UDC 624.97.014.2-472.2/012.45

THE ANALYSIS OF TECHNICAL CONDITION OF TOWER STEEL FRAMES ACCORDING TO THEIR DYNAMIC CHARACTERISTICS

Ihor Davydov, Ph.D. (Tech.), Assoc. Prof., **Viacheslav Chaban**, Ph.D. (Tech.), Assoc. Prof., **Tetiana Kovtun-Horbachova**, Ph.D. (Tech.), Assoc. Prof.

State Higher Education Institution
"Prydniprovska State Academy of Civil Engineering and Architecture"

Problem statement. In Ukraine there are a lot of structures in operation which were calculated according obsolete standards. The periods of their service life exceed the periods of their design working life. The structures are damaged and the current loads exceed those that were designed. Moreover, their replacement is not planned.

The assessment methods of technical condition of load-bearing tower steel frames based on the comparative analysis of dynamic characteristics are developed [1]. The methods of structural dynamics analysis can be successfully applied to solve risk problems and durability problems taking into account the service life of a structure [1-4].

Purpose of the study. Steel space frames, such as water-cooling tower (27 m tall, with 9.5 m between the bands in the lower section and 6.8 m – in the upper section); technological structure with dynamic test facility of zero-gravity (18m × 18m, 40 m high); three-edged lattice tower of ventilation duct with cross diagonal web (113.5 m high, with 5.5 m outer diameter of gas exhaust duct inside the tower) were taken as survey items.

Methods of research – examination of technical condition of building structures according to [5]; measurements of structure vibrations with the use of Vibran devices of Interpribor company and seismic sensors; modeling and calculations by means of SCAD Office 21.1 software package.

The techniques to analyze dynamic characteristics of structures in order to evaluate fast technical condition of load-bearing structures is developed. The methods of practical evaluation of technical condition [5], methods of dynamic models, methods of dynamic calculations and tests, as well as forecasting methods of dynamic response of structure [1; 3; 4] were summarized to be the basis of this approach.

The comparative analysis in order to identify frequency and forms of vibrations before and after damage is performed. Processing of vibration records of free decreasing vibrations allows for the analysis of friction changes in construction (additional parameter for comparison). Computer models are specified according to the field measurements results of dynamic characteristics.

Main results. Interconnection between structural elements damage of different groups and dynamic characteristics changes of the item were detected.

The scheme of the water-cooling tower is shown in Fig.1.

Damage (failure) of horizontal truss elements causes the decrease in the frequency of principal mode. The forms with higher relative strain of horizontal trusses with up 1 Hz frequency instead of forms of higher relative strain of tower bands with 6.2…9.3 Hz frequency are displaced to the first place in frequency spectrum.

Damage of tower band elements leads to the decrease in the frequency of principal mode up to 15 %.

Fig. 2 shows that damage of vertical ties in columns gives lower frequency of principal mode. The forms conforming to 'tortional' (conditional twisting against standing axis) and specified by the curve of columns with up to 1 Hz frequency instead of the curved forms by analogy with cantilever bar with 2Hz−3Hz frequency are displaced to the first place in frequency spectrum.

