



Opponent's review of the Doctoral Thesis

Candidate Ing. Arsenii Trush

Title of the doctoral thesis Turbulence Effects on Wind-Induced Fatigue of Slender Steel Structures

Branch of study Building and Structural Engineering

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Topicality of the doctoral thesis theme

Commentary: Thesis is primarily focused on vortex-induced vibration of steel cables. Vibration of cables is usually a crucial factor for reliability of cable structures. Theme is topical, for instance, for a large number of guyed masts with guy cables near the end of their lifetime. A better understanding of vibration of cables and fatigue process can lead to more precise estimation of their residual lifetime. Decision when to replace the cables significantly affects the reliability as well as economy of the structures. Theme is important also for design of new cable structures.

☒ excellent ☐ above average ☐ average ☐ below average ☐ poor

Fulfilment of the doctoral thesis objectives

Commentary: Thesis objectives

- investigation of simultaneous effect of the free stream turbulence and various parameters of surface roughness on vortex-induced vibration
 - measurement of the rough cylinders wake characteristics in the low, moderate and high turbulent flow
 - improvement of testing facilities and developing experimental methodology
 - fatigue risk assessment based on experimental results
- were met.

☐ excellent ☒ above average ☐ average ☐ below average ☐ poor

Research methods and procedures

Commentary: Investigation of vortex-induced vibration in various turbulent flows and for various surface roughnesses is very exacting. Theoretical solution using numerical simulations is not still reliable and applicable. Dissertant used series of wind tunnel tests as a main tool for his investigation. Wind tunnel tests are the most suitable method for thesis objectives. Two wind tunnels were used for experiments - wind tunnel in Bochum and wind tunnel in Telč. Such experimental research requires a deep knowledge of flow and the structure modelling. Dissertant was able to take full advantage of these facilities. Moreover, he improved and developed new testing stand and carried out an extensive measurement to determine characteristics of turbulent flow in the wind tunnel.

Fatigue of cables (chapter 6) is analysed theoretically using some data resulting from

experiments. Other input parameters are assumed according to standard EN 1991-1-4 or they are estimated by dissertant. Some of the input parameters are not clearly described. It would be a beneficial to compare theoretically determined amplitudes of vibration with full-scale measurement. I suppose, the owner of the mast would agree with measurement including replacement of dampers for the time of the measurement. Of course, this measurement would require additional costs.

☒ excellent ☐ above average ☐ average ☐ below average ☐ poor

Results of the doctoral thesis – dissertant's concrete achievements

Commentary: Valuable achievements are results of wind tunnel tests. In particular, description of how the wind turbulence and surface roughness affects vortex-induced vibration. Other significant achievements are improvement of testing facility and measurement of turbulence characteristics in the wind tunnel. This work will be surely beneficial also for other experimental research in future.

☒ excellent ☐ above average ☐ average ☐ below average ☐ poor

Importance for practice and for development within a branch of science

Commentary: Important achievement for practice is evaluation of large number of wind tunnel tests. Not many similar experiments considering various turbulence characteristics are available.

Acquired experimental data can be used to validate numerical simulations in the future.

Fatigue assessment of cables in chapter 6 would require, in my opinion, an additional research to be fully applicable in practice. For instance, damping of cables in high modes of vibration, stresses near the socket, space correlation of vortex shedding has also a significant effect on the resulting response and fatigue of cables. Detailed research of all these parameters, however, goes beyond the scope of one doctoral thesis.

☐ excellent ☒ above average ☐ average ☐ below average ☐ poor

Formal layout of the doctoral thesis and the level of language used

Commentary: Thesis is well arranged. There is possible to find some grammatical mistakes, but the language level does not reduce the quality of the carefully performed work.

☐ excellent ☒ above average ☐ average ☐ below average ☐ poor

Remarks

p. 13, eq. (3.6), (3.7), (3.8): Turbulence intensity should be defined as the standard deviation of fluctuating wind velocity divided by the mean wind velocity.

Experiments were carried out on models with restricted motion in torsion. Can be influence of cable torsion significant for vortex-induced vibration?

Experiments were done with different turbulence intensities of flow in the wind tunnel (0.75%, 4.5%, 6.5% and 12.3%). What is the expected relation between the turbulence intensity in the wind tunnel and in full-scale conditions? Can it be considered identical?

One of conclusion is "An increase in flow turbulence along with a simultaneous reduction of turbulence length scales causes a decrease in response and a contraction of the lock-in domain for all test cases." (see p. 102). Not every results are in agreement with this sentence, for instance see Fig. 5.30 versus Fig. 5.27, Fig. 5.33 versus Fig. 5.31 or 5.32, Fig. 5.52 versus Fig. 5.51.

Fatigue analysis (chapter 6):

It is not described what the bending stiffness of the cable was considered in the calculation and how it was determined.

Mass of socket at the end of cable and rotation resistance of pin causes rigidity of cable support for dynamic high-frequency responses. Thus, the stresses near the socket will be higher than stresses on the free length of the cable.

It is not clear how the stress ranges were determined. Stress ranges in Tabs. 11.1 – 11.50 do not correspond to stresses depicted in Figs. 10.134 - 10.138. For instance, see Fig. 10.138 (bottom right) and Tab. 11.20.

Mean wind profile according to standard EN 1991-1-4 was considered for fatigue analysis. This profile is valid for strong winds. Profile of moderate mean wind can be different and more unfavourable for VIV.

Final assessment of the doctoral thesis

Dissertant mastered higher parts of wind engineering, mechanics and dynamics of structures. His experimental work represents a significant contribution to research of vortex-induced vibration. Dissertant proved the ability of independent scientific work. Therefore I recommend, in the case of a successful defense of the thesis, granting a title philosophiae doctor - Ph.D.

Following a successful defence of the doctoral thesis I recommend the granting of the Ph.D. degree

yes ☒ no ☐

Date: 5. 1. 2020

Opponent's signature: 