# *MSC.PATRAN AS A MAIN TOOL TO INCREASE PRODUCTIVITY FOR MODEL GENERATION*


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# PILE MODEL GENERATOR:

## Motivation for the work:

- ***Requirement of Analysis of several complex Models in a Short Period of Time***

# PROBLEM DESCRIPTION

- 3D Pile Analysis embedded in soil
- Symmetric and non-symmetric models
- Contact interface between pile and soil
- Soil properties varying according to depth
- Proprietary Preference to AEEEC3D proprietary solver developed by PETROBRAS for Soil Analysis

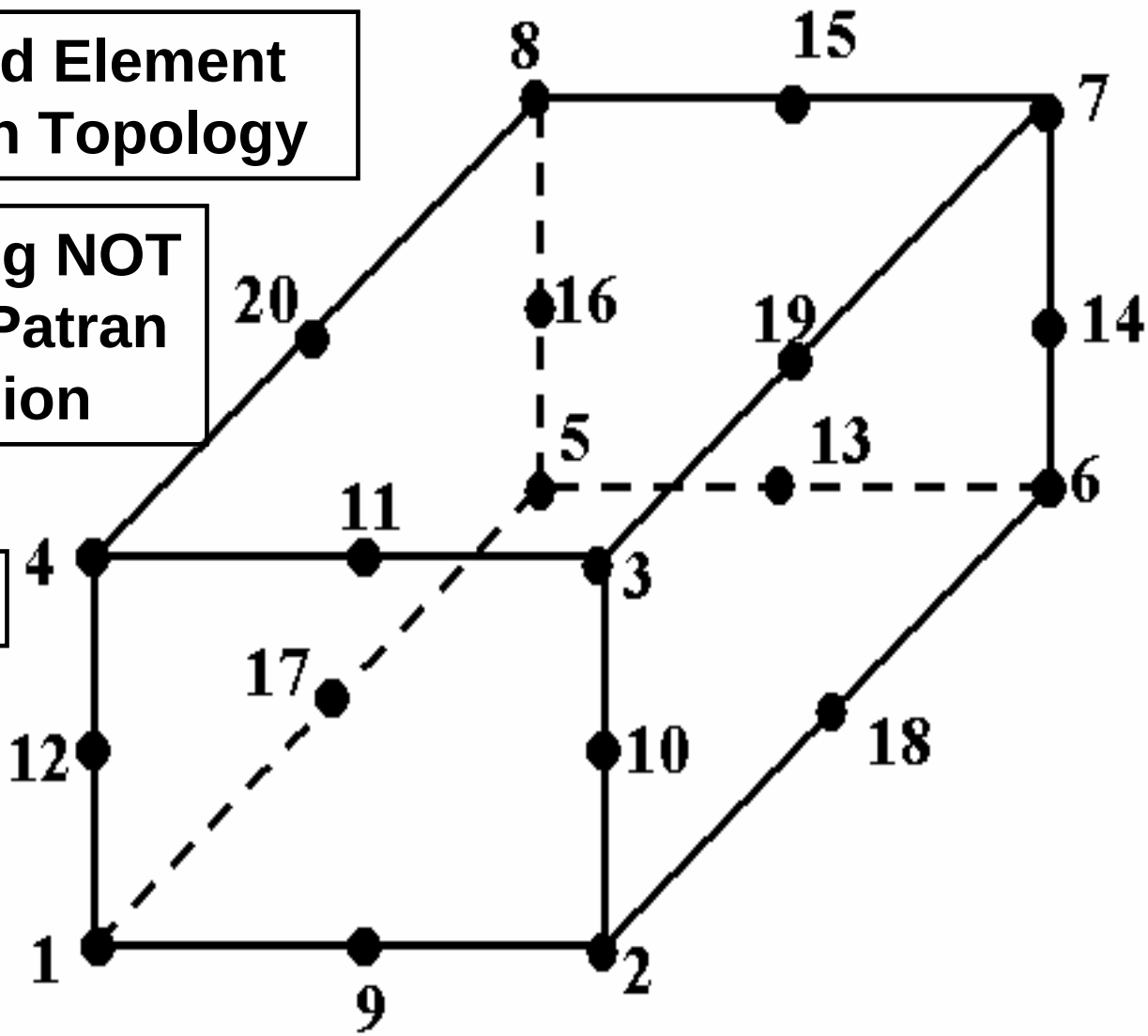
# FEATURES for AEEPEC3D Preference

- 3D Solid Brick element with 20 nodes with a specific sequence numbering NOT supported by MSC.Patran
- 3D Solid Brick element with 16 nodes for contact representation
- 3D Solid Brick element with 12 nodes for infinite elements representation

