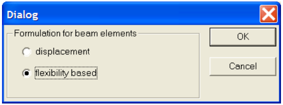
Structures: Beams/Axisymmetric shells

25.08.2009

Structural applications: Examples

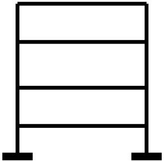
- **Example 1**

At the material level in group **Main**



Next slide

Frame structure (static/pushover/dynamic analysis

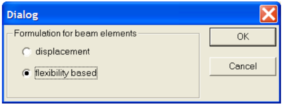


Remark: Each member is discretized by one element (not necessarily for reinforced concrete because of different amount and position of the reinforcement)

Structural applications: Examples

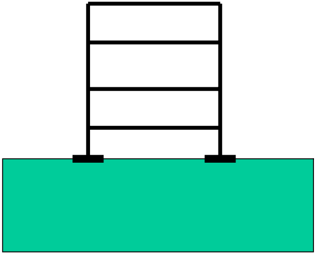
- **Example 2**

At the material level in group **Main**



Next slide

Frame structure resisting on soil (static analysis)

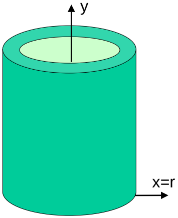


Remark: Each member is discretized by one element (not necessarily for reinforced concrete because of different amount and position of the reinforcement)

Structural applications: Examples

- **Example 3**

Cylindrical water container (axisymmetry)



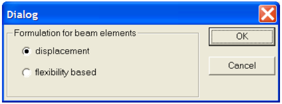
Next slide

Remark: Here standard discretization must be used

Soil-structure interaction: Examples

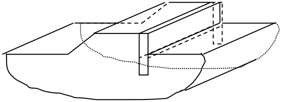
- **Example 1**

At the material level in group **Main**

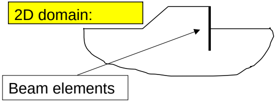


Next slide

Continuum shell



Computational model (Interval between beams $L = 1$ m)

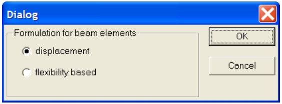


Remark: Each member is discretized with at least few elements; results are given per beam (!)

Soil-structure interaction: Examples

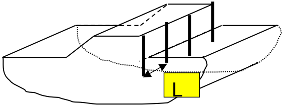
- **Example 2**

At the material level in group **Main**

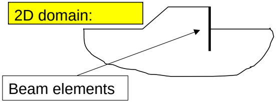


Next slide

Discrete rib system



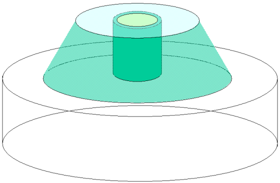
Computational model (Interval between beams L is user defined)

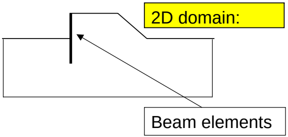


Remark: Each member is discretized with at least few elements; results are given per beam (!)

Soil-structure interaction: Examples

- **Example 3** **Continuum axisymmetric shell**

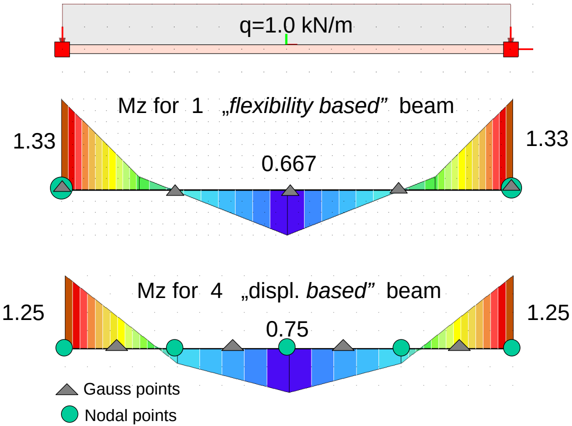




Next slide

Remark: Standard discretization must be used for that case; beam is switched to the axisymmetric shell

Flexibility vs displacement based beam formulation



Note that result for `Flexibility` based beam (one per member) is exact !

