

ABSTRACT

Title: Integration of “Anleet” and “Anvect” programs in MSC/PATRAN environment

Authors: Alejandro Andueza, MSc. – Sercon Consulting Services- Rio de Janeiro, Brazil.

Claudio dos Santos Amaral, MSc. – Petrobrás/Cenpes - Rio de Janeiro, Brazil.

Alvaro Maia, Ph.D. – Petrobrás/Cenpes - Rio de Janeiro, Brazil.

Sercon is a consulting company committed to offering Finite Element design solutions to the market. We have a long-term experience in the oilfield market, offering FEA analysis and design of subsea equipment. Most recently, as part of a close relationship between Sercon and MSC Brazilian office, we have also been offering customized solutions to MSC clients.

Petrobrás is one of the biggest oil companies in the world with an annual revenue of over 20 billion dollars. It is currently committed to developing technology to extract oil from deep-water. Petrobrás has already found oil fields at depths of over 8000 ft of water.

“Anleet” and “Anvect” programs are custom tools developed by Petrobrás to help it in the design of special piles and anchors which are used as fixed points of the anchoring lines of floating production units such as sub-submersibles and FPSO’s. These programs have specific features that MSC/PATRAN is not able to pre-process in its commercial version. Prior to the development of this work, Petrobrás took too much time to generate the input deck for “Anleet” and “Anvect” programs using external programming in order to modify MSC/PATRAN neutral file.

The purpose of this paper is to show the integration process developed by Sercon to attend Petrobrás’s requirements using MSC/PATRAN open architecture. As part of the integration process we have developed specific mesh generators for 3D contact elements and 3D infinite elements.

We have also developed a parametric model to help Petrobrás to speed up the optimization process of the anchor design.

INTRODUCTION

This paper is intended to show the integration of “Anleet” and “Anvect” programs in MSC/PATRAN environment. We are also presenting a parametric model developed to speed up the optimization process of Petrobrás’s anchors design problem.

“Anleet” and “Anvect” are custom tools developed by Petrobrás through its effort to extract oil from deep-water. These programs require some specific features that MSC/PATRAN is not able to supply in its commercial version, like non-symmetric elements and new types of boundary conditions.

We used MSC/PATRAN open architecture to develop three new elements. The first one for 3D contact, the second one for 3D infinite boundary representation, and the last one a solid element with a node numbering not supplied by MSC/PATRAN element library.

PROBLEM DEFINITION

We require the generation of the following new elements:

- Solid element – 20 nodes (see figure 1)
- 3D contact element – 16 nodes (see figure 2)
- 3D infinite element – 12 nodes (see figure 3)