# 3D Quadratic Solid Element
# HEX20 MSC.Patran Topology

**Sequence Numbering NOT supported by MSC.Patran Commercial Version**

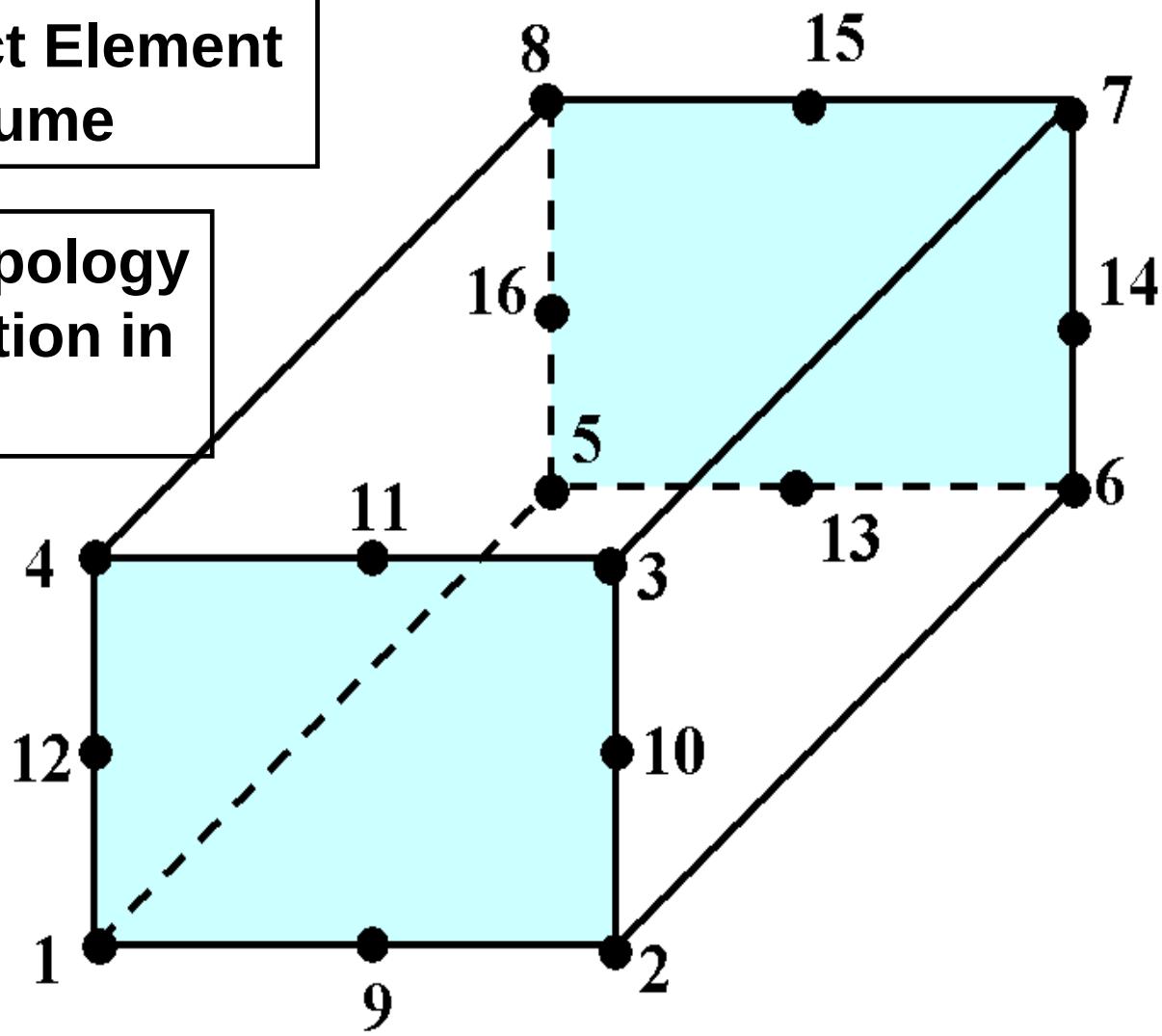
**20 Nodes Element**



**3D Quadratic Contact Element with ZERO Volume**

**HEX20 MSC.Patran Topology used to Store Information in the Database**

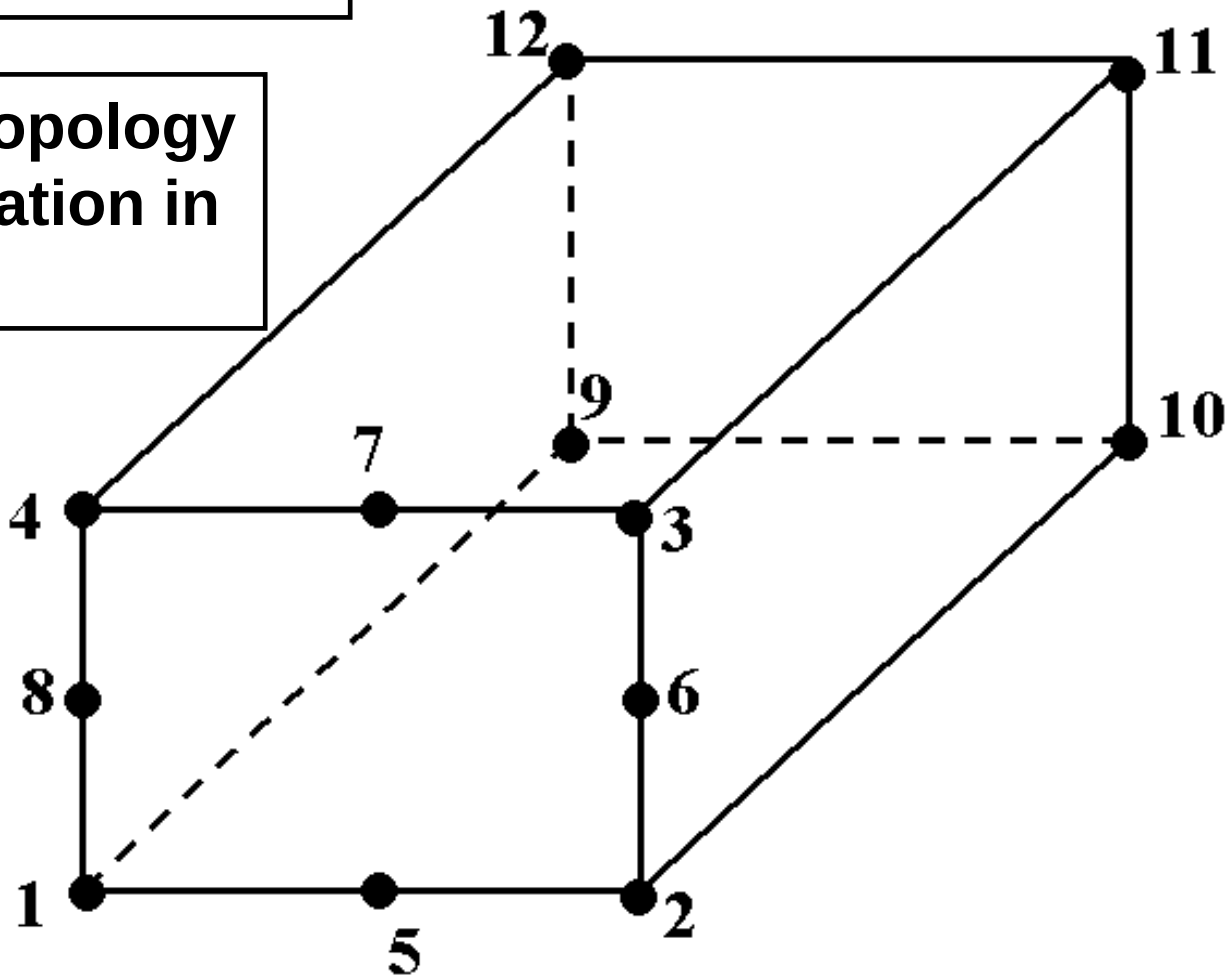
**16 Nodes Element**



# 3D Quadratic Infinite Element

## HEX20 MSC.Patran Topology used to Store Information in the Database

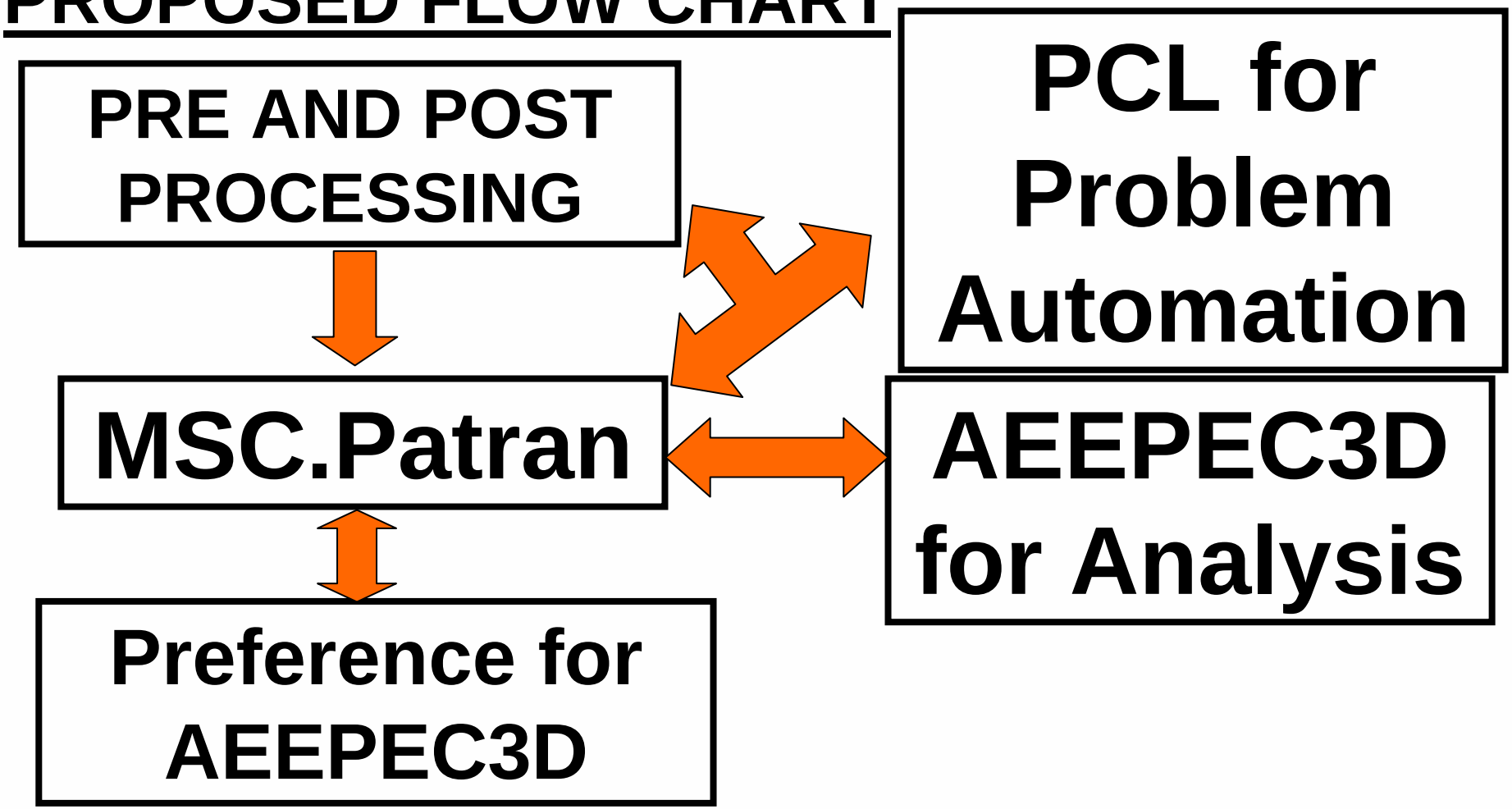
## 12 Nodes Element



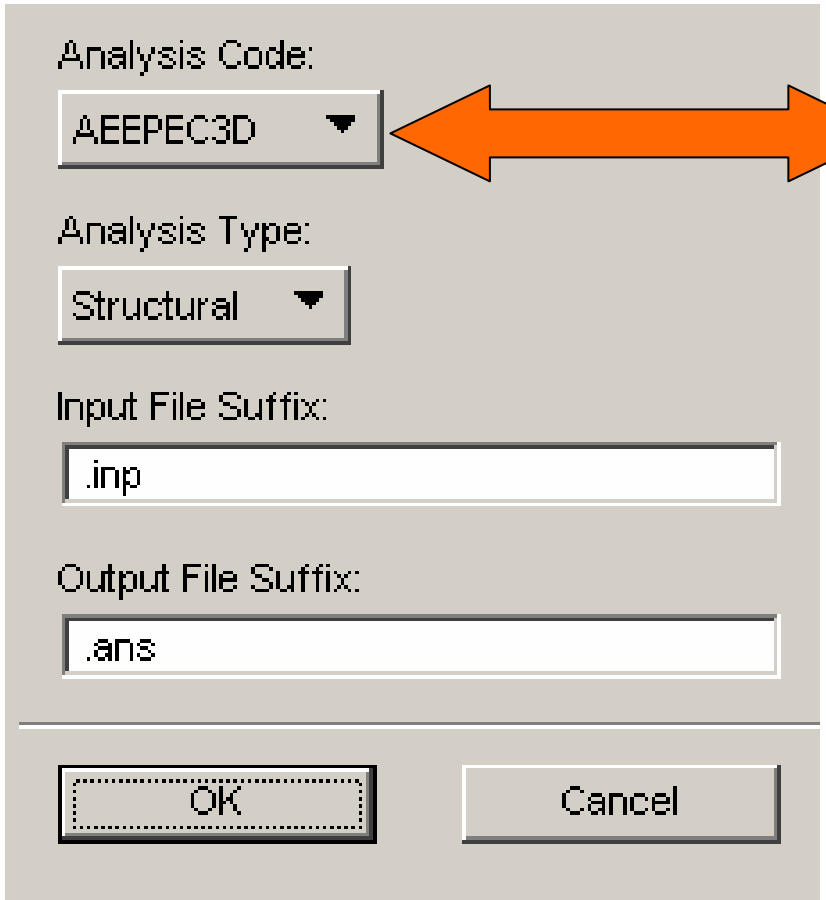
# STRATEGIC APPROACH

- Completely automated model generation
- Procedure to be used for non-expert MSC.Patran users
- Model generation througth PCL (Parametric Command Language)
- Process controled by G.U.I. (Graphics User Interface)
- Preference Creation for AEEPEC3D

