



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

Authors:

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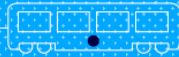
Alvaro Maia da Costa - Petrobras/R&D



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

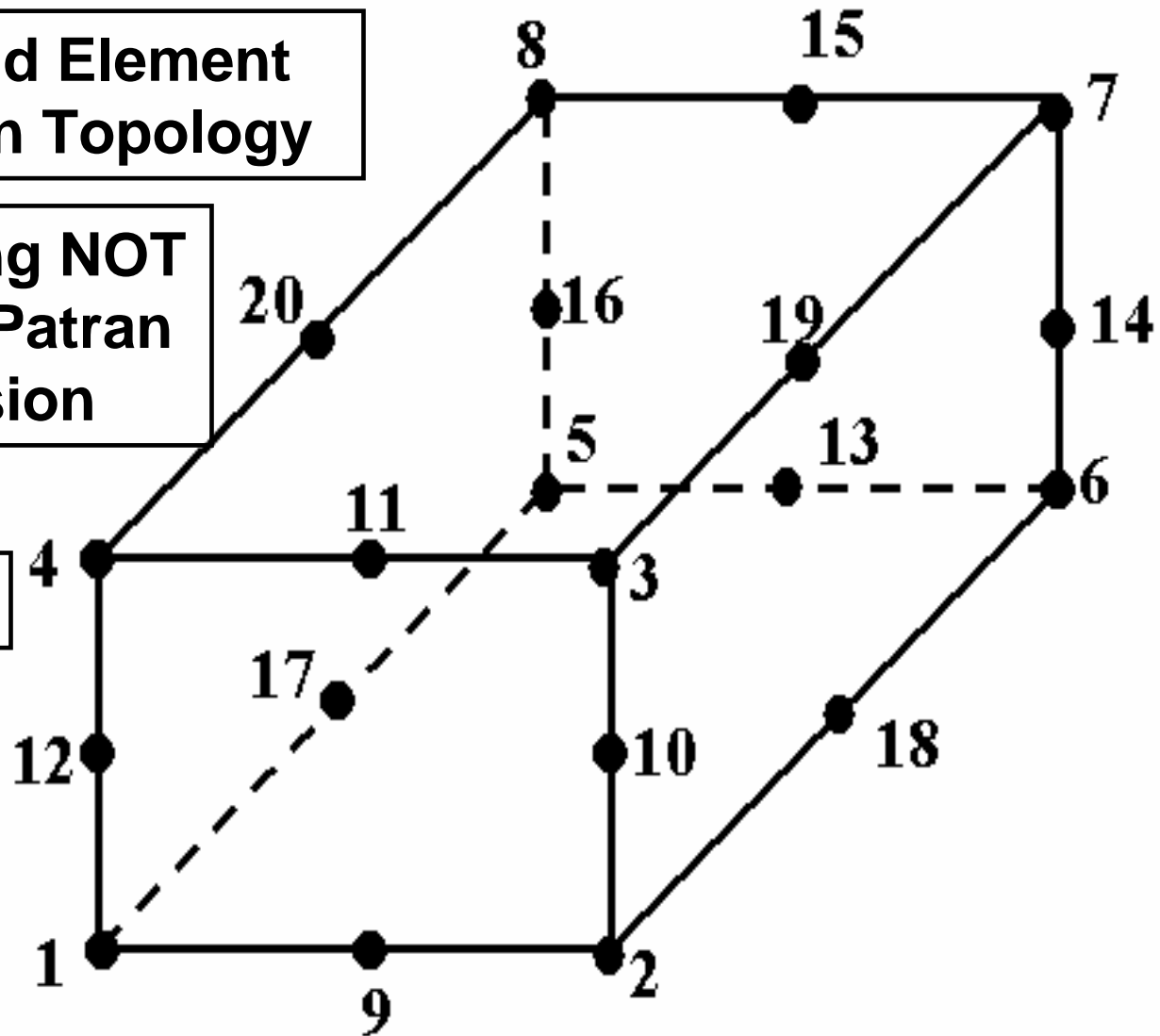
- 3D Solid Brick element with 20 nodes with a specific sequence numbering **NOT** supported by MSC.Patran
- 3D Solid Brick element with 16 nodes for contact representation
- 3D Solid Brick element with 12 nodes for infinite elements representation

