UNIVERSITÀ POLITECNICA DELLE MARCHE

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A METHODOLOGICAL APPROACH TO SUPPORT THE DESIGN OPTIMIZAZION OF A STEEL CONSTRUCTION

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design tools & methods

A steel construction is a building with steel beams. A typical steel structure consists of metal beams for the internal support and exterior cladding. Usually, construction blocks are prefabricated before and mounted on site.

Steel constructions are widely used in civil applications as well as in several industries such as in Oil&Gas power applications. A steel building contains two levels of metal structures: the supporting structure (main frame) and the secondary structure (Fig. 1) which increases the construction rigidity.

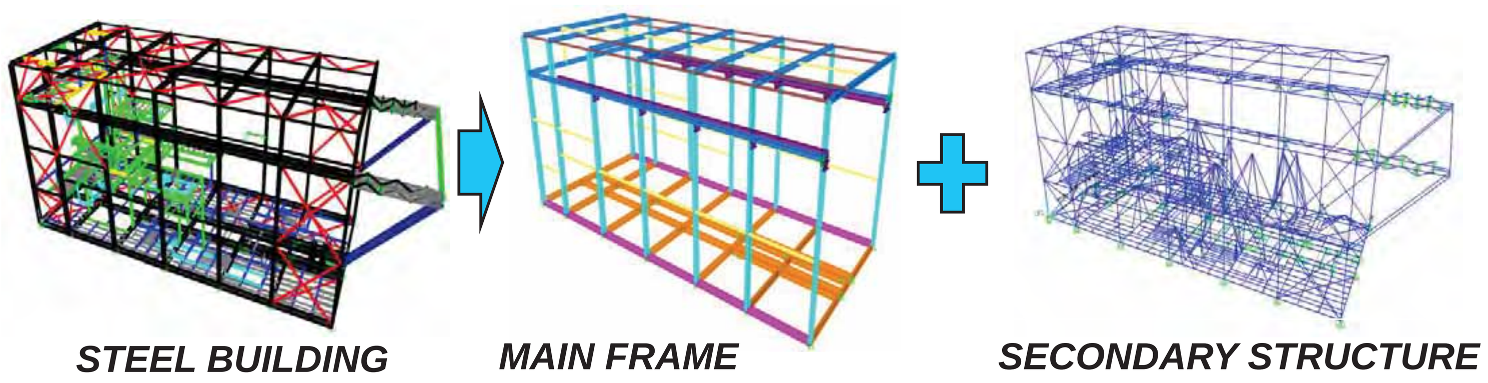

Fig. 1 Comparison between supporting structure and full frame

The research aims to reduce time and cost related to the early design phase of a steel construction such as an offshore building. Particularly, the design of an offshore building takes into account many different analyses as shown in Fig. 2.

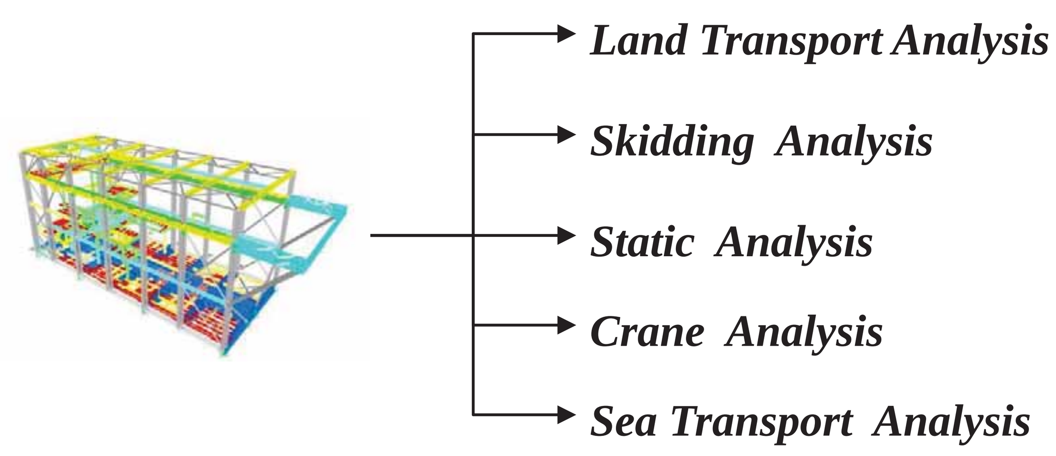

Fig. 2 Design analysis for an offshore building

OBJECTIVES

The aim of the research is to define a method and tool to support the rapid optimization of a steel building during the early design phase. A good early optimization study is very suitable in order to achieve a better project in the next executive phase. The main objective is a method to reduce the cost and the weight of a steel building.

