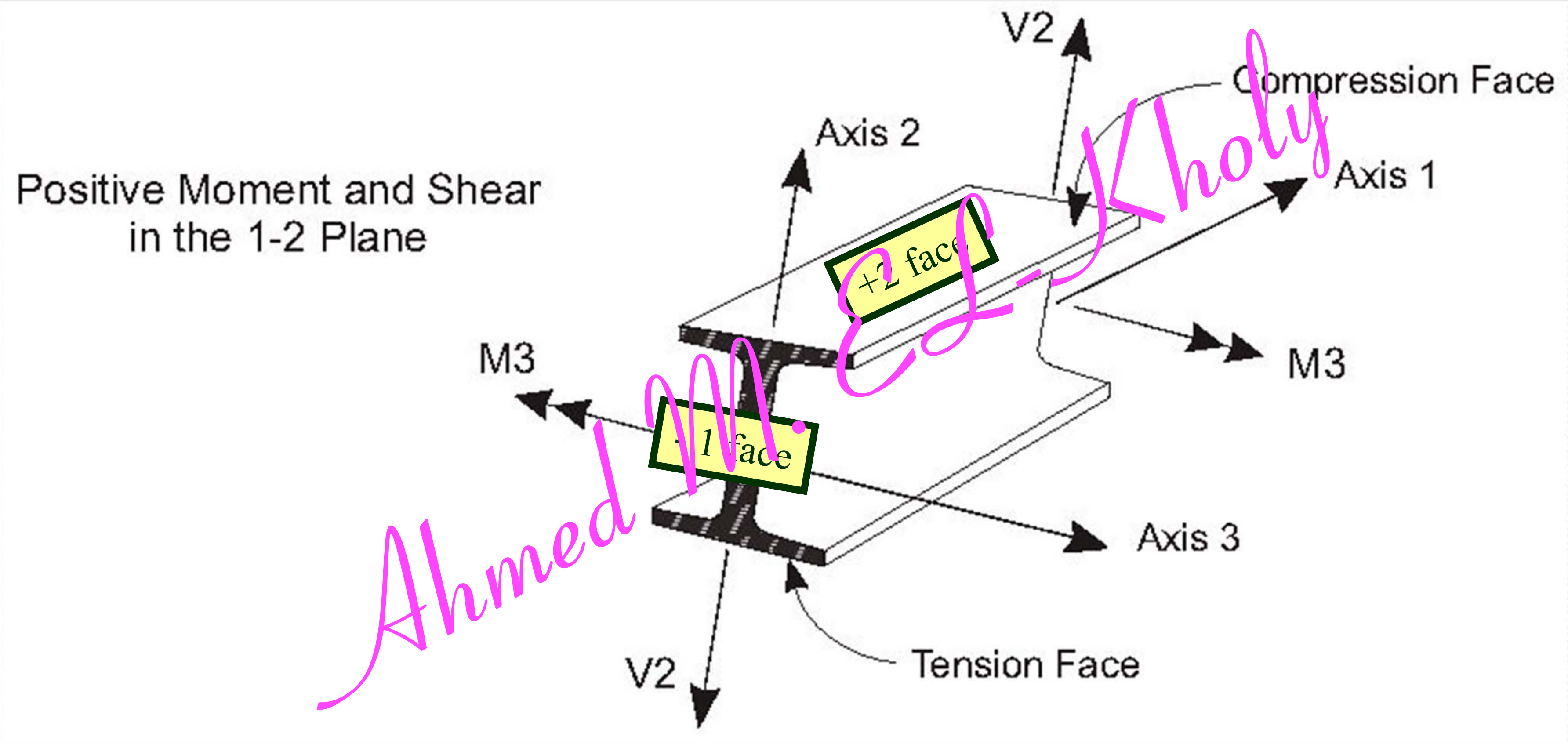


- 1 face

Positive Axial Force & Torque

Parallel to axis 1 at face+1

Frame Sign Convention

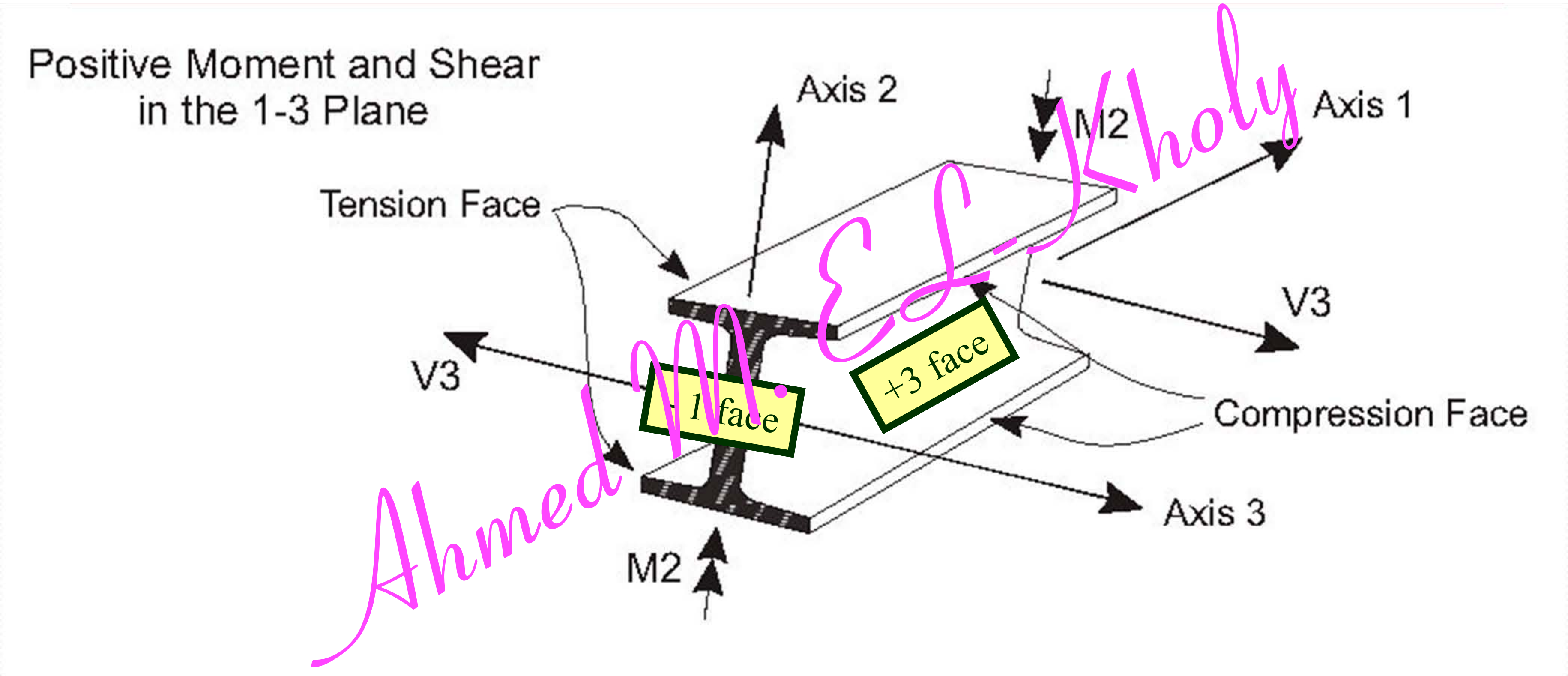


Positive M3 & V2

Compresses face+2

Parallel to axis 2 at face+1

Frame Sign Convention



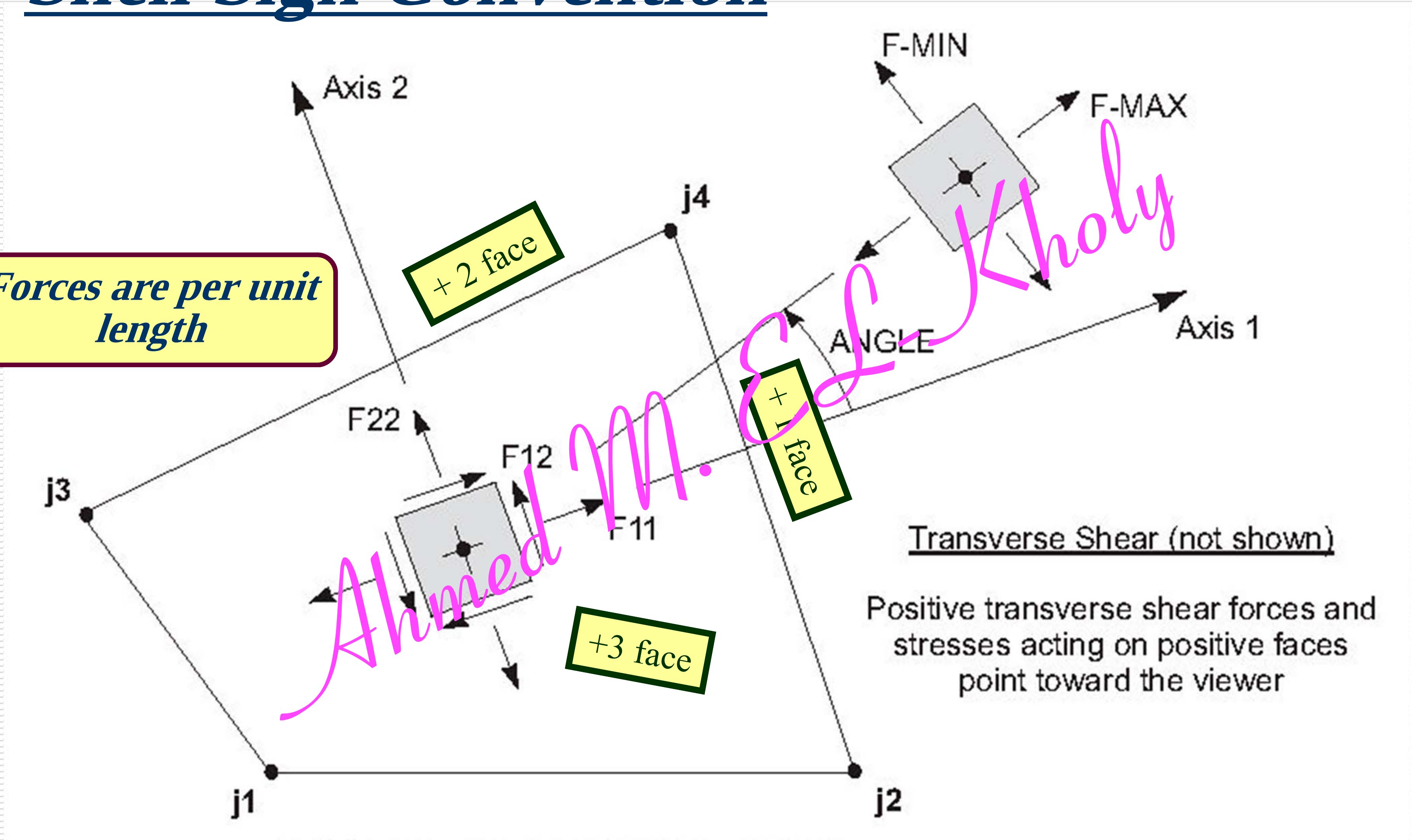
Positive M2 & V3

Compresses face+3

Parallel to axis 3 at face+1

Shell Sign Convention

Forces are per unit length



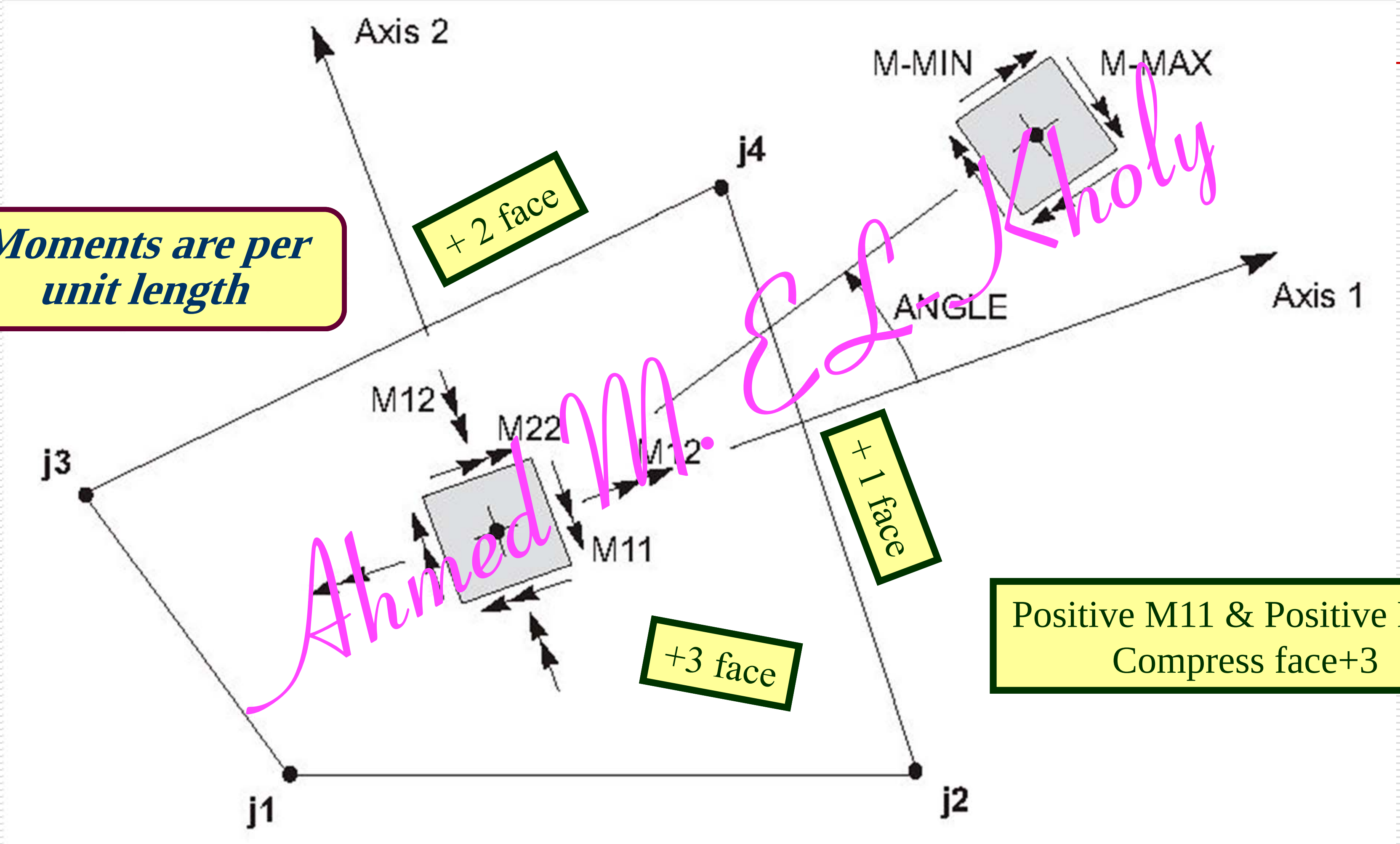
Transverse Shear (not shown)

Positive transverse shear forces and stresses acting on positive faces point toward the viewer

Positive Stresses and In-Plane Forces

Shell Sign Convention

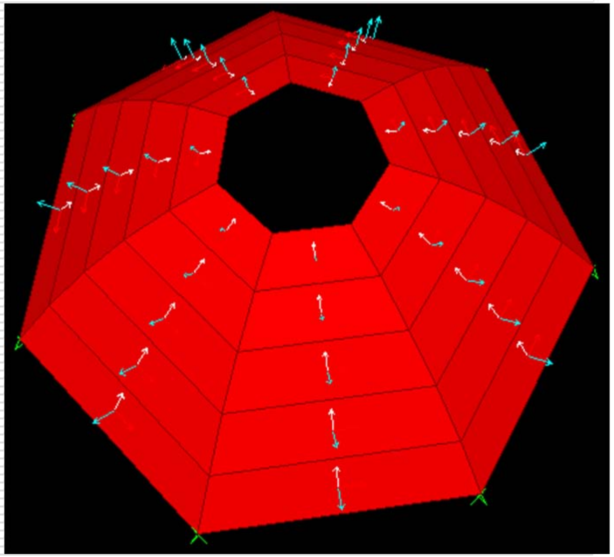
Moments are per unit length

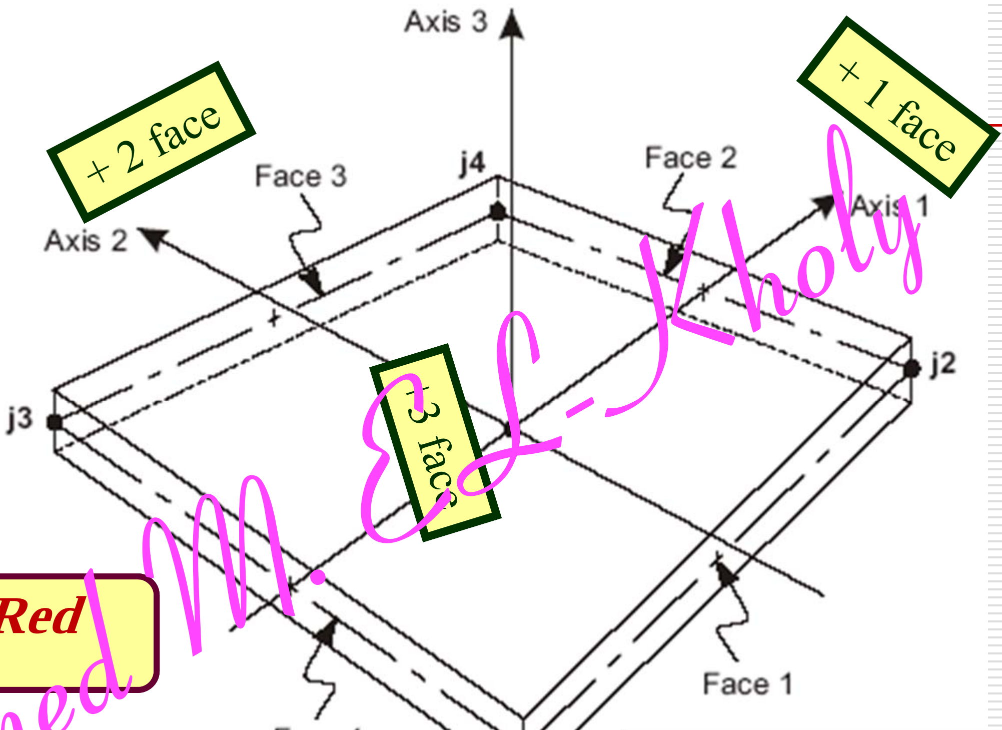


Positive M11 & Positive M22
Compress face+3

Positive Bending Moments

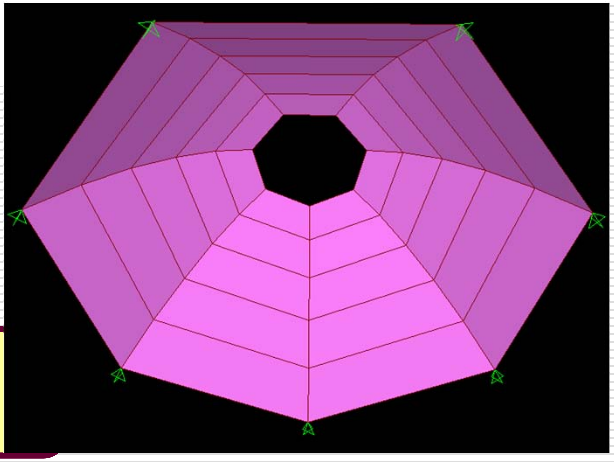
Default Colors of faces +3 & -3





face 6 = face+3 = Red

face 5 = face-3 = Pink



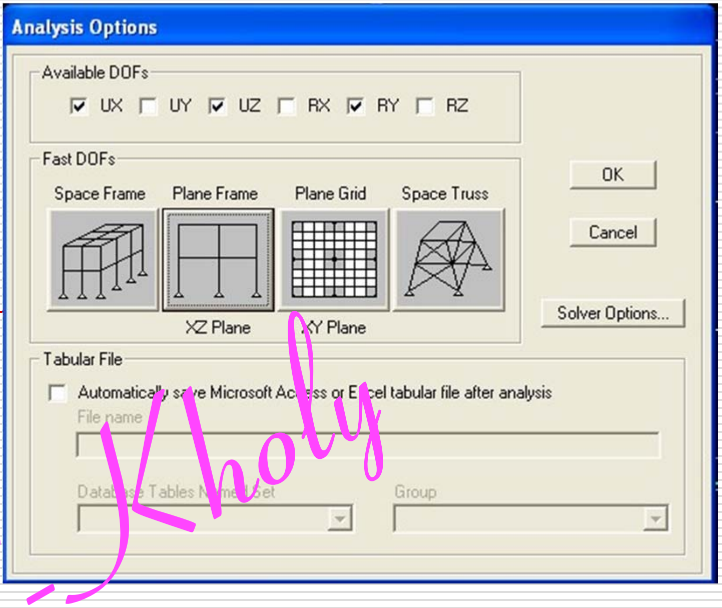
Positive Bending Moments

Degrees of Freedom

..Analyze…Set Analysis Options

Degrees of Freedom

..Analyze… Set Analysis Options


Analysis Options

Available DOFs

☑ UX ☐ UY ☑ UZ ☐ RX ☑ RY ☐ RZ

Fast DOFs

Tabular File

☐ Automatically save Microsoft Access or Excel tabular file after analysis

Any space joint has 6 DOF

	Ux	Uy	Uz	Rx	Ry	Rz
2D Frame XZ Plane	√	----	√	----	√	----
2D Frame XY Plane	√	√	----	----	----	√
3D Frame	√	√	√	√	√	√
3D Truss	√	√	√	----	----	----
2D Truss XZ Plane	√	----	√	----	----	----
XY Slab **(Vertical Loads)**	----	----	√	√	√	----
XY Slab **(Vertical & Horizontal Loads)**	√	√	√	√	√	√

Load Patterns, Load Cases, Load Combinations

..Define… Load Patterns…

..Define… Load Cases…

..Define… Load Combinations…

?Load Patterns, Load Cases, Load Combinations

..Define… Load Patterns…, Load Cases…, Load Combinations

2

Load Case

Static Load Cases

Liner or Non-Linear

- OW
- Flooring
- Wall Weight
- Live
- Wind
- EQ-Static
- Temperature
- EQ-Dynamic
- Buckling
- Moving Load

3

Load Combination

Dead=OW+Flooring+Wall Weight

Work=Dead+Live

Ult=1.4Dead+1.6Live

Follow Chapter 3
in ECP-RC

…….

…….

…….

……

…….

……

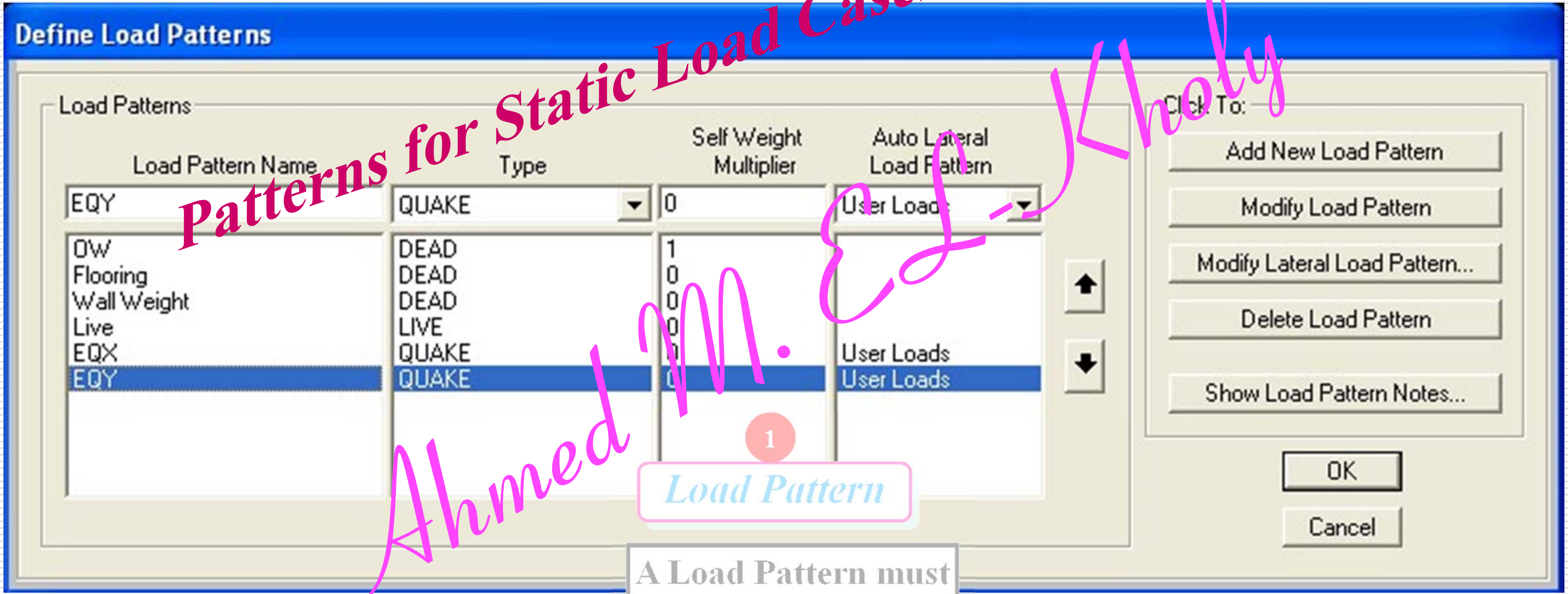
1

Load Pattern

A Load Pattern must be created for every Static Load Case to enter the patterns (values & shapes) of applied loads in the case

?Load Patterns, Load Cases, Load Combinations

..Define… Load Patterns…



Define Load Patterns

Load Patterns

Load Pattern Name	Type	Self Weight Multiplier	Auto Lateral Load Pattern
EQY	QUAKE	0	User Loads
OW	DEAD	1	
Flooring	DEAD	0	
Wall Weight	DEAD	0	
Live	LIVE	0	
EQX	QUAKE	0	User Loads
EQY	QUAKE	0	User Loads

Patterns for Static Load Cases

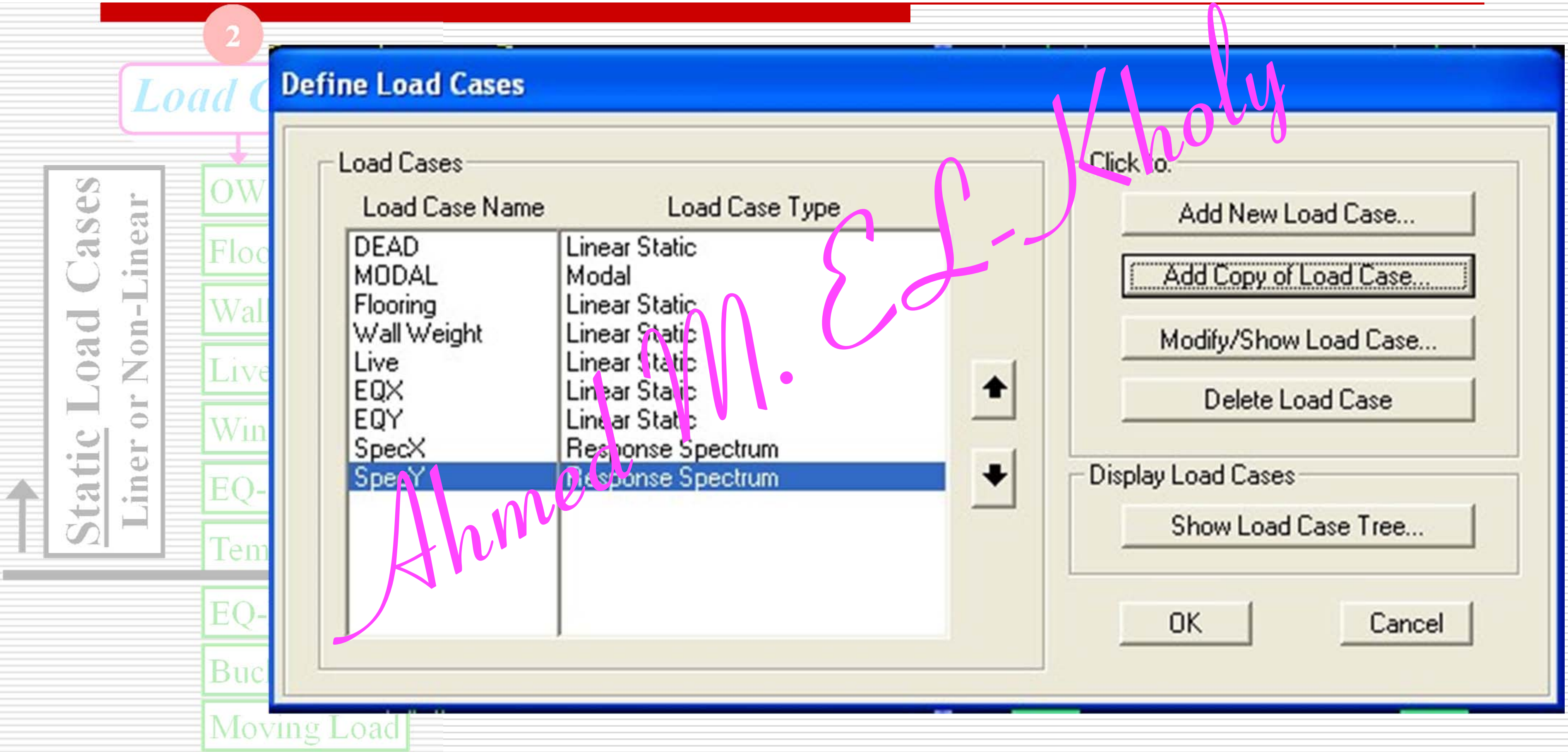
1

Load Pattern

A Load Pattern must be created for every Static Load Case to enter the patterns (values & shapes) of applied loads in the case

Load Patterns, ?Load Cases, Load Combinations

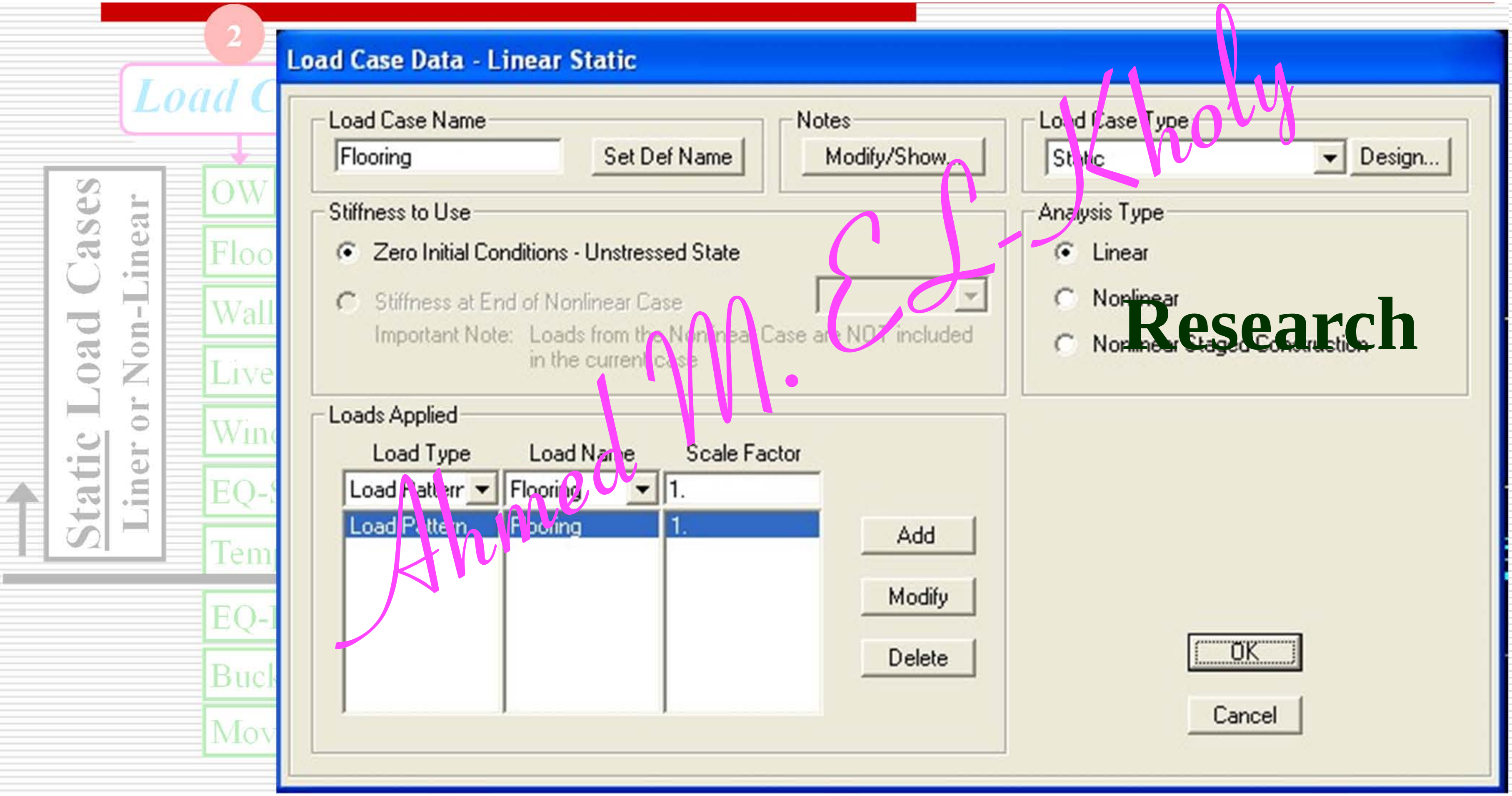
..Define… Load Cases…



Load Case Name	Load Case Type
DEAD	Linear Static
MODAL	Modal
Flooring	Linear Static
Wall Weight	Linear Static
Live	Linear Static
EQX	Linear Static
EQY	Linear Static
SpecX	Response Spectrum
SpecY	Response Spectrum

Load Patterns, ?Load Cases, Load Combinations

..Define… Load Cases… Flooring (modify/show case)



Load Case Data - Linear Static

Load Case Name: Flooring

Notes

Load Case Type: Static

Stiffness to Use

● Zero Initial Conditions - Unstressed State

○ Stiffness at End of Nonlinear Case

Important Note: Loads from the Nonlinear Case are NOT included in the current case

Analysis Type

● Linear

○ Nonlinear

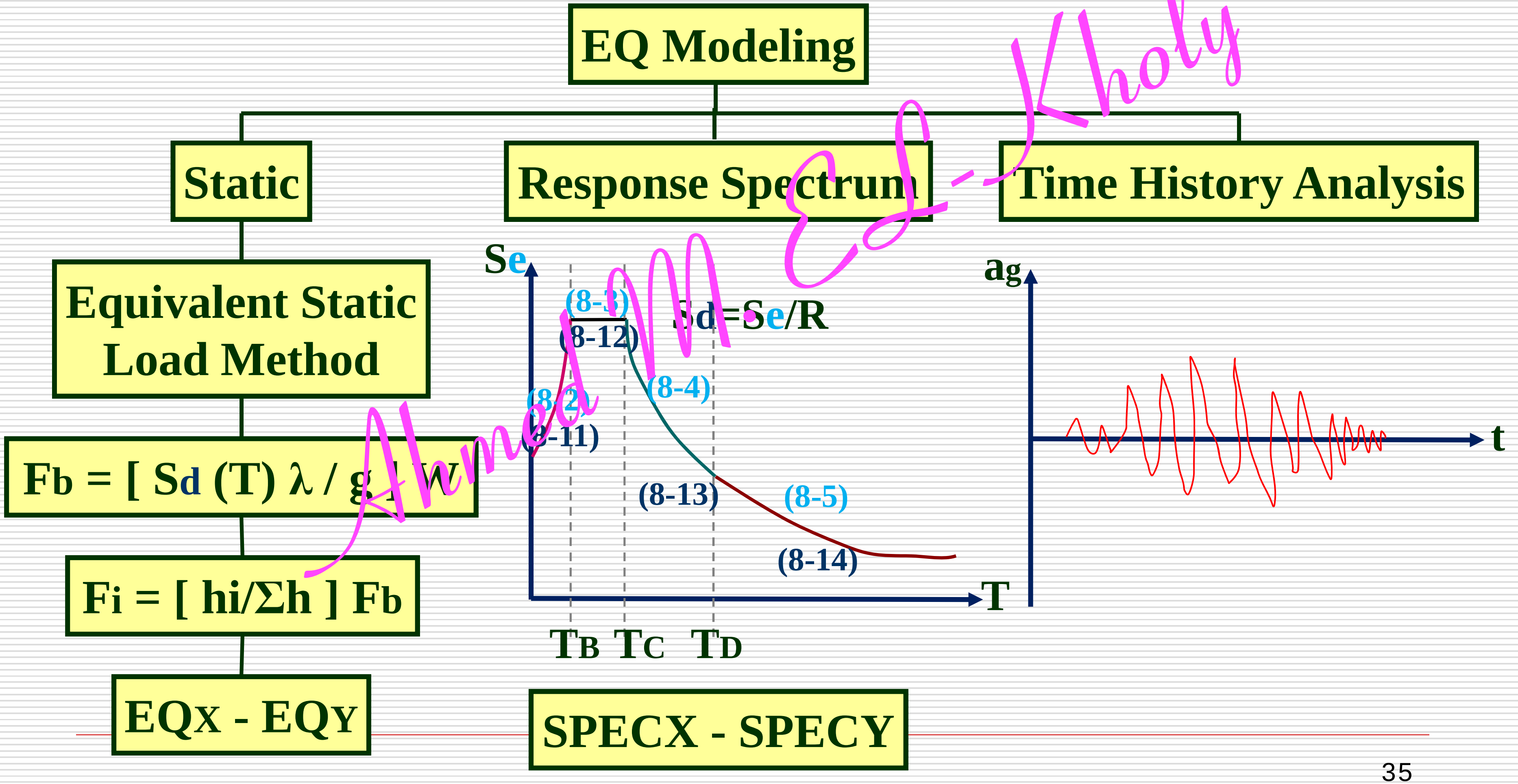
○ Nonlinear Staged Construction

Loads Applied

Load Type	Load Name	Scale Factor
Load Pattern	Flooring	1.
Load Pattern	Flooring	1.