# PROPOSED FLOW CHART



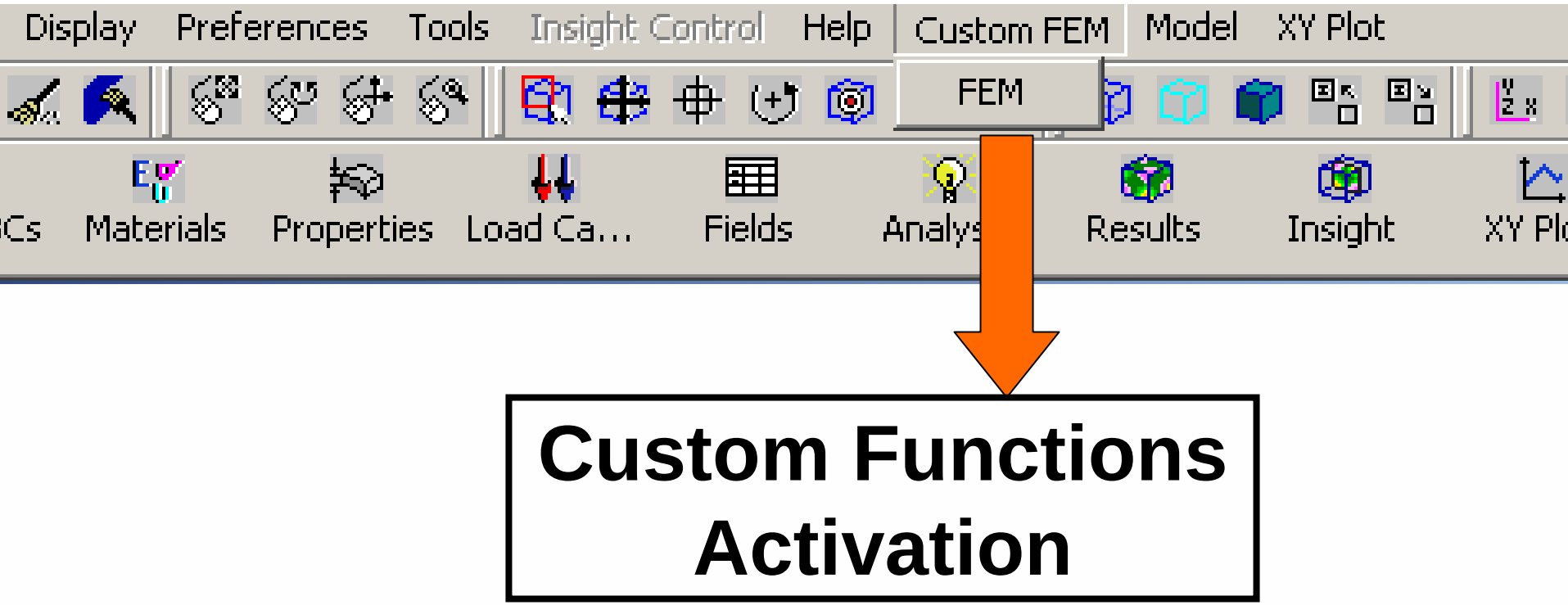
# AEEPEC3D Preference Selection




**AEEPEC3D Analysis Code**

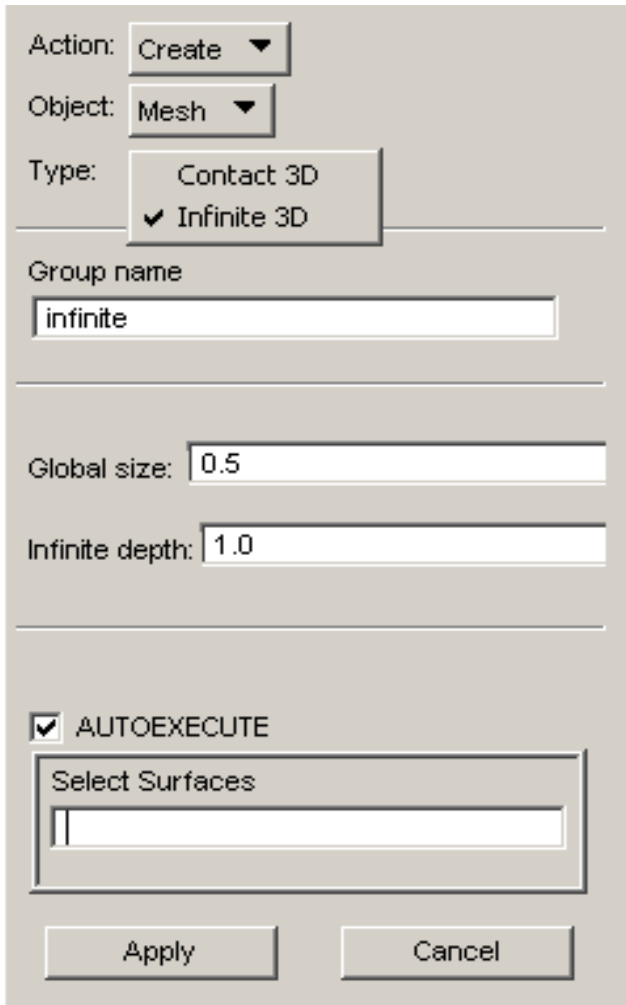
# AEEPEC3D PREFERENCE

## G.U.I. - Graphic User Interface to Control the Process

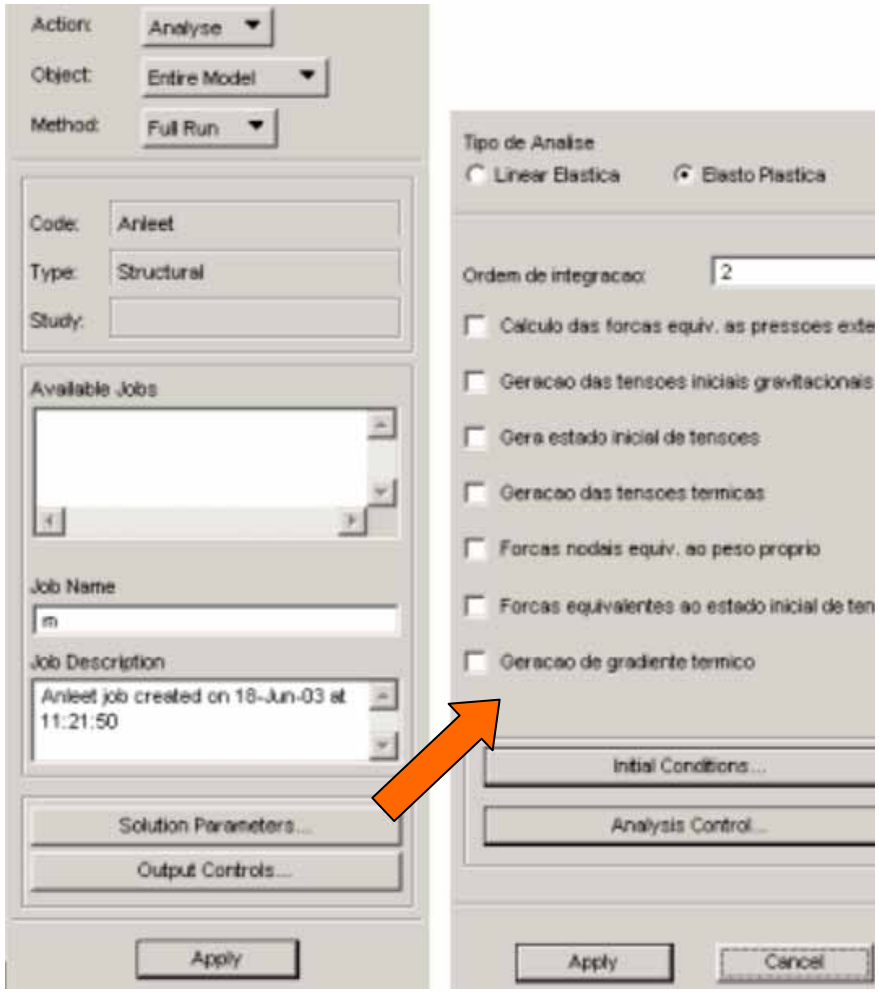



**Custom Functions Activation**

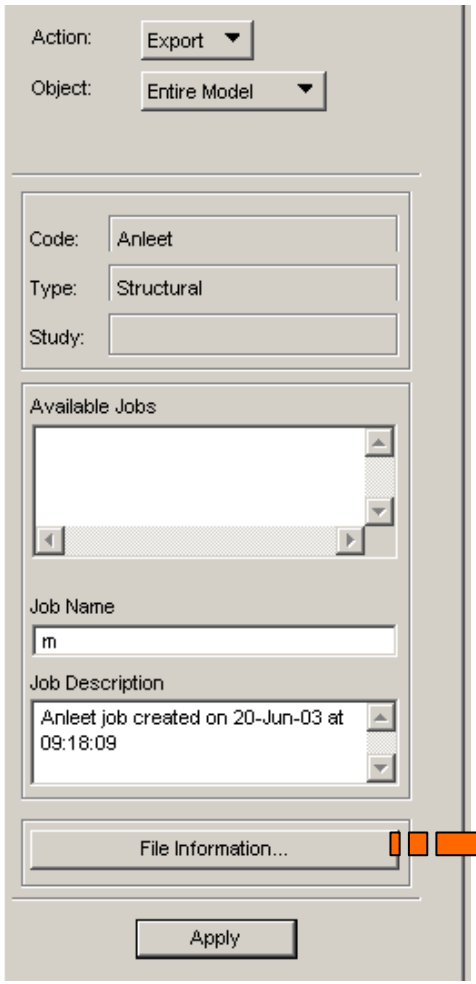
# Mesh Generator Screen

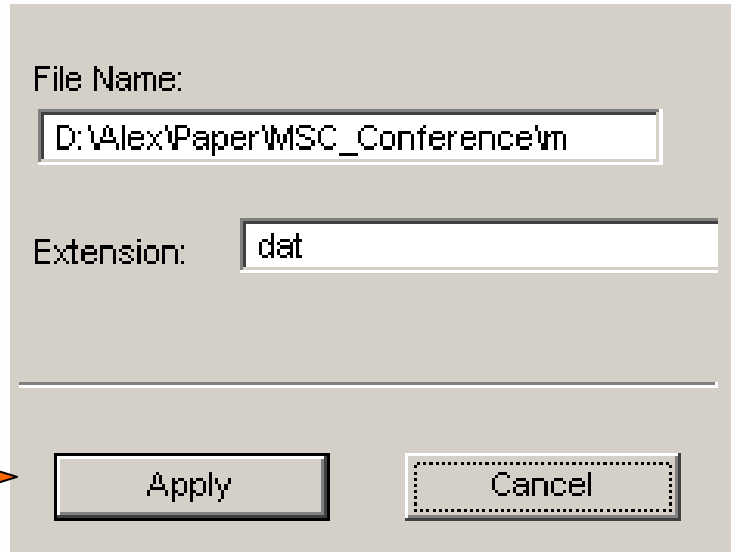
# Analysis Control Screens



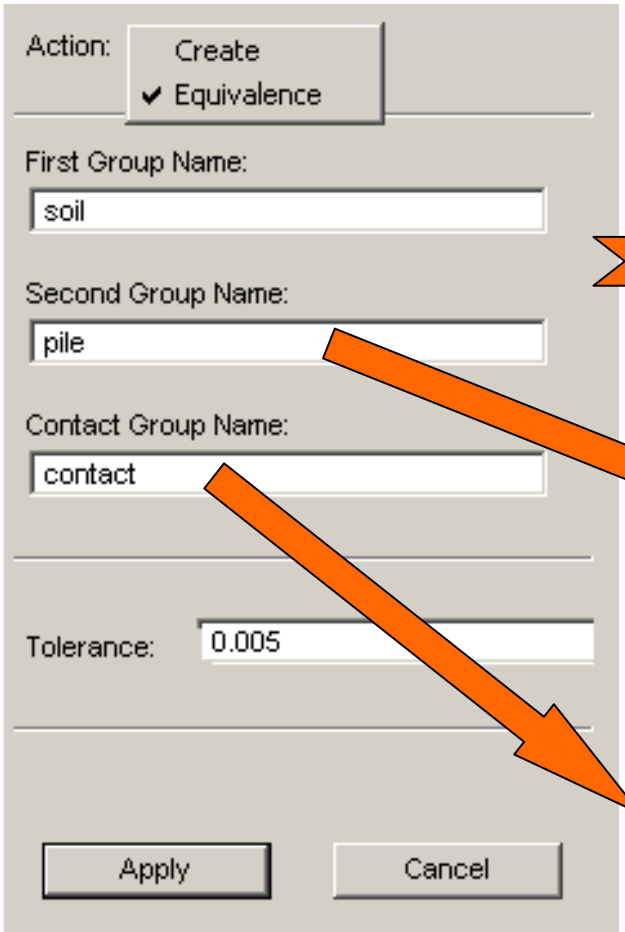
# Analysis File Generation Screen




**Creation of file for Analysis**



# CUSTOM EQUIVALENCE FUNCTION




**Required because of the ZERO VOLUME 3D Contact Element**

**Group Name with Pile elements**

**Group Name with Contact Elements**

# PARAMETRIC MODEL GENERATORS

## G.U.I. - Graphic User Interface to Control the Process


**Activate Pile Model Generation Procedure**

# Parameters for Paramentric Modeling

MODEL TYPE:
symetric  non symetric

Model Data

| | |
|---|---|
| Diâmetro externo: | 0.762 |
| Altura_estaca: | 12.0 |
| Altura_estaca-Topo 1: | 0.4 |
| Altura_estaca-Topo 2: | 1.0 |
| Altura_estaca-Base 2: | 0.4 |
| Espessura da estaca: | 0.038 |
| Altura da aleta: | 7.5 |
| Largura aleta: | 0.45 |
| Espessura aleta: | 0.038 |
| Angulo da estaca: | 0.0 |
| Altura do solo superior: | 6.0 |
| Altura do solo inferior: | 7.0 |
| Diametro infinito: | 42.0 |
| Lim. de escoamento: | 345000.0 |
| Força integral: | 5000.0 |
| Angulo da força: | 36.7 |

Mesh seeds

PG for mesh seeds

Parametric Model Generation

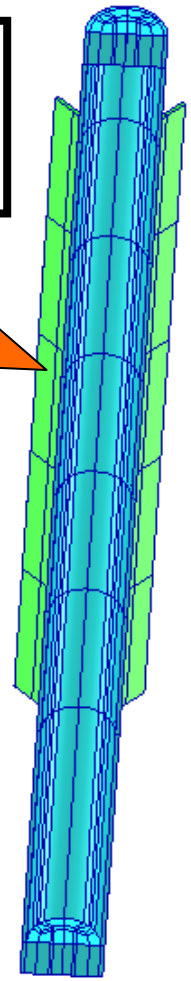
| | |
|---|---|
| Estaca (1/4 do diametro): | 2 |
| Largura Aleta: | 3 |
| Altura da aleta: | 5 |
| Solo superior acima da aleta: | 1 |
| Solo inferior abaixo da aleta: | 1 |
| Solo superior: | 7 |
| Solo inferior: | 4 |
| Solo radial: | 6 |

Apply  Cancel

| | |
|---|---|
| Estaca (1/4 do diametro): | 2 |
| Largura Aleta: | 3 |
| Altura da aleta: | 5 |
| Solo superior acima da aleta: | 1 |
| Solo inferior abaixo da aleta: | 1 |
| Solo superior: | 7 |
| Solo inferior: | 4 |
| Solo radial: | 6 |