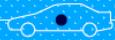


**3D Quadratic Solid Element
HEX20 MSC.Patran Topology**

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

20 Nodes Element

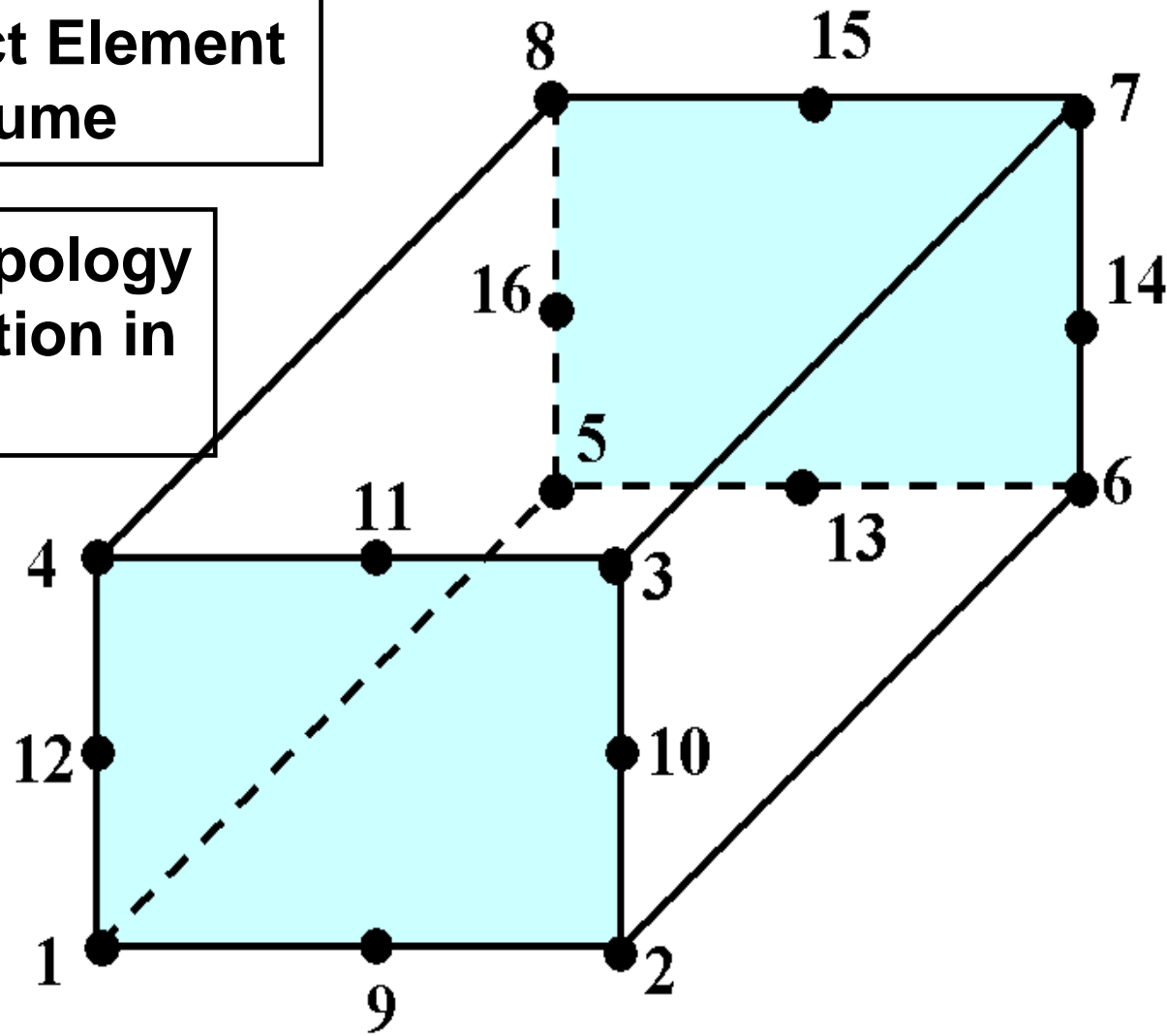




**3D Quadratic Contact Element
with ZERO Volume**

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

16 Nodes Element

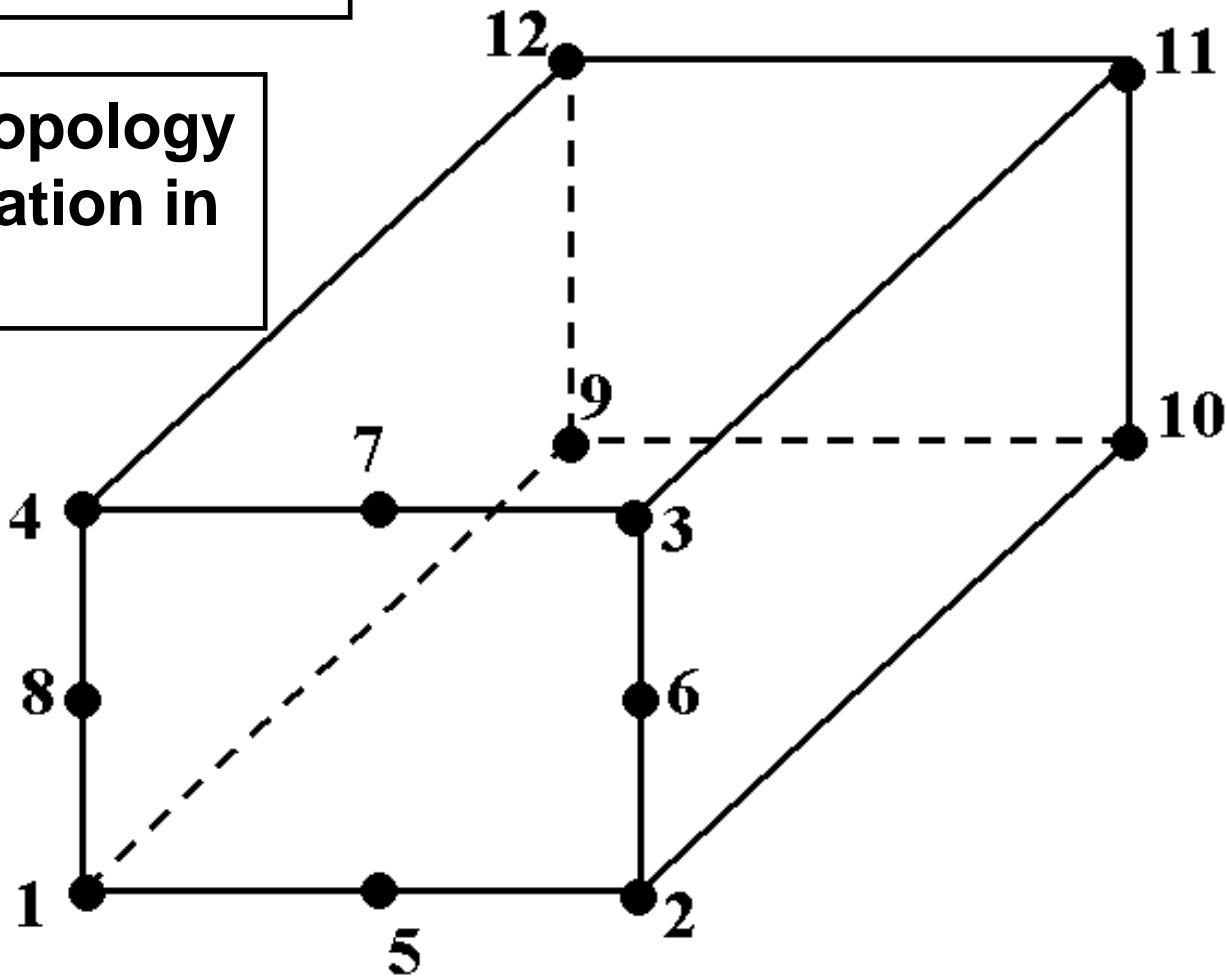




3D Quadratic Infinite Element

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 through PCL (Parametric Command Language)
- Process controlled by G.U.I. (Graphics User Interface)
- Preference Creation for AEEPEC3D

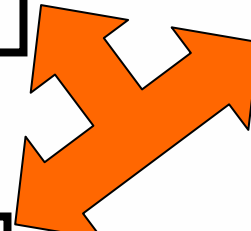


PROPOSED FLOW CHART

**PRE AND POST
PROCESSING**



MSC.Patran



**Preference for
AEEPEC3D**

**PCL for
Problem
Automation**

**AEEPEC3D
for Analysis**





AEEPEC3D Preference Selection

Analysis Code:

AEEPEC3D

Analysis Type:

Structural

Input File Suffix:

.inp

Output File Suffix:

.ans

OK

Cancel

**AEEPEC3D
Analysis Code**





AEEPEC3D PREFERENCE

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



**Custom Functions
Activation**



Mesh Generator Screen

Action: Create ▾
Object: Mesh ▾
Type: Contact 3D ▾

Group name

Global size:

AUTOEXECUTE
Select Surfaces

Action: Create ▾
Object: Mesh ▾
Type: Contact 3D
 Infinite 3D

Group name

Global size:
Infinite depth:

AUTOEXECUTE
Select Surfaces



Analysis Control Screens

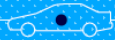
The image shows two overlapping dialog boxes for configuring an analysis job. The left dialog box contains the following fields:

- Action: Analyse (dropdown)
- Object: Entire Model (dropdown)
- Method: Full Run (dropdown)
- Code: Anleet (text field)
- Type: Structural (text field)
- Study: (empty text field)
- Available Jobs: (empty list box)
- Job Name: m (text field)
- Job Description: Anleet job created on 18-Jun-03 at 11:21:50 (text field)
- Solution Parameters... (button)
- Output Controls... (button)
- Apply (button)

The right dialog box contains the following options:

- Tipo de Analise:
 - Linear Elastica
 - Elasto Plastica
- Ordem de integracao: 2 (text field)
- Calculo das forcas equiv. as pressoes este...
- Geracao das tensoes iniciais gravitacionais
- Gera estado inicial de tensoes
- Geracao das tensoes termicas
- Forcas nodeis equiv. ao peso proprio
- Forcas equivalentes ao estado inicial de ten...
- Geracao de gradiente termico
- Initial Conditions... (button)
- Analysis Control... (button)
- Apply (button)
- Cancel (button)

An orange arrow points from the Job Description field in the left dialog to the Analysis Control... button in the right dialog.



Analysis File Generation Screen

Action:

Object:

Code:

Type:

Study:

Available Jobs

--

Job Name:

Job Description:

**Creation of file
for Analysis**

File Name:

Extension:



CUSTOM EQUIVALENCE FUNCTION

Action: Equivalence

First Group Name:

Second Group Name:

Contact Group Name:

Tolerance:

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

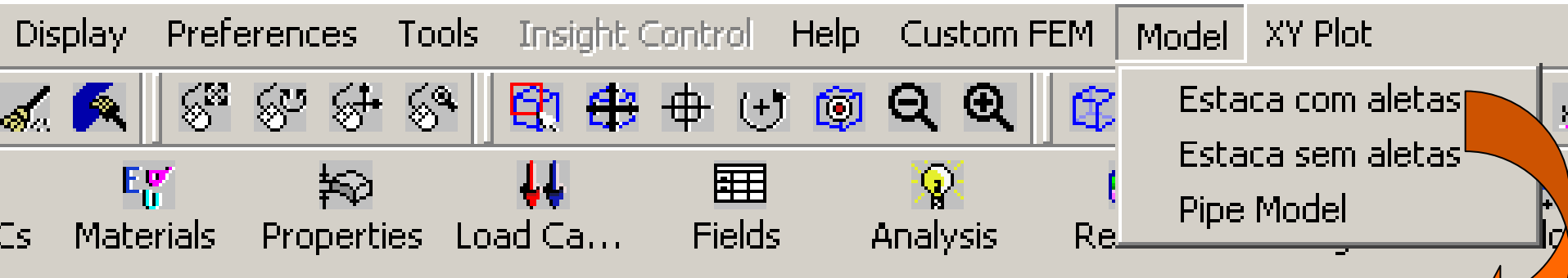
**Group Name with Pile
elements**

**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 Parametric Modeling

MODEL TYPE:
 symmetric non symmetric

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

Pile with Wings

Estaca (1/4 do diametro): 2

Largura Aleta: 3

Altura da aleta: 5

Solo superior acima da aleta: 1

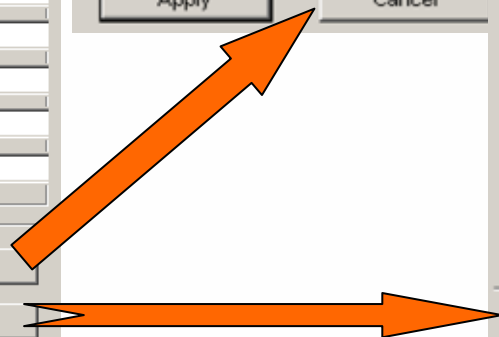
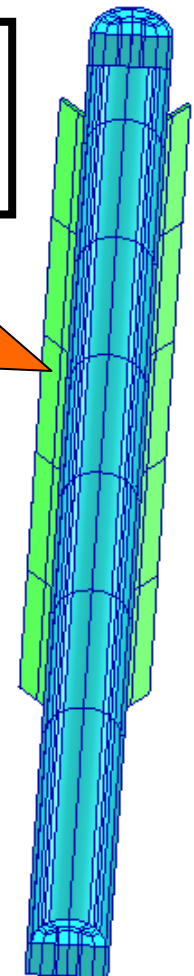
Solo inferior abaixo da aleta: 1

