INCREMENTAL-ITERATIVE METHOD SOLUTION OF MECHANICAL PROBLEMS

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For a better understanding of the behavior of structures and materials, it has increased the demand to formulate algorithms that are able to realistically simulate the complete behavior of the structure/material. Among one of the applications we can mention the simulation of a structure to its complete destruction. In this way it allows us to design more efficiently the structure in order to face a disaster (earthquakes, explosions, etc.). To achieve this objective we must take into account non-linearity behavior. Basically we can highlight two types of non-linearity:

- Material Non-Linearity;
- Geometric Non-Linearity.

The material non-linearity appears when the stress-strain relationship is non-linear. The geometric non-linearity occurs when deformed configuration (current state) has great influence in the outcome. When we are dealing with the Finite Element Formulation the strain field $\varepsilon(\vec{x})$ is related to the nodal displacements $\{U\}^{(e)}$ by means the matrix which contains the derivatives of the shape functions [**B**], which in small deformation regime is only a function of initial geometric parameters, $\varepsilon(\vec{x}) = [B]\{U\}^{(e)}$. In the case of finite deformation regime the matrix [**B**] is also a function of the displacement field, i.e. $\varepsilon(\vec{x}) = [B(U)]\{U\}^{(e)}$. And as consequence the stiffness matrix is also a function of the displacement field.

In general, the geometric non-linearity is a consequence of the large displacement that undergoes the structure. Then, the measure of strain adopted must be able to capture the real displacement of the structure. Several measures of strain have been established, e.g. Green-Lagrange strain tensor, Almansi strain tensor, Logarithmic strain tensor, etc.

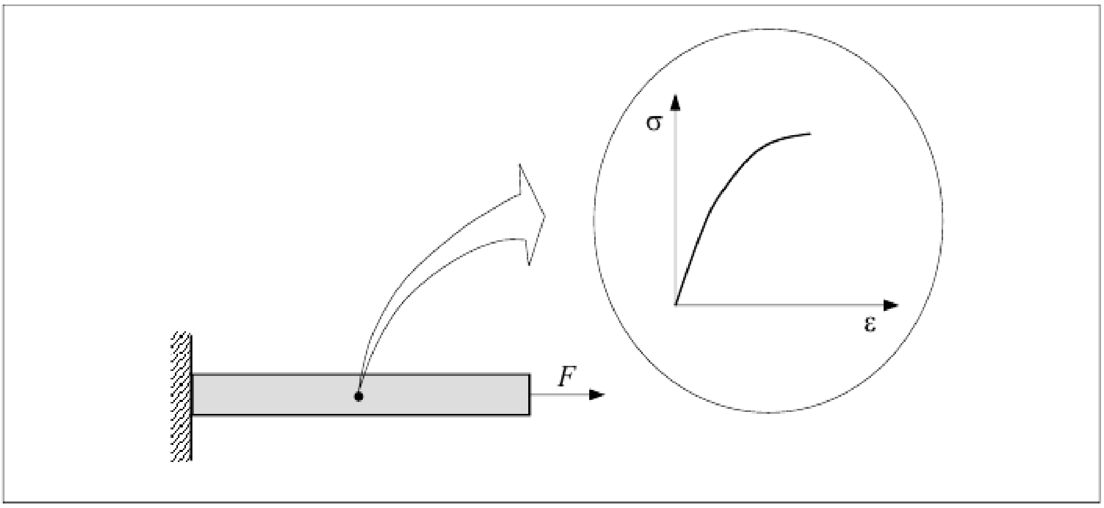

Figure 1: Material non-linearity.

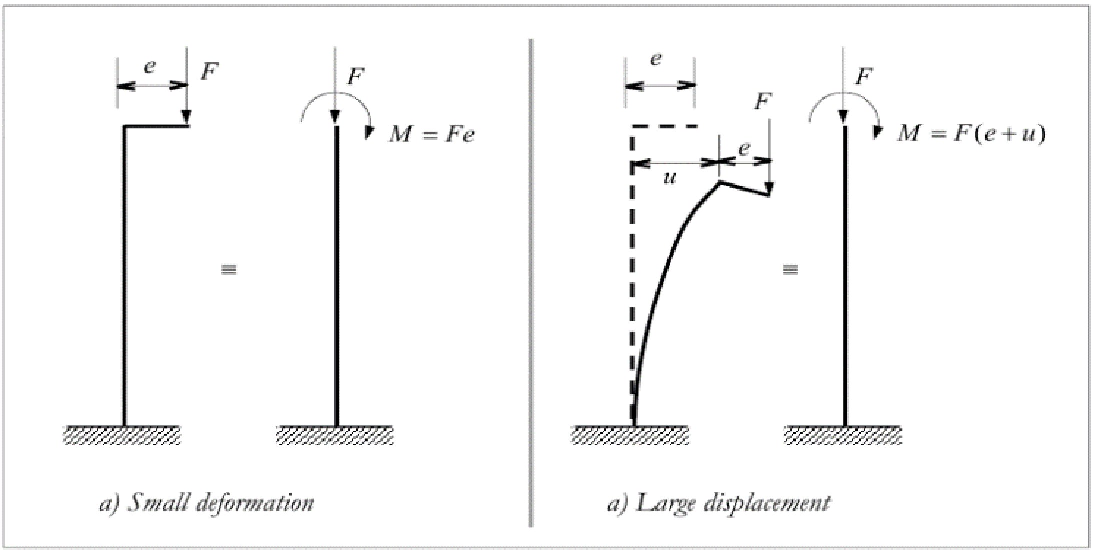

Figure 2: Boundary conditions non-linearity.

