Structures: Membranes

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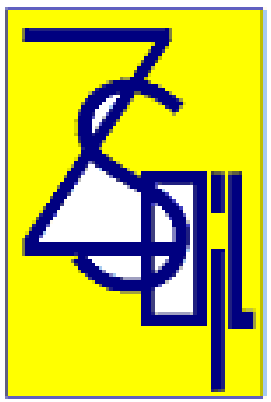
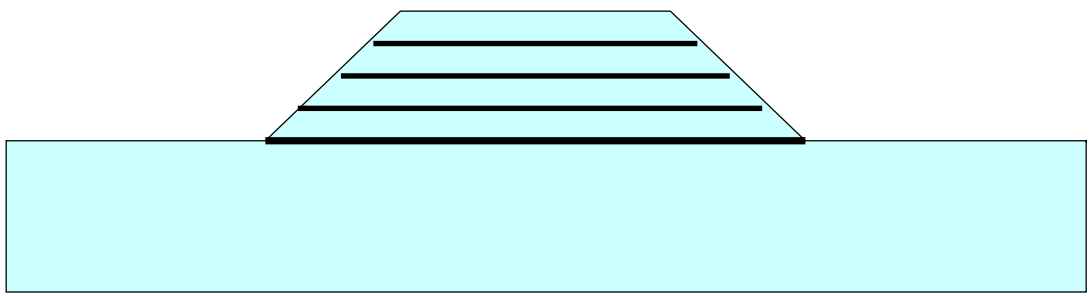


Soil-structure interaction: Example

- **Example**

Geotextiles/geogrids

- Stabilization of steep slopes
- Retaining walls and abutments
- Road construction



