Multi-Platform Simulation using VecTor Suite of Programs

Vahid Sadeghian

Civil Engineering
UNIVERSITY OF TORONTO

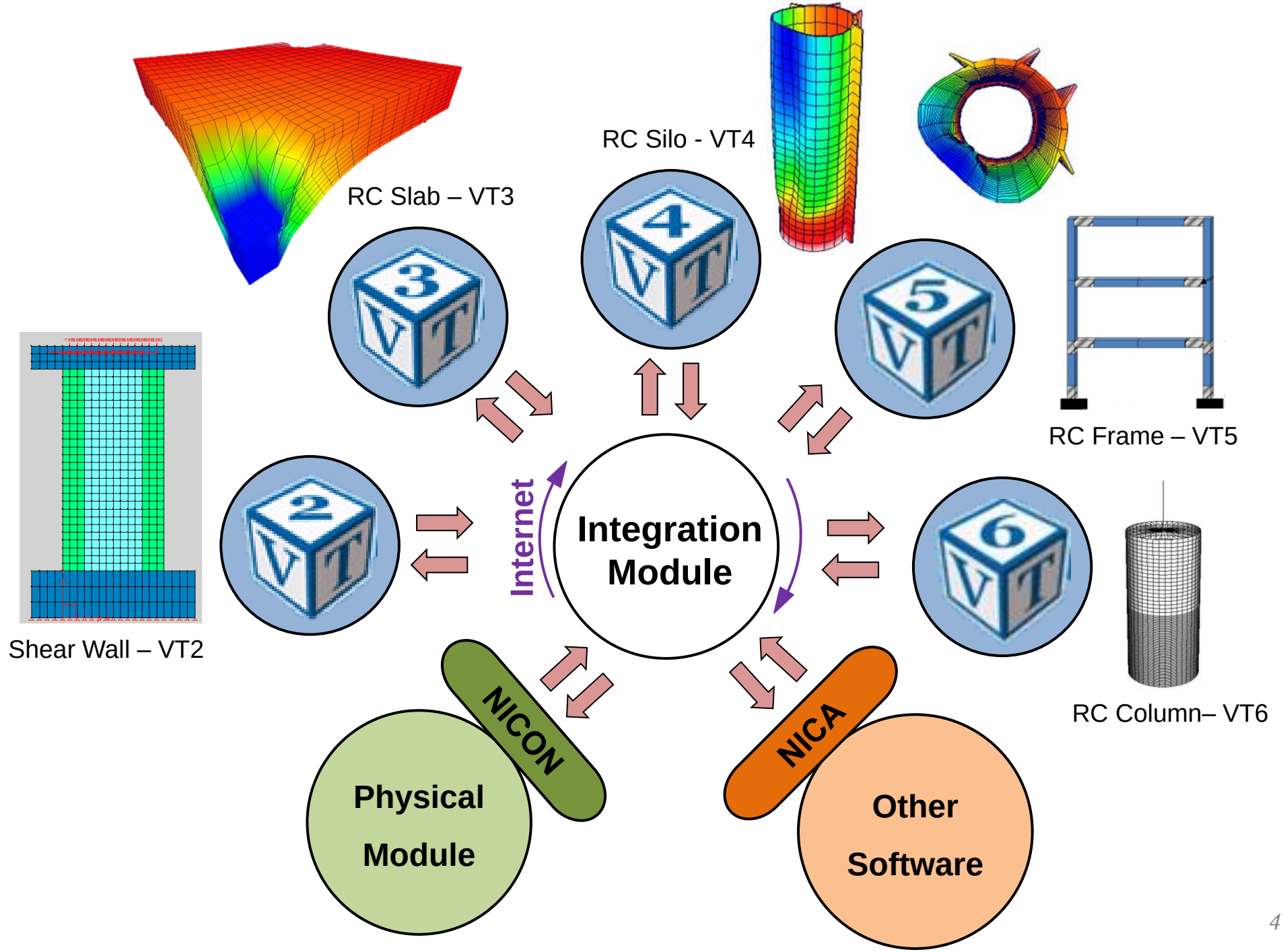
Outline

- Introduction to the VecTor suite of programs.
- **Example 1:** Modelling a shear-critical reinforced concrete beam.
- **Example 2:** Modelling beam-column joints substructure module.

Background

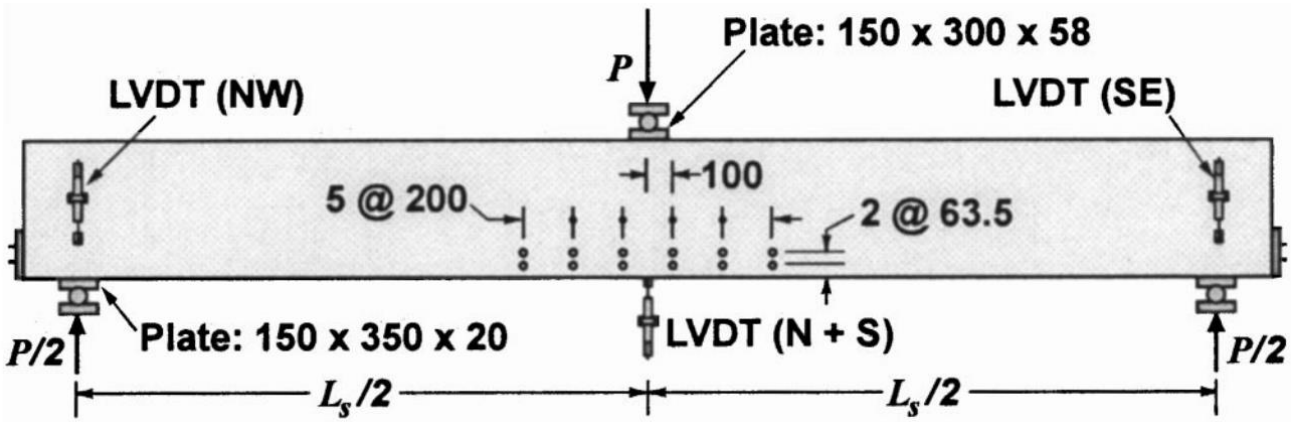
- **VecTor Suite of Software**

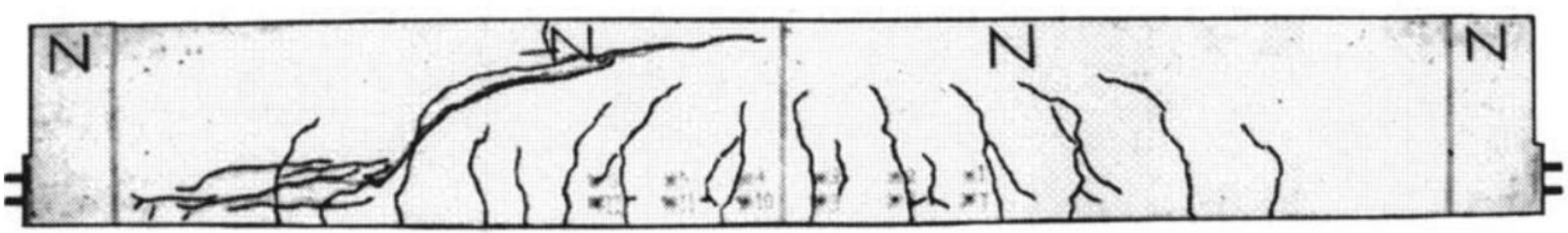
Software	Structure Type	Analysis Procedure	Element Library
VecTor2	2D Membranes	Repaired members with FRP sheets	
VecTor3	3D Solids	Nonlinear fire analysis	
VecTor4	Shells	Out-of-plane shear	
VecTor5	Frames	Computationally fast	
VecTor6	Axisymmetric Solids	Computationally fast	


RC Slab – VT3
RC Silo - VT4
RC Frame – VT5
Shear Wall – VT2
RC Column– VT6
Internet
Integration Module
NICON
NICA
Physical Module
Other Software

Example 1

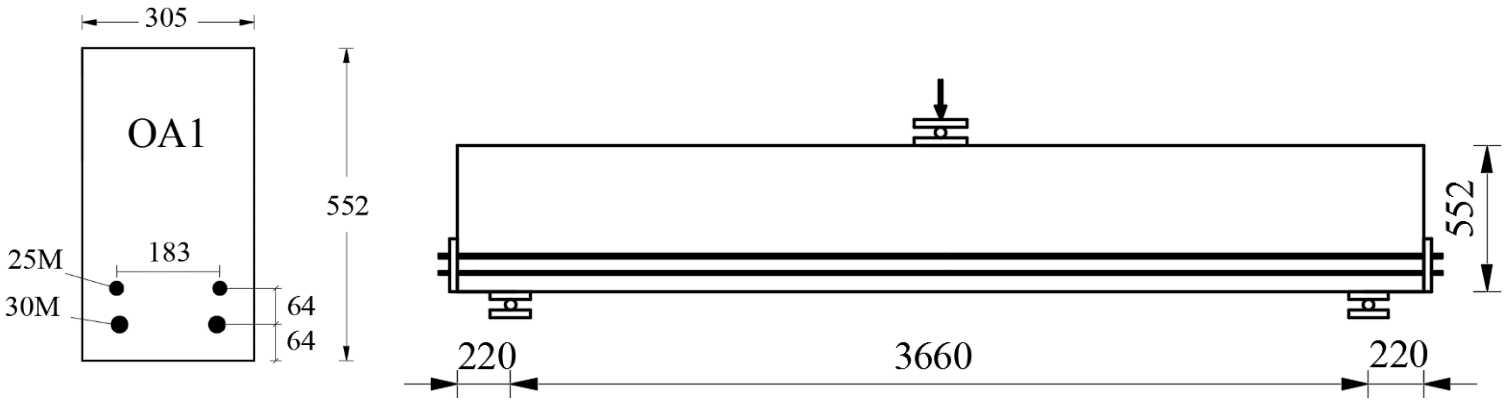
Modelling a Shear-Critical RC Beam in VecTor2