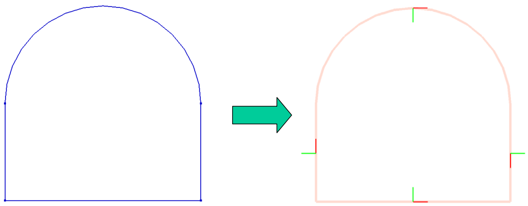
Geometrical model: Macro level

1. **Create beams on objects**
2. **Set director (2D)**
3. **Set X-axis**
4. **Set offsets**

Step:A Select objects:
Macro-model/Objects/Select/....

Step:B Create beams :
Macro-model/Subdomain/Create/Beam(s) on objects

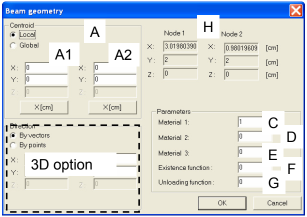
NB. Split preserves the initial beam geometry

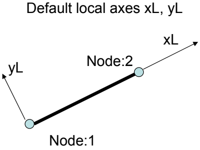


Next slide

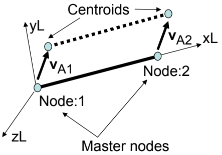
Geometrical model: Macro level

1. **Create beams on objects**
2. **Set director (2D)**
3. **Set X-axis**
4. **Set offsets**





Offset definition by vectors: $\mathbf{v}_{A1}$, $\mathbf{v}_{A2}$

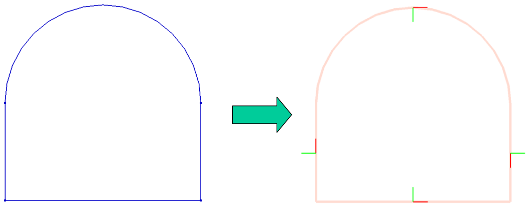


Next slide

A Use method: Macro-model/Subdomain/Update/Reverse direction to flip y_L axis

Geometrical model: Macro level

1. **Create beams on objects**
2. **Set director (2D)**
3. **Set X-axis**
4. **Set offsets**

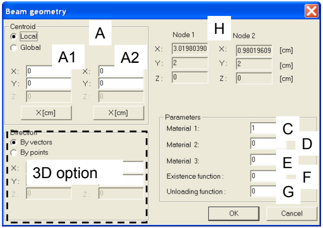


A Use method: Macro-model/Subdomain/Update/Reverse X axis

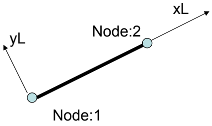
Next slide

Geometrical model: Macro level

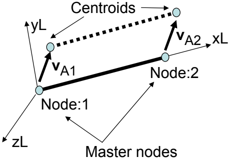
1. **Create beams on objects**
2. **Set director (2D)**
3. **Set X-axis**
4. **Set offsets**

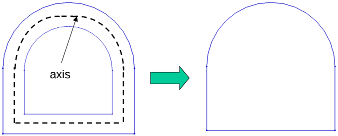


Default local axes xL, yL



Offset definition by vectors: $\mathbf{v}_{A1}$, $\mathbf{v}_{A2}$





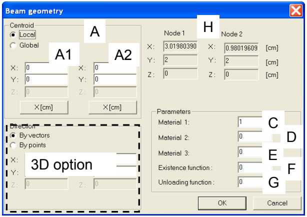
Tunnel lining

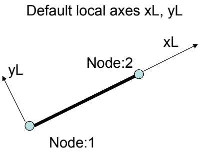
FE representation

Next slide

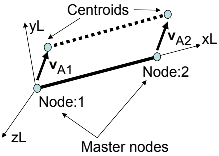
Geometrical model: FE level

1. **Create beams**
2. **Set director (2D)**
3. **Set X-axis**
4. **Set offsets**





