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STUDIES REGARDING THE STATE OF STRESS AND STRAIN IN WINDBRACING BARS OF THE GANTRY CRANES. THE DYNAMIC ANSWER AT THE DISPLACEMENT OF THE CRANE'S CARRIAGE UNDER CONSTANT LOAD

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Abstract: *The present paper is a part of a succession of analysis concerning the behavior of the loaded gantry crane. One achieved the conclusion that researches based on modern software are necessary ("strong software"); new designing, tests and checking methods of the lifting plants. In the final purpose (target) is to increase the working safety; at its base stands the precise knowing of the state of strain both in the assembly and in the elements.*
Of great importance is the knowing of the structure's answer in static and dynamic state, mainly expressed through the values of the stress and strain field.
The paper contains, mainly, information concerning the dynamic answer of the stress in windbracings at the shift of the crane's carriage subjected to a constant load, the effect of the longitudinal and transversal swinging of the load lifted by the crane, conclusions regarding both the state of stress and the sectional (cross section) internal forces in the maximum loaded beams of the crane (elements).
Keywords: *stress, deformation, strain, windbracing, longitudinal swinging*

1. INTRODUCTION

In order to determine the state of stress in the elements which are susceptible to fracture, a preliminary analysis of the potential failure zones of the crane was performed.

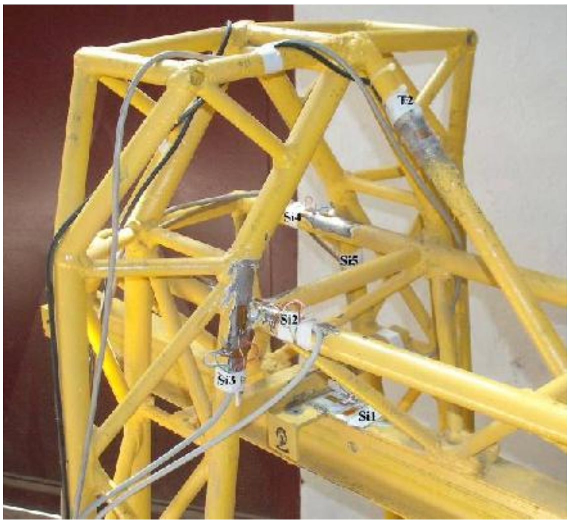

Figure 1. Maximum loaded main areas

After this analysis, the following areas were selected (considered to be at maximum load), fig. 1:
- the main beam, I profile, in the welding area to the support beam, denoted by Si 1;
- the longitudinal pipe, in the welding area to the support leg, indicated by Si 2;

- the left longitudinal pipe, in the area of the welded joint to the support stand, positioned by Si 4;
- Si 5, support leg in the welded joint area of the left longitudinal pipe.

The measurement system SPIDER 8 determines the specific elongation □ in the area where the strain gages are applied. The loadings take place in the limit of the linear relation between the stresses and the strains (Hooke's law of elasticity); one multiplies "□" by the longitudinal modulus of elasticity E [MPa] and the normal stress □ [MPa] in the measurement area results.

The crane's carriage was successfully placed in points P1, P2 … P7, according to figure 2, so that the direction of the pull rope meets the vertical line which crosses through th before mentioned points. A constant load was manufactured from a turntable with a central rod and plates with the total weight 1444 N. The load was attached to the crane's hook through the force transducer U2B – 10 [kN].

Figure 2. Assembling scheme for the deflections measurement

2. WINDBRACINGS STRESSES AND INTERNAL FORCES AT THE DISPLACEMENT OF THE CRANE'S CARRIAGE

One performed the displacement of the crane's carriage loaded with weight sets according to the load of 1444 N, from point P7 to P1, figure 2. During the displacement, the following parameters were recorded:
- the forces in windbracings, denoted by T1 and T2;
- the force in the weightsets support rope, FN;
- the stresses denoted by Si 1, …, Si 5 [MPa].

One achieved the spectral analysis diagrams in frequency of the force acting on the hook, of the forces in windbracings and of the stresses (the displacement of the load on the beam) were obtained, Figure 3 and Figure 4.

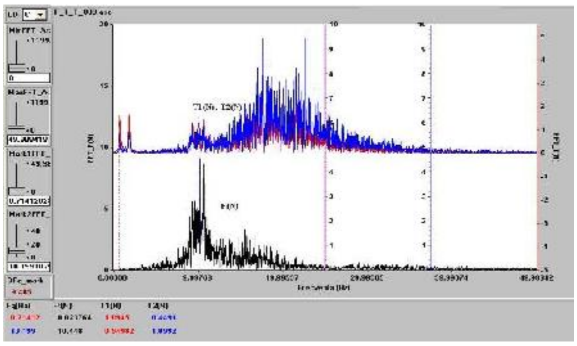

Figure 3. The frequency spectrum of the force at hook and of the forces in windbracings

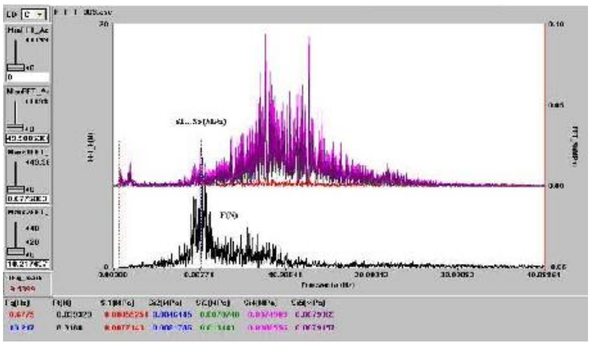

Figure 4. The frequency spectrum of the force at hook and of stresses

3. STRESSES AND INTERNAL FORCES IN WINDBRACINGS AT LONGITUDINAL AND TRANSVERSE SWINGING OF THE CRANE'S CARRIAGE

One induced a longitudinal swinging of the suspended weight, carried by the crane's carriage (horizontally swinging, along the main beam). The following registrations were performed:

- the internal forces in windbracings, T1 and T2;
- the internal forces in the support rope of the weight F;
- the normal stresses □: Si 1 … Si 5.