(Vecchio and Shim, 2004)

Example 1: Modelling a Shear-Critical RC Beam in VecTor2



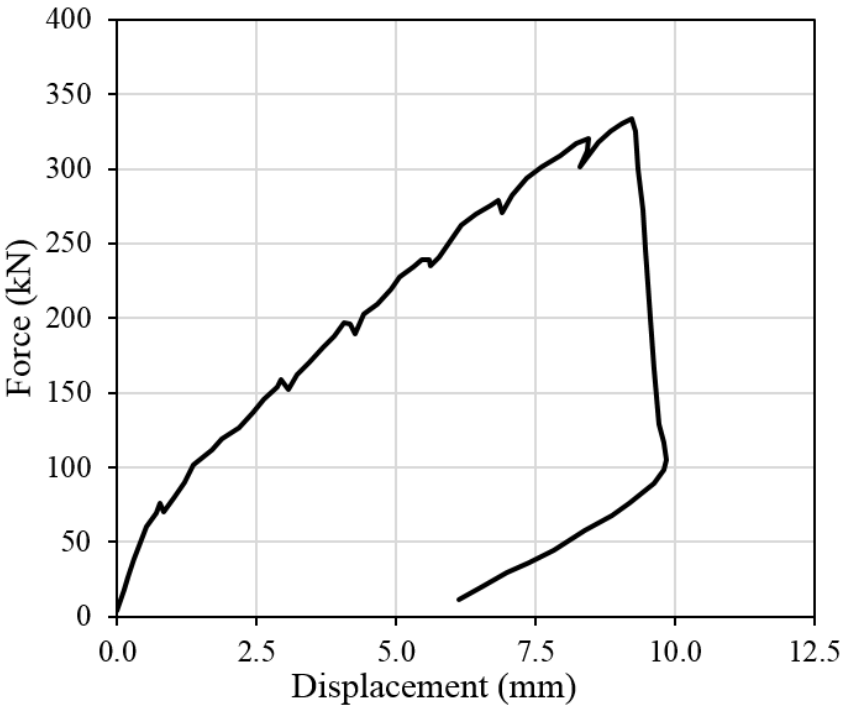
Details of OA1 beam tested by Vecchio and Shim (2004)

Concrete				
f'_c (MPa)	ε_o ($\times 10^{-3}$)	E_c (MPa)	f_{sp} (MPa)	Max Agg. Size (mm)
22.6	1.6	36,500	2.37	20

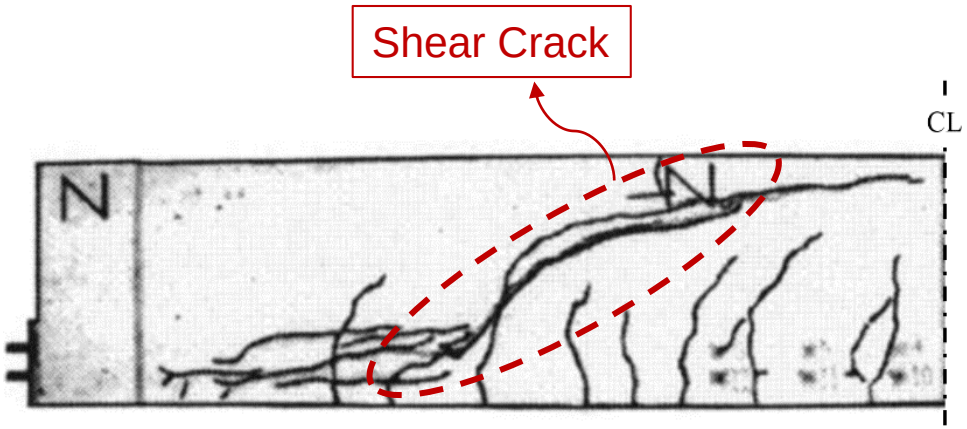
Reinforcement							
Bar Size	Diameter (mm)	Area (mm^2)	f_y (MPa)	f_u (MPa)	E_s (MPa)	ε_{sh} ($\times 10^{-3}$)	ε_u ($\times 10^{-3}$)
25M	25.2	500	445	680	220,000	8.5	216
30M	29.9	700	436	700	200,000	11.4	175