Load Patterns, ?Load Cases, Load Combinations

..EQ Modeling…………



EQ Modeling

Static

Equivalent Static Load Method

$F_b = [\ S_d\ (T)\ \lambda / g\ ]\ W$

$F_i = [\ h_i/\Sigma h\ ]\ F_b$

EQX - EQY

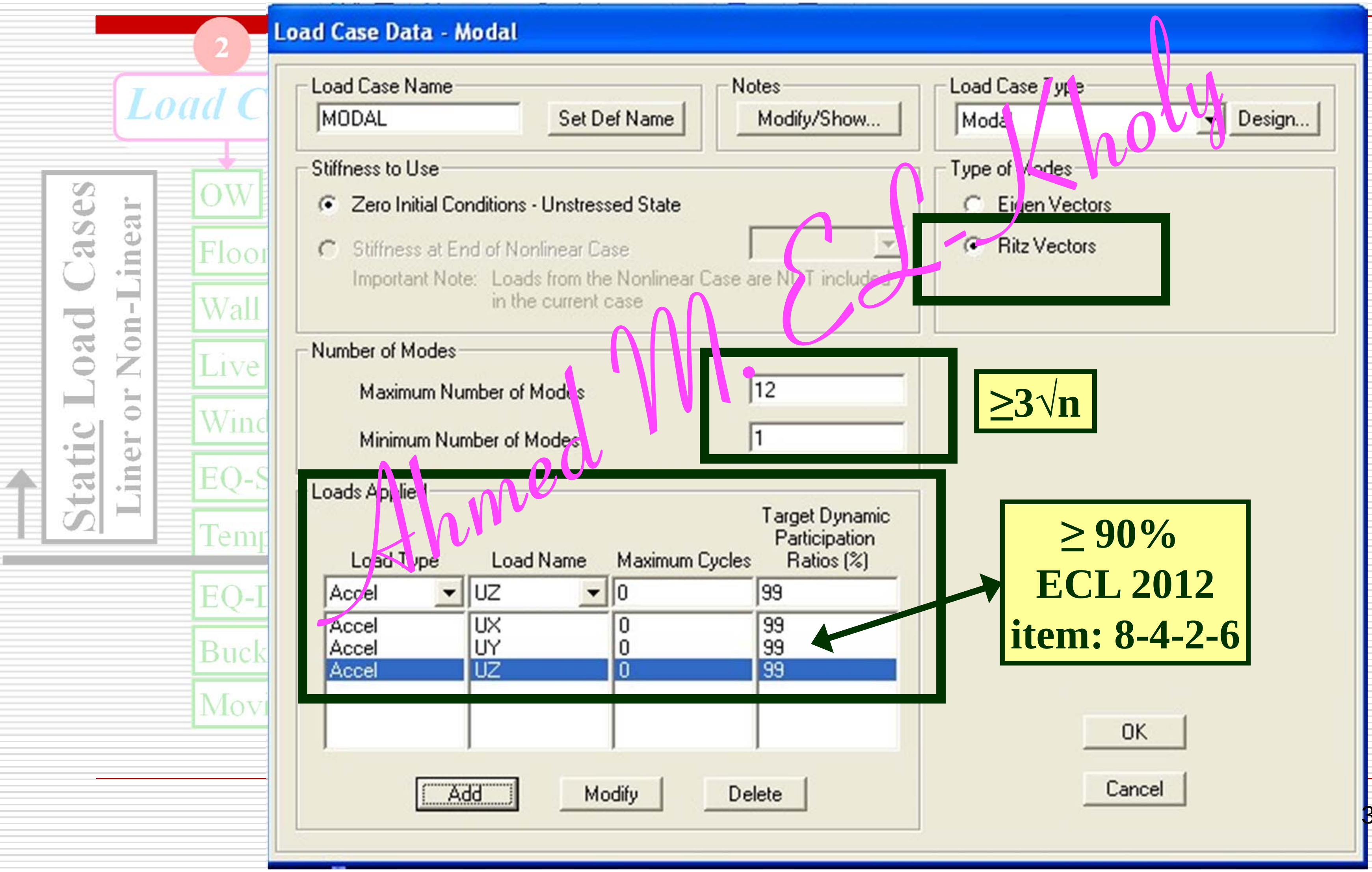
Response Spectrum

SPECX - SPECY

Time History Analysis

Load Patterns, ?Load Cases, Load Combinations

..Define… Load Cases… Modal (modify/show case)



Load Case Data - Modal

Load Case Name: MODAL

Notes

Load Case Type: Modal

Stiffness to Use
- ● Zero Initial Conditions - Unstressed State
- ○ Stiffness at End of Nonlinear Case

Important Note: Loads from the Nonlinear Case are NOT included in the current case

Type of Modes
- ○ Eigen Vectors
- ● Ritz Vectors

Number of Modes
Maximum Number of Modes: 12
Minimum Number of Modes: 1

Loads Applied

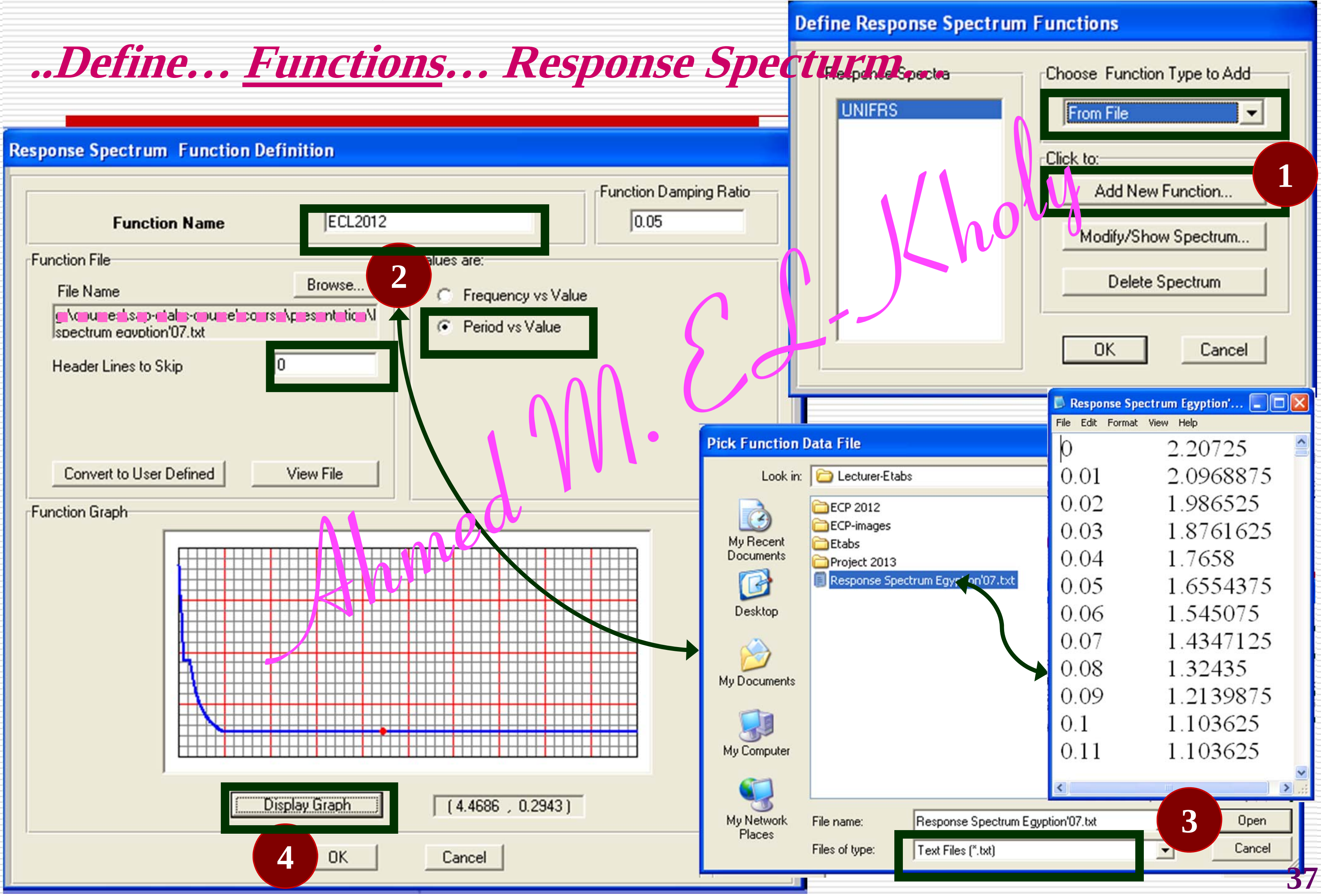
Load Type	Load Name	Maximum Cycles	Target Dynamic Participation Ratios (%)
Accel	UZ	0	99
Accel	UX	0	99
Accel	UY	0	99
Accel	UZ	0	99

≥3√n

≥ 90%
ECL 2012
item: 8-4-2-6

Load Patterns, ?Load Cases, Load Combinations

..Define… Functions… Response Specturm…



Define Response Spectrum Functions

Response Spectra: UNIFRS

Choose Function Type to Add: From File

Click to: Add New Function... / Modify/Show Spectrum... / Delete Spectrum

Response Spectrum Function Definition

Function Name: ECL2012

Function Damping Ratio: 0.05

Function File

File Name: [illegible]
spectrum egyption'07.txt

Header Lines to Skip: 0

Values are: ○ Frequency vs Value ● Period vs Value

(4.4686 , 0.2943)

Pick Function Data File

Look in: Lecturer-Etabs

ECP 2012
ECP-images
Etabs
Project 2013
Response Spectrum Egyption'07.txt

File name: Response Spectrum Egyption'07.txt

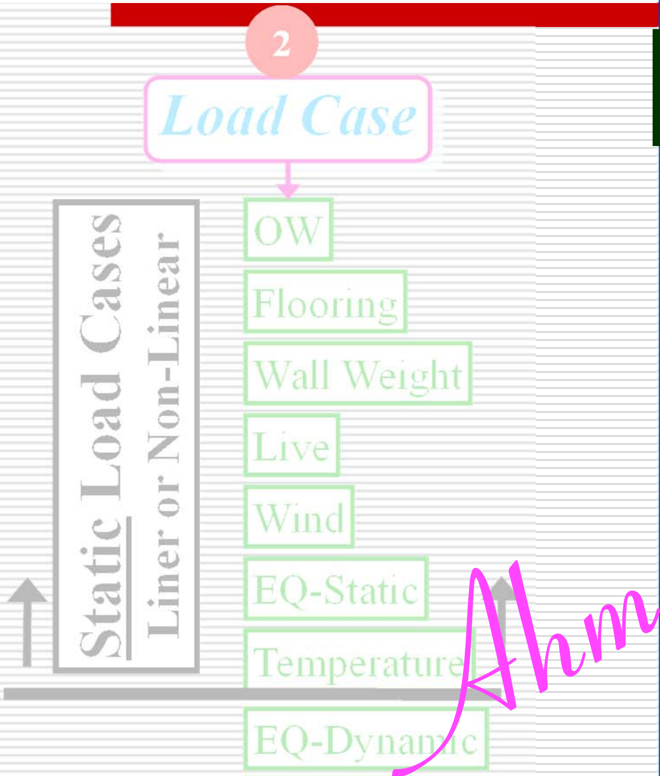
Files of type: Text Files (*.txt)

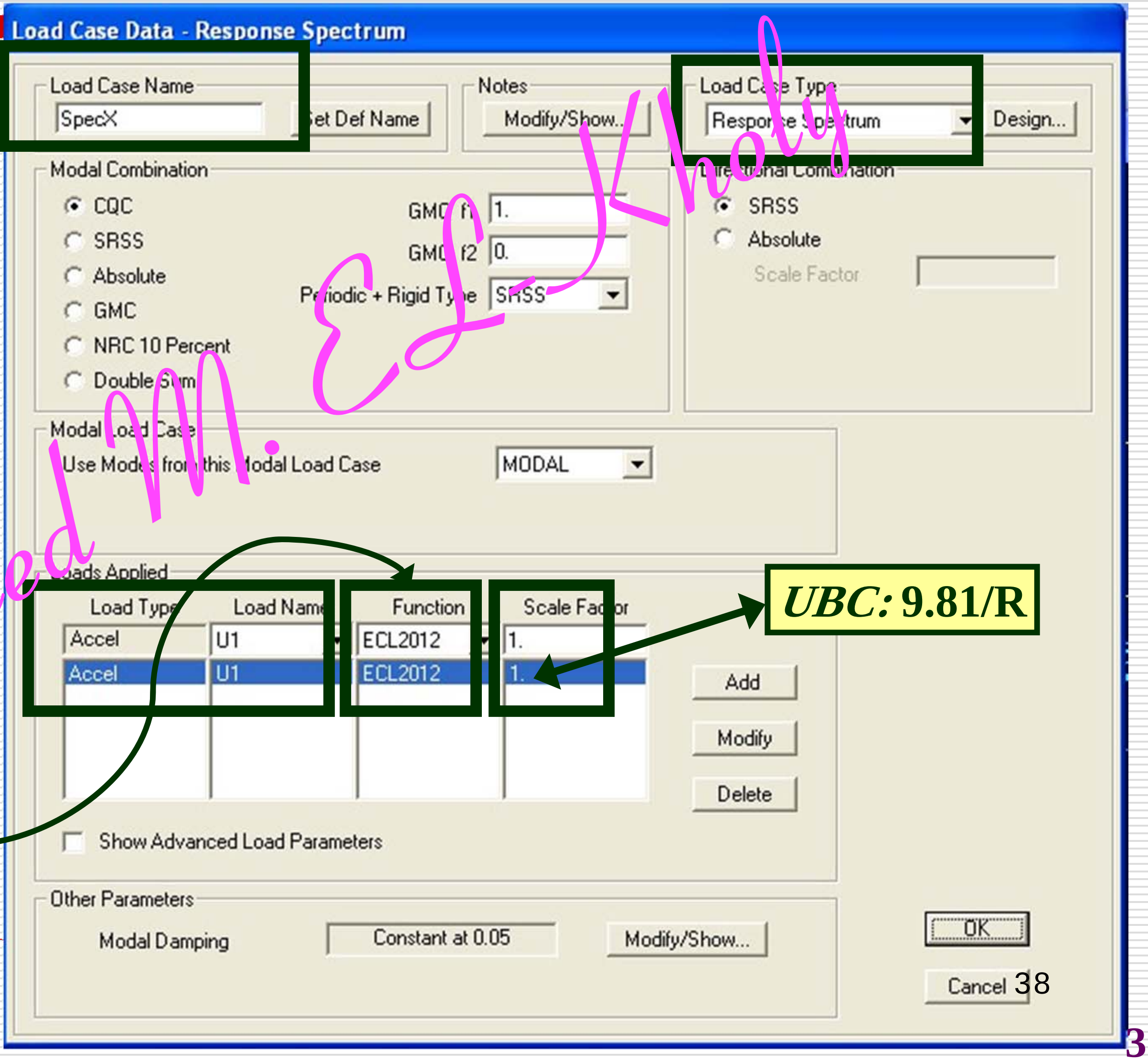
Response Spectrum Egyption'...

0	2.20725
0.01	2.0968875
0.02	1.986525
0.03	1.8761625
0.04	1.7658
0.05	1.6554375
0.06	1.545075
0.07	1.4347125
0.08	1.32435
0.09	1.2139875
0.1	1.103625
0.11	1.103625

Load Patterns, ?Load Cases, Load Combinations

..Define… Load Cases… Add New Load Case… Response Spec..




Load Case Data - Response Spectrum

Load Case Name: SpecX

Load Case Type: Response Spectrum

Modal Combination: ● CQC ○ SRSS ○ Absolute ○ GMC ○ NRC 10 Percent ○ Double Sum

GMC f1: 1.

GMC f2: 0.

Periodic + Rigid Type: SRSS

Directional Combination: ● SRSS ○ Absolute

Modal Load Case – Use Modes from this Modal Load Case: MODAL

Loads Applied

Load Type	Load Name	Function	Scale Factor
Accel	U1	ECL2012	1.
Accel	U1	ECL2012	1.

☐ Show Advanced Load Parameters

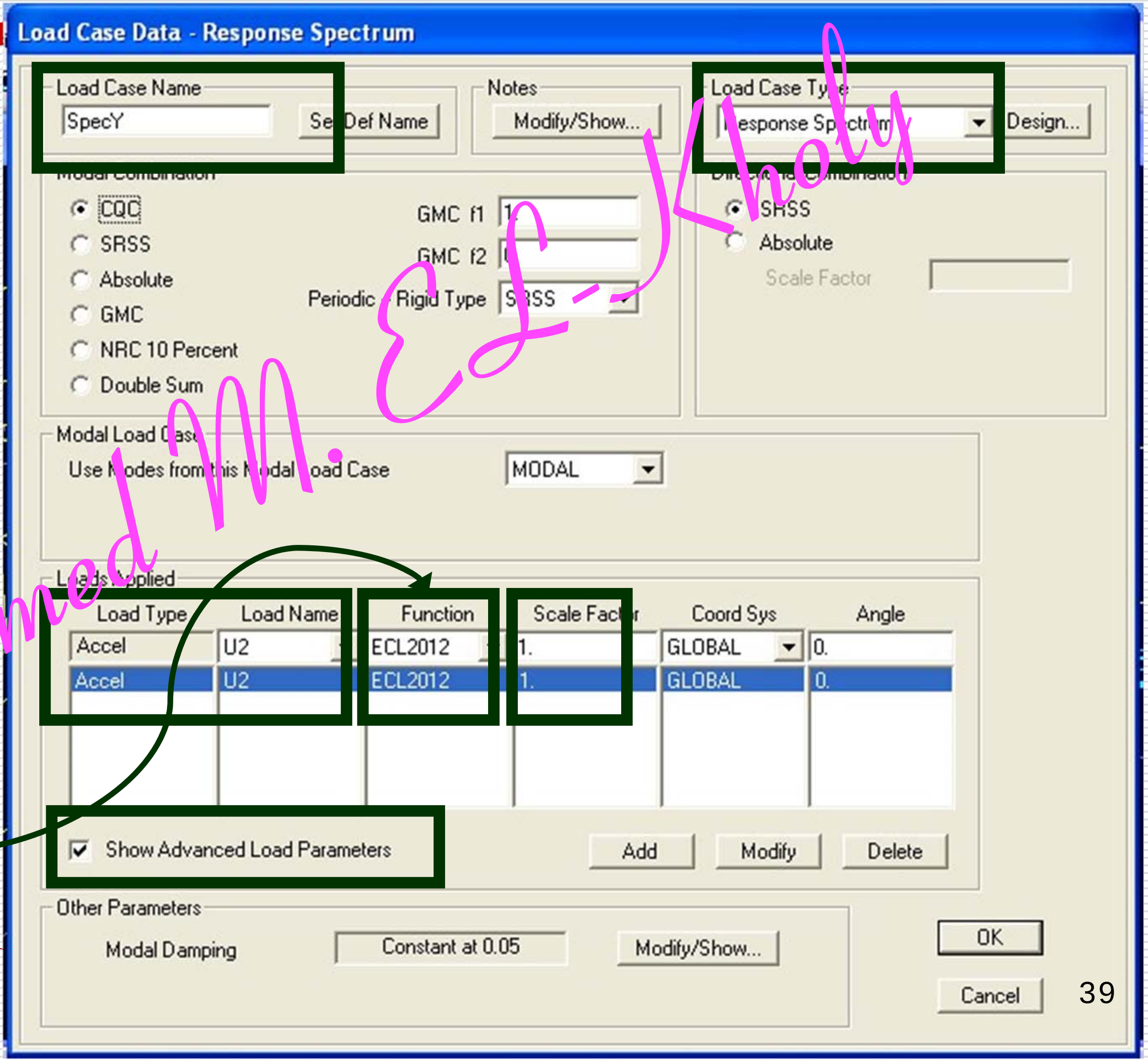
Other Parameters – Modal Damping: Constant at 0.05

UBC: 9.81/R

..Define… Functions… Response Spectrum…

Load Patterns, ?Load Cases, Load Combinations

..Define… Load Cases… Add New Load Case… Response Spec..



Load Case Data - Response Spectrum

Load Case Name: SpecY (Set Def Name)

Notes: Modify/Show...

Load Case Type: Response Spectrum (Design...)

Modal Combination:
- ● CQC
- ○ SRSS
- ○ Absolute
- ○ GMC
- ○ NRC 10 Percent
- ○ Double Sum

GMC f1: 1.
GMC f2: 0.
Periodic + Rigid Type: SRSS

Directional Combination:
- ● SRSS
- ○ Absolute

Scale Factor:

Modal Load Case
Use Modes from this Modal Load Case: MODAL

Loads Applied

Load Type	Load Name	Function	Scale Factor	Coord Sys	Angle
Accel	U2	ECL2012	1.	GLOBAL	0.
Accel	U2	ECL2012	1.	GLOBAL	0.

☑ Show Advanced Load Parameters

Add | Modify | Delete

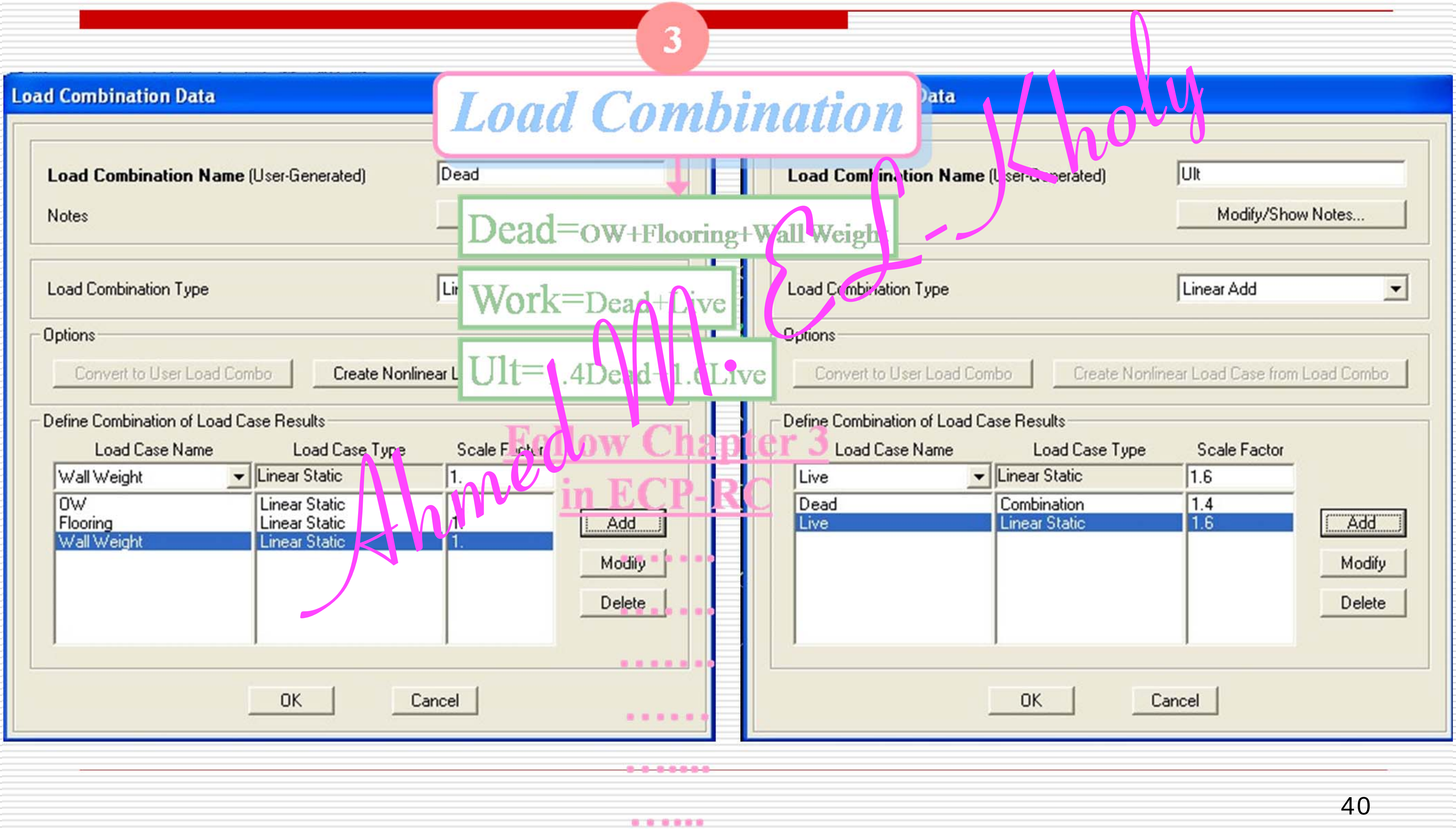
Other Parameters
Modal Damping: Constant at 0.05 (Modify/Show...)

OK | Cancel

**..Define…
Functions…
Response Spectrum…**

Load Patterns, Load Cases, ?Load Combinations

..Define… Load Combinations…



3

Load Combination

Dead=OW+Flooring+Wall Weight

Work=Dead+Live

Ult=1.4Dead+1.6Live

Follow Chapter 3 in ECP-RC

Load Combination Data

Load Combination Name (User-Generated): Dead

Notes

Load Combination Type: Li

Options

Define Combination of Load Case Results

Load Case Name	Load Case Type	Scale Factor
Wall Weight	Linear Static	1.
OW	Linear Static	1.
Flooring	Linear Static	1.
Wall Weight	Linear Static	1.

Load Combination Data

Load Combination Name (User-Generated): Ult

Load Combination Type: Linear Add

Options

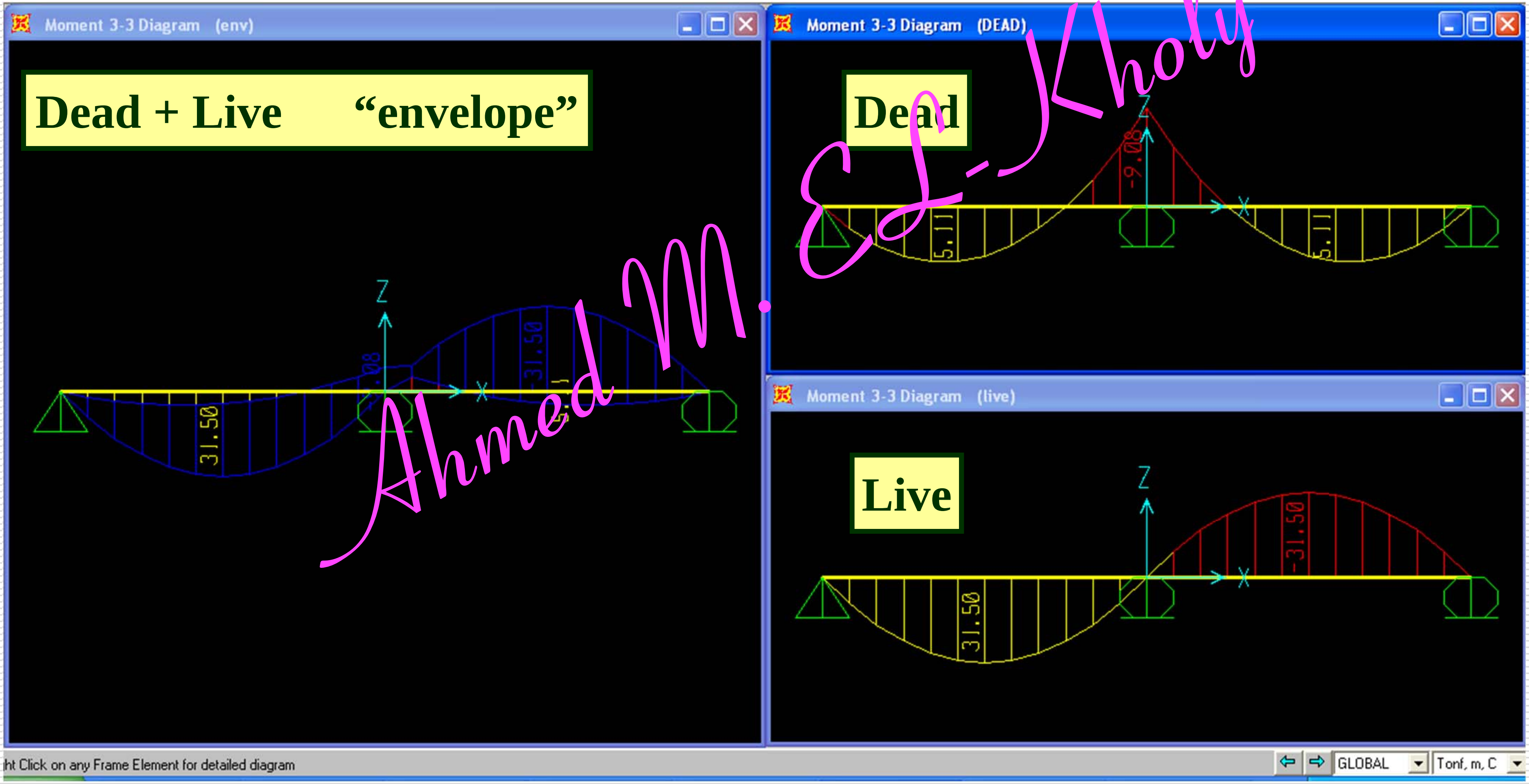
Define Combination of Load Case Results

Load Case Name	Load Case Type	Scale Factor
Live	Linear Static	1.6
Dead	Combination	1.4
Live	Linear Static	1.6

Load Patterns, Load Cases, ?Load Combinations

..Define… Load Combinations…

Envelope



Dead + Live “envelope”

Dead

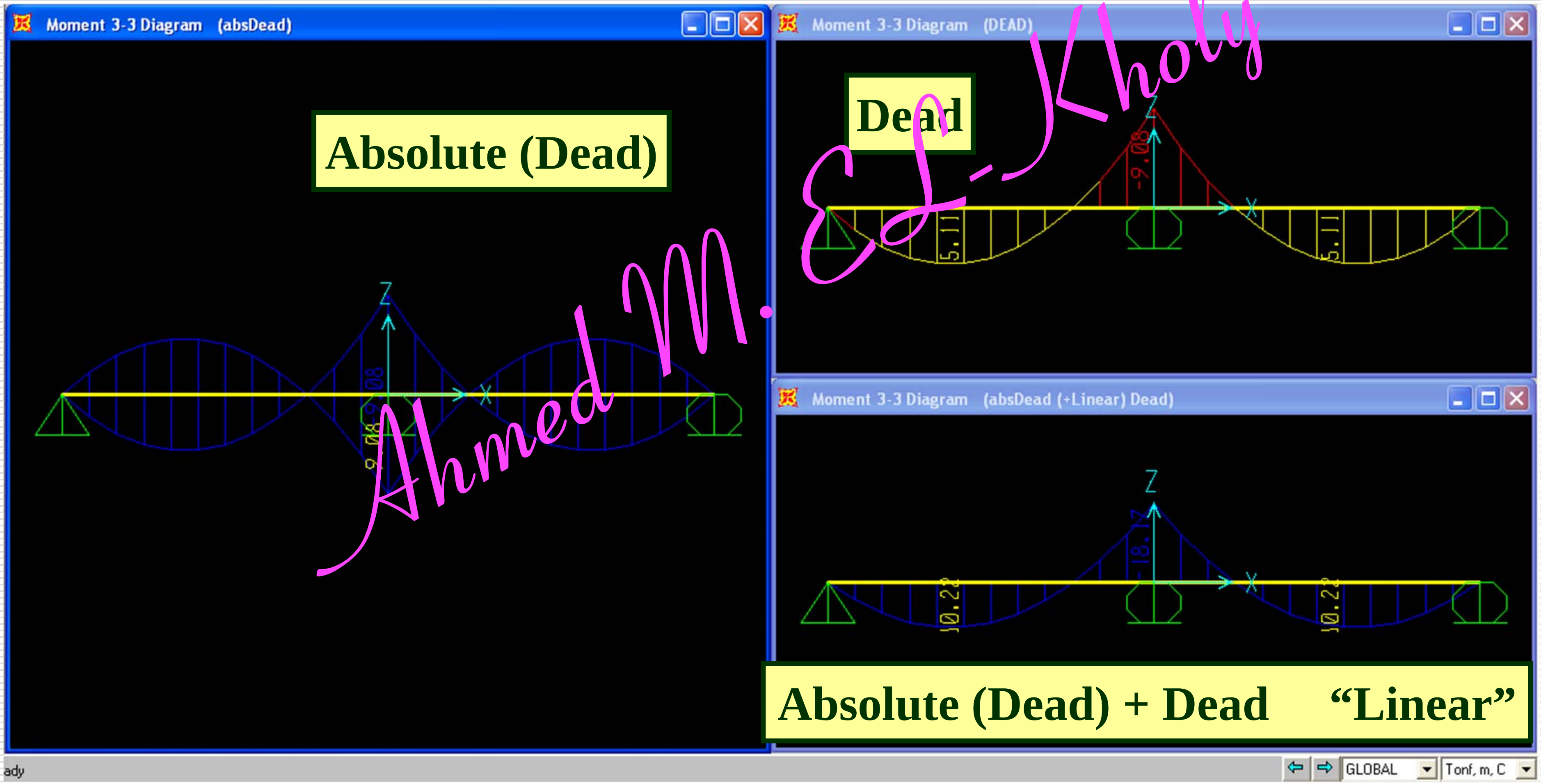
Live

ht Click on any Frame Element for detailed diagram

Load Patterns, Load Cases, ?Load Combinations

..Define… Load Combinations…

Absolute



Absolute (Dead)

Dead

Absolute (Dead) + Dead “Linear”

Steps of Building a SAP Model

Steps of Building a SAP Model

1. **Units** ↔ **Bottom Right Screen**

X0.00 Y0.00 Z0.00 GLOBAL Tonf, m, C

2. **New Model**
3. **Available DOF** ↔ **Slide 29**
4. **Define… Materials, Sections, Functions, L Patterns, L Cases, L Combinations** — **Slide 31~42**
5. **Draw the Structure & Assign Sections**
6. **Assign Joint.. Restraints, Constraints, Springs**
7. **Assign Frame.. Releases, End Offset, Intersection Points, Output Stations**
8. **Assign Area.. Springs**
9. **Assign Joint Loads & Frame Loads & Area Loads**
10. **Display.. Show Loads & Misc Assignments**
11. **Run**
12. **Check Warnings & Errors in the Log File**
13. **Display… Show Deformed Shape** ↔ **Slide 8**
14. **Read Deflections, Forces, Moments….**

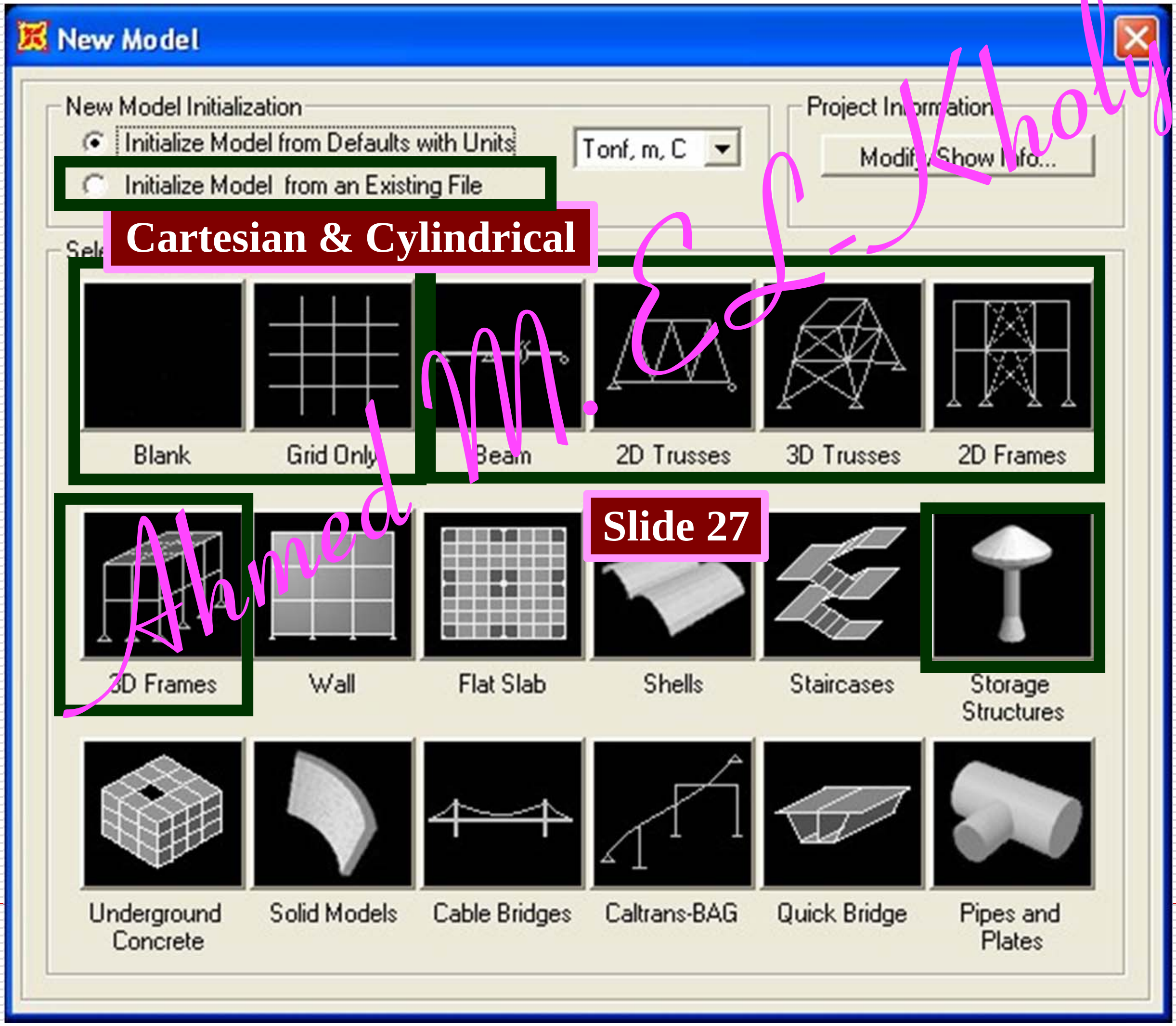
Alternative 2

- 4* **Draw the Structure**
- 5* **Define………….**
- 5* **Assign Sections**

Step 2
New Model …

Step 3. New Model

..File… New Model…



New Model

New Model Initialization

● Initialize Model from Defaults with Units Tonf, m, C

○ Initialize Model from an Existing File

Project Information

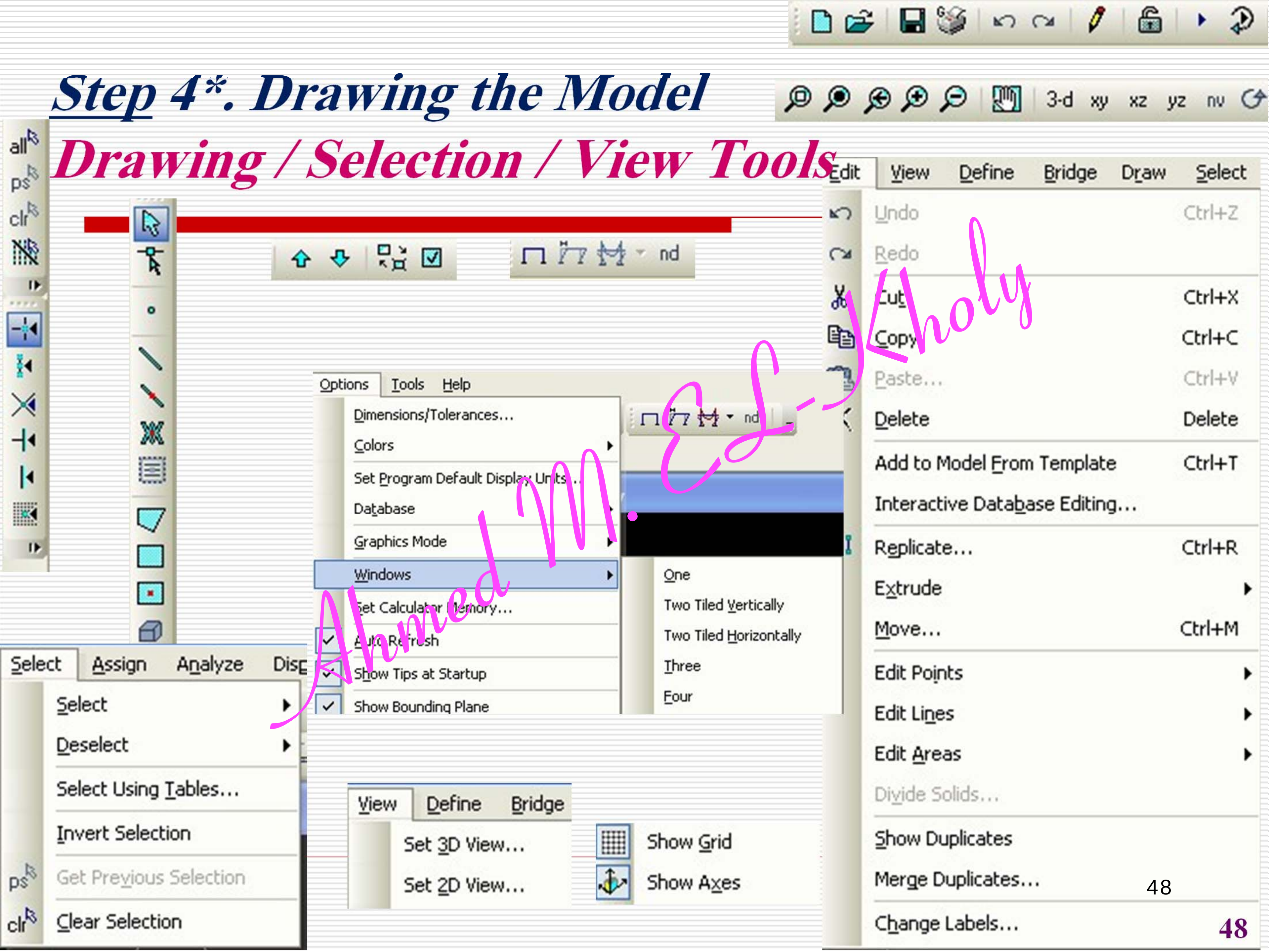
Cartesian & Cylindrical

Slide 27

Step 4*
Draw the Model …
Drawing Tools

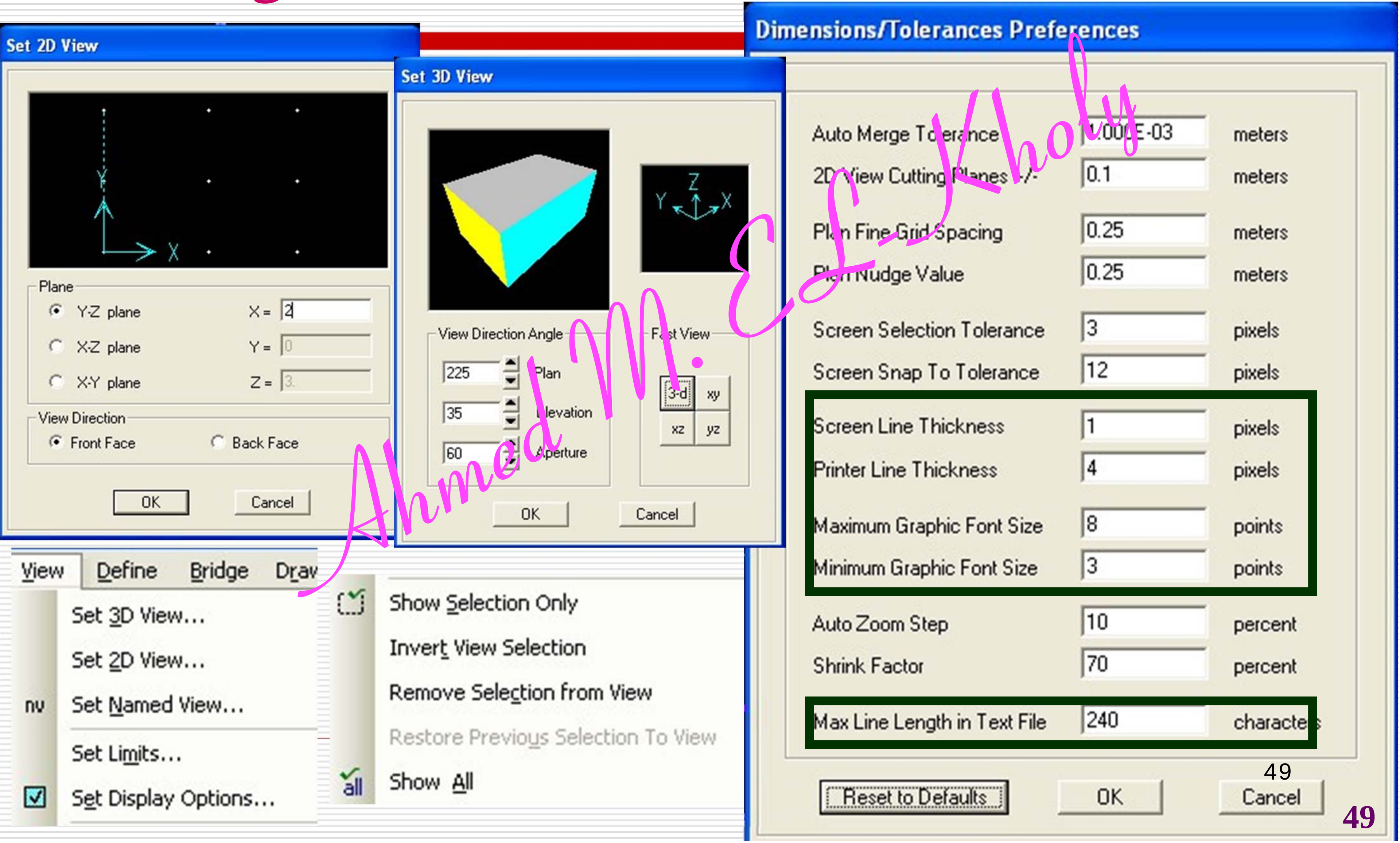
Step 4*. Drawing the Model

Drawing / Selection / View Tools



Step 4. Drawing the Model*

Drawing / Selection / View Tools



Set 2D View

Plane
● Y-Z plane X = 2
○ X-Z plane Y = 0
○ X-Y plane Z = 3.