Apply  Cancel

**Pile with Wings**



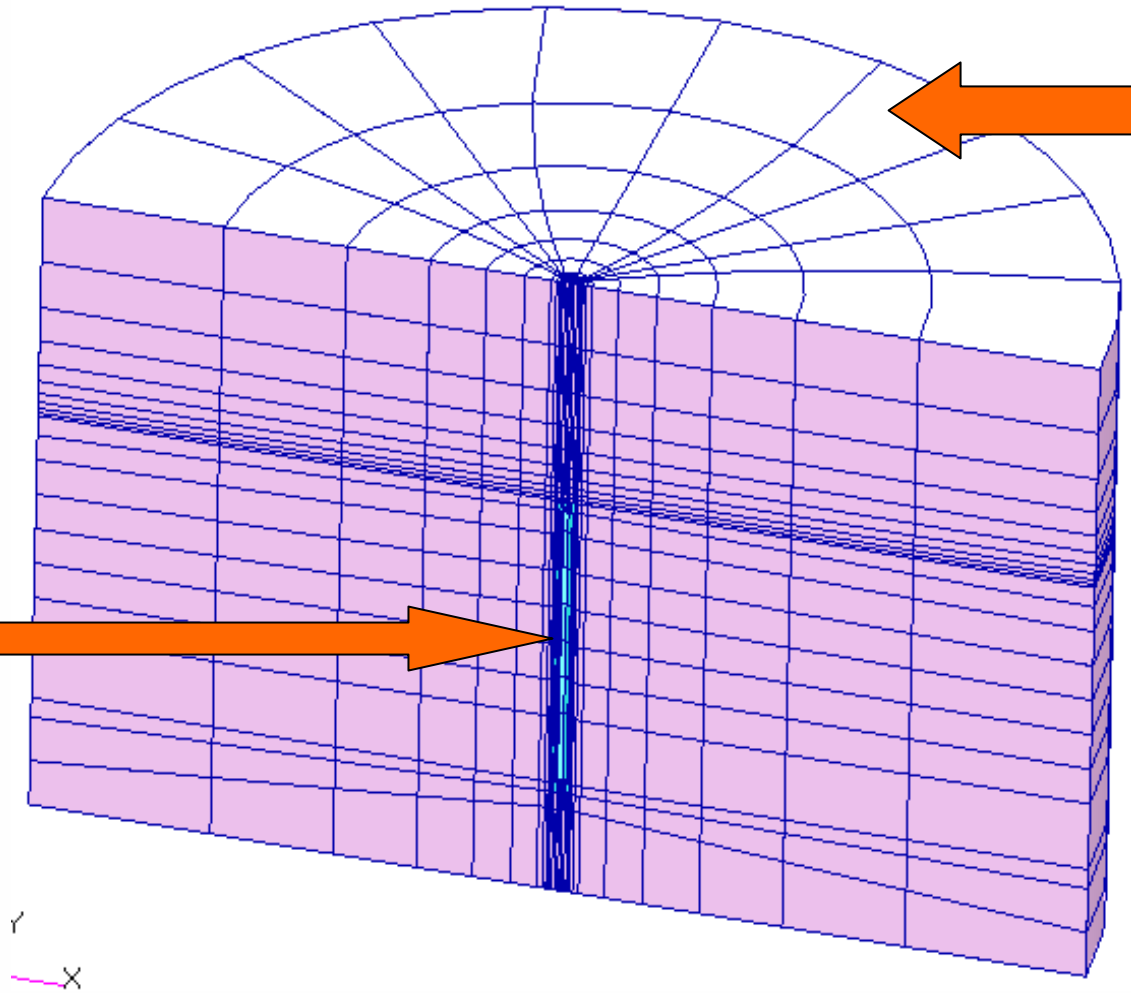
# PIPE DEFAULTS TEXT FILE

```
$*** escoamento do material
Sy,345000.

$*** Dados da força (total mesmo no modelo simétrico)
Forca,11000.
Angulo da forca,43.6

$*** Dados geométricos
DE da estaca,1.067
Angulo da estaca,30.
Espessura da estaca,0.038
Espessura da aleta,0.05
largura da aleta,0.901
DE do solo,56.
Profundidade do infinito,5.
Altura da estaca,14.58
Altura do topo da estaca 1,0.35
Altura do topo da estaca 2,0.65
Altura da aleta,9.58
Altura do solo superior,16.
Altura do solo inferior,5.
Altura da base da estaca 2,0.35

$*** Discretizações do modelo
Discretizacao altura solo sup,2
Discretizacao altura solo inf,1
Discretizacao altura aleta,2
Discretizacao altura solo inf aleta,1
Discretizacao altura solo sup aleta,1
Discretizacao estaca circulo 45 graus,1
Discretizacao largura da aleta,1
Discretizacao solo radial,1

$*** PG das discretizações
pg largura da aleta,3.
pg solo radial,7.
pg estaca circulo 45 graus,0.3
pg altura solo sup,20.
pg altura solo inf,5.
```

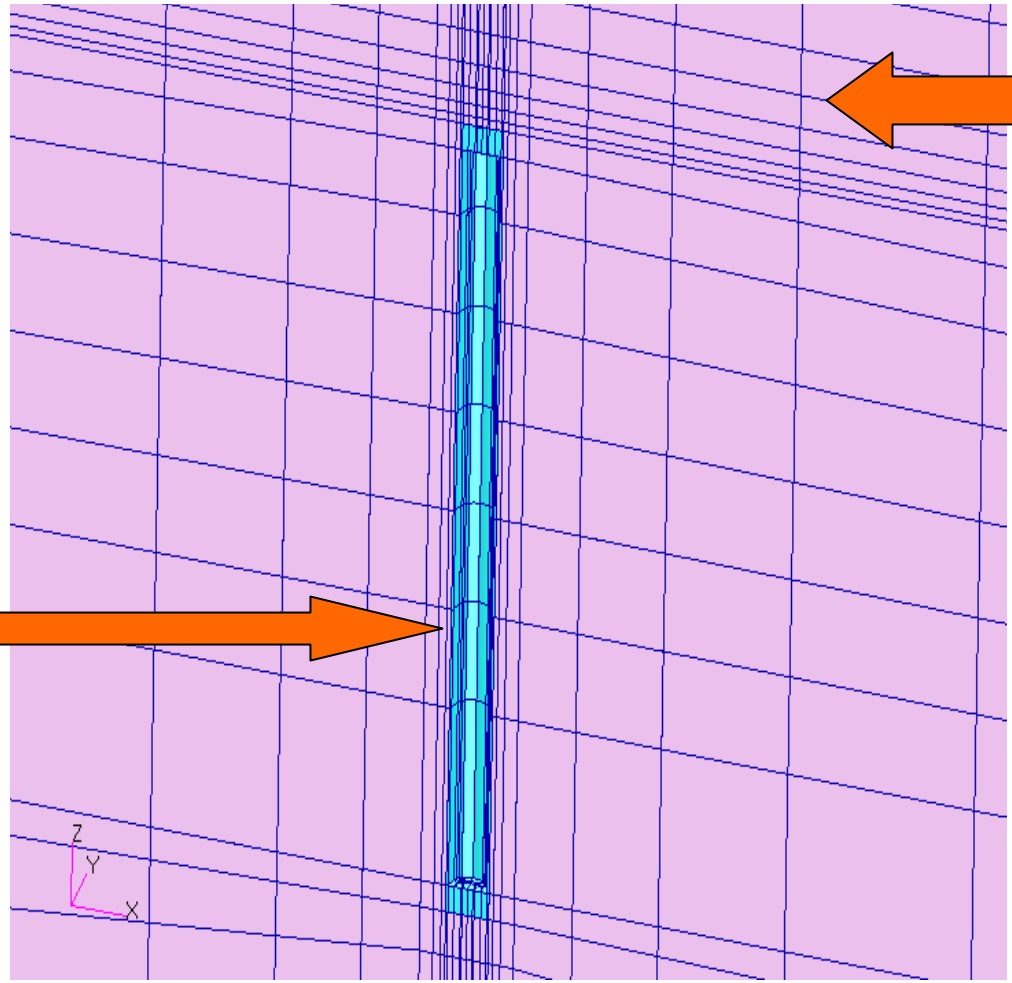
**Text File to fill values to the main screens**

