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AN ANALYSIS OF JIB CRANE CONSTRUCTIVE SOLUTION IN EXPLOATATION

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ABSTRACT
In this work a wider analysing methodology for construction and static-dynamic behaviour of specific crane's type – jib crane is given. A considerated methodology is applyable also on other types of cranes, what gives a certain width and expediency of its consideration. An application of CAD technologies and calculation numerical methods to this complex structures is of a great importance, which gives modern access in the actual design and constructive diagnostics. In this work a comparative analysis of several concept solutions of jib cranes is given, with application of KOMIPS system, as well as detail analysis of a selected solution. An analysis of jib crane's design is given also by application of the I-DEAS 11 NX Series software. Results of the static-dynamic analysis of complex configuration behaviour can be of great importance for signiffically improvement of construction, and presented methodology is applyable for different types of crane's construction.
Key words: jib crane, reduced model, dynamic analysis, CAD technologies.

1. INTRODUCTION

In modern industry, higher economic-technological demands are often requested from different kinds of transportations devices. An objects of interest in this paper are some construction solutions of jib cranes. Some situations exists in which usually implemented construction solutions are not quite optimal through static-dynamic behaviour analysis. For complex systems, like jib cranes are, analytical approach of calculations are not enough to determine global structure integrity. Total description of system static-dynamic behaviour can be determined only with CAD technologies implementations or experimental evaluations. There is no doubt that numerical 3D modelling, discretization, stress strain and dynamic analysis are of a great importance, especially in optimization of existing real or virtual models of cranes. In this paper a methodology of implementation of beam, plate and volume type finite elements will be also appointed for this kind of constructions. Several types of parameters, as deformation energy over construction elements, kinetic and potential energy over mode shapes of natural frequenties, etc., will be used for local elements optimization. In that manner, several static-dynamic analysis for real exploitation conditions are done using numerical modelling and discretization in software I-DEAS, and creating reduced and plate type finite elements models in system KOMIPS. This methodology appointed to quite different model of jib crane in related domain of constructive solution.

2. NUMERICAL MODELLING AND CALCULATIONS OF COMPLEX STRUCTURE

In this chapter a short numerical calculations with volume finite elements discretization of FE model of initial jib crane construction is shown. In Table 1, a main characteristics of jib crane is given. 3D model of jib crane is given, Figure 1. Stress-strain analysis under the total value of dynamic loads is given, Figure 2. It can be seen that open thin-wall profiles are not appropriate in some circumstances.

Table 1. Technical datas of initial jib crane's model

Characteristic	Value	Units
Jib crane capacity	10	kN
Jib crane's hight	3670	mm
Inner and outer diameter of a column	D = 410 ; d = 378	mm
I profile dimensions	h = 360 , b = 170 , t = 12,7 , s = 8 , r = 18	mm
Lifting hight	2685	mm
Console length	4150	mm
Column weight	523	kg
Console weight	314	kg
Trolley weight	150	kg
Lifting power	2,2	kW
Trolley moving power	0,5	kW
Console rotating power	4,0	kW
Console number of revolutions	4	o/min
Actuation time	4	s

