VARYING PRESSURE DISTRIBUTION OVER A GROUP OF ELEMENTS USING MSC/XL

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ABSTRACT

A commonly encountered problem in FEA is applying pressures of linear or non-linear nature, over a group of elements. This paper presents a simple but effective way of specifying these kind of pressures using MSC/XL.

Introduction

In practice, pressure loads in FEA are specified at the corner nodes of each element. The job of a preprocessor is to calculate and distribute the loads applied, over the surface of elements. Currently MSC/XL requires nodal pressures (same or different) to be input for each element manually.

To apply the three dimensional pressure distribution shown in Fig. (1) on a spherical surface, it is necessary to find out the magnitude and pressure direction for each element. This can be applied easily if all the elements have the same nodal pressures. But it is time consuming effort to apply, when the pressure varies in a linear (or non-linear) fashion over the elements as shown in Fig. (1), even if the mesh is regular. The same is true for 1D and 2D elements with different pressure variations. This is a frequently encountered problem as it is not possible to specify nodal pressures always and there is no direct way of doing this in MSC/XL.

To address the above problem a method has been developed using MSC/XL macros.

Suggested Approach

The following procedure explains the method of using "Pressure Surface" or "Pressure Curve" concept for determining the elemental pressures from the given surface loads with the help of Figs. (2) to (6).

Step 1) Creation of Reference Plane

'Reference Plane' forms the basis for defining the magnitude and direction of pressure load.

Reference plane is defined by means of four or three corner grids for elements on regular planar surfaces. For elements forming irregular shapes or on non-planar surfaces, the reference plane is directly defined using MSC/XL geometry functions (Fig. 2). It is essential to ensure that projection of all the elements should be within the reference plane.

Step 2) Definition of " Pressure Surface(s)"

Pressure loads can be defined in two ways.

When the pressure is varying linearly over the elements it can be defined at the corner grids i,e those are used for defining the reference plane. Using corner pressures, a 'Pressure Surface' is created in a direction normal to the reference plane. (Fig. 3).

For pressures of non-linear variation (can be used for linear variation also), the "Pressure Surface" is defined by the user with MSC/XL geometry functions and positioned properly with respect to the reference plane. User can define a set of "Pressure Surface"s, if the non-linear variation can't be defined by a single "Pressure Surface". Care should be taken to avoid overlapping of the surfaces.

Step 3) Calculation of Elemental Pressures

Projection method is used to find out the individual elemental pressures. All the grids falling within the reference plane are projected (in a direction normal to the reference plane) on to the " Pressure Surface(s)" (Fig. 4) and also on to the reference plane (in reverse normal direction). The distance between the projected points on pressure surface and the reference plane (is calculated automatically by the program) provides magnitude of the nodal pressure for each element (Fig. 5 & Fig. 6).

The above procedure is used for plate and solid elements. For line elements "Pressure Curve" is defined instead of "Pressure Surface". It is required to define a third point apart from the corner grids, to construct the plane of application of load. A "reference line" is created for the purpose of measuring the pressure loads.

In the same way as is defined for plate and solid elements, the pressure can be defined either at the corner points for linearly varying loads or by means of defining "Pressure Curve" (Fig. 7) using MSC/XL, for non-linear variation. Then all the grids falling within the end points are then projected onto the "Pressure Curve" (Fig. 8) and on to reference line. The distance between the projected grids on pressure curve and the reference line (is calculated automatically by the program) gives the magnitude of the elemental pressures.

Fig. (9) to (12) show the application of non-linear pressures on plate, solid and line elements.

User Input

User is required to define the group of elements that are subjected to pressure loads, using "group" utility of MSC/XL. The loads can be defined at the corner grids or by "Pressure surface" or "Pressure Curve" definition.

For 3D elements, the faces of the elements that are subjected to the loading, are defined by means of "free faces".

To ensure good results

It is assumed that all the elements/grid points fall within the reference plane when they are projected onto it (for 1D elements all should be within the end points). It is very important to remove the duplicate elements/grids before using this program. The defined pressure surface/curve should extend by some 10% or so beyond the reference plane/line so that all the grids will be projected properly.

Verification and Testing

The method has been used successfully for applying varying pressures on plates, cylindrical surfaces, complex surfaces etc.

Conclusions

This program, which is written entirely using MSC/XL macros, is very useful for applying non-linear pressures over irregular meshes. The method doesn't depend on the element or node numbering and also on the type of elements in the mesh. For example plate elements can contain QUAD4, QUAD8, TRIA3 etc. The program is very useful for applying any kind of pressure variations on 1D, 2D and 3D elements. This will enhance the MSC/XL functionality in practical situations.

REFERENCES

MSC/PRODUCTS

(1) MSC/XL V3A Users Manual, The MacNeal-Schwendler Corporation, Los Angeles, CA, March 1992.

(2) MSC/NASTRAN V67 Reference Manual Vol. 1 & 2, The MacNeal-Schwendler Corporation, Los Angeles, CA, August 1991.