View Direction
● Front Face ○ Back Face

Set 3D View

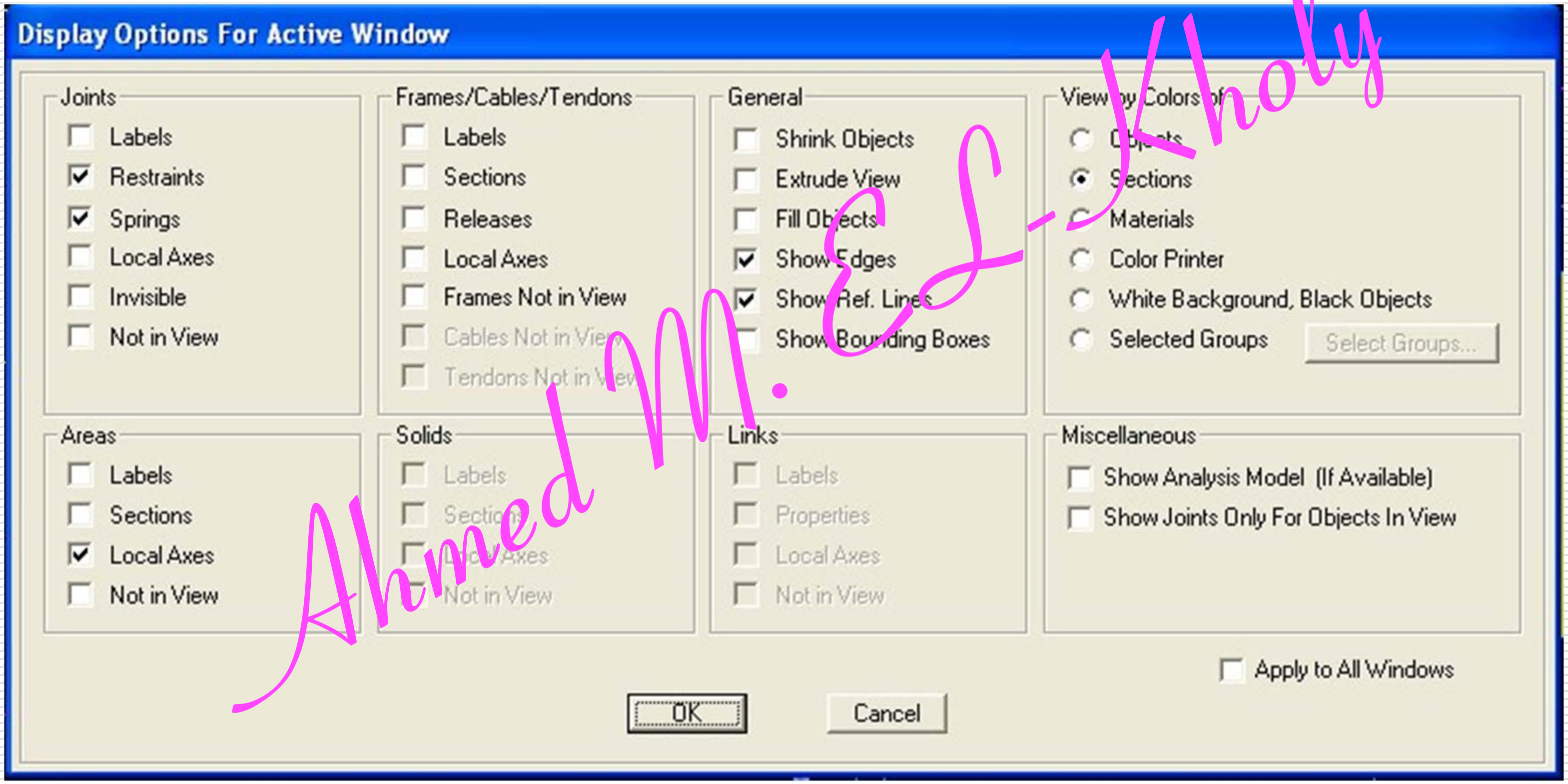
View Direction Angle
225 Plan
35 Elevation
60 Aperture

Dimensions/Tolerances Preferences

Auto Merge Tolerance	1.000E-03	meters
2D View Cutting Planes +/-	0.1	meters
Plan Fine Grid Spacing	0.25	meters
Plan Nudge Value	0.25	meters
Screen Selection Tolerance	3	pixels
Screen Snap To Tolerance	12	pixels
Screen Line Thickness	1	pixels
Printer Line Thickness	4	pixels
Maximum Graphic Font Size	8	points
Minimum Graphic Font Size	3	points
Auto Zoom Step	10	percent
Shrink Factor	70	percent
Max Line Length in Text File	240	characters

Step 4*. Drawing the Model

Drawing / Selection / View Tools



Display Options For Active Window

Joints
- ☐ Labels
- ☑ Restraints
- ☑ Springs
- ☐ Local Axes
- ☐ Invisible
- ☐ Not in View

Frames/Cables/Tendons
- ☐ Labels
- ☐ Sections
- ☐ Releases
- ☐ Local Axes
- ☐ Frames Not in View
- ☐ Cables Not in View
- ☐ Tendons Not in View

General
- ☐ Shrink Objects
- ☐ Extrude View
- ☐ Fill Objects
- ☑ Show Edges
- ☑ Show Ref. Lines
- ☐ Show Bounding Boxes

View by Colors of
- ○ Objects
- ● Sections
- ○ Materials
- ○ Color Printer
- ○ White Background, Black Objects
- ○ Selected Groups

Areas
- ☐ Labels
- ☐ Sections
- ☑ Local Axes
- ☐ Not in View

Solids
- ☐ Labels
- ☐ Sections
- ☐ Local Axes
- ☐ Not in View

Links
- ☐ Labels
- ☐ Properties
- ☐ Local Axes
- ☐ Not in View

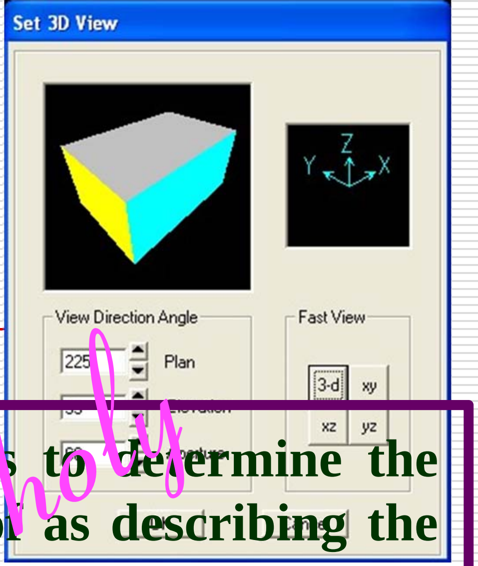
Miscellaneous
- ☐ Show Analysis Model (If Available)
- ☐ Show Joints Only For Objects In View

☐ Apply to All Windows

Step 4. Drawing the Model*

Drawing / Selection / View Tools

..View… Set 3D View...



<u>View Direction Angle options</u>: Set these three angles to determine the orientation of the view. These angles can be thought of as describing the location of your eye, looking toward the origin

<u>Plan angle</u>: Your location in the X-Y plane, where zero is on the positive X axis, and 90 is on the positive Y axis

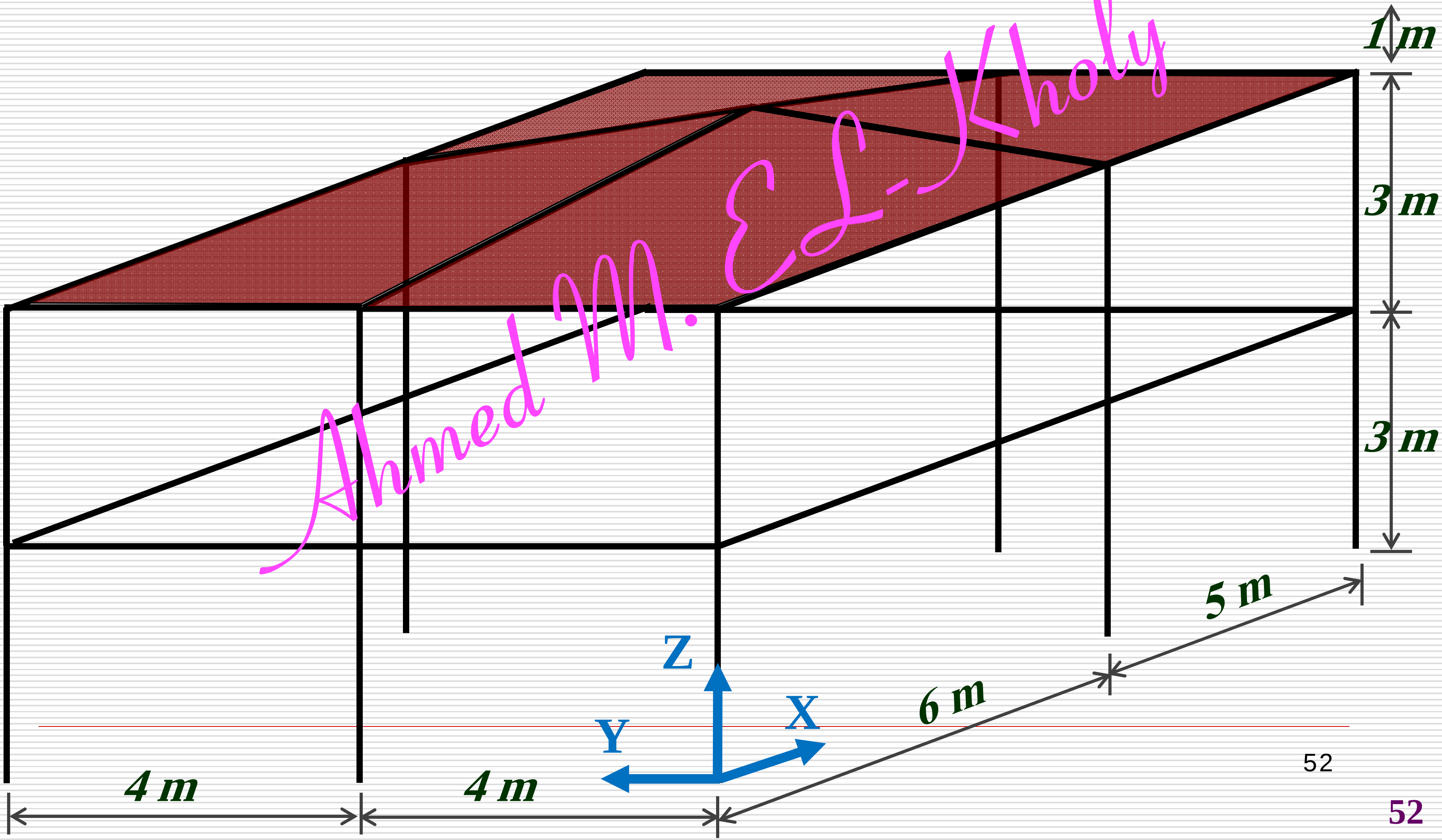
<u>Elevation angle</u>: Your location above or below the X-Y plane, where zero is on the X-Y plane, and 90 is on the positive Z axis

<u>Aperture angle</u>: A measure of how strong the perspective effect is, or how far away you are from the origin. Zero indicates that you are infinitely far away, and all receding lines are parallel (no perspective). A value between 30 and 60 is usually adequate

Step 4*. Drawing the Model

Drawing / Selection / View Tools

Training Example



Step 4*. Drawing the Model

Using Excel

Drawing a Joint

Type	Name	X	Y	Z	USER
POINT	1	2	3	1	Y

Drawing a Frame

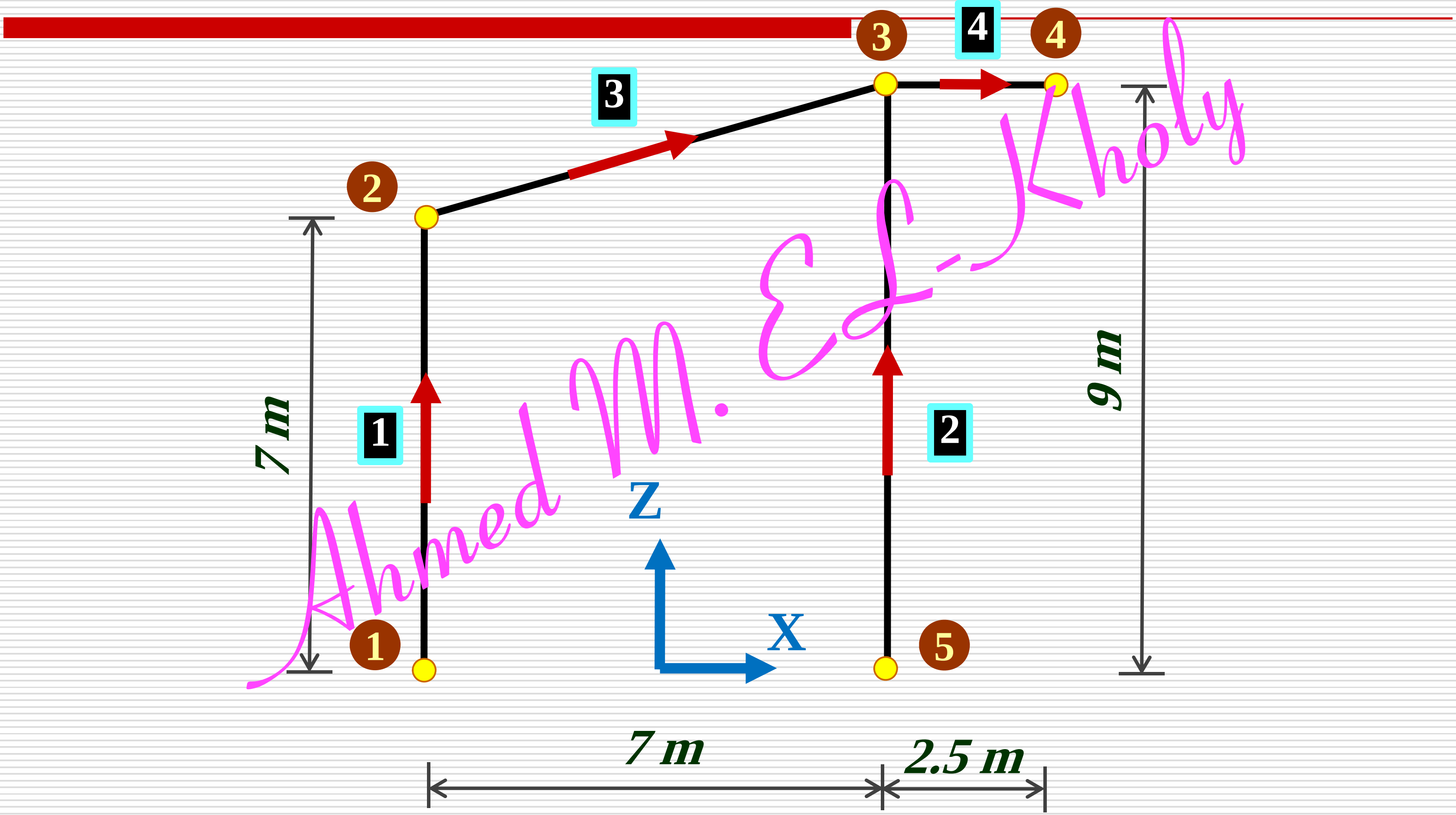
Type	Name	XI	YI	ZI	XJ	YJ	ZJ
LINE	1	3	5	0	7	5	0

Drawing an Area

Type	Name	NumPoints	X1	Y1	Z1	X2	Y2	Z2	X3	Y3	Z3	X4	Y4	Z4
AREA	1	4	3	5	0	5	5	0	4.6	8.9	0	1.1	7.2	0

Step 4*. Drawing the Model

Using Excel :: Training Example



Joint Constraints

..Define… Joint Constraints…

..Assign… Joint Constraints…

Joint Constraints

..Define/Assign… Joint Constraints..

Body

A Body Constraint causes all of its constrained joints to move together as a three-dimensional rigid body. If a large number of these constraints must be created, consider using the **weld constraint** instead.

Diaphragm

Weld

Plate

Rod

Equal

A Diaphragm Constraint causes all of its constrained joints to move together as a planar diaphragm that is rigid against membrane (in-plane) deformation.

This constraint can be used to model concrete floors .

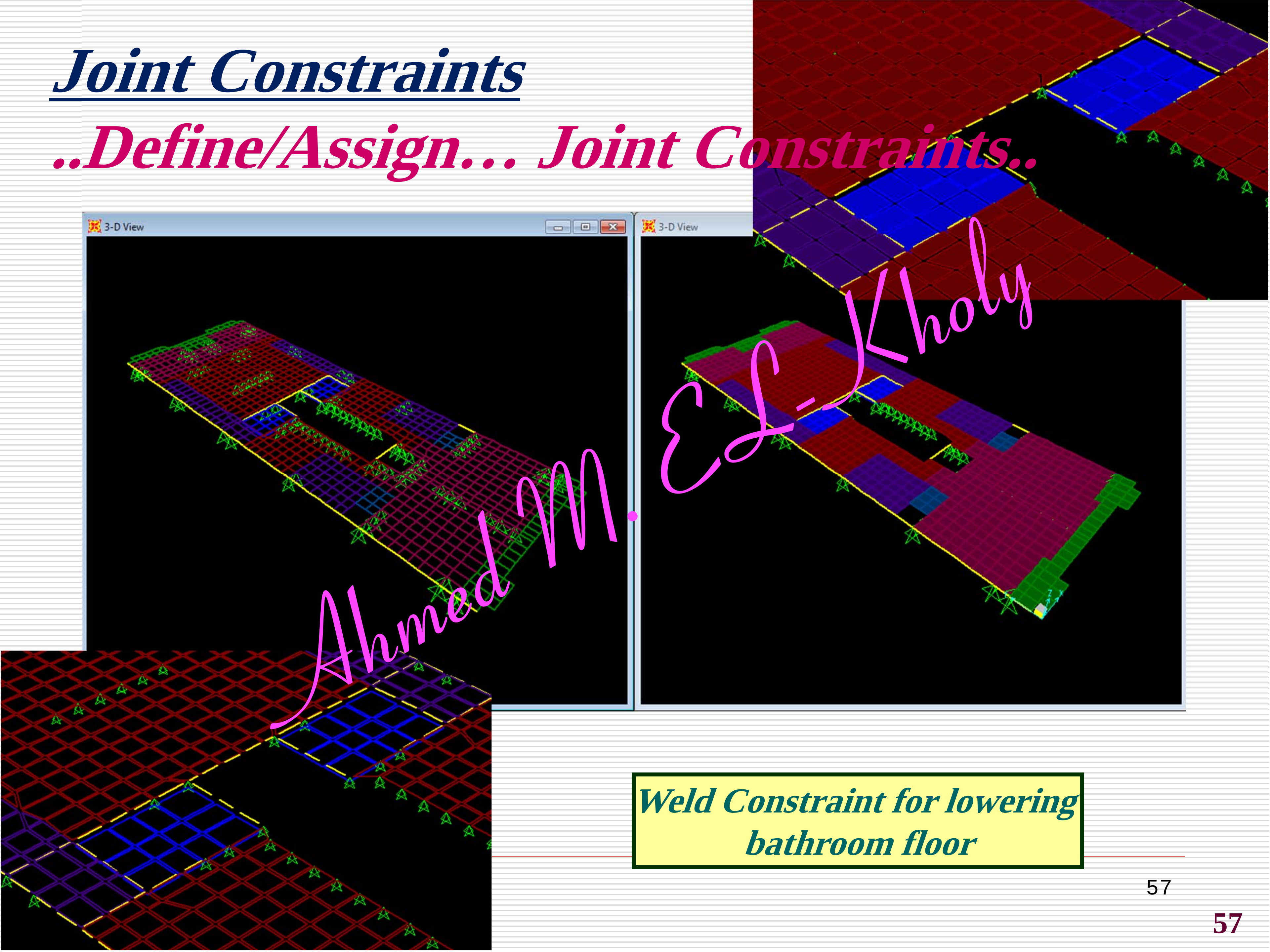
if the Z axis is chosen, this constraint is equivalent to a body constraint in the same coordinate system with translations X and Y and rotation Z chosen.

Column cross section – Roller support

Lateral load at slab CG – Hidden beams

Joint Constraints

..Define/Assign… Joint Constraints..

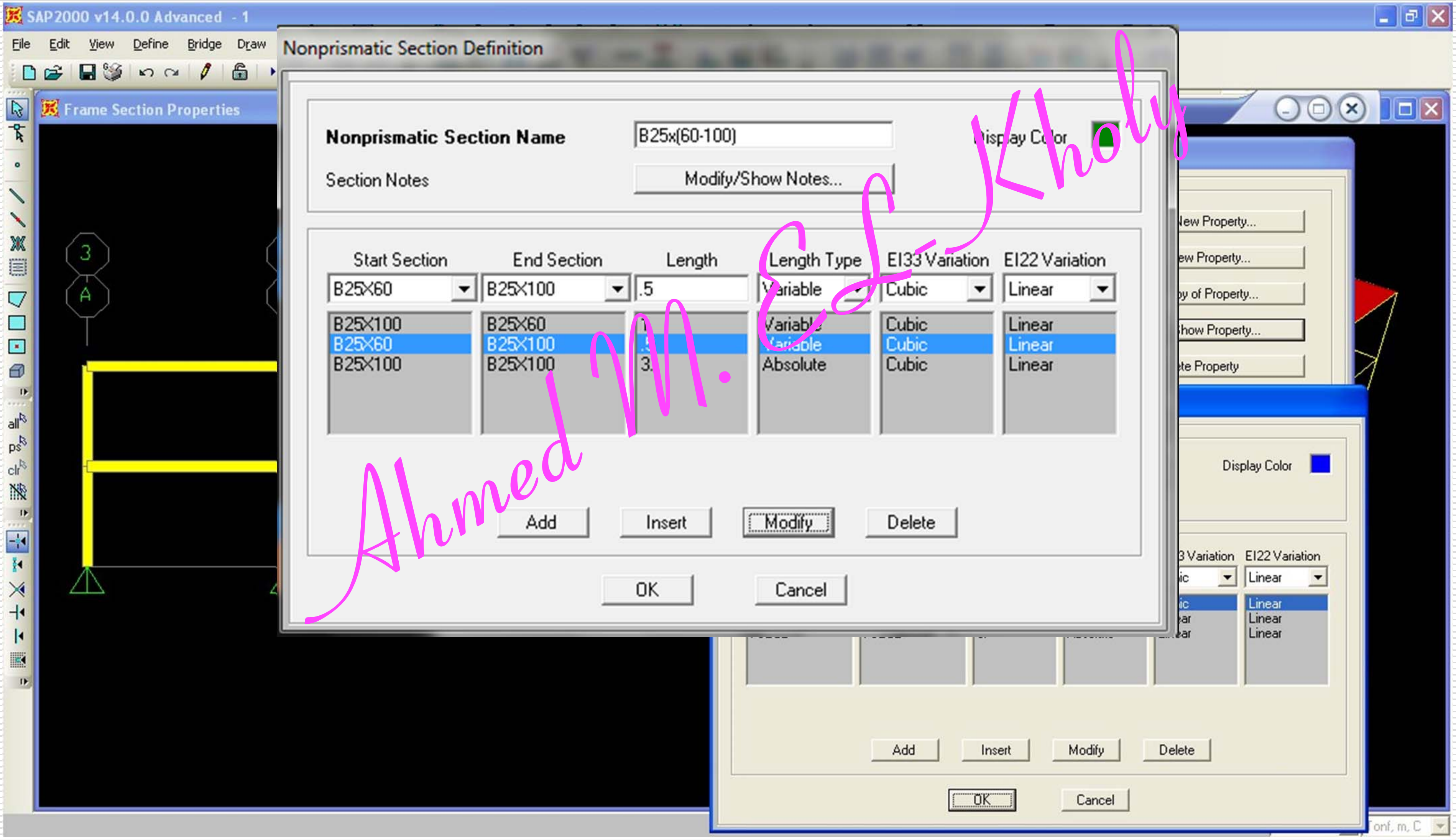


Weld Constraint for lowering bathroom floor

Definition of Non Prismatic Section

Nonprismatic Section

..Define..Section Properties..Frame..Add New..Other..Nonprismatic



Nonprismatic Section Name B25x(60-100)

Section Notes

Display Color 🟩

Start Section	End Section	Length	Length Type	EI33 Variation	EI22 Variation
B25X60	B25X100	.5	Variable	Cubic	Linear
B25X100	B25X60	1	Variable	Cubic	Linear
B25X60	B25X100	.5	Variable	Cubic	Linear
B25X100	B25X100	3.	Absolute	Cubic	Linear

Nonprismatic Section

..Define..Section Properties..Frame..Add New..Other..Nonprismatic

A linear variation in t2 for the rectangular shape would require eivar33=1

A linear variation in t3 for the rectangular shape would require eivar33=3.

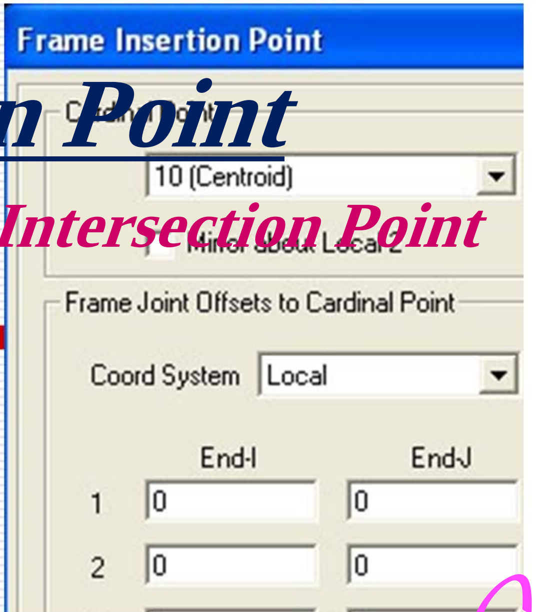
A linear variation in t3 for the I- shape would require eivar33=2

The interpolation of the bending stiffness in the 1-2 plane, i22 × e1, is defined in the same manner by the parameter eivar22

Frame Intersection Point
Cardinal Point

Intersection Point

..Assign..Frame..Intersection Point



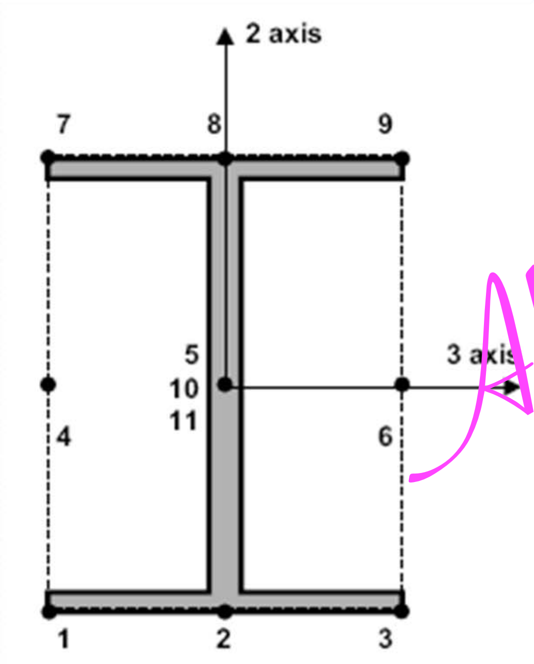
Cardinal Point: 10 (Centroid)

Mirror about Local 2

Frame Joint Offsets to Cardinal Point

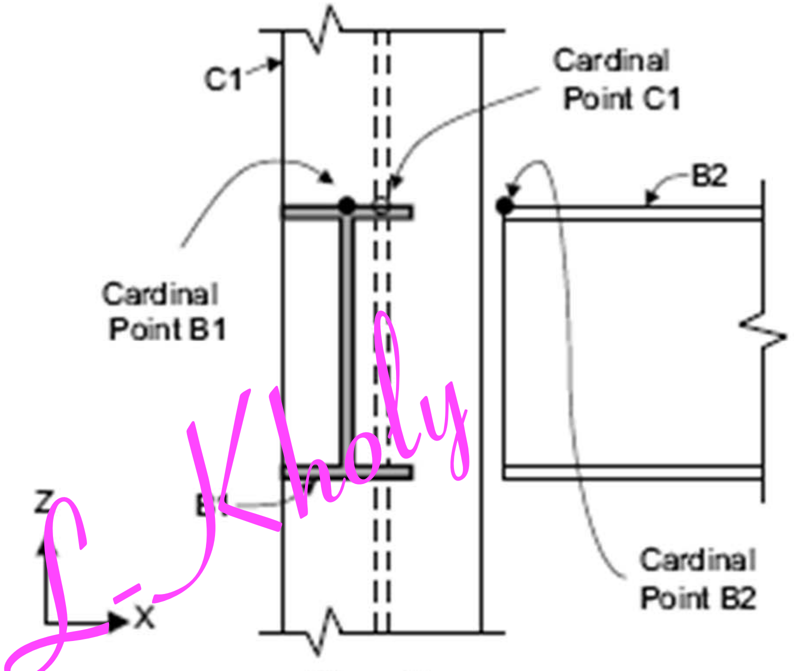
Coord System: Local

	End-I	End-J
1	0	0
2	0	0
		0

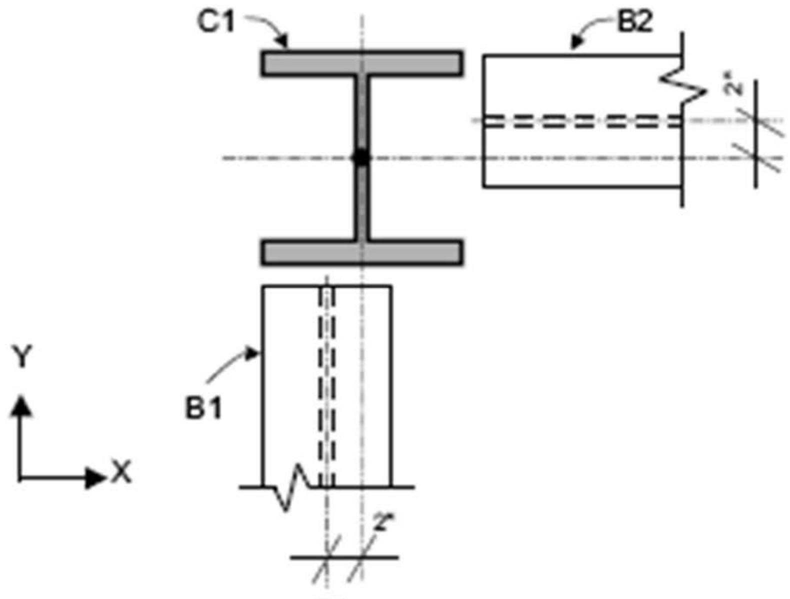


1. Bottom left
2. Bottom center
3. Bottom right
4. Middle left
5. Middle center
6. Middle right
7. Top left
8. Top center
9. Top right
10. Centroid
11. Shear center

Note: For doubly symmetric members such as this one, cardinal points 5, 10, and 11 are the same.



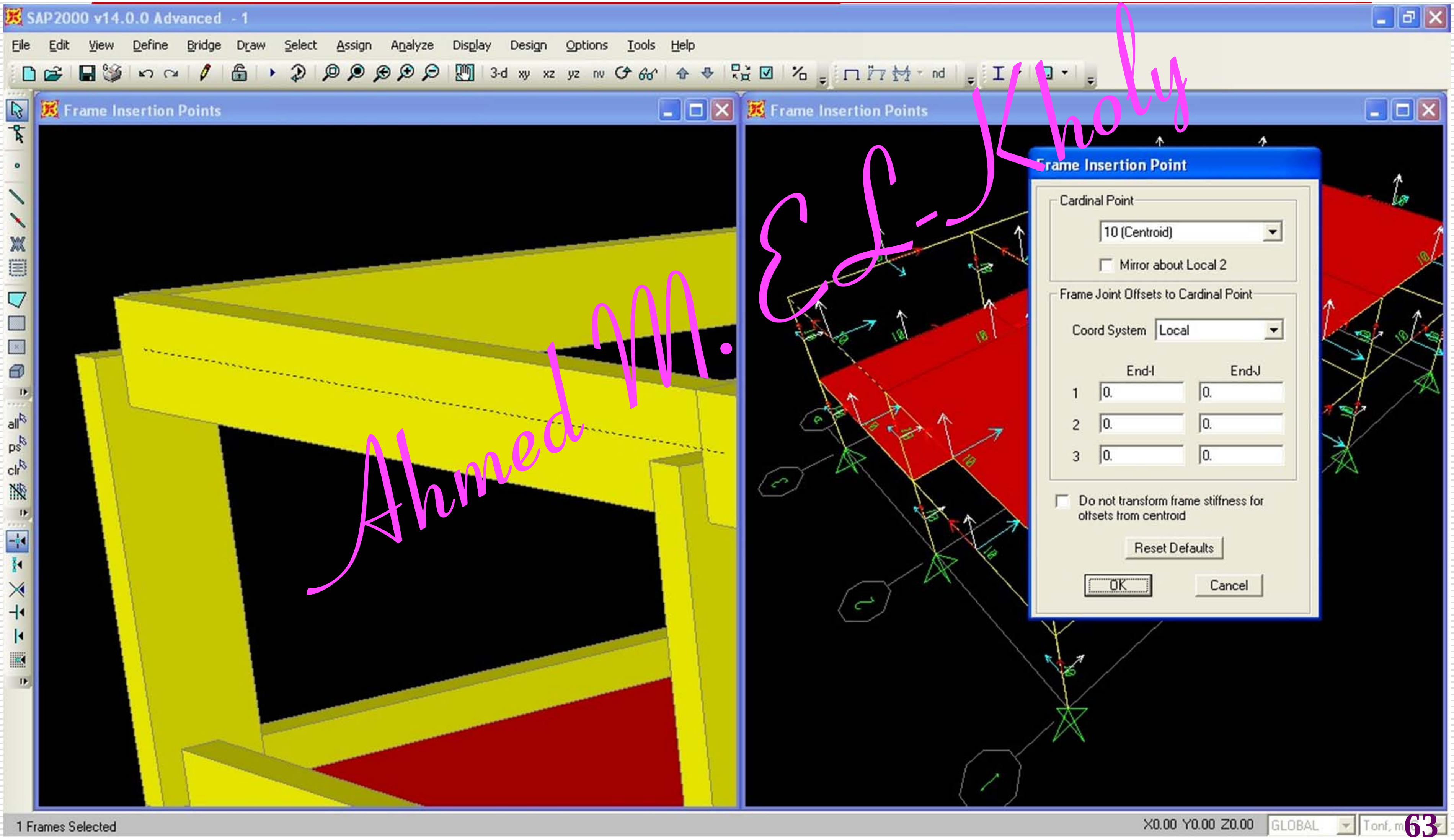
Elevation



Plan

Intersection Point

..Assign..Frame..Intersection Point



Frame Insertion Point

Cardinal Point: 10 (Centroid)

☐ Mirror about Local 2

Frame Joint Offsets to Cardinal Point

Coord System: Local

	End-I	End-J
1	0.	0.
2	0.	0.
3	0.	0.

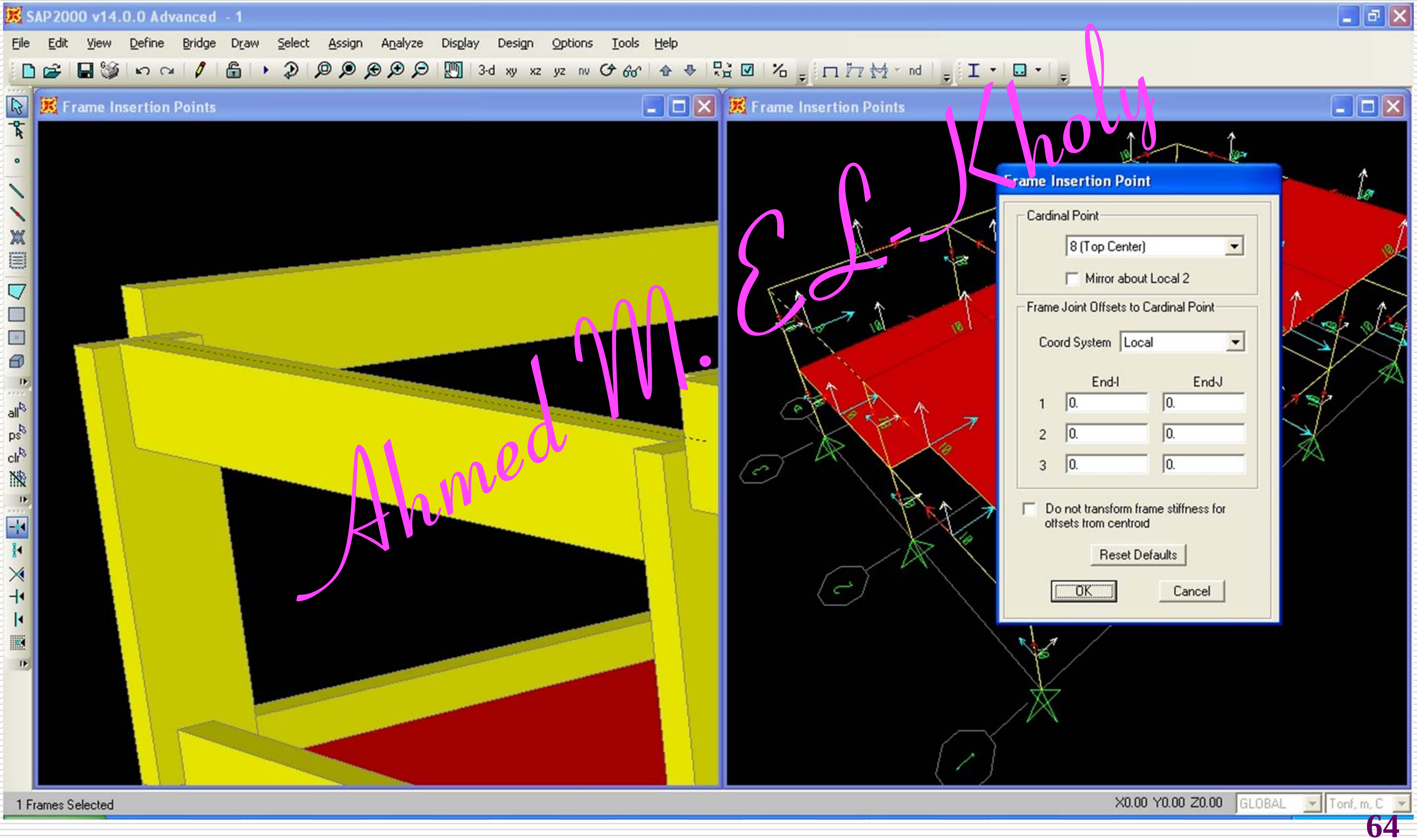
☐ Do not transform frame stiffness for offsets from centroid

1 Frames Selected

X0.00 Y0.00 Z0.00 GLOBAL Tonf, m

Intersection Point

..Assign..Frame..Intersection Point



Frame Insertion Point

Cardinal Point

8 (Top Center)

☐ Mirror about Local 2

Frame Joint Offsets to Cardinal Point

Coord System: Local

	End-I	End-J
1	0.	0.
2	0.	0.
3	0.	0.

