Advances in Engineering Software 40 (2009) 1112–1118

Contents lists available at ScienceDirect

Advances in Engineering Software

journal homepage: www.elsevier.com/locate/advengsoft

Cost optimization of composite beams using genetic algorithms

Ahmed B. Senouci *, Mohammed S. Al-Ansari

Department of Civil Engineering, Qatar University, P.O. Box 2713, Doha, Qatar

ARTICLE INFO

Article history:
Received 12 September 2007
Received in revised form 19 December 2008
Accepted 1 June 2009
Available online 27 June 2009

Keywords:
Genetic algorithms
Cost optimization
Composite beam
Information technology (IT)
Computer-aided design

ABSTRACT

This paper presents a genetic algorithm model for the cost optimization of composite beams based on the load and resistance factor design (LRFD) specifications of the AISC. The model formulation includes the cost of concrete, steel beam, and shear studs. Two design examples taken from the literature were analyzed in order to validate the proposed model, to illustrate its use, and to demonstrate its capabilities in optimizing composite beam designs. The results obtained show that the model is capable of achieving substantial cost savings. Hence, it can be of practical value to structural designers. A parametric study was also conducted to investigate the effects of beam spans and loadings on the cost optimization of composite beams.

1. Introduction

Because of its economy, composite floor construction is widely used in commercial multistory buildings. To create a composite floor, a concrete slab is often mechanically connected to a hot-rolled steel section through shear connectors.

In practice, a composite beam is designed in a trial-and-error process to select the following parameters: (1) the concrete type expressed by its compressive strength and its unit weight, (2) the slab thickness, (3) the steel section size expressed by its cross-sectional area, and its steel grade expressed by its yield strength, and (4) the strength of the shear connectors expressed by its shear resistance, and the number of shear connectors provided.

The design of composite beams is complicated and highly iterative. Depending on the design parameters, a beam may be fully or partially composite. In the case of the LRFD design code [3], the plastic deformation has to be considered. A source of complexity is due to the fact that the location of the plastic neutral axis (PNA) may lie within the concrete slab, the flange of the steel beam, or the web of the steel beam. Since the value of a design parameter affects other values, all design parameters cannot be found simultaneously.

Mathematical optimizations provide methodologies to automate the complicated design process [1]. Moreover, one can achieve an optimum solution out of numerous solutions on the basis of a selected criterion such as the minimum weight or the minimum cost. The majority of the articles that have been published on the optimization of structural systems focused on the minimum weight design. Only a small fraction of these articles has dealt with the minimum total cost. Sarma and Adeli [17,18] published a review of the articles dealing with the cost optimization of concrete and steel structures, respectively. Jármai and Farkas [6] discussed the cost calculation and the optimization of welded steel structures.

Few journal articles on the optimization of composite beams have also been published. Zahn [19] discussed the economies of the LRFD design code versus the AISC allowable stress design code in the design of composite beams through the weight comparison of some 2500 composite designs using A36 steel. The results indicated that the LRFD design code yielded a saving of 6–15% for span lengths ranging from 3 m to 13.7 m. Lorenz [15] discussed the minimum cost design of composite beams based on the AISC–LRFD design code and argued that the real advantage of the AISC–LRFD concept could be realized in the minimum cost design. Bhatti [4] attempted to build upon the idea by casting the problem into a standard optimization formulation and solving the problem approximately using the symbolic algebra *Mathematica* [16]. His cost function, however, only includes the cost of the steel beams and the field-installed shear studs, neglecting the cost of concrete. Long et al. [14] presented a non-linear programming based optimization of cable-stayed bridges with composite superstructures and proposed a cost objective function which contained the costs of concrete, structural steel, reinforcement, cables and formwork. Kravanja and Šilih [10] introduced a non-linear programming optimization models for composite I beams. Kravanja and Šilih [11] also introduced a mixed-integer non-linear programming approach for cost optimization of composite I beams.

* Corresponding author. Tel.: +974 5809682; fax: +974 4851781.
E-mail addresses: a.senouci@qu.edu.qa (A.B. Senouci), m.alansari@qu.edu.qa (M.S. Al-Ansari).

0965-9978/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.advengsoft.2009.06.001