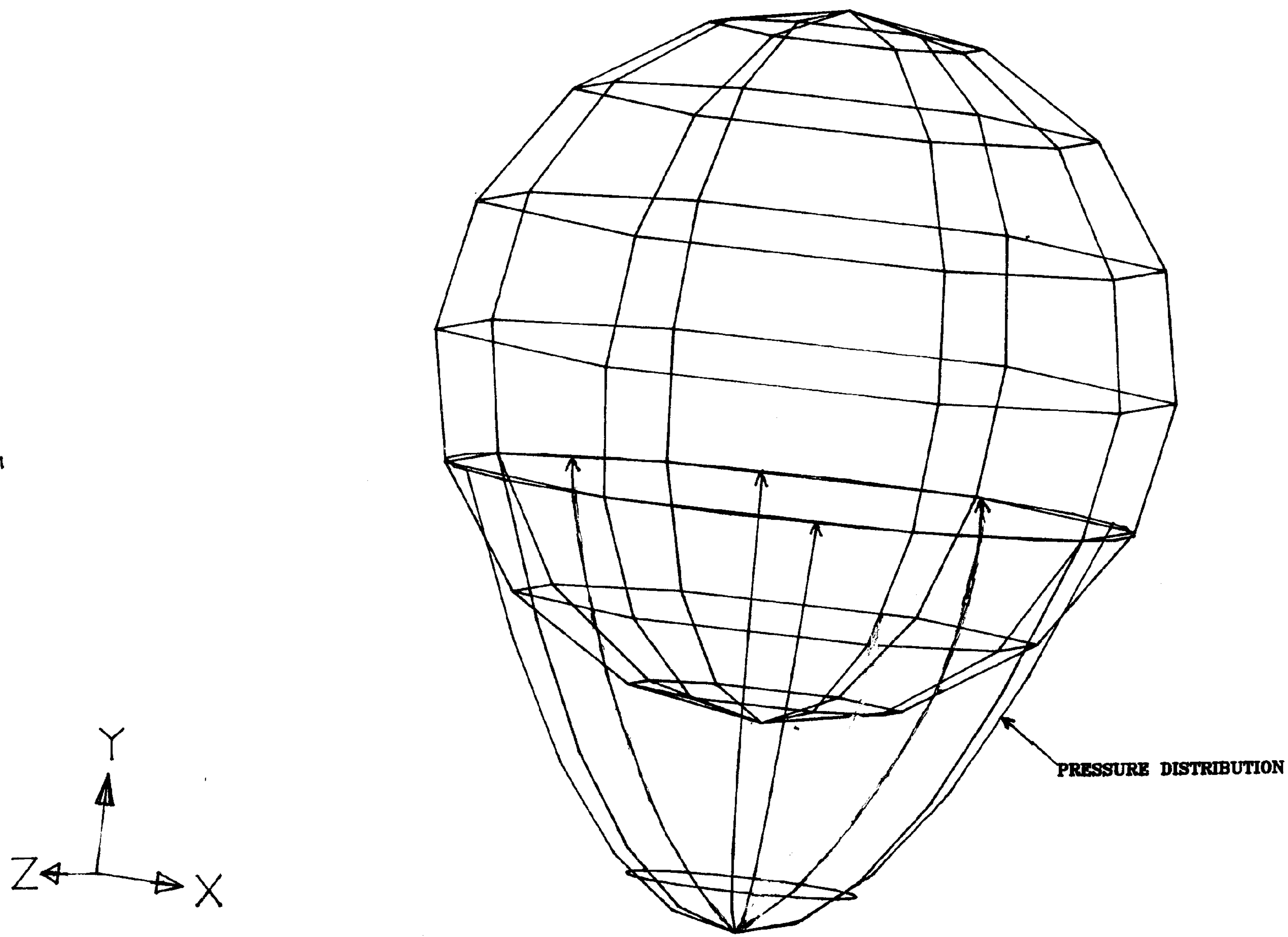

FIG. (1) - PRESSURE DISTRIBUTION ON SPHERICAL SURFACE

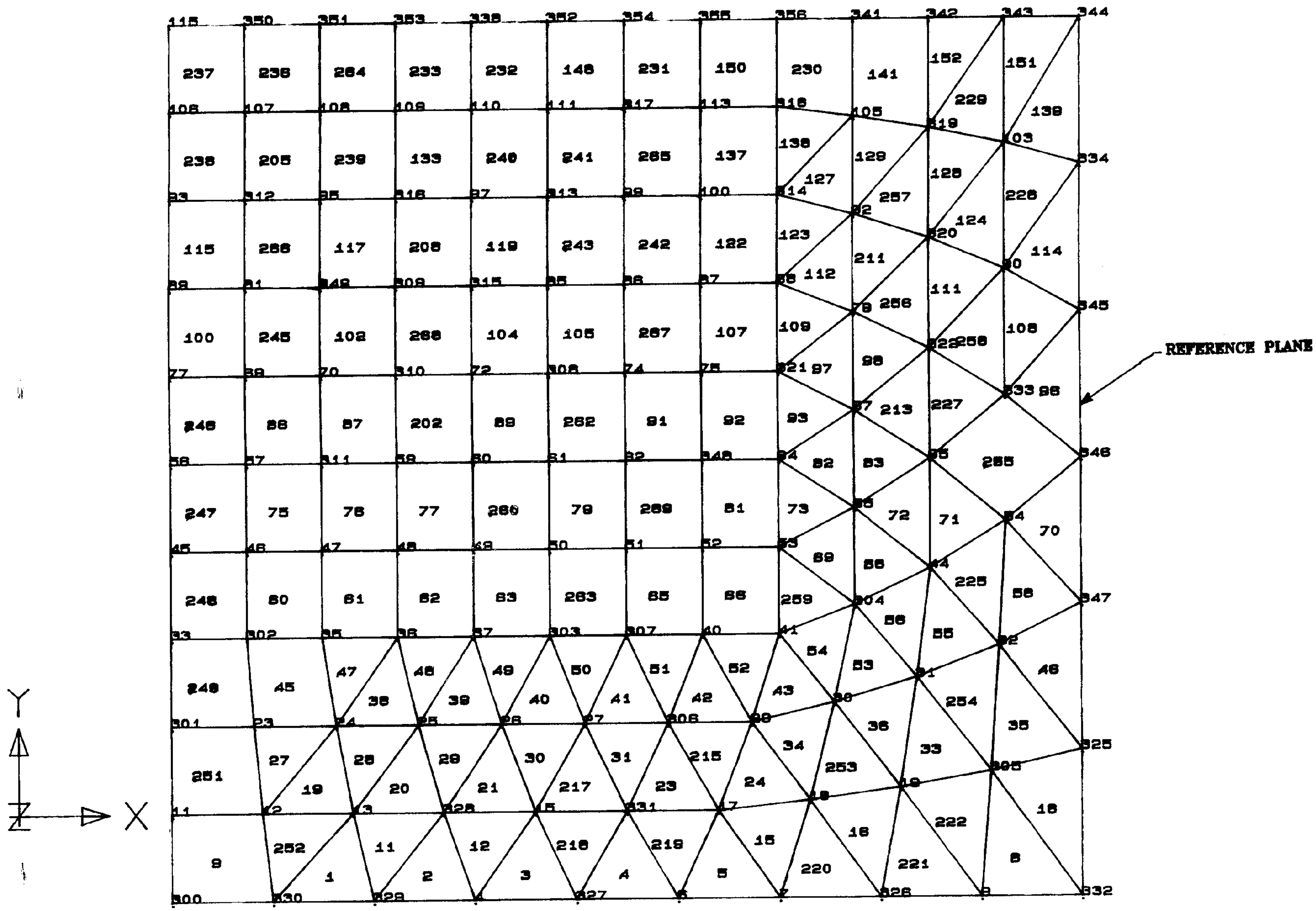

FIG. (2) – ELEMENTS AND GRIDS ON A PLANE