Solo superior: 7

Solo inferior: 4

Solo radial: 6

Apply Cancel



PRODUCT DEVELOPMENT CONFERENCE



PIPE DEFAULTS TEXT FILE

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

```
$*** Dados da força (total mesmo no modelo simétrico)  
Força,11000.  
Angulo da força,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.
```



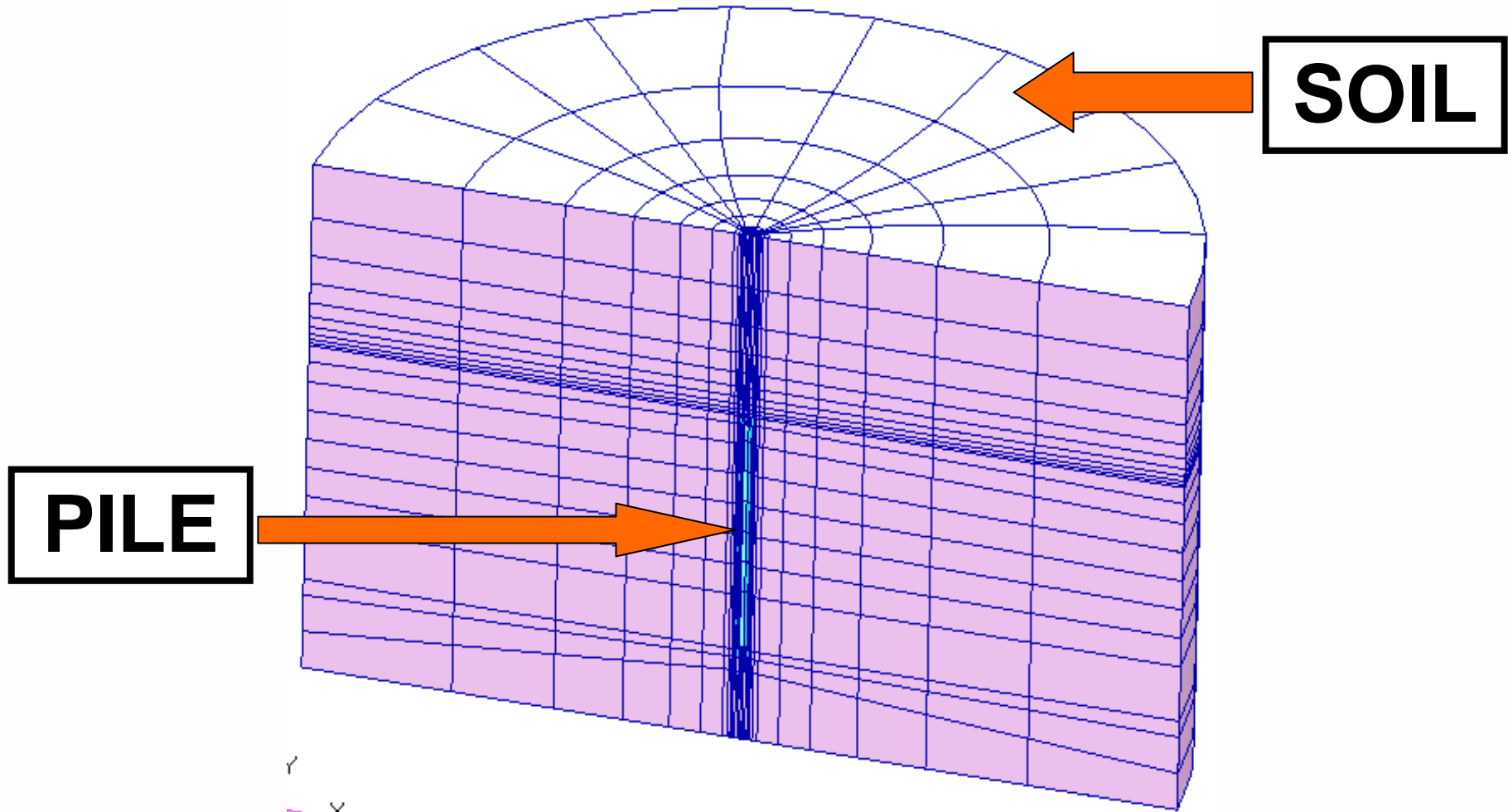
**Text File to fill values
to the main screens**