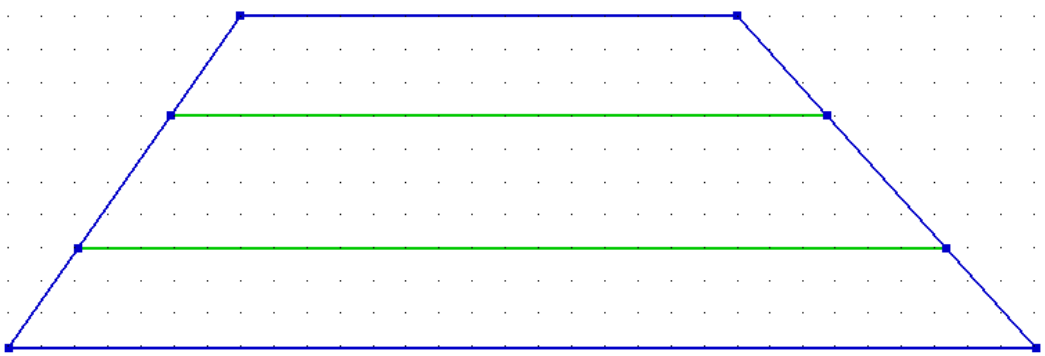
Geometrical model: Macro level

- **Create membrane on objects**

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

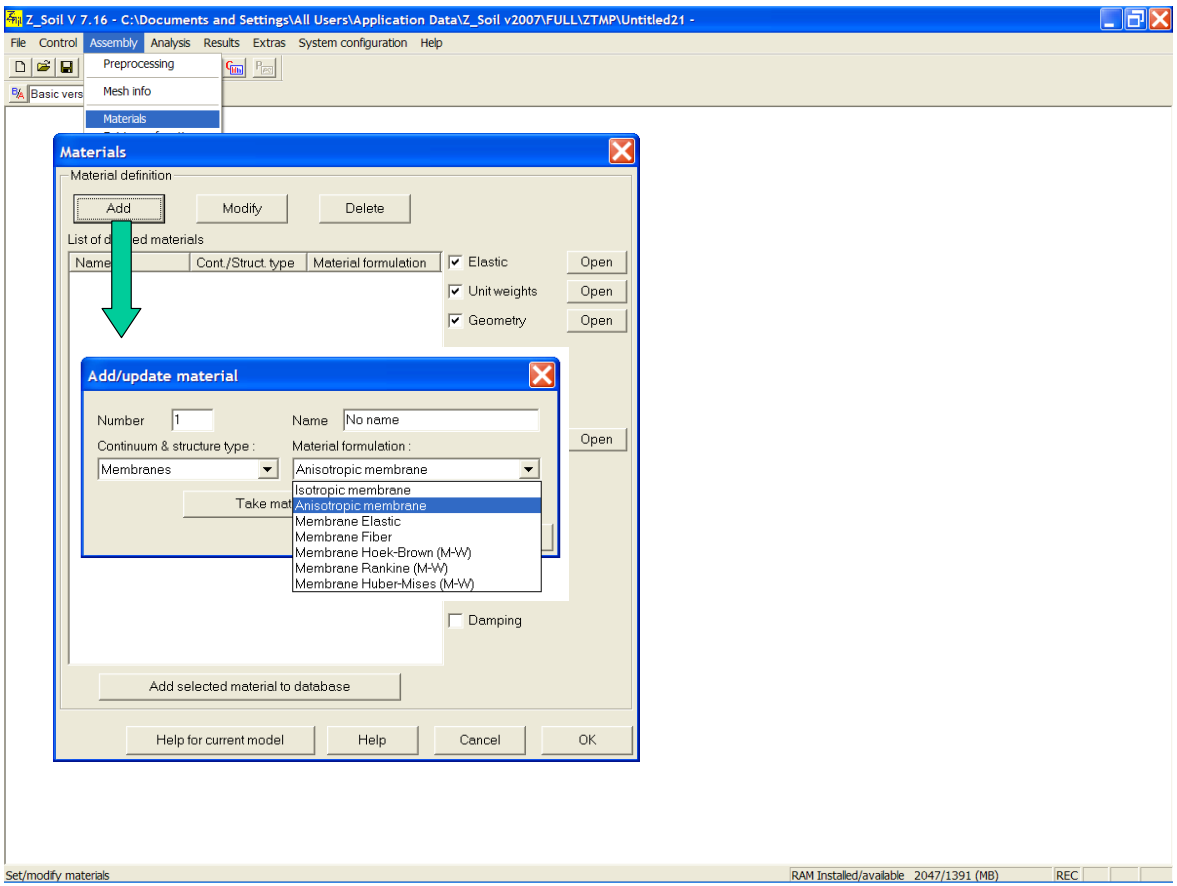
Step:B Create membs :
Macro-model/Subdomain/Create/Membrane(s) on objects

NB. Split preserves the initial curved membrane geometry
All methods at the FE level are similar to the ones designed for Macro-model level but geometry is restricted only to the straight line segment