**Free format using KEYWORDS**

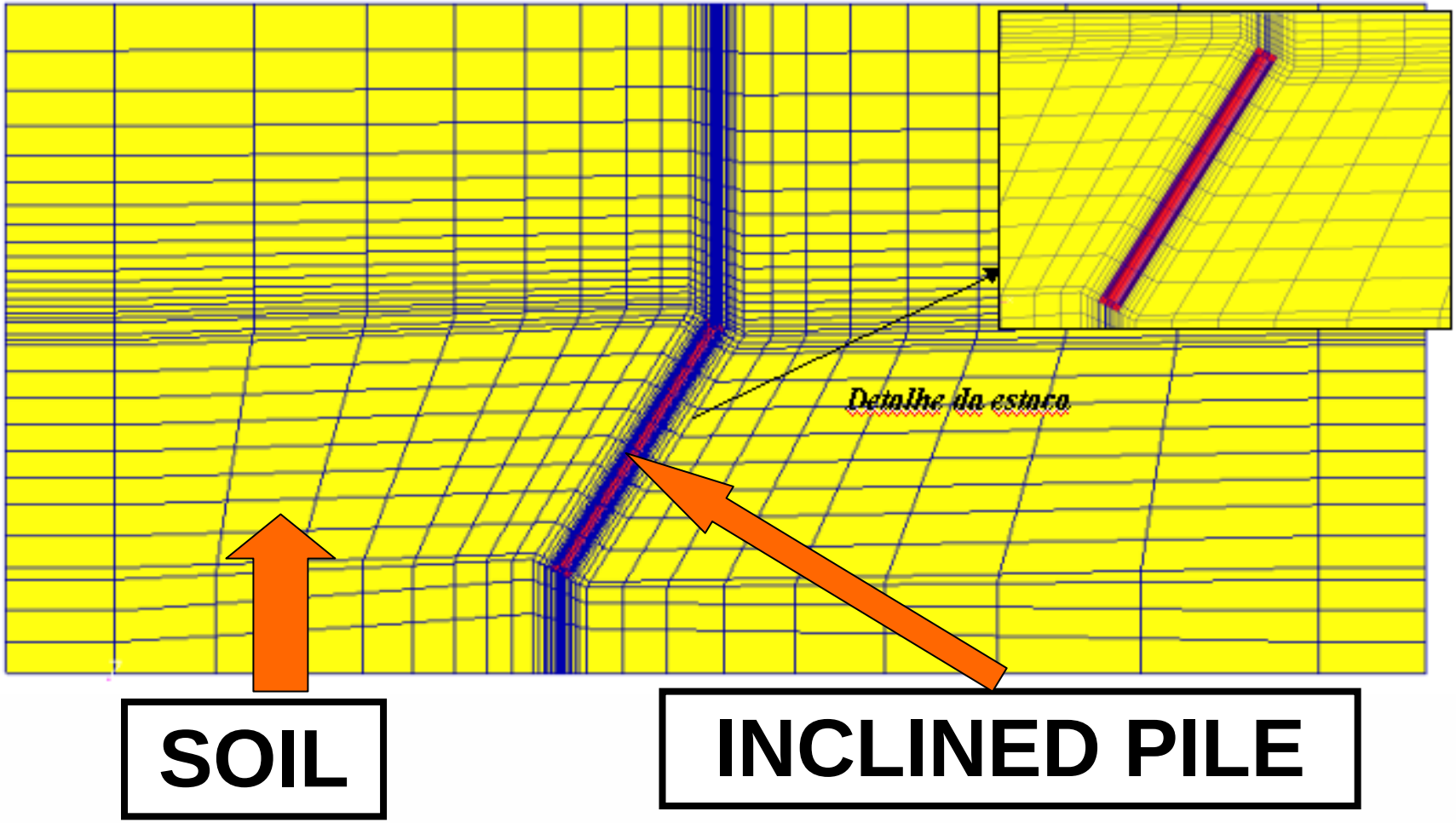
# SYMMETRIC PILE MODEL



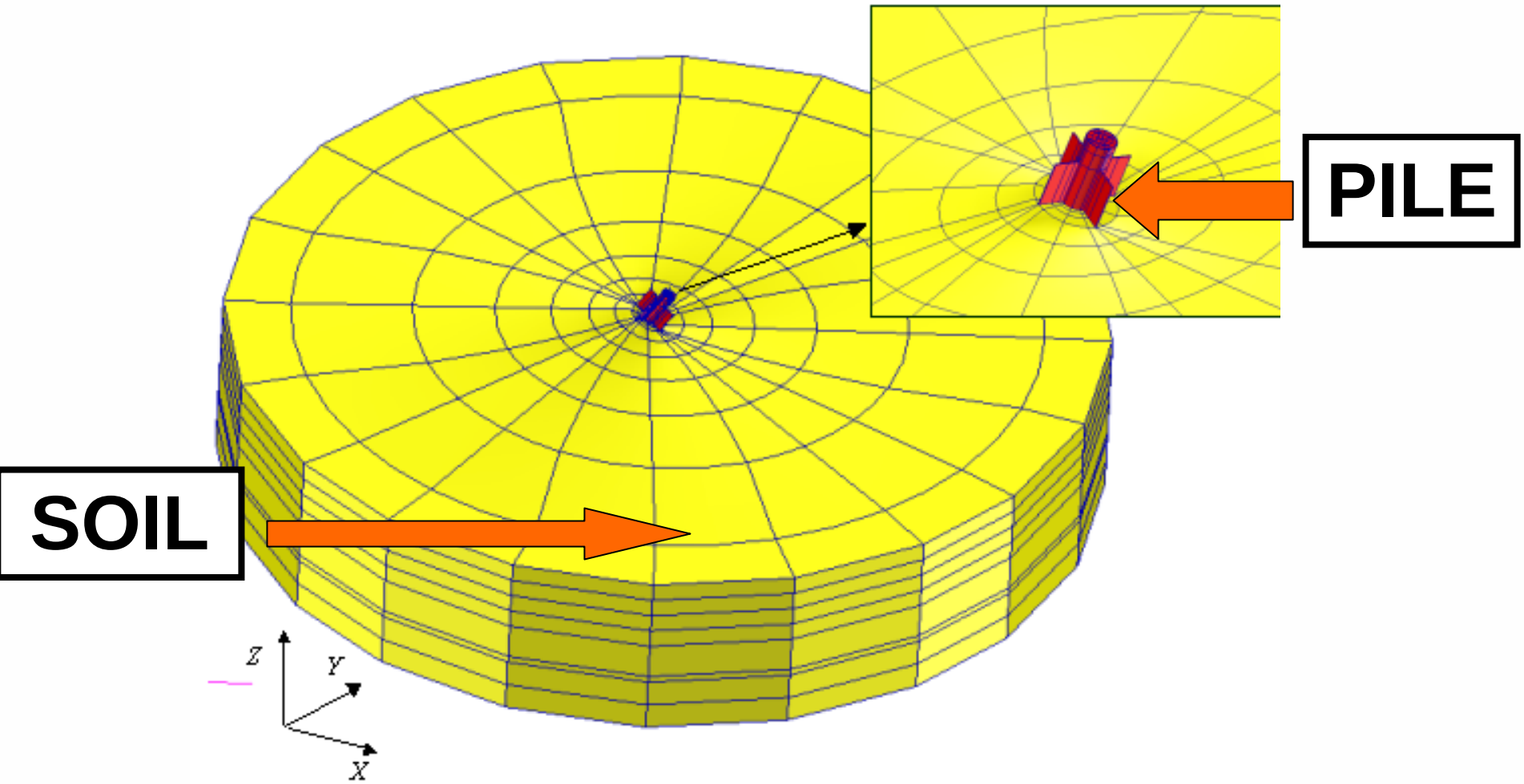
# DETAIL OF THE SYMMETRIC MODEL



# NON-SYMMETRIC MODEL



# NON-SYMMETRIC MODEL - DETAIL

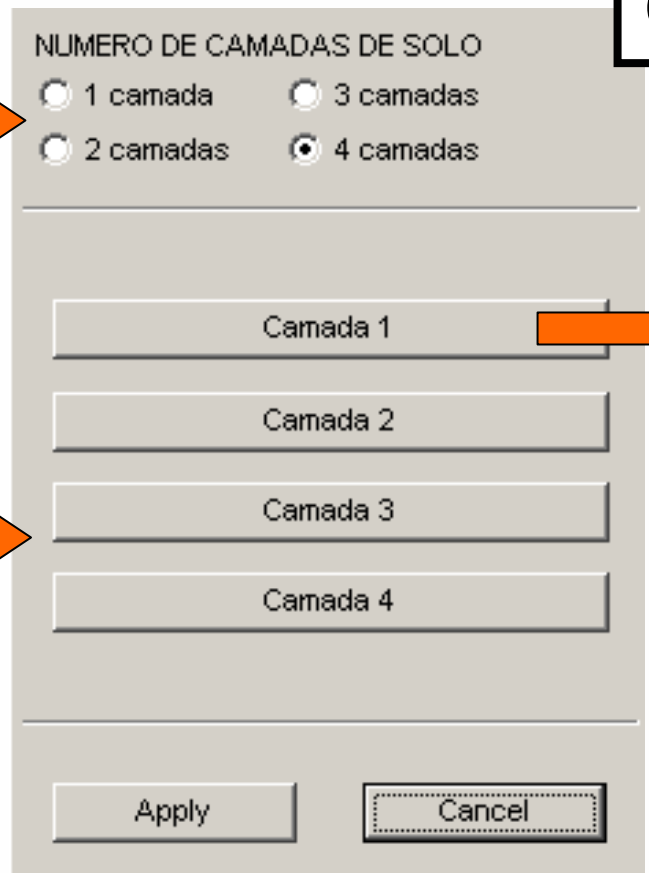


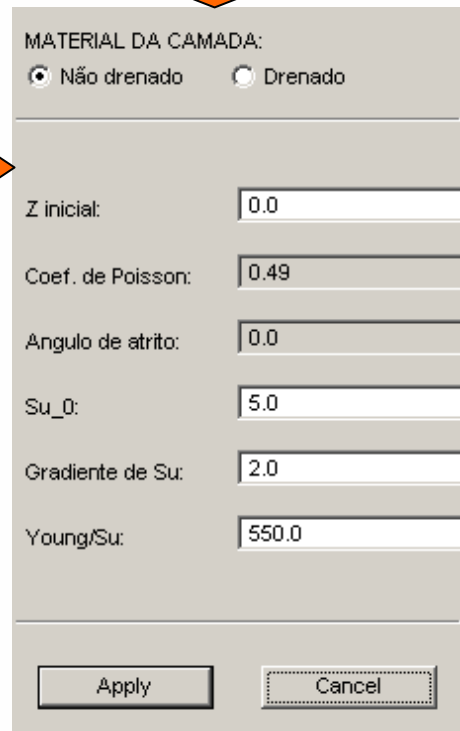
# SOIL DATA DEFINITION

**Number of Soil LAYERS**

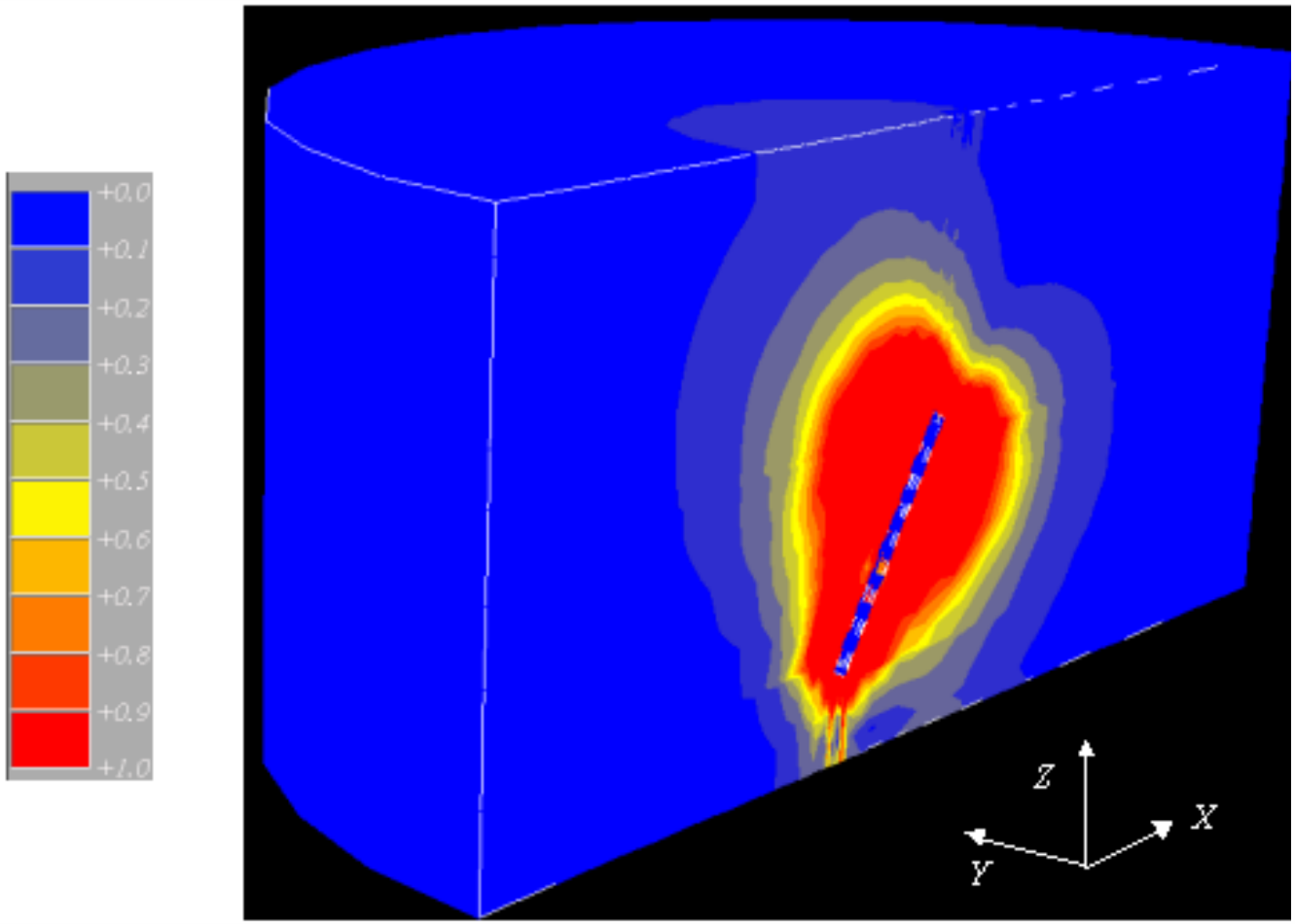
**Buttons for LAYERS definition**

**Equation for each LAYER**

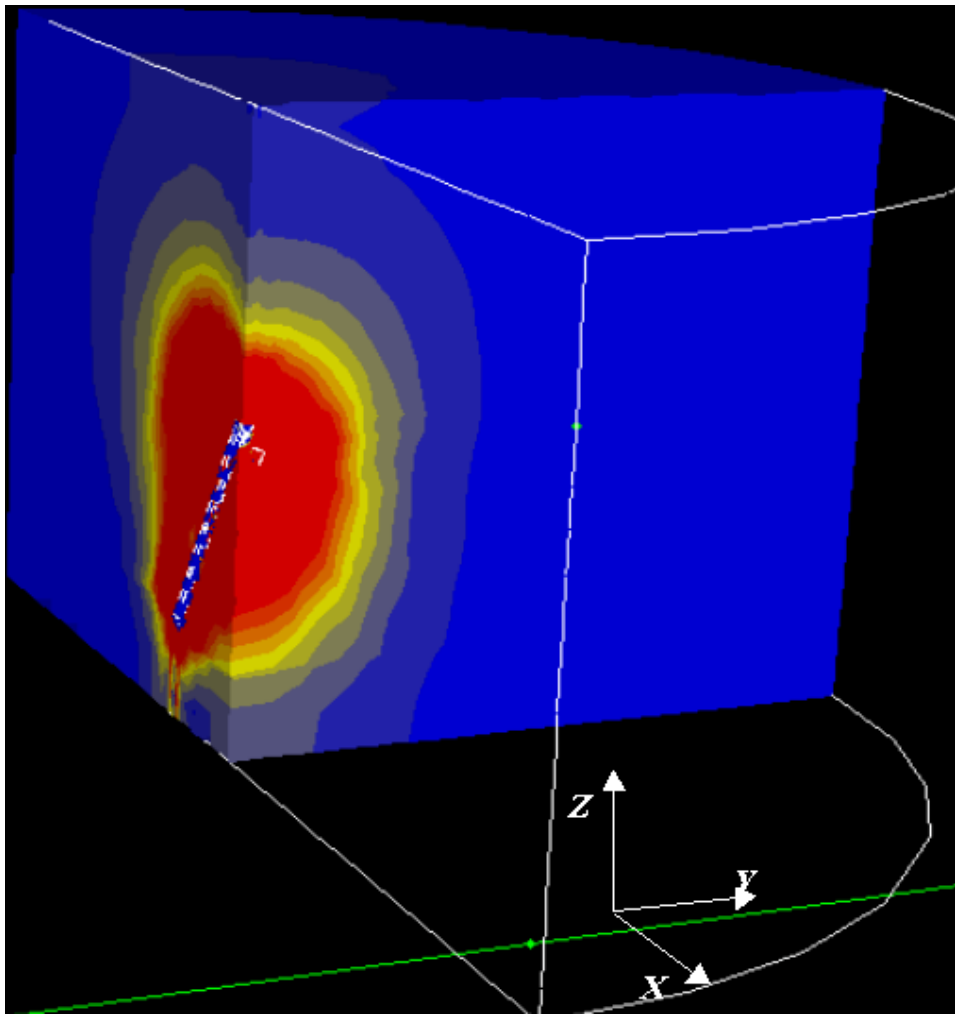


# POST-PROCESSING USING POS-3D



# POST-PROCESSING USING POS-3D



# ADVANTAGES of AUTOMATION

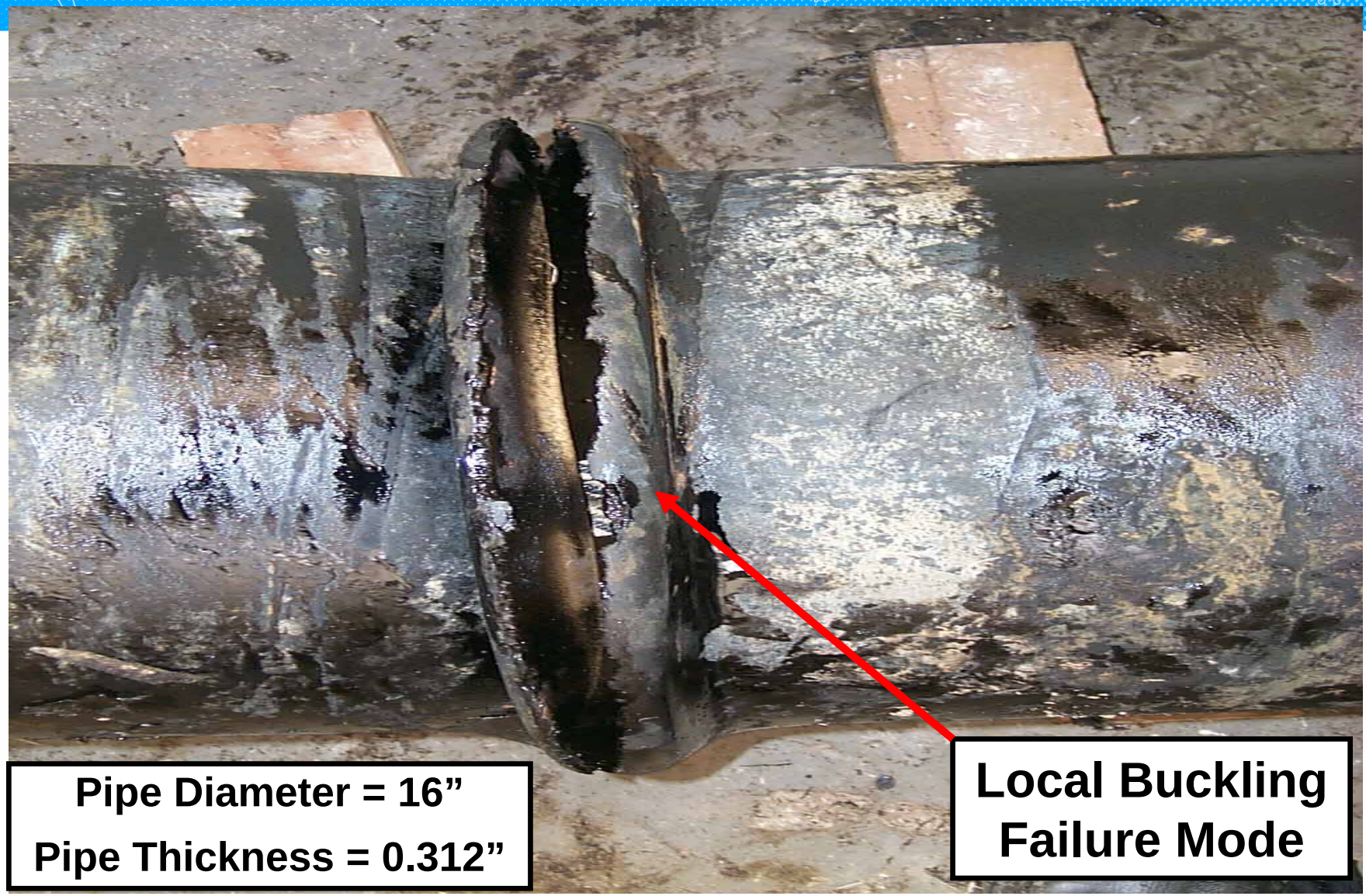
- Substantial Time Reduction for Model Generation from DAYS to MINUTES
- Productivity Increase
- Model Generation with varying Soil Properties
- Possibility of Model generation by Non-Experts users of MSC.Patran
- Reliabilty in Model Generation produced by the Automation Process.