Example 1: Modelling a Shear-Critical RC Beam in VecTor2

❑ Experimentally Reported Results



Load-deflection response



Crack pattern

Example 1: Modelling a Shear-Critical RC Beam in VecTor2

❑ Modelling Steps Overview

- Step 1) Define Materials

  Concrete Material ; Steel Material ; Bearing Material

- Step 2) Create finite element Mesh

  Concrete Regions ; Longitudinal Reinforcement ; Constraint Point

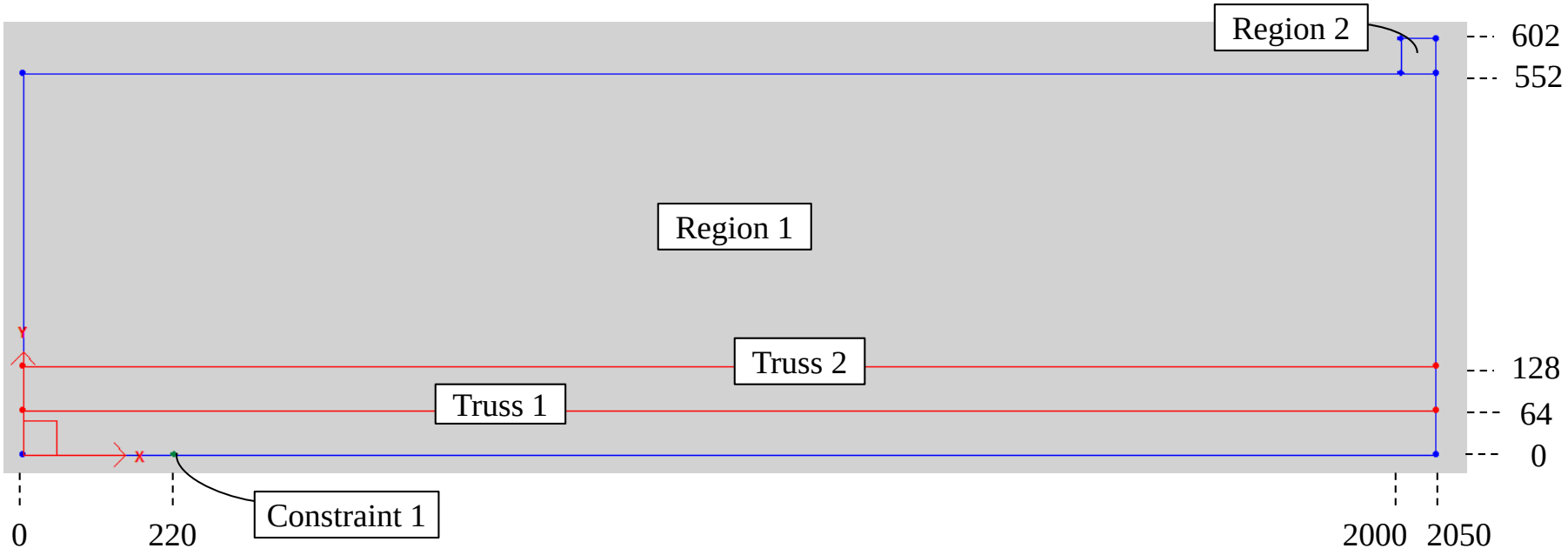
- Step 3) Define Support Restraints

- Step 4) Define Loads

- Step 5) Select Analysis Options

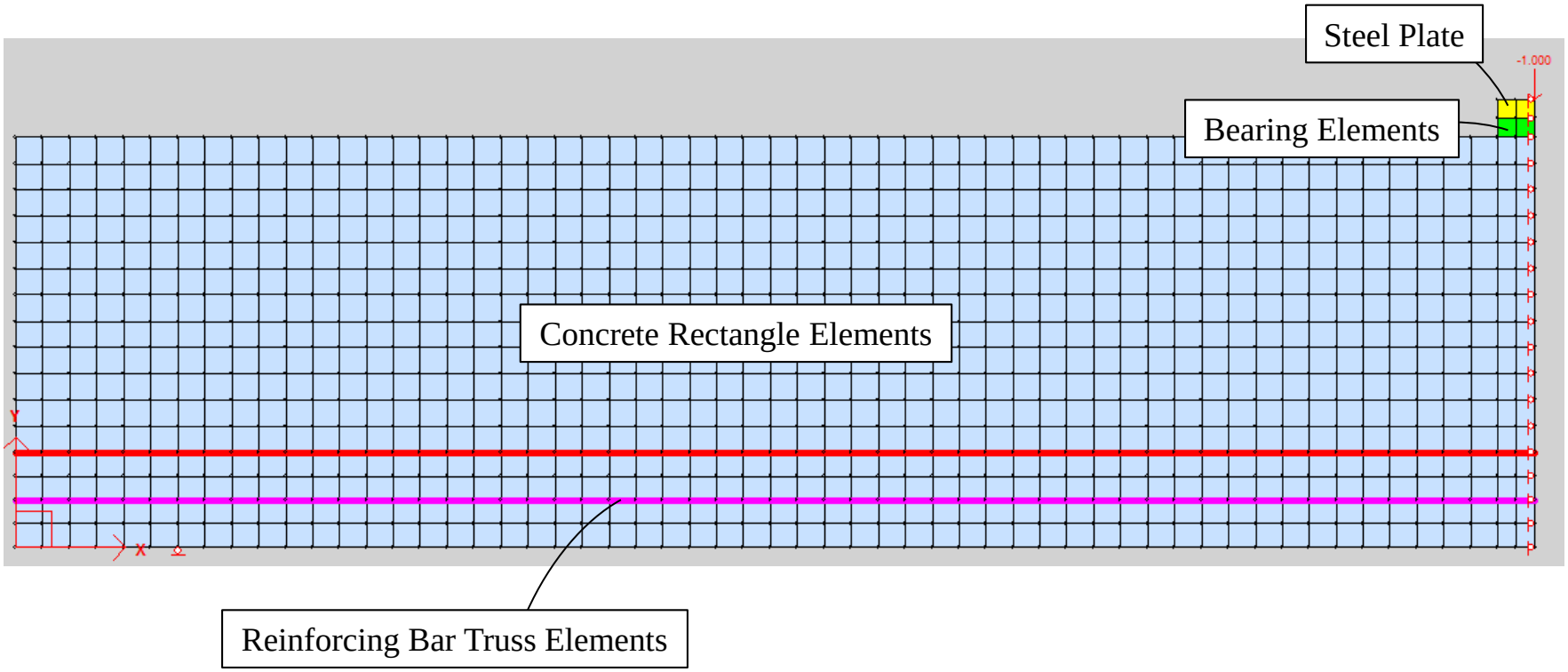
Example 1: Modelling a Shear-Critical RC Beam in VecTor2

❑ Create Finite Element Mesh



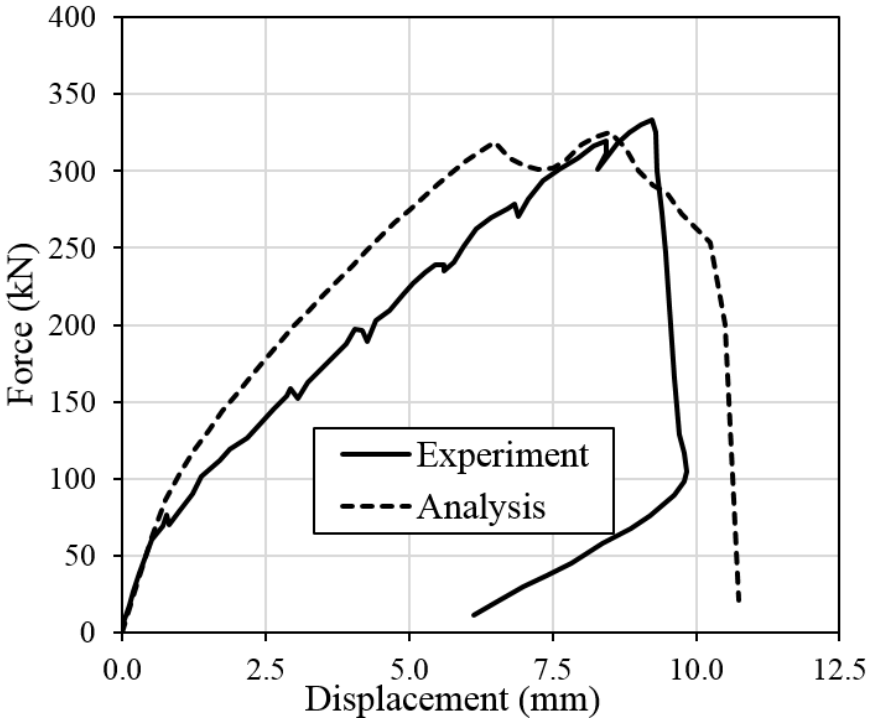
Example 1: Modelling a Shear-Critical RC Beam in VecTor2

