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Review article

ON SOME INTERESTING TRENDS IN RESEARCH OF STEEL AND COMPOSITE STRUCTURES

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Abstract

This paper is a kind of introduction to the special issue of CEER devoted to metal and composite structures. Papers collected in this issue were ordered from Authors who took part in International Conference on Metal Structures which was held in Zielona Góra in 2016. Selection of Authors and theme of ordered papers were done in cooperation with Metal Structures Section of the Civil Engineering Committee of the Polish Academy of Sciences. Selected papers included in this special issue of CEER were shortly presented in this editorial.

Keywords: Steel and composite structures, research trends, ordered papers

This special issue of the Civil and Environmental Engineering Reports quarterly is published in collaboration with the Metal Structures Section of the Civil Engineering Committee of the Polish Academy of Sciences and particularly with its Chairman Marian Giżejowski, Professor of the Warsaw University of Technology. The initial proposal was submitted to the Editorial Board of the journal at the end of 2016 and gained approval. The presented issue contains papers prepared by authors attending the 13th International Conference on Metal Structures ICMS'2016 organized at the University of Zielona Góra and held under the patronage of Professor Tadeusz Kuczyński, the Rector of the University of Zielona Góra. The undersigned was the Chairman of