One performed the spectral analysis of the above presented registrations and one achieved the frequency spectrum, Figure 5 and Figure 6.

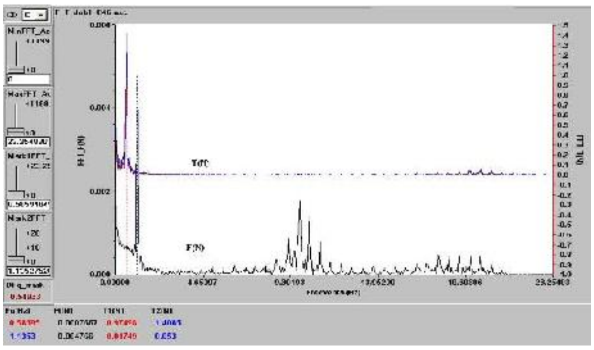

Figure 5. The frequency spectrum of the force at hook and of the forces in windbracings

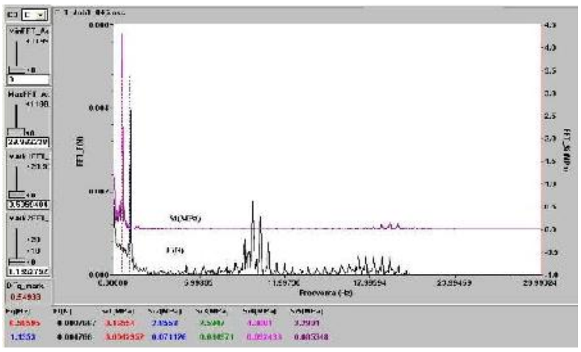

Figure 6. The frequency spectrum of the force at hook and of the stresses

One also performed a study for the case of transverse swinging (horizontally swinging, normal on the main beam of the crane) of the load hanging at the hook of the crane's carriage.
The same elements as in the case of the longitudinal swinging were recorded. One made the spectral analysis of the mentioned registrations and one achieved the frequency spectrum of the force at hook (support rope), of the internal forces in windbracings and of the stresses Si 1 … Si 5. For the two swinging states of the hanging load in pointes P1 and P4, Figure 2, are determined the average values and the top values of the forces in the support rope of the load, in windbracings and of the stresses (denoted by F, T and Si). These are presented in Table 1.

Table 1. Average and top values of the internal forces in the support rope of the load, in windbracings and stresses S1, S2 … S5.

Parametru/ Direcţie		F (N)	T1 (N)	T2 (N)	S1 (MPa)	S2 (MPa)	S3 (MPa)	S4 (MPa)	S5 (MPa)
$\tilde{X}_{mediu}$	Balans long. în P4	1444	-7.6	-235	0.29	0.206	2.3	1.23	-1.8
$\hat{X}_{var\ f}$		1444.03	-9.8	237.9	0.51	7.1	6.8	8.7	-7.6
$\tilde{X}_{mediu}$	Balans long. în P1	-1444.1	-829.1	-555.2	-0.534	-0.073	-0.66	-1.94	2.61
$\hat{X}_{var\ f}$		-1444.2	-1077.8	-560.7	-0.93	-0.51	-2.77	-98.3	7.7
$\tilde{X}_{mediu}$	Balans trans. în P4	1444	-7.64	-235	0.26	0.41	2.39	1.19	-1.8
$\hat{X}_{var\ f}$		1444.03	-8.05	-235.6	0.46	4.5	3.7	2	-2.7
$\tilde{X}_{mediu}$	Balans trans. în P1	-1444.1	-829	-555	-0.54	-0.071	-0.65	-1.9	2.6
$\hat{X}_{var\ f}$		-1444.2	-870.45	-556.11	-0.9558	-0.11928	-0.975	-20.71	4.5

4. CONCLUSIONS

From the analysis of the above presented registrations, of the achieved frequency spectrum and of the values from Table 1, one draws some very important conclusions:

- The swinging of the load has a strong negative effect on the state of stress of the elements which are susceptible to fracture. One achieves to an oscillation of high amplitude which can lead the state of stress around the allowable values (even to the elastic limit of the material);

- The stresses due to the longitudinal swinging of the hanging load are higher than the ones due to the transverse balancing;
- The swinging of the load in both directions (longitudinal and transverse), has as result a very low damped oscillation. It is that of a pendulum whose frequency is given by the weight of the hanging load and by the length of the drive cable. For the case analyzed in the present paper, the oscillation frequency is 0,58 Hz;
- The internal forces in windbracing and the stresses in the elements which are susceptible to fracture, contain harmonic oscillation whose frequency is 0,58 Hz. These are due to the horizontally oscillations of the cable – hanging mass system.

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