❑ Finite Element Mesh

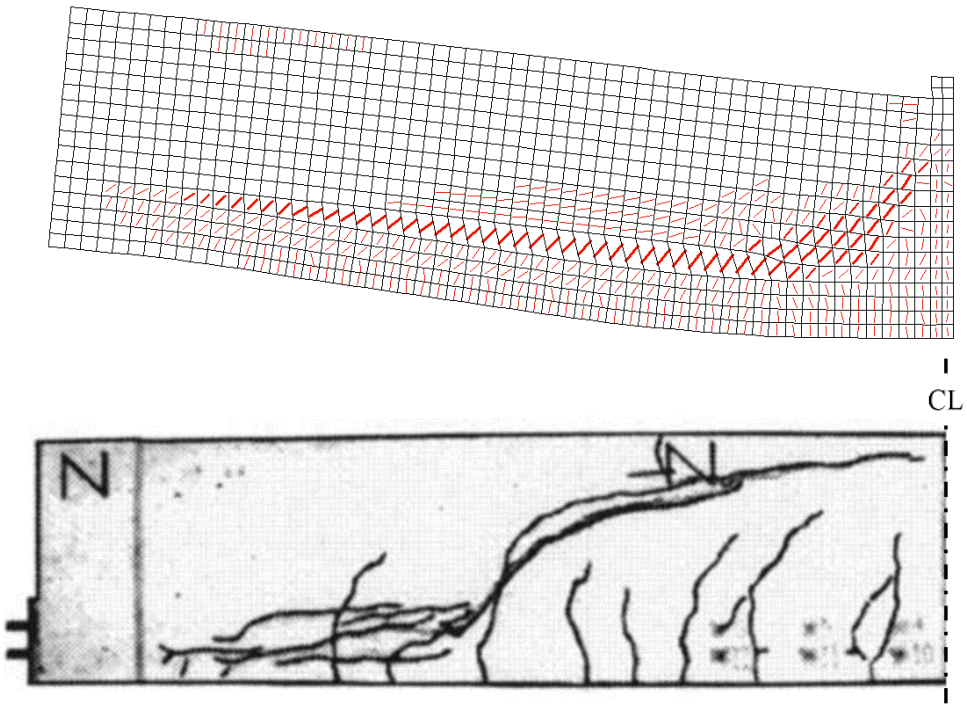


Example 1: Modelling a Shear-Critical RC Beam in VecTor2

❑ Comparison of the Results



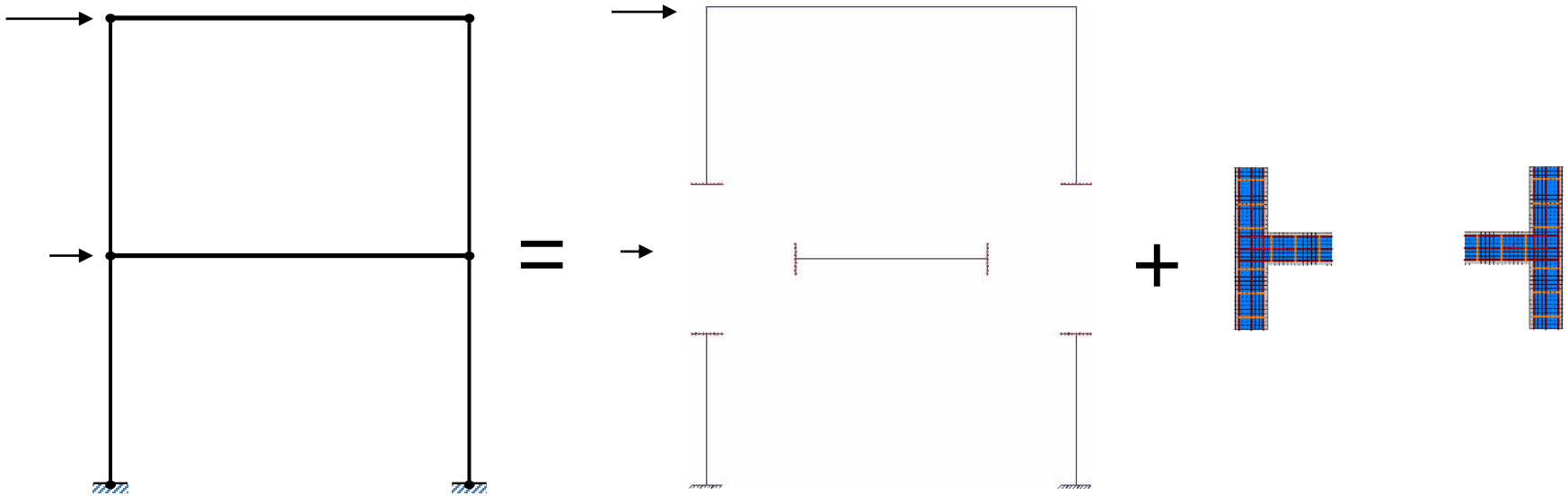
Load-deflection responses



Crack patterns

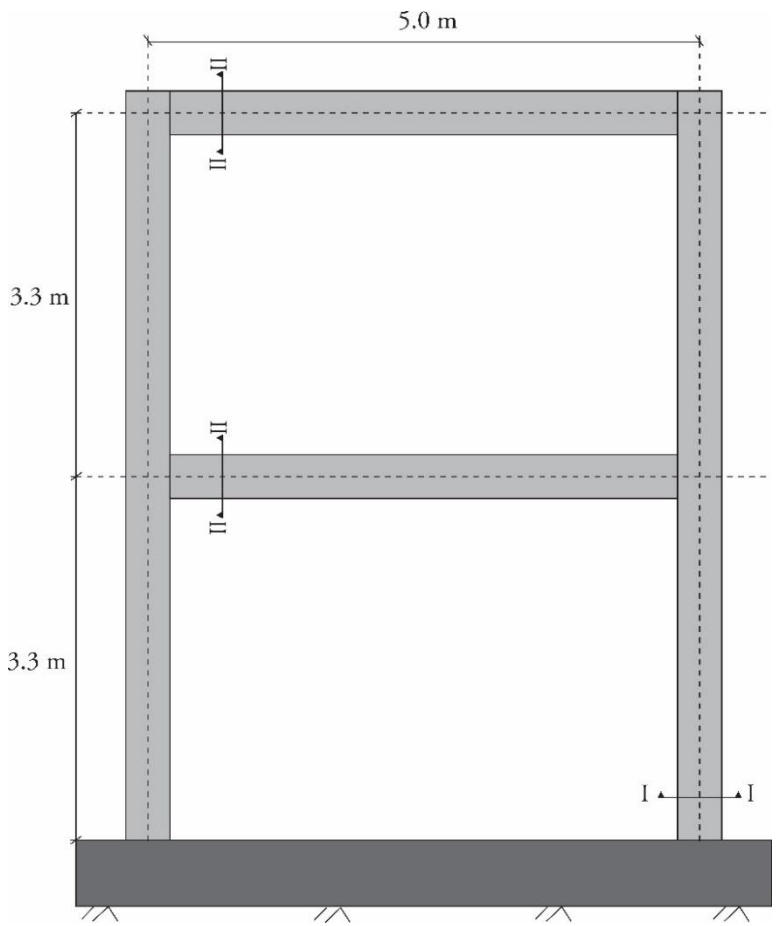
Example 2

Modelling Beam-Column Joints Substructure Module in VecTor2

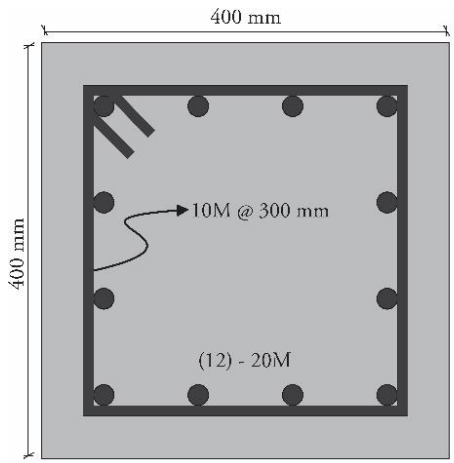


Complete Model S-FRAME Sub-Model VecTor2 Sub-Model

Example 2: Beam-Column Joints Substructure in VecTor2

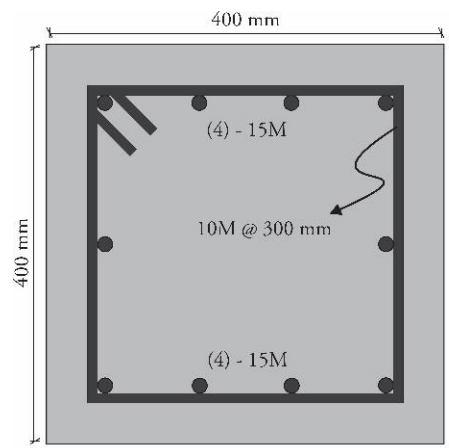


Structure details



SECTION I - I : COLUMN DETAIL

Column details



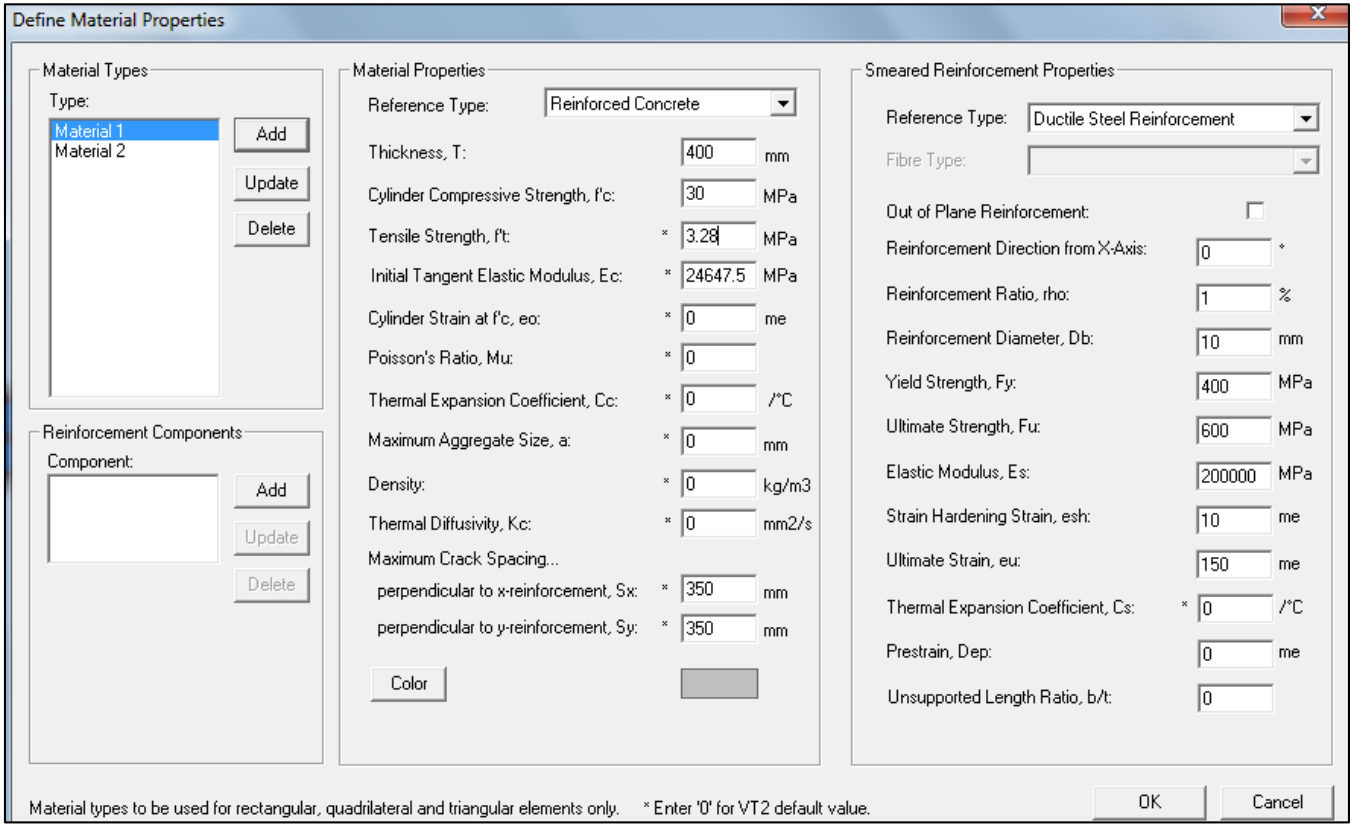
SECTION II - II : BEAM DETAIL

Beam details

Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 1) Create Concrete Materials

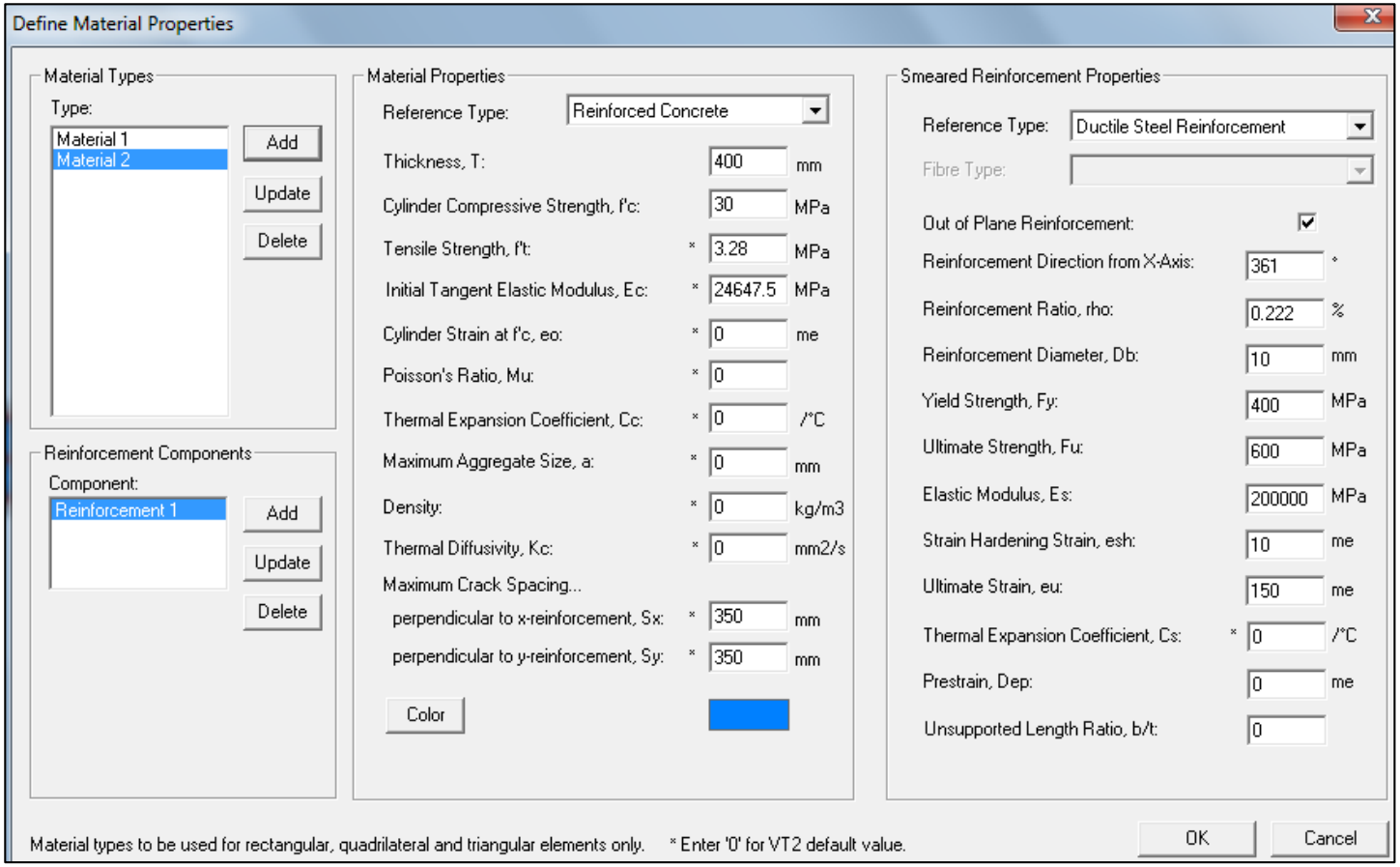
- Material 1: Concrete cover (unconfined concrete)



Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 1) Create Concrete Materials

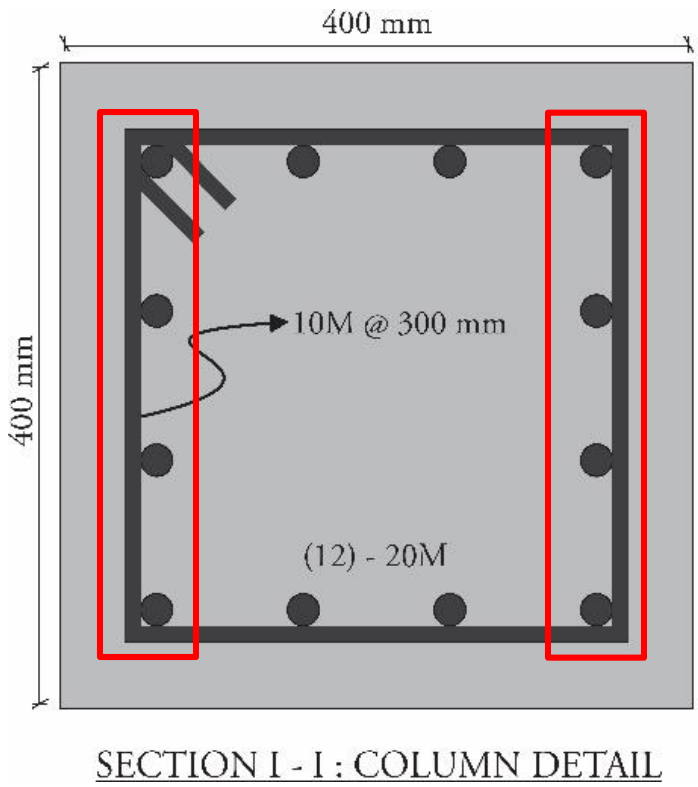
- Material 2: Confined concrete

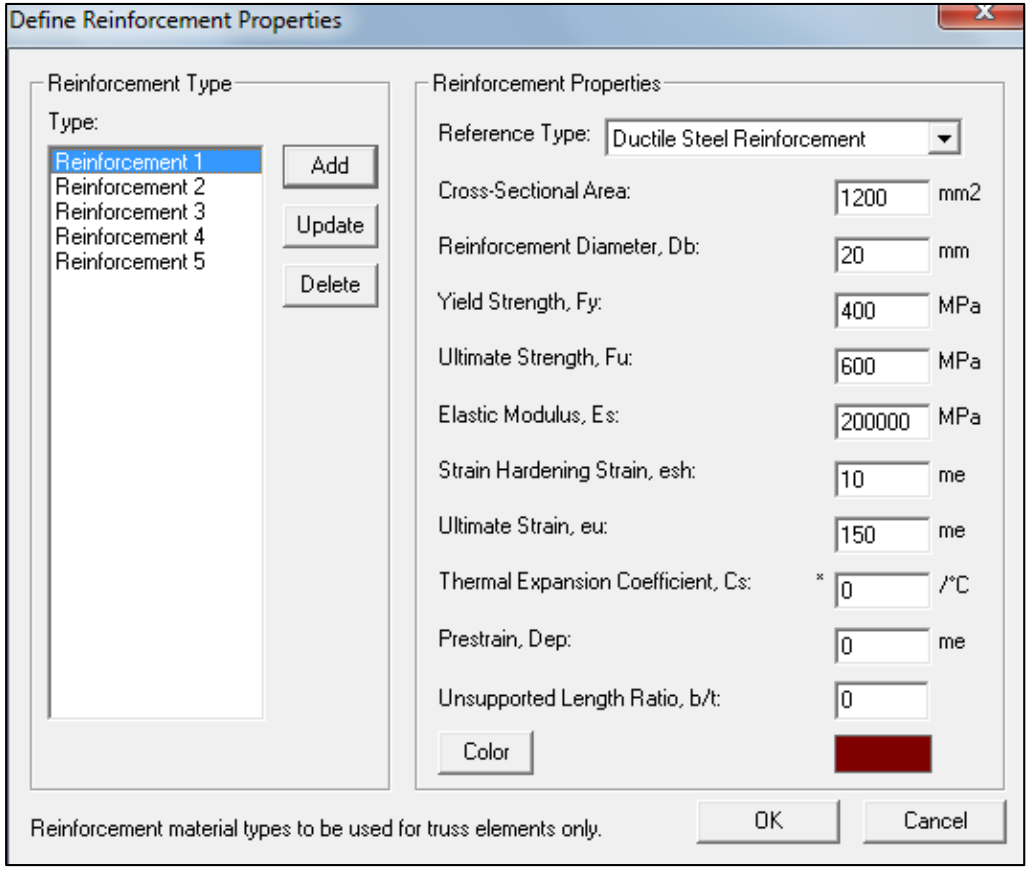


Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 2) Create Reinforcement Materials