Add new material for membranes

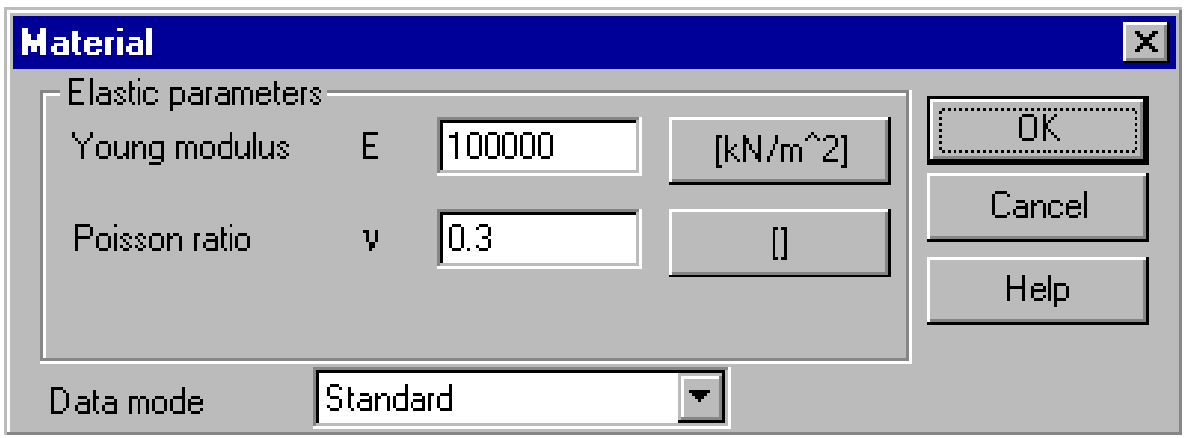
1. **Add new membrane material**



Elastic membrane: data groups

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

Obligatory



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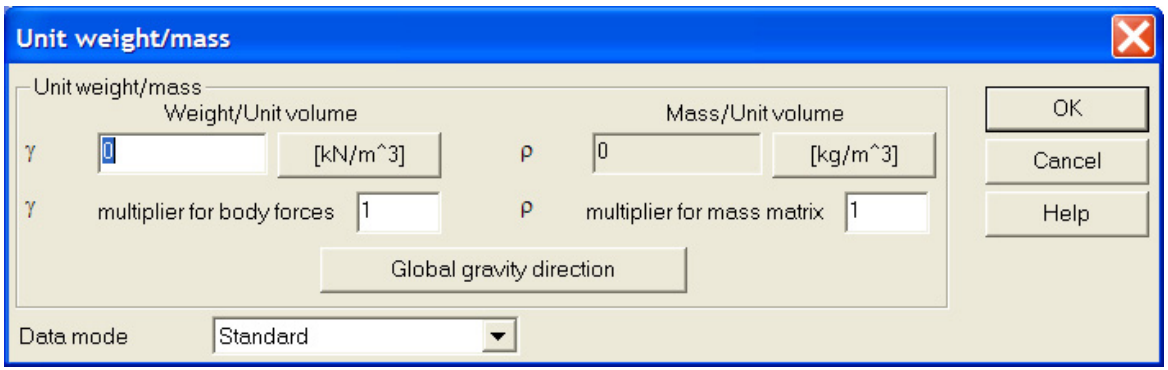
Elastic membrane: data groups

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

Optional



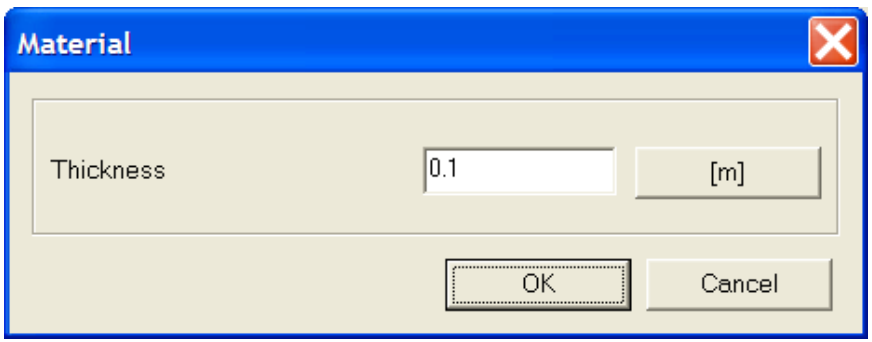
NB. Mass and body force multipliers visible only if Dynamics is activated in the project preselection

Next slide

Elastic membrane: data groups

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

Obligatory



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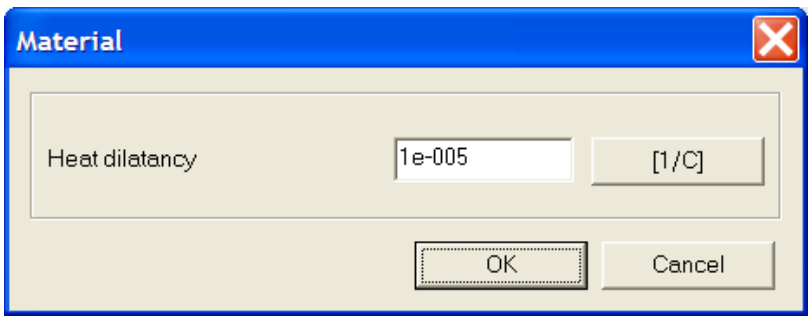
Elastic membrane: data groups

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

Optional



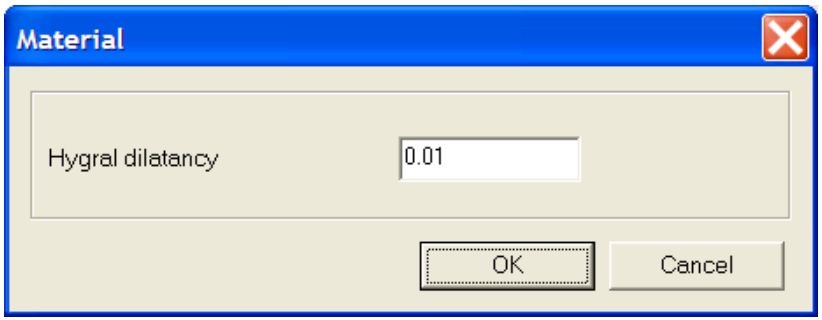
NB. Preprocessed thermal strains (by Heat project) are handled by membrane elements

Next slide

Elastic membrane: data groups

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

Optional



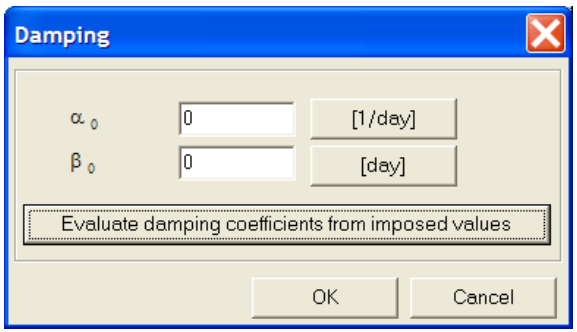
NB. Preprocessed hygral strains (by Humidity project) are handled by membrane elements

