10th International DIANA Users Meeting
29-30 October 2015

Validating the Guidelines for Nonlinear Finite Element Analysis

Beatrice Belletti*, Cecilia Damoni*, Max Hendriks#, Ane de Boer+

* University of Parma, Parco Area delle Scienze 181/A 43124 Parma, Italy
# Delft University of Technology, Stevinweg 1, 2628CN Delft, The Netherlands
+ Rijkswaterstaat, Ministry of Infrastructure and the Environment

The Dutch Ministry of Infrastructure and the Environment run a project to re-evaluate the load carrying capacity of existing bridges and viaducts in the whole country because of the increase of traffic and the reallocation of emercency lanes to traffic lanes. For a certain amount of Dutch bridges and other infrastructures the safety verifications were not satisfied if the usual analytical procedures, proposed by the current norms, were adopted in the calculations. For this reason the Dutch Ministry of Ministry of Infrastructure and the Environment proposed to make a structural assessment of existing structures through the use of nonlinear finite element analyses with the final release of a document containing guidelines for nonlinear finite element (NLFE) analyses of reinforced and prestressed concrete elements [1]. After the publication it became necessary widespreading the procedure for the application of the guidelines; hence to this aim the Dutch Ministry of Transport, Public Works and Water Management proposed to extend the project. In the project, presented in the paper, four reinforced concrete (RC) beams, four prestressed concrete (PC) beams and five RC slabs, characterized by different failure modes, are analyzed by means of nonlinear finite element analyses and analytical calculations. For all case studies analyzed the reporting of results follows a specific scheme, in order to systematize the analysis process and to facilitate users of finite element codes in the reading and validation of the results obtained. In particular for each case study are described: the geometry, the experimental results available from literature, the finite element modeling, the material constitutive model used in NLFE analyses and the convergence criteria. The results obtained are analyzed by means of reporting the significant material limit state, the crack pattern and the convergence trend. In order to control the results obtained from NLFE analyses in terms of bearing capacity and failure mode, analytical calculation are also performed in accordance to the current design codes and guidelines [2], [3]. Furthermore, according to the Model Code 2010 philosophy, the level of approximation approach has been applied to all case studies through the safety format methods. Thanks to the application of safety format methods, used for the evaluation of the design resistance by means of both analytical and numerical calculations, it has been in fact possible to estimate the difference in terms of structural bearing capacity between standard analytical calculations and the results obtained from NLFE analyses, and hence to estimate the advantages of using NLFE analyses.

[1] Guidelines for Non-linear Finite Element Analyses of Concrete Structures. Rijkswaterstaat Technisch Document RTD:1016:2012, Utrecht: Rijkswaterstaat Centre for Infrastructure; 2012.
[2] CEB-FIP Bulletin d'Information 65&66 - Model Code 2010.
[3] UNI EN 1992-1-1:2005: Eurocode 2 - Design of concrete structures - Part 1-1: General rules and rules for buildings.