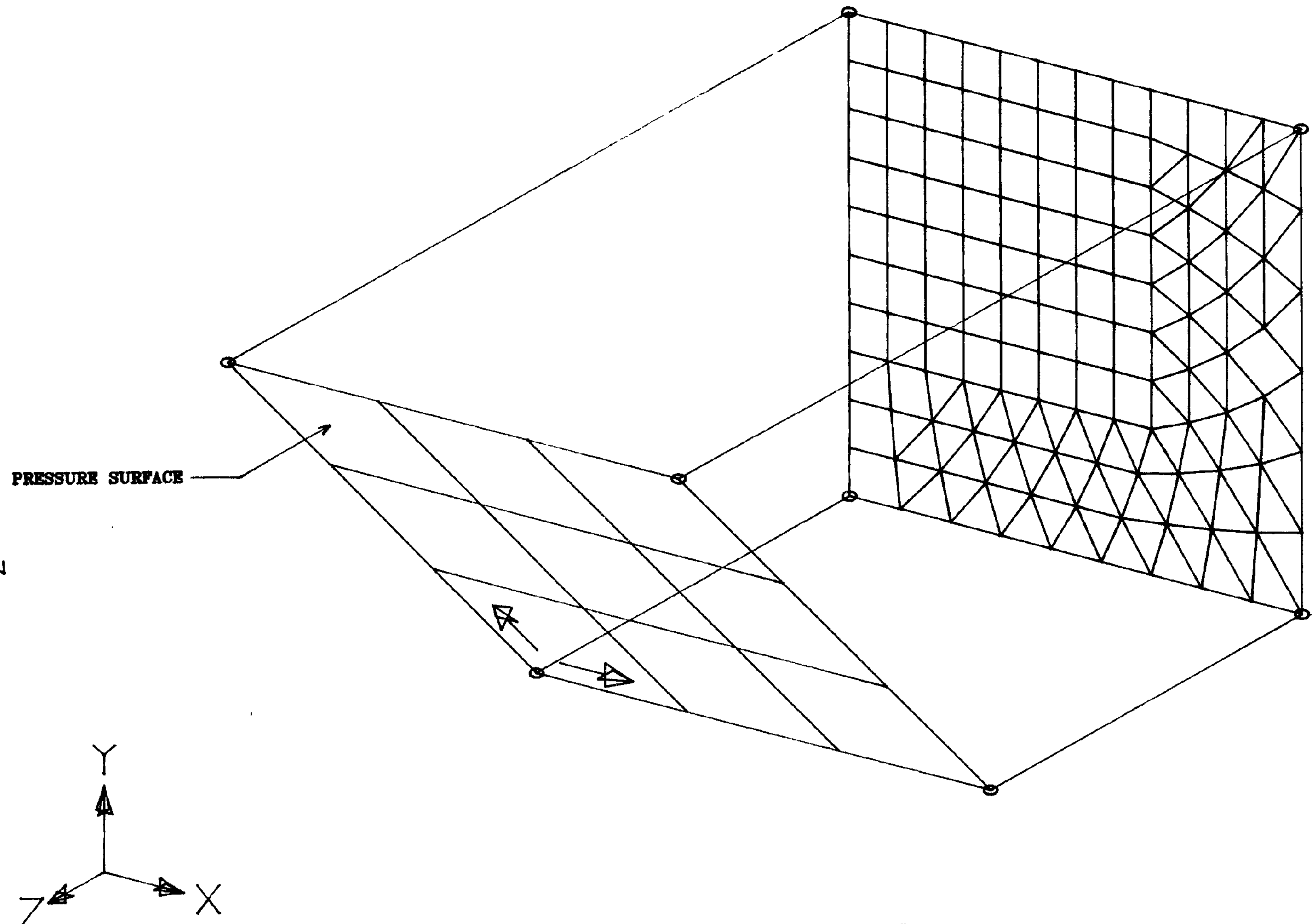

FIG. (3) – "PRESSURE SURFACE" CREATION

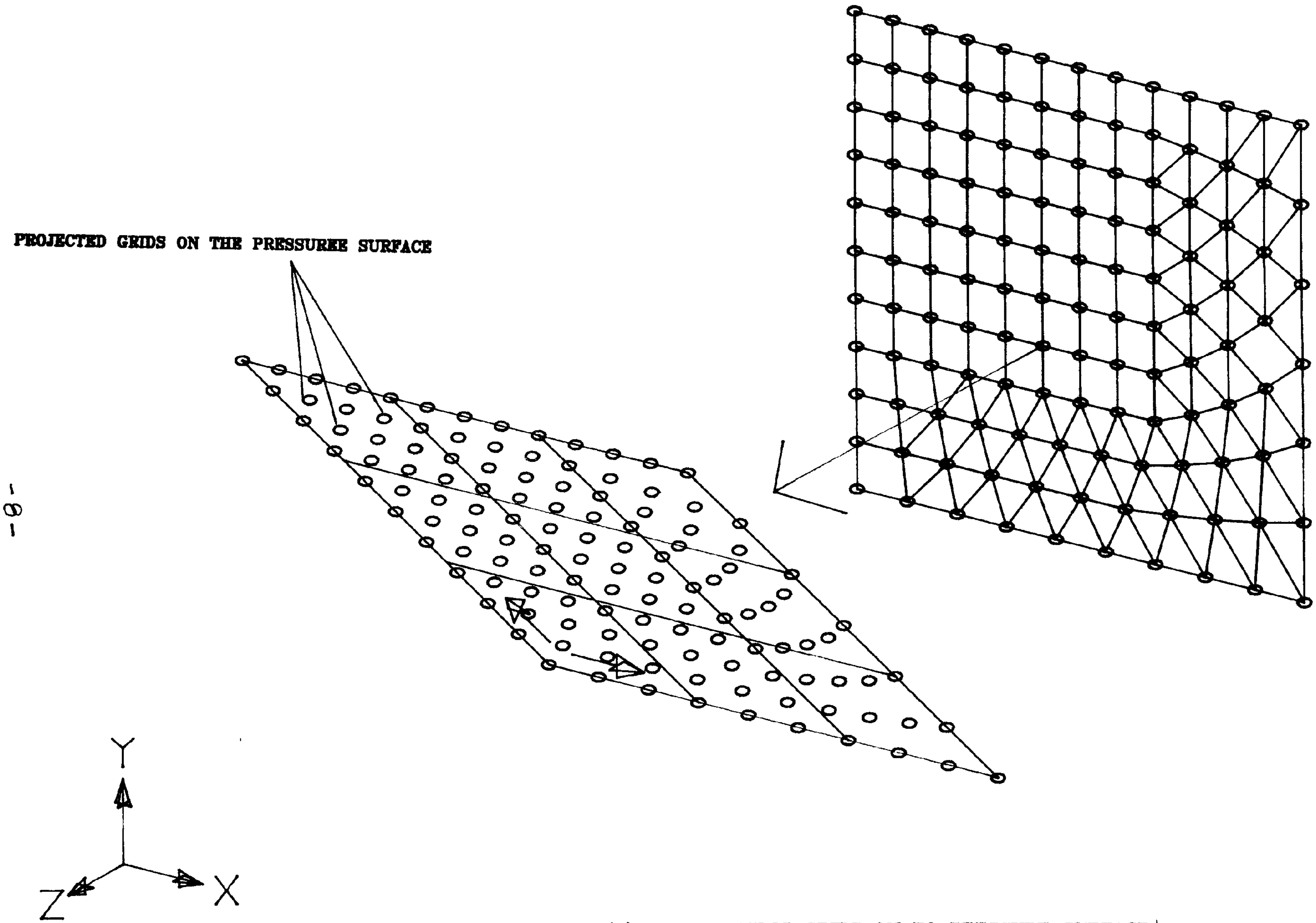

FIG. (4) - PROJECTING GRIDS ON TO PRESSURE SURFACE