# PIPELINE MODEL GENERATOR:

## Motivation for the work:

***Accident in PETROBRAS PE-2 pipeline in Guanabara Bay - January 2000 - Brazil***

**Leakage of 1.300.000 liters of oil**


Pipe Diameter = 16”
Pipe Thickness = 0.312”
Local Buckling Failure Mode

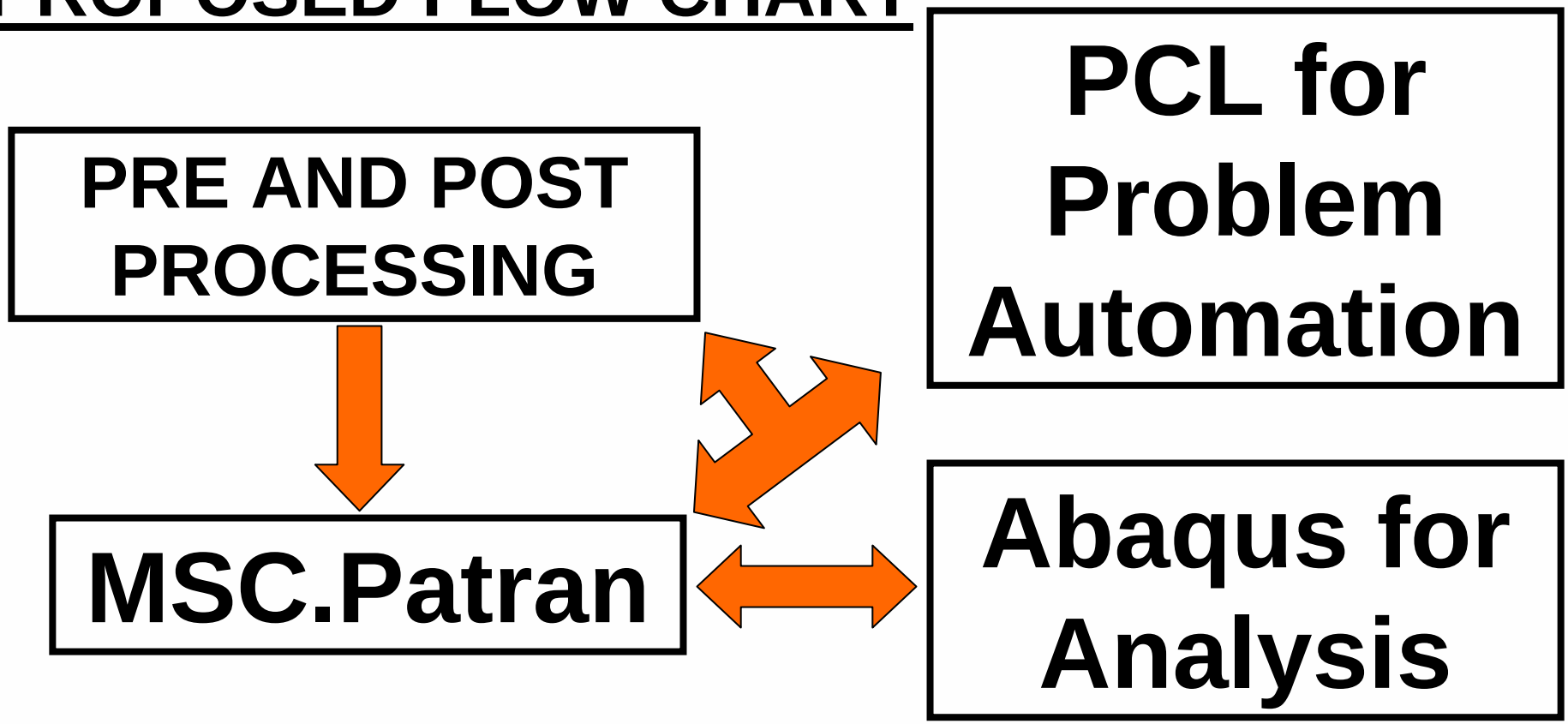
# PROBLEM DESCRIPTION

- 3D Pipeline Analysis
- The pipeline is buried in soil (drained or undrained)
- Arbitrary geometry measured from inertial pig
- Physical non-linear behavior for the materials must be considered
- Thermal Buckling Analysis
- Internal pressure must be considered

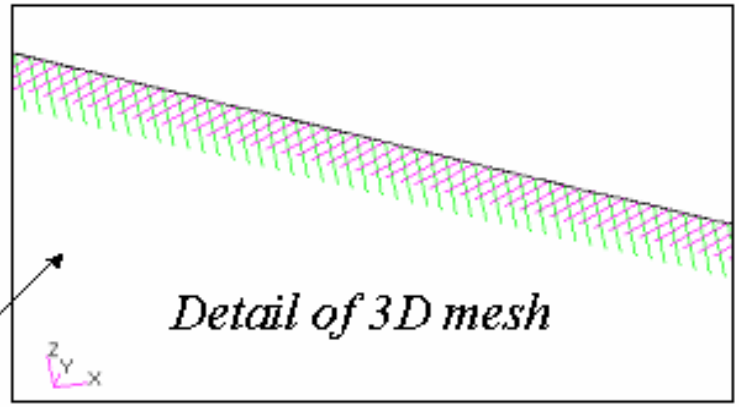
# STRATEGIC APPROACH

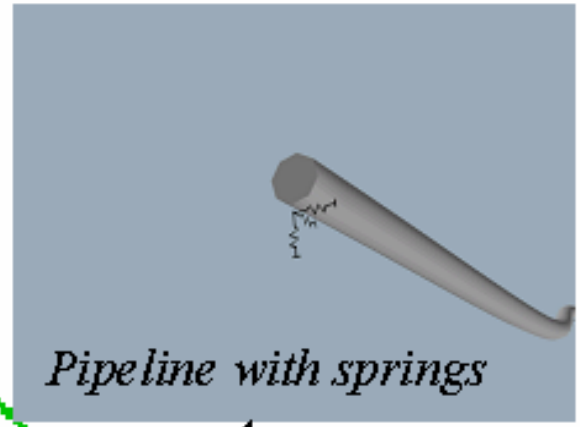
- Completely automated model generation
- Procedure to be used for non-experts MSC.Patran users
- Model generation througth PCL (Parametric Command Language)
- Process controled by G.U.I. (Graphics User Interface)