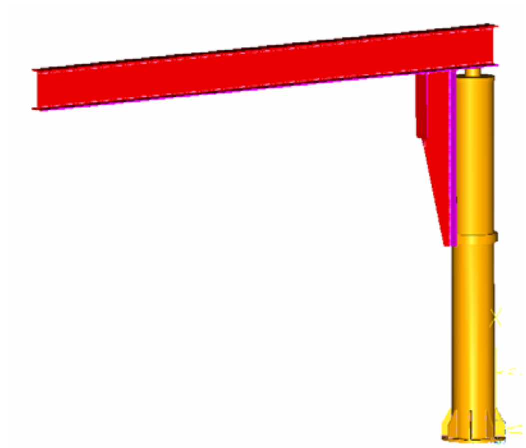


Figure 1. 3D model of jib crane

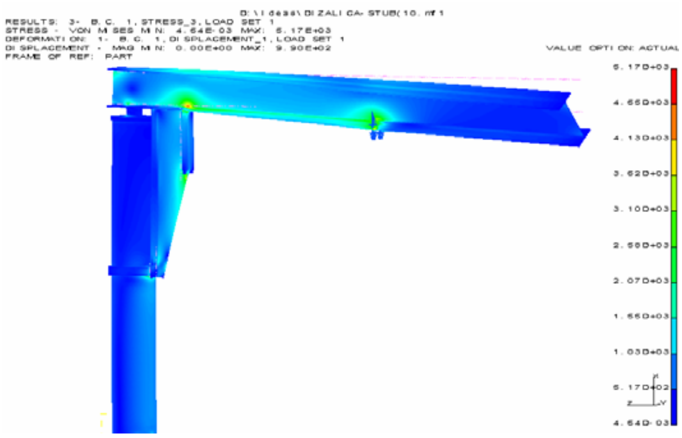
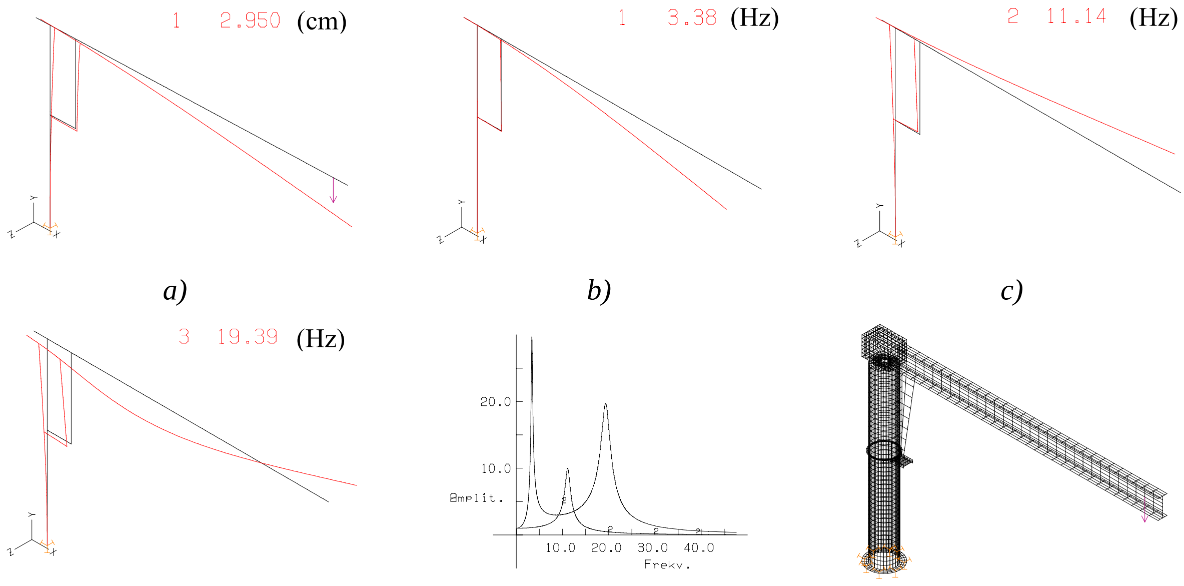


Figure 2. Stress-strain state under dynamic load

2.1. Static-dynamic calculations of complex structure with reduced finite element models

Reduced finite element models with beam sections are very suitable for static, and esspecially for dynamic analysis of complex structures. Some additional options of system KOMIPS are very suitable for determinition of optimization places over construction, [1]. Figure 3 shows results of stati-dynamic analysis with numerical values: max. static deformation 2,95 (cm), first modal frequency 3,38 (Hz), second modal frequency 11,14 (Hz), third modal frequency 19,39 (Hz). Frequency spectrum diagram, Figure 3-e shows a large value of dynamic amplification value. In Figure 3-f a plate finite element model of jib crane is shown. Because of lack of space in this paper stress-strain analysis of initial and optimized construction of jib crane will not be presented.

In Tables 2 and 3 deformation energy over construction elements before and after optimization, and kinetic and potential energy configuration over construction elements for first natural frequency are shown, respectively.



d) e) f)

Figure 3. Discretization and boundary conditions of static and dynamic complex structure analysis; a)flection form, b)first modal shape, c)second modal shape, d)third modal shape, e)ampl.-freque. diagram of frequency analysis, f)plate type finite element model

Table 2. Deformation energy configuration over construction elements before and after optimization

Elements	Total energy of elemen. flection (%) (BEFORE OPT.)	Total energy of elemen. flection (%) (AFTER OPT.)
Column	48,1	34,4
Console	48,4	58,8
Recline plate	0,0	0,1
Console plate/box shape plate	3,5	6,7
Console end	0,0	0,0

Table 3. Kinetic and potential energy configuration for first mode frequency before and after optimization

	Frequency 3,38 [Hz] (BEFORE OPT.)		Frequency 5,79 [Hz] (AFTER OPT.)	
Elements	Ep (%)	Ek (%)	Ep (%)	Ek (%)
Column	19.1	0.0	36,1	0.1
Console	76.3	99.9	53,2	99.7
Recline plate	1.1	0.0	3.1	0.0
Console plate/box shape plate	3.5	0.1	7,6	0.2
Console end	0.0	0.0	0.0	0.0

This investigations of deformation energy over construction elements and configuration of kinetic and potential energy over construction elements are appointed to elements on construction with great and less importance to carrying loads. Elements, among the others, which are appointed as good for optimization was jib crane's console, console plate and stiff-plates. An optimization of stiff-plates will not be presented in this paper.