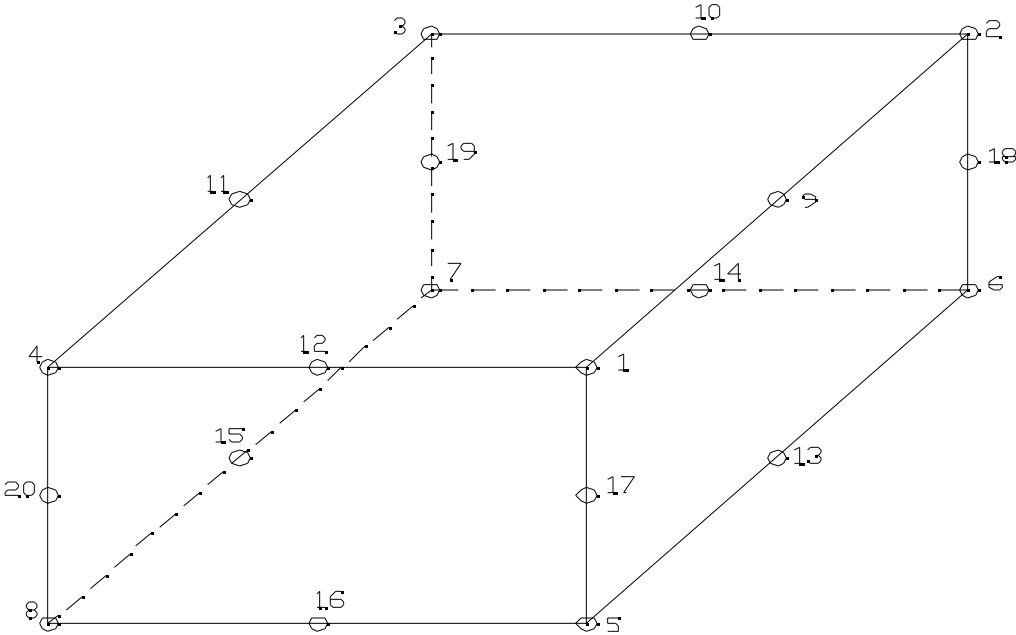


Figure 1 – 3D Solid Element

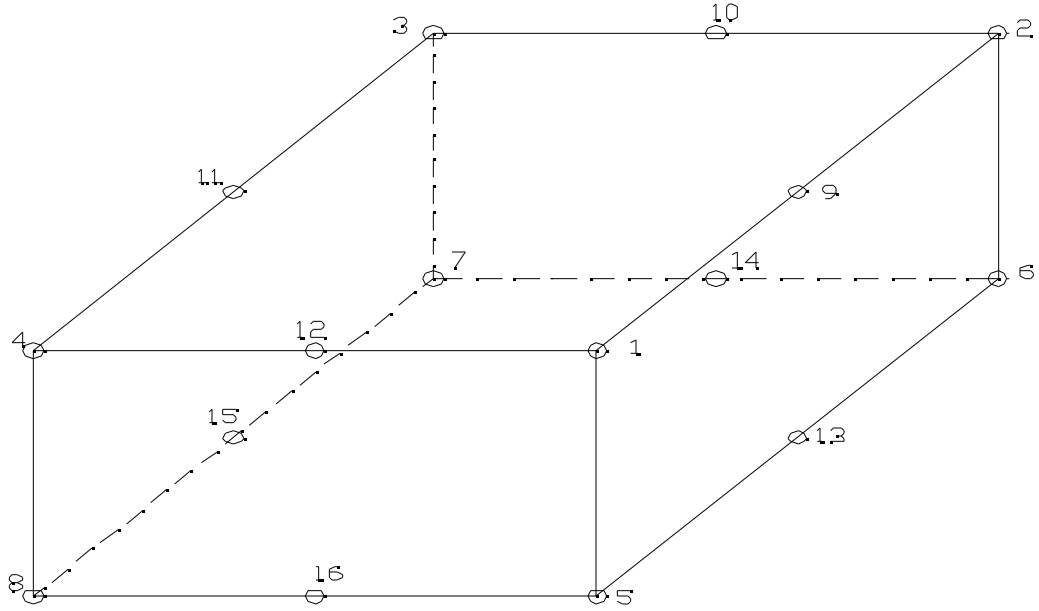


Figure 2 - 3D Contact Element

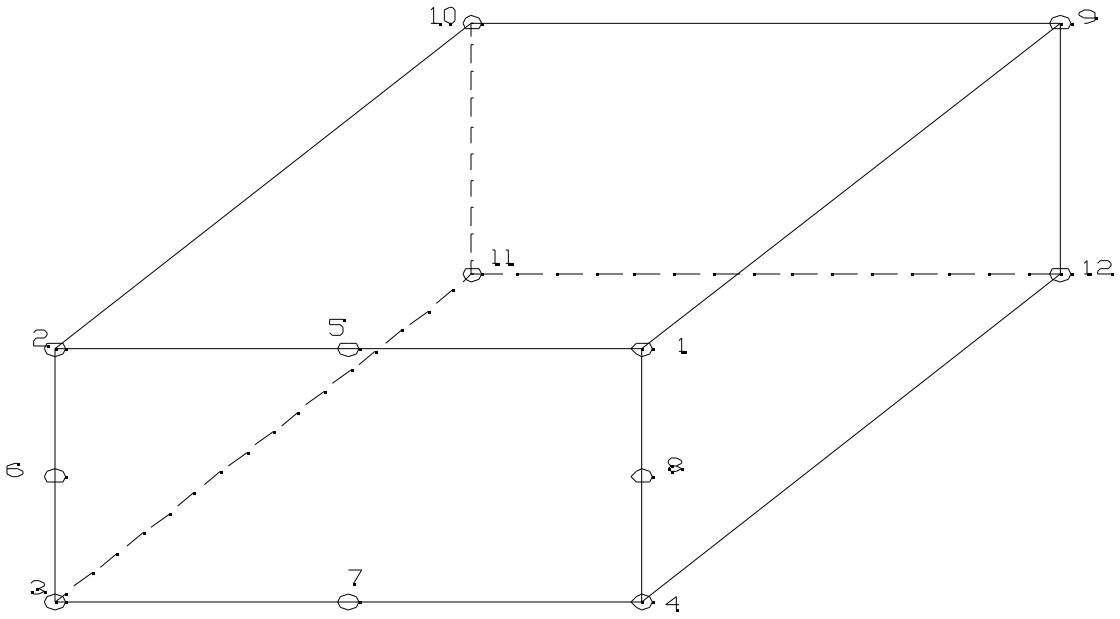
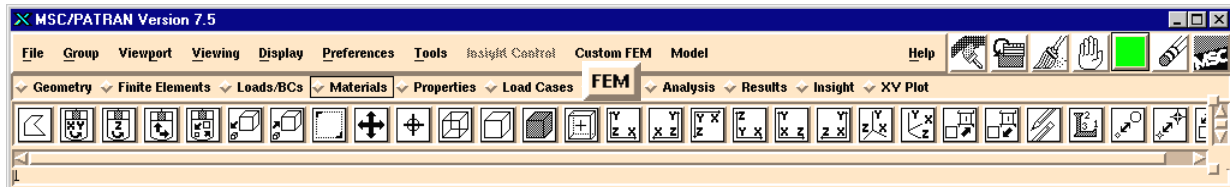


