

ASSESSMENT THE DYNAMIC'S CONDITION OF THE SLOPPING BRIDGE no2. IN TPP BITOLA

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Abstract: The main objective of the research work in the paper is to define the dynamic stability of the construction of sloping bridge No.2 in REK Bitola (thermo power plant) by FFT analysis with measured vibration characteristic places and compared the results with FEM analysis.

Characteristic of this case study is that there are no any standards in relevant literature that treat this issue. The sloping bridge and the objective will be met through access to comparative measurements of vibration of the two constructions of bridges around the same operating conditions and compared the results to find reasons for increased vibrations of the sloping bridge No.2. This approach and methodology used, and the results of comparative analysis should serve as a benchmark for future measurements of these and similar structures.

KEYWORDS: VIBRATION, SLOPPING BRIDGE, DYNAMICS ANALYSIS, THERMO POWER PLANT

1. Introduction

Mining and Power Company ELEM REK "Bitola" is the largest power generating capacity in Macedonia. It provides more than 70% of power and part of the coal needed for the industry and households in Macedonia.

Social economic importance of the energetic, especially in the last decades, after the oil shock crisis, gets special importance and needs special attention from all citizens and employees to the energy savings from one side and from the employed into energy sector on the other side from which depends safety and reliability of the operation of the energetic plants, equipment life cycle and the price of generated power (1).

Power Generation as all other technologies is a common effort of multidisciplinary specialists. Its efficient operation mostly depends from the quality and reliability of the technology and from the people operating and maintaining the equipment.

Power production process in ELEM REK "Bitola" is organized in two production units: Coal Mine and Thermal Power Plant. Scheme of production technology of electricity from coal mining to the handover of power to consumers is shown in fig 1.

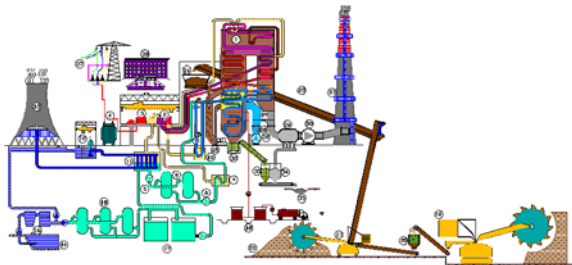


Fig.1 Scheme of production technology of ELEM REK "BITOLA"

During the work reported increased levels of vibration sloping Bridge Np.2 (fig.2) in terms of sloping Bridge No.1. Because of the exceptional importance of coal in the bridge supply coal to the TE approach to this problem seriously and carried out preliminary measurements to determine the vibration state of the construction of the sloping bridge. Measurements are performed with the FFT analyzer, which is a new trend in the field of vibration diagnostics. It is capable of a second to display a frequency range of vibration signal, to memorize it and at some subsequent time when necessary to perform the signal processing.

Initial measurements were carried out vibration of the plants (T5.1' and T5.2') to determine the vibration condition of the plants. It turned out that their vibration condition is permissible limits, so approaches to defining the measurement plane, measurement points and parameters of recording the construction of the sloping bridge.

Because there are no norms that treat this issue of the sloping bridge, measurements are performed on both oblique bridges,

approximately the same operating conditions for the comparison of results obtained.



Fig.2. Slopping bridge in TPP

2. Parameters for defining the dynamic stability

To define the optimal frequency range, a several measurements in frequency area from 0 to 100 Hz are made. The results of the measurements show that the most frequently a vibration shows on the area of 0 to 200Hz. The slopping bridge construction dynamic behavior isn't stationary but variable in the time function, a three type of vibration measurement are made and each of that measurement with eight average results. Amplitudes of the vibrations displacements (PEAK TO PEAK) was the parameter chosen for monitoring the vibrations, and accelerations a made with simple calculations. SKF instrument Microlog CMVA60 was used for measurement the vibrations condition. The best cross sections and measurement points are chosen and defined from Fig.3a, 3b. Cross sections are between two basic supporting pillars as a most loaded element of the construction, and two measurements are made on point's shows in fig.3a.



a)

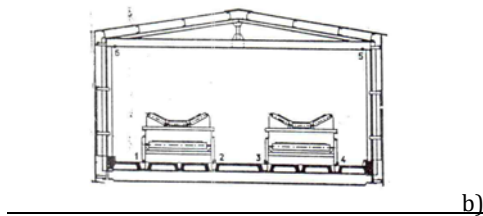


Fig.3 a) Slopping bridge – dispositions of measuring cross-sections
b) Dispositions of the measuring points

