Structural engineering: tools, core task and interfaces

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Summary

This paper deals with aspects of code checking related to efforts, computer supported applications in code checking and the recent change of codes in The Netherlands. Moreover core tasks and tools of the structural engineer are discussed and interface aspects between the structural engineer's domain and the surrounding environment are presented.

1. Codes, artist's pencil or imposed forced labour?

The use and application of codes by structural engineers can roughly be split up as follows:
-codes as verification document
-codes as design tool.

1.1 Codes as verification document

The use of codes as verification document contains a variety of aspects:
Legislation
Specific clauses of the euro code based Dutch concrete code presently come into force form part of the legal frame work. Clauses concerned relate to safety, serviceability, health and environment.

Contractual
Integral codes or specific aspects of codes often form part of the contractual relation between parties involved in the construction industry.

Safety/reliability
As a verification document codes provide comfort to the structural engineer once his concept complies with the relevant clauses of the code.

Functional requirements
Compliance with requirements related to durability and stiffness can be demonstrated through code checks.

Code checking is normally performed as a systematic check.
As such the integral contents of a code is considered. Two specific issues are related to this integral character of the code check: level of detailing of the codes: the more detailed codes are, the more detailed code checks will be.

Process of the code check: manually or automated by computer
The level of detailing of the euro codes and the present Dutch codes is more extensive then the recently laid off codes, mainly in the field of partial factors and parameters to describe crack width and deflections:
this is a logical consequence of the research based ability to describe processes like cracking and deflections more fundamentally.

To demonstrate the differences in efforts between the previous and present Dutch concrete code, a comparative study has been carried out [1].
The structure considered is a multiple span girder, loaded with uniform distributed live loads. The calculations were carried out by an qualified engineer, but with a relative short track record in structural engineering, thus avoiding the jump-through-the-code performance of well experienced engineers.
From an evaluation of the results following conclusions were drawn:
- If code checks are carried out systematically and without experience driven cut-off's, the checks are almost identical.
- Due to the more detailed level of the present code, there is an increase in efforts, mainly due to the extent of numerical calculations

Given the conclusion, comparable but more of the same exercise, the question of computerized code checks is of current interest.
A review of the state of the art software related to code checking [2], learned that code checking by computer is feasible to quite an extent and has significant potentials. The computerized code check has an impact on the time demand for the checking procedures and allows a more extensive parameter check.
So, shouldn't the professional community switch over to such an approach?

1.2 Codes as design tool

Code checking is more than just a numerical exercise:
From the evaluation of the comparative code checking exercise [1] and from in-house experience gained during the development of an knowledge based expert system for building pits, it can be concluded that structural engineers perform their tasks within an experience based reference frame.

This reference frame of methods and values enables the engineer to judge at intermediate steps as whether he is on the right track, heading towards a solution or digging into the ground. An example in this respect related to values is the practical shear stress value in beams, which is above the limit value for unreinforced concrete but appropriate because of practical stirrups to be applied anyway. This reference system is a personnel system for each engineer individually as it is developed by permanently setting results against choices made.
Strictly object oriented, final results can be set against initial choices; most structural engineers however perform within a more universal environment and as such need much more indicators as reference system. This reference system is experienced by the authors as of vital importance for professional performance
The recent change in the Netherlands from integral safety factors towards partial safety factors and also the amendment of specific calculational procedures results into a loss of specific parts of the reference frame.
Given the blessings of information technology and the more detailed level of modern, euro code based, codes, the temptation to fly into automated code check procedures isn't fictitious. Regardless the question as to whether the automated procedures cover all aspects, such approach would create blanks in the reference frame. Manually processed code checks provide the engineer the data to restore the blanks caused by the introduction of the new codes.
As reflected in the investigation on automated code check possibilities [2] authors have the opinion that automated code checks form part of the engineer's luggage, especially for routine work, but after restoration or build-up of the engineer's reference frame. As such an and/and strategy is opted for.

The question as raised in the heading of this section can't be answered in general as even for the individual structural engineer the answer may switch as times go by.

2. Structural engineering, playground or battlefield.

The environment in which the structural engineer nowadays performs is extensive and fast, interactive with a variety of disciplines and surrounded by an increasing spread of techniques, highly specialized software and regularly changing codes.
His performance is expected to be reliable, against low fee, fast and also to reflect the state of the art of modern technologies.
This environment is challenging but requires a strict discipline of the engineer: distinction and control of interfaces between core task and the surrounding environment; not suggesting isolation but controlled interaction.

2.1 Core task

The core task of the structural engineer is to turn degrees of freedom into solutions which comply with functional requirements, specifications and/or codes. In practice this means the selection of concepts, static schemes, materials, dimensions and details. This core task is to be performed in strong interaction with the surrounding environment at interfaces.

2.2 Interfaces

The surrounding environment can be itemized as follows:
Co-operative entities
Supporting entities
Controlling entities, not further discussed in this paper.

The co-operative entities may consist of engineering disciplines in case of multi discipline projects and/or non-engineering disciplines from the construction industry. As concluded from an internal evaluation of a complex design/construct contract [3] the structured and strictly programmed exchange of information at the interface is of vital importance to control the interface and the process as a whole. Recently developed computer systems like VDT (virtual design team) demonstrate and confirm this statement. At present VDT is applied in Delta Marine Consultants to investigate the overall tender process of a submerged tunnel project.

Supporting entities should deliver tools, fit for purpose, at the interface.
Tools may consist of

- Networks, to have access to literature, codes and data banks and to allow exchange of information
- Software; although this might sound as hammering on an open door, due attention is required. From a recent publication in Civil Engineering [4], it was concluded that, in general, there is a gap between software as offered and the engineer's needs. The suggestion to opt for object oriented technology is considered by the authors as a sensible direction, given own experience with the earlier mentioned in-house development of an object oriented system for building pits.
- Results from research and development. Given the structural engineer's working environment as sketched before and the fundamental level reached by research nowadays, it should be obvious that achievements of research have to be processed before they are offered to the structural engineer's community at the interface.
  A survey of structural engineers [5] showed that a highly sophisticated tool wasn't fully explored as the tool didn't match properly at the connection with the user. Improvements at the interface proved to be fairly effective.

Whether the environment in which the structural engineer performs develops as a battlefield or as a playground, heavily depends on the understanding of the underlying processes presented above and the discipline to stick to the consequential playing rules of all parties and above all, all individuals involved.

References

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