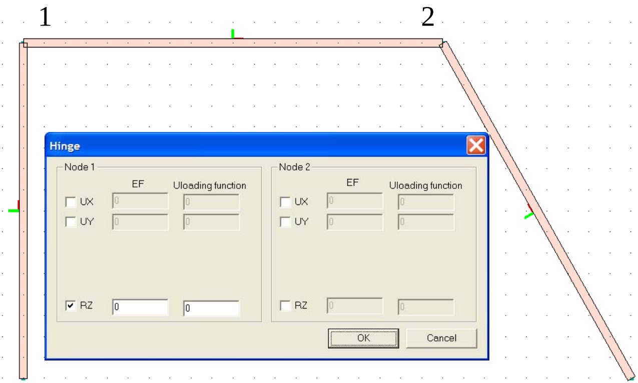
Offset definition by vectors: $\mathbf{v}_{A1}$, $\mathbf{v}_{A2}$



Next slide

A All methods are similar to the ones designed for Macro-model level but geometry is restricted only to the straight line segment

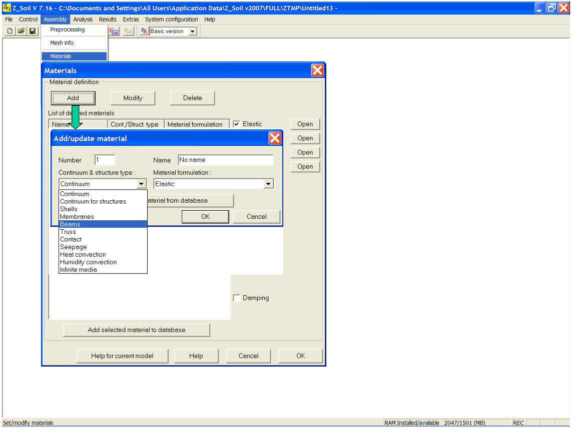
Geometrical model: FE level: Hinges



- Hinges are defined in the local $x_L - y_L - z_L$ coordinate system of a selected beam element
- Existence/Unloading functions can be associated with the hinge

Add new linear beam material

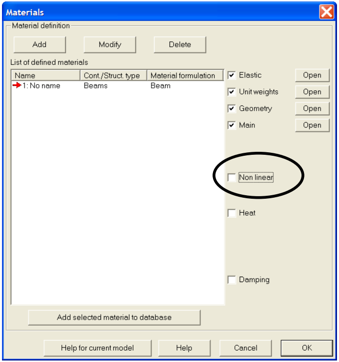
1. **Add new beam material**
2. **Set linear mode**



Next slide

Add new linear beam material

1. **Add new beam material**
2. **Set linear mode**

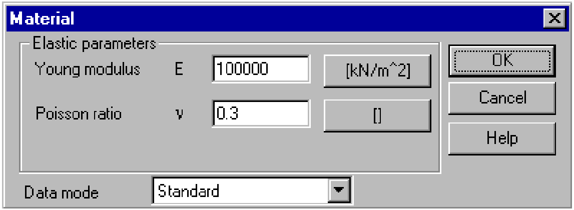


Next slide

Materials for linear beams: data groups

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Obligatory

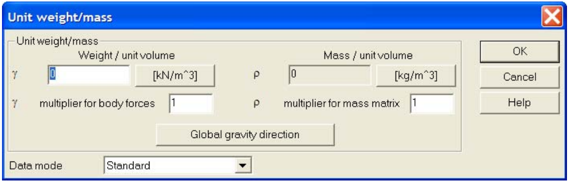


Next slide

Materials for linear beams: data groups

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Main**
5. **Heat**
6. **Damping**