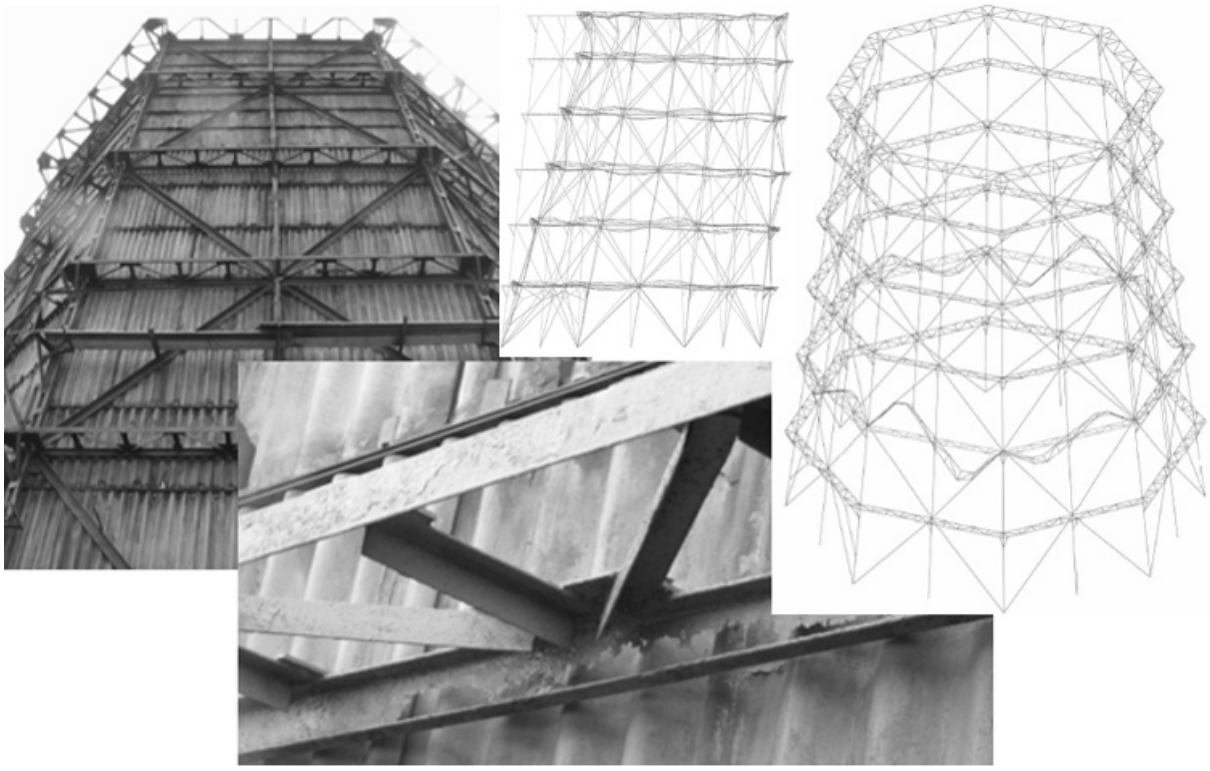

Fig. 1. Water-cooling tower, vibration mode variations of the damaged horizontal trusses

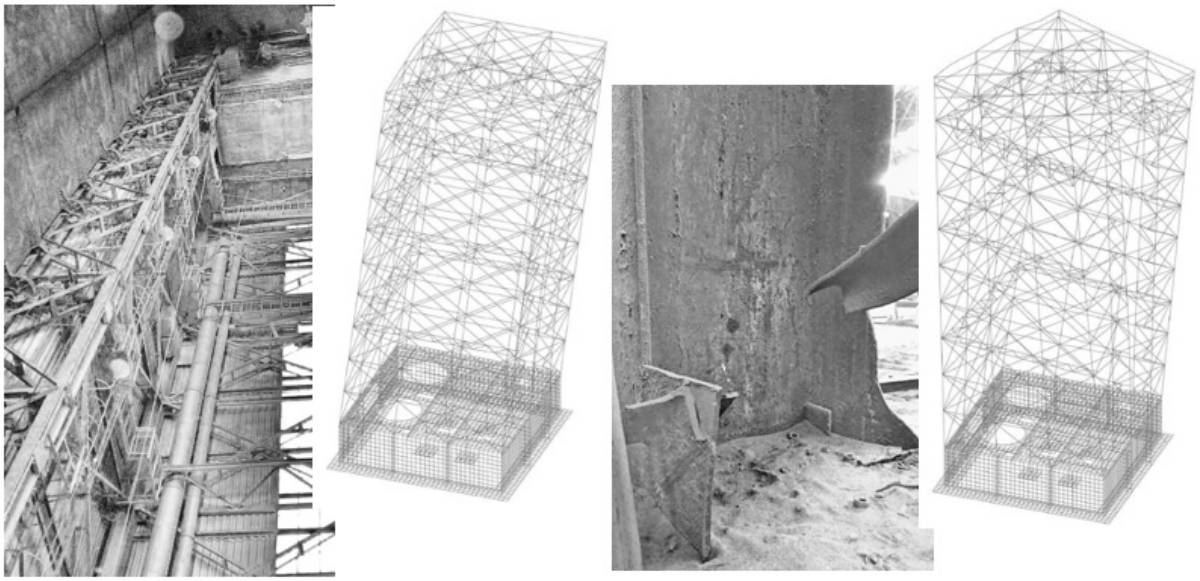

Fig. 2. Skeleton structure, vibration mode variations of the damaged X-brace columns