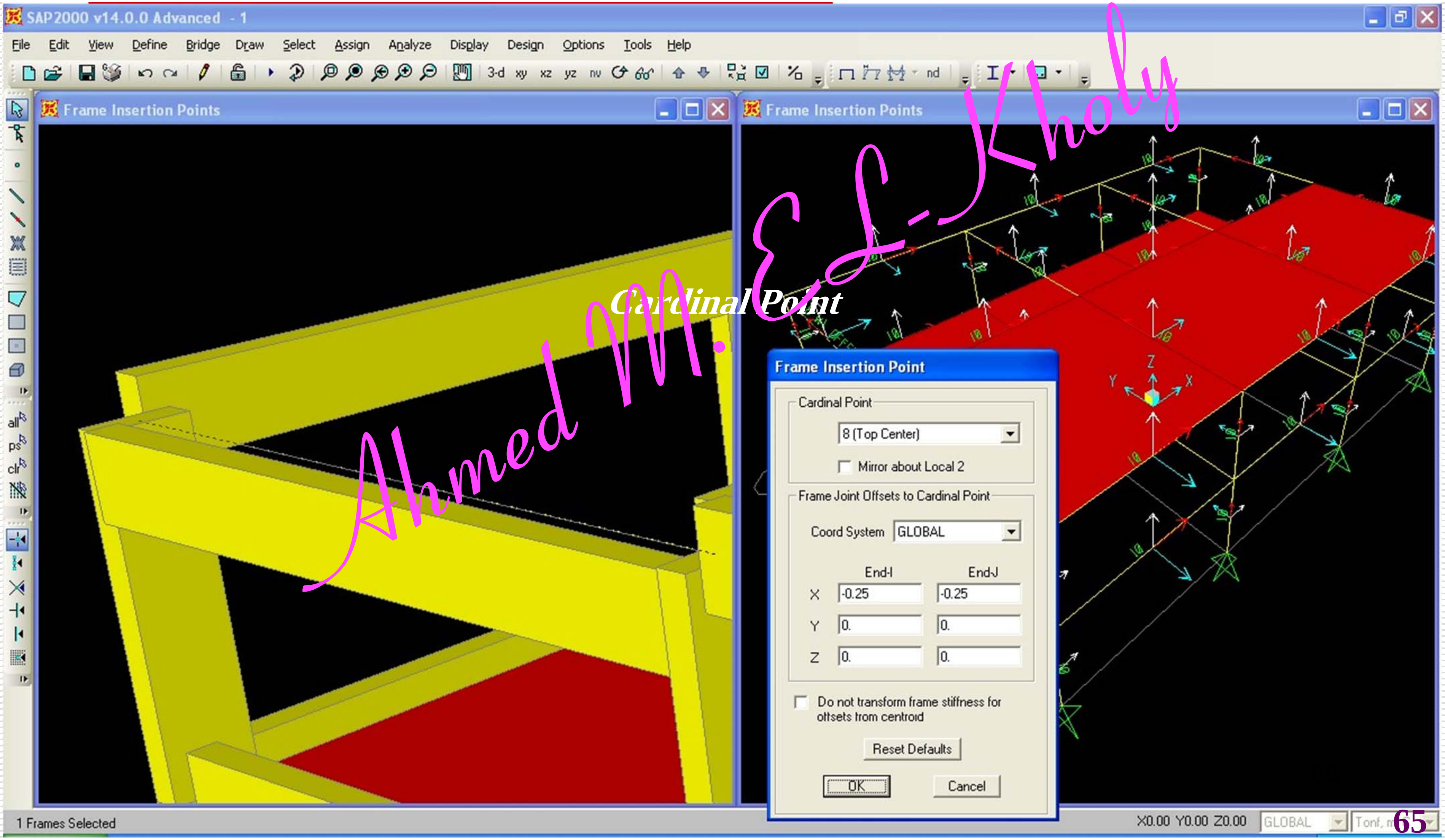
☐ Do not transform frame stiffness for offsets from centroid

1 Frames Selected

X0.00 Y0.00 Z0.00

Intersection Point

..Assign..Frame..Intersection Point



Cardinal Point

Frame Insertion Point

Cardinal Point

8 (Top Center)

☐ Mirror about Local 2

Frame Joint Offsets to Cardinal Point

Coord System: GLOBAL

	End-I	End-J
X	-0.25	-0.25
Y	0.	0.
Z	0.	0.

☐ Do not transform frame stiffness for offsets from centroid

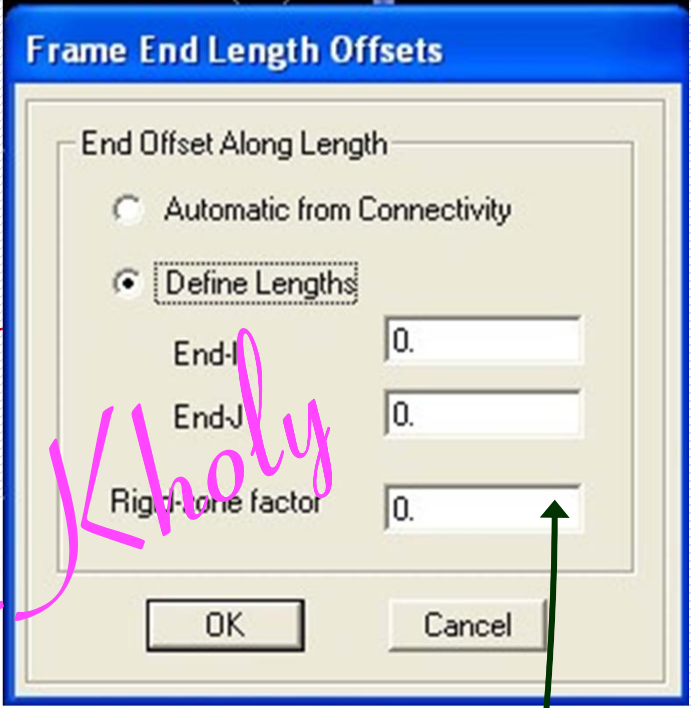
1 Frames Selected

X0.00 Y0.00 Z0.00 GLOBAL Tonf, m

Frame End Offset

End Offset

..Assign..Frame..End Offset



Frame End Length Offsets

End Offset Along Length

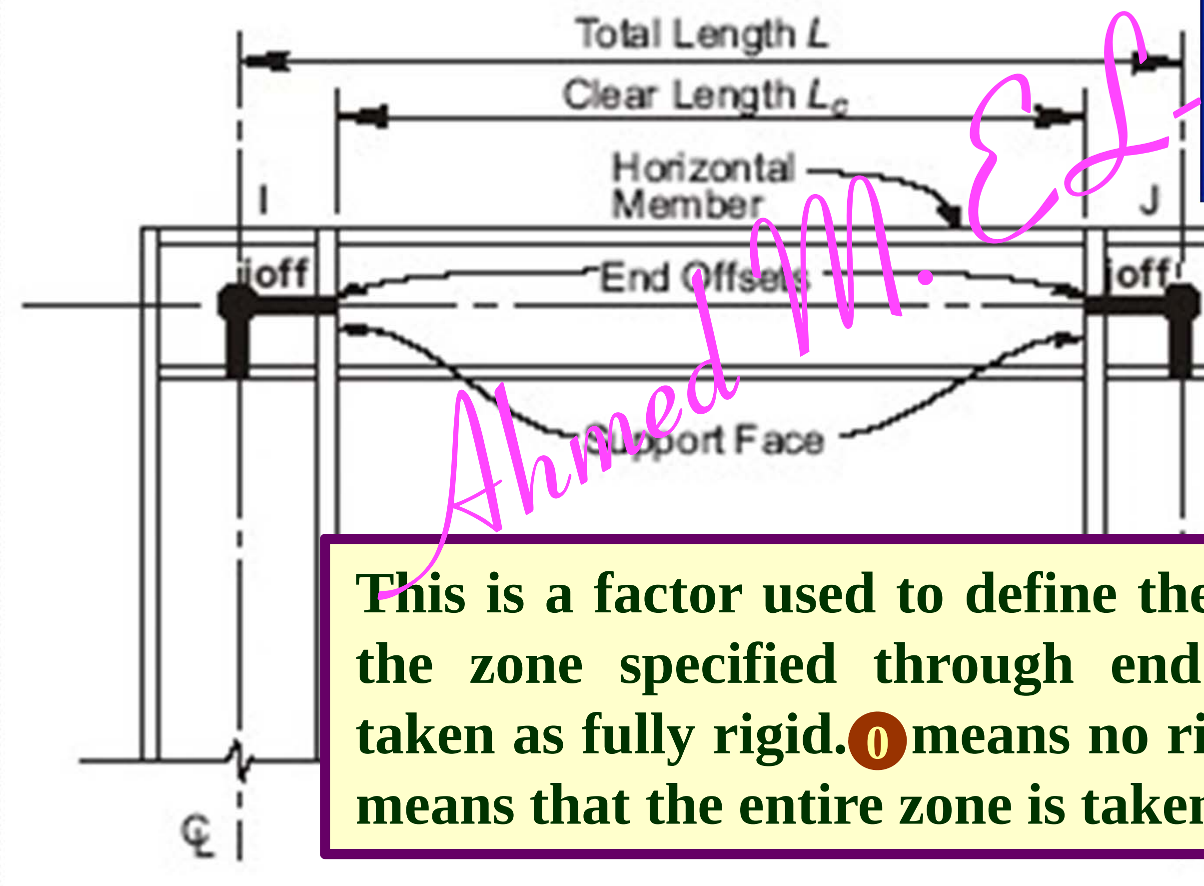
○ Automatic from Connectivity

● Define Lengths

End-I 0.

End-J 0.

Rigid-zone factor 0.



This is a factor used to define the percentage of the zone specified through end offsets to be taken as fully rigid. 0 means no rigid zone and 1 means that the entire zone is taken as rigid.

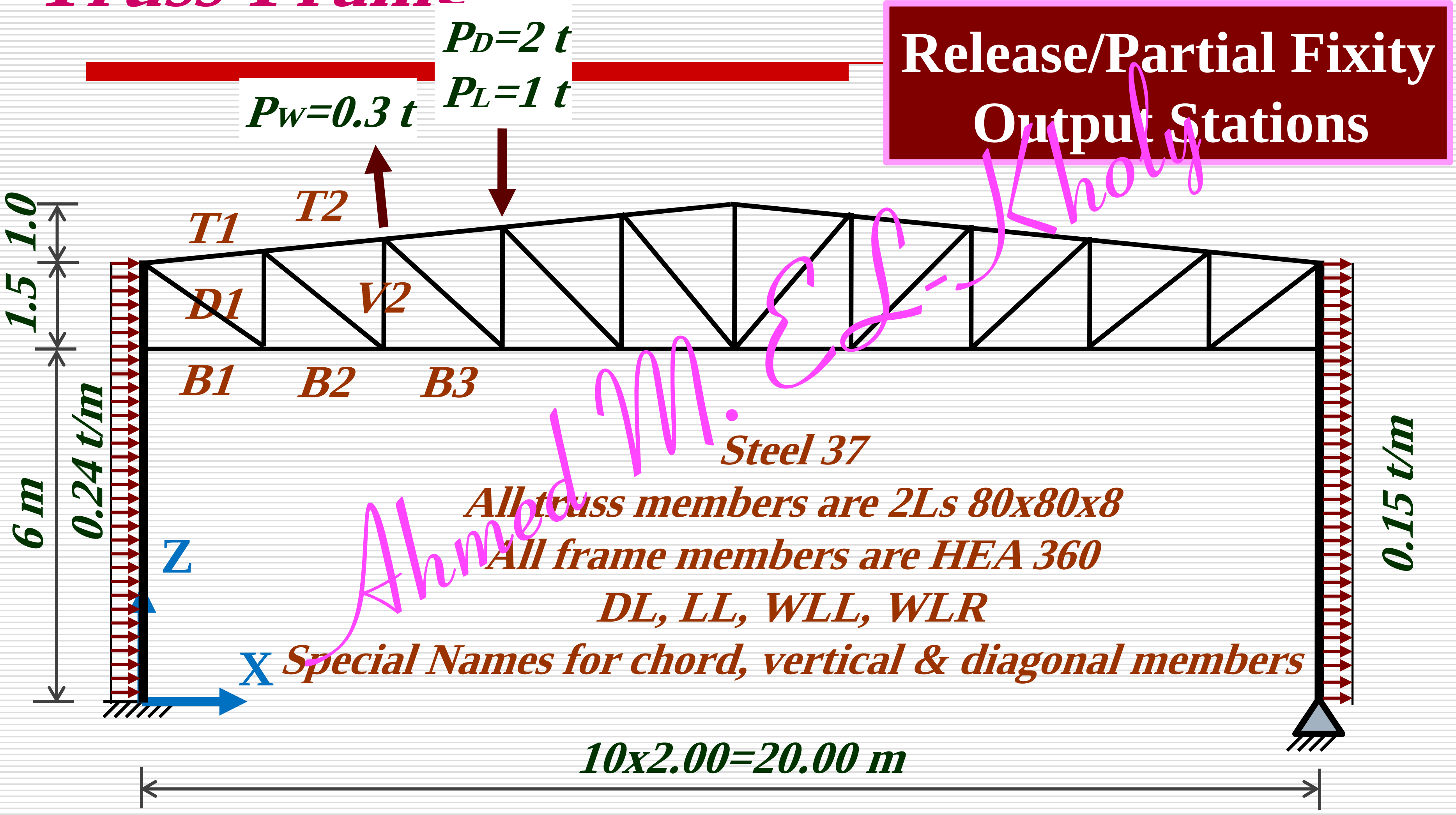
Examples

Copy Excel files to Lab PC(s)

Example 1

Truss-Frame

Release/Partial Fixity Output Stations



Steel 37

All truss members are 2Ls 80x80x8

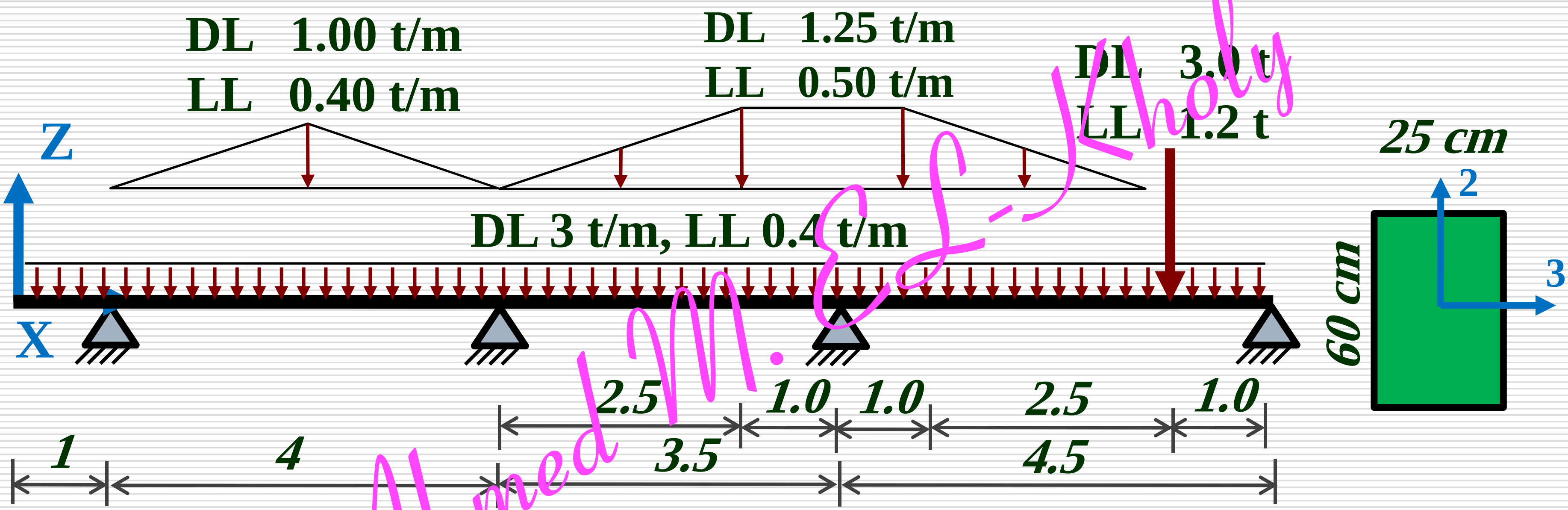
All frame members are HEA 360

DL, LL, WLL, WLR

Special Names for chord, vertical & diagonal members

Example 2

RC-Beam



Concrete Fcu=250 Kg/cm^2

E=14000 $\sqrt{Fcu}$= 221359.4362 Kg/cm^2

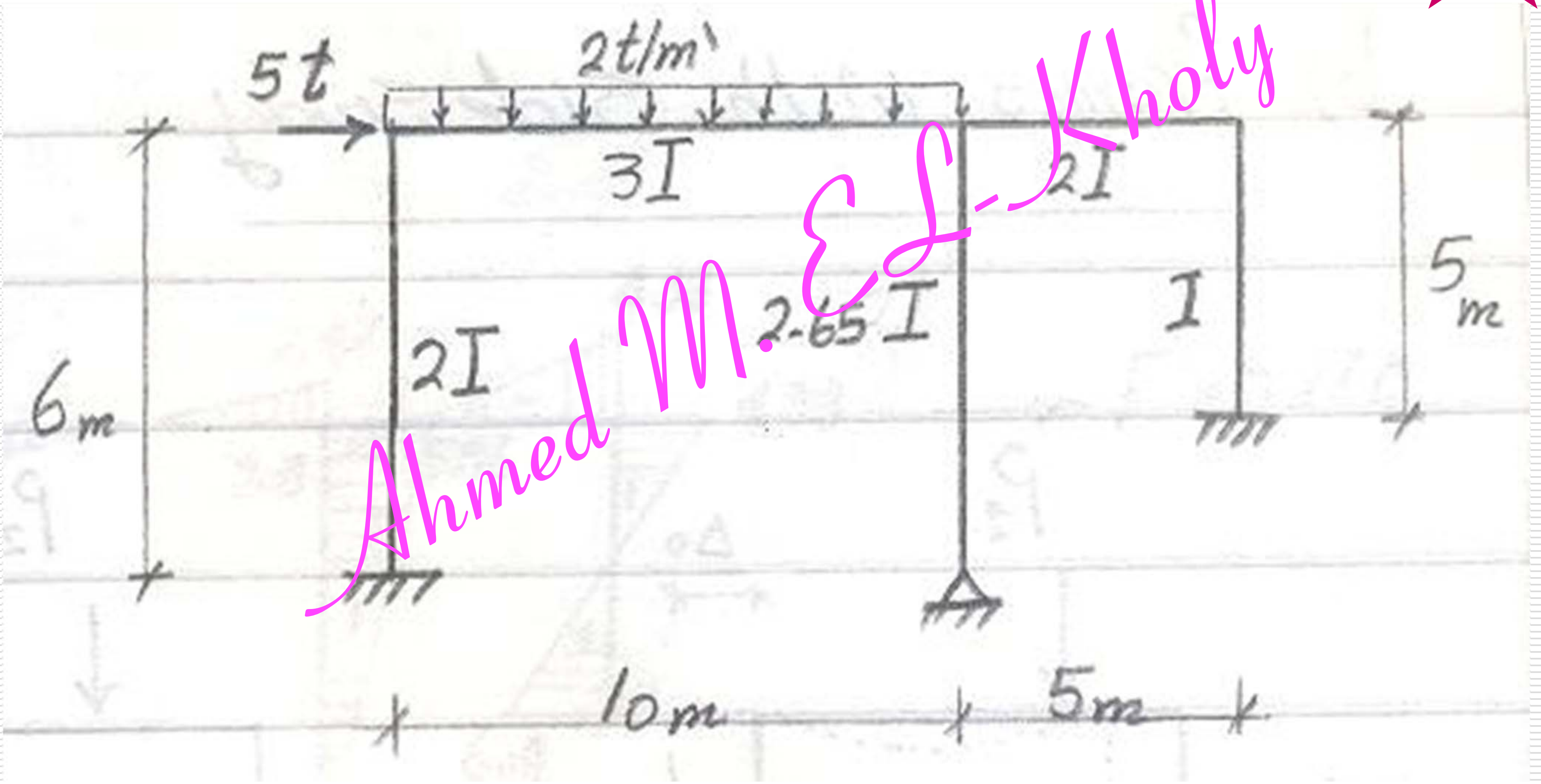
DL, LL, Work, Ultimate

Alive Model & Output Stations

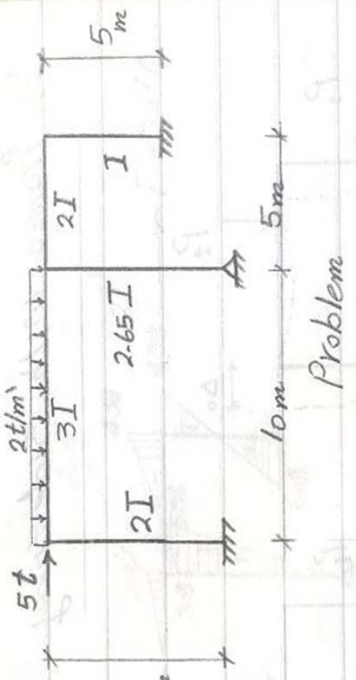
Example 3

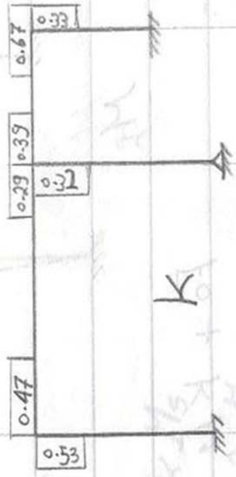
Frame Verification

Modifiers
Using Two different alternatives



Example 10

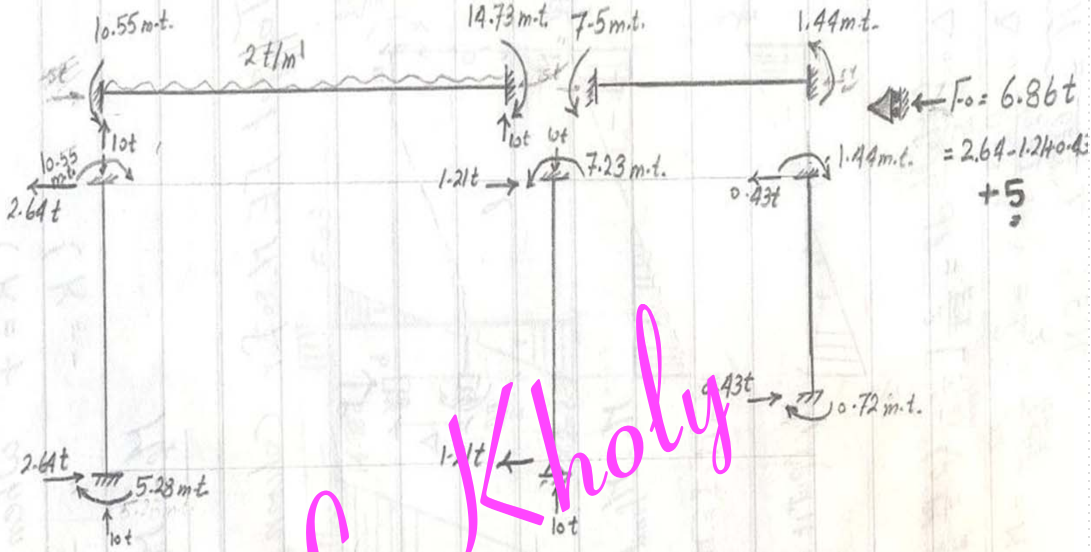




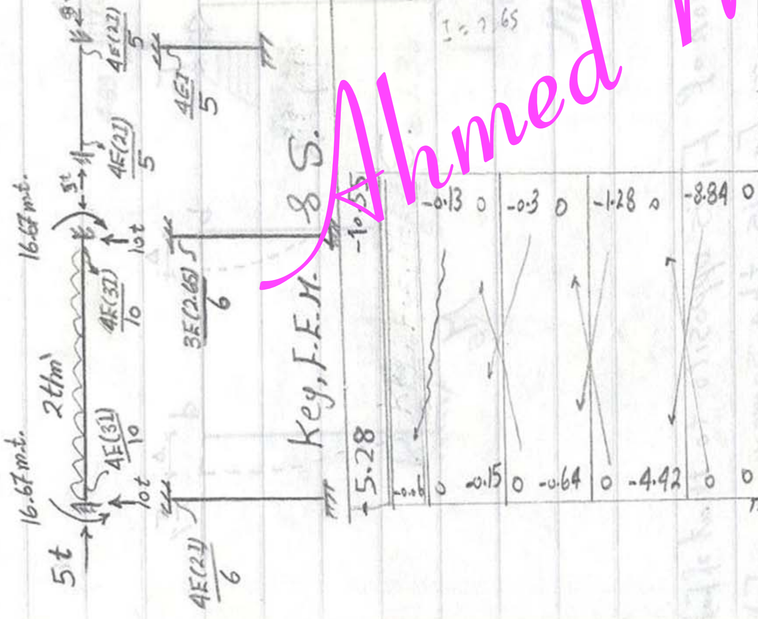
$0.32 = \frac{0.5 I}{1.2 + 1.6 + 0.5 I}$

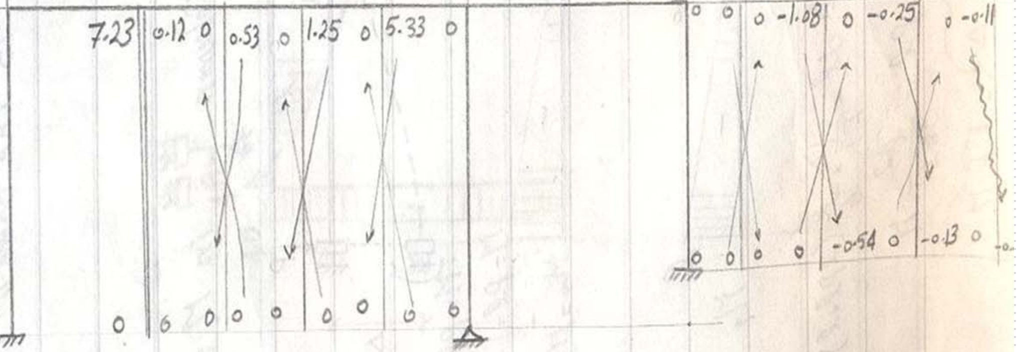
$0.9 + 0.16 I = 0.5 I$

$I = 2.65$

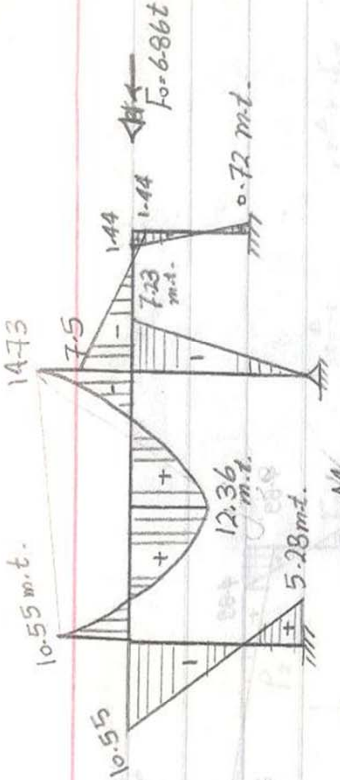


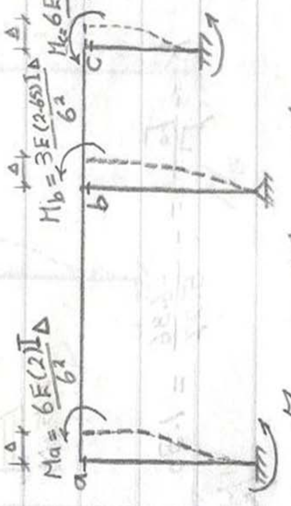
10.55	-14.73	7.5	1.44	M final
-0.11	0.12	0.16	-0.22	DIS.
0.24	-0.14	-0.26	0.33	C.O.M.
-0.27	0.48	0.65	-0.52	DIS.
0.57	-0.57	-1.09	0.77	C.O.M.
-1.14	1.14	1.53	-2.18	DIS.
2.42	-3.92	0	3.26	C.O.M.
-7.83	4.83	6.51	0	DIS.
16.67	-16.67	0	0	F.E.M.





Non-Sway ... Solution ....





$M_a = \frac{6E(2)I\Delta}{6^2}$

$M_b = \frac{3E(2.65)I\Delta}{6^2}$

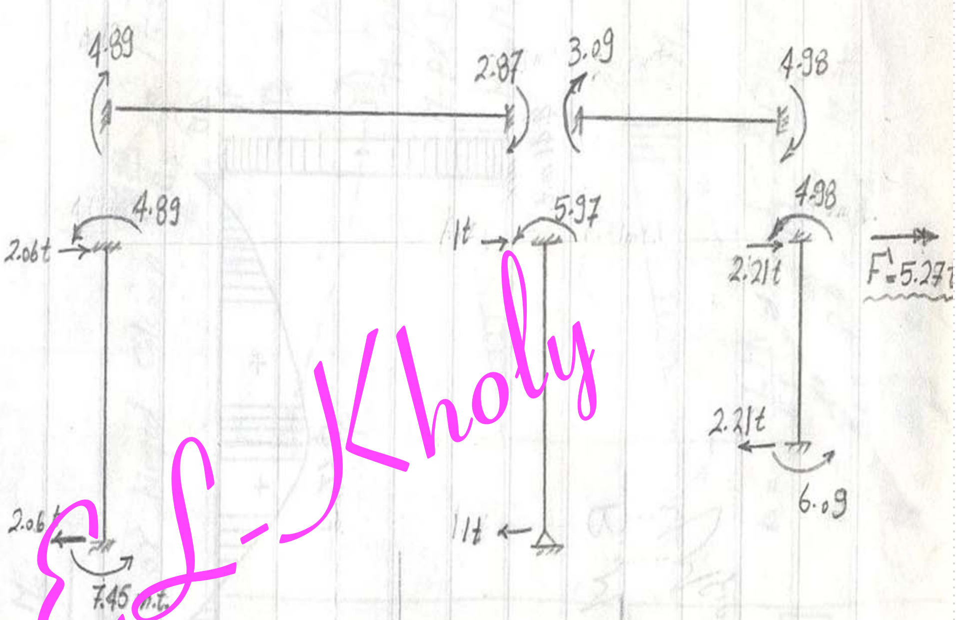
$M_c = \frac{6EI\Delta}{5^2}$

$\therefore M_a : M_b : M_c$

$= \frac{1}{3} : 0.2208 : 0.24$

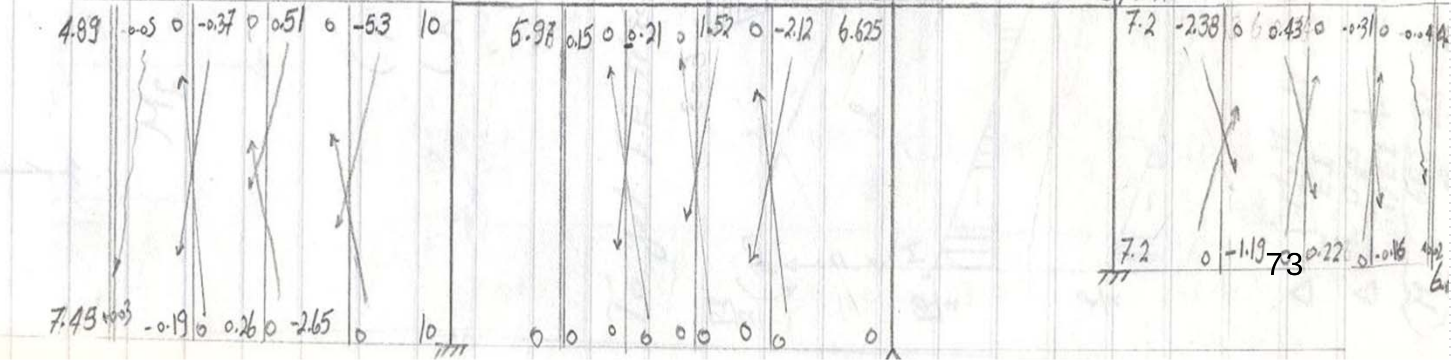
Assume $M_a = 10$ m.t.

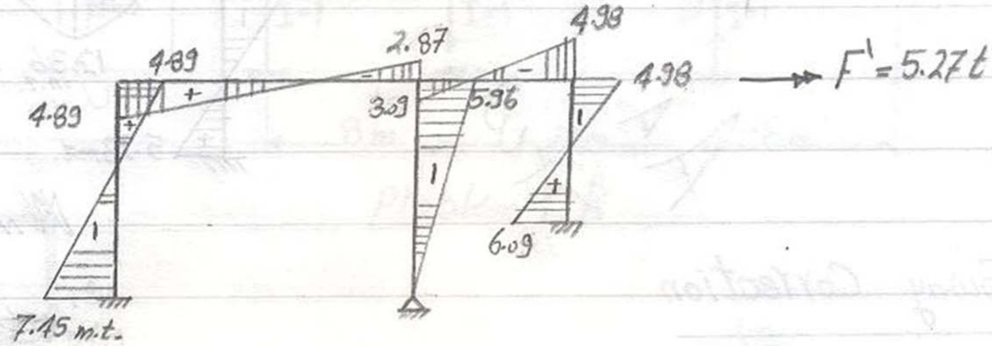
$\therefore M_b = 6.625$ m.t., $M_c = 7.2$ m.t.



-4.89	-2.87	-3.09	-4.98	
-0.05	0.14	0.18	-0.09	DIS.
-0.10	-0.16	-0.31	-0.13	C.O.M.
-0.32	-0.19	-0.26	-0.62	DIS.
0.69	0.23	0.43	0.93	C.O.M.
0.45	1.38	1.86	0.86	DIS.
-0.96	-2.35	-2.41	-1.29	C.O.M.
-4.7	-1.92	-2.58	-4.82	DIS.
0	0	0	0	F.E.M.