Optional



Next slide

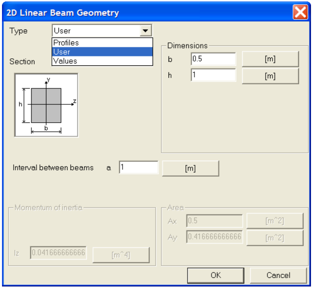
NB. Mass and body force multipliers visible only if Dynamics is activated in the project preselection

Materials for linear beams: data groups

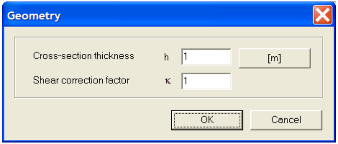
1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Main**
5. **Heat**
6. **Damping**

Obligatory

2D/3D



Axisymmetric case

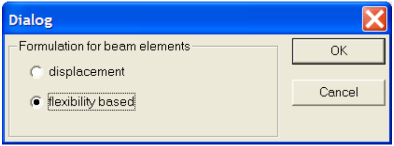


Next slide

Materials for linear beams: data groups

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Obligatory



NB. Use ◎ **Flexibility...** for structural applications and ◎ **Displacement...** for soil-structure interaction;

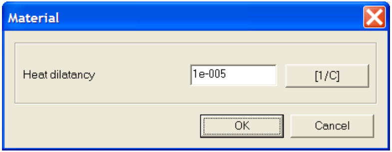
Not meaningful for axisymmetry (!)

Next slide

Materials for linear beams: data groups

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Main**
5. **Heat**
6. **Damping**

Not meaningful for linear beams



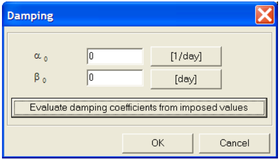
NB. Preprocessed thermal strains (by Heat project) are not handled in linear (non-layered) mode (☒ **Nonlinear** mode must be activated for that case)

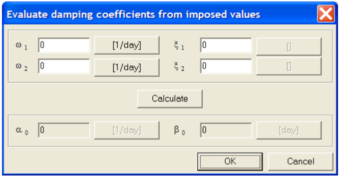
Next slide

Materials for linear beams: data groups

Optional

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping



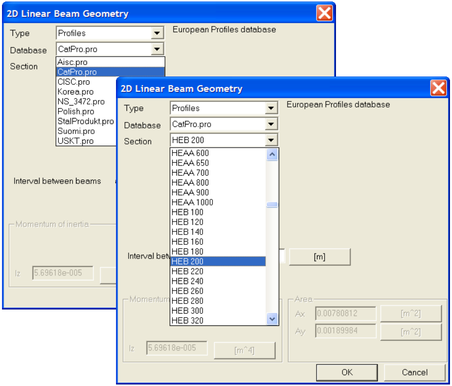


Next slide

NB. Meaningful only for Dynamics

Cross section definitions

1. **Profiles**
2. **User**
3. **Values**



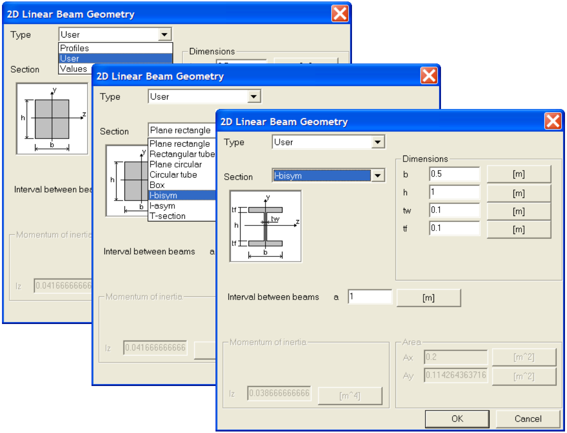
Next slide

NB. Valid only for 2D (plane-strain) and 3D

Cross section definitions

1. **Profiles**
2. **User**
3. **Values**

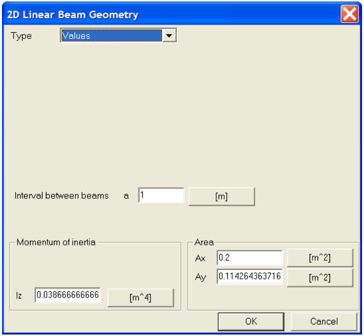
Next slide



NB. For axisymmetric case only rectabular shape is considered with unit width ($b = 1.0$)