The proposed approach was defined and evaluated in the context of two students degree theses.

APPROACH

Fig. 3 describes the methodology approach studied to support the optimization process concerning the early design of a steel building. The achieved methodology integrates virtual prototyping technologies such as an Optimization Tool, based on Genetic Algorithms, and a Structural Solver which allows the virtual experiments to be solved using a FEM analysis.

The geometry of a steel structure was considered as a collection of many set of metal beams. Each set has a different shape of the beam section. The optimization tool combines each geometric parameter in order to configure different virtual experiments according to a DOE table or adaptive genetic algorithms.

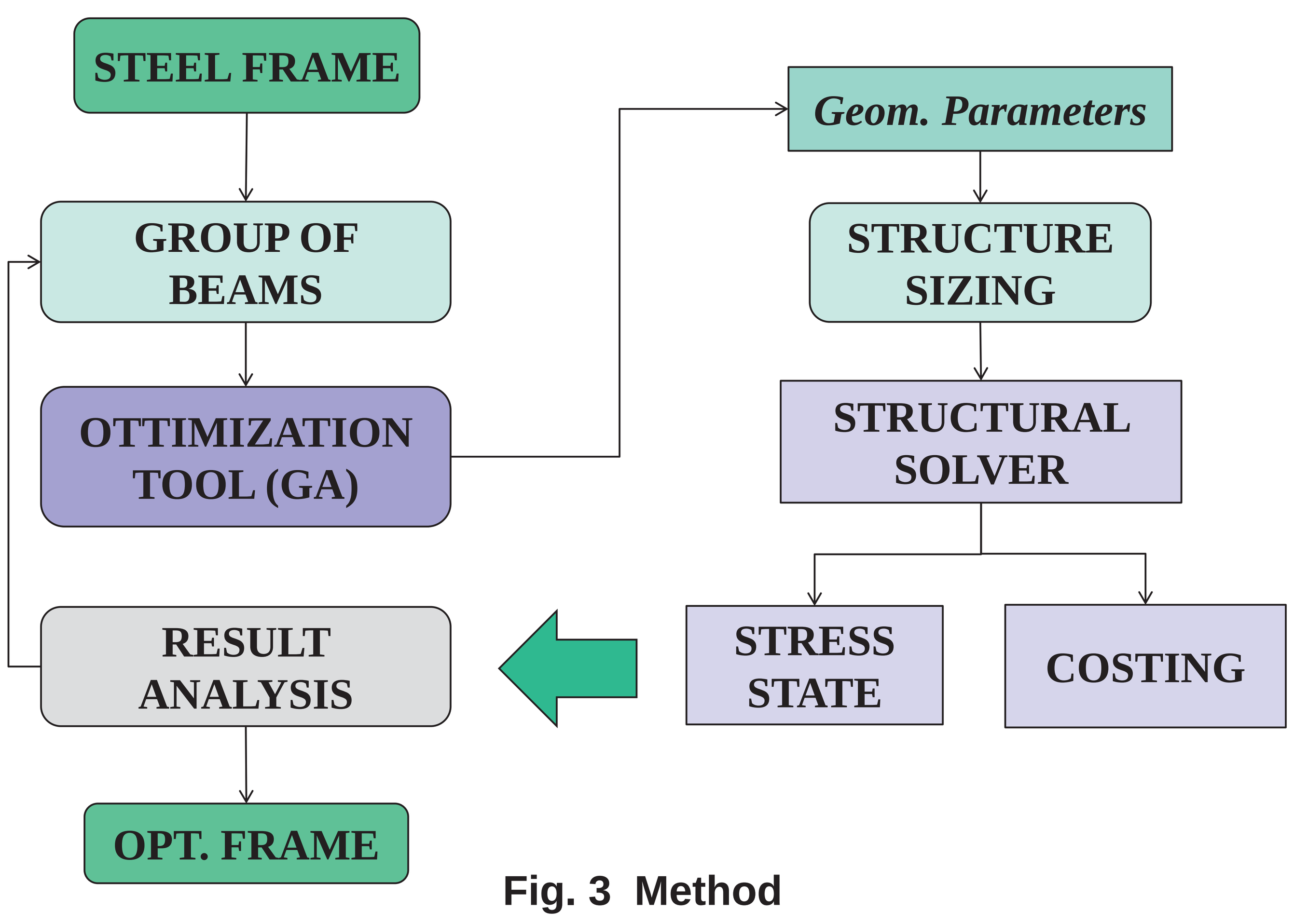

Fig. 3 Method

SYSTEM IMPLEMENTATION

The optimization approach was implemented in a platform-tool developed using modeFRONTIER®, a multi-objective optimization tool with a design environment. The platform architecture includes also the SAP2000 software, used for the structural analysis.

Fig. 4 shows the workflow elaborated in the proposed research activity. Input data is the geometrical parameterization which describes the section of the main beams. Input parameters are elaborated using a spreadsheet developed in Microsoft® Excel environment. The optimization analysis was based on the pilOPT algorithm while the virtual experiments were calculated with SAP2000. The interaction between SAP2000 and modeFRONTIER® was performed by an application implemented in the Microsoft® Visual Studio .NET platform.