**Free format using
KEYWORDS**



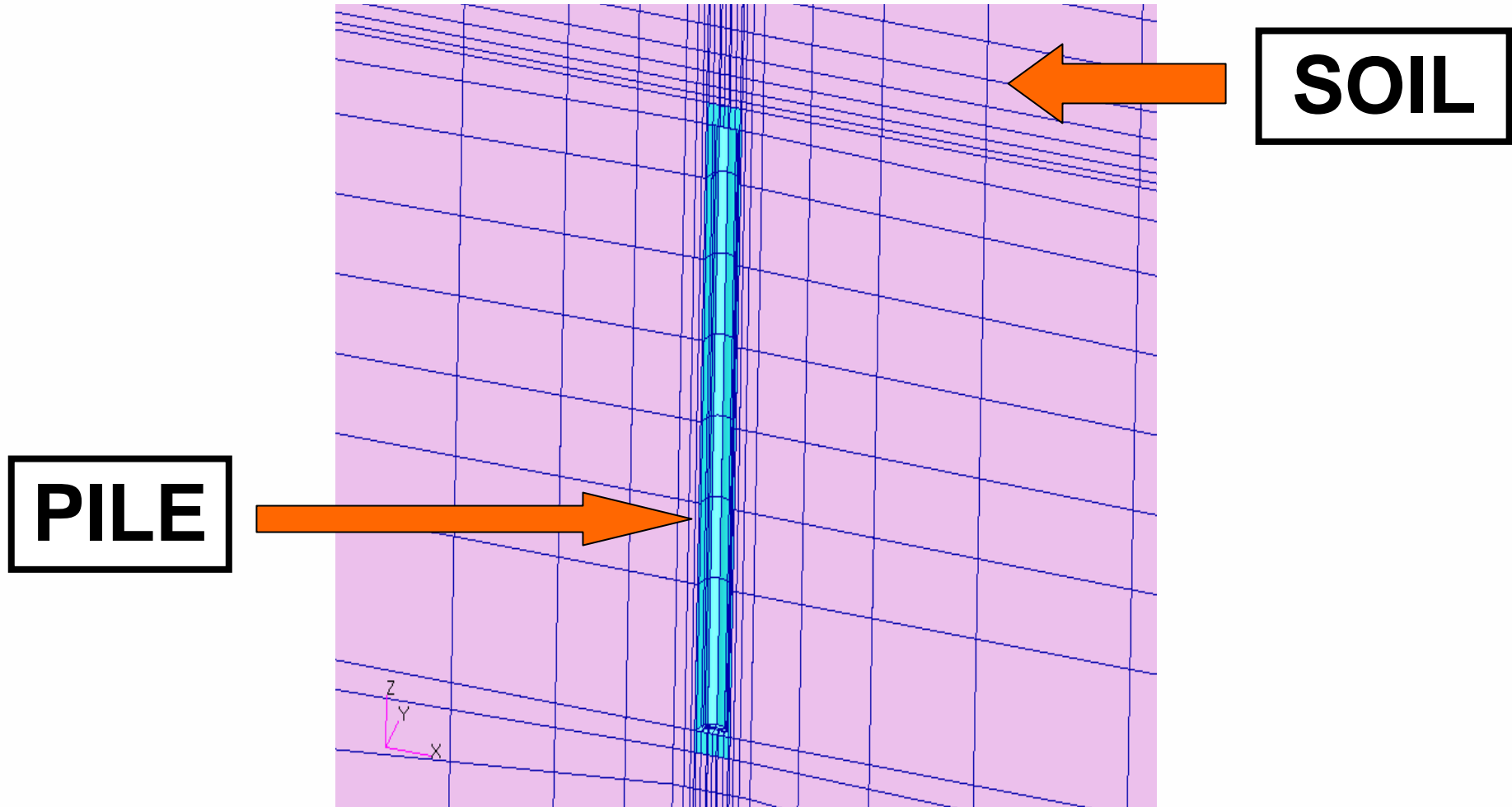
SYMMETRIC PILE MODEL



PRODUCT DEVELOPMENT CONFERENCE



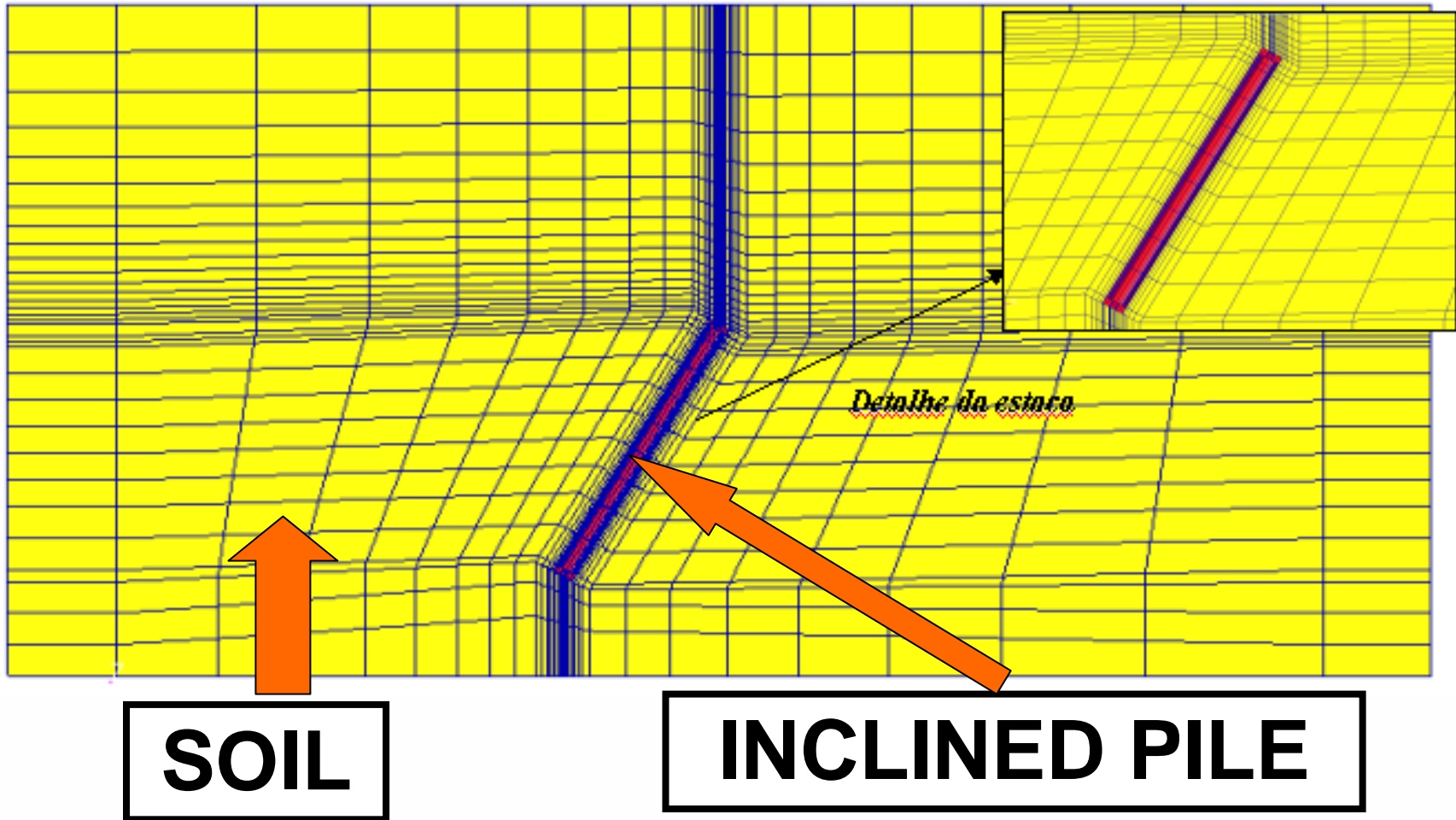
DETAIL OF THE SYMMETRIC MODEL

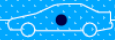


PRODUCT DEVELOPMENT CONFERENCE

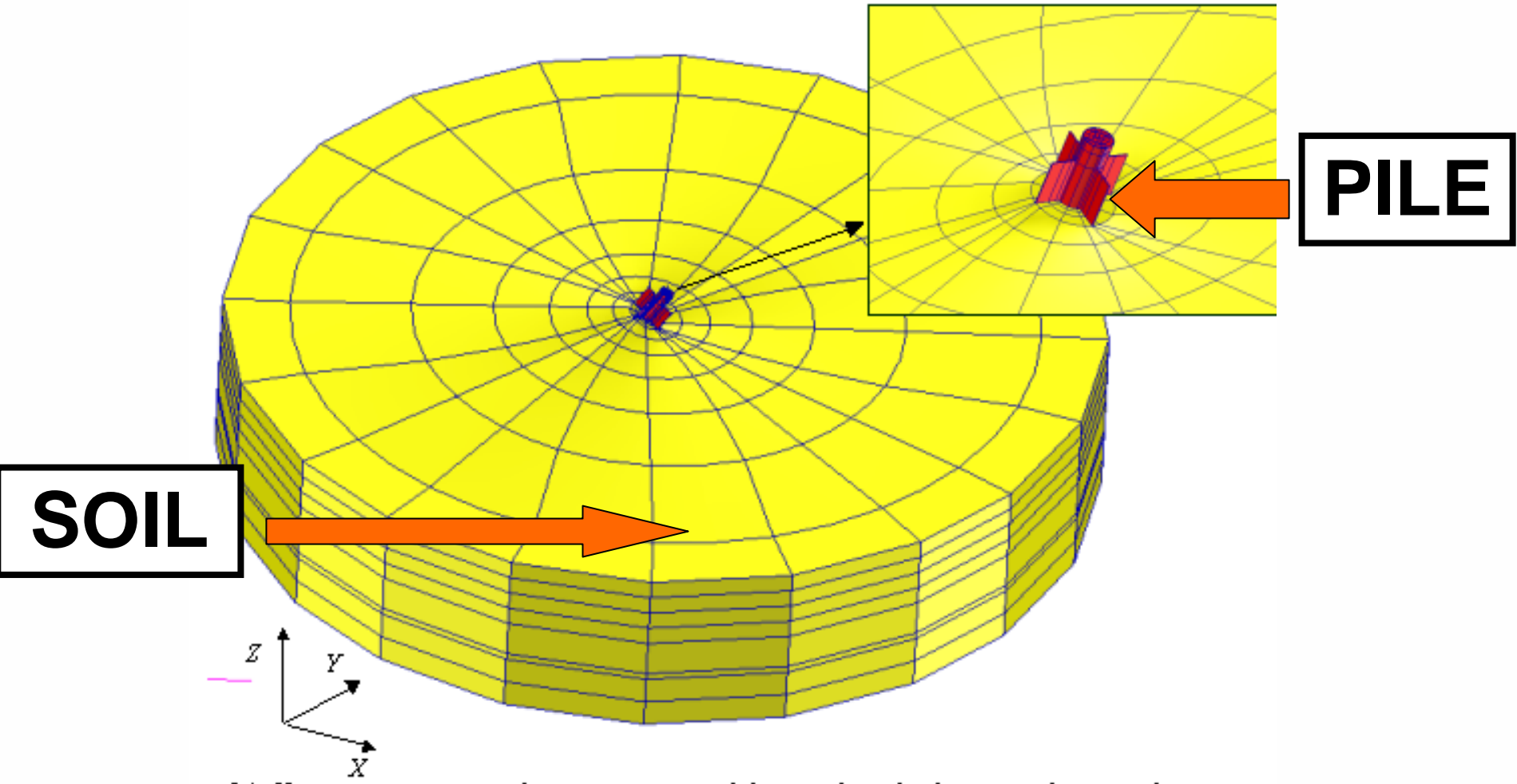


NON-SYMMETRIC MODEL





NON-SYMMETRIC MODEL - DETAIL



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SOIL DATA DEFINITION

**Number of
Soil
LAYERS**

**Buttons for
LAYERS
definition**

NUMERO DE CAMADAS DE SOLO

- 1 camada 3 camadas
 2 camadas 4 camadas

Camada 1

Camada 2

Camada 3

Camada 4

Apply

Cancel

**Equation for
each LAYER**

MATERIAL DA CAMADA:

- Não drenado Drenado

Z inicial:

Coef. de Poisson:

Angulo de atrito:

Su_0:

Gradiente de Su:

Young/Su:

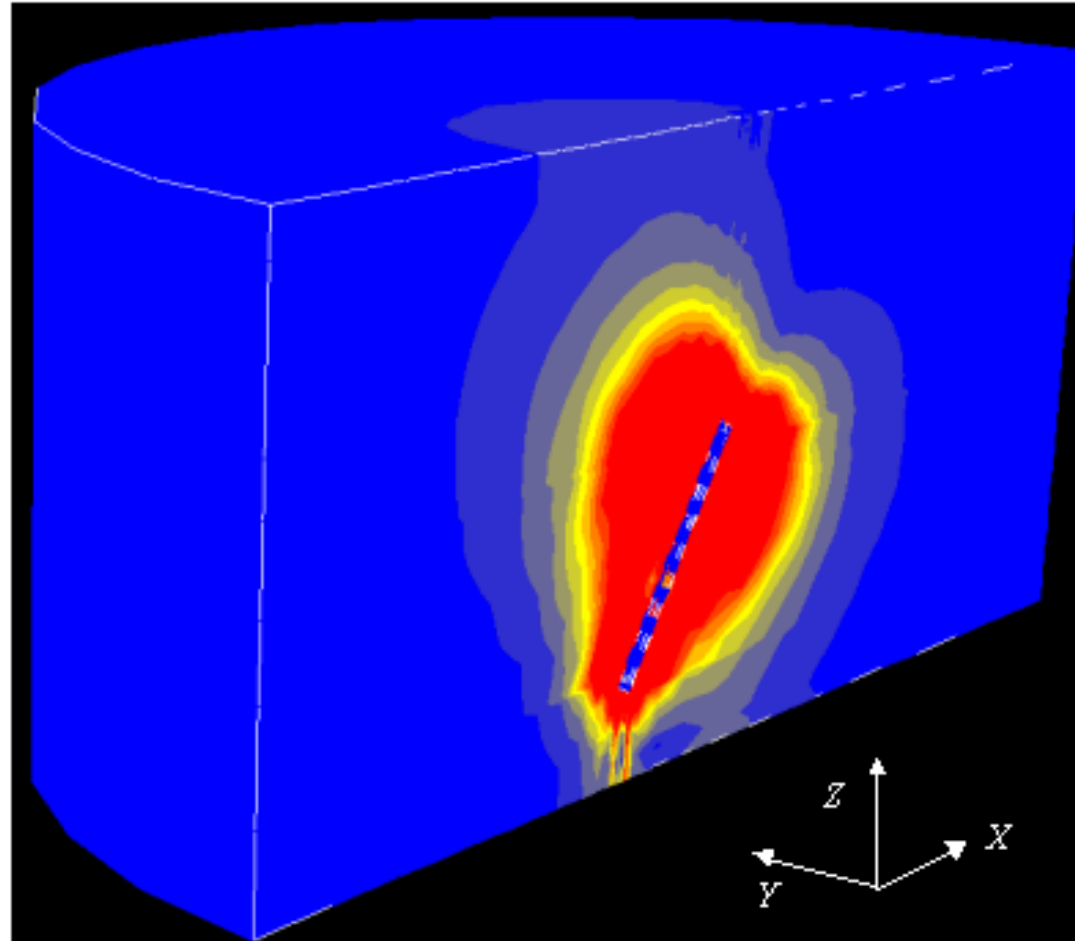
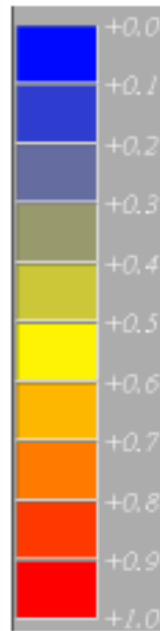
Apply

Cancel

PRODUCT DEVELOPMENT CONFERENCE



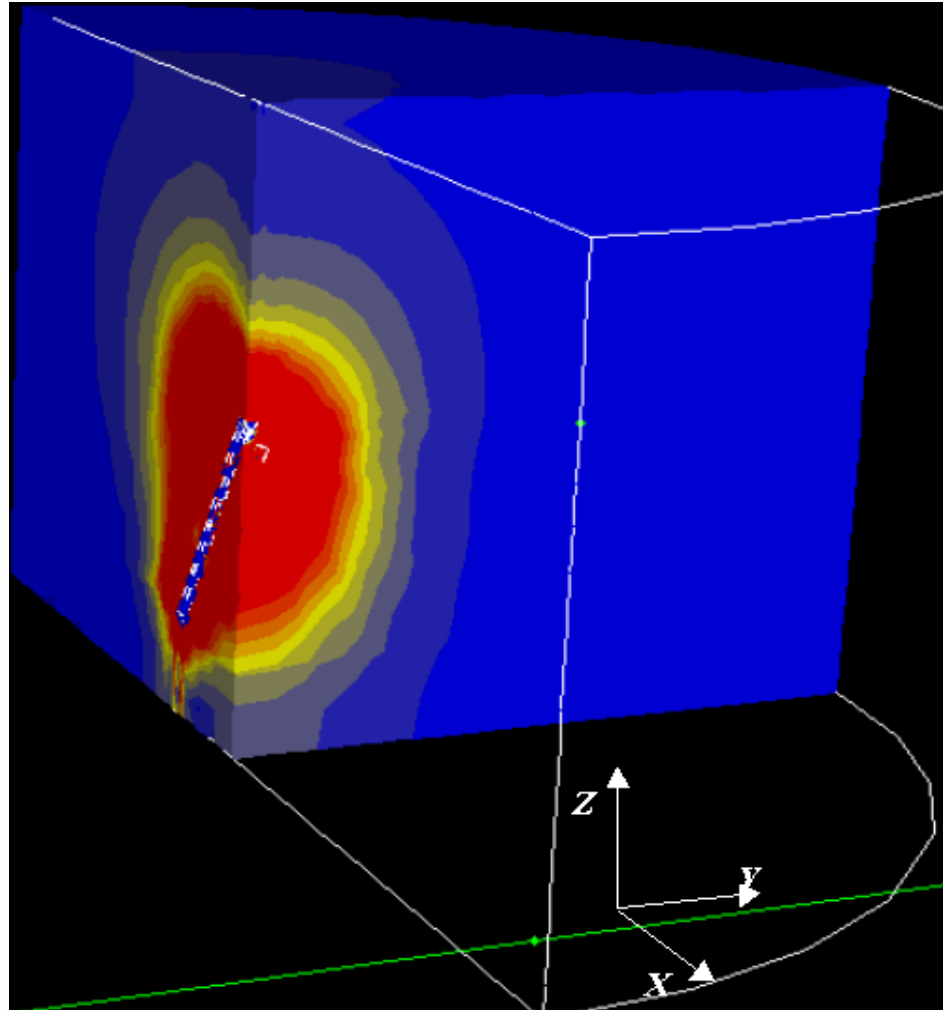
POST-PROCESSING USING POS-3D



PRODUCT DEVELOPMENT CONFERENCE



POST-PROCESSING USING POS-3D



PRODUCT DEVELOPMENT CONFERENCE



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
- Reliability in Model Generation produced by the Automation Process.