# PROPOSED FLOW CHART



**3 spring elements/node**



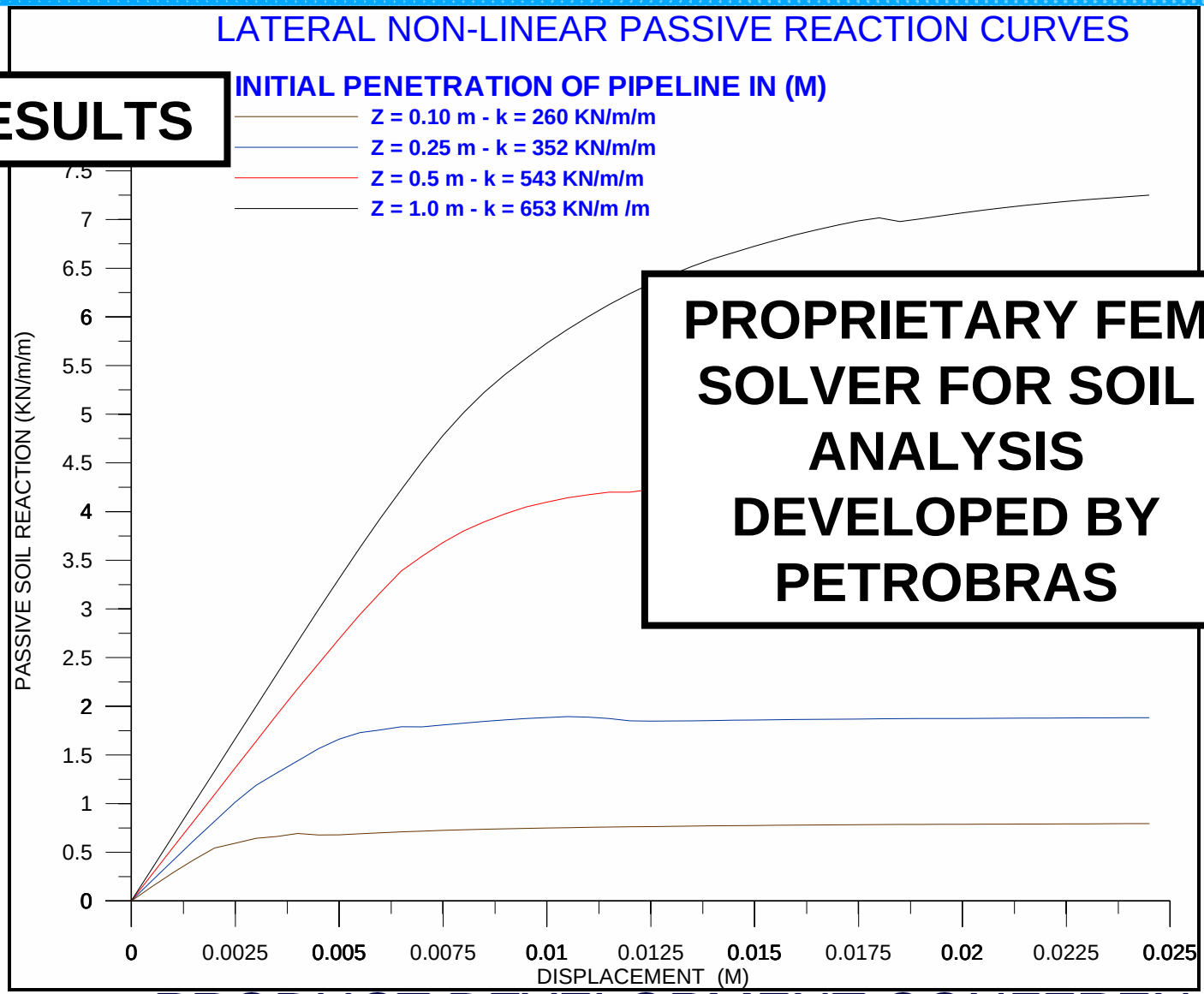




**Elements for longitudinal soil strength NOT shown**

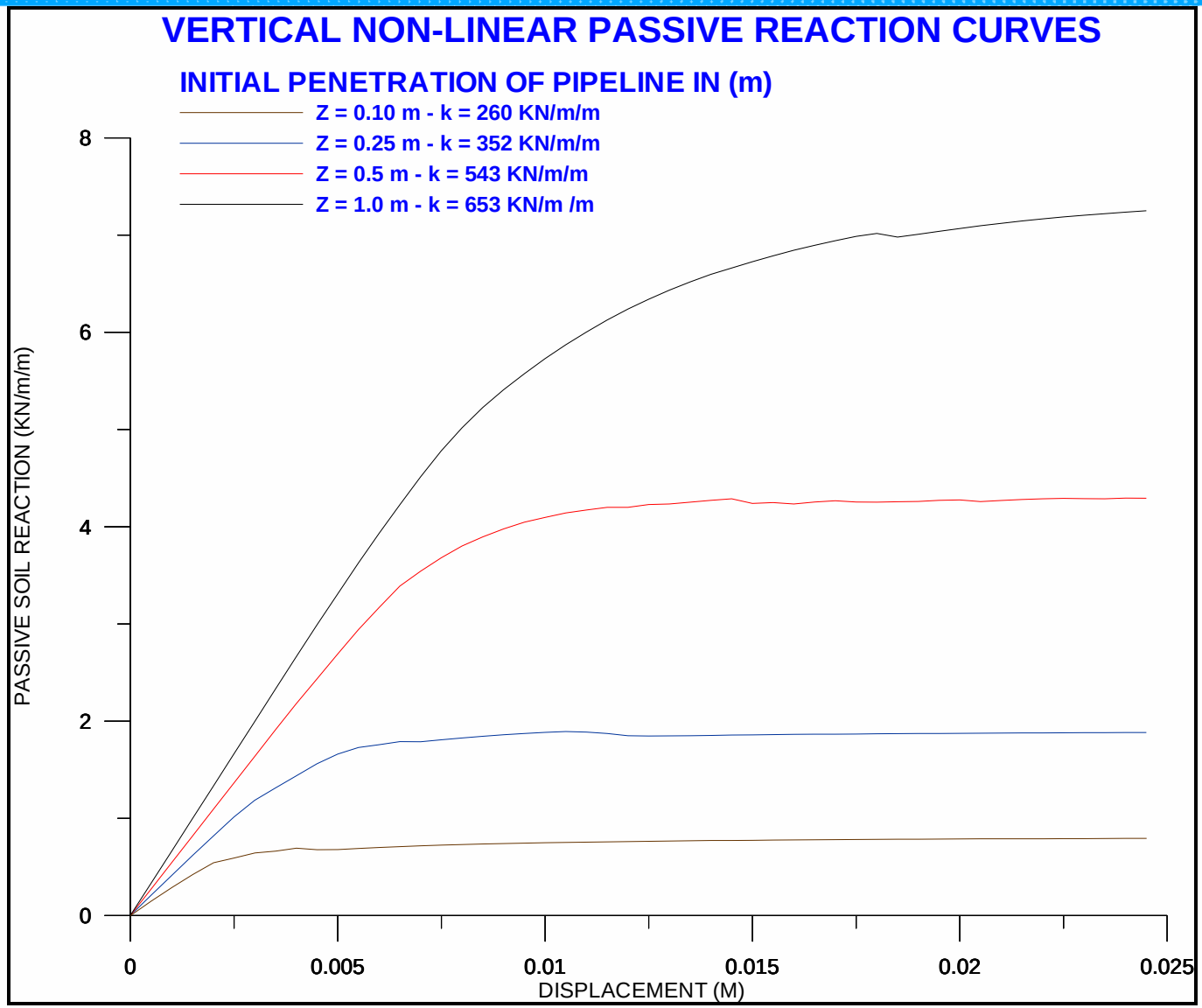
# MODEL FEATURES

- 3 non-linear Spring elements representing soil strength for each pipeline node
- Soil properties varying along the pipeline
- Geometry data supplied by text file
- Soil data data supplied by text file

# AEEPECD RESULTS




**PROPRIETARY FEM SOLVER FOR SOIL ANALYSIS DEVELOPED BY PETROBRAS**

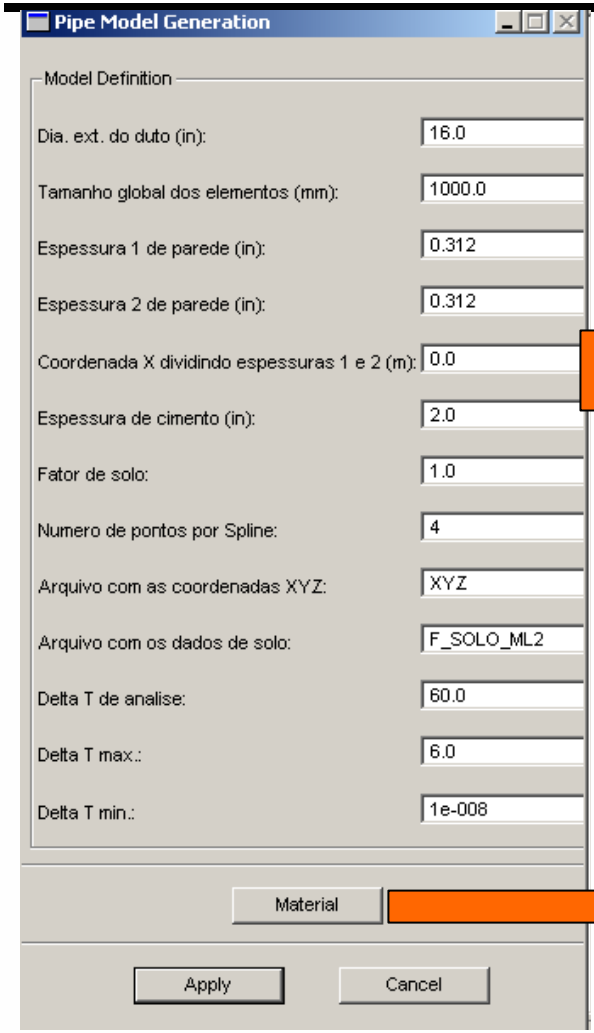

VERTICAL NON-LINEAR PASSIVE REACTION CURVES
INITIAL PENETRATION OF PIPELINE IN (m)
Z = 0.10 m - k = 260 KN/m/m
Z = 0.25 m - k = 352 KN/m/m
Z = 0.5 m - k = 543 KN/m/m
Z = 1.0 m - k = 653 KN/m /m
PASSIVE SOIL REACTION (KN/m/m)
0
2
4
6
8
0
0.005
0.01
0.015
0.02
0.025
DISPLACEMENT (M)

# PROPRIETARY USER INTERFACE

## G.U.I. - Graphic User Interface to Control the Process

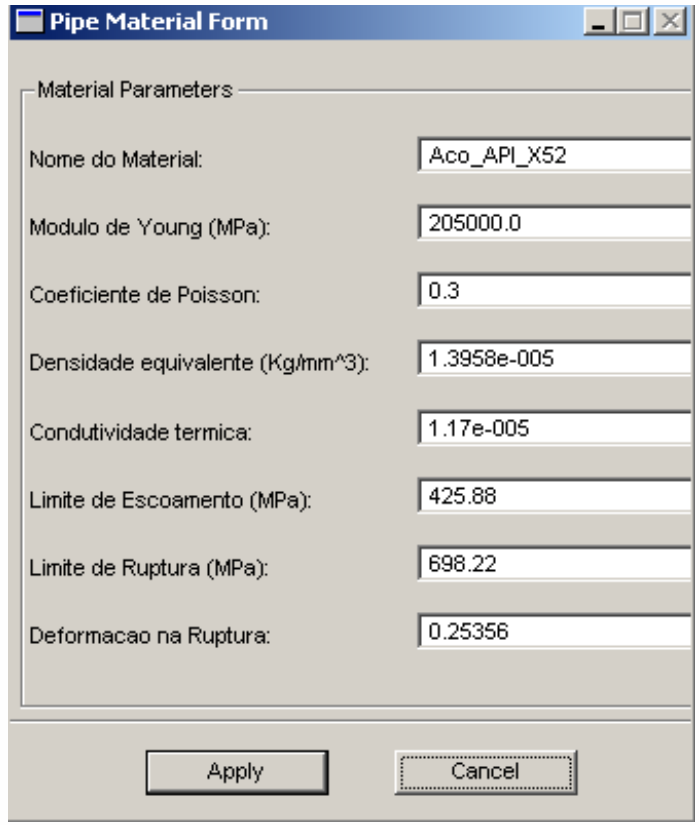

**Activate Pipe Model Generation Procedure**

# SCREENS FOR DATA ENTRY




**Main Screen Data**

**Material Data**



# PIPE DEFAULTS TEXT FILE

```
Diametro duto , 16.
Espessura 1 , 0.5
Espessura 2 , 0.5
X divisor , 0.
Espessura cimento , 2.
Fator solo , 1.
Pontos/spline , 4
Arquivo XYZ , XYZ
Arquivo de solo , F_SOLO_ML2
Nome material , Aco_API_grB
Modulo de young , 205000.
Poisson , 0.3
Densidade equivalente , 1.3958e-5
Condutividade termica , 1.17e-5
Limite de escoamento , 241.9
Limite de ruptura , 463.9
Deformacao na ruptura , 0.11107
```