Cross section definitions

1. **Profiles**
2. **User**
3. **Values**

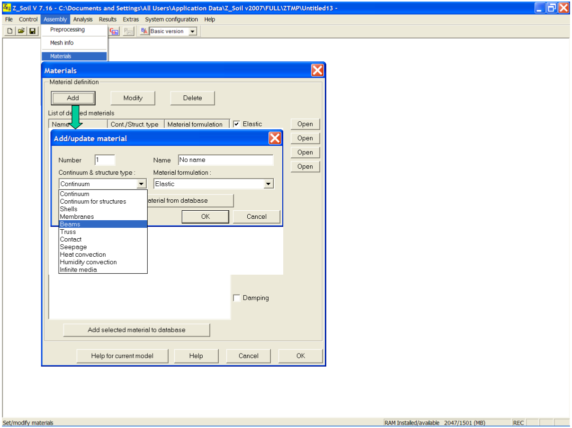


Next slide

NB. Valid only for 2D (plane-strain) and 3D

Add new non-linear beam material

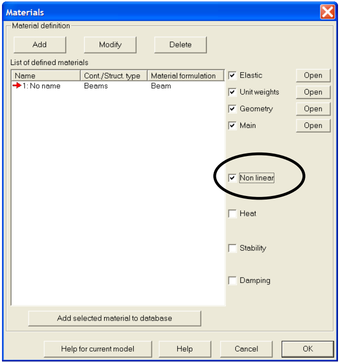
1. **Add new beam material**
2. **Set non-linear mode**



Next slide

Add new non-linear beam material

1. **Add new beam material**
2. **Set non-linear mode**



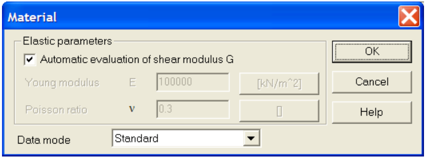
Next slide

Material data groups for non-linear beams:

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Main**
5. **Heat**
6. **Damping**

Next slide

Obligatory

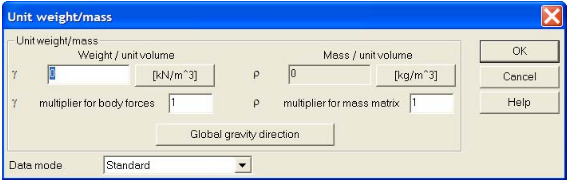


- These parameters are used only to specify shear modulus G as shear is decoupled from bending
- IF ☒ **Automatic..** mode is OFF $G = \dfrac{E}{2\,(1+\nu)}$
- IF ☒ **Automatic..** mode is ON G will be computed from material data for layers

Material data groups for non-linear beams:

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Optional (same as for linear)



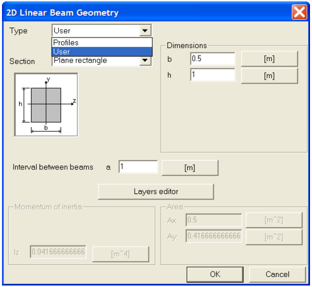
Next slide

NB. Mass and body force multipliers visible only if Dynamics is activated in the project preselection

Material data groups for non-linear beams:

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Main**
5. **Heat**
6. **Damping**

Obligatory



NB. Use **Layers editor** to Add/Delete/Modify material layers:

- Area
- Constitutive model and its properties for layers

For axisymmetry only rectangular cross section is meaningful with $b = 1.0$

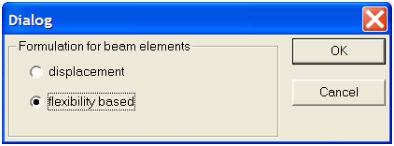
Next slide

Material data groups for non-linear beams:

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Next slide

Obligatory (same as for linear)



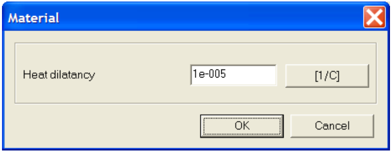
NB. Use ⊚ **Flexibility...** for structural applications and ⊚ **Displacement...** for soil-structure interaction;

Not meaningful for axisymmetry (!)