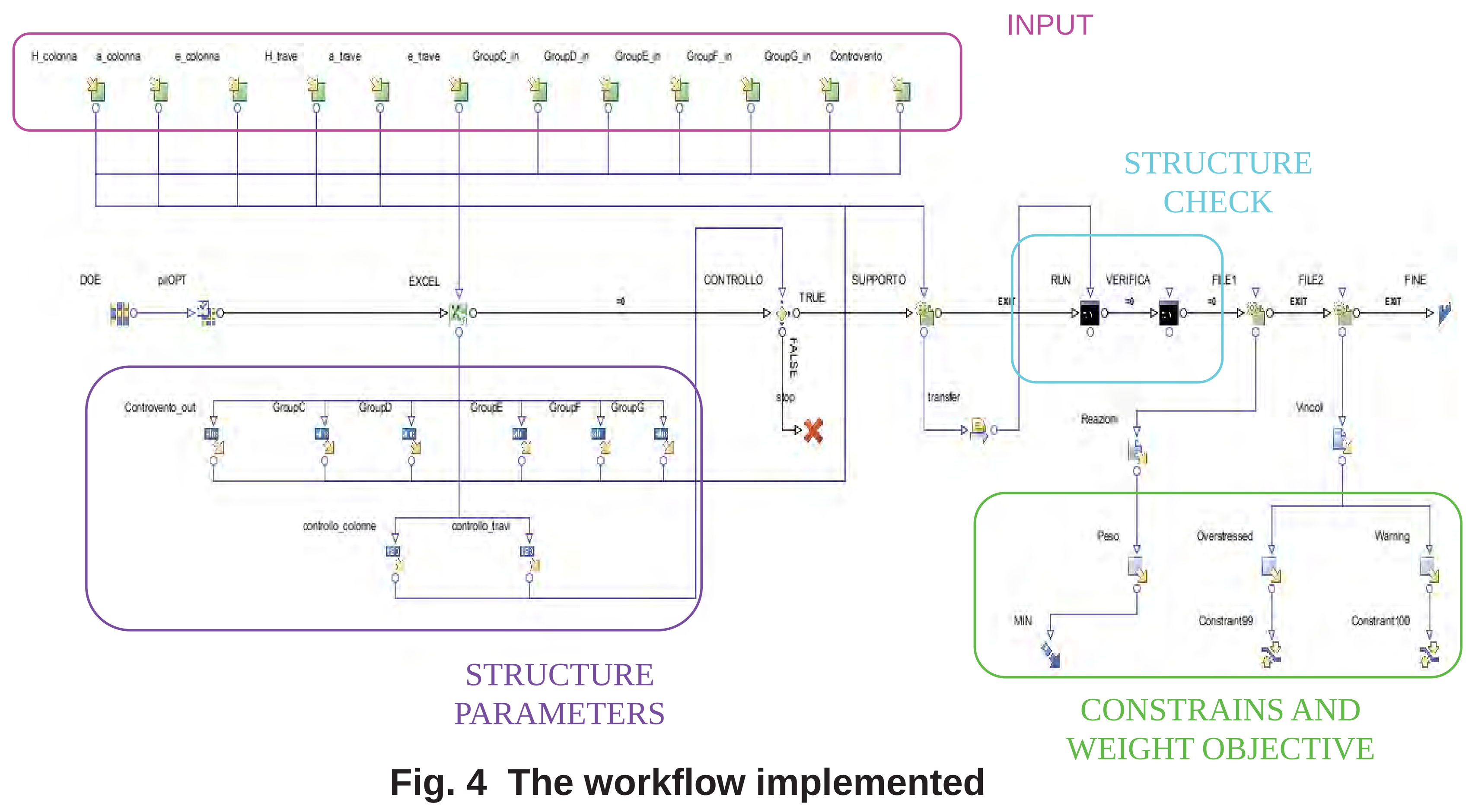

Fig. 4 The workflow implemented

SYSTEM EXPERIMENTATION

The proposed approach was experimented to simulate an optimization process focused on an example of a steel building for an offshore application. The proposed test case is a virtual building similar to those used in Oil&Gas industry.

The virtual model analyzed was simplified in many points and a lot of equipment was not considered.

The second simplification is that only static analyses were considered in the simulation of the virtual experiments instead of the all FEM analyses shown in Fig. 2.

The test case analyzes a steel construction divided in two structures: the supporting frame and the secondary structure. The proposed approach was applied firstly to the optimization of the supporting structure. Secondly the study was enlarged to the optimization of the secondary structure, which is mounted on the supporting frame. While the first experiment optimizes the geometrical dimensions of the basic structure, the second one proposes the study of the additional beams.