Every measurement cross section had 6 measurement points (Fig.3b). On measurement point no.4 are made measurements in three way (horizontal, vertical and axial) to get the whole picture about vibration field (Fig.4)

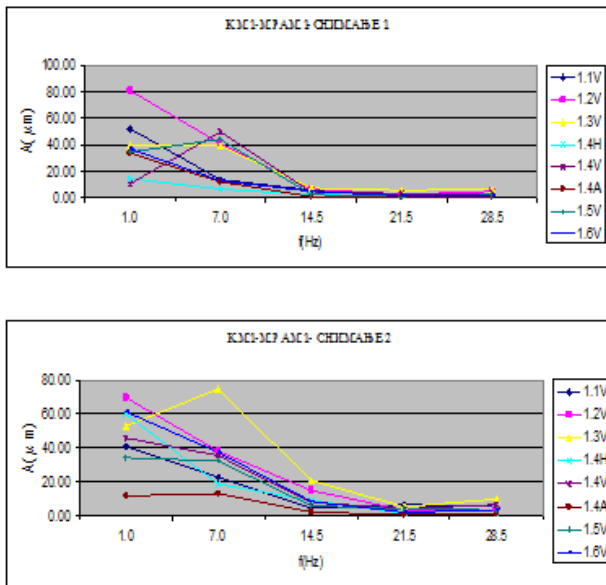
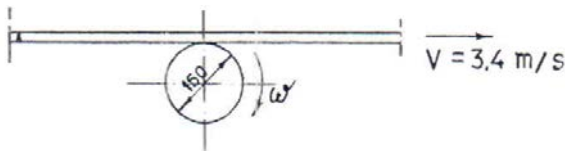


Fig.4. Some measurement results in point no.4

The results of the measurements obtained these conclusions:

- Dominant vibration component had a 7Hz frequency with high harmonics 14,21,28 Hz are dominant in frequency specter of the vibrations
- This situation probably was the result of ribbon conveyer working. This conclusion was provoked by the same level of dominant measured vibration component (7Hz) and rotation frequents of the ribbon conveyer rollers.



$$V = R\omega \approx 0.08 \frac{n}{10}$$

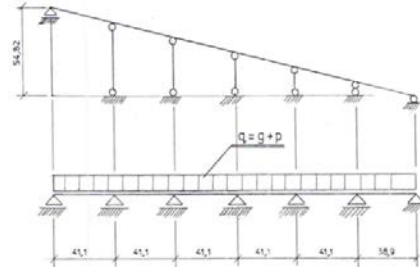
$$n = \frac{10 \times V}{0.08} = \frac{10 \times 3.4}{0.08} \approx 425 \frac{o}{min} \approx 7 Hz$$

- Time domain vibration characteristic hasn't some concrete depending
- The vibration level depends of ribbon conveyer loading, and with increasing the loading, the

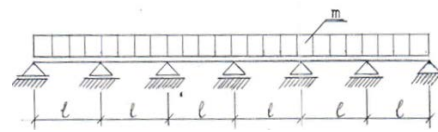
displacements amplitude of the construction increase too.

Forced vibrations of the slopping bridge construction was measured and analyzed by displacements amplitudes, and acceleration amplitudes are calculated.

The main construction system of the slopping bridge is rack carrier system continuous loaded beam of six fields shown on the figure 5:



Simplified model:



Cross section:



$$\text{For } 2 \leq 20; A = 64.4 \cdot 10^{-4} \text{ m}^2$$

$$J_x = 2 \cdot 2 \cdot 64.4 \cdot 10^{-4} \cdot 1.6^2 = 659 \cdot 10^{-4} \text{ m}^4$$

Fig.5. Approximation the construction as continuous beam

Continuously distributed load on the beam is:

$$q = 22.95 \text{ KN/m}' \sim 23.0 \text{ KN/m}'$$

Continuously distributed mass on the beam is:

$$m = \frac{23.0}{9.81} = 2.34 \text{ t/m}'$$

First of all, it must be solved frequency of free oscillations of the system as a part of dynamics characteristic assessment. For that purpose, it defined one model as continual beam with continually mass distribution and constant linear stiffness. All distance between each other are the same, until the last distance of 38.9m is different than others for 6%.