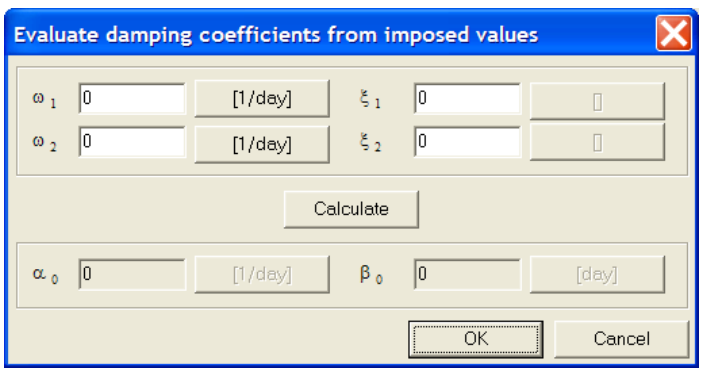
Next slide

Elastic membrane: data groups

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

Optional





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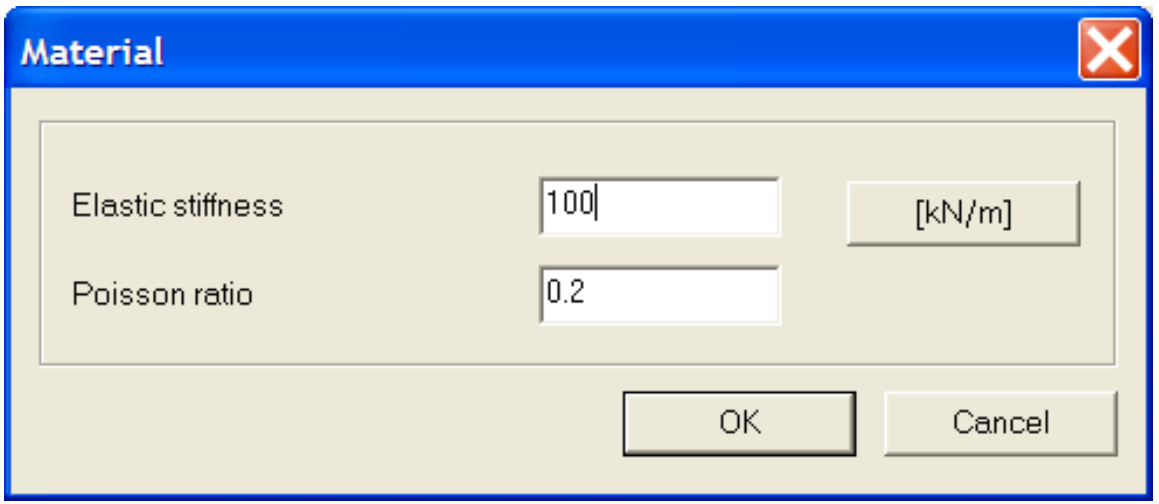
NB. Meaningful only for Dynamics

Isotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Obligatory



Next slide

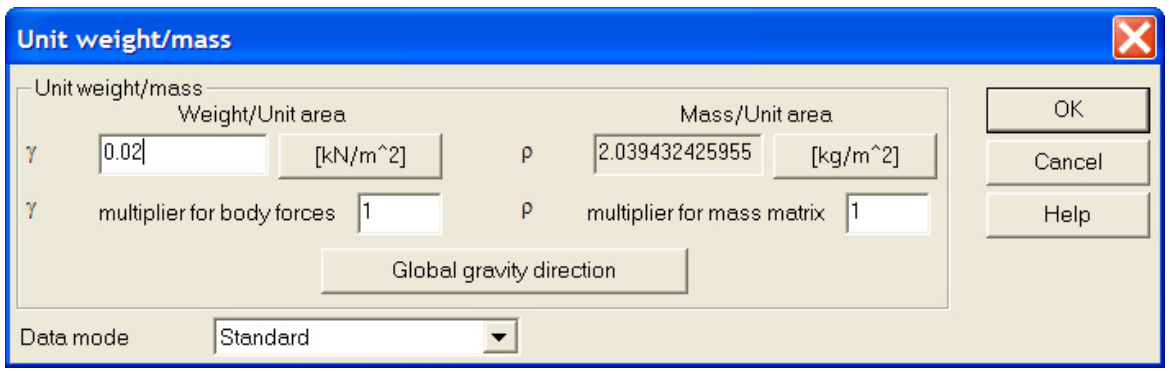
NB. Thickness is already included in stiffness parameter