Sway Correction



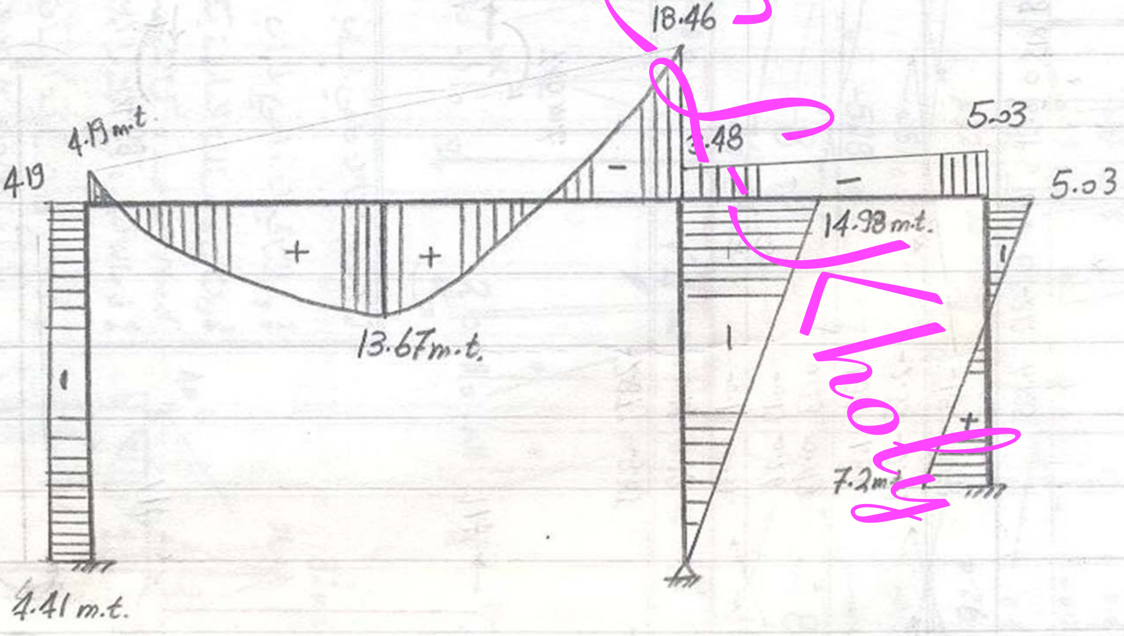


M_s

$$K = -\frac{F_o}{F'} = -\frac{-6.86}{5.27} = 1.30$$

$$M_f = M_{N.S.} + K\,M_s$$

$$M_f = M_{N.S.} + 1.30\,M_s$$

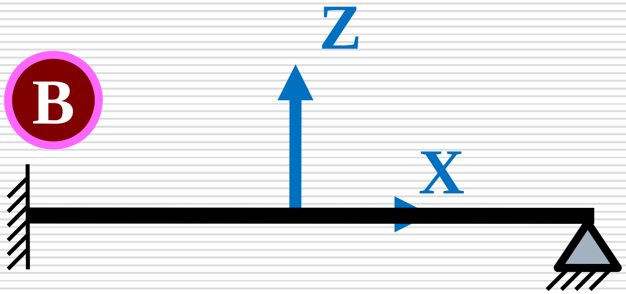


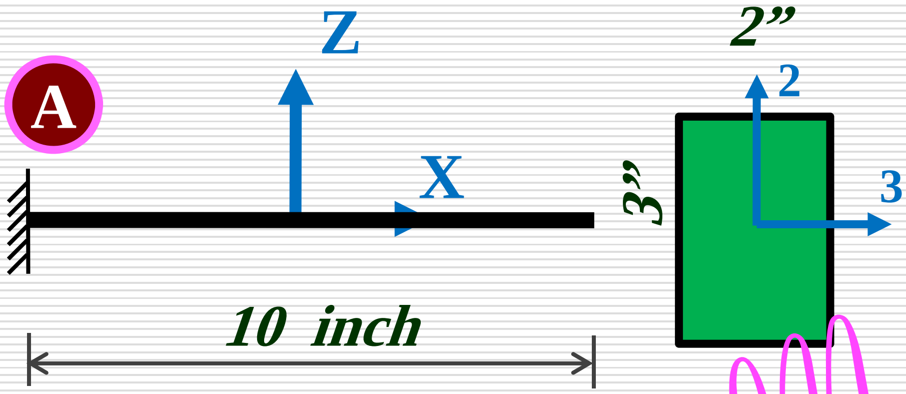
B.M.D

M_{final}

Example 4

Beam under Temperature





Mater1

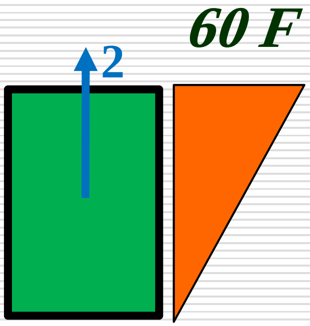
E=29000 k/in^2

α=0.0000065 /F

Load Case 1: Increase 20 F

Load Case 2: Increase 2 F/inch along X-axis

Load Case 3: Linear Increase 60 F on the top fiber



Case1: Temperature=+20 (+ increase)

Case2: Define/Assign (Joint Patterns) Temperature=2X+10

Case3: Gradient22=+60/3=+20 (+ increase with local 2)

Example 4

Beam under Temperature

	Case A	Case B
Load Case	**U**	**F**
1	Ux=0.0013	Fx=-22.62
2	Ux=0.00065	Fx=-11.31
3	Uz=-0.0065	Fz=2.545

Example 5

Frame under different loads and temperature +Settlement + Inclined Support

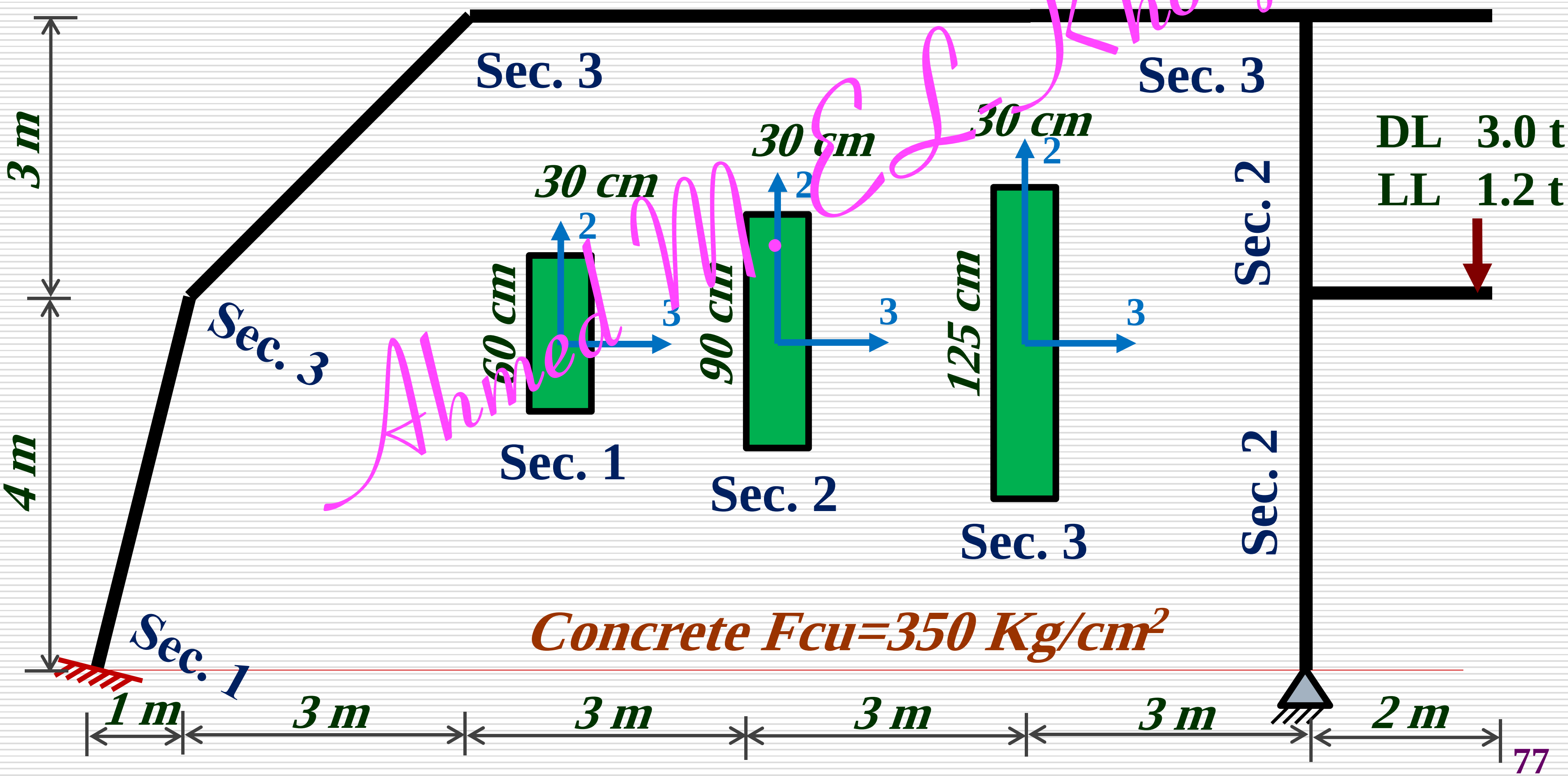
DL

LL

WL

Utemp

NUTemp



Concrete Fcu=350 Kg/cm²

Example 5

Frame under different loads and temperature +Settlement + Inclined Support

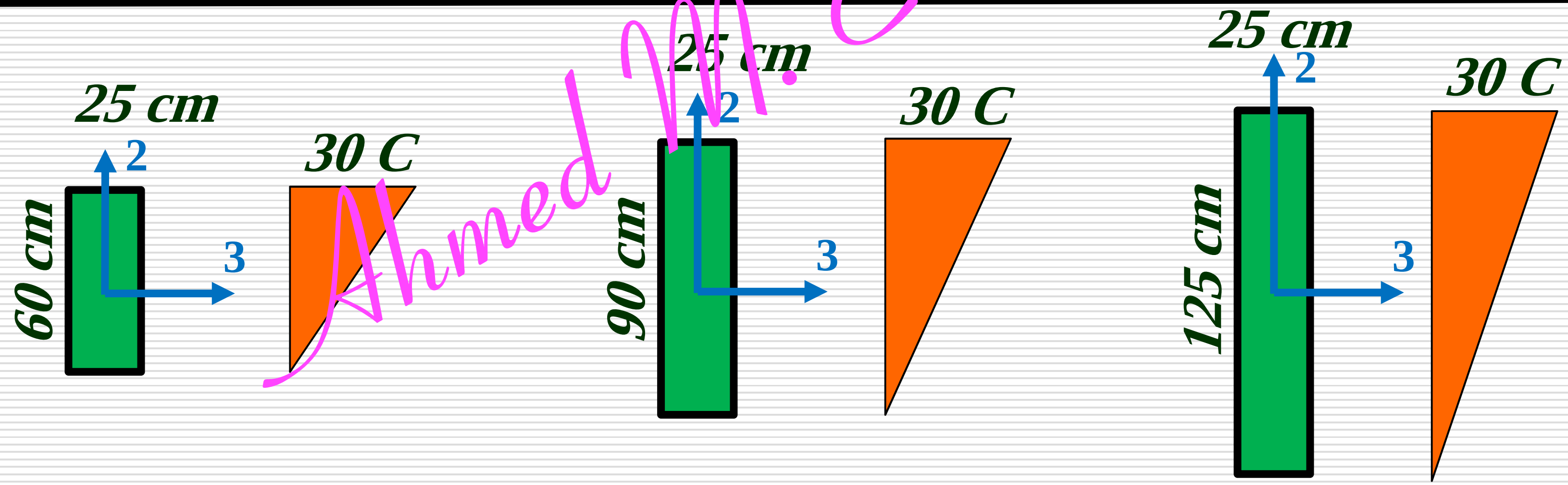
6 Cases of Loading

1-DL Case

2-LL Case

3-WL Case

4-Utemp Case :: Uniform Increase 20 C



5-NUTemp Case:: Increase 30 C outside the frame

6-Settel Case:: Downward settlement of 1 cm at hinged support

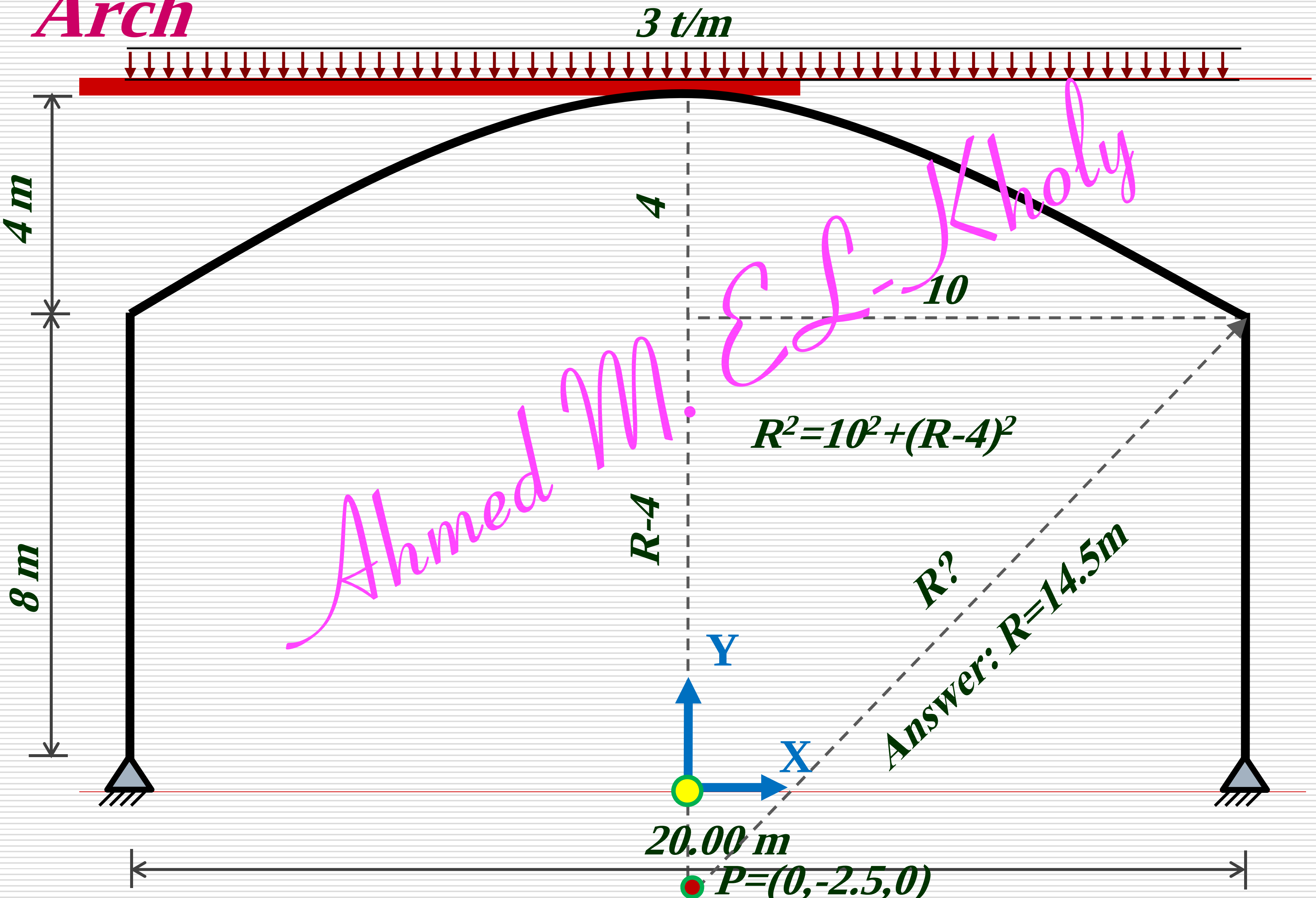
Example 5

Frame under different loads and temperature +Settlement + Inclined Support

Example 6

Arch

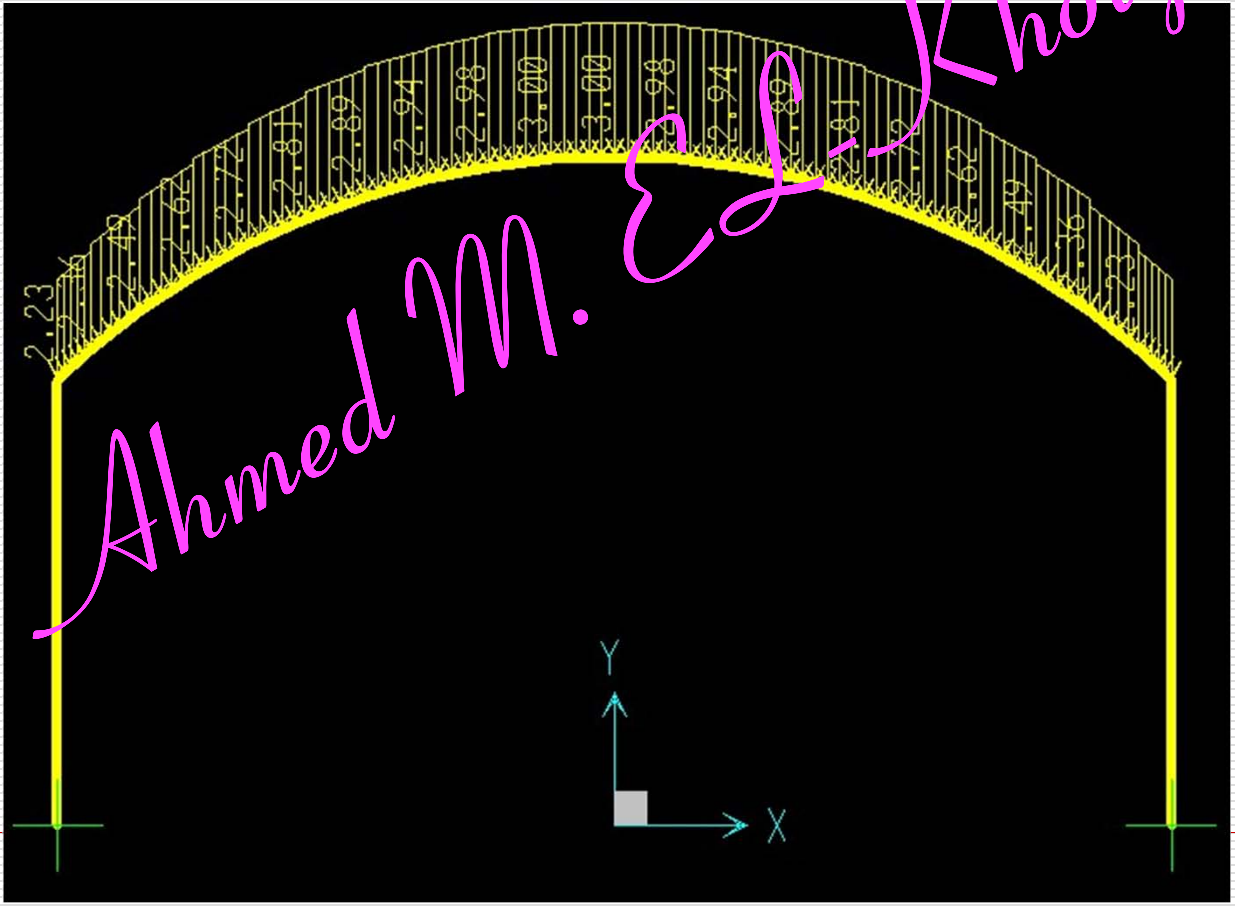
Cartesian 2-2-1-20-8-…
Cylindrical 2-41-1-14.5-4.5-… & Origin=P
Replicate Radial



Example 6

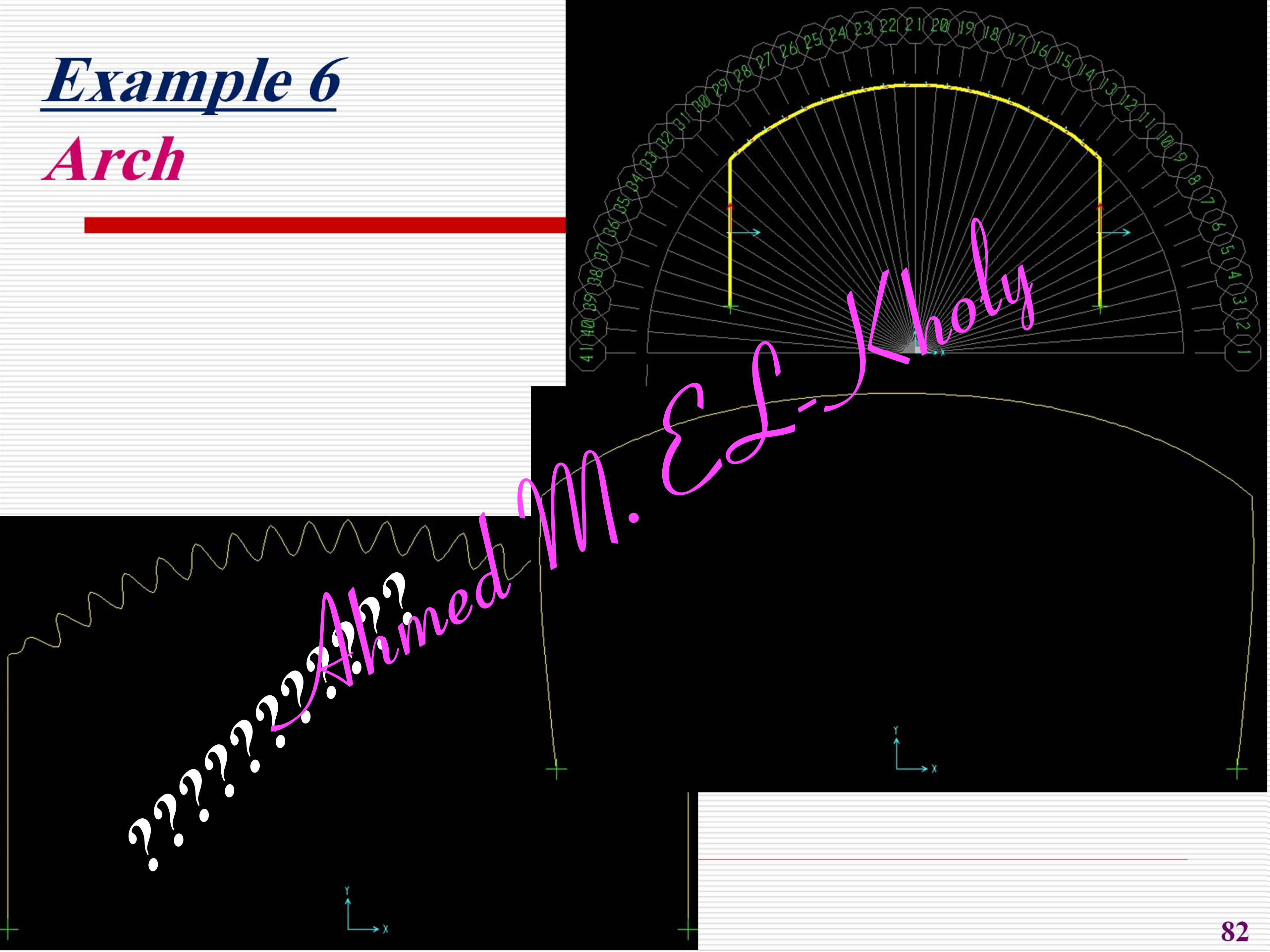
Arch

Horizontal Projection Load



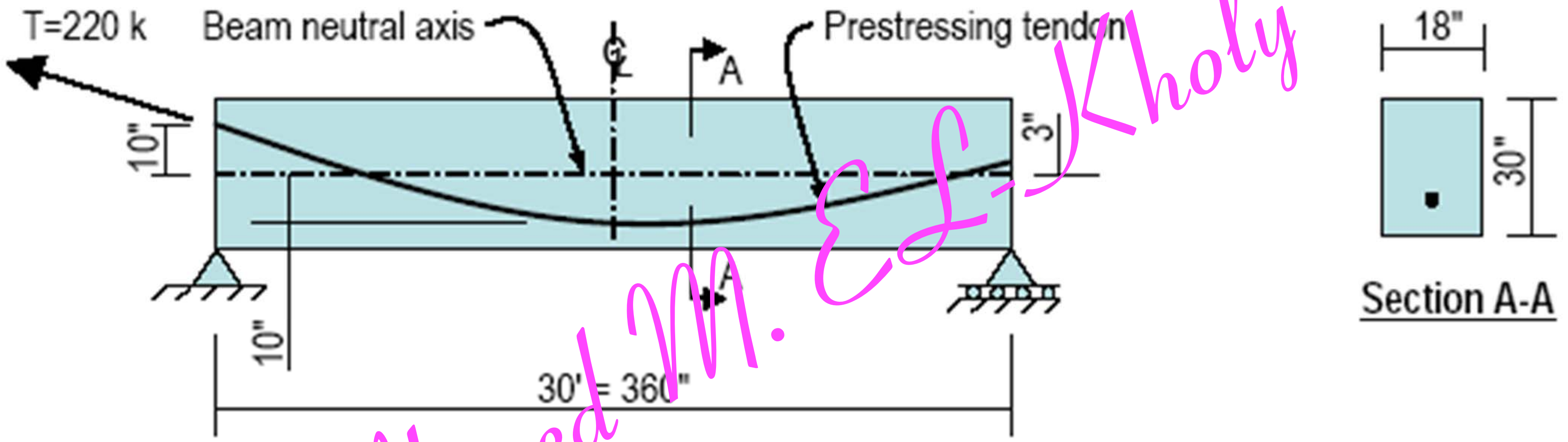
Example 6

Arch



Example 7

Prestress Beam – Using Tendon Element



Material Properties

$E = 3600$ k/in^2
$v = 0.2$
$G = 1500$ k/in^2

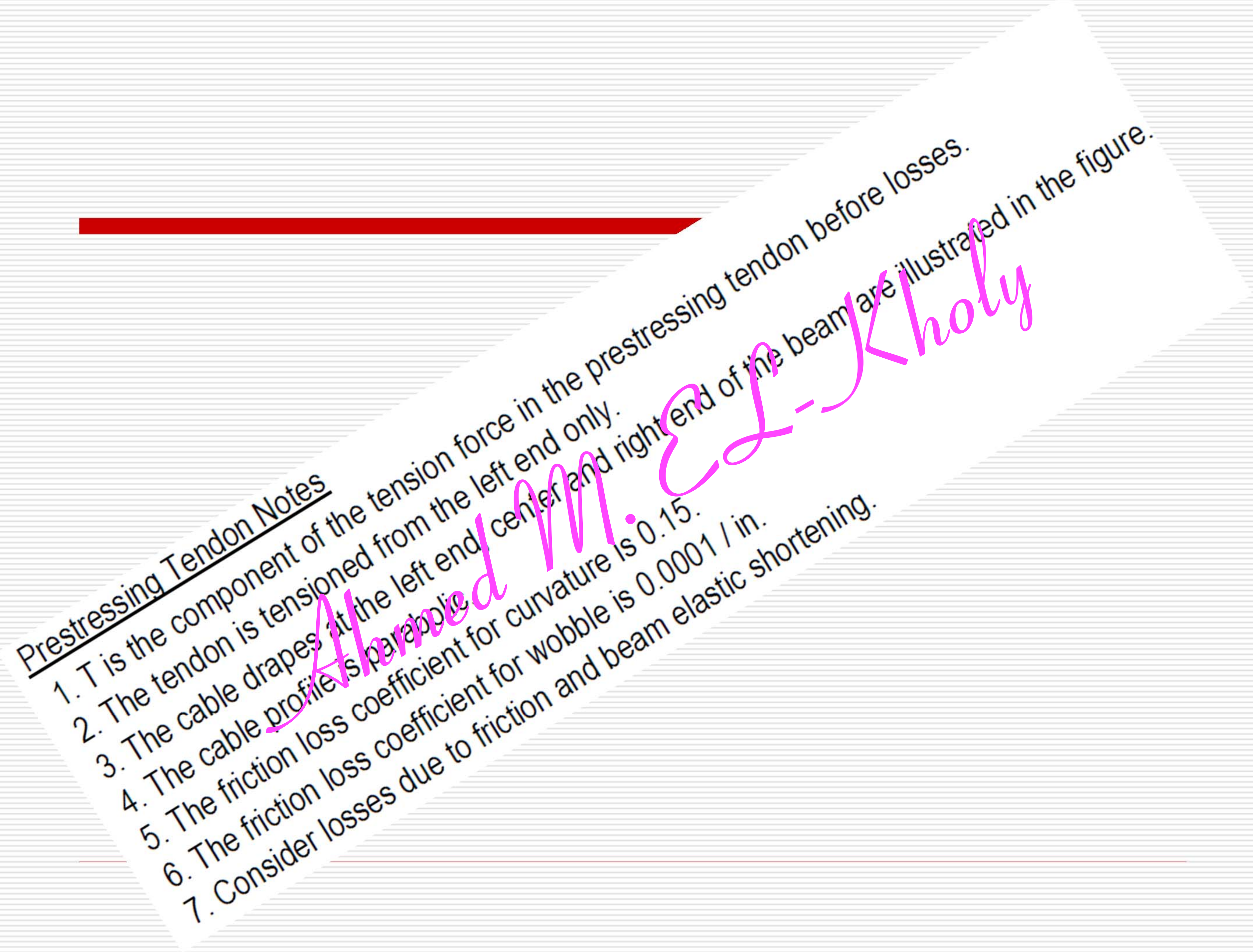
Section Properties

b = 18 in
d = 30 in
A = 540 in^2

Prestress Properties

A = 1.5 in2
E = 29000 k/in2
v = 0.3

Uz=0.165 inch & M=2004 Kip



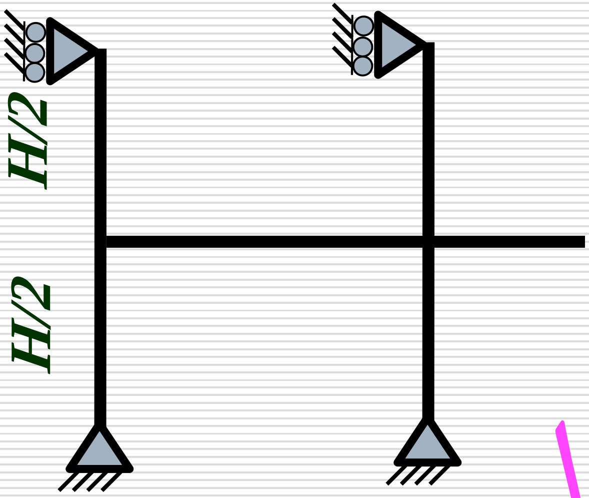
Prestressing Tendon Notes

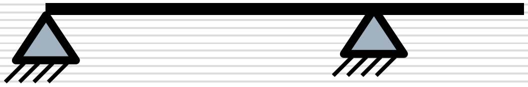
1. T is the component of the tension force in the prestressing tendon before losses.
2. The tendon is tensioned from the left end only.
3. The cable drapes at the left end, center and right end of the beam are illustrated in the figure.
4. The cable profile is parabolic.
5. The friction loss coefficient for curvature is 0.15.
6. The friction loss coefficient for wobble is 0.0001 / in.
7. Consider losses due to friction and beam elastic shortening.

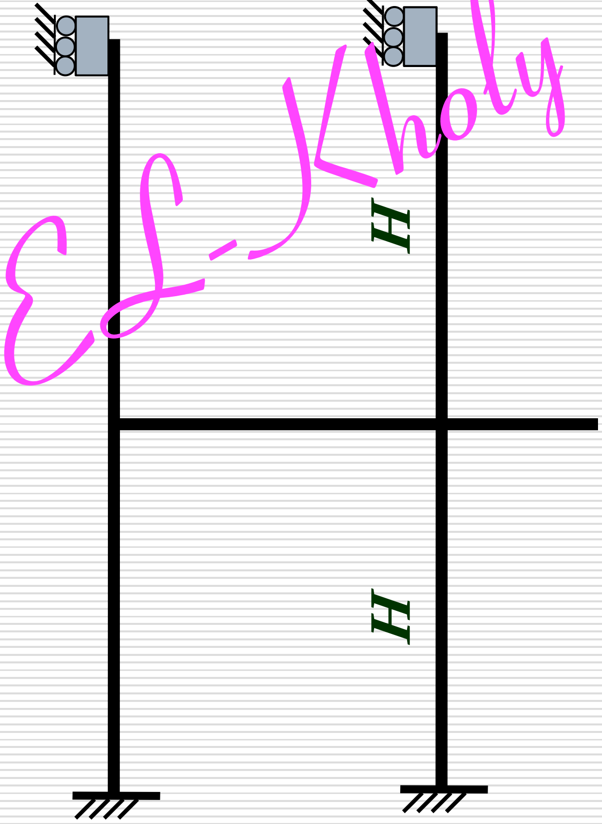
Flat Slab Example

Flat Slab Example

Flat Slab Modeling ::: 3 Alternatives







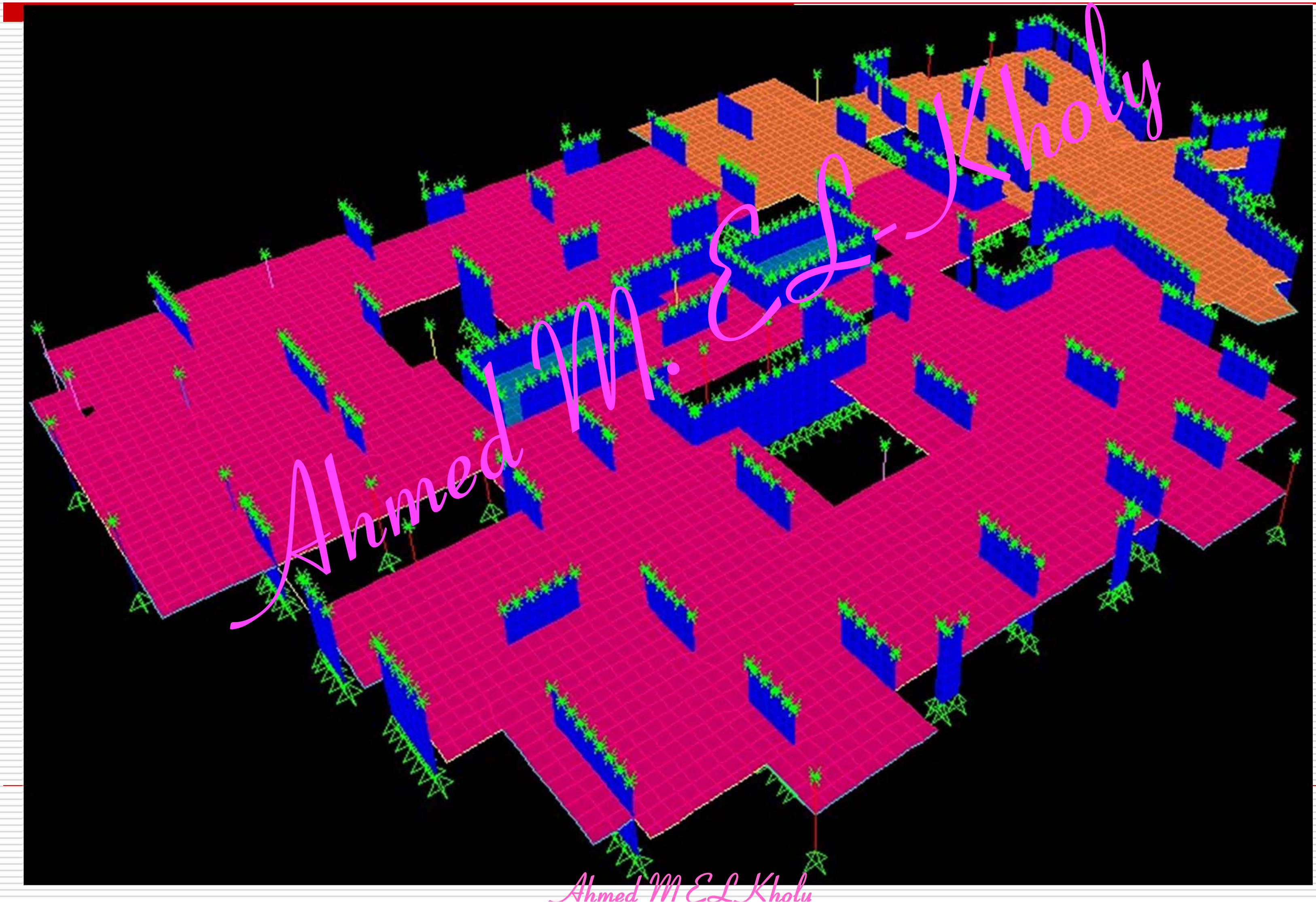
Flat Slab Example

Minimum Dimensions

1. ts=15 cm.
2. ts=L/32 for edge spans.
3. ts=L/36 for internal spans.
4. bc=1/20 span.
5. bc=30 cm.
6. bc=1/15 floor height.
7. Edge beam depth ≥ 3ts

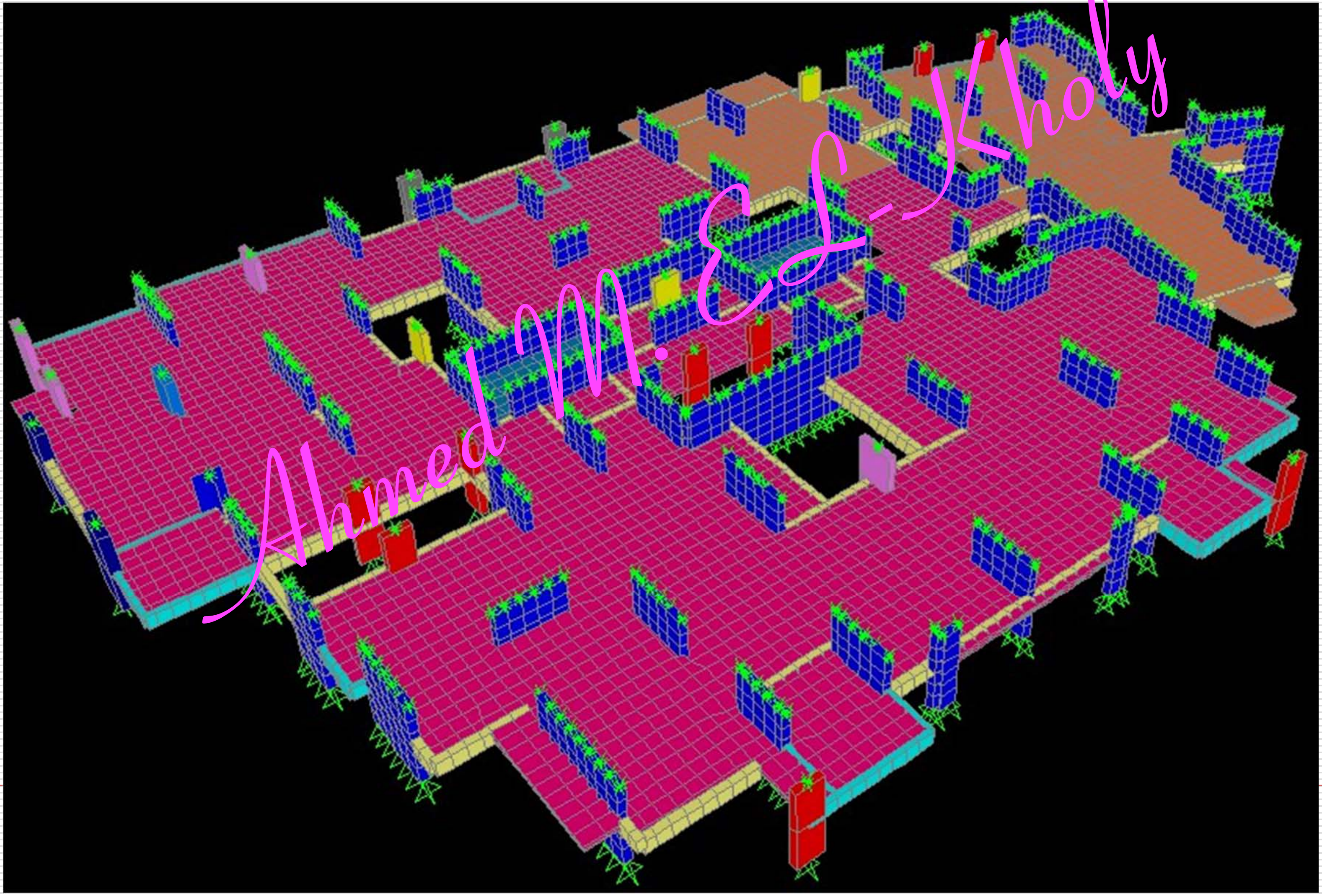
Flat Slab Example

Flat Slab Modeling ::: 3 Alternatives



Flat Slab Example

Flat Slab Modeling ::: 3 Alternatives



Flat Slab Example

AutoCAD DXF

1. **Choose carefully & fix (0,0) point in CAD & SAP**
2. **Mesh 0.25x0.25 ~ 1.0x1.0 m^2**
3. **Align the mesh at the beams lines, building edges and lines separating different loads areas.**
4. **A t least one joint must exist in the column C.G.**
5. **Large columns may be represented by more joints.**
6. **Avoid triangle and irregular elements shapes as much as possible**
7. **Delete the openings.**
8. **Apply the rules given in slides 4~6 and 19~20.**
9. **Draw Slabs in CAD & (Col, beams, SW) in SAP**

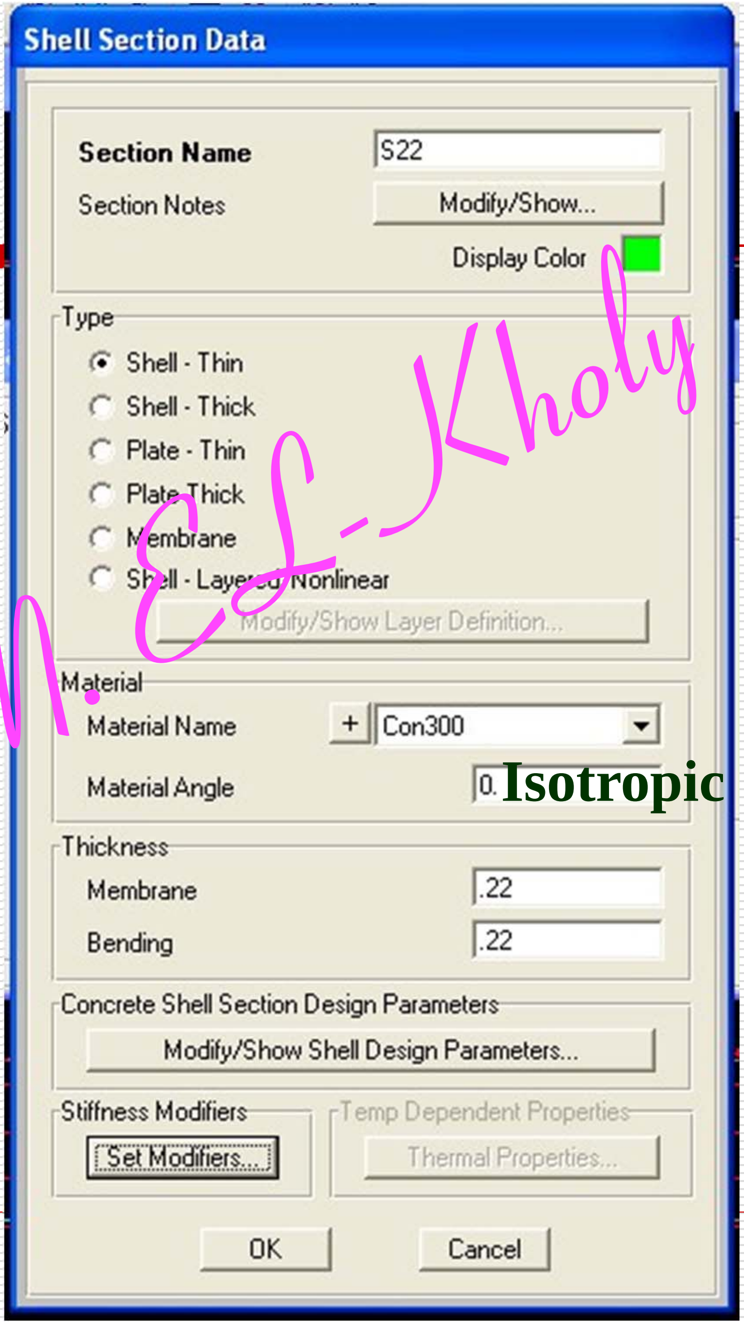
Flat Slab Example

Input

1. **Fcu=300 Kg/cm2**
2. **Slab 22 cm “Isotropic == Material angle=0”**
3. **Beam B25X70**
4. **Patterns: OW, Flooring, Wall& LL**
5. **Cases: Patterns**
6. **Combinations: DL & Work & Ultimate**
7. **Flooring=200 Kg/m2 & Walls=350 Kg/m2**

Flat Slab Example

Material Angle



Shell Section Data

Section Name: S22

Section Notes

Display Color: 🟩

Type

- ● Shell - Thin
- ○ Shell - Thick
- ○ Plate - Thin
- ○ Plate - Thick
- ○ Membrane
- ○ Shell - Layered/Nonlinear

Material

Material Name: Con300

Material Angle: 0.