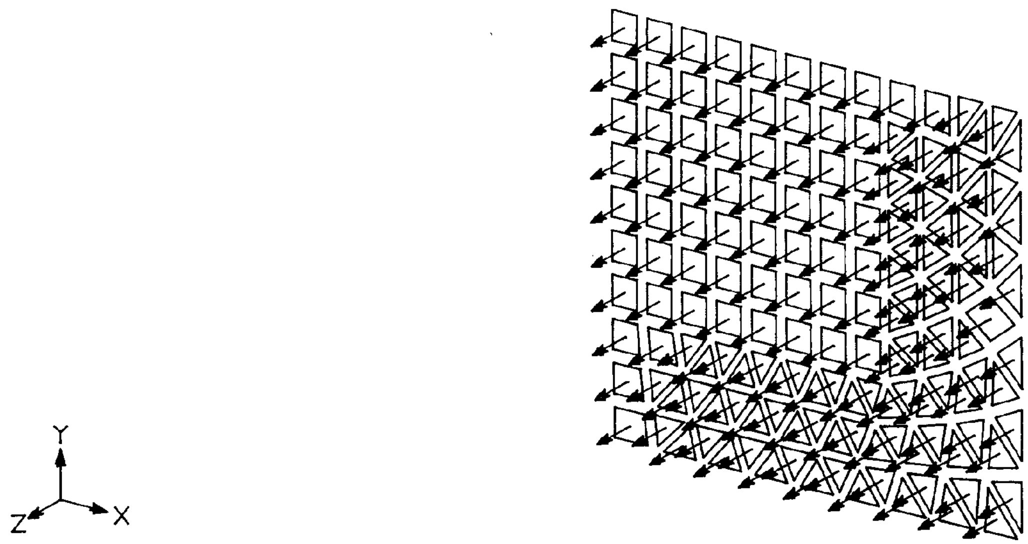

FIG. (5) – CALCULATED PRESSURE DISTRIBUTION ON 2D ELEMENTS – 3D VIEW

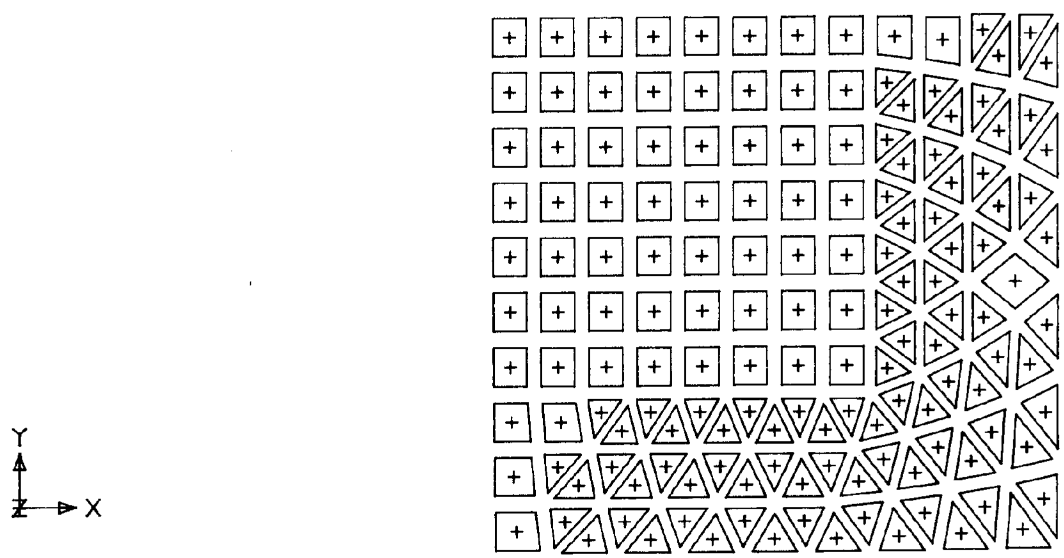