Solution Strategies

To achieve the previous objectives, various solution techniques have been proposed. The choice of numerical algorithm depends on the given problem. For example, if the structure response is represented by a curve Force vs. Displacement, (see Figure 3), the aim is to obtain the complete curve of the graph in question. As we will see later, we can use a strategy that is force increment (force control). But there may be a point, for instance, point A of the graph, where the force control procedure will get a no desired point as solution (point F) or even a divergence of the solution. Another strategy used is through incremental displacement (displacement control), which can also have undesirable solution if we are at point B and to a further increment in displacement we reach the point D of the graph missing all curve from B to D . Another strategy which can be employed is a

combination of the two above methodologies, i.e. force control and displacement control simultaneously, which is known as Arc-length control.

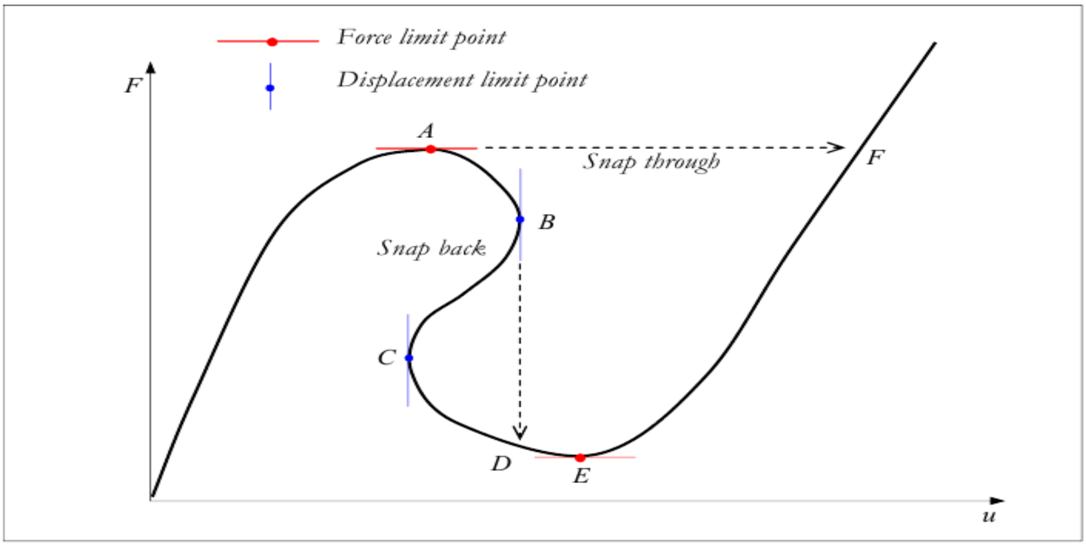

Figure 3: Force-displacement curve.

Sometimes when we are using an incremental strategy it has an error associated with it or even the solution can diverge, (see Figure 4). To overcome this drawback we must use an incremental-iterative scheme. Among the iterative methods we can mention the Newton-Raphson's method.

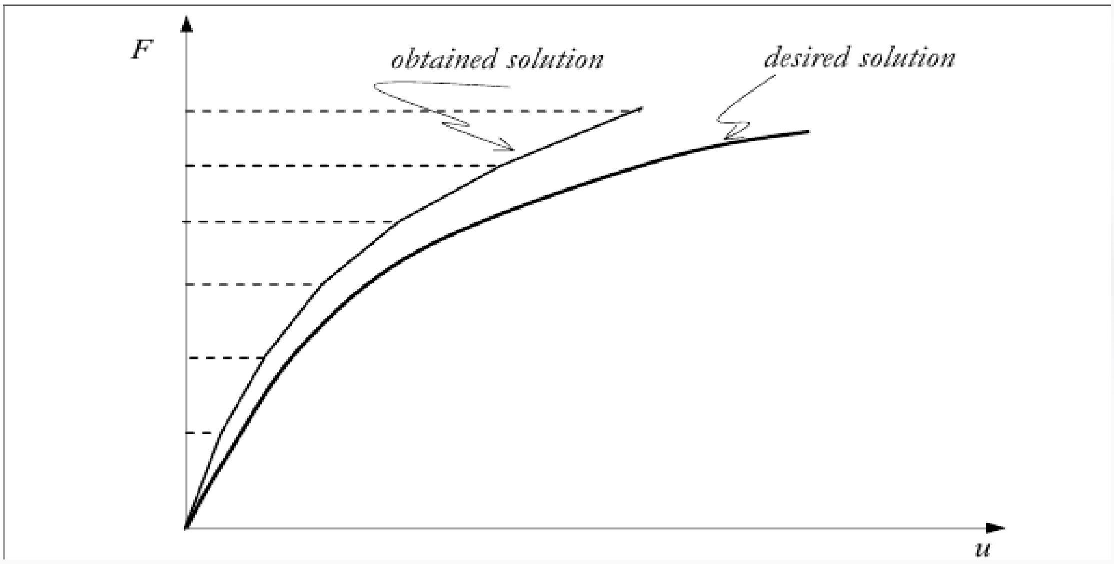

Figure 4: Diverting of the solution

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