**Text File to fill values to the main screens**

**Name of the Text File with geometry data**

**Name of the Text File with soil data**

# PIPELINE GEOMETRY

| X | Y | Z | |
|---|---|---|---|
| 0.0000 , | 0.0000 , | 5.2705 , | 0.0000 |
| 0.9670 , | -0.2470 , | 5.3029 , | 0.0000 |
| 1.9310 , | -0.5020 , | 5.3244 , | 0.0000 |
| 2.8900 , | -0.7610 , | 5.2818 , | 0.0000 |
| 3.6400 , | -0.9720 , | 4.6753 , | 0.0000 |
| 4.3240 , | -1.1630 , | 3.9788 , | 0.0000 |
| 5.0290 , | -1.3610 , | 3.3012 , | 0.0000 |
| 5.9500 , | -1.6160 , | 3.1087 , | 0.0000 |
| 6.9130 , | -1.8800 , | 3.1331 , | 0.0000 |
| 7.8490 , | -2.2190 , | 3.1486 , | 0.0000 |
| 8.7230 , | -2.6990 , | 3.1641 , | 0.0000 |
| 9.5980 , | -3.1810 , | 3.1745 , | 0.0000 |
| 10.4730 , | -3.6610 , | 3.1820 , | 0.0000 |
| 11.3500 , | -4.1390 , | 3.1924 , | 0.0000 |
| 12.2200 , | -4.6130 , | 3.0929 , | 0.0000 |
| 13.0540 , | -5.0720 , | 2.8024 , | 0.0000 |
| 13.8150 , | -5.4970 , | 2.3238 , | 0.0000 |
| 14.5010 , | -5.8820 , | 1.7133 , | 0.0000 |
| 15.2500 , | -6.3020 , | 1.2128 , | 0.0000 |
| 16.0760 , | -6.7640 , | 0.9012 , | 0.0000 |
| 16.9380 , | -7.2460 , | 0.7807 , | 0.0000 |
| 17.8080 , | -7.7390 , | 0.7821 , | 0.0000 |
| 18.6710 , | -8.2370 , | 0.7896 , | 0.0000 |
| 19.5460 , | -8.7080 , | 0.7091 , | 0.0000 |
| 20.4210 , | -9.0990 , | 0.4435 , | 0.0000 |
| 21.2630 , | -9.3950 , | 0.0020 , | 0.0000 |
| 22.0870 , | -9.6680 , | -0.4876 , | 0.2000 |
| 22.9770 , | -9.9840 , | -0.7991 , | 0.2000 |

**Geometry Data from Inertial PIG**

**1 line / measured point**

**Level of Embeddement**

# SOIL STRENGTH DATA

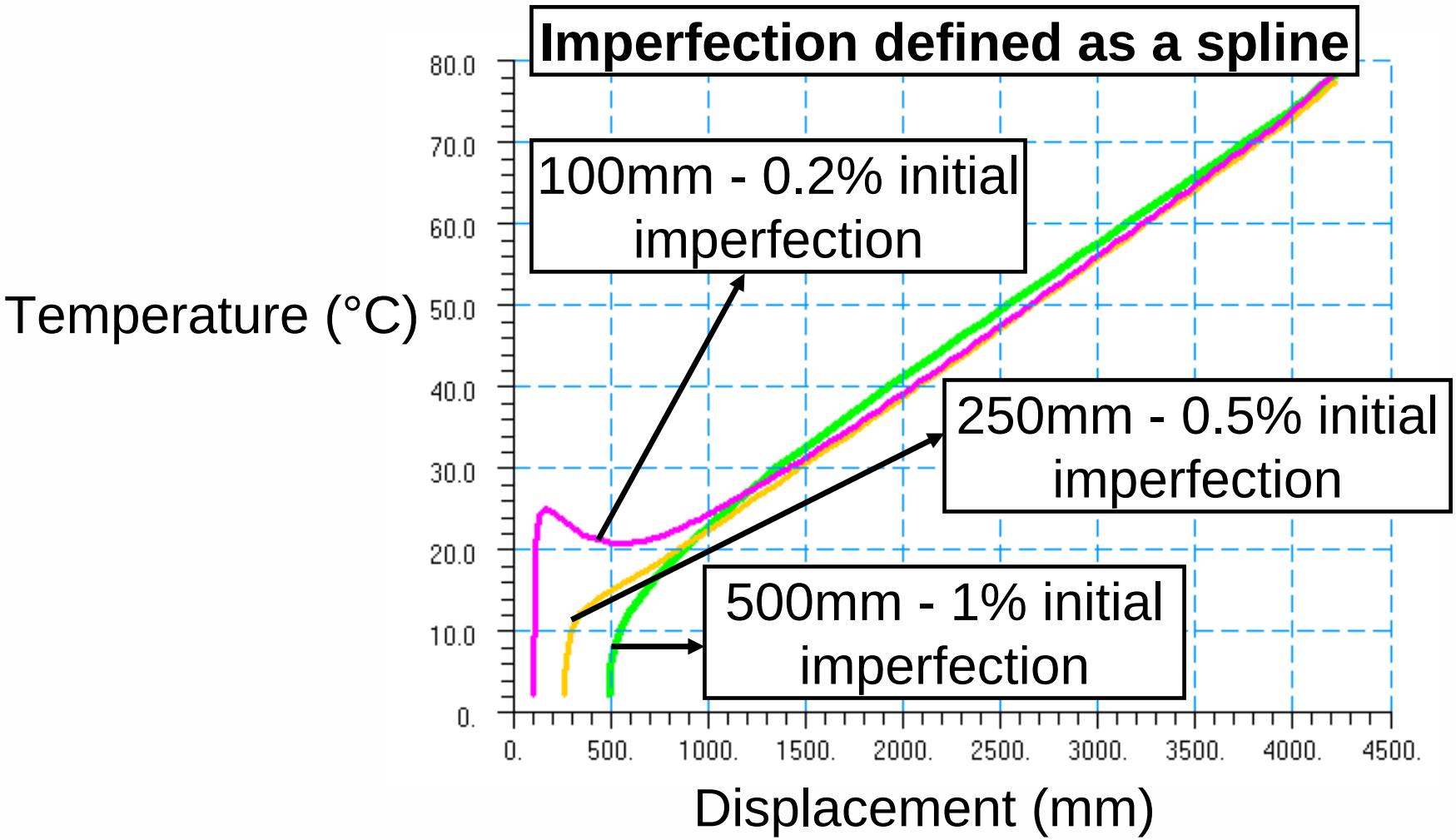
Maximum number of points for any curve

Displacement according to the Force

| 3 | Lateral | Longitudinal | Vertical | Lateral | Longitudinal | Vertical | Lateral | Longitudinal | Vertical |
|---|---|---|---|---|---|---|---|---|---|
| Z / D | 12. | 12. | 12. | 25.4 | 25.4 | 25.4 | 500. | 500. | 500. |
| 0.000 | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| 0.020 | 216.4 | 271.0 | 1663.1 | 256.9 | 284.6 | 1751.9 | 297.4 | 298.8 | 1840.6 |
| 0.050 | 412.1 | 435.0 | 2191.6 | 434.9 | 456.8 | 2439.4 | 457.7 | 479.6 | 2687.2 |
| 0.100 | 761.1 | 633.0 | 2781.8 | 794.7 | 664.7 | 3191.3 | 828.2 | 697.9 | 3600.8 |
| 0.250 | 1850.4 | 1106.0 | 3455.0 | 1883.1 | 1161.3 | 4111.8 | 1915.7 | 1219.4 | 4768.6 |
| 0.500 | 4199.8 | 2164.0 | 4222.0 | 4292.9 | 2272.2 | 5159.8 | 4386.0 | 2385.8 | 6097.7 |
| 1.000 | 6238.8 | 2471.0 | 6014.3 | 7250.7 | 2594.6 | 7557.0 | 8262.6 | 2724.3 | 9099.7 |
| 1.500 | 7046.1 | 2778.0 | 7543.1 | 9361.9 | 2916.9 | 9482.1 | 11677.6 | 3062.7 | 11421.2 |
| 2.500 | 7990.0 | 3391.0 | 8972.8 | 11500.0 | 3560.6 | 12292.7 | 15010.0 | 3738.6 | 15612.6 |
| 5.000 | 10039.0 | 4924.0 | 11284.7 | 15472.0 | 5170.2 | 16399.2 | 20905.0 | 5428.7 | 21513.7 |
| 15.000 | 10039.0 | 4924.0 | 11284.7 | 15472.0 | 5170.2 | 16399.2 | 20905.0 | 5428.7 | 21513.7 |

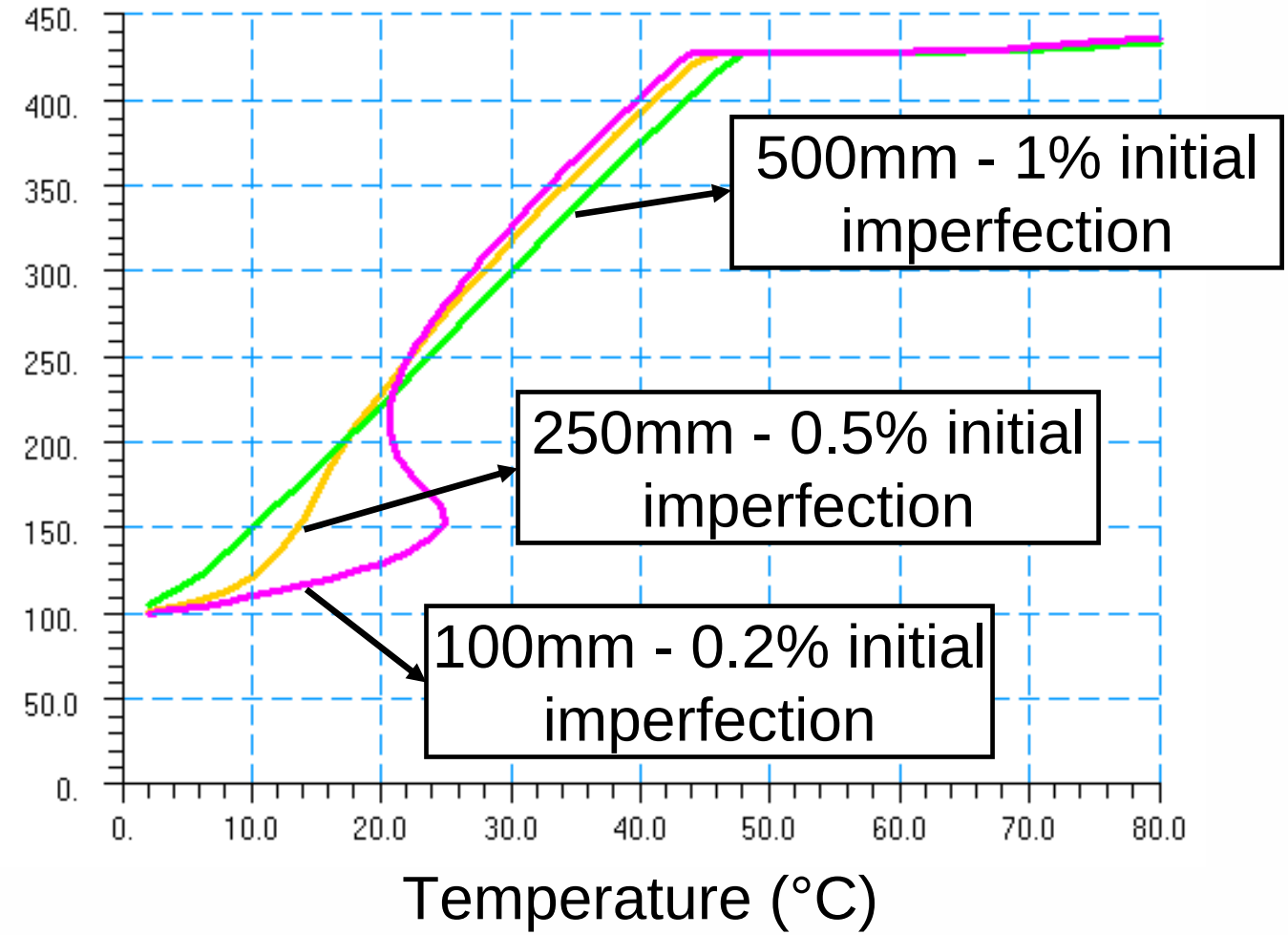
Point 1 | Point 2 | Point 3

# Results for Different Initial Imperfections



# Results for Different Initial Imperfections

Von Mises Stress (MPa)



# ADVANTAGES of AUTOMATION

- Substantial Time Reduction for Model Generation from DAYS to MINUTES
- Productivity Increase
- Model Generation with varying level of embedment
- Possibility of Model generation by Non-Expert users of MSC.Patran
- Reliabilty in Model Generation produced by the Automation Process.