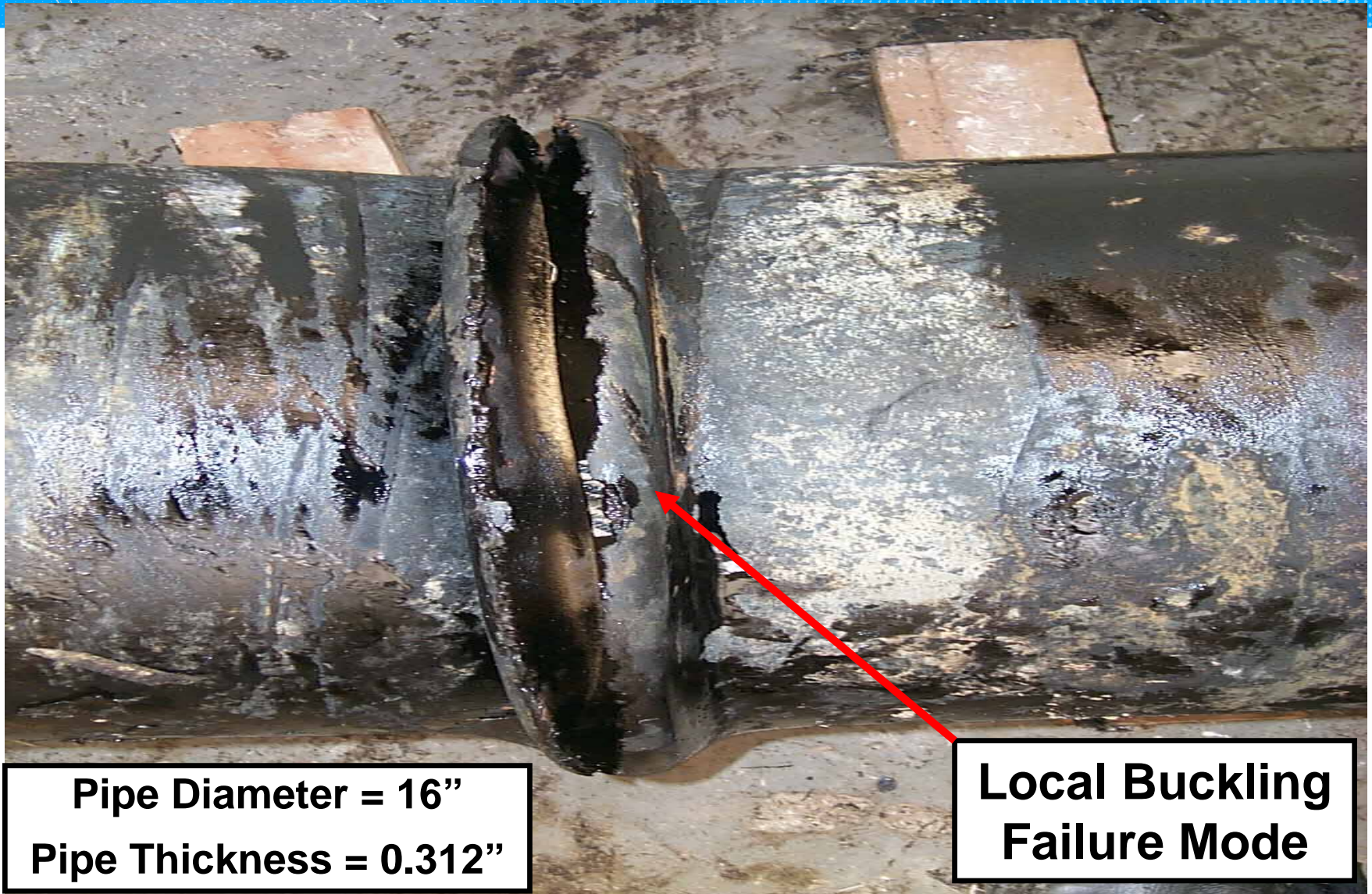


PIPELINE MODEL GENERATOR:

Motivation for the work:

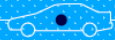
*Accident in PETROBRAS PE-2 pipeline
in Guanabara Bay - January 2000 -
Brazil*

Leakage of 1.300.000 liters of oil



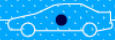
Pipe Diameter = 16"
Pipe Thickness = 0.312"

**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**



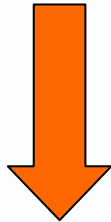
STRATEGIC APPROACH

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MSC.Patran users
- Model generation through PCL (Parametric Command Language)
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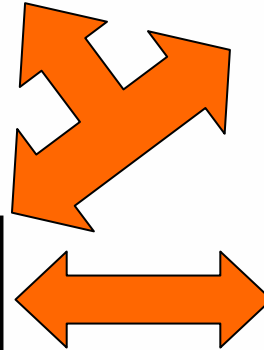