The frequency of free transversal oscillations is:

$$\vartheta_i = \frac{1}{2\pi} \frac{a i^2}{1^2} \sqrt{\frac{EJ}{m}} \quad [Hz]$$

For the steel, $E = 2.1 \cdot 10^8 \text{ KN/m}^2$

$$\sqrt{\frac{EJ}{m}} = \sqrt{\frac{2.1 \cdot 10^8 \cdot 659 \cdot 10^{-4}}{2.34}} = 24.3 \cdot 10^2$$

$$\vartheta_i = \frac{1}{6.28} \frac{1}{41.1} 24.3 \cdot 10^2 a i^2 = 0.229 a i^2$$

α_i^2 -square of characteristics equations for the different tones

form i	1	2	3	4	5	6
α_i^2	9.91	10.95	13.69	17.25	20.70	39.48
ϑ_i [Hz]	2.30	2.50	3.10	4.00	4.70	9.00

Frequency ϑ_1 to ϑ_5 define the first zone of thickening of frequencies, and ϑ_6 represent the second zone of thickening.

Maximal measured displacement of the vibrations in working conditions of the equipment is:

$$A = \frac{112}{2} = 56 \mu m = 0,056 mm$$

when the frequency is 7 Hz.

Maximal acceleration of $0,556 \text{ m/sek}^2$ calculated on frequency of 28Hz which is fare of the frequency of the systems free oscillations. Because of that, the system may become in resonant condition only in the zone of high tone forms, where the influence of the dynamics condition is significant.

Increasing level of the stress condition was calculated approximately. Maximal acceleration in frequency domain of 28 Hz is:

$$a = \pm 0,556 \text{ m/s}^2$$

Additional inertia load is:

$$q_{in} = \pm ma = \pm 2.34 * 0.556 = \pm 1.3 \text{ KN/m'}$$

And, the whole load is:

$$q_{vk} = q \pm q_{in} = 23.0 \pm 1.3 = \frac{24.3}{21.7} \text{ KN/m'}$$

Choosing the first bigger value, the increasing of the load in percent becomes:

$$p = \frac{24.3 - 23.0}{23.0} 100 \sim 6\%$$

This was a significant increasing the load in the safety dynamical and statically conditions.

3. FEM dynamics analysis of the slopping bridge

FEM analysis of the slopping bridge construction was done using the software package FEMAP (Finite Element Modeling and Post-processing). FEMAP allows displaying a number of outputs (results) that can be combined in different ways. We will consider only their own frequency modes (forms) in the analyzed structure. The analysis program calculates the first ten frequencies (modes shapes) are shown in Fig.6

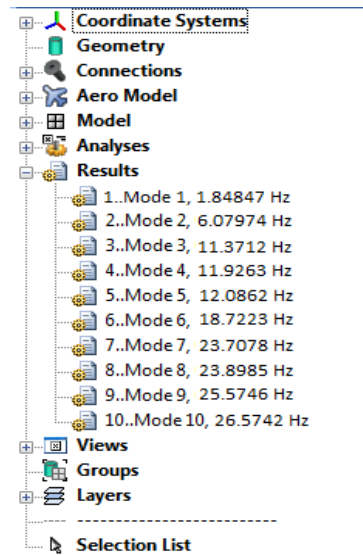


Fig.6. Frequency of the transversal free oscillations

Frequency f_1 to f_5 represent the first zone of thickening of frequencies, and frequencies from f_6 to f_{10} represent the second zone of thickening of frequencies. First five modes give on Fig.7