Figure 3 - 3D Infinite Element

All of these new elements were stored using the HEX20 MSC/PATRAN topology. No new topology was created.

The main menu below shows the way to activate the menu that controls the mesh generation for the new contact and infinite elements.



In order to customize MSC/PATRAN to the new codes, we created two new preferences. The first one for “Anleet” and the second one for “Anvect” programs. These new preferences allow the input of all the specific parameters of the programs, as well as specific new boundary condition types.

GENERATION OF 3D SOLID ELEMENT

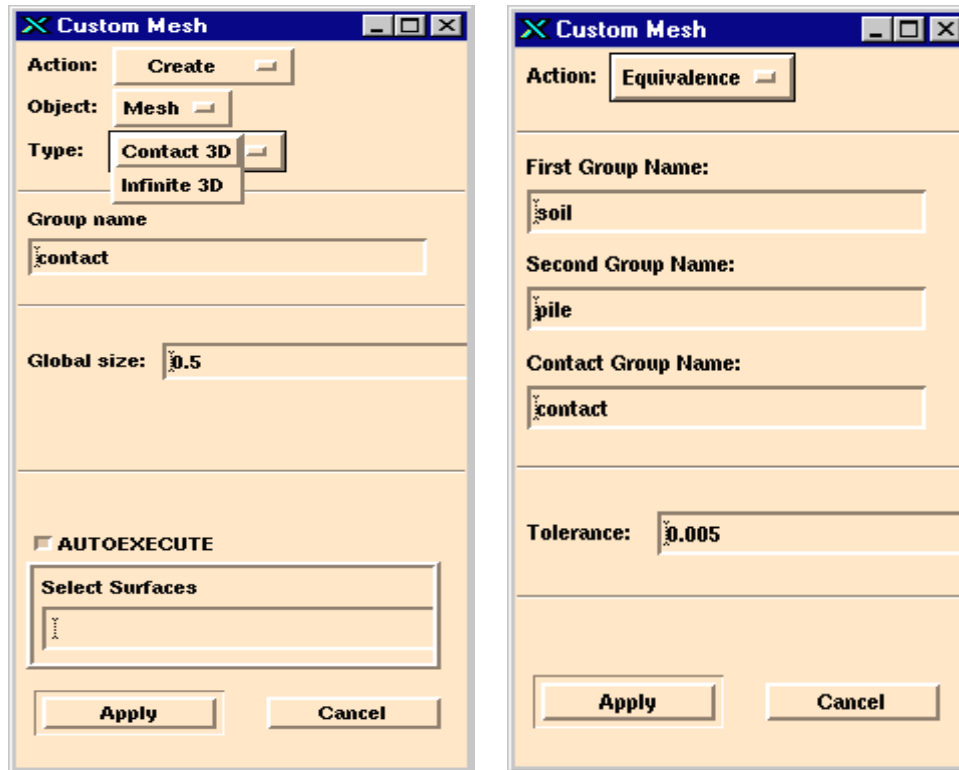
We needed to create the 3D solid element showed in figure 1. This element has a specific numbering that MSC/PATRAN does not support. This is the simplest of the three new elements to generate. The normal 3D solid element is used and the new numbering order is implemented during the generation of the input deck for the programs.