Material data groups for non-linear beams:

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Optional



NB. Preprocessed thermal strains (by Heat project) are computed at each layer as

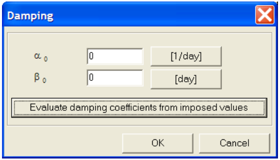
$$\Delta\varepsilon_{ox} = \Delta\varepsilon_{oy} = \Delta\varepsilon_{oz} = \alpha\ \Delta\ T$$

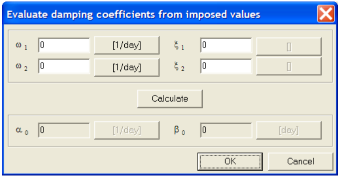
Next slide

Material data groups for non-linear beams:

1. Elastic
2. Unit weight
3. Geometry
4. Main
5. Heat
6. Damping

Optional (same as for linear)



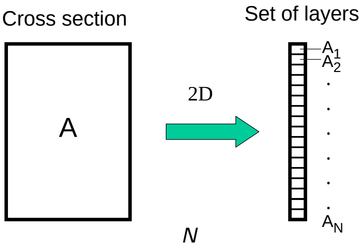


Next slide

NB. Meaningful only for Dynamics

Discretization (2D) of profiles

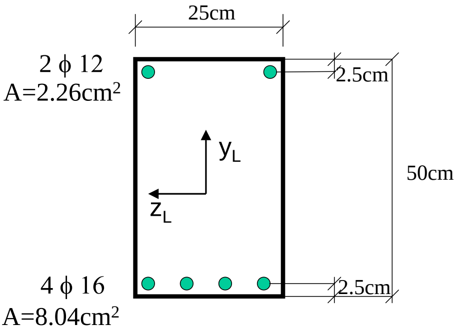
- The **Profile** or **User** predefined cross section is discretized automatically (subdivided to layers)
- By default all created layers are treated as a **Core** material characterized by elastic properties only
- To create a reinforced concrete cross section we can add additional layers of reinforcement



$$A = \sum_{i=1}^{N} A_i$$

How to edit layered cross section for beam?

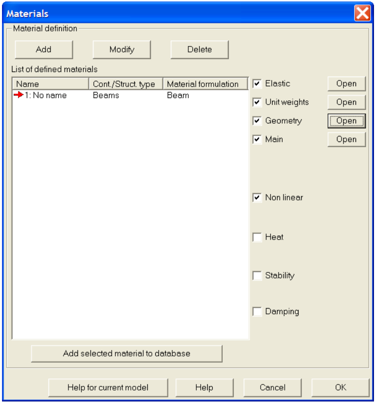
Example: Reinforced concrete cross section with elasto-plastic material models for both concrete (Core) and steel