According to static and dynamic analysis of jib crane's optimized construction, several static-dynamic parameters are achieved with better values, Figure 4.

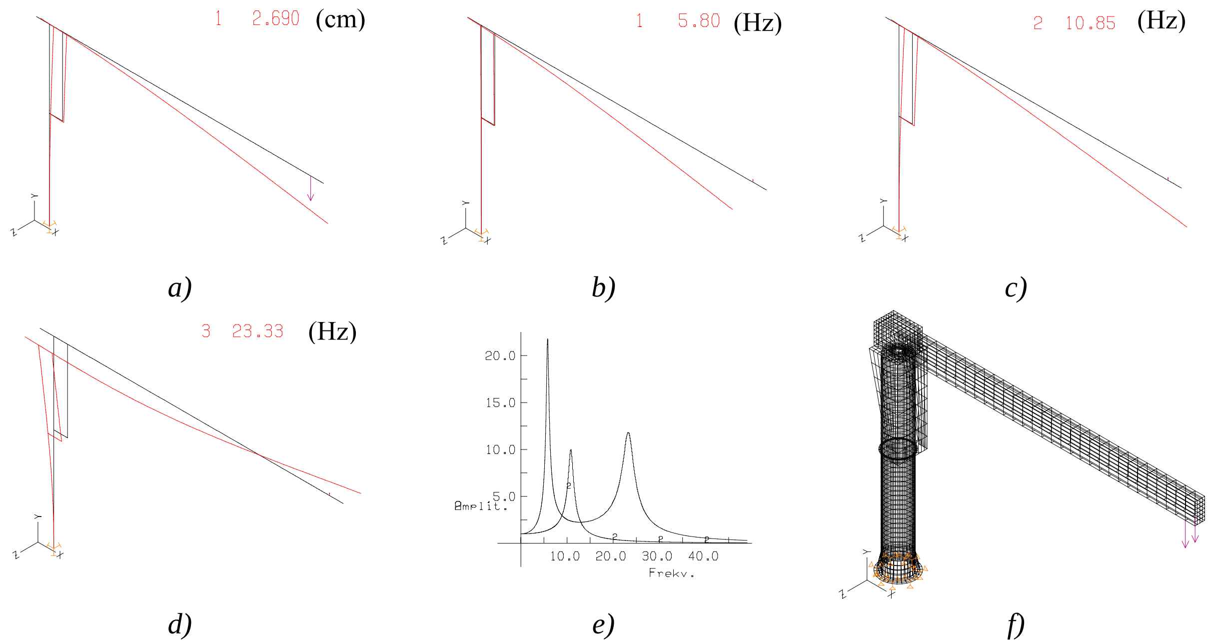


Figure 4. Discretization and boundary conditions of static and dynamic optimized structure analysis; a)flection form, b)first modal shape, c)second modal shape, d)third modal shape, e)ampl.-freque. diagram of frequency analysis, f)plate type finite element model of optimized construction

3. CONCLUSIONS

In this paper an effective methodology of calculation and design of real model of jib crane construction, with final goal of local and global structure optimization using CAD technologies is presented. That methodology resulted with new structural conception of same domain of jib crane with better static and dynamic parameters. With modification of structure geometry several goals are achieved, as for example:

- reduction of max. deformation parameter up to 20 (%),
- reduction of equivalent stresses up to 75 (%),
- fine configuration of stress fields over construction,
- greater natural frequencies - first 81 (%), third 20 (%),
- reduction of factors of dynamic amplification for first and third frequency up to 28 (%) and 40 (%), respectively,
- energy increase on odd and less changes for even modal shapes,
- deformation energy increase over some construction elements, etc.

It is quite clear that modifications of some parameters can be achieved in some levels and domains, [2,3]. For greater changes (higher frequencies and smaller dynamic amplification factors for example), a global structural modifications must be done, but in that cases it is about other conception type of crane.

4. REFERENCES

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