FIG. (6) – CALCULATED PRESSURE DISTRIBUTION ON 2D ELEMENTS – 2D VIEW

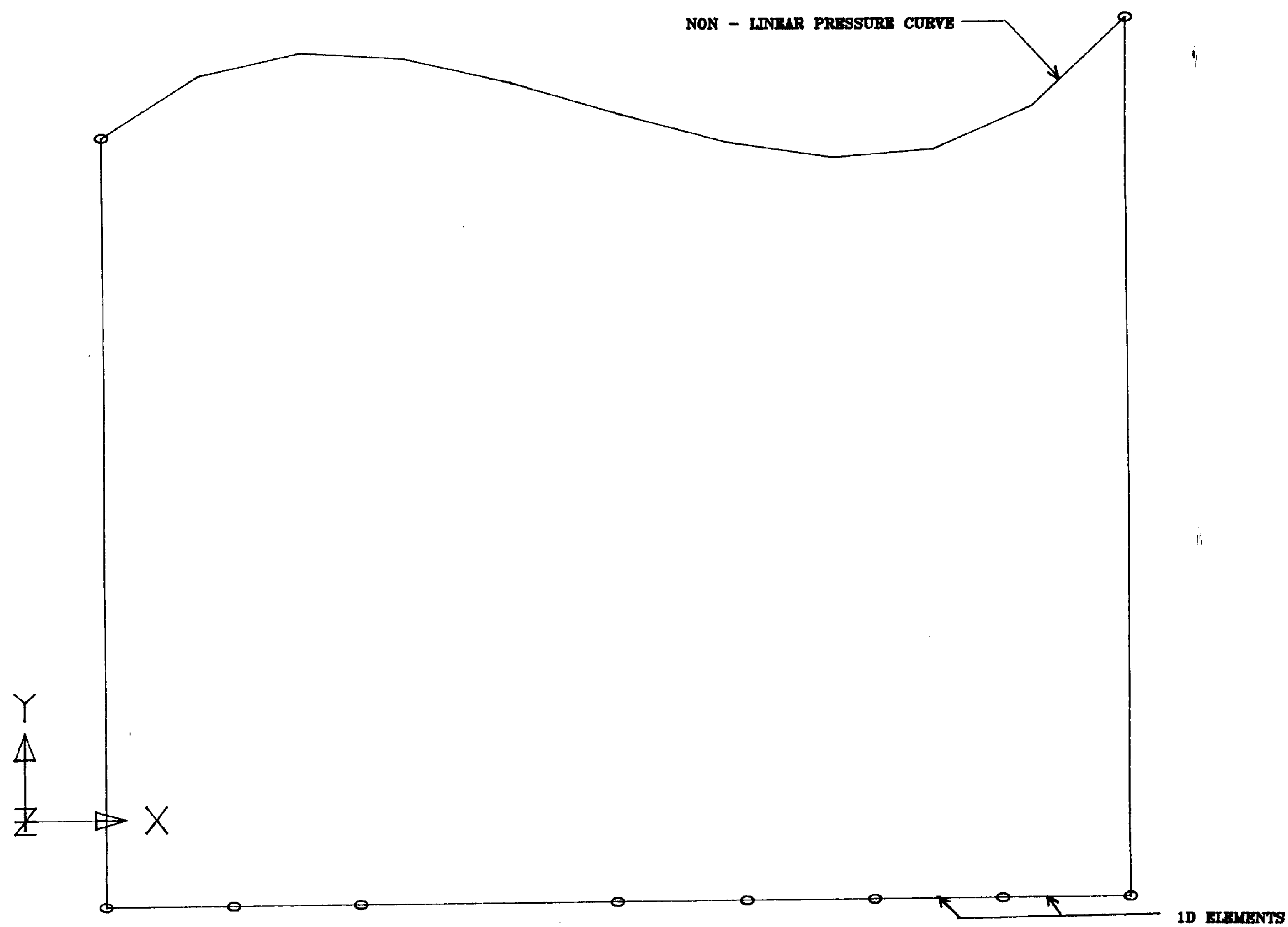

FIG. (7) - NON - LINEAR PRESSURE LOAD ON 1D ELEMENTS

