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APPLICATION OF BIOLOGY CONCEPTS TO METALLIC STRUCTURES OPTIMIZATION OF CIVIL ENGINEERING

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ABSTRACT

The computer aided design is realized today by the significant development of computational tools. These computer codes are often intended for advanced design phase of projects. However, there is to our knowledge very few design support tools in preliminary design phase. Indeed, in the life cycle of a construction project, the design phase is often the place of conflicting situations that prevent the overall optimization of the said projects production costs. During this phase, various technical treatments should be held to verify the feasibility of the works in relation to the structural constraints, neighborhood, implementation, etc... In this work, we propose a formulation of the optimization problem of the overall design of a simple metal structure and a methodology of resolution based on the approach of Genetic Algorithms. The aim is to minimize the overall execution cost.

Keywords: multidisciplinary optimization, numerical programming, genetic algorithms.

INTRODUCTION

The building industry has knew many improvements, so much on an architectural level as technological and economic levels due to the results provided by the scientific research. However, one still feels the need that this work (or product) must be perfected yet. It is therefore to optimize the qualities of multi-levels building. In the life cycle of a metallic structure, the design phase is often the location of discontinuities which prevent the overall optimization of production costs. During this phase, various technical treatments take place to test the feasibility of the structure, in terms of structural constraints, neighborhood, implementation, etc. However, these verifications take place once the designer has made the main choices on the shape of the structure, the arrangement of the different components, the holder system, the foundation system, etc. These choices influence considerably the technical and economic characteristics of the project and the realization of the structure. The traditional approach of optimization of metallic structures is based on the minimization of weigh of the structure. However, the assemblies rarely exceed 5% of total weight of a structure. This low percentage hides in reality a high cost which can reach 30% of the total manufacturing cost of a structure [Hamchaoui, 1997]. Indeed, the cost of a structure consists mainly by the cost of labor which essentially depends on the complexity of the assemblies. An optimized structure definition, made only on the unique weight criterion may therefore lead to structural arrangements far from optimal in terms of realization cost.

On the other hand, the modeling of assemblies can affect, significantly, the distribution of internal forces in the structure and also the forces to resume in the foundations. That is why

Eurocode 3 (through its National Application Document) now allows the use and justification of semi-rigid connections. The aim is to approach as much as possible, the actual behavior of connections. The Taking into account of the behavior of nodes in the overall analysis is an innovative but promising aspect. The economic benefits of this approach were the subject of various benchmarking [Colson et al, 1996]. Its implementation is greatly facilitated by appropriate analysis software already available on the market [Galea et al, 1998] and various aids to calculation and to characterizing the nodes [Jaspart, 1994]. The optimization of the global design process of steel structures therefore requires anticipating further upstream construction problems in the early steps of design. For this, we have developed an optimization methodology based on minimizing the total cost of realization of the structure.

RESULTS AND CONCLUSIONS

The structure we studied is as represented in figure 1 (a), and modelled by the approach of genetic algorithms (b).

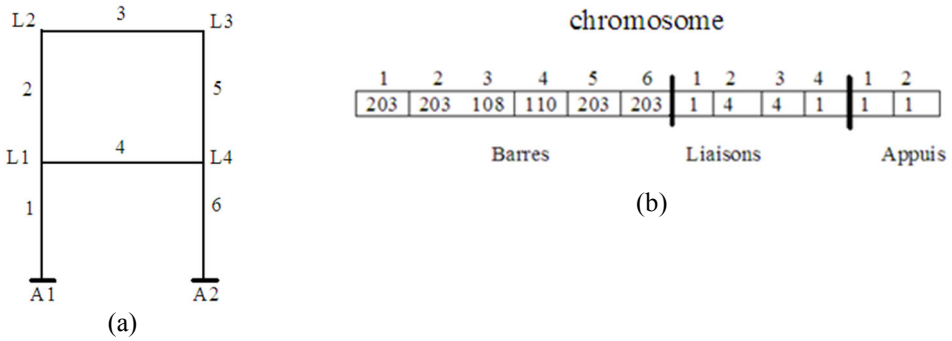

Fig. 1 - Structure and genetic algorithms model

To be able to be used in Genetic Algorithm, the dimensional characteristics of different standard profiles are stored in the form of a database in which they are coded. To do this, we propose an integer coding allowing to distinguish the type of the profile (IPE, HE A, HEB, etc.) as well as its number in the list. Information about the type of connections and supports of a design solution is also encoded in the Genetic Algorithm through a string of integers.

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