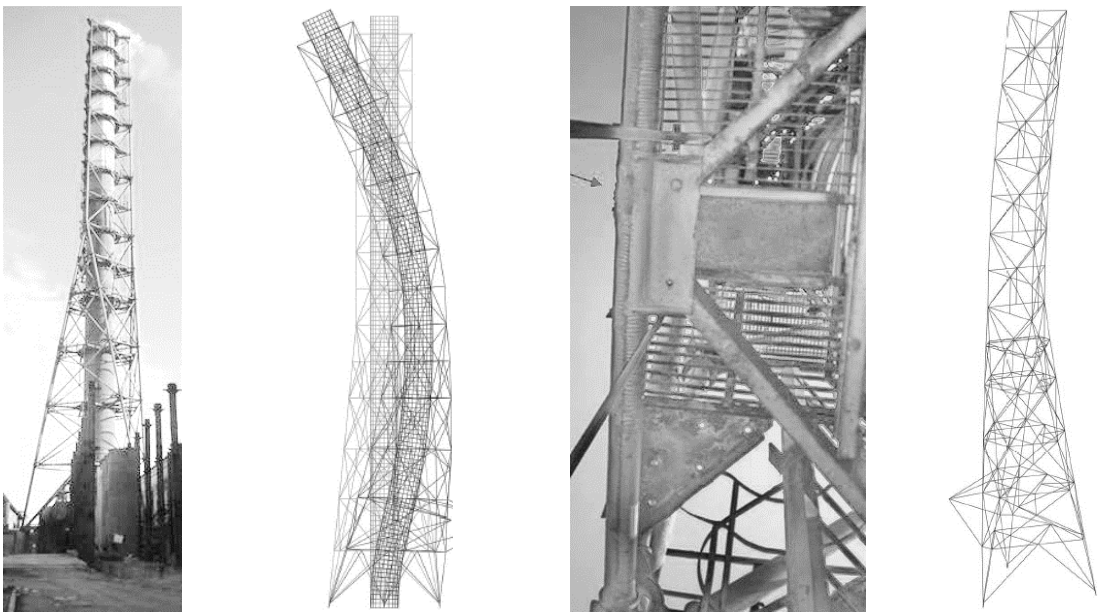

Fig.3. Ventilation duct power

Fig.3. shows that local failures leads to the local vibration mode in the beginning of the spectrum.

Conclusion. The variation analysis of dynamic characteristics allows identifying the group of damaged elements and separate units without detailed examination of the whole structure. Further recommendations concerning dynamic models and methods of vibration measurements will be given in the report. The atlases of vibration forms and frequency for certain types of standard construction units should be made. It will make possible not only to examine failures, but also to develop rational reinforcement ways without full durability test calculations at the initial stage.

References

1. Davydov I.I. and Linnik O.S. Estimation of the technical condition and strengthening of metal structures of the mobile communication mash. *Construction, materials science, mechanical engineering.* 2018, pp. 121−128. URL: http://srd.pgasa.dp.ua:8080/bitstream/ 123456789/ 2961/1/DAVYDIV.pdf

2. Eremin K., Raizer V., Telichenko V., Kulyabko V. and other. Safety assessment of existing buildings and structures. Stockholm, Sweden : FSV Construction, 2016, 268 p.

3. Kulyabko V., Macarow A., Nechitailo O. and Yaroshenko D. Structure dynamics: calculations, designing, diagnostic tests and nonlinear damping. *Harvard Journal of Fundamental and Applied Studies*. Harvard University Press, 2015, no. 1 (7), pp. 520−530.

4. Lv Zhou, Jiming Guo, Xuelin Wen, Jun Ma, Fei Yang, Cheng Wang and Di Zhang. Monitoring and Analysis of Dynamic Characteristics of Super High-rise Buildings using GB-RAR: A Case Study of the WGC under Construction, China. *Appl. Sci*. 2020, no. 10 (3), 808. URL: https://doi.org/10.3390/app10030808

5. DSTU B B.2.6-210:2016. Assessment of the technical condition of steel structures in operation. Kyiv : Ministry of Regional Development of Ukraine, 2017, 80 p.