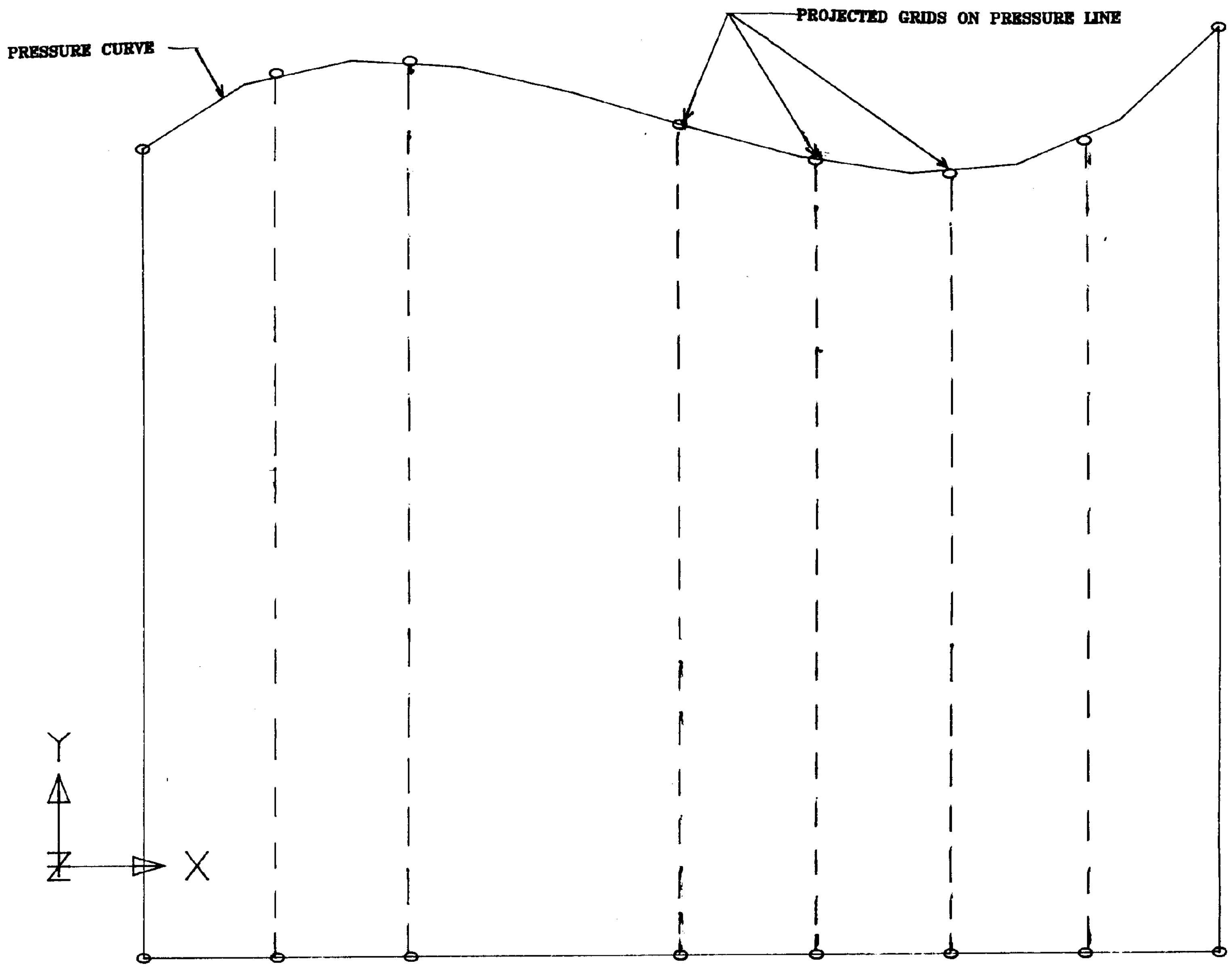

FIG. (8) – CALCULATION OF ELEMENTAL PRESSURES

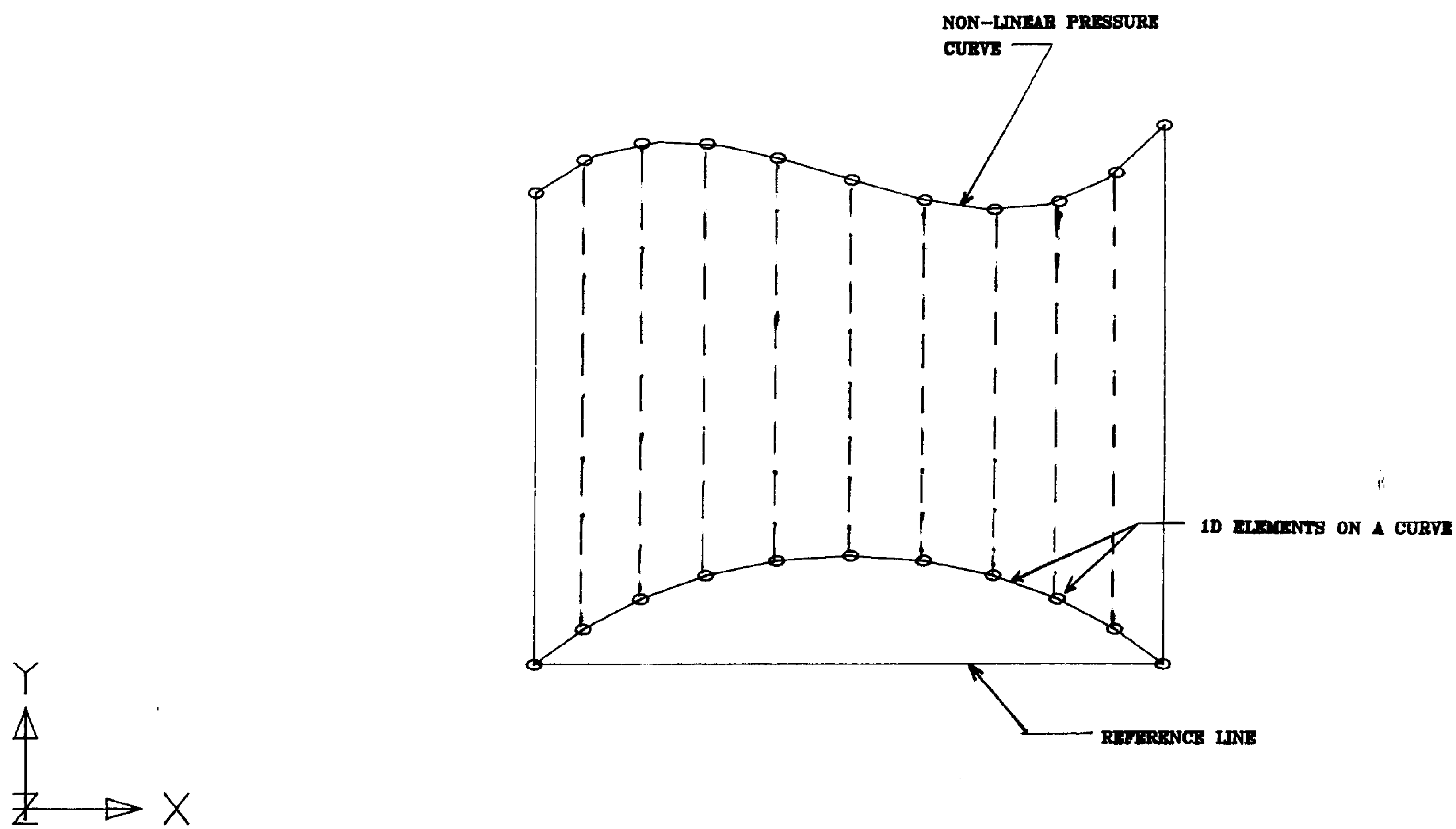