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Elastic membrane` model

Isotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Optional



Next slide

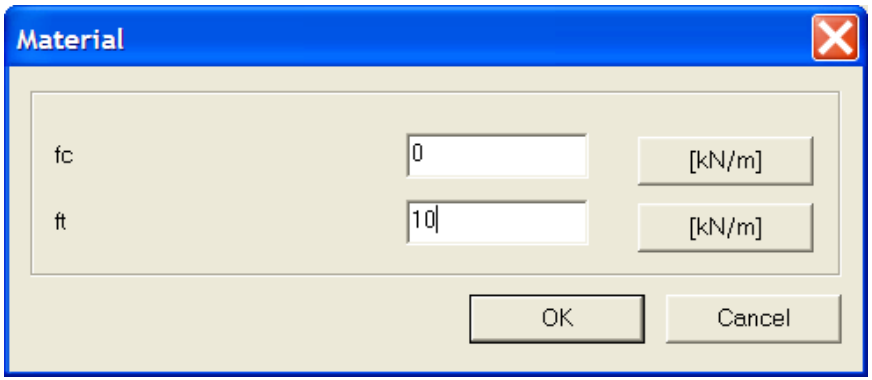
NB. Mass and body force multipliers visible only if Dynamics is activated in the project preselection

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Elastic membrane` model

Isotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Obligatory



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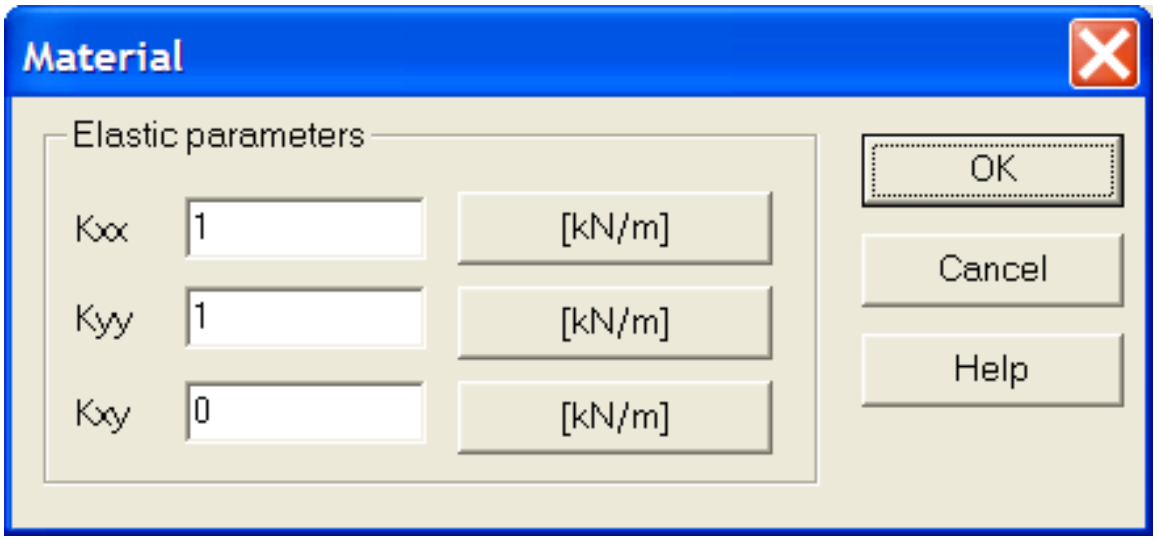
NB. Compressive force should be set to $f_c = 0$ to avoid parasitic compressive forces; a plane-stress elasto-plastic model with cut-off conditions for the tensile and compressive principal membrane forces is applied

Properties in `Heat`, `Humidity` **and** `Damping` **data groups are the same as for the** `Elastic membrane` **model**

Anisotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Obligatory



Next slide

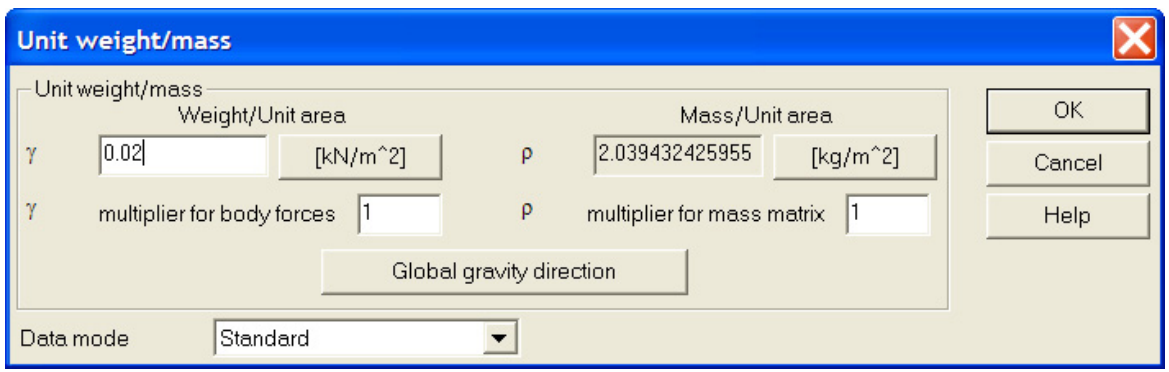
NB. Thickness is already included in stiffness parameters

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Anisotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Optional



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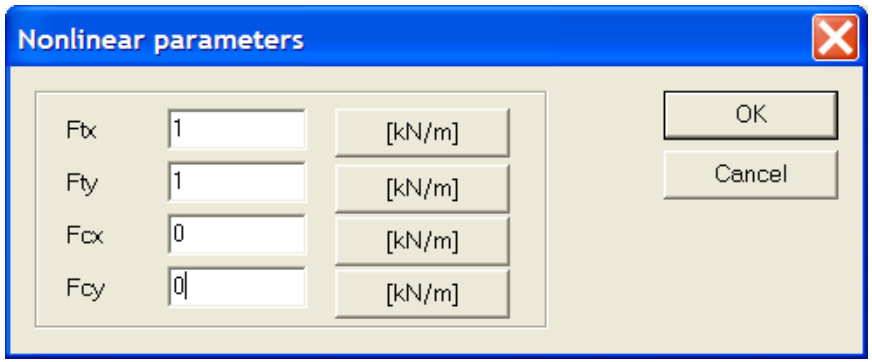
NB. Mass and body force multipliers visible only if Dynamics is activated in the project preselection

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Anisotropic membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Nonlinear**

Obligatory



NB. Compressive limit forces should be set to $f_{cx} = 0$, $f_{cy} = 0$ to avoid parasitic compressive forces; a plane-stress elasto-plastic model with cut-off conditions for the tensile and compressive principal membrane forces is applied

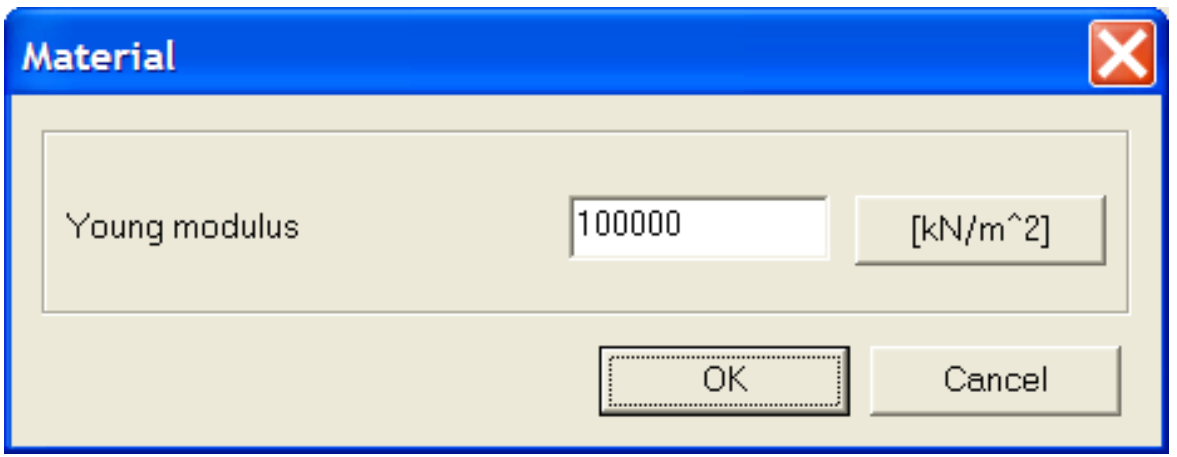
Next slide

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Fiber membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Nonlinear**

