Finite Element (FE) calculations – a paradigm shift

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It is no exaggeration to say that FE calculations applied to civil engineering structures are a paradigm shift for structural analysis. Indeed, it is possible to transpose to structural engineering the concept of paradigm as defined by Thomas Kuhn in The Structure of Scientific Revolutions. According to him, paradigms are “universally recognized scientific discoveries, which provide to a community of researchers typical problems and their solutions for some time.”

Despite its seemingly trivial aspect, the appearance of FE calculations truly is a revolution. The ancient world is one of the classical Strength of Materials based on the hypotheses of Saint Venant and Navier-Bernoulli. The latter translate into the beam and thin plate theories. Thus, the ancient world relies on a coherent set of hypotheses and resolution methods, whose results are then transformed into design principles for structures and their reinforcements.

The new world that uses FE calculations is built on other foundations. The behaviors of the materials themselves are not questioned, but the structural analysis hypotheses are. They affect, on the one hand, the meshing (the principle and precision of discretization of the structures,) and on the other hand, the choice of the types of elements (the range of displacements considered.) The results require new analytical methods to allow the accurate design of the structures and their reinforcements.

The calculation rules, mainly the Eurocodes, are largely established in the logic of the classical Strength of Materials theories. They propose simple rules mostly based on experience with well-recognized validity domains. Some examples are the strut-and-tie method, the dimensioning of consoles, punching control, etc... These regulations allow the FE computations of the structures but give shallow explanations concerning the methods used (meshing, choice of elements) and the interpretation of the results. Various technics exist to transcribe results in terms that are compatible with the regulations. However, the “finite elements calculations doctrine” is certainly still in the development phase.

The AFGC guide that you are reading aims to participate in establishing this new doctrine. It reflects the AFGC's willingness to accompany the development and innovation in the field of civil engineering by representing a place of sharing and transmission of knowledge and technological advancement.

I want to thank the redaction group and particularly the two facilitators Didier Guth and Claude Le Quéré for their incredible work. I am convinced that this guide along with the website will remain for a long time a point of reference to the engineers working in design offices.

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