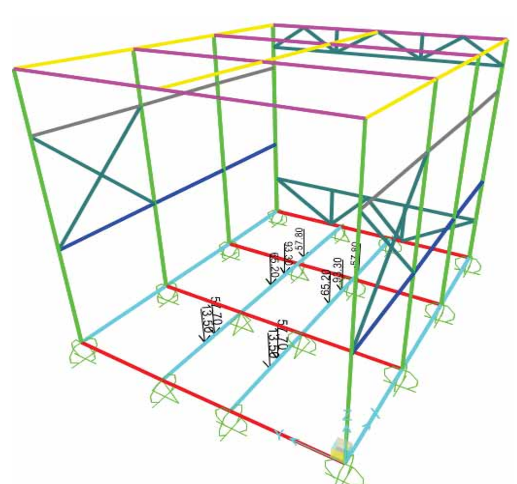

Fig. 5 A simplified supporting structure

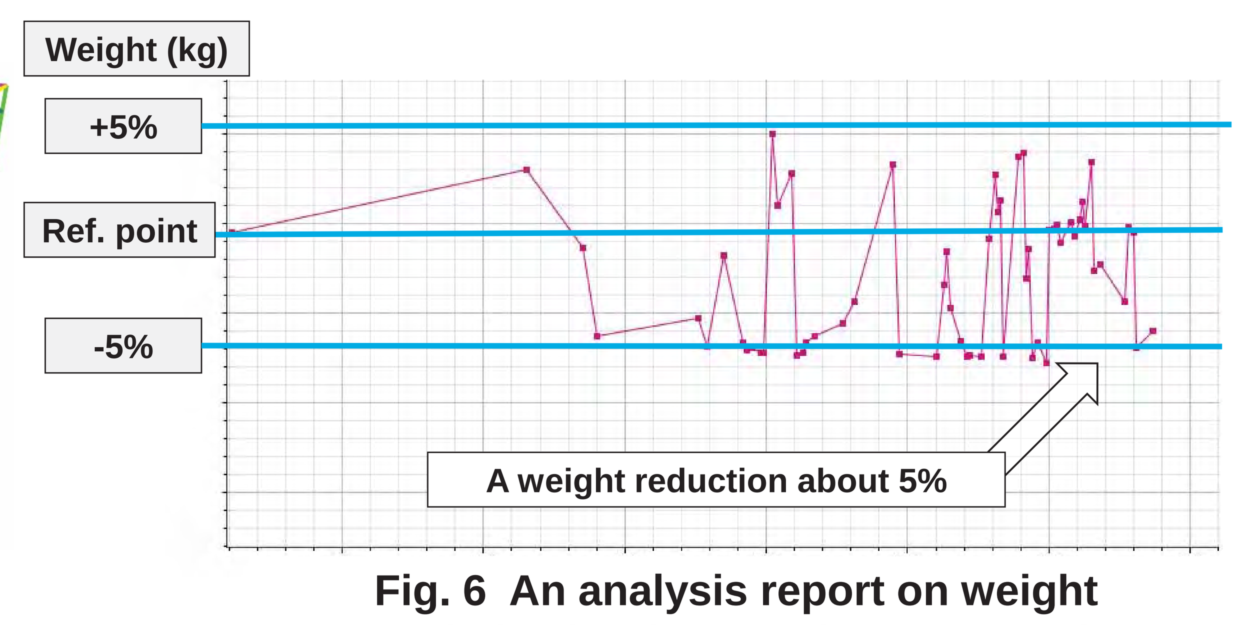

Fig. 6 An analysis report on weight optimization (supporting structure)

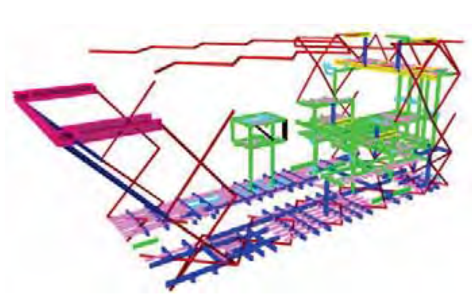