Isotropic

Thickness

Membrane: .22

Bending: .22

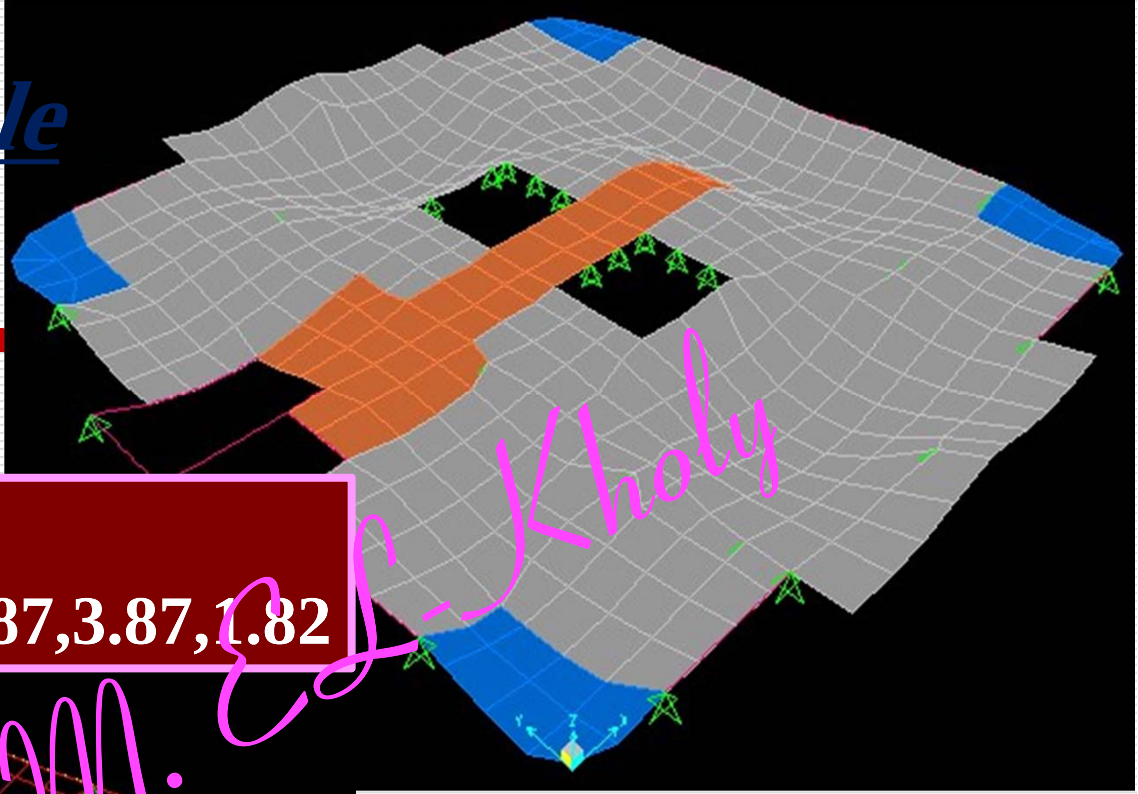
Concrete Shell Section Design Parameters

Stiffness Modifiers

Temp Dependent Properties

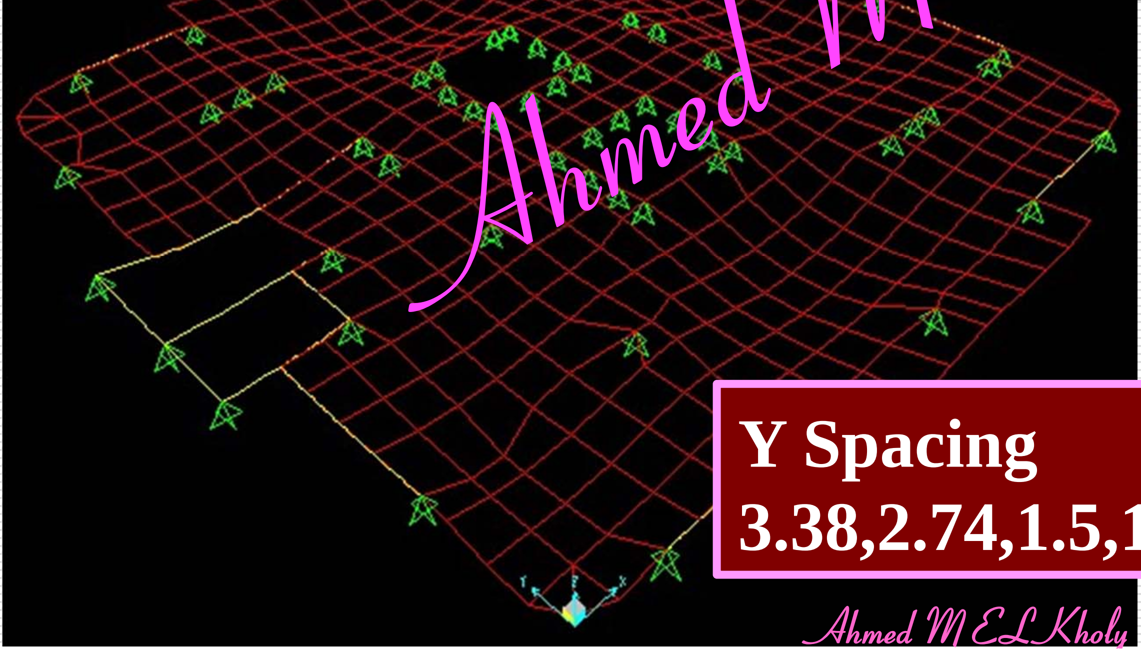
Flat Slab Example

Input



Grid 9,10,1

X Spacing
1.82,3.87,2.87,1.63,1.63,2.87,3.87,1.82



Y Spacing
3.38,2.74,1.5,1.31,2.25,1.31,1.5,2.68,3.44

Flat Slab Example

Reactions

Display… Show Forces… Joints
Display … Show Tables..

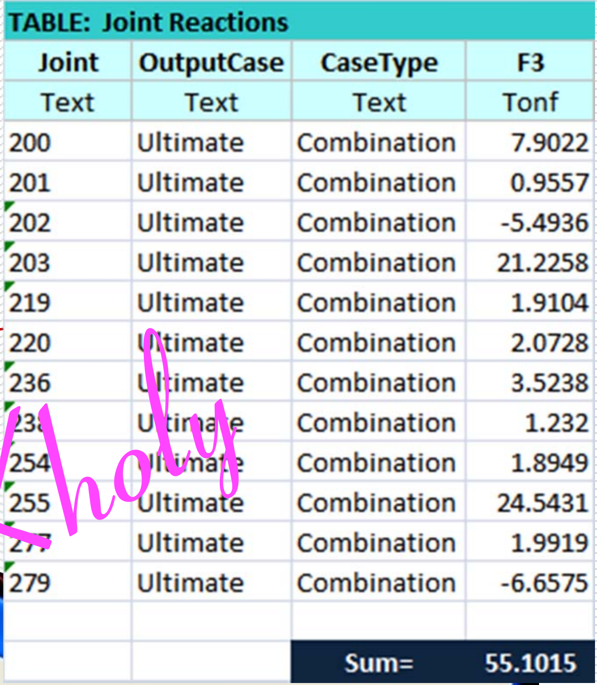
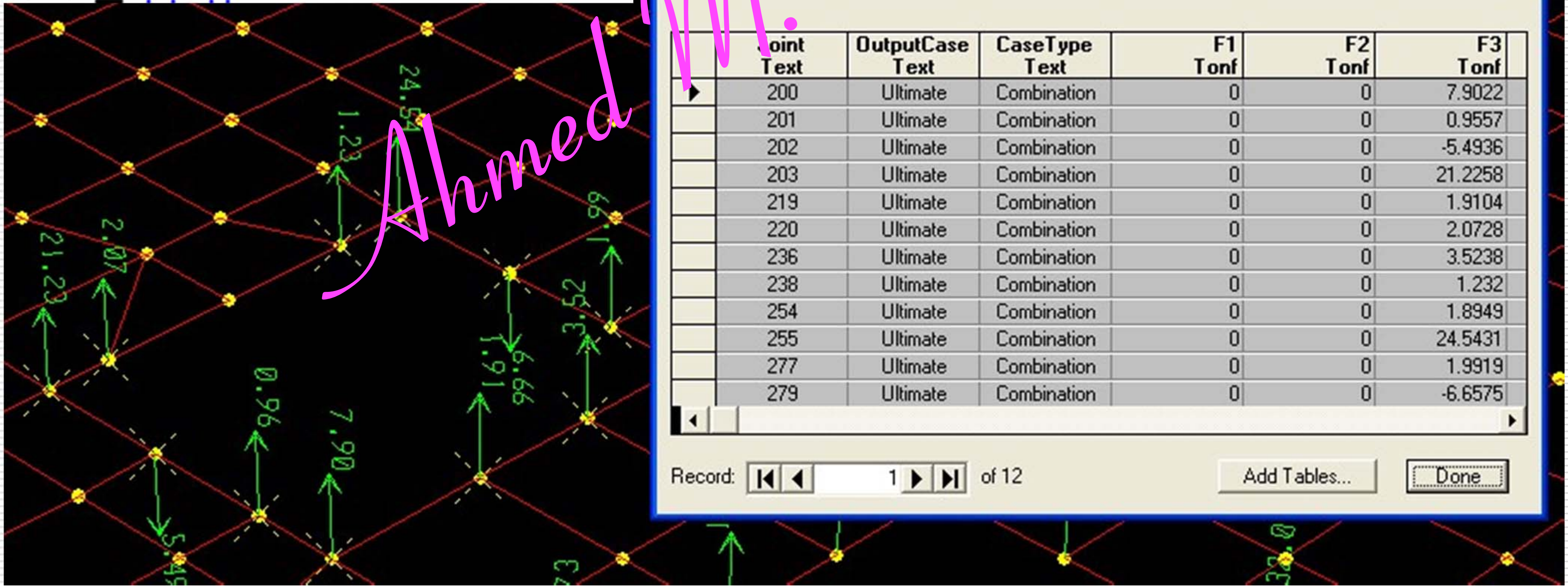


TABLE: Joint Reactions

Joint	OutputCase	CaseType	F3
Text	Text	Text	Tonf
200	Ultimate	Combination	7.9022
201	Ultimate	Combination	0.9557
202	Ultimate	Combination	-5.4936
203	Ultimate	Combination	21.2258
219	Ultimate	Combination	1.9104
220	Ultimate	Combination	2.0728
236	Ultimate	Combination	3.5238
238	Ultimate	Combination	1.232
254	Ultimate	Combination	1.8949
255	Ultimate	Combination	24.5431
277	Ultimate	Combination	1.9919
279	Ultimate	Combination	-6.6575
		Sum=	55.1015

⊟ ☒ ANALYSIS RESULTS (1 of 12 tables
- ⊟ ☒ Joint Output
  - ⊞ ☐ Displacements
  - ⊟ ☒ Reactions
    - ☒ Table: Joint Reactions



Joint Reactions

File View Format-Filter-Sort Select Options

Units: As Noted | Joint Reactions

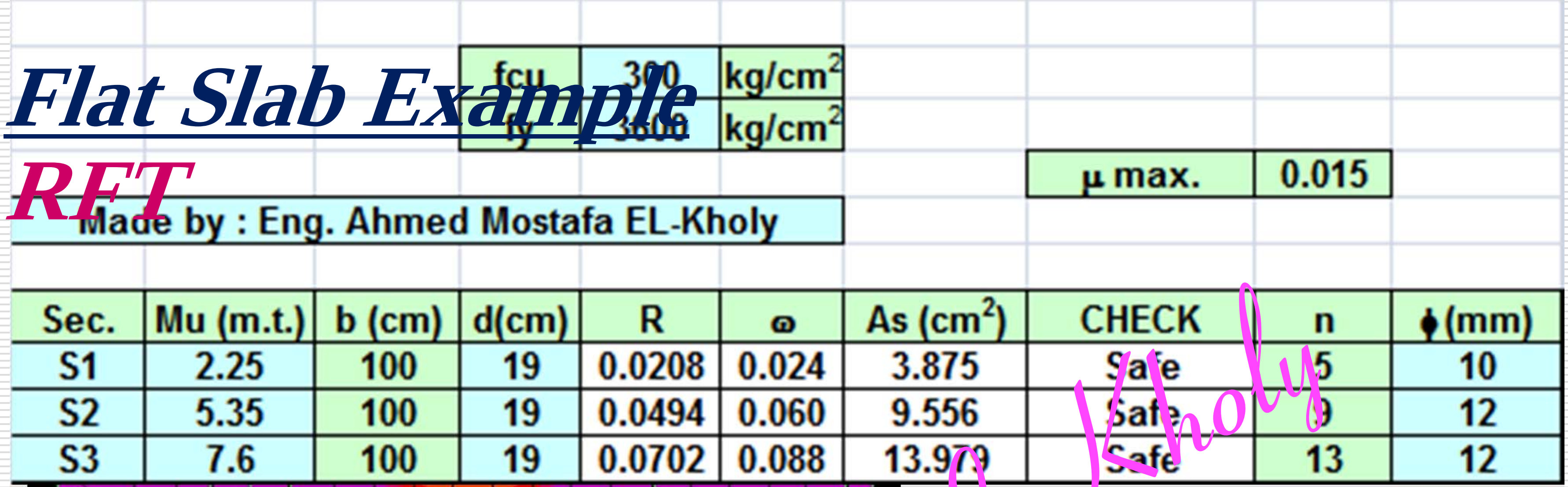
Joint Text	OutputCase Text	CaseType Text	F1 Tonf	F2 Tonf	F3 Tonf
200	Ultimate	Combination	0	0	7.9022
201	Ultimate	Combination	0	0	0.9557
202	Ultimate	Combination	0	0	-5.4936
203	Ultimate	Combination	0	0	21.2258
219	Ultimate	Combination	0	0	1.9104
220	Ultimate	Combination	0	0	2.0728
236	Ultimate	Combination	0	0	3.5238
238	Ultimate	Combination	0	0	1.232
254	Ultimate	Combination	0	0	1.8949
255	Ultimate	Combination	0	0	24.5431
277	Ultimate	Combination	0	0	1.9919
279	Ultimate	Combination	0	0	-6.6575

Record: 1 of 12

Add Tables... Done

Flat Slab Example

RFT



fcu	300	kg/cm^2
fy	3600	kg/cm^2

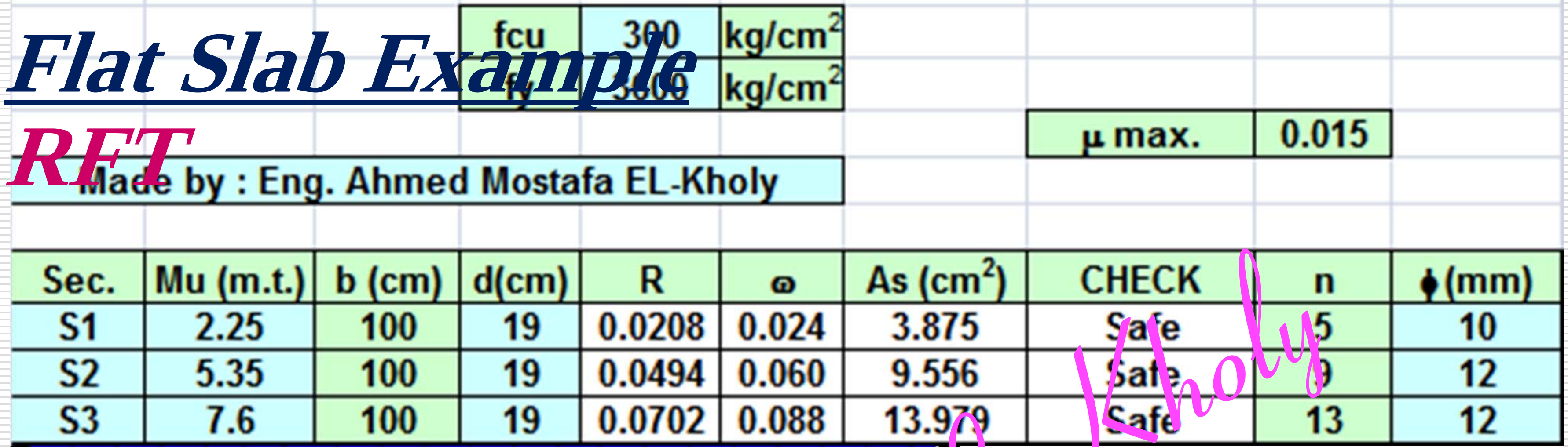
μ max. 0.015

Made by : Eng. Ahmed Mostafa EL-Kholy

Sec.	Mu (m.t.)	b (cm)	d(cm)	R	ω	As (cm^2)	CHECK	n	ϕ (mm)
S1	2.25	100	19	0.0208	0.024	3.875	Safe	5	10
S2	5.35	100	19	0.0494	0.060	9.556	Safe	9	12
S3	7.6	100	19	0.0702	0.088	13.979	Safe	13	12

Flat Slab Example

RFT



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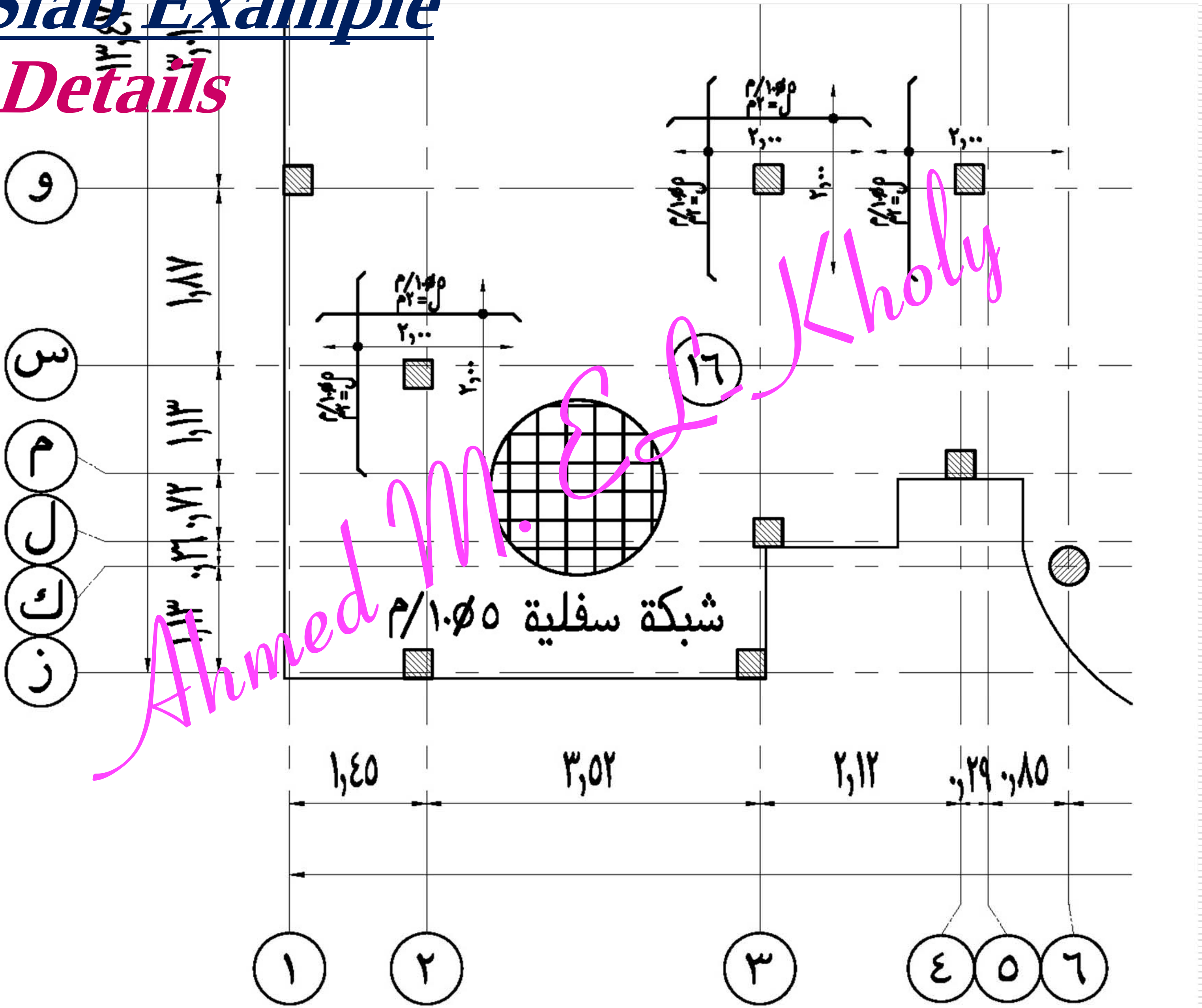
S3	7.6	100	19	0.0702	0.088	13.979	Safe	13	12

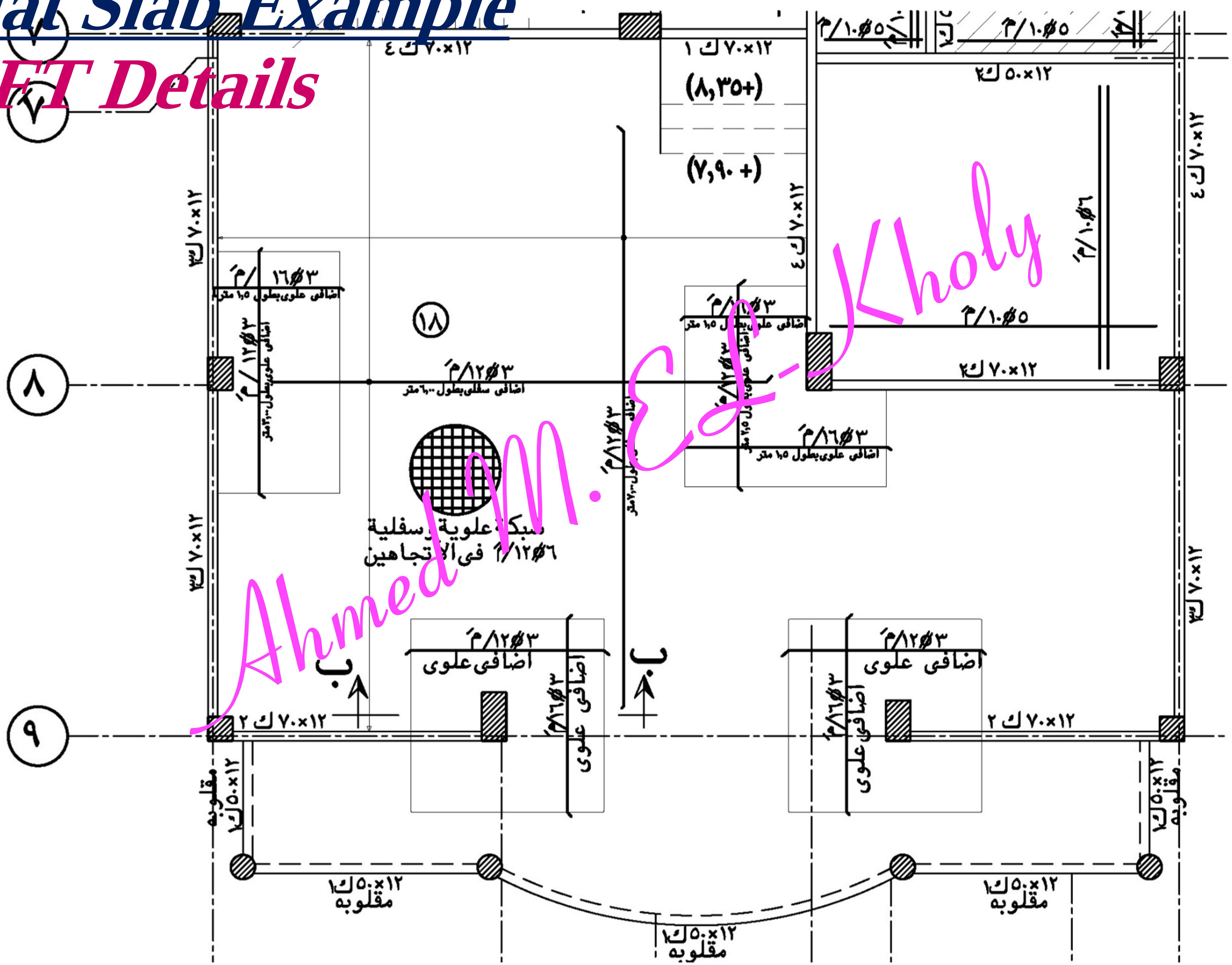
Flat Slab Example

RFT Details



Flat Slab Example

RFT Details



Flat Slab Example

Development Length & Embedment Length

1. **Item 4-2-5-1 ECP RC Structures**
2. **$L_d \geq L_d + 0.3d$ from critical section (Column Face for –M and mid span for +M)**
3. **$L_e \geq d$ & $L_e \geq 0.3d + 10\Phi$**

Check Punching

1. **$q = Q\beta / b_0 d$ (6-25) $\leq$ Eq. (4-32-a & 4-32-b & 4-33)**
2. **$\beta = 1.15$ for internal columns**
3. **$\beta = 1.30$ for edge columns**
4. **$\beta = 1.50$ for corner columns**

Flat Slab Example

Check Deflection – item 4-3-1-1

1. $\Delta_{D+L+Creep} \leq L/250$
2. $\Delta_{D+L+Creep} \leq L/480$ **“non structural elements likely to be damaged by large deflection”**
3. $\Delta_{L} \leq L/360$
4. **L?**
5. Δ **: from SAP or** $\int MM/EI$
6. **Ie must be used for estimating** Δ
7. $Ie = (Mcr/Ma)^3 Ig + (1-(Mcr/Ma)^3) Ic$
8. **SAP modifier= Ie/Ig**

Flat Slab Example

Check Deflection – item 4-3-1-1

Khatib & Alami

DESIGN CALCULATION SHEET

Sheet No.		Computed by
of	--	Batool
Checked by		Approved by

Subject

Building

Calculation of Deflection According to ACI 318M-05

Concrete Compressive Strength (f'_c) = 300.00 Kg/cm2 = 30.00 MPa

Concrete Modulus of Rupture (f_r) = 3.40 MPa (Eq. 9-9)

Concrete Modulus of Elasticity (E_c) = 2.6E+04 MPa (Clause 8.5.1)

n (E_s/E_c) = 7.77 (Clause 8.5.2)

Section Properties

Thickness of Section (t) = 32.00 cm

Depth of Ten. Reinforcement (d) = 32.00 cm

Breadth of Section (b) = 100.00 cm

Depth of Comp. Reinforcement (d') = 3.00 cm

Tension Reinforcement (A_s) = 14.00 cm^2

Compression Reinforcement ($A_{s'}$) = 8.00 cm^2

Span (l) = 10.00 m

Nutral Axis Depth (z) = 7.06 cm

Gross Moment of Inertia (I_g) = 273066.67 cm^4 = 2.73E+09 mm^4

Cracked Moment of Inertial (I_{cr}) = 80276.33 cm^4 = 8.03E+08 mm^4

Cracking Moment (M_{cr}) = 5.80E+07 N mm = 5.80 m. t (Eq. 9-8)

Service Straining Actions

Bending Moment Due to Dead Load only (M_d) = 5.40 m.t = 5.4E+07 N. mm

Bending Moment Due to Live Load only (M_l) = 2.66 m.t = 2.7E+07 N. mm

% of Sustained Load from the Live Load = 50%

% of Gross Inertia Used in Calculation = 100%

Bending Moment Due to Sustained Load (M_{sus}) = 6.73 m.t = 6.7E+07 N. mm

Calculated Short Time Deflection

(Calculated by total or percentage of gross moment of inertia)

Deflection due to Dead Load $(\Delta_i)_d$ = 0.3000 cm = 3.000 mm

Deflection due to Live Load $(\Delta_i)_l$ = 0.1700 cm = 1.700 mm

Flat Slab Example

Check Deflection – item 4-3-1-1

Efffective Moment of Inertia (Eq. 9-7)

Under Dead Load Only $(I_e)_d$ = 273066.67 cm^4 = 2.73E+09 mm^4

Under Sustained Load $(I_e)_{sus}$ = 203400.45 cm^4 = 2.03E+09 mm^4

Under Dead + Live Load $(I_e)_{d+l}$ = 151953.891 cm^4 = 1.52E+09 mm^4

Modified Short time Deflection

Deflection due to Dead Load $(\Delta_i)_d$ = 0.3000 cm

Deflection due to Sustained Load $(\Delta_i)_{sus}$ = 0.5169 cm

Deflection due to Dead + Live Load $(\Delta_i)_{d+l}$ = 0.8446 cm

Deflection due to Live Load $(\Delta_i)_l$ = 0.5446 cm

Additional Long Term Deflection (Clause 9.5.2.5)

For 5 years or more (Δ_{long}) = 0.91887 cm

For 12 months (Δ_{long}) = 0.64321 cm

For 6 months (Δ_{long}) = 0.55132 cm

For 3 months (Δ_{long}) = 0.45944 cm

Results

-- Flat roofs not supporting and not attached to nonstructural elements likely to be damaged by large defelections:

$(\Delta_i)_l$ = 0.5446 cm < l/180 = 5.5556 cm

-- Floors not supporting and not attached to nonstructural elements likely to be damaged by large deflections:

$(\Delta_i)_l$ = 0.5446 cm < l/360 = 2.7778 cm

-- Roof or floor construction supporting or attached to nonstructural elements likely to be damaged by large deflections:

$(\Delta_{long}) + (\Delta_i)_l$ = 1.4635 cm < l/480 = 2.08333 cm

-- Roof or floor construction supporting or attached to nonstructural elements not likely to be damaged by large deflections:

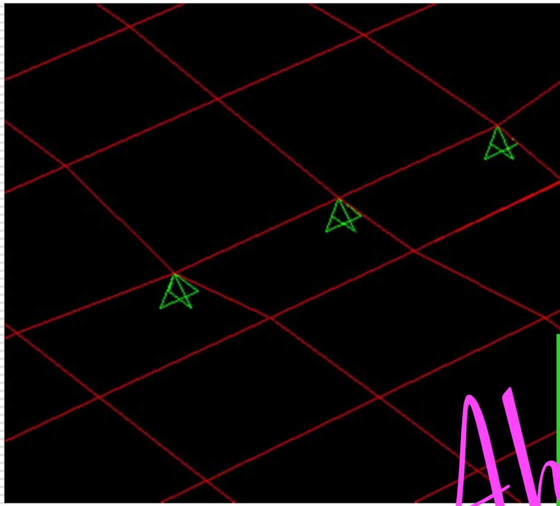
$(\Delta_{long}) + (\Delta_i)_l$ = 1.4635 cm < l/240 = 4.1667 cm

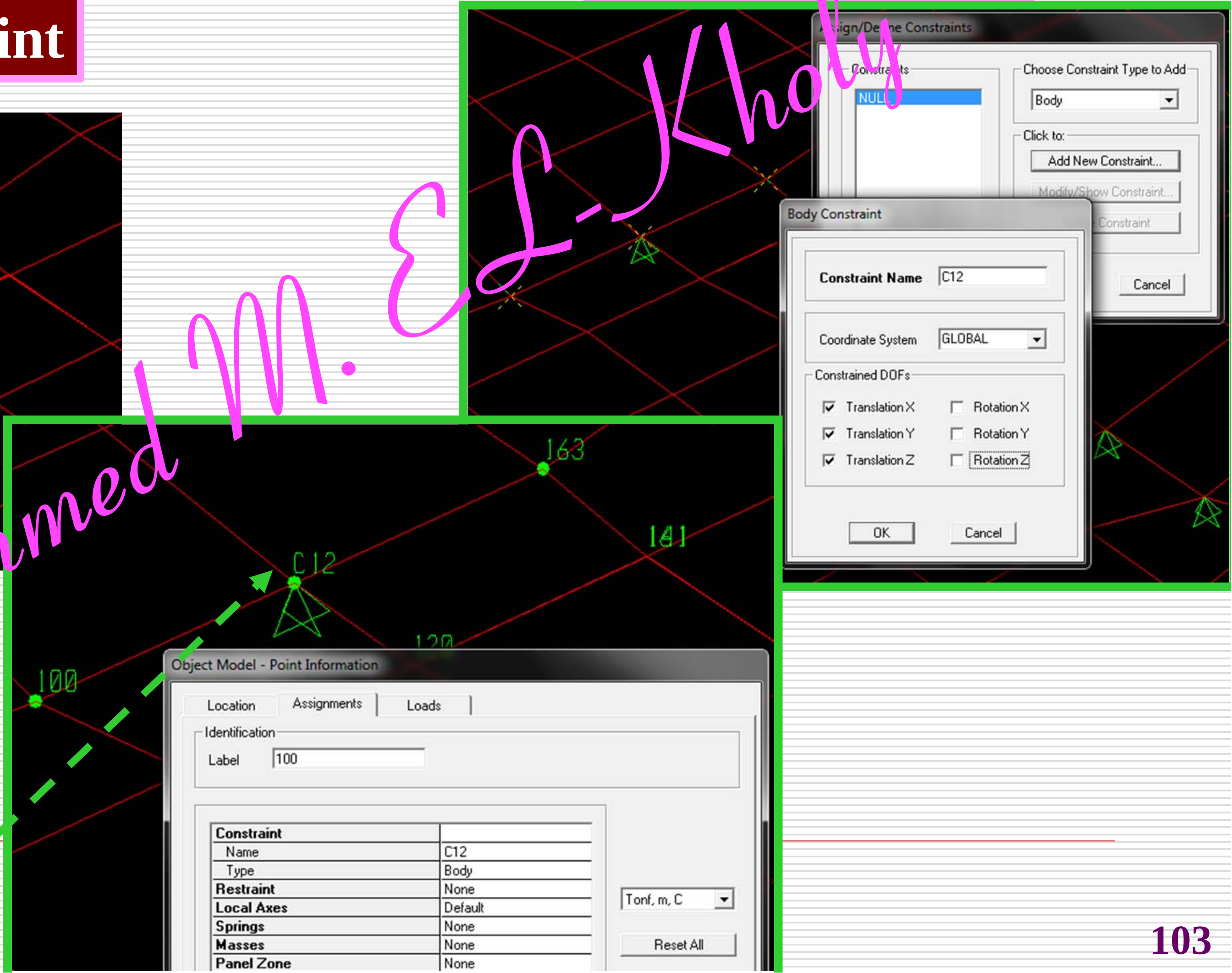
Flat Slab Example

Reactions Slide 88 & Constraint Column Joints

With Constraint

Without Constraint





Choose Constraint Type to Add: Body

Constraint Name: C12

Coordinate System: GLOBAL

Constrained DOFs

☑ Translation X ☐ Rotation X

☑ Translation Y ☐ Rotation Y

☑ Translation Z ☐ Rotation Z

Identification

Label: 100

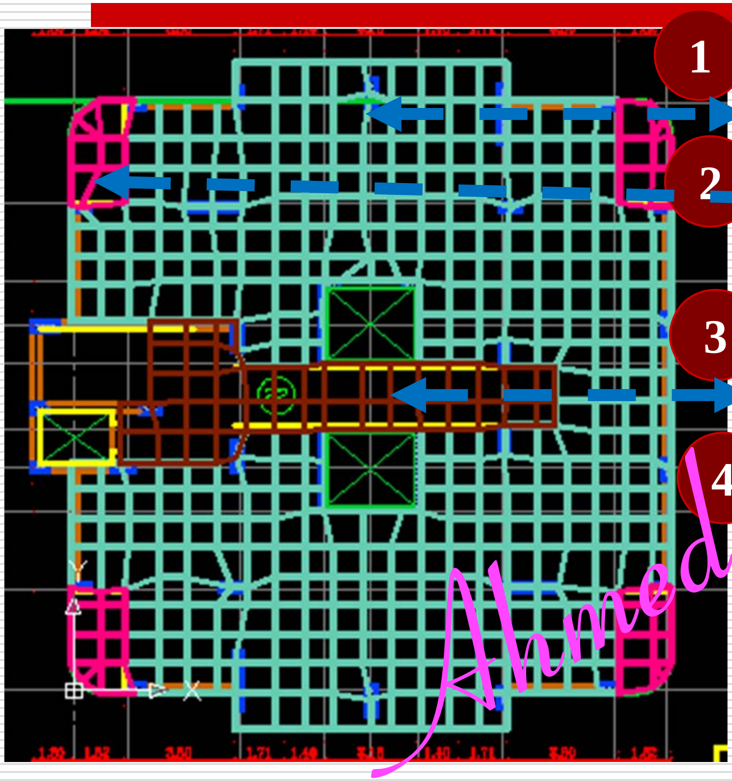
Constraint	
Name	C12
Type	Body
Restraint	None
Local Axes	Default
Springs	None
Masses	None
Panel Zone	None

Tonf, m, C

Change Label of the master joint

Flat Slab Example

Advanced Import

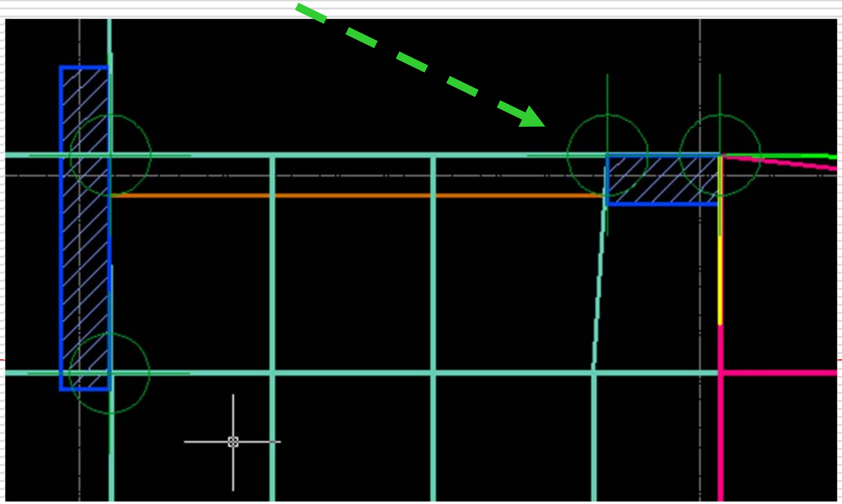


① **Layer: SAP-Slab** — **Section: S22**

② **Layer: SAP-Slab-b** — **Section: S22-b**

③ **Layer: SAP-Slab-C** — **Section: S22-C**

④ **Layer: SAP-Col** — **Restraint**



Flat Slab Example

Stairs & Bathrooms

Two alternatives

Flat Assignment Due
Raft Assignment Due
Thursday 03 Sep

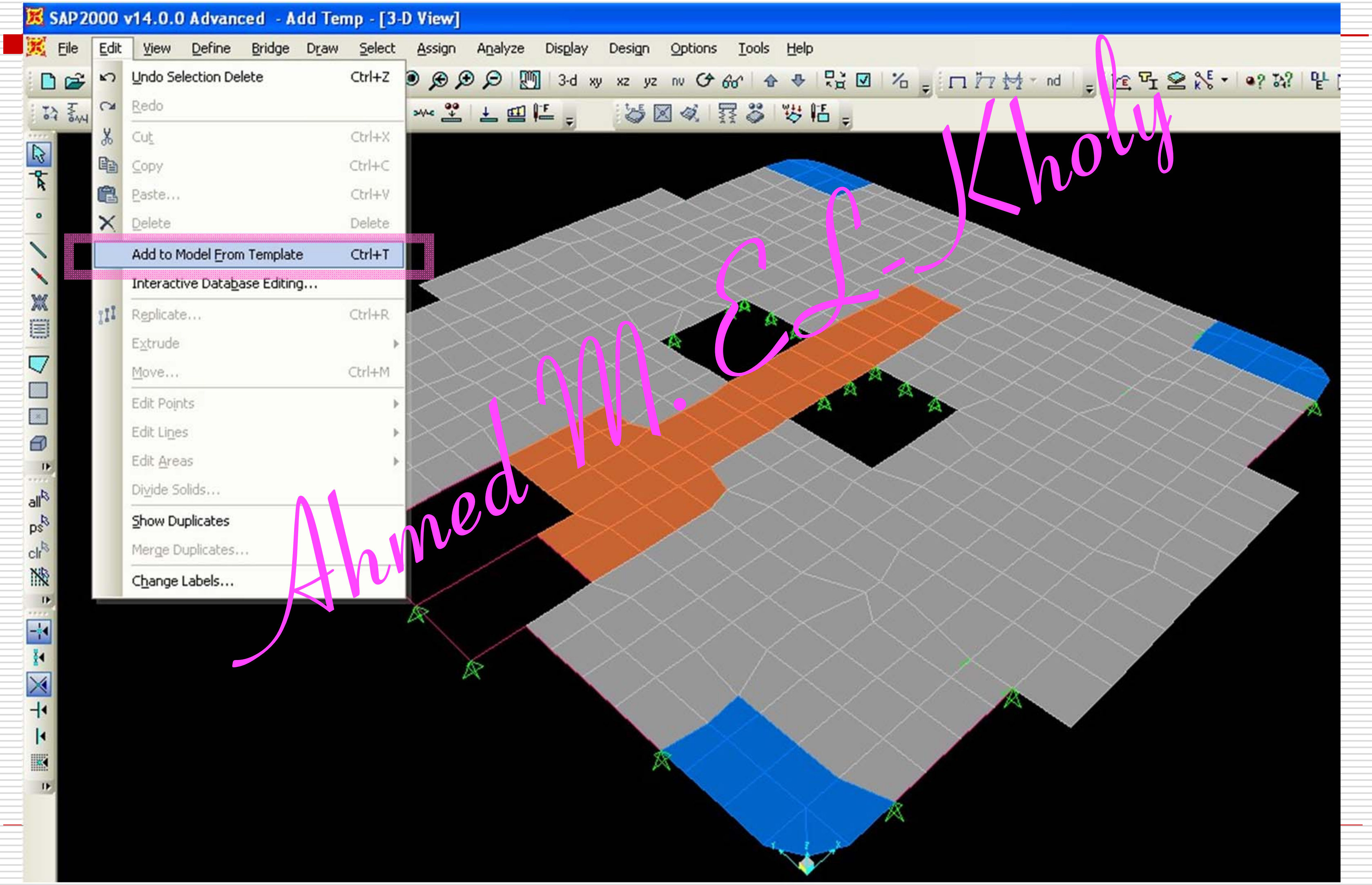
First Etabs Assignment Due
Thursday 10 Sep