MESH GENERATOR FOR 3D CONTACT ELEMENTS

We developed a new mesh generator to automatically create 3D contact collapsed element meshes using PCL programming language. The new elements are completely integrated in MSC/PATRAN environment, allowing any kind of operation.

The mesh generator requires as input a list of surfaces (representing the contact area) and a group name in which the new elements will be included. The mesh seeds may be defined through MSC/PATRAN normal procedures. The routine also allows a global size length parameter definition.

The algorithm meshes the surfaces with 2D QUAD8 elements at first, using MSC/PATRAN mesher. After that, the program uses the information of the 2D elements to create 3D collapsed solid HEX20 elements using only 16 nodes. So, each contact element has 4 zero positions in the connectivity matrix for the HEX20 information.



The node information for each 8-node-face for these contact elements is stored in separated groups in order to allow a correct equivalence procedure. We created a special equivalence function to use with these new elements in order to merge the nodes of these elements correctly with the rest of the model. This is due to the fact that we have duplicated nodes, on the contact surface, that cannot be merged.

The user interface for these functions is presented on the next page. We used the same concept [Action-Object-Type] used by MSC/PATRAN, in order to make the procedure easy to be learned. We defined default values for all the information required for this function to work.

The surface selection may be made through MSC/PATRAN picking capabilities.

MESH GENERATOR FOR 3D INFINITE ELEMENTS

We developed a new mesh generator to automatically create 3D infinite element meshes using PCL programming language. The new elements are completely integrated in MSC/PATRAN environment, allowing any kind of operation. “Anleet” and “Anvect” codes use these elements to impose boundary conditions of the infinite.

The mesh generator requires as input, a list of surfaces (representing the infinite boundary division) and a group name in which the new elements will be included. The mesh seeds may be defined through the normal MSC/PATRAN procedures. The routine also allows a global size length and infinite “thickness” parameters in order to create the mesh.

The surface selection may be made through MSC/PATRAN picking capabilities.



The algorithm meshes the surfaces with 2D QUAD8 elements at first, using MSC/PATRAN mesher. After that, the program uses the information of the 2D elements to create 3D solid HEX20 elements using the “*sweep-element-normal*” command. The generated elements should be modified in order to remove 8 of their 20 nodes that will no longer be used for the new element. So, each infinite element has 8 zero positions in the connectivity matrix. The final required operation is the removal of the nodes that are no longer used from the database.

The user interface for this function is presented above. We utilized the same concept [Action-Object-Type] used by MSC/PATRAN, in order to make the procedure easy to be learned.

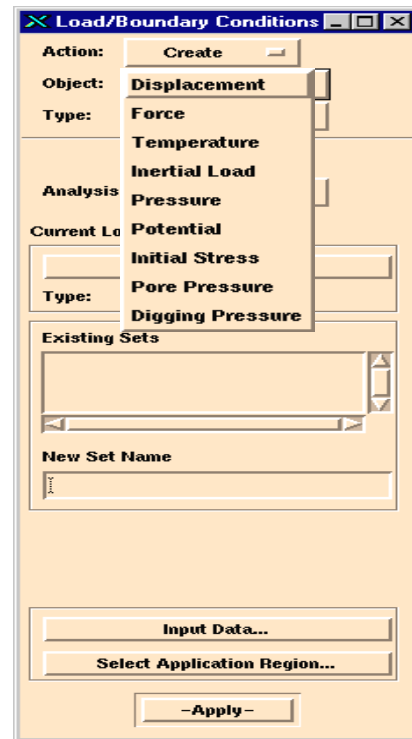
“ANLEET” AND “ANVECT” THROUGH MSC/PATRAN ENVIRONMENT

We created two different preferences for “Anleet” and “Anvect”. These programs have many specific features to model excavation of elements in soil and rock mass.

These specific features require new load/boundary conditions not normally required by the codes supported by MSC/PATRAN.