Obligatory



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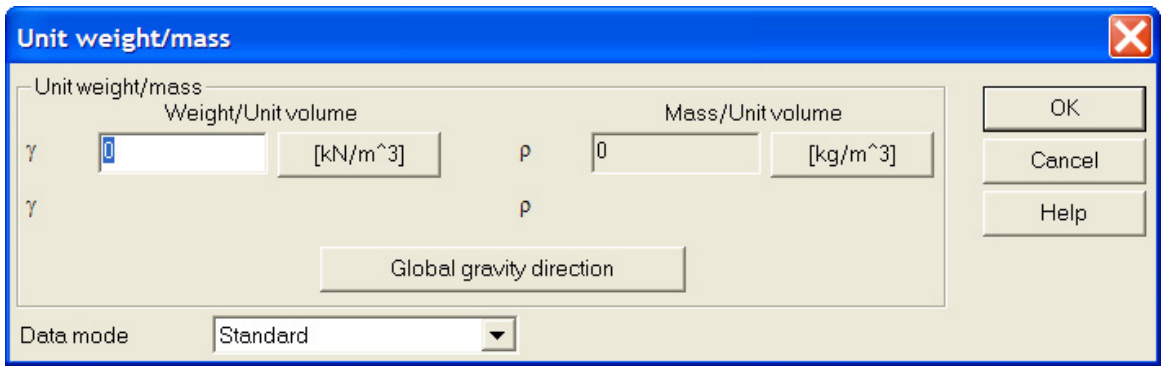
Fiber model generates stiffness only in one direction !

Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Fiber membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Nonlinear**

Optional



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

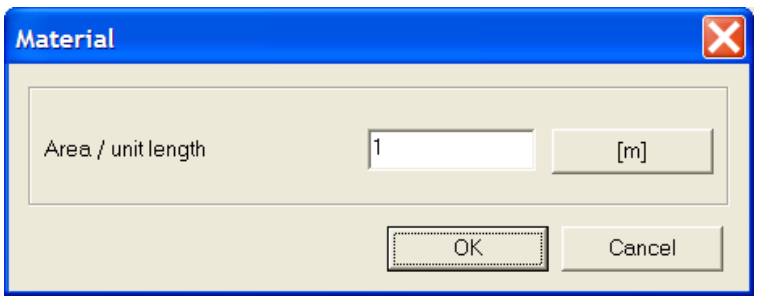
Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Fiber membrane: data groups

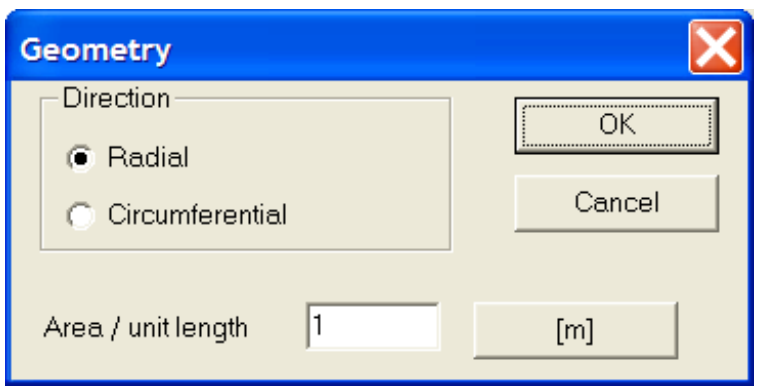
1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Nonlinear**

Obligatory

2D/3D



Axisymmetry



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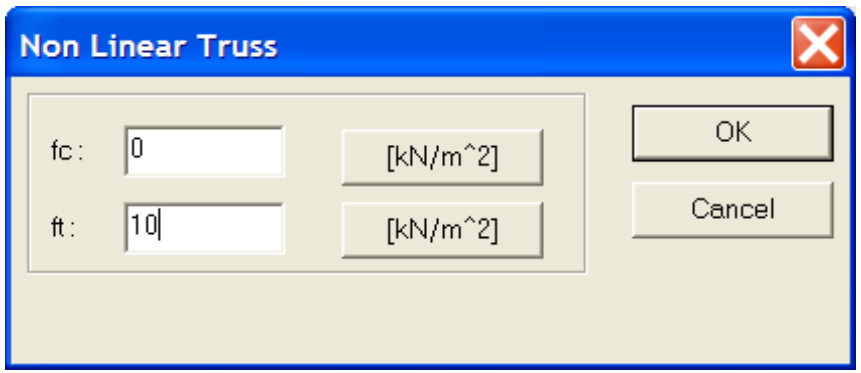
Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Fiber membrane: data groups