- Reinforcement 1: Column longitudinal reinforcements

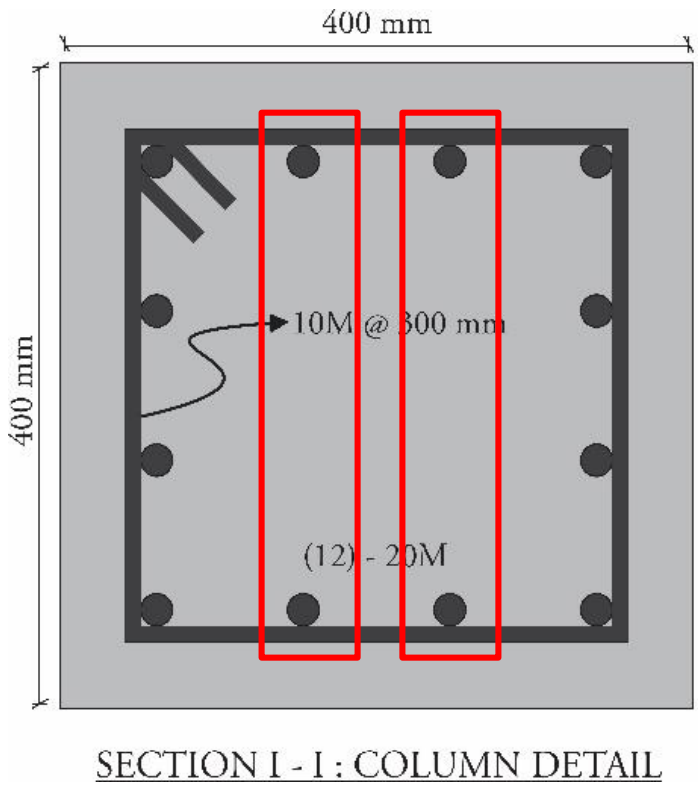


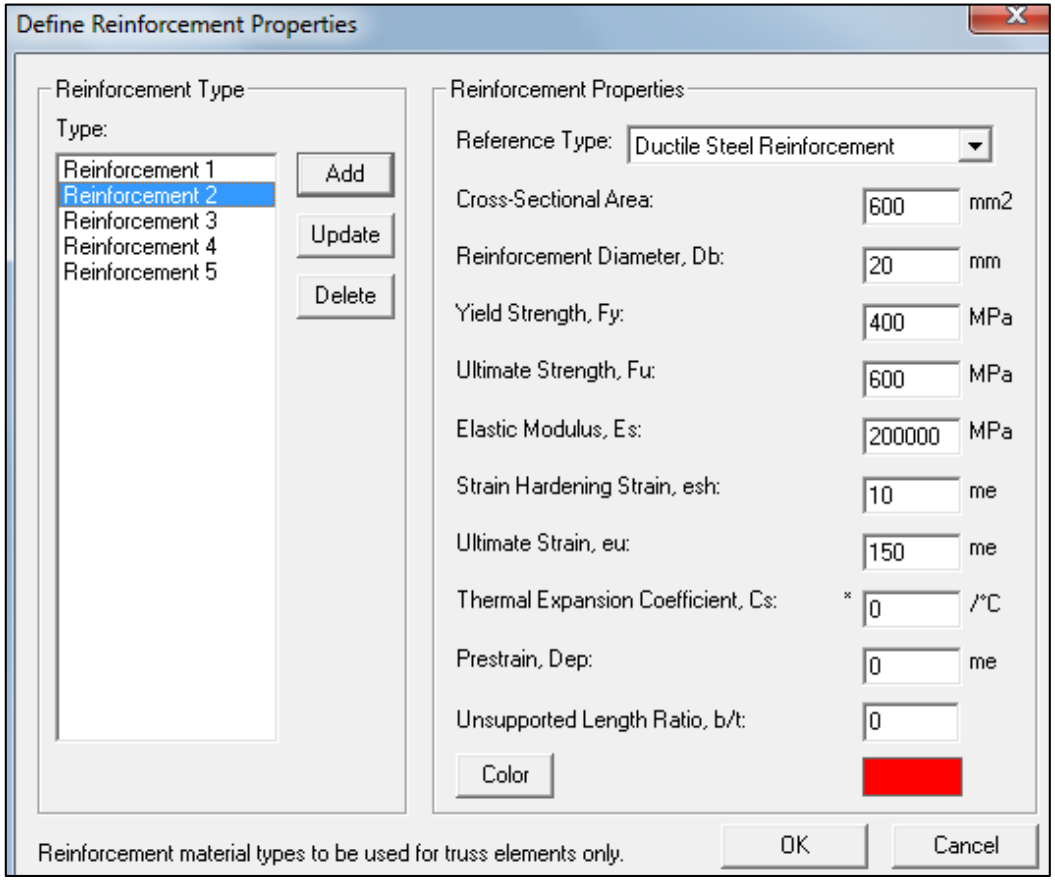


Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 2) Create Reinforcement Materials

- Reinforcement 2: Column longitudinal reinforcements

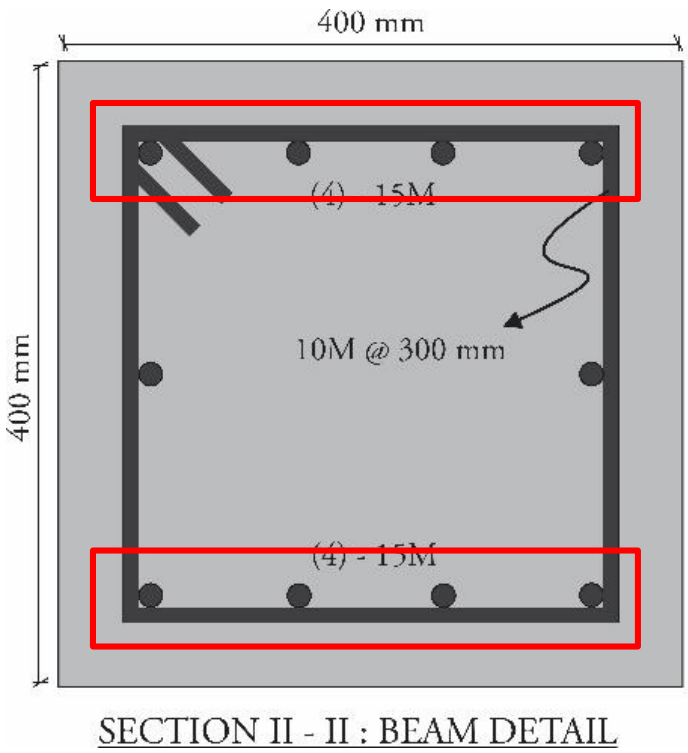


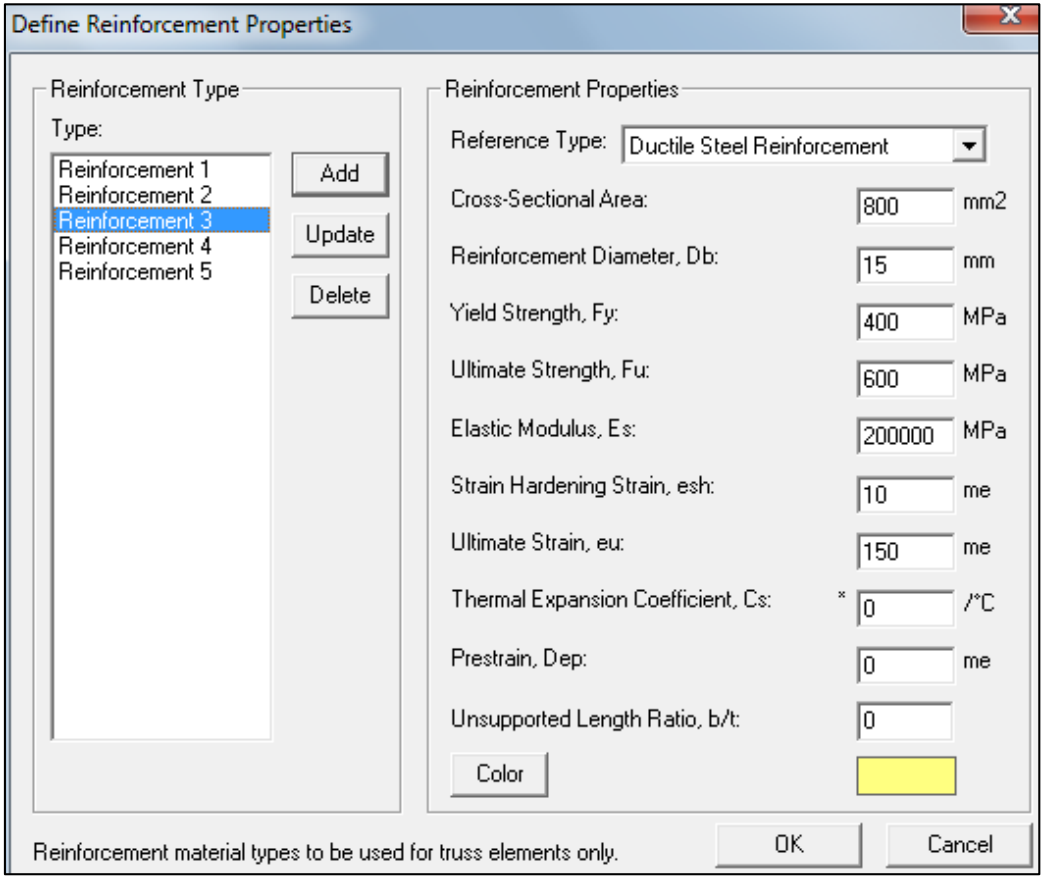


Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 2) Create Reinforcement Materials