PROPOSED FLOW CHART

**PRE AND POST
PROCESSING**



MSC.Patran

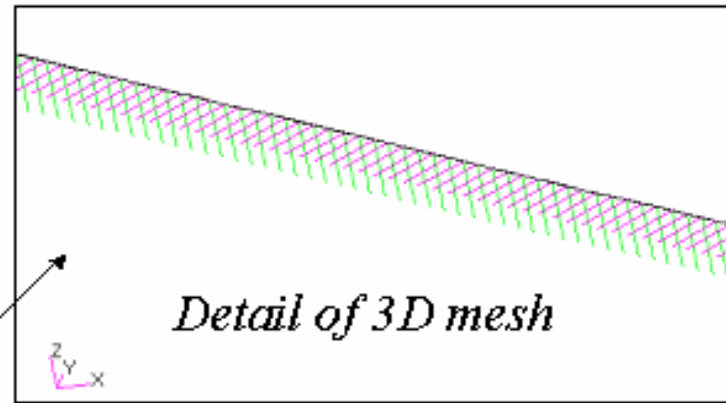


**PCL for
Problem
Automation**

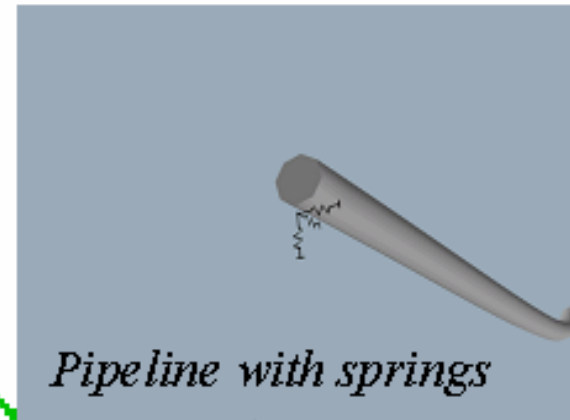
**Abaqus for
Analysis**



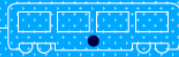
3 spring elements/node



Elements for longitudinal soil strength NOT shown



PRODUCT DEVELOPMENT CONFERENCE



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

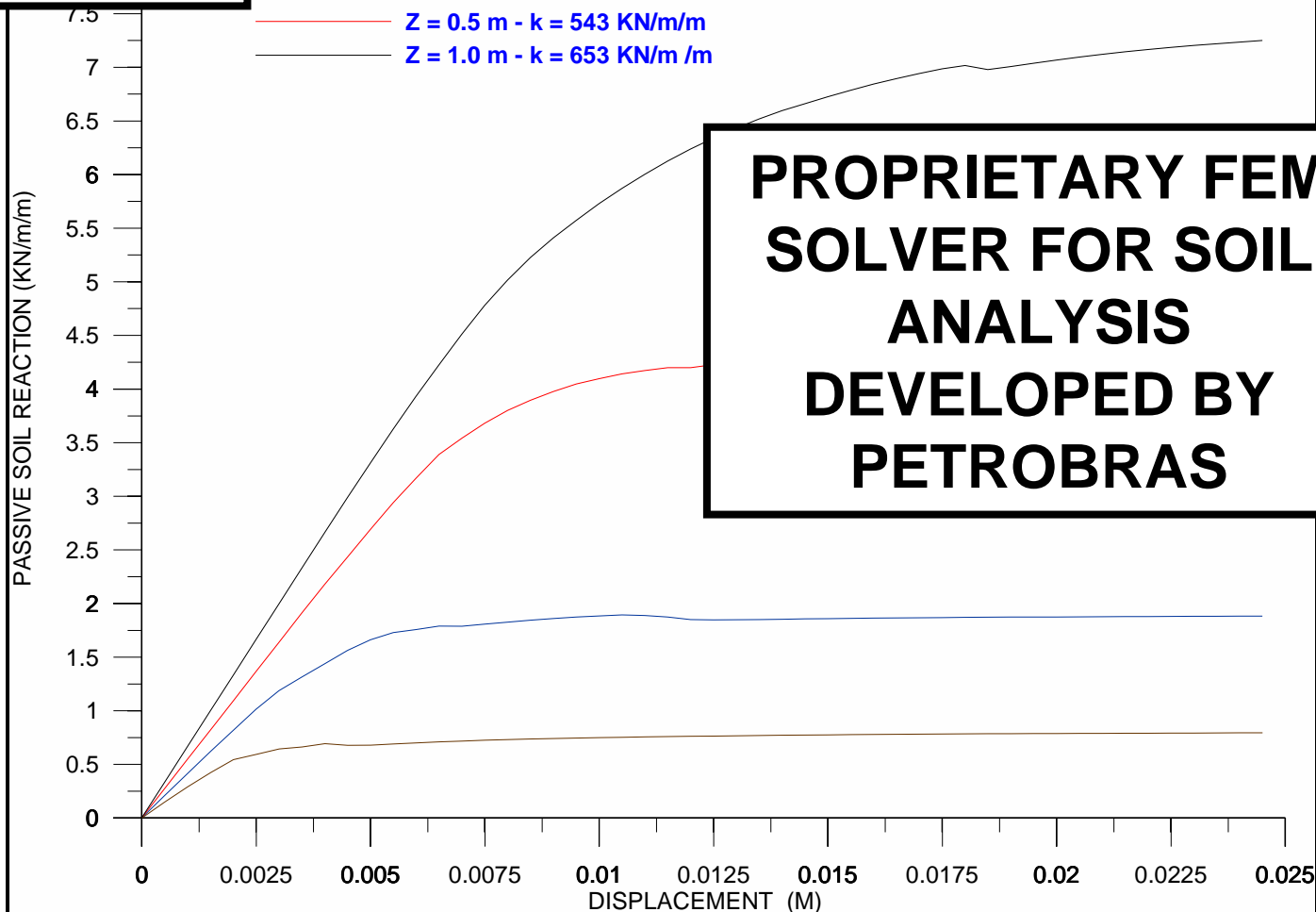


LATERAL NON-LINEAR PASSIVE REACTION CURVES

AEEPECD RESULTS

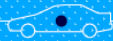
INITIAL PENETRATION OF PIPELINE IN (M)

- 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



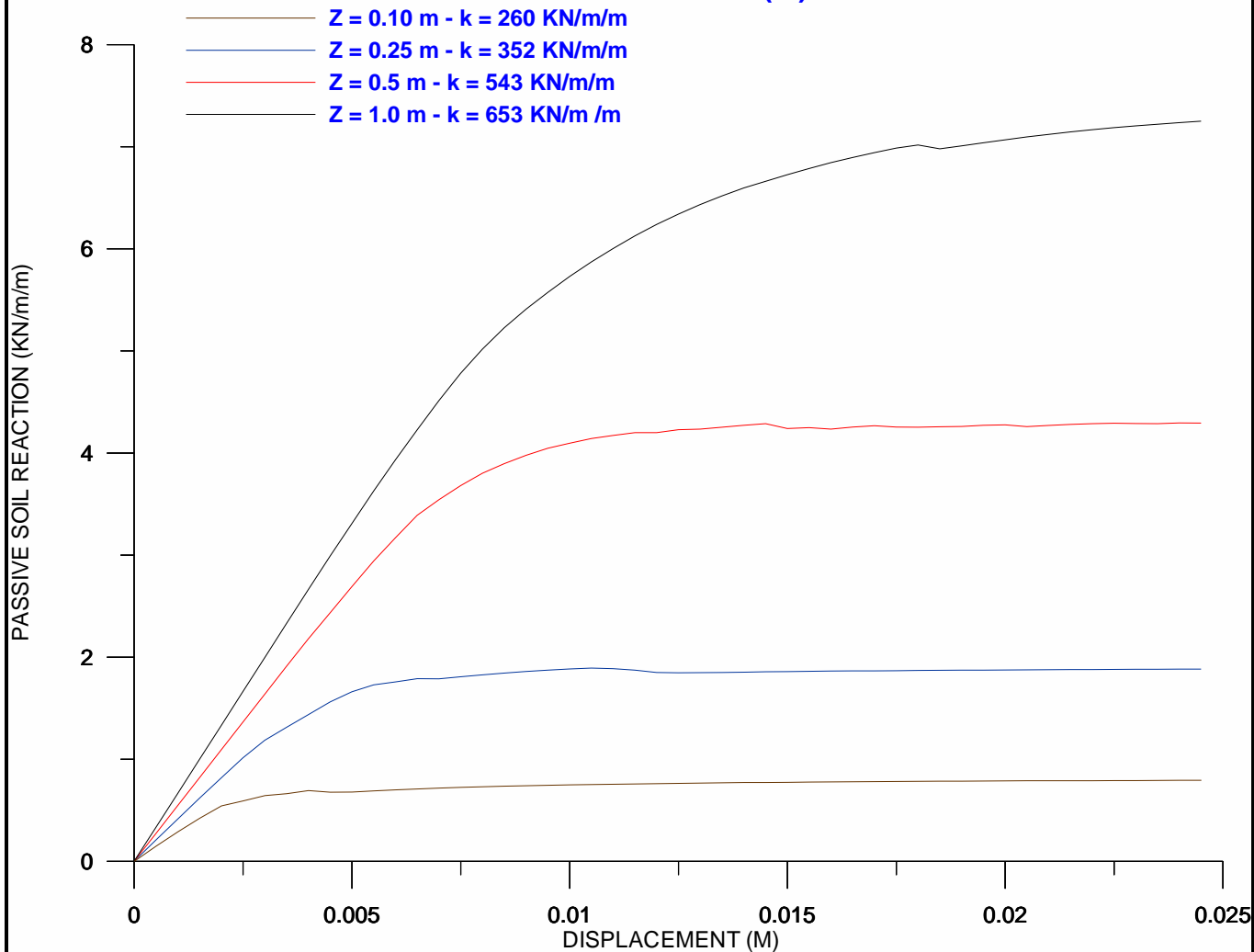
**PROPRIETARY FEM
SOLVER FOR SOIL
ANALYSIS
DEVELOPED BY
PETROBRAS**

PRODUCT DEVELOPMENT CONFERENCE

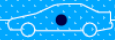


VERTICAL NON-LINEAR PASSIVE REACTION CURVES

INITIAL PENETRATION OF PIPELINE IN (m)

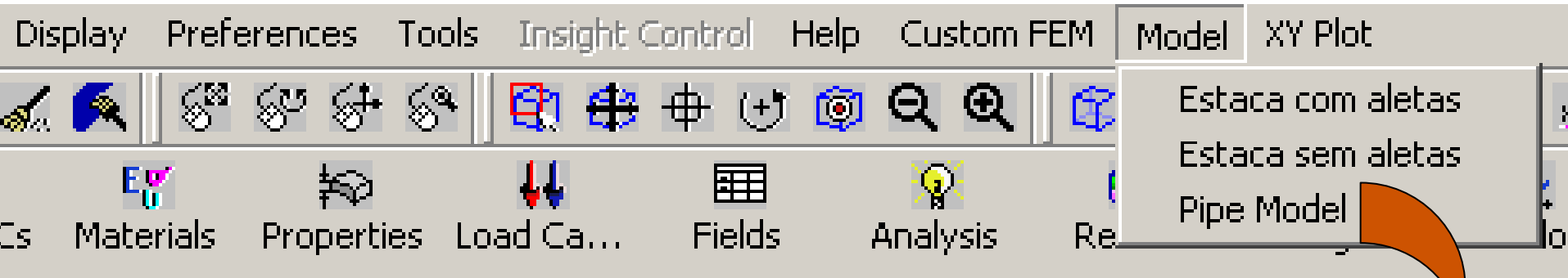


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PROPRIETARY USER INTERFACE

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



**Activate Pipe Model
Generation Procedure**



SCREENS FOR DATA ENTRY

Pipe Model Generation

Model Definition

Dia. ext. do duto (in):	16.0
Tamanho global dos elementos (mm):	1000.0
Espessura 1 de parede (in):	0.312
Espessura 2 de parede (in):	0.312
Coordenada X dividindo espessuras 1 e 2 (m):	0.0
Espessura de cimento (in):	2.0
Fator de solo:	1.0
Numero de pontos por Spline:	4
Arquivo com as coordenadas XYZ:	XYZ
Arquivo com os dados de solo:	F_SOLO_ML2
Delta T de analise:	60.0
Delta T max.:	6.0
Delta T min.:	1e-008

Material

Apply Cancel

Main Screen Data

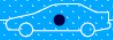
Material Data

Pipe Material Form

Material Parameters

Nome do Material:	Aco_API_X52
Modulo de Young (MPa):	205000.0
Coeficiente de Poisson:	0.3
Densidade equivalente (Kg/mm ³):	1.3958e-005
Condutividade termica:	1.17e-005
Limite de Escoamento (MPa):	425.88
Limite de Ruptura (MPa):	698.22
Deformacao na Ruptura:	0.25356