Complex Model

Add to Model from Template

Complex Examples

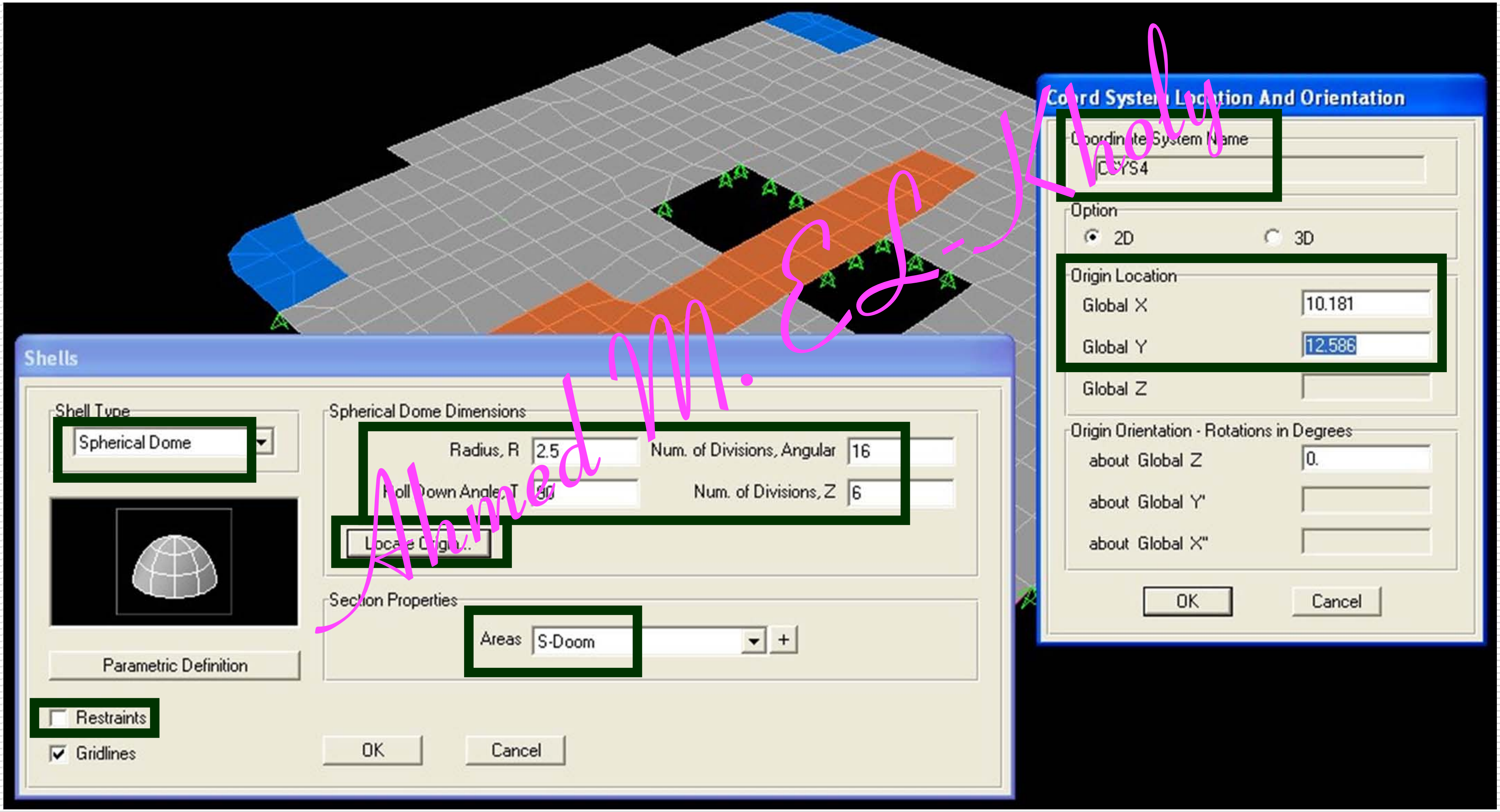
…Edit.. Add to Model from Template…



Complex Examples

…Edit.. Add to Model from Template…

Define, S-Doom
R 2.5, Z divisions 6
Origin 10.181, 12.586



Shells

Shell Type: Spherical Dome

Spherical Dome Dimensions
Radius, R: 2.5
Num. of Divisions, Angular: 16
Roll Down Angle, T: 90
Num. of Divisions, Z: 6

Section Properties
Areas: S-Doom

☐ Restraints
☑ Gridlines

Coord System Location And Orientation

Coordinate System Name: CSYS4

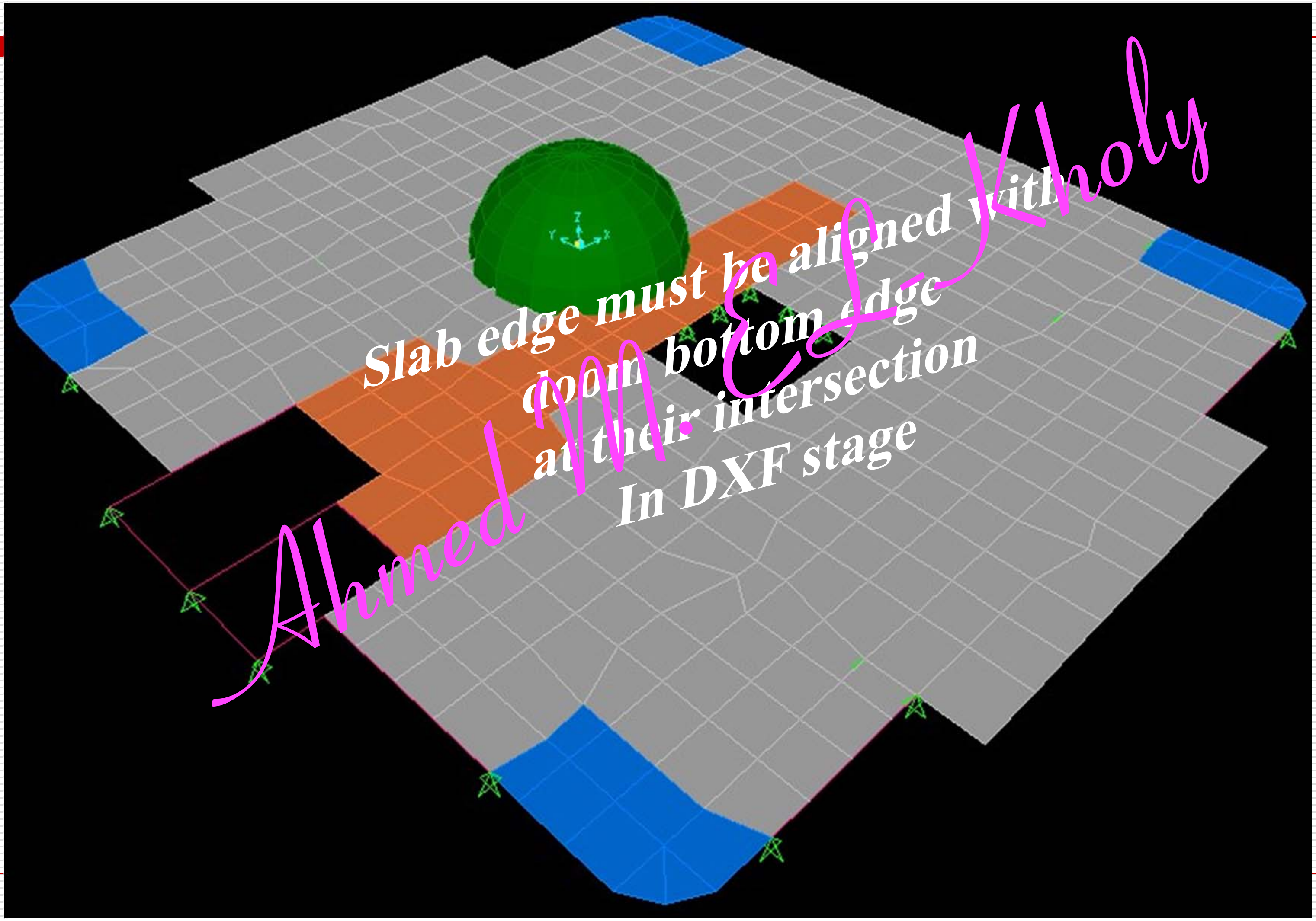
Option: ● 2D ○ 3D

Origin Location
Global X: 10.181
Global Y: 12.586
Global Z:

Origin Orientation - Rotations in Degrees
about Global Z: 0.
about Global Y':
about Global X'':

Complex Examples

…Edit.. Add to Model from Template…

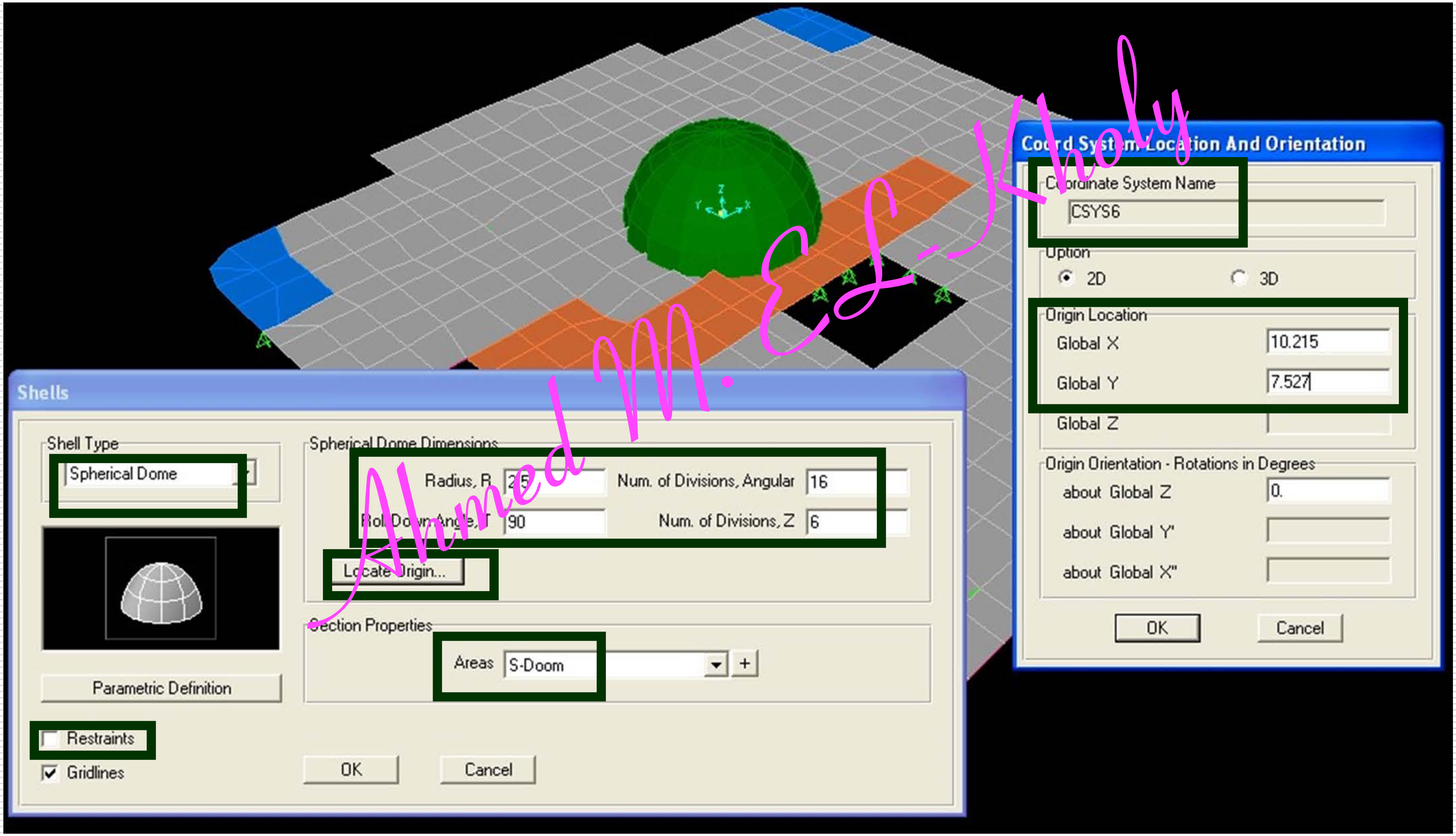


Slab edge must be aligned with doom bottom edge at their intersection In DXF stage

Complex Examples

…Edit.. Add to Model from Template…

R 2.5, Z divisions 6
Origin 10.215, 7.527



Shells

Shell Type: Spherical Dome

Spherical Dome Dimensions

Radius, R: 2.5
Num. of Divisions, Angular: 16
Roll Down Angle, T: 90
Num. of Divisions, Z: 6

Section Properties

Areas: S-Doom

☐ Restraints
☑ Gridlines

Coord System Location And Orientation

Coordinate System Name: CSYS6

Option: ● 2D ○ 3D

Origin Location

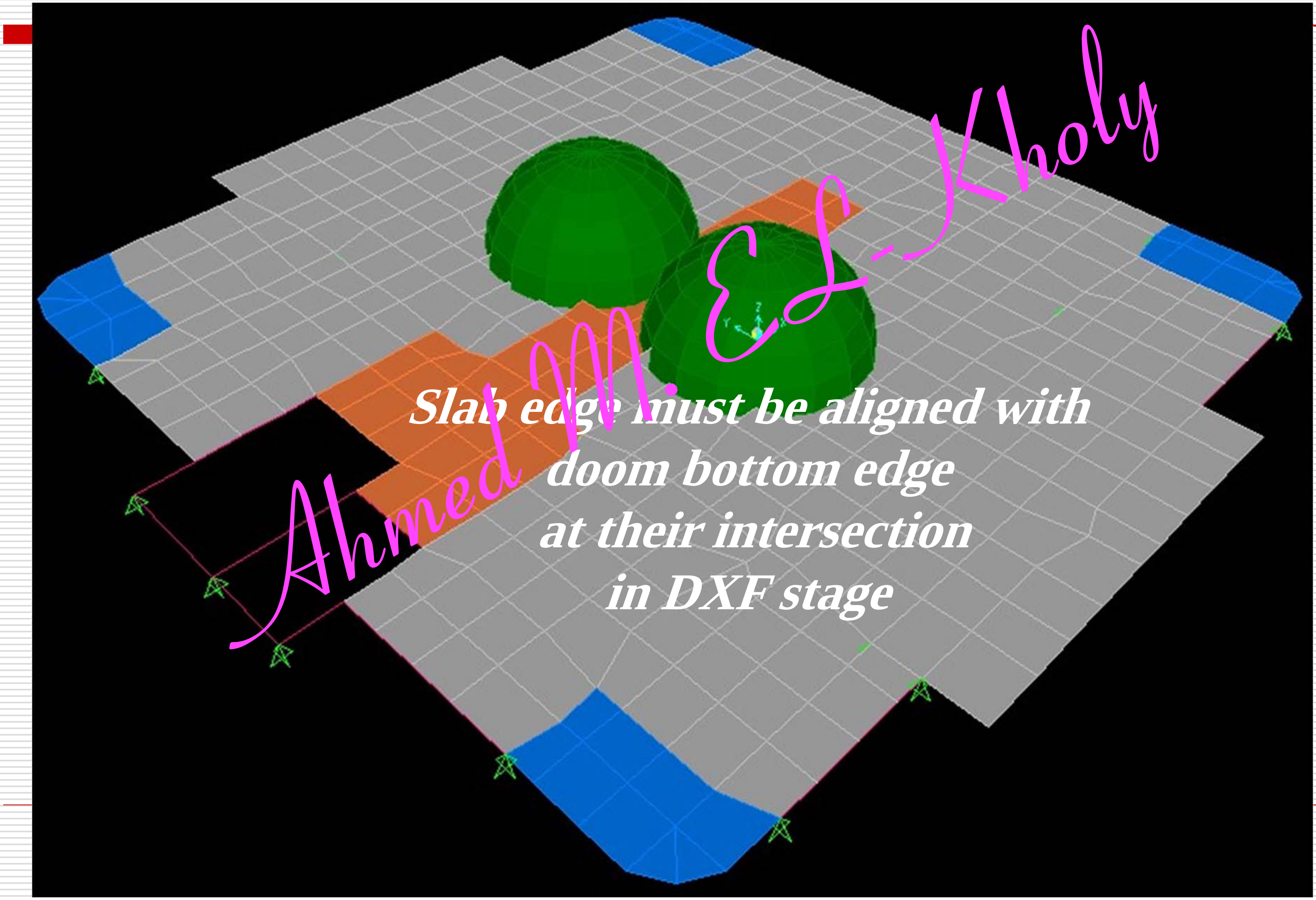
Global X: 10.215
Global Y: 7.527
Global Z:

Origin Orientation - Rotations in Degrees

about Global Z: 0.
about Global Y':
about Global X'':

Complex Examples

…Edit.. Add to Model from Template…

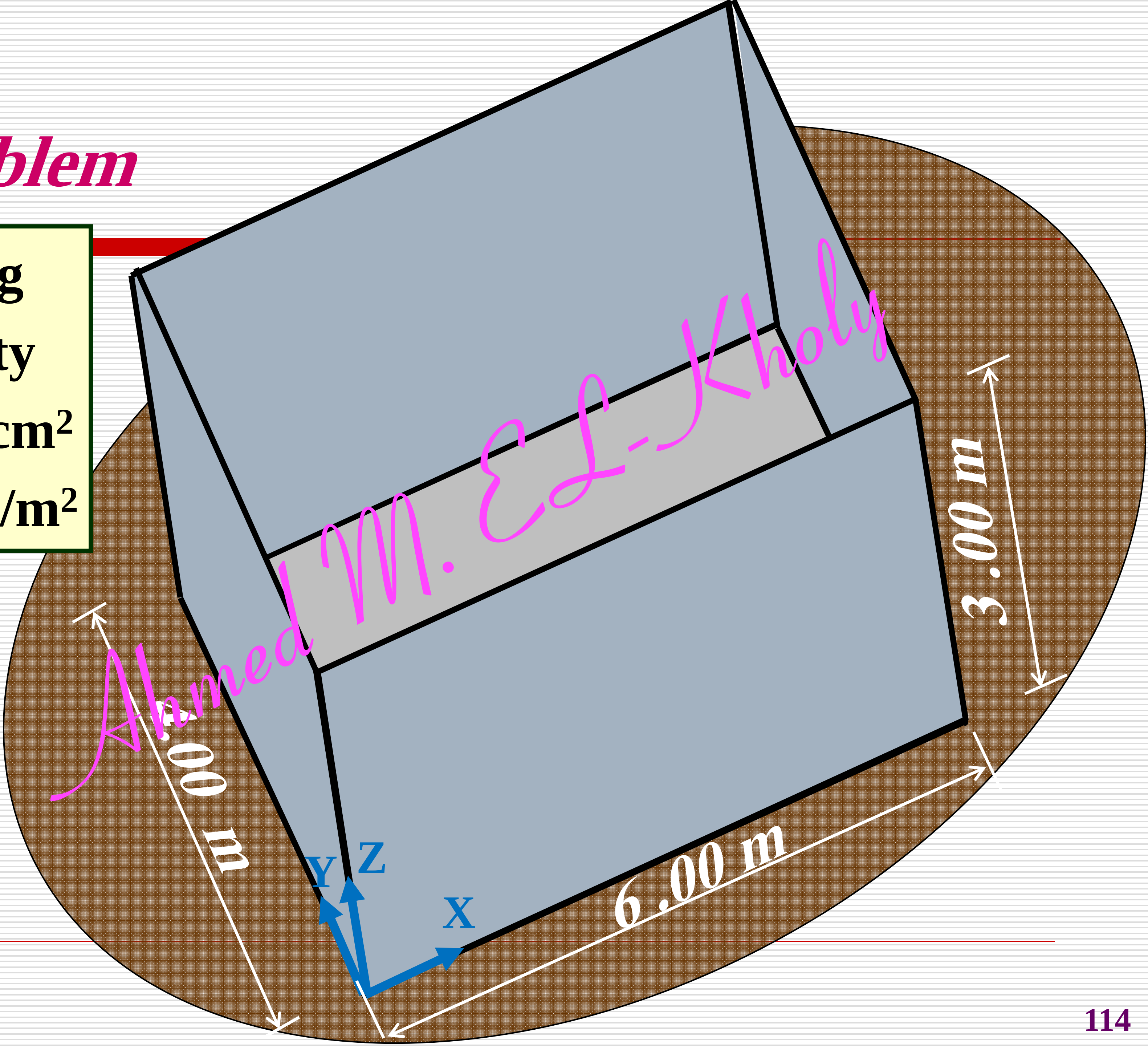


Slab edge must be aligned with doom bottom edge at their intersection in DXF stage

Tanks

Tanks
…Problem

Bearing Capacity
=1.0 Kg/cm^2
=10.0 ton/m^2

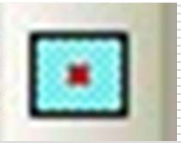


Tanks

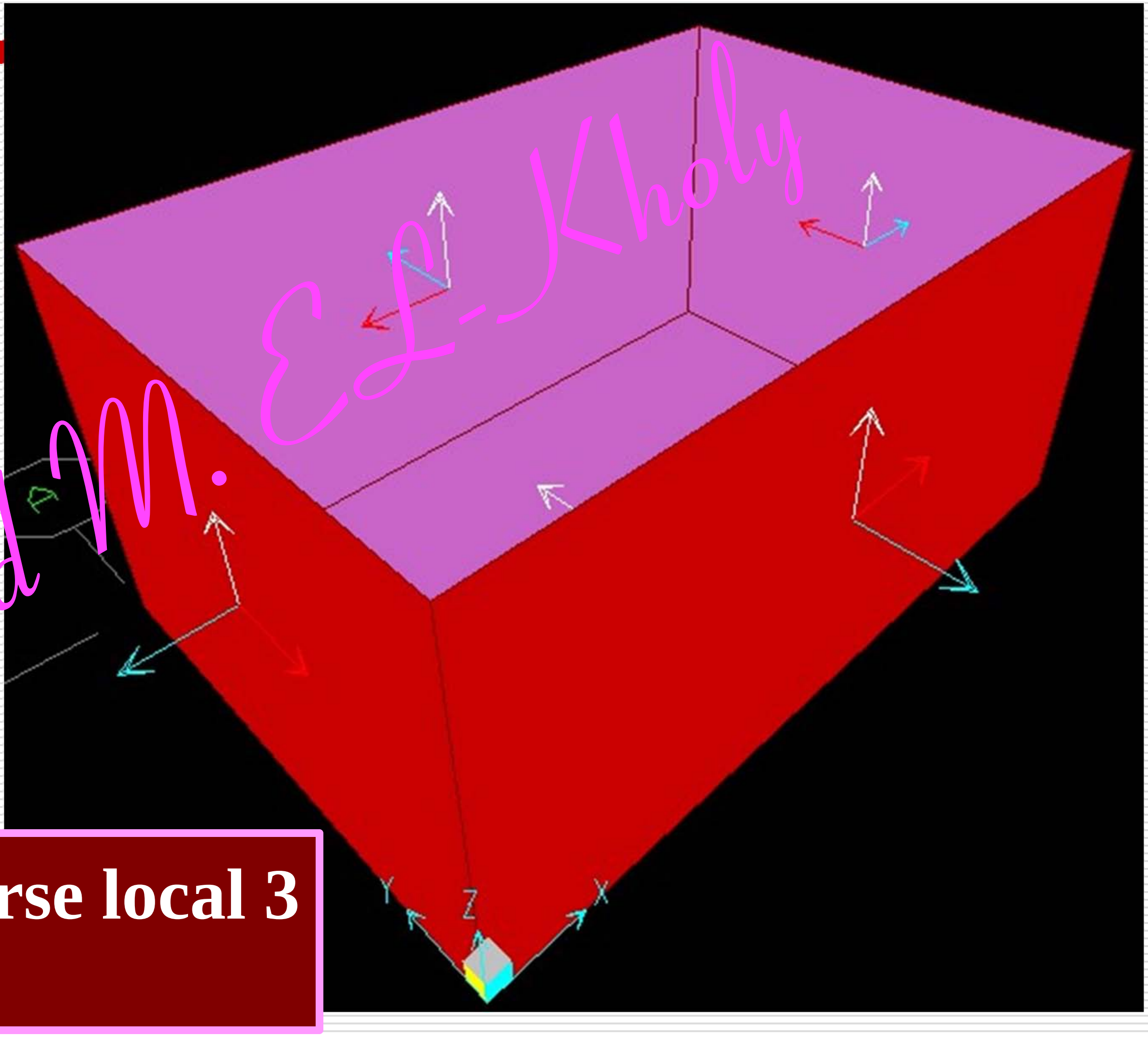
…Model

Grid
2
2
2
6
4
3

Quick Area



5 Areas



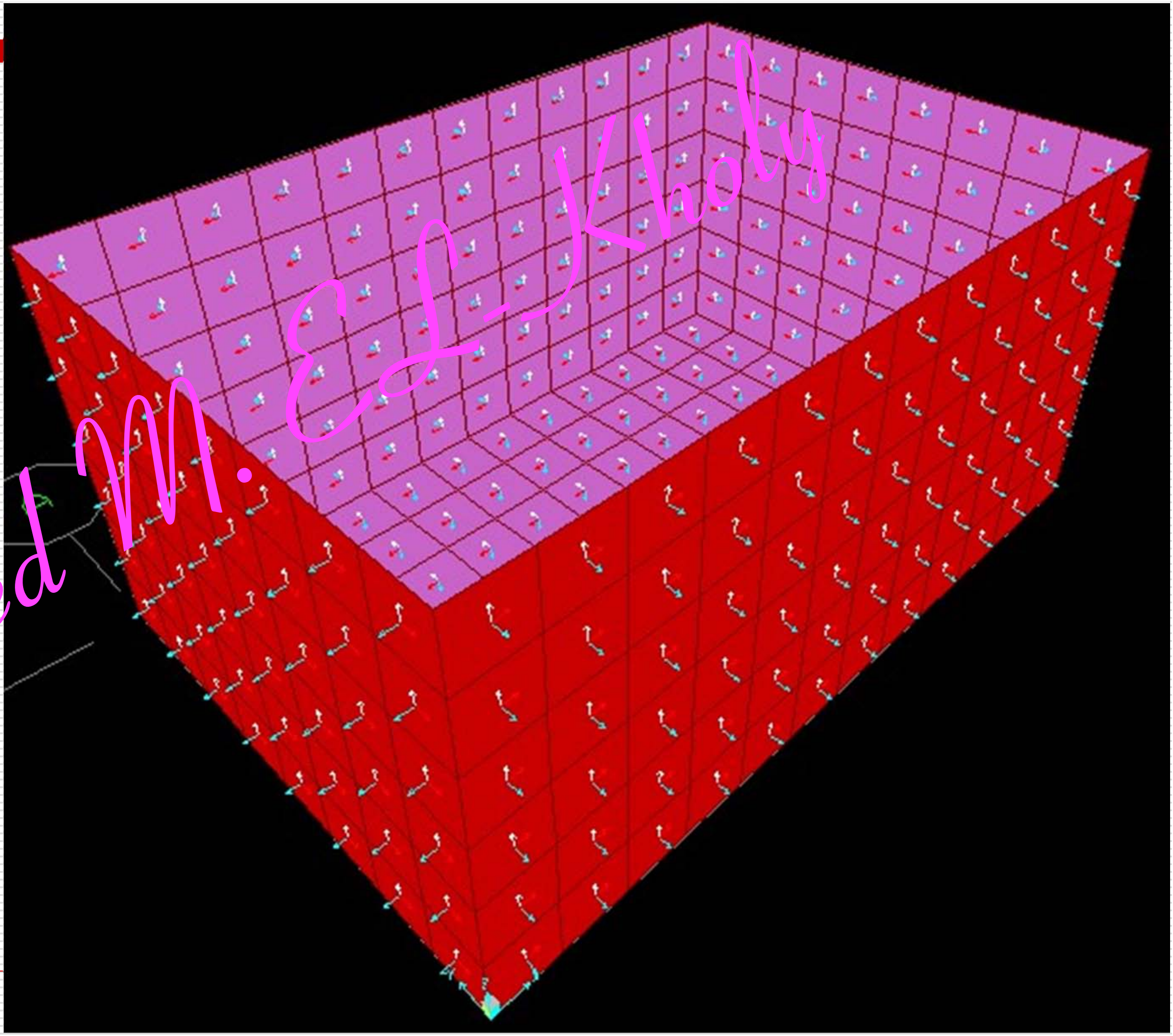
Assign… Area .. Reverse local 3 +3 face out

Tanks

…Model 0.5x0.5 m^2

Edit… Edit Areas… Divide Areas … (0.5x0.5 m^2)

Face by Face to avoid errors

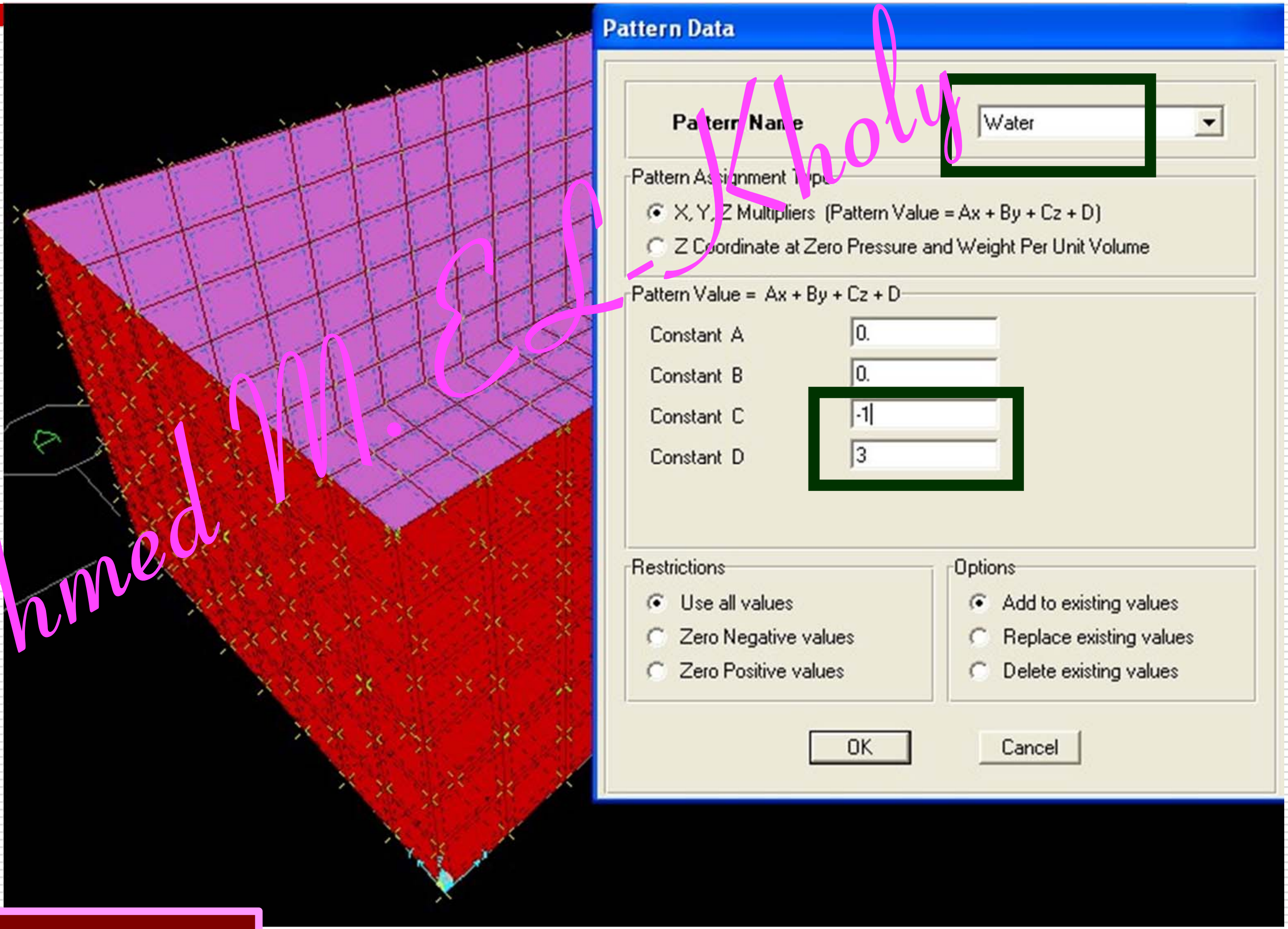


Tanks

Define..J Patterns, ..Assign…Joint Patterns

Define
Joint Patterns

Assign
Joint Patterns



Pattern Data

Pattern Name: Water

Pattern Assignment Type
● X, Y, Z Multipliers (Pattern Value = Ax + By + Cz + D)
○ Z Coordinate at Zero Pressure and Weight Per Unit Volume

Pattern Value = Ax + By + Cz + D
Constant A: 0.
Constant B: 0.
Constant C: -1
Constant D: 3

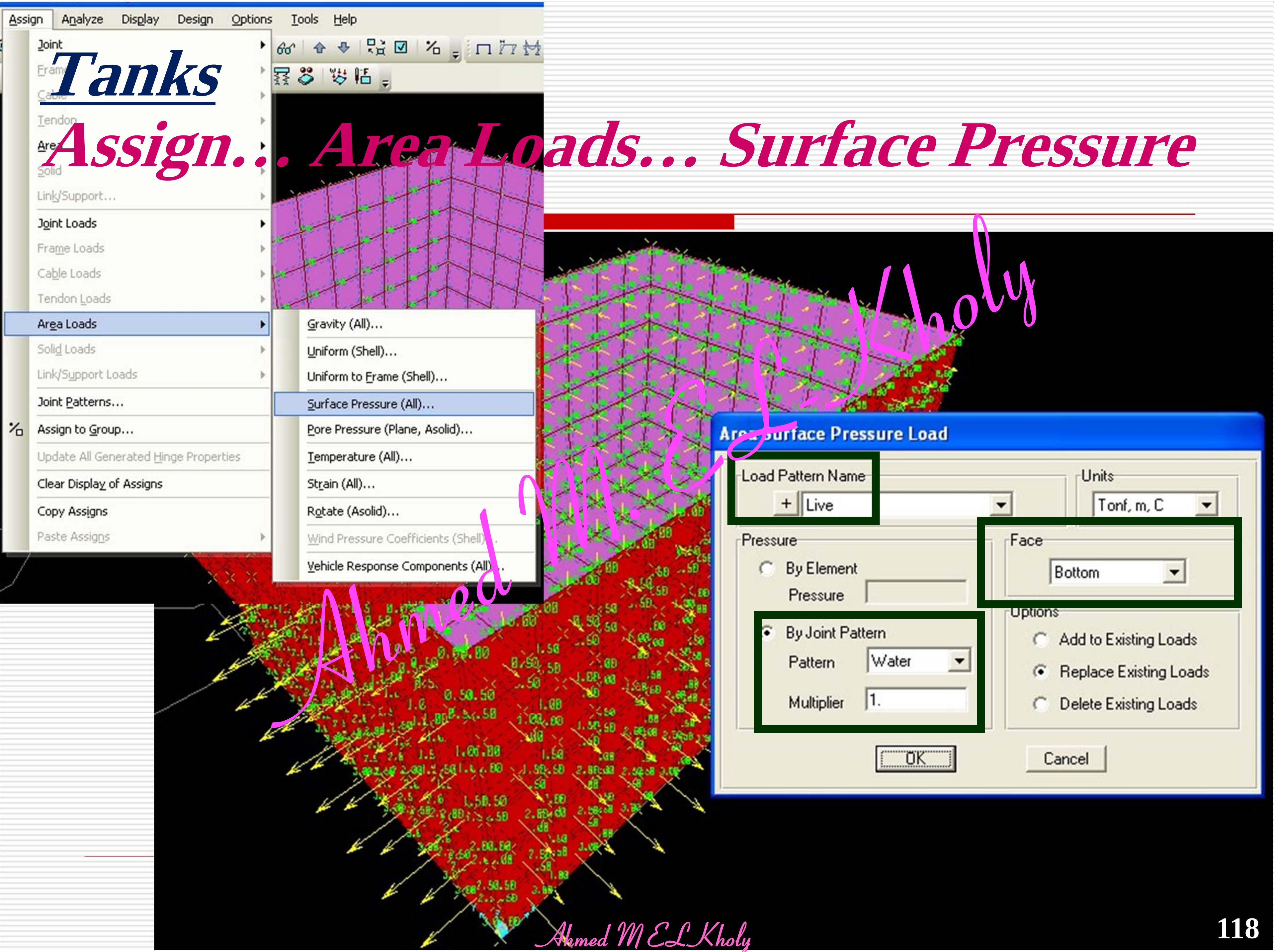
Restrictions
● Use all values
○ Zero Negative values
○ Zero Positive values

Options
● Add to existing values
○ Replace existing values
○ Delete existing values

Water Pressure=3-(1)Z

Tanks

Assign… Area Loads… Surface Pressure



Area Surface Pressure Load

Load Pattern Name: Live

Units: Tonf, m, C

Pressure

○ By Element

Pressure:

● By Joint Pattern

Pattern: Water

Multiplier: 1.