FIG. (9) - NON - LINEAR PRESSURE VARIATION ON 1D ELEMENTS

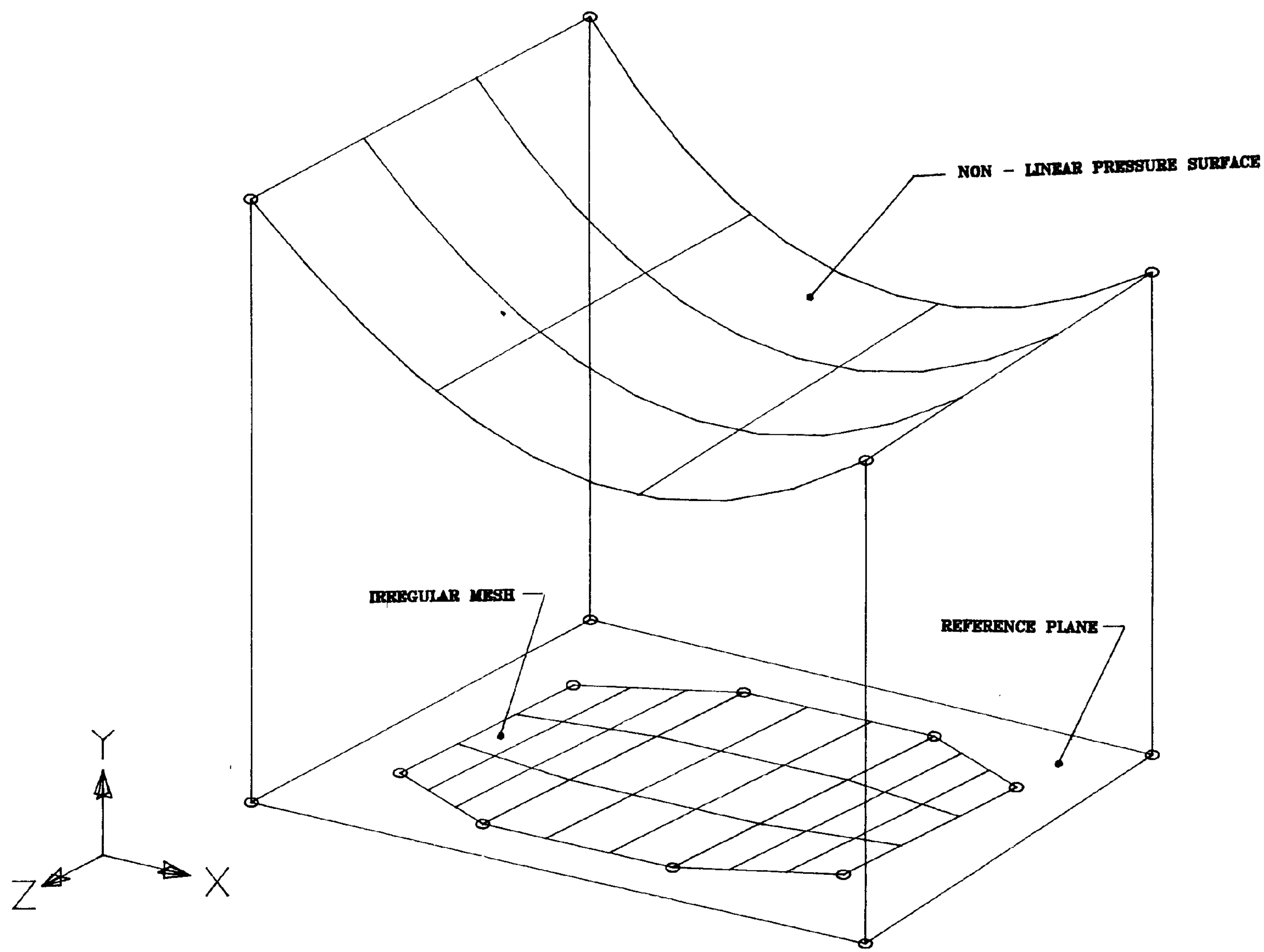

FIG. (10) - NON - LINEAR PRESSURE VARIATION ON 2D ELEMENTS OF IRREGULAR MESH