1. **Elastic**
2. **Unit weight**
3. **Geometry**
4. **Nonlinear**

Obligatory



NB. Compressive strength should be set to $f_c = 0$ to avoid parasitic compressive stresses

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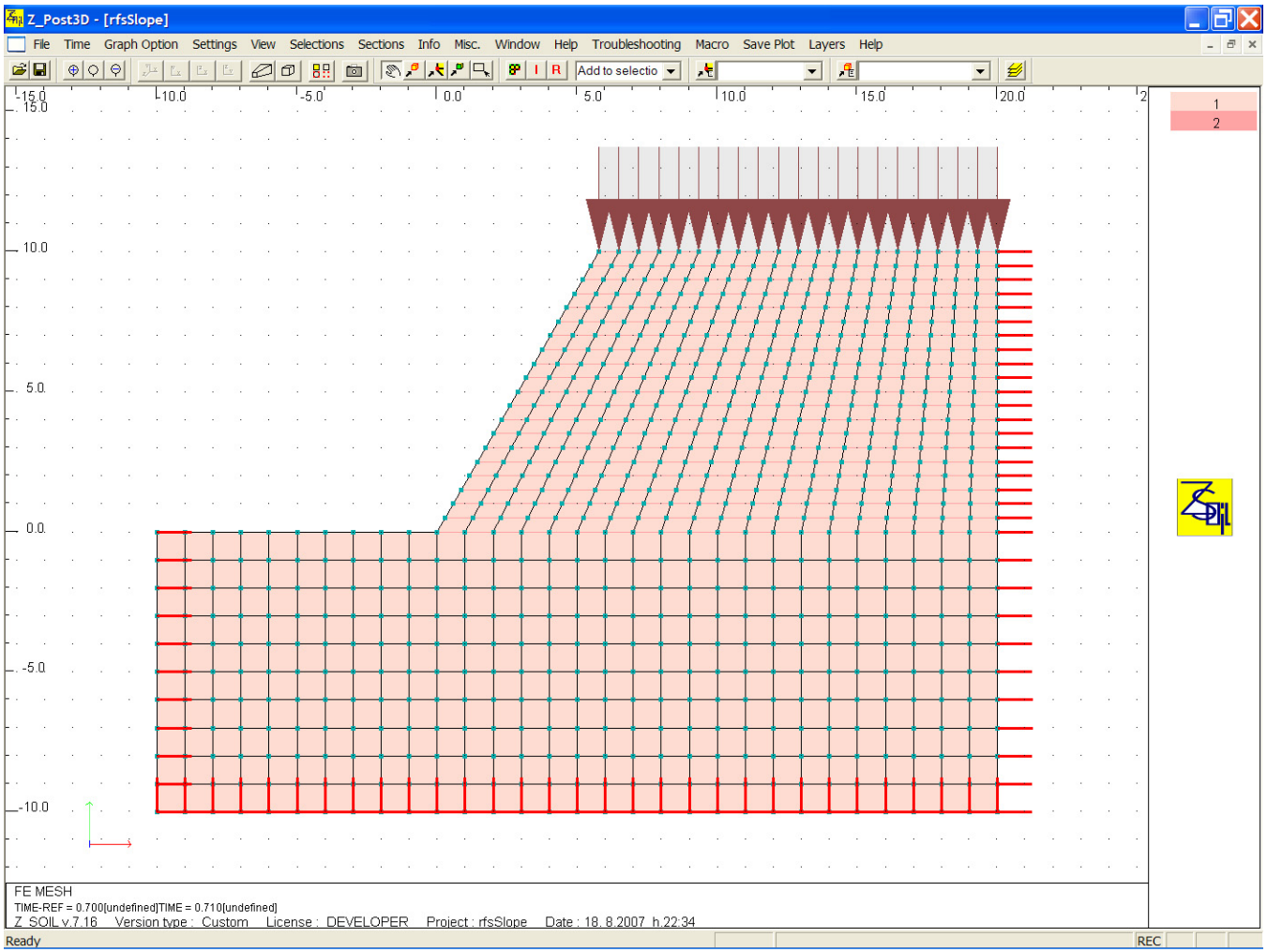
Properties in `Heat`, `Humidity` and `Damping` data groups are the same as for the `Isotropic membrane` model

Example of limit state analysis of reinforced slope: Mesh



NB.21 layers of membrane fibers are added

Example of limit state analysis of reinforced slope: Failure mode