Face: Bottom

Options

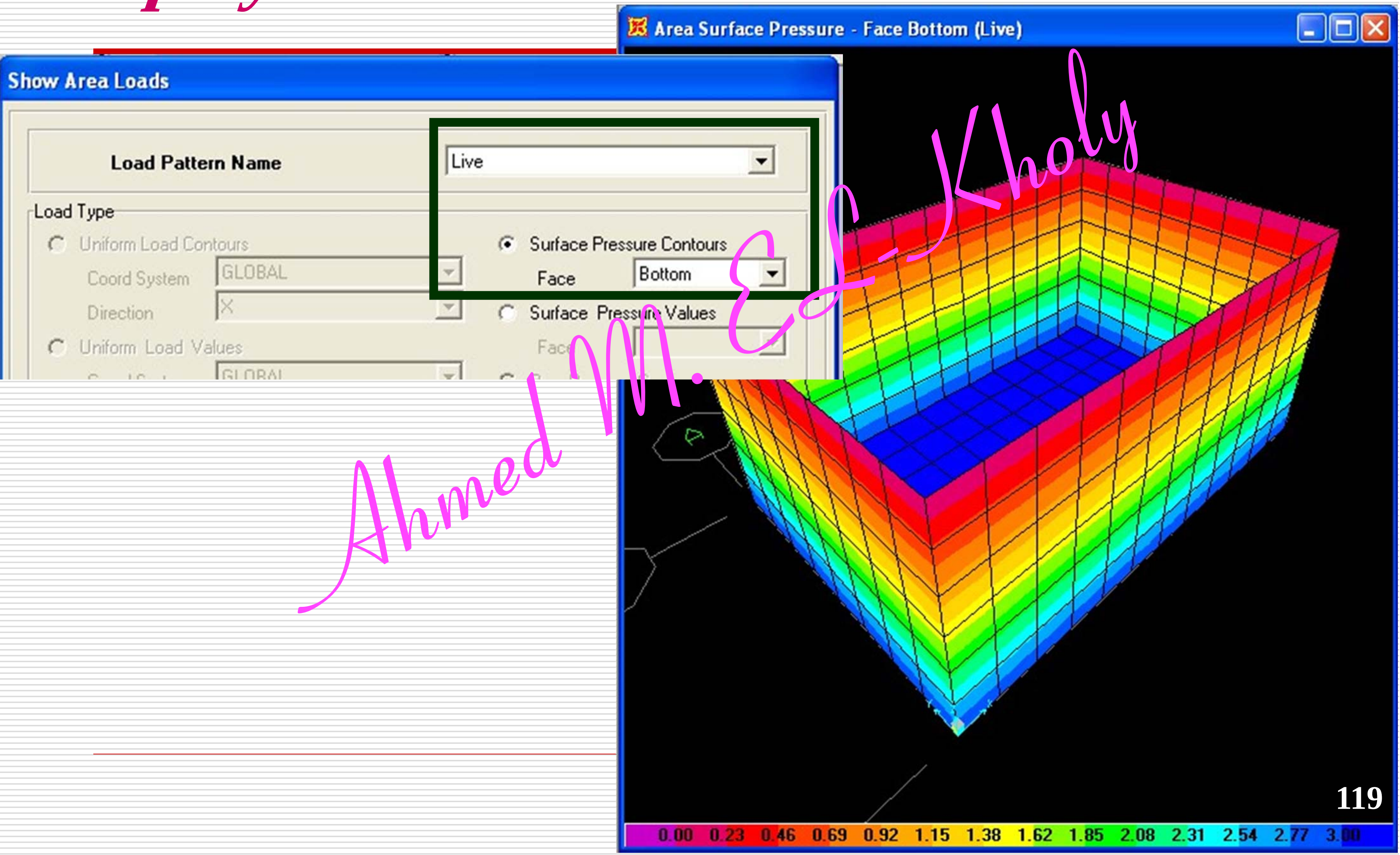
○ Add to Existing Loads

● Replace Existing Loads

○ Delete Existing Loads

Tanks

Display… Show Loads…Area…Contours



Show Area Loads

Load Pattern Name Live

Load Type

○ Uniform Load Contours

Coord System GLOBAL

Direction X

● Surface Pressure Contours

Face Bottom

○ Surface Pressure Values

Face

○ Uniform Load Values

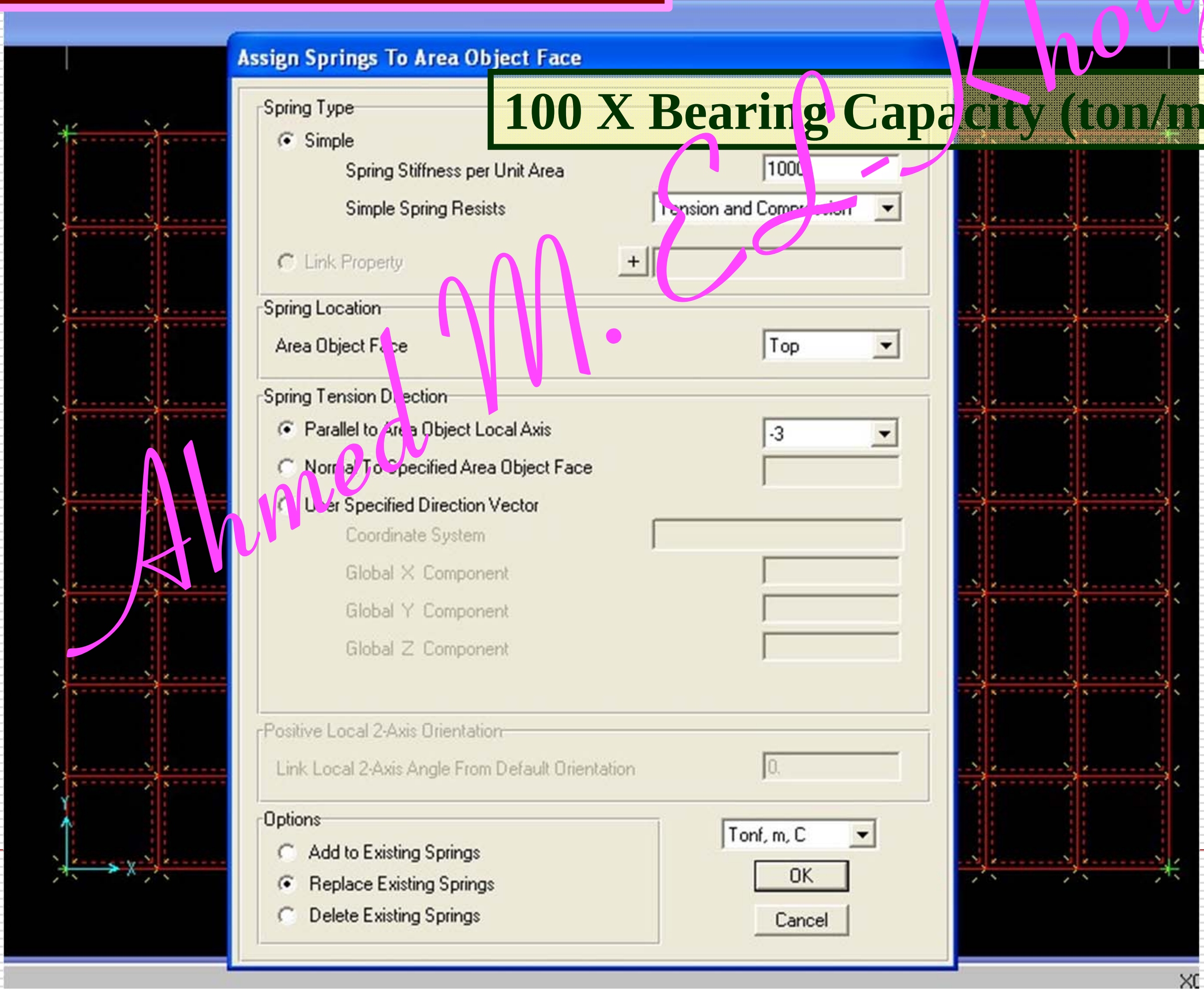
GLOBAL

Area Surface Pressure - Face Bottom (Live)

Tanks

Assign…Joints OR Area … Springs

Alternative 1:: Area Springs



Assign Springs To Area Object Face

Spring Type

● Simple

Spring Stiffness per Unit Area: 1000

Simple Spring Resists: Tension and Compression

○ Link Property

Spring Location

Area Object Face: Top

Spring Tension Direction

● Parallel to Area Object Local Axis: -3

○ Normal To Specified Area Object Face

○ User Specified Direction Vector

Coordinate System

Global X Component

Global Y Component

Global Z Component

Positive Local 2-Axis Orientation

Link Local 2-Axis Angle From Default Orientation: 0.

Options

○ Add to Existing Springs

● Replace Existing Springs

○ Delete Existing Springs

Tonf, m, C

100 X Bearing Capacity (ton/m^2)

Tanks

Assign…Joint

Alternative 2:: Joint Springs

1

All Base Joints

Joint Springs (Local CSys)

Joint Springs

Spring Direction

Coordinate System: Local

Spring Stiffness

Translation 1: 0.

Translation 2: 0.

Translation 3: 250.

Rotation about 3: 0.

Options

○ Add to Existing Springs

● Replace Existing Springs

○ Delete Existing Springs

100 X Bearing Capacity (ton/m^2) X 0.5X0.5

2

Edge Joints

Joint Springs (Local C

Joint Springs

Coordinate System: Local

Spring Stiffness

Translation 1: 0.

Translation 2: 0.

Translation 3: 125

Rotation about 1: 0.

Rotation about 2: 0.

Rotation about 3: 0.

○ Add to Existing Springs

● Replace Existing Springs

○ Delete Existing Springs

100 X Bearing Capacity (ton/m^2) X 0. 5X0.25

3

Corner Joints

X-Y Plane @ Z=0

Joint Springs

Spring Direction

Coordinate System: Local

Spring Stiffness

Translation 1: 0.

Translation 2: 0.

Translation 3: 62.5

Rotation about 1: 0.

Rotation about 2: 0.

Rotation about 3: 0.

Options

○ Add to Existing Springs

● Replace Existing Springs

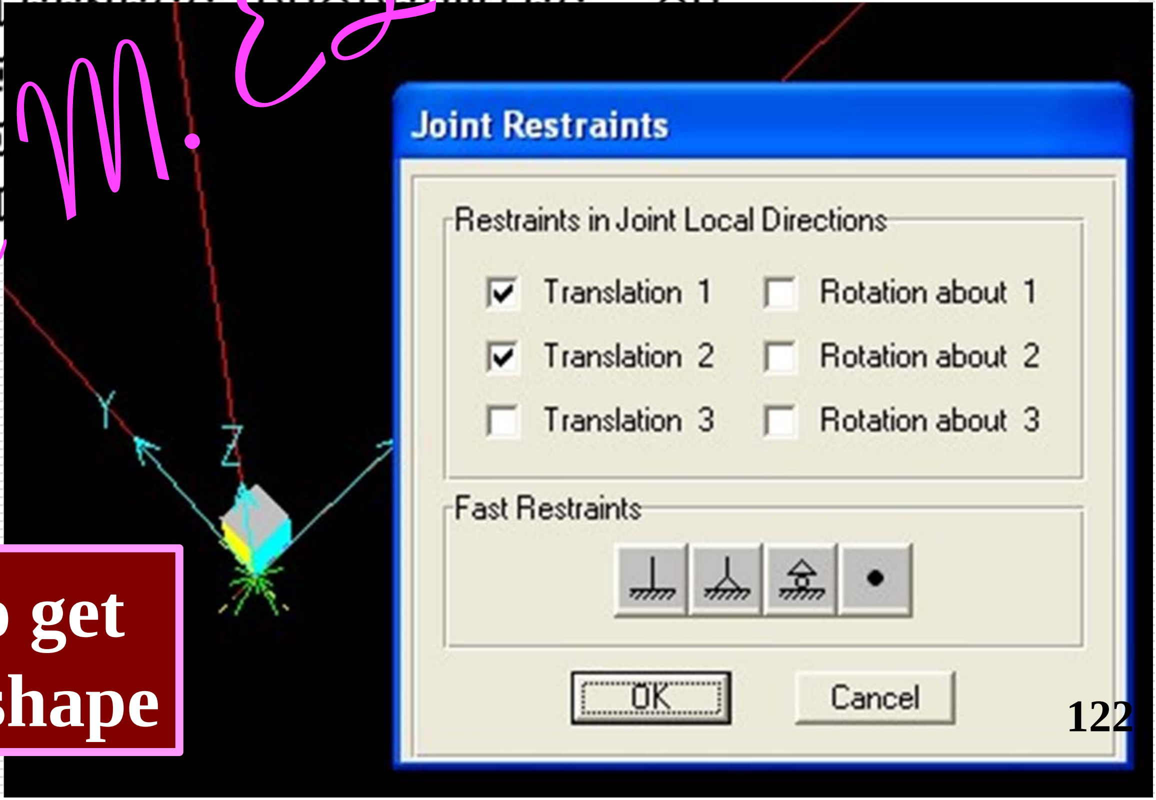
○ Delete Existing Springs

100 X Bearing Capacity (ton/m^2) X 0.25X0.25

Tanks

Run….Unstable!!

```
* * * W A R N I N G * * *
THE STRUCTURE IS UNSTABLE OR ILL-CONDITIONED !!
CHECK THE STRUCTURE CAREFULLY FOR:
- INADEQUATE SUPPORT CONDITIONS, OR
- ONE OR MORE INTERNAL MECHANISMS, OR
- ZERO OR NEGATIVE STI
- EXTREMELY LARGE STI
- BUCKLING DUE TO P-DE
- A FREQUENCY SHIFT (I
```



Joint Restraints

Restraints in Joint Local Directions

☑ Translation 1 ☐ Rotation about 1

☑ Translation 2 ☐ Rotation about 2

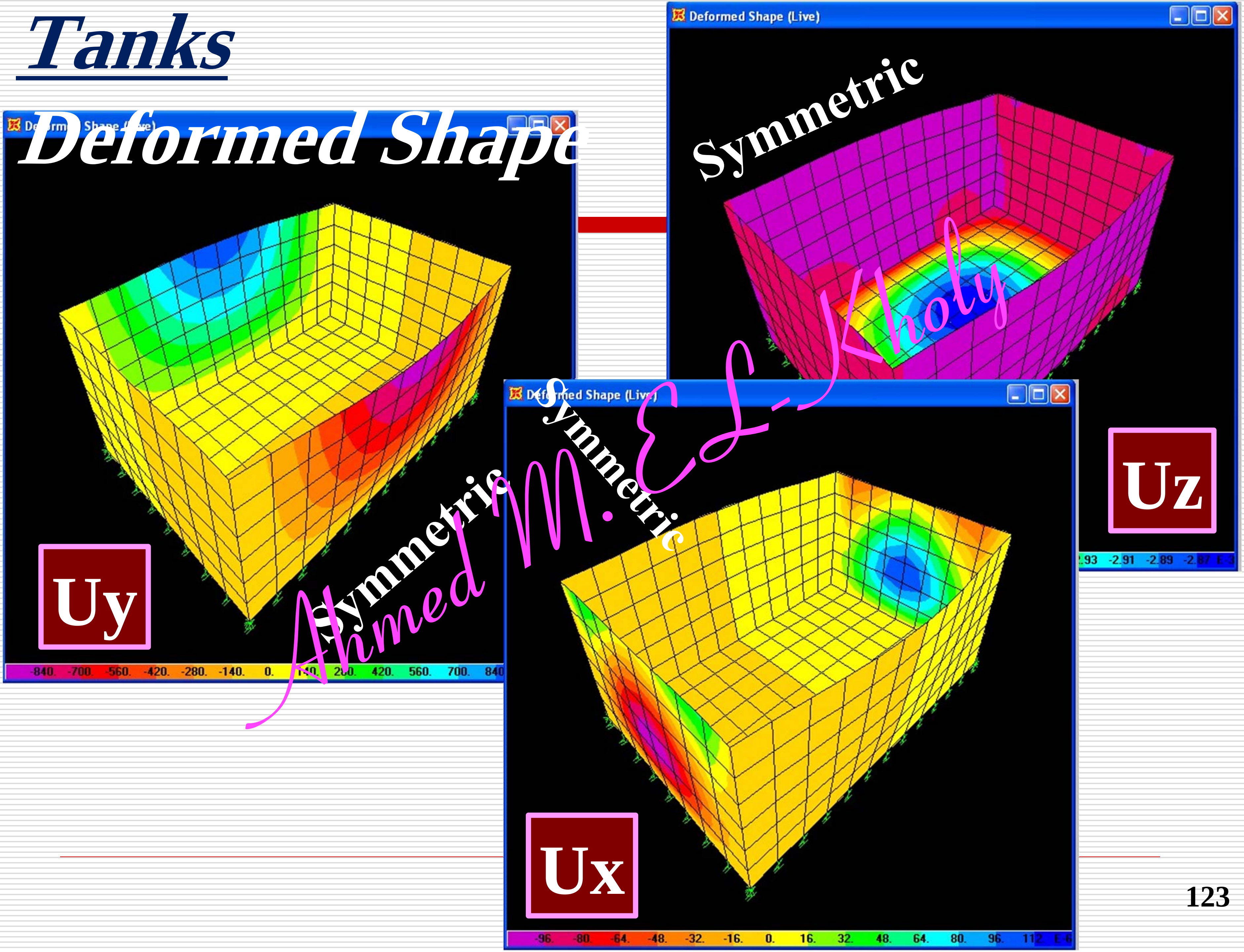
☐ Translation 3 ☐ Rotation about 3

Fast Restraints

Four corner points to get symmetric deformed shape

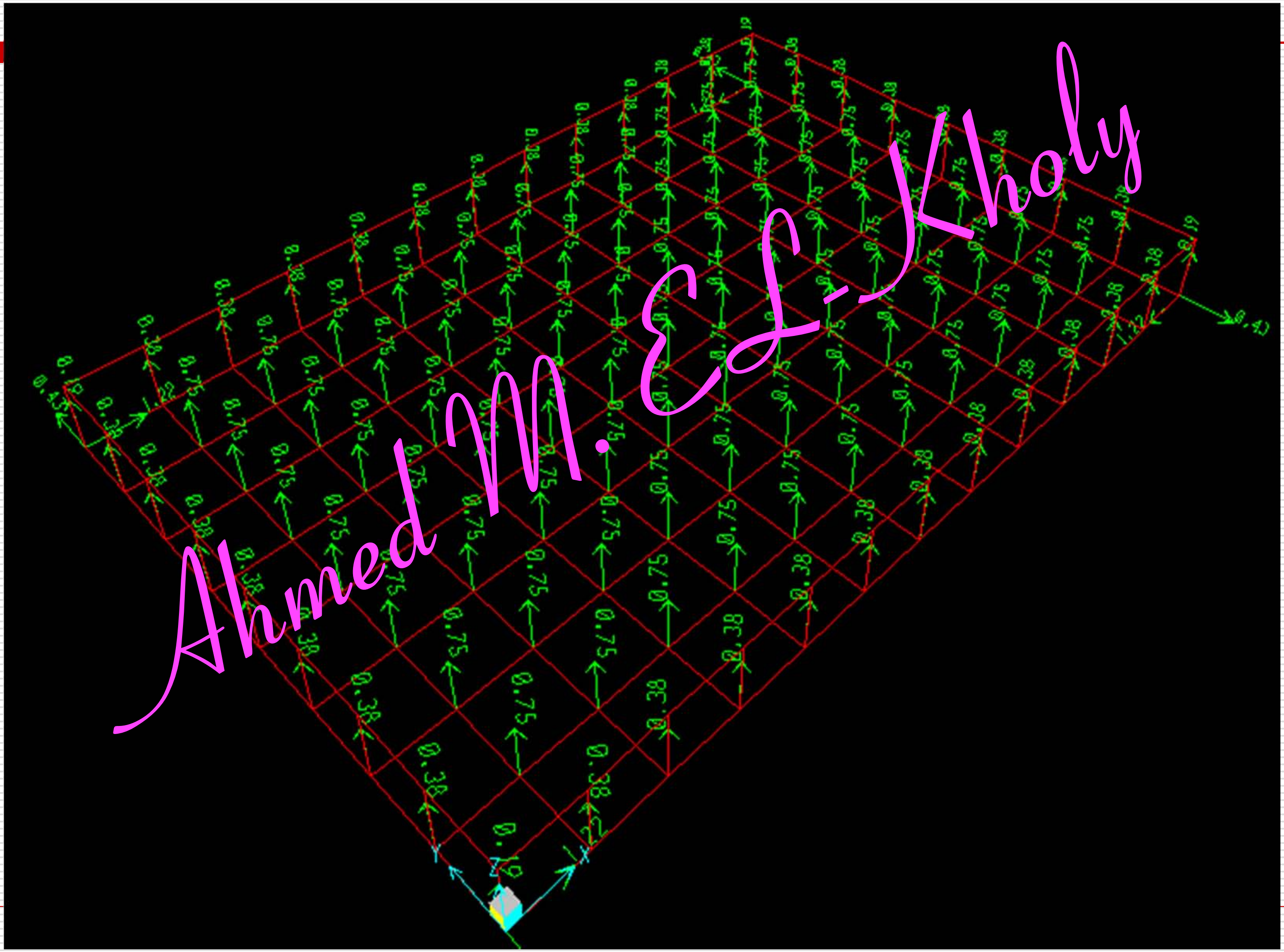
Tanks

Deformed Shape



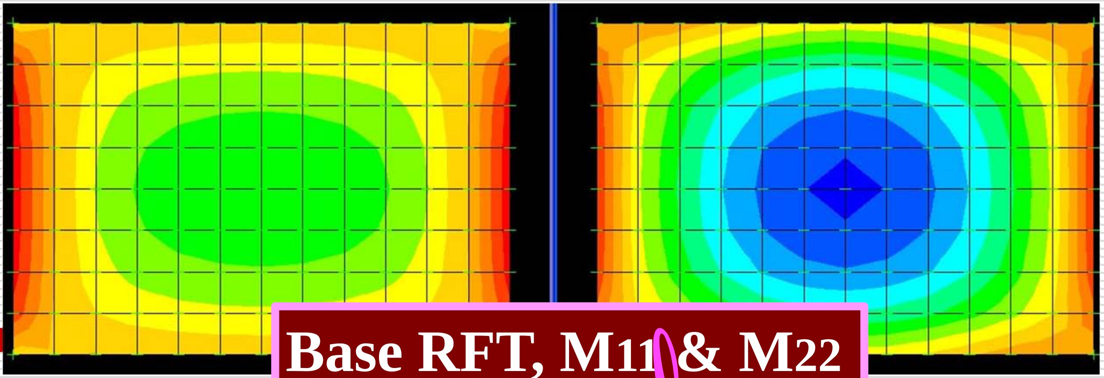
Tanks

Spring Forces

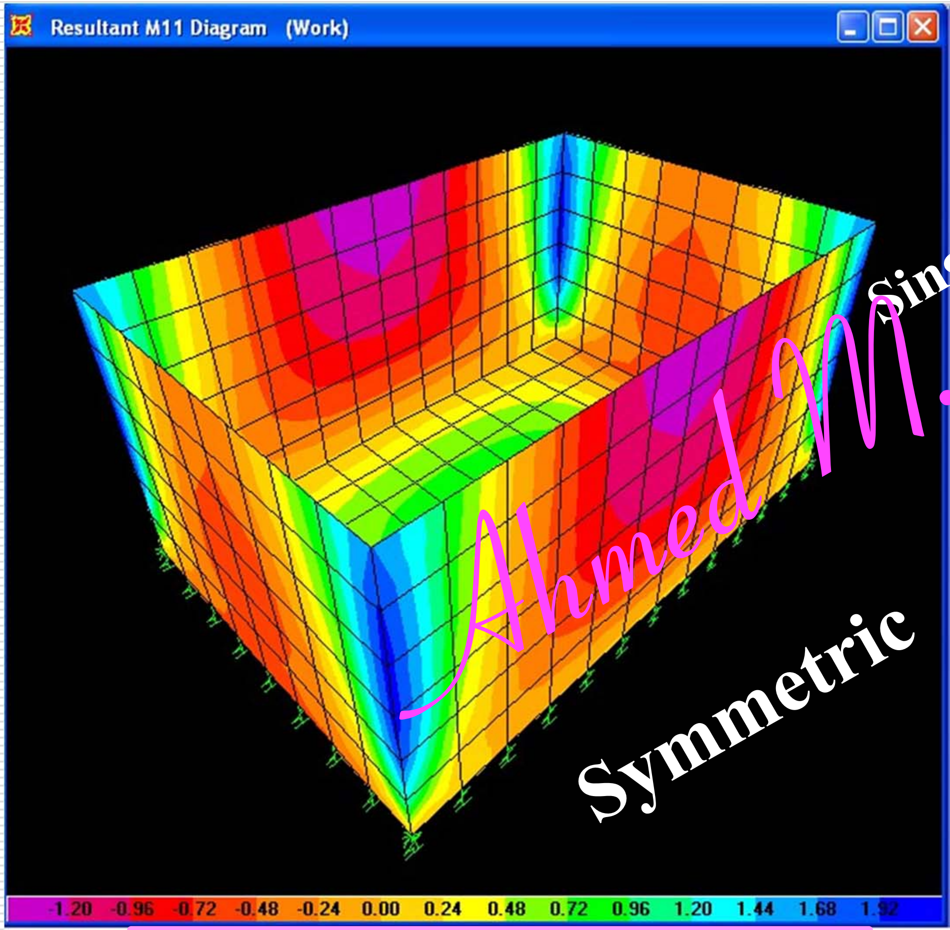


Tanks

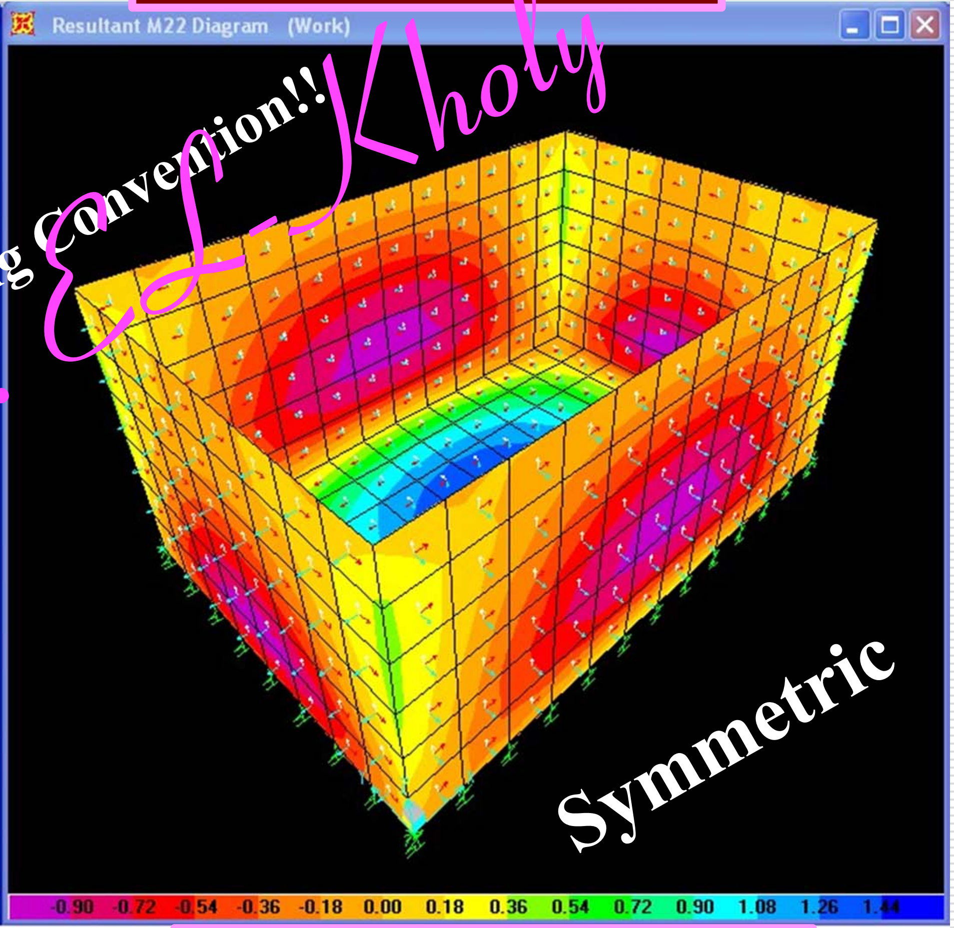
Moments & RFT



Base RFT, M_{11} & M_{22}



Symmetric



Sing Convention!!

Symmetric

M_{11} Horizontal RFT

M_{22} Vertical RFT

Tanks

Check Bearing Capcity

RAFT

RAFT
...Problem

Ultimate Change

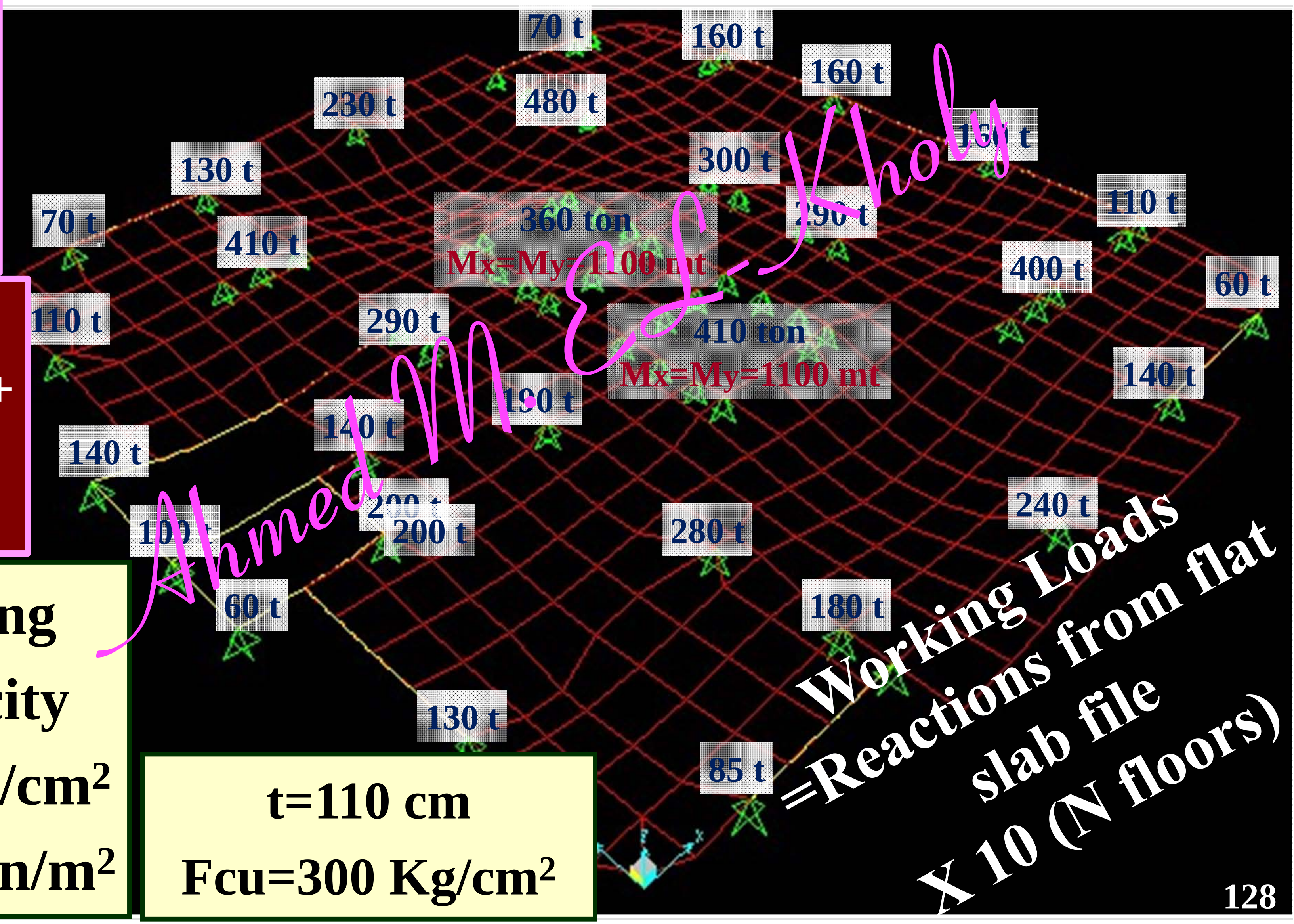
DL+LL Column Loads are given in blue

EQ Core Moments are given in Red

Patterns
SDL
SEX
SEY

Cases
Patterns+
SEXN
SEYN

Bearing Capacity
=2.0 Kg/cm^2
=20.0 ton/m^2



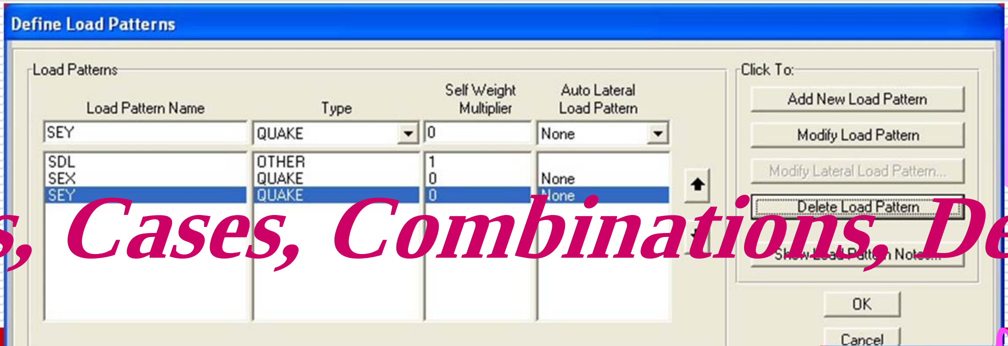
Working Loads
=Reactions from flat slab file
X 10 (N floors)

t=110 cm
Fcu=300 Kg/cm^2

RAFT

…Patterns, Cases, Combinations, Design M

Change to Ultimate


Define Load Patterns

Load Patterns

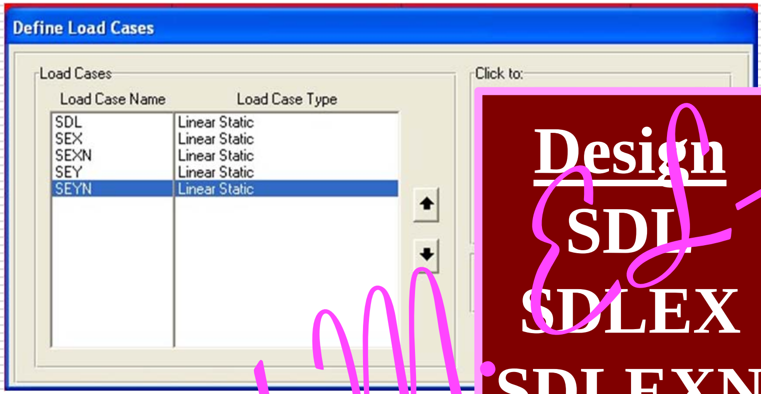
Load Pattern Name	Type	Self Weight Multiplier	Auto Lateral Load Pattern
SEY	QUAKE	0	None
SDL	OTHER	1	
SEX	QUAKE	0	None
SEY	QUAKE	0	None

Patterns

SDL

SEX

SEY


Define Load Cases

Load Cases

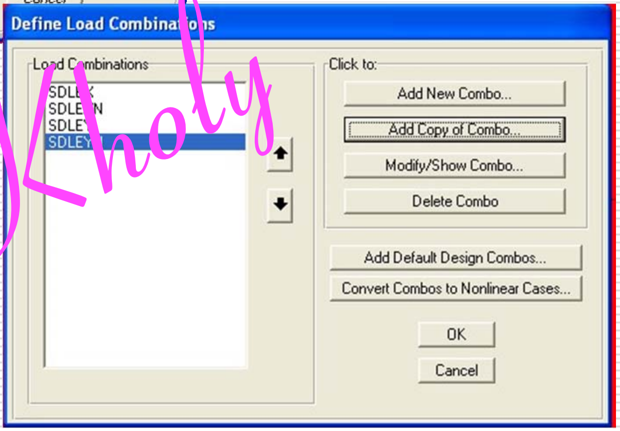
Load Case Name	Load Case Type
SDL	Linear Static
SEX	Linear Static
SEXN	Linear Static
SEY	Linear Static
SEYN	Linear Static

Cases

Patterns+

SEXN

SEYN


Define Load Combinations

Load Combinations

SDLEX
SDLEXN
SDLEY
SDLEYN

Design

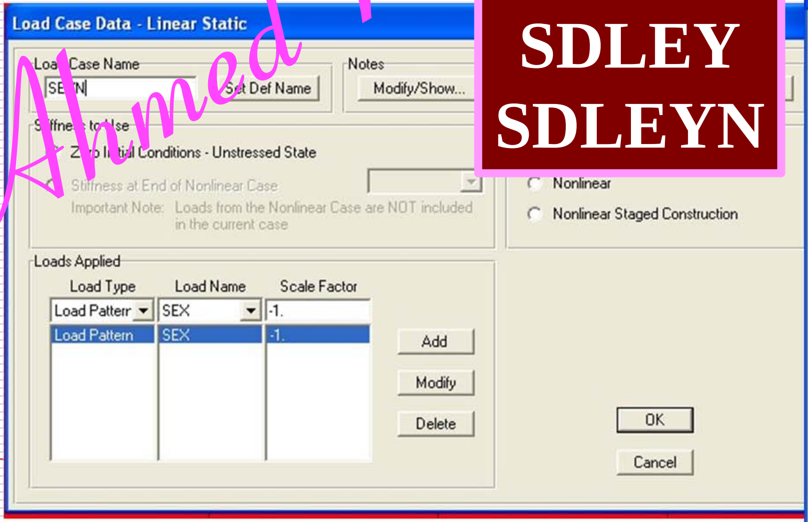
SDL

SDLEX

SDLEXN

SDLEY

SDLEYN


Load Case Data - Linear Static

Load Case Name: SEYN

Stiffness to Use

○ Zero Initial Conditions - Unstressed State

○ Stiffness at End of Nonlinear Case

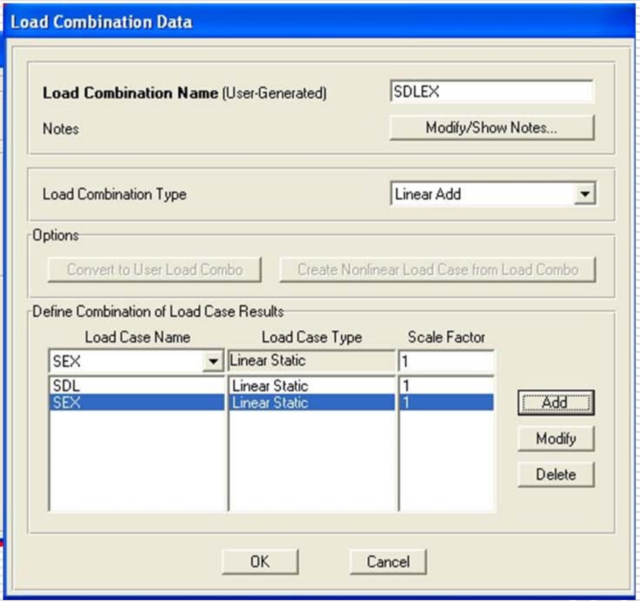
Important Note: Loads from the Nonlinear Case are NOT included in the current case

○ Nonlinear

○ Nonlinear Staged Construction

Loads Applied

Load Type	Load Name	Scale Factor
Load Pattern	SEX	-1.
Load Pattern	SEX	-1.


Load Combination Data

Load Combination Name (User-Generated): SDLEX

Load Combination Type: Linear Add

Options

Define Combination of Load Case Results

Load Case Name	Load Case Type	Scale Factor
SEX	Linear Static	1
SDL	Linear Static	1
SEX	Linear Static	1

Combinations

SDLEX

SDLEXN

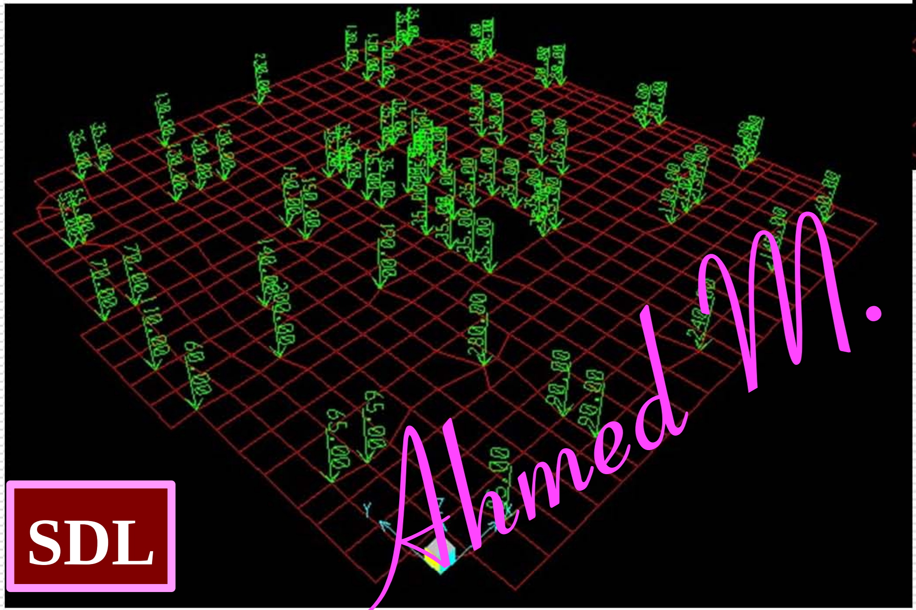
SDLEY

SDLEYN

RAFT
…Loads

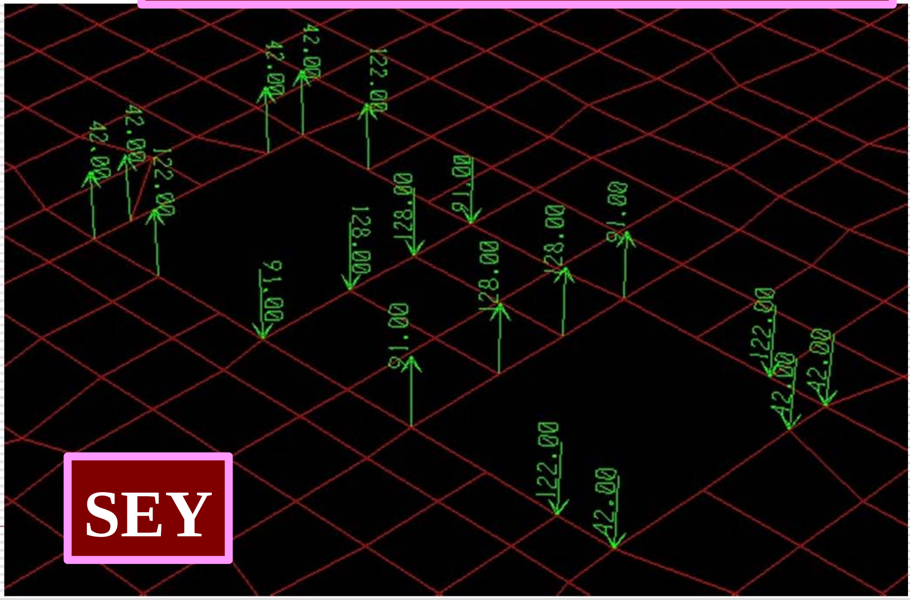
Patterns
SDL
SEX
SEY

SEX



SDL

Load SEX & SEY will be explained in the lecture



SEY

Change to Ultimate

Complete Raft in the two center openings

Flat Assignment Due
Monday 08 Sep

Raft Assignment Due
Wednesday 10 Sep

Etabs Assignment Due
Wednesday 17 Sep