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Numerical models at the service of concrete eco-construction

Pierre Rossi

MAST-EMGCU, Univ Gustave Eiffel, IFSTTAR,
F-77447 Marne-la-Vallée, France

Eco-designing a concrete construction is not only about decreasing the amount of cement and steel in this construction. It is therefore essential to achieve an optimized design of the geometry and dimensions of the construction using efficient dimensioning tools.

The use of finite element calculation meets this need

The first instinct when associating eco-design and concrete construction is to emphasize the necessary reduction in the quantity of cement to be used and the use of cement with a low carbon footprint. This reflex, which may seem natural and logical in view of the ecological "dunce's cap" with which this material is adorned (carbon footprint, natural resources, etc.), is not so clearly relevant when we carry out a more in-depth analysis on the subject. Indeed, what must be analyzed and evaluated in this quest for the eco-design of concrete constructions is not only the material used but the construction itself over its entire life cycle. This construction has one or more functions. It is therefore necessary to design these constructions so that they fulfill these functions while respecting the rules of eco-design as well as possible. Thus, depending on the type of construction and the functions attached to it, the importance and impact of the concrete material will be more or less important. It should not be forgotten that using less cement per cubic meter of concrete generally leads to a more porous concrete which is therefore less resistant and less durable. If, then, the construction in question must undergo significant mechanical stresses and it is desired to use a cement-depleted concrete, the quantity of materials to be used must be significantly increased. It is not then obvious that we will end up with a more "ecological" construction. If in addition, the durability of this construction is an important factor, we may have it all wrong. In other words, in the field of eco-design of concrete constructions, one must be wary of false good ideas. To pursue this logic, it is interesting to mention the use of fiber reinforced concretes (including ultra-high-performance fiber reinforced concretes, UHPFRC). These materials are more and, sometimes, much more durable and tough than their non-fiber counterparts. They have, on the other hand, the unfortunate (for those who are only attached to the material) habit of containing more and for some, such as UHPFRCs, much more cement per cubic meter. Consequently, for a given construction, much less of these materials would have to be used to perform the same functions. However, to do this, it would be necessary that the dimensioning methods, used today, make it possible to consider, as much and as best as possible, the increased performances of these materials (mechanical and physico-chemical performance).

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This is unfortunately not the case!

The Eurocodes are poorly adapted to these new cementitious materials. Optimizing the design of a concrete construction containing fiber reinforced concrete using the Eurocodes is like driving a Ferrari with boxing gloves. The only way out for these concretes, which can be described as innovative, consists in using innovative design methods such as those based on the use of non-linear finite elements. These numerical methods are now commonly used in other industries. These numerical models, which make it possible to consider the behavior of concrete structures, have existed for a long time. On the other hand, two main brakes delay their use in the field of concrete construction:

- The very great conservatism of the construction industry for whom the Eurocodes constitute a sort of bible.

- Insufficient validation of existing numerical models due, in large part, to the above-mentioned conservatism (not enough means and energy are implemented for this objective).

It is therefore essential that, in order to eco-design concrete constructions, our profession decides to change the century by developing and using more numerical tools, in particular finite element calculations.

To conclude, eco-design in concrete will go through innovation, both in terms of the material used and the design tools implemented.