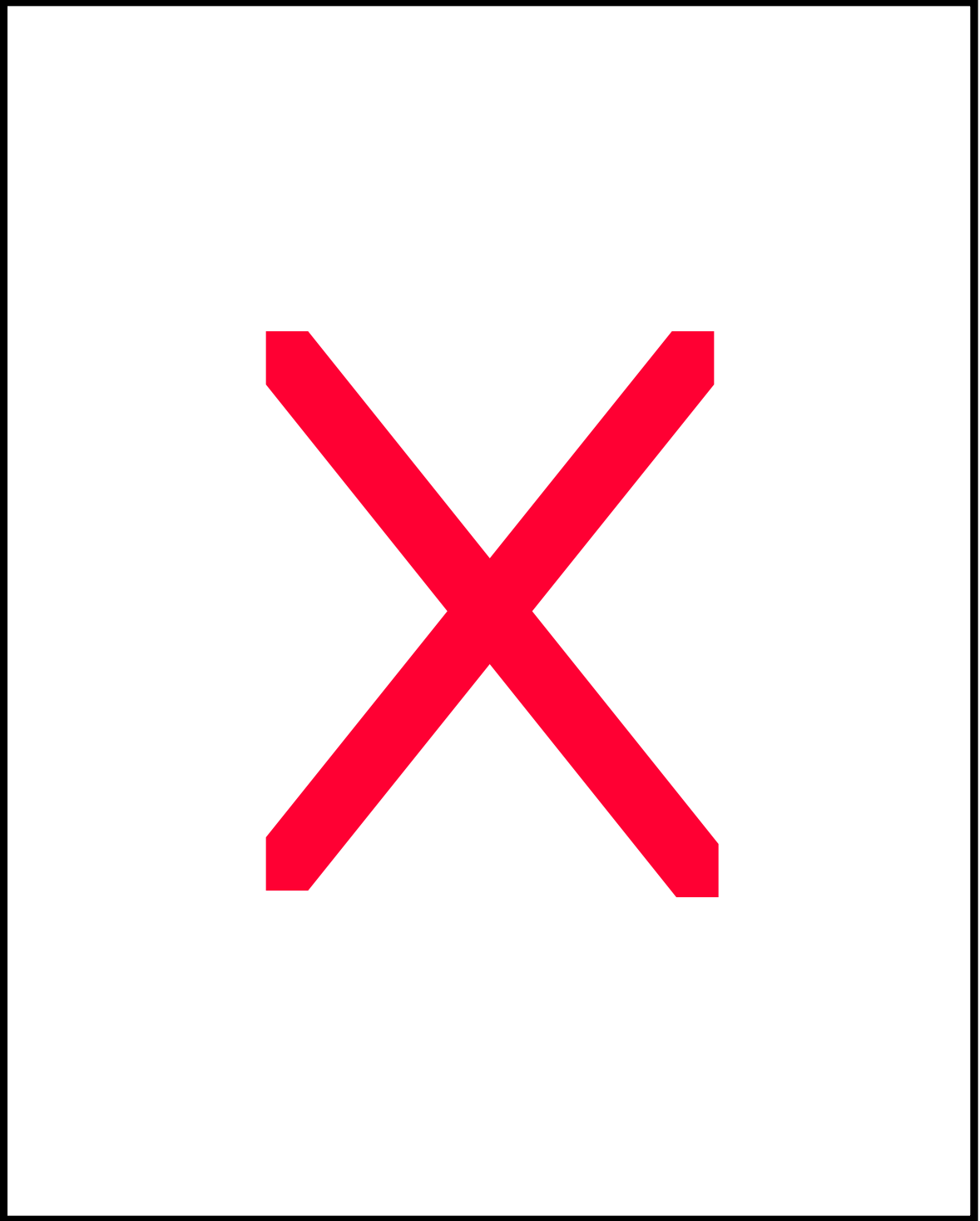
So, new boundary conditions were created like “*Potential*”, “*Initial Stress*”, “*Pore Pressure*” and “*Excavation Pressure*”. The figure beside shows the user interface to create these new LBC.

The codes also require the definition of materials with specific characteristics. So, two material types are allowed, “*Isotropic*” for 3D solid elements and “*contact*” for 3D contact elements.



The forms for material definition are presented on the next page. The preference supports two constitutive models, “*Linear Elastic*” and “*Elasto-Plastic*” for 3D solid elements. The preference also supports one contact constitutive model for 3D contact elements.

The specific Analysis form for “Anleet” program is presented on the next page. Two subordinate forms were defined for the “*Solution Parameters*” control and for the “*Output Controls*”. The information is defined through “*toggles*”, “*switches*”, “*databoxes*” and “*select databoxes*”, using MSC/PATRAN user interface capabilities.