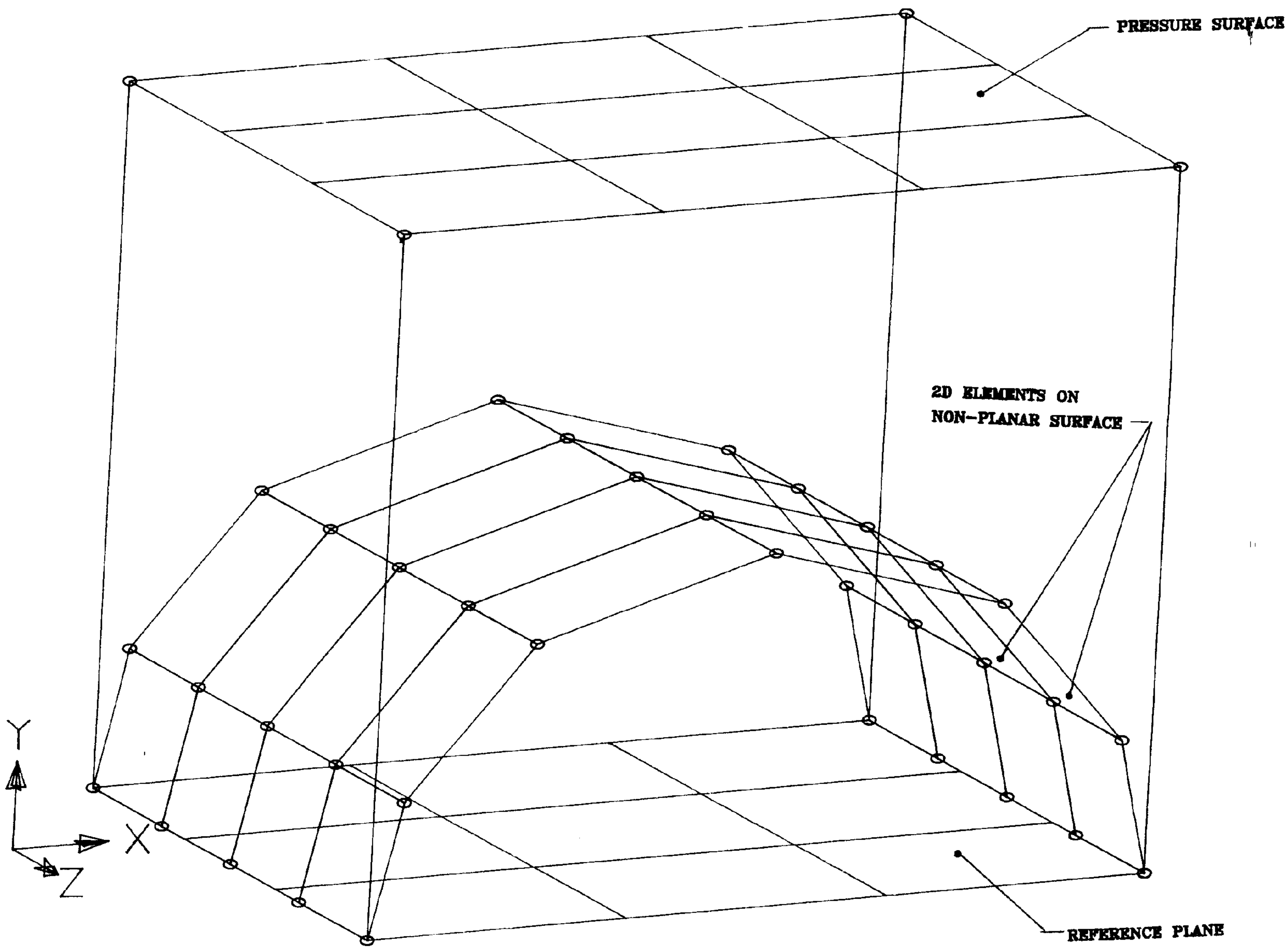

FIG. (11) - ELEMENTS ON A NON - PLANAR SURFACE

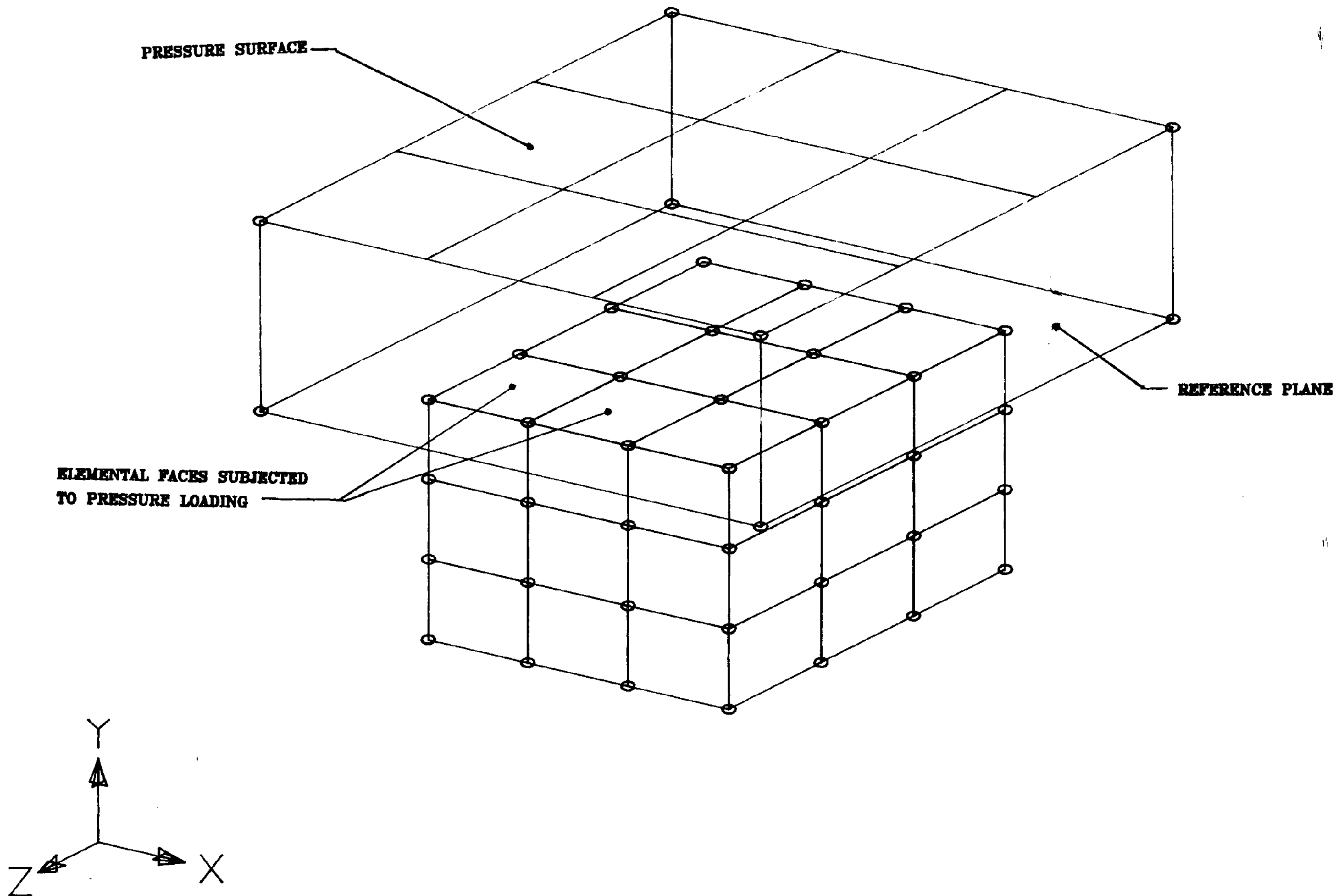

FIG. (12) – PRESSURE VARIATION ON 3D ELEMENTS