- Reinforcement 3: Beam longitudinal reinforcements

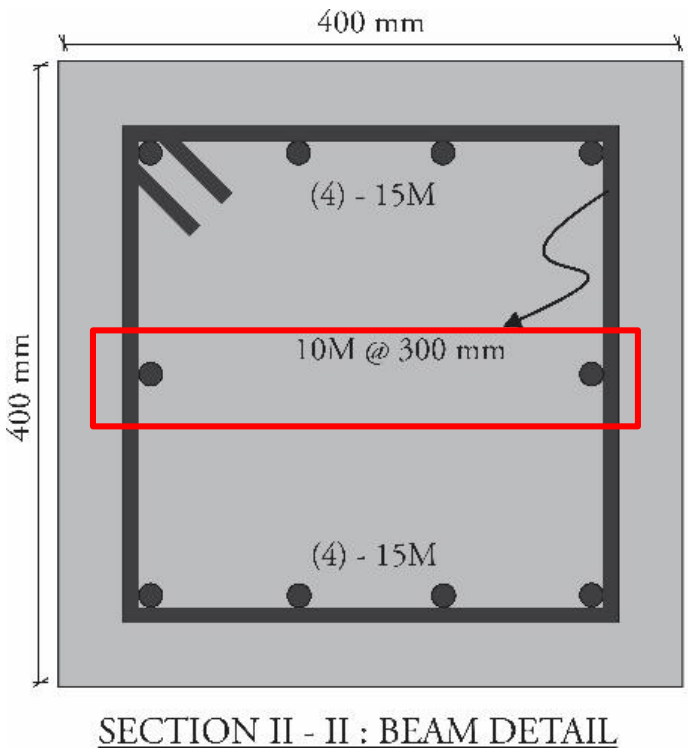


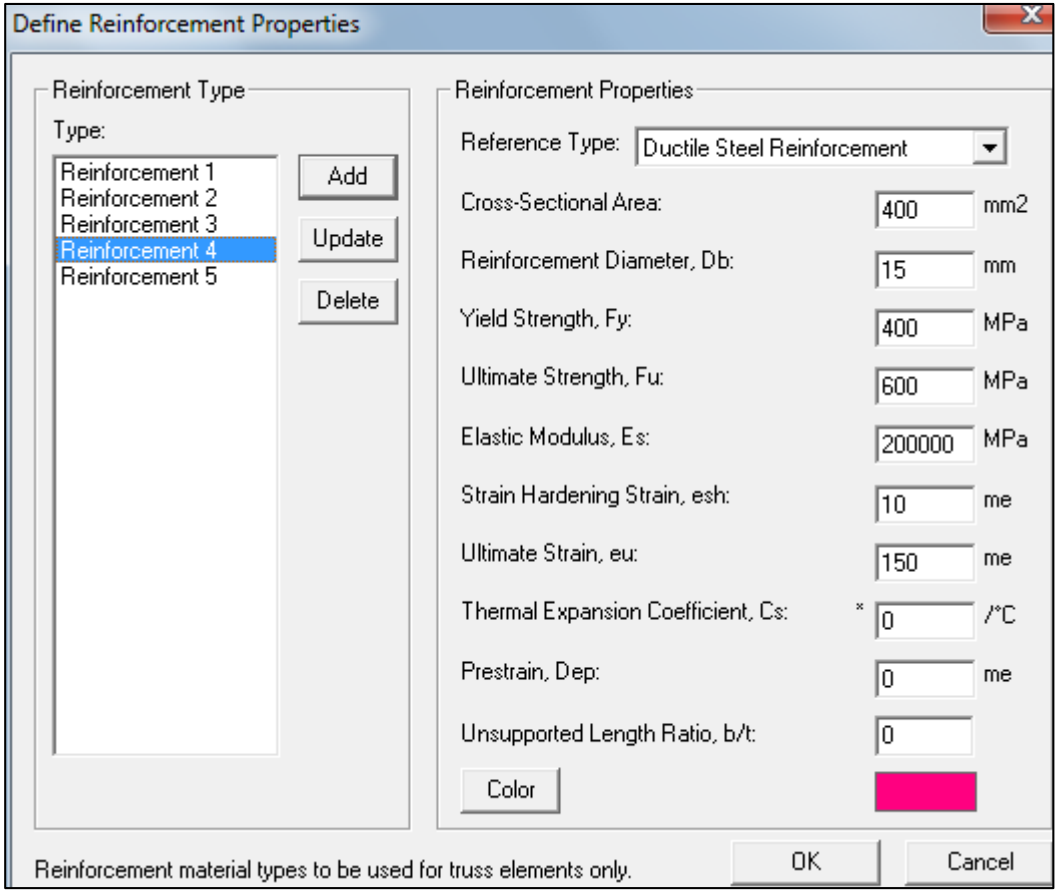


Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 2) Create Reinforcement Materials

- Reinforcement 4: Beam longitudinal reinforcements

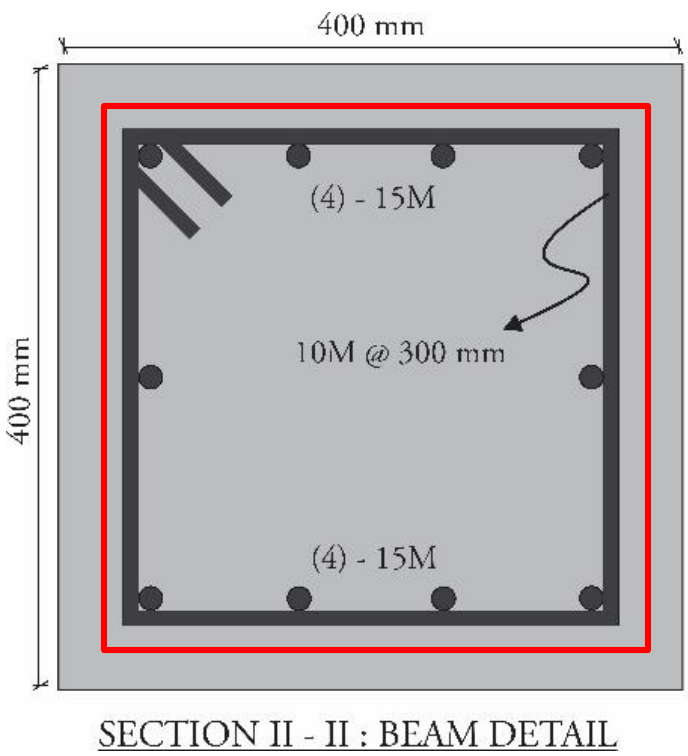


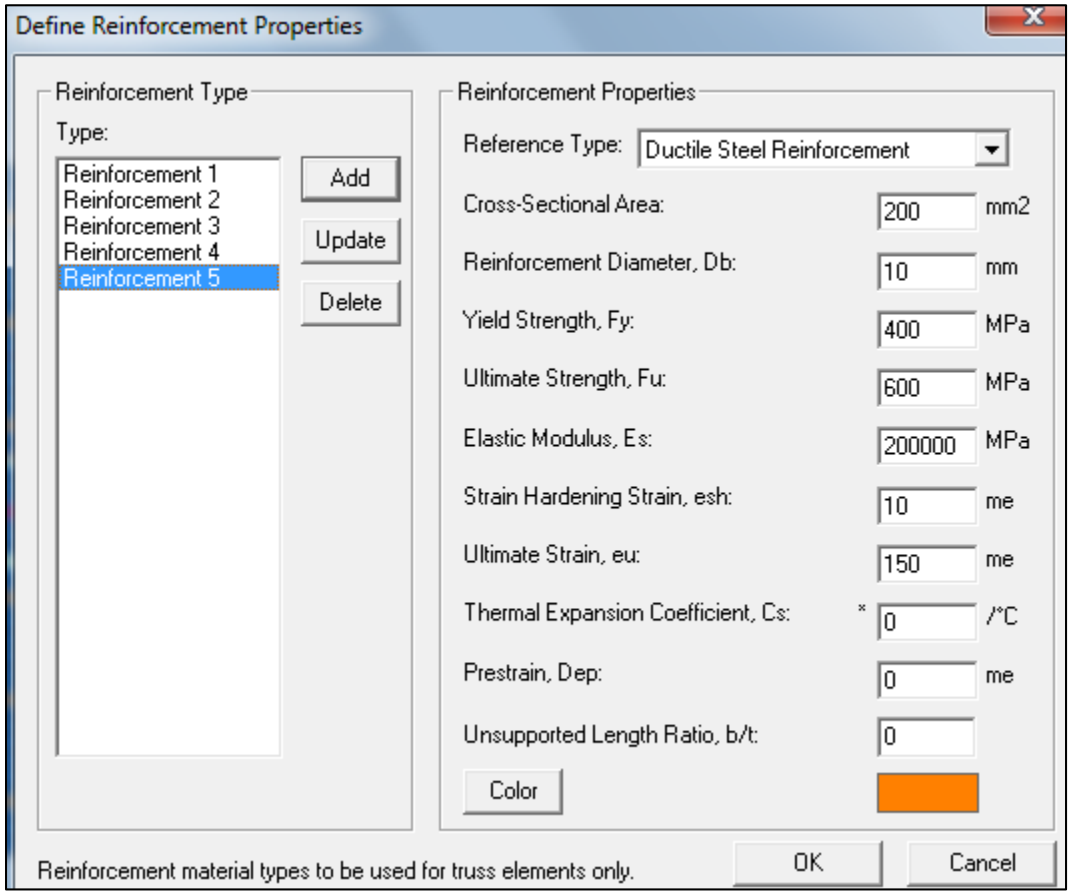


Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 2) Create Reinforcement Materials