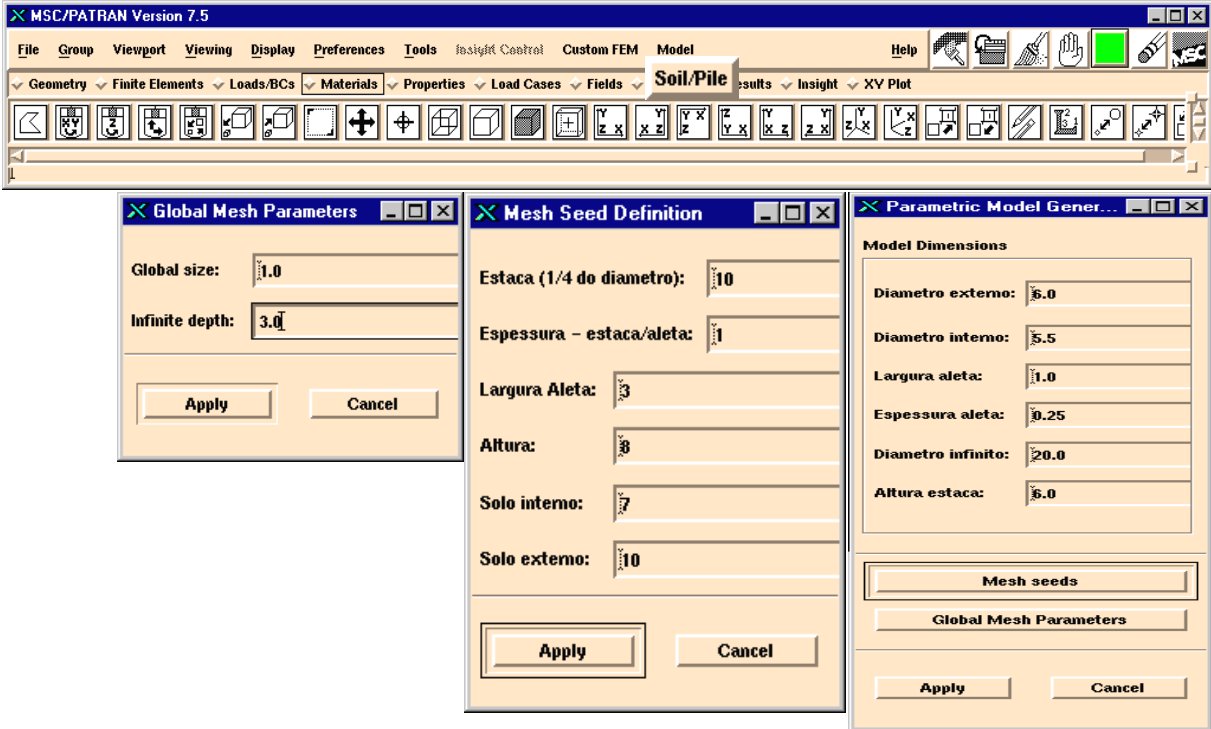


PARAMETRIC MODEL OF A PILE

In order to speed up the anchor design cycle we created a parametric model of the problem.

This parametric PCL program creates a 3D model of the pile and soil elements including the generation of the 3D contact elements and the 3D infinite elements. We used as parameters not only the dimensions of the problem but also the mesh seeds selected by the user. This parametric model used the elements presented in figures 1 to 3.

The PCL code automatically separates the whole model into groups for organization and also sets up the groups' colors. The menus presented below control the model generation.



CONCLUSION

MSC/PATRAN open architecture is a powerful tool to solve integration problems with third party programs, not currently supported by the commercial version, at a very competitive cost.

The integration of “Anleet” and “Anvect” proprietary codes in MSC/PATRAN environment made the generation process of models much easier for Petrobrás’s users as well as reduced the time from **weeks** to **hours**.

The creation of a parametric model reduced dramatically the model generation time from **weeks** to **minutes**. This automated process allowed the analysis of several design options in order to optimize the pile height.

ACKNOWLEDGEMENT

To Petrobrás for the opportunity to develop this paper.

To MSC Brazilian office for the great support before and after the sale of the customization service.

To MSC Corporation for the outstanding training received that speeded up the development of the interface.

REFERENCES

- (1) MSC/PATRAN User’s Manual, Version 7.5, The MacNeal-Schwendler Corporation, Los Angeles, CA August 1996.
- (2) ANLEET User’s Manual, Documentation 1.00 – sep/94.
- (3) ANVECT User’s Manual, Documentation 1.00 – sep/94.