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Discussion of "Concrete structures. Contribution to the safety assessment of existing structures by Couto, D.; Carvalho, M.; Cintra, A. and Helene, P. Rev. IBRACON Estrut. Mater. 2015, vol.8, n.3, pp. 365-389"

Discussão de "Estruturas de concreto. Contribuição à análise de segurança em estruturas existentes, por Couto, D.; Carvalho, M.; Cintra, A. and Helene, P. Rev. IBRACON Estrut. Mater. 2015, vol.8, n.3, pp. 365-389"

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DISCUSSION | DISCUSSÃO

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The article under discussion presents incorrect assertions and conclusions which lead to inconsistent interpretations of technical codes, compromising structural safety.

In the abstract, the authors state that, for an existing structure, the partial safety factors can be loosened, since "a large number of unknown factors at the design stage are already defined and can be measured". These coefficients can be altered if and only if relevant information regarding structural safety are measured and analyzed, such as (Melchers, [1]):

- Preliminary on-site inspection (to ascertain location, condition, loadings, environmental influences, special features, necessity for further testing);
- Recovery and review of all relevant documentation, including loading history, maintenance, repair and alterations;
- Specific on-site testing and measurements, including, perhaps, proof loading;
- Analysis of collected data to refine (or 'up-date') the probabilistic models for structural resistance (and perhaps loading);
- Accurate (re-)analysis of the structure with up-date loading and resistance parameters (i.e. development and refinement of the limit state functions);
- Structural reliability analyses;
- Decision analysis.

As previously stated, there is a series of assessment procedures that need to be adopted in order to reduce the partial safety factors. Although the authors recognize part of these procedures in the abstract and introduction of their paper, the main text largely ignores a great portion of the latter, focusing instead on concrete strength.

Concrete strength losses must be compensated by gains such as variability reduction, load reduction or cross-section enlargement. However, it is important to highlight that concrete strength is the most relevant random variable in column reliability, in the usual case of low live-to-dead load ratio [2].

Additionally, determining the actual values of the various parameters involved in structural safety is not a straightforward task and may introduce new uncertainties.

In section 2, the authors attempt to define values for the components of γ_c (γ_{c1}, γ_{c2}, γ_{c3}). These values are difficult to obtain and need to be assessed in a probabilistic manner.

Still on section 2, the authors state that an experimental approximation of the γ_c coefficient can be obtained through comparison studies between the controlling strength presented on ABNT NBR 12655: 2006 and the average effective resistance measured from core tests. This assertion is incorrect because the γ_c coefficient does not concern solely concrete strength variability. Furthermore, the extraction of the core itself introduces uncertainties and variabilities. In addition, the cores are usually extracted from regions with low reinforcement ratio which are easily concreted.

Section 4.13 cannot be enforced by national standards. The use of reduced partial safety factors as suggested (γ_c<1,27 and γ_s=1,05) cannot be utilized since it cannot be sustained, up to this moment, by structural reliability analysis. Furthermore, concrete non-conformity is pervasive in Brazil (see [2]), therefore reducing those coefficients may encourage production of concrete with lower strength than specified in design.

Section 4.2.1.2 is incorrect since ACI 318-11 [20] was improperly referenced. The statement "When the first step does not achieve compliance or wherever there are existing structures, ACI 318-11 (Chapter 20) requires estimation of equivalent strength f'_c a more accurate way, through ACI 214.4R-10" is not correct since ACI 318-11 does not allow for utilization of the methods described in ACI 214.4R in cases of non-compliance, in accordance with R20.2.3 (page 324, [20]) reproduced as follows:

> "R20.2.3 – ACI Committee 214 has developed two methods for determining f'_c from cores taken from an existing structure. These methods are described in ACI 214.4R[20.1] and rely on statistical analysis techniques. The procedures described are only appropriate where the determination of an equivalent f'_c is necessary for the strength evaluation of an existing structure and should not be used to investigate low cylinder strength test in new construction, which is considered in 5.6.5."

The same inconsistency appears in section 4.2.1.3, since it refers to ACI 214.4R, even though it deals with new or under construction structures with non-compliant concrete.

Section 4.2.4 does not clarify whether the procedures described are valid for new/under construction structures with low cylinder strength test results or for existing structures, thus omitting that the code EN 13791 [24] allows for the use of equations (16) and (17) only for old structures. In the event of non-compliance, a different set of procedures is used.

The example presented in section 5 reproduces and illustrates some of the aforementioned inconsistencies. The article does not specify whether the structure would be in construction, new or existing. The example also does not clarify whether the evaluation of concrete core strength is motivated by non-compliance issues or, for instance, by changes in bridge traffic loads or changes in structure occupancy.

Although the example does not presents the cylinder tests results, the compressive strength values obtained from 8 cores produced much smaller results ($f_{c,\,max}$ = 19,1 MPa) than the values specified in design. The highest test result equals to 76% of f_{ck}. The natural conclusion is that this is an instance of non-compliant concrete and, therefore, the utilization of ACI 214.4R and EN 13791 procedures on the example is improper.

The modification of the partial safety factors shown in Table 3 is justified, according to ACI 318-11, by the use of accurate field-obtained material properties, actual in-place dimensions and well-understood methods of analysis. Therefore, it is not correct to alter these factors (as indicated by the article) without inspection and re-analysis of the structural model. This is true because newly acquired data is relevant and may result in an increase in internal forces or a decrease in resistances, that is, it can lead to unfavorable effects (results).

[1] MELCHERS RE. Structural Reliability Analysis and Prediction". John Wiley & Sons, Chichester, 1999.

[2] SANTIAGO, W.C.; BECK, A. T. Estudo da (Não-)Conformidade de Concretos Produzidos no Brasil e sua Influência na Confiabilidade de Pilares Curtos. Revista IBRACON de Estruturas e Materiais, v.4, p.663 - 690, 2011.