Apply Cancel



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**



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SOIL STRENGTH DATA

Maximum number of points for any curve

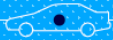
Displacement according to the Force

	Lateral	Longitudinal	Vertical	Lateral	Longitudinal	Vertical	Lateral	Longitudinal	Vertical
3	12.	12.	12.	25.4	25.4	25.4	500.	500.	500.
Z / D	0.	0.	0.	0.	0.	0.	0.	0.	0.
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

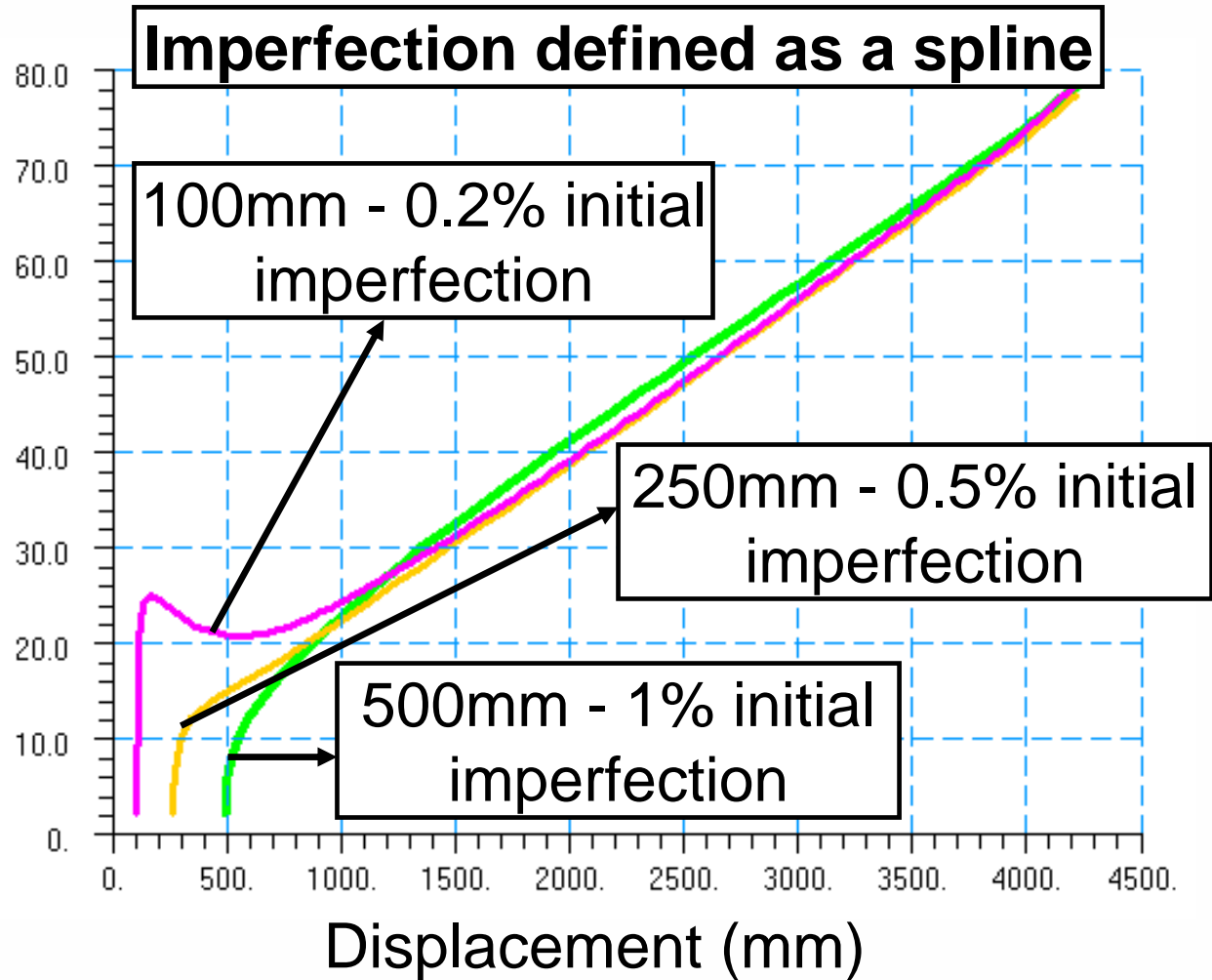
Point 1

Point 2

Point 3



Results for Different Initial Imperfections

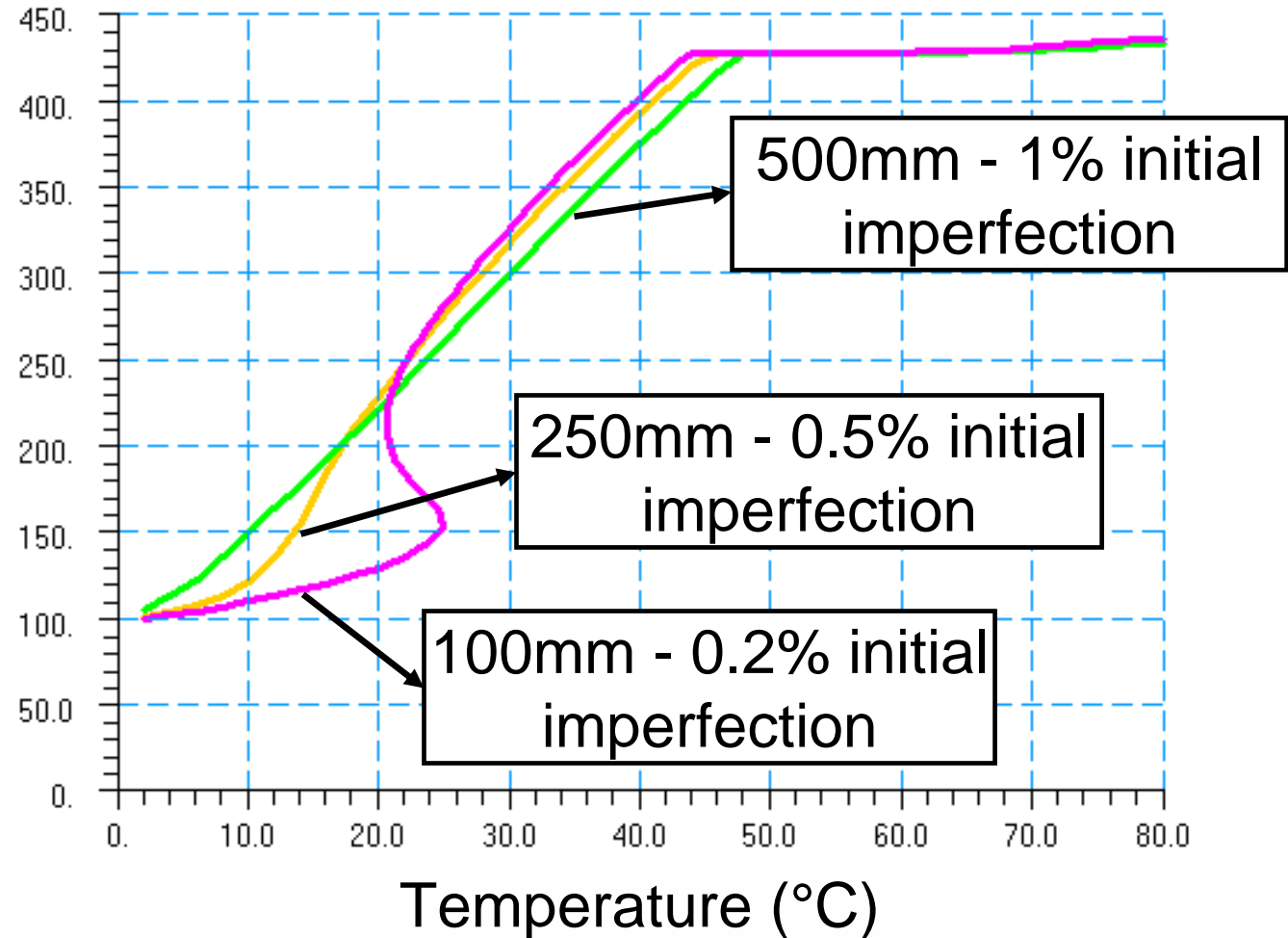


PRODUCT DEVELOPMENT CONFERENCE

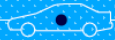


Results for Different Initial Imperfections

Von Mises
Stress (MPa)



PRODUCT DEVELOPMENT CONFERENCE



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
- Reliability in Model Generation produced by the Automation Process.