Fig. 7 A simplified secondary structure

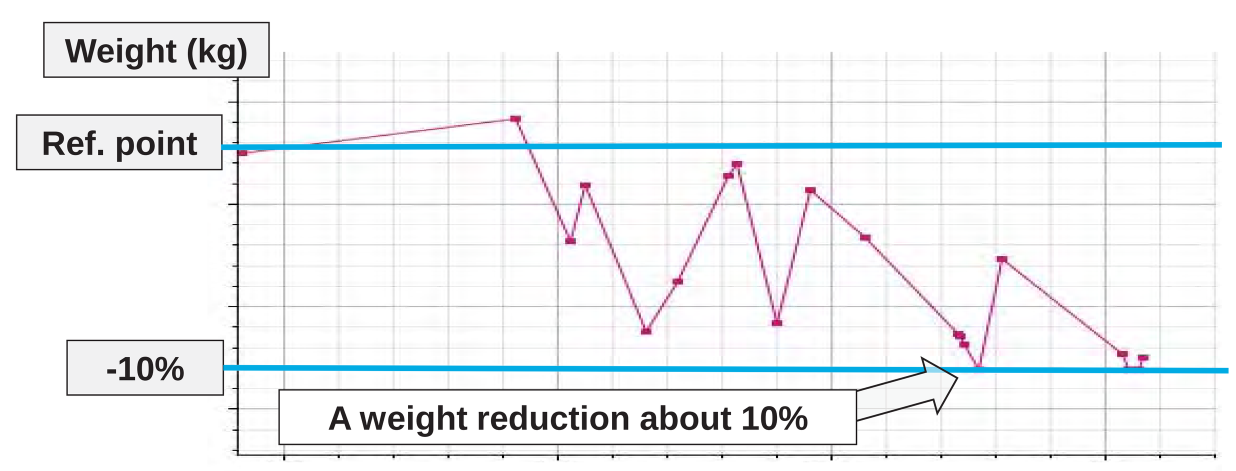

Fig. 8 An analysis report on weight optimization (secondary structure)

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