EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1236

SUSTAINABLE DESIGN OPTIMIZATION OF REINFORCED CONCRETE FRAMES CONSIDERING CO2 EMISSION MINIMIZATION

Alberto Martins[1], Luís Simões[2], João Negrão[2]

[1]Universidade de Coimbra, Portugal
alberto@dec.uc.pt

[2]University of Coimbra, Portugal
lcsimoes@dec.uc.pt, jhnegrao@dec.uc.pt

Keywords: Optimization; Reinforced concrete; CO2 emissions; Sustainable design

Abstract: Nowadays, the environmental consequences of global warming are of major concern. Worldwide, efforts are being made to reduce the CO2 (carbon dioxide) emissions in order to mitigate the greenhouse effect. Since the environmental impact of construction industry is significant, construction sustainability is gaining increasing relevance in the last years. In this way it is important, in the design of civil engineering structures, to consider besides the construction costs also the environmental costs. The environmental costs are related to the CO2 emissions generated during the production of the construction materials and during building of the structure. Structural design is an iterative process which, through changes in some parameters of the structural system, seeks a solution that satisfies a set of criteria related to safety, serviceability and economy. Nowadays, sustainability criteria should also be included. Although structural optimization is not commonly used in civil engineering practice, the use of optimization tools in the design of reinforced concrete framed structures naturally arises as an efficient way to compute the cross-sectional dimensions of the beams and columns, the amount of reinforcing steel and the concrete grade, aiming at reducing the material and environmental costs and therefore obtaining economical, structurally efficient and "environmentally-friendly" solutions. In this work a numerical model for the design of reinforced concrete frames was developed. The structural analysis includes all the actions and relevant effects, namely, dead and live loads, the time-dependent effects and the geometrical nonlinearities. The structural response to changes in the design variables is done by a discrete direct sensitivity analysis procedure. The design of reinforced concrete frames is formulated as a multi-objective optimization problem with objectives of minimum construction cost, minimum CO2 emissions, minimum deflections and stresses and a Pareto solution is sought. The minimax solution is found by the minimization of a convex scalar function obtained through an entropy-based approach. The displacements and stresses design objectives are established according to the Eurocode 2 recommendations for the design of framed structures. The design variables considered are the beams and columns cross-sectional dimensions, the steel reinforcement area and the concrete grade. The gradient-based optimization algorithm used proved to be efficient to find the continuous optimum solution. Practical solutions from the engineering point of view are achieved by rounding the continuous solution. The features and applicability of the developed numerical model are demonstrated by numerical examples concerning the optimization of real sized reinforced concrete frames.