- Reinforcement 5: Transverse reinforcements



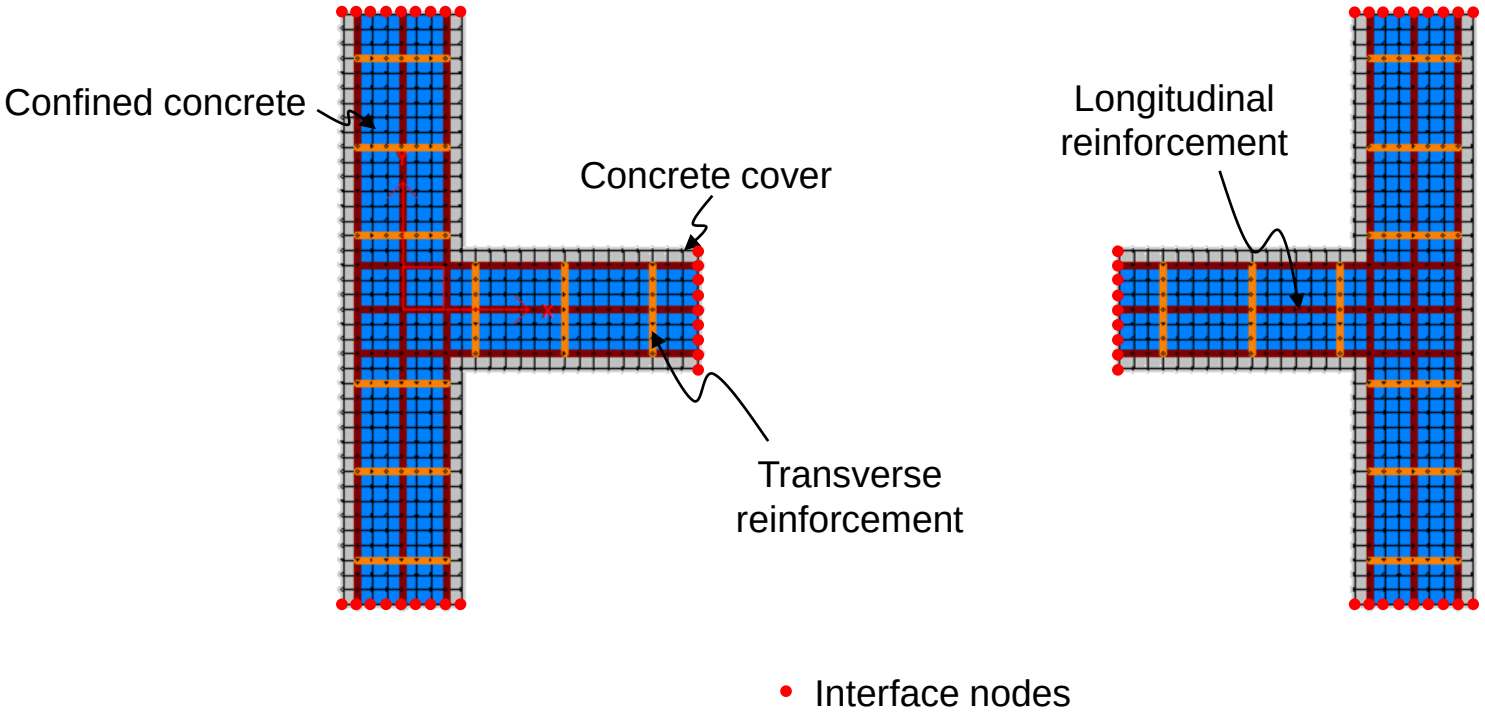


Example 2: Beam-Column Joints Substructure in VecTor2

- **Step 3) Create Concrete Regions and Truss Bars**

Example 2: Beam-Column Joints Substructure in VecTor2

❑ Step 4) Create FE Mesh and Assign Materials



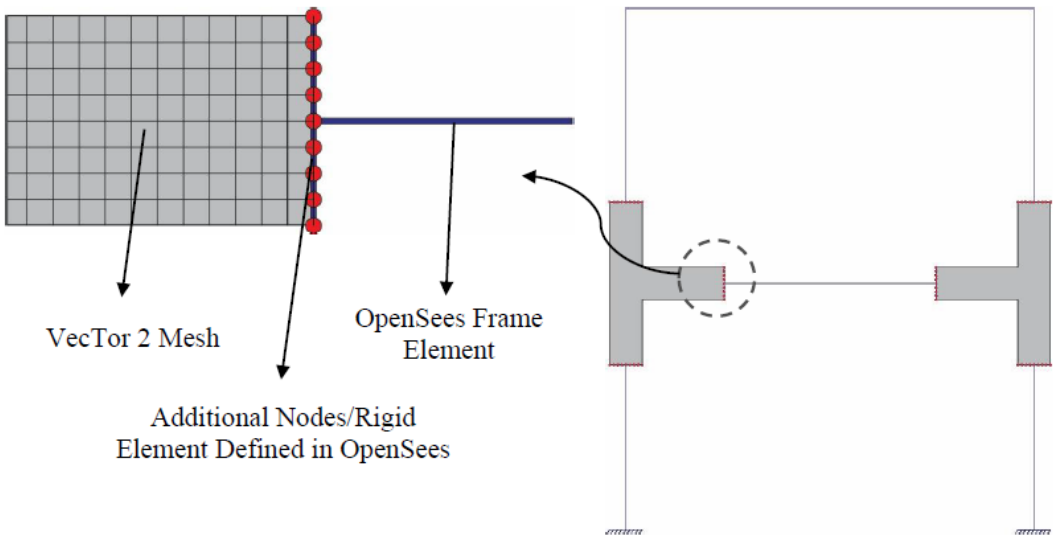
Example 2: Beam-Column Joints Substructure in VecTor2

- **Step 5) Map Interface Nodes: OpenSees-VecTor2 Integration**

NICON.TXT - Notepad

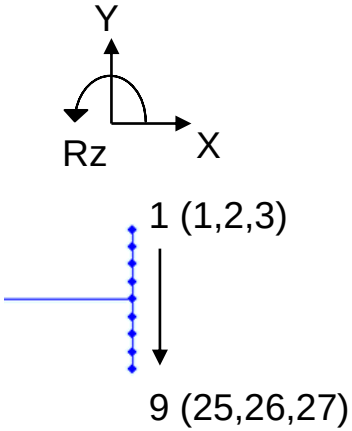
File Edit Format View Help

```
Format:
Number of coupled DOFs
Local Node Number      DOFx      DOFy
**********************************
108
1 1 1
3 1 1
81 1 1
82 1 1
83 1 1
123 1 1
124 1 1
```

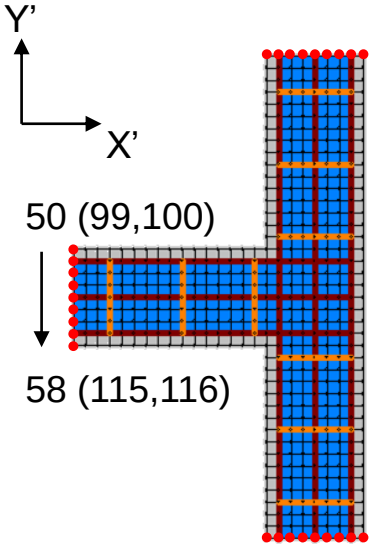


Example 2: Beam-Column Joints Substructure in VecTor2

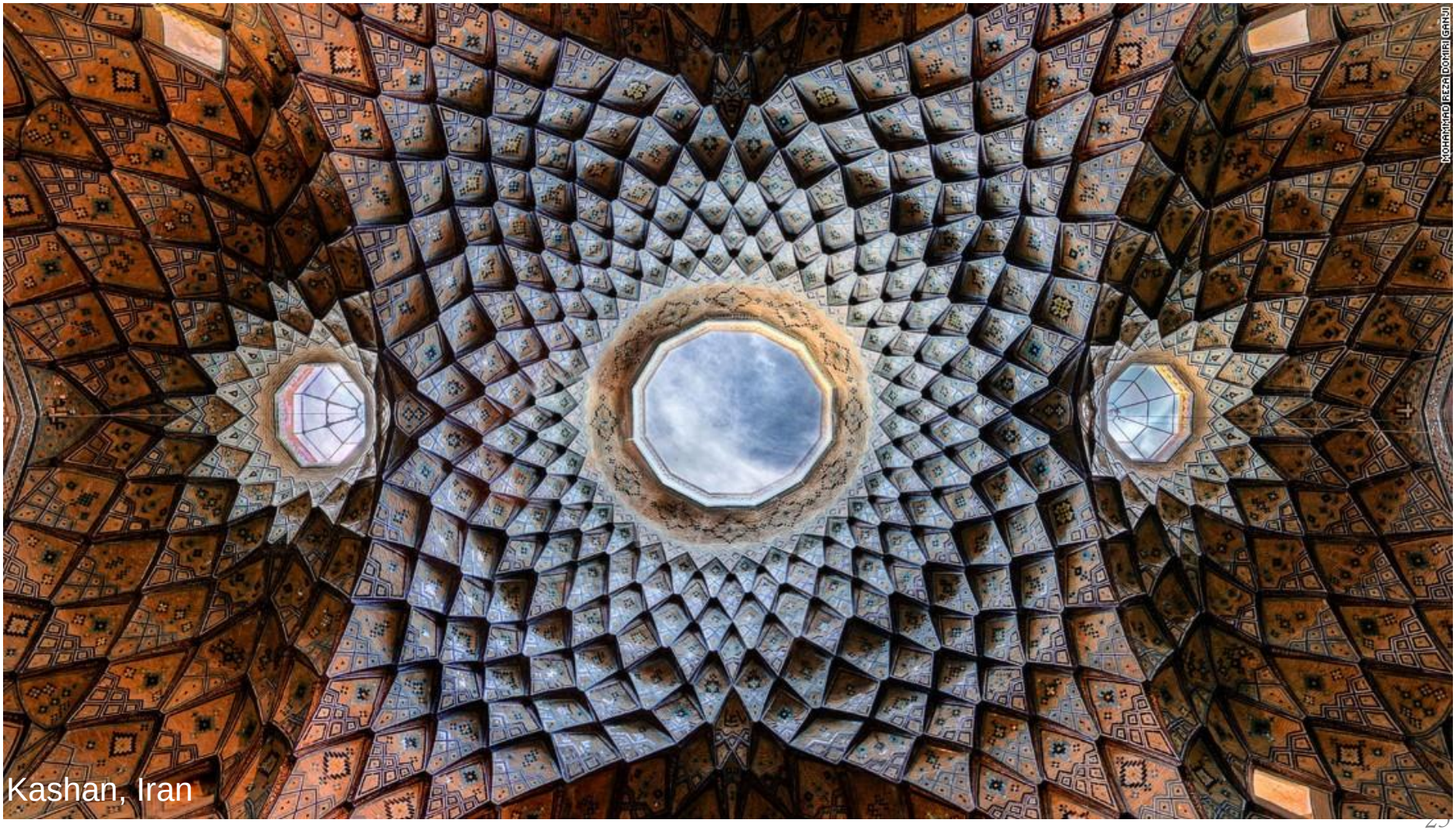
❑ Step 5) Map Interface Nodes: SFRAME-VecTor2 Integration



S-FRAME		VecTor2s	
Node	DOF	DOF	Node
1	1	99	50
	2	100	
2	4	101	51
	5	102	
3	7	103	52
	8	104	
4	10	105	53
	11	106	
5	13	107	54
	14	108	
6	16	109	55
	17	110	
7	19	111	56
	20	112	
8	22	113	57
	23	114	
9	25	115	58
	26	116	



Thank You



Kashan, Iran