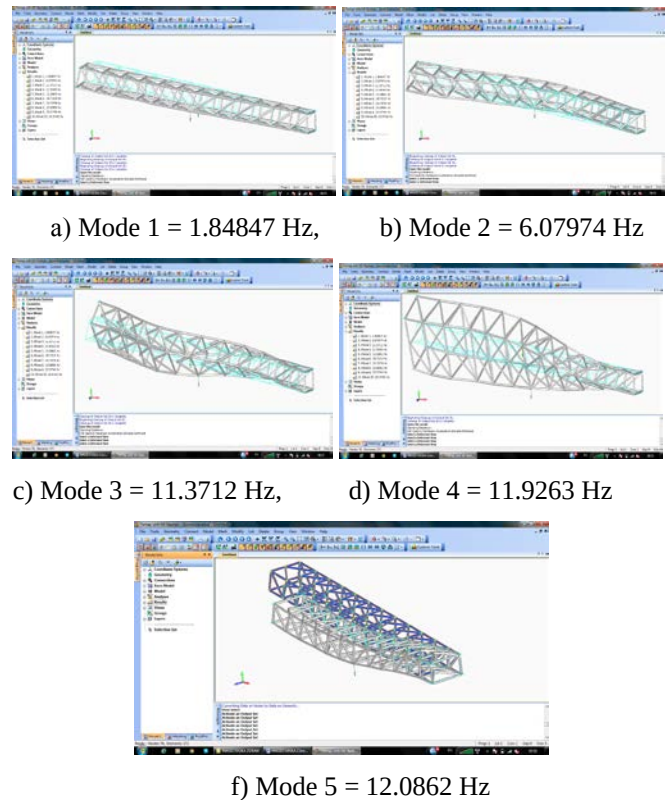


Fig.7. First five modes of frequencies

First five modes of the total displacements are given in Fig.8.

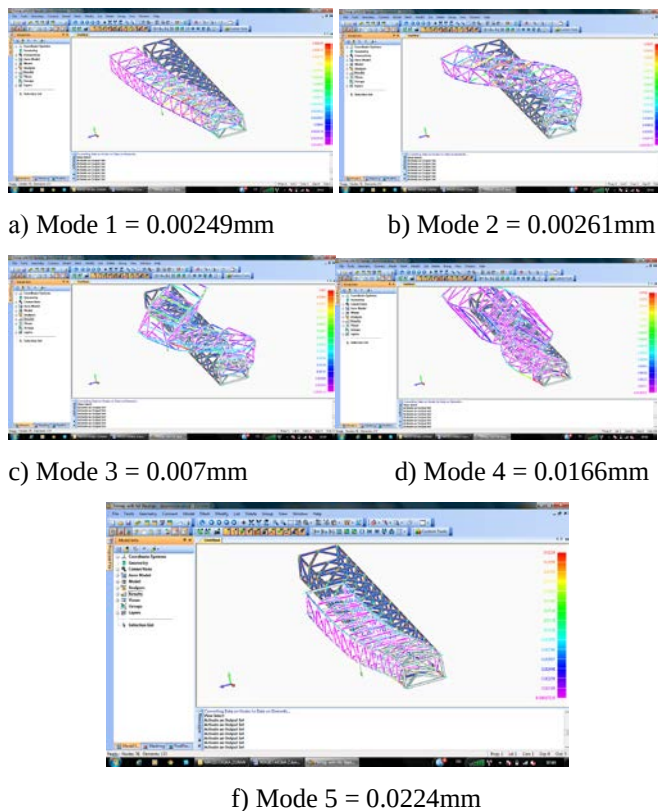


Fig.8. First five modes of total displacements

3. RESULTS AND DISCUSSION

The calculation shows that the maximum displacement in the first zone of frequencies is 0.0224mm. Also, when measuring the vibration of the system in conditions when the equipment is in operation, measured a maximum displacement of 0,056 mm at a frequency of 7 Hz .

The maximum speed of 0,556 m/sek² registered at a frequency of 28 Hz which is far from the frequencies of frequent tones forms the free oscillations of the system or the first zone of thickening of frequencies ranging from 1.84Hz to 12.08Hz. Thus the system can come into resonance condition in many forms treble, with no significant impact on the dynamic state.

This vibration picture probably is the result of the work of ribbon conveyor. This conclusion comes from the fact that the same rollers rotate with the same frequency as the established dominant vibration component (7Hz).

Also, based on the measurements of forced vibrations of the supporting structure of sloping bridge No.2 and performed dynamic analysis of their oscillations, it can be concluded that the construction of the bridge, the normal operation of technological equipment, poorly responding to the dynamic effects of the same .

If we compare the results of measuring the bridge 2 with results in bridge 1, which are of the same design and loaded with the same load, we can conclude that the level of the vibration on the bridge 2 is higher. This indicates that the bridge 2 construction that ribbon conveyor generates slightly larger amplitudes of the basic bridge structure.

4. CONCLUSION

Some general conclusions as a part of the researching:

- During the detail review as a part of the reconstruction phase of the whole construction of the slopping bridge, check all joint connection between elements and led to its original condition
- Check the rollers from the ribbon conveyor; if they are damaged or lost their rotation ability, replace them with the new
- Regularly cleaned (washed) hair floors of bridges, but for security reasons, and for raising the supporting static and dynamic reserves of construction.

It is necessary to continue monitoring the behavior of the structure and perform vibration measurements from time to time with the same assessment of the safety aspect of construction.

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