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REVIEW

of a dissertation for awarding the educational and scientific degree "Doctor"

Scientific area: 5. Technical sciences

Professional field: 5.1. Mechanical Engineering

Scientific specialty: 02.19.08 Dynamics, strength and reliability of machines, appliances, devices and systems

Author: M.Sc. Eng. Chavdar Stavrev Georgiev

Dissertation topic: Research and Optimization of Mechanical Structures with Sudden Loss of Stability

Reviewer: Prof. Dr. Eng. Juliana Javorova Georgieva, UCTM Sofia

1. Relevance of the problem developed in the dissertation in scientific and scientific-applied terms.

The dissertation examines the application of virtual engineering and computer-aided design for the analysis and optimization of mechanical structures at risk of sudden loss of stability. The work focuses on the study of various simulation models based on the finite element method and computer structural optimization for solving buckling optimization problems, both from practical applications and typical theoretical examples using leading commercial software.

Innovative methods and approaches are proposed for optimal dimensioning and enhancing the stability of structures and components subjected to compressive loads, which provide a high degree of reliability in solving complex industrial projects. All of this predetermines the relevance and significance of the research in both scientific and applied aspects.

2. Degree of knowledge on the state of the problem and creative interpretation of the literary material.

A total of 95 literary sources in English, German, Bulgarian and Russian have been studied within the framework of the dissertation work, 86 of them are in Latin and 9 in Cyrillic.

In the literature survey, the concept of loss of stability was clarified and the most common types of loaded structures at risk of loss of stability were analyzed. Different types of computer-aided design systems are examined, as well as the processes and methods of virtual engineering, product life cycle management, and the concept of a

digital twin. A brief description of the development and theory of the finite element method is presented.

The literature review ends with conclusions, from which logically follow a precise formulation of the purpose and tasks of the dissertation. My general impression of the literature survey is that the PhD student knows the researched matter well, handles literary facts competently and has a good knowledge of the state of the problem. The literature review itself is sufficiently complete and provides the necessary overview of the research.

3. Correspondence of the chosen research methodology with the set goal and tasks of the dissertation work

In the dissertation, an investigation based on the finite element method was carried out concerning mechanical structures prone to sudden loss of stability. Simulation models of such structures have been developed.

Simulation methods for structural optimization are investigated and methods for optimizing models with loss of stability are identified.

The theoretical research method, the comparative analysis method, and the validation method were also used for some of the results.

I consider that the chosen methodology of scientific research and simulations is suitable for the set goal and tasks of the dissertation work and allows the proof of the results achieved.

4. Brief analytical description of the nature and assessment of the credibility of the material on which the contributions of the dissertation are based.

The dissertation is organized into 6 chapters and a volume of 133 pages, contains 87 figures and 9 tables. In the first chapter, a literature review is presented, which ends with a clearly formulated goal, and the tasks of the work follow logically from it. The second chapter is devoted to the analysis approaches and investigation of the loss of stability with FEM. The accuracy of the calculations has been verified. Four simulation models of different structures prone to loss of stability were developed, and for one of them a comparison was made with a real industrial sample. In the third chapter, various strategies (based on the capabilities of the TOSCA and Optimus software packages) for computer structural optimization are presented, as well as approaches for optimizing the models with loss of stability including topology of structures under different boundary conditions and optimality criteria. In the fourth chapter, the solutions of five different optimization problems with loss of stability are shown. On this basis, a new methodology and classification has been developed with potential applicability in solving complex industrial tasks for dimensioning structures and components subjected to compressive loads. The fifth chapter deals with the possibilities of using artificial intelligence and machine learning in finite element numerical simulations. Here, a new methodology for using neural networks and artificial intelligence to predict simulation results with loss of stability is tested also a continuous learning test version is presented. In the sixth chapter, a summary of the obtained results is made and the contributions of the dissertation are presented.

The dissertation thesis can be considered as a very successful attempt to apply computer-aided design and virtual engineering (study of simulation models based on FEM and computer-aided structural optimization) for the analysis and optimization of mechanical structures at risk of sudden loss of stability.

5. Scientific and/or scientific-applied contributions of the dissertation work

The results of the conducted research contain the following more significant scientific-applied and applied contributions.

Scientific-applied contributions:

1. A new methodology and classification has been developed on the basis of the studied samples and the obtained optimization results, of the approaches in dimensioning structures and details subjected to compressive loads with a high degree of reliability when solving complex industrial projects.
2. An innovative method for using neural networks (NN) and artificial intelligence to predict buckling simulation results without having performed real specialized analysis through simulations was created.
3. The developed innovative method is tested using neural networks to predict simulation results with loss of stability by being able to upgrade and complement an already trained algorithm (continuous learning), to increase the accuracy of the results and faster convergence between the predicted and simulated variants.

Applied contributions

1. The specifics are presented and a summary of the analytical approaches and investigation of the loss of stability with the finite element method is systematized. The basic concepts and mathematical formulations for calculating the critical force are considered.
2. Four simulation models of real geometric, structures prone to loss of stability were developed and the main indicators of buckling were analyzed.
3. Based on the capabilities of the TOSCA and Optimus software packages, a complex study of different strategies for computer structural optimization using simulation models as a method of the virtual engineering has been developed.
4. The developed methods and approaches are tested in solutions of optimization tasks with loss of stability, both from practice and typical theoretical examples with leading commercial software products.
5. The results of the predictions of the trained neural networks (NN) as the behavior of the modeling object are validated against the results of specialized analysis.

6. Assessment of the degree of personal participation of the doctoral student in the contributions.

I consider that the research, simulations, obtained results and contributions in the dissertation work of M.Sc. Eng. Chavdar Stavrev Georgiev are his personal work. This is also confirmed by his publications, which are commented on in the next section.

7. Assessment of publications on the dissertation work

On the topic of the dissertation, the doctoral student has 5 publications, of which 1 is like a single author, and in the remaining 4 he is the first co-author. Two of the publications are in the "Bulgarian Journal of Engineering Design", and the others are in Proceedings of scientific conferences and in the Annual of TU-Sofia. Patent and utility model registrations are also enclosed to the dissertation.

No citations are known for the publications provided. I consider that the amount of publications is sufficient for the awarding the educational and scientific degree "Doctor" and represents to a large extent the work process and the results achieved. Scientific indicators exceed those required for PF 5.1.

8. Assessment of the compliance of the Abstract with the requirements for its preparation, as well as the adequacy of reflecting the main points and contributions of the dissertation work.

The Abstract of dissertation submitted by the doctoral student has a volume of 32 pages and adequately reflects the goals, tasks, content by chapters and the contributions achieved in the dissertation work. The abstract has been prepared and formatted according to the requirements of TU-Sofia and I consider that it undoubtedly bears the essential features of the dissertation work and reflects its content in an appropriate volume and in a correct manner.

9. Comments, recommendations and remarks.

The dissertation testifies to the author's knowledge of the subject area and provides an opportunity to develop the achieved results and their practical application.

I would like to make some notes on the presented work:

- I consider it incorrect that the literary sources include 4 of the dissertation publications;

- Usually a long scientific text (monograph, dissertation, article, etc.), in which there is an Introduction, ends after the main exposition with a Conclusion, which is missing here. In this sense, including in the work even a very short Conclusion would give a more complete look to this doctoral thesis.

Furthermore, I would recommend the doctoral student to work for spreading his scientific results in publications abroad, which will lead to wider publicity, and hence citations of the scientific production.

The remarks and recommendation do not in any way affect the significance of the results and contributions achieved in the dissertation work. My overall opinion of the dissertation work is positive - topical subject matter, original approach, well-structured work with high quality of illustrative material.

10. Conclusion with a clear positive or negative assessment of the dissertation work.

My final assessment regarding the content and contributions of the dissertation work is positive. I consider that the presented dissertation meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application, as well as the requirements for obtaining the educational and scientific degree "Doctor" at TU - Sofia.

The above gives me reason to recommend to the respected Scientific Jury to award the educational and scientific degree "Doctor" to M.Sc. Eng. Chavdar Stavrev Georgiev in Scientific area 5. Technical sciences, Professional field 5.1. Mechanical Engineering, Scientific specialty 02.19.08. Dynamics, strength and reliability of machines, devices, apparatus and systems.

Sofia, 17.06.2024

Reviewer:

/ Prof. Dr. Eng. Juliana Javorova/