NB. **Top fibers are always placed on the positive side of y_L axis !**

Setting Core material

1. **Set Core cross section type**

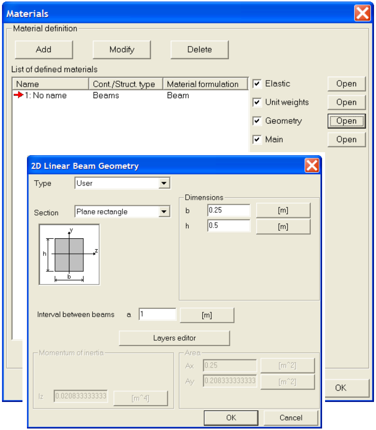


Next slide

- Press $\boxed{\textbf{Open}}$ next to the ☒ $\boxed{\textbf{Geometry}}$

Setting Core material

1. **Set Core cross section type**
2. **Activate layers editor**

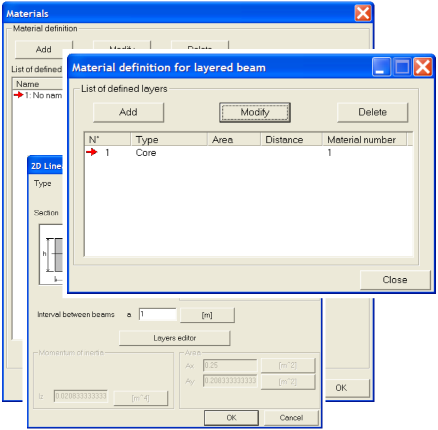


Next slide

- Press button **Layer editor**

Setting Core material

1. **Set Core cross section type**
2. **Activate layers editor**
3. **Modify Core properties**

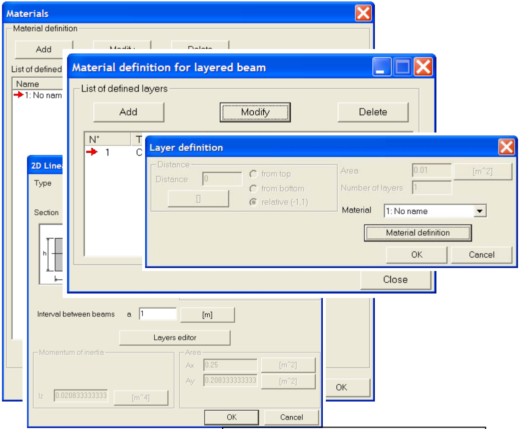


Next slide

- Press button **Modify**

Setting Core material

1. Set Core cross section type
2. Activate layers editor
3. Modify Core properties
4. Enter to properties dialog box

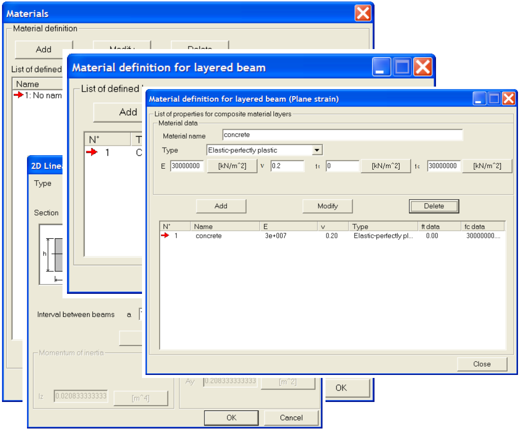


- Press button $\boxed{\textbf{Material definition}}$
- From combo-box select material ID

Next slide

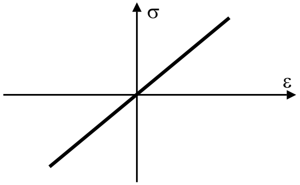
Setting Core material

1. **Set Core cross section type**
2. **Activate layers editor**
3. **Modify Core properties**
4. **Enter to properties dialog box**
5. **Edit properties**

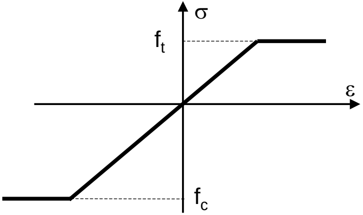


Next slide

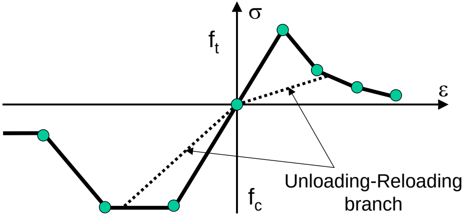
Constitutive models for uniaxial fibers



Elastic



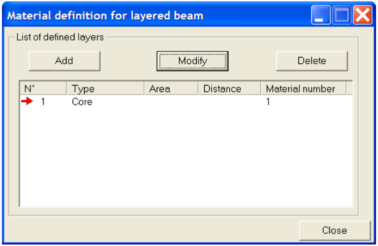
Elastic-perfectly plastic



User defined

Adding top reinforcement set

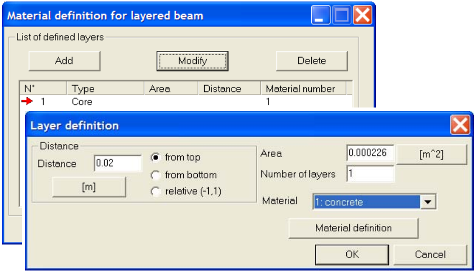
1. **Add reinforcement**



Next slide

Adding top reinforcement set

1. **Add reinforcement**
2. **Set its area/location and apply proper material ID**

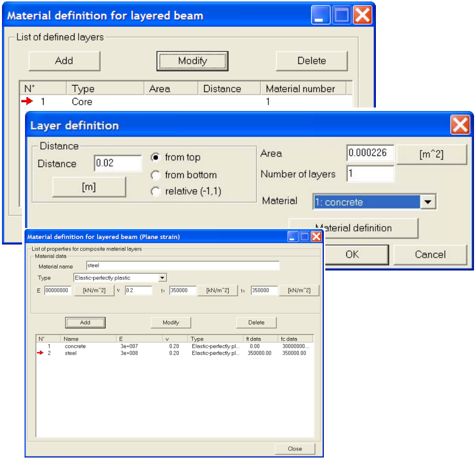


- Steel properties are not yet defined so we must add a new property

Next slide

Adding top reinforcement set

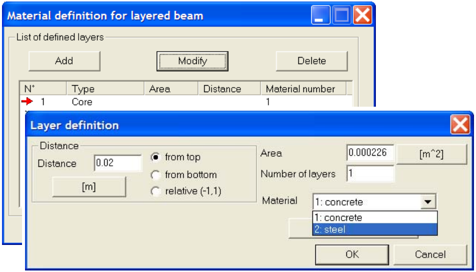
1. **Add reinforcement**
2. **Set its area/location and apply proper material ID**
3. **Edit properties**



Next slide

Adding top reinforcement set

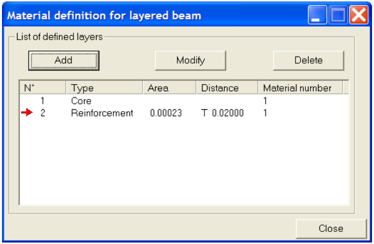
1. **Add reinforcement**
2. **Set its area/location and apply proper material ID**
3. **Edit properties**
4. **Apply steel ID to this layer**



Next slide

Adding bottom reinforcement set

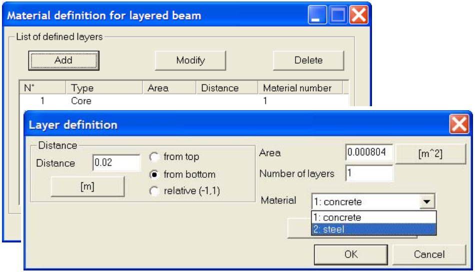
1. **Add reinforcement**



Next slide

Adding bottom reinforcement set

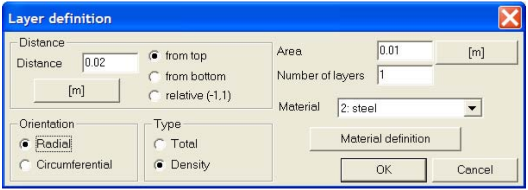
1. **Add reinforcement**
2. **Set its area/location and apply proper material ID**



Next slide

Adding reinforcement in axisymmetric case

- Radial reinforcement (total area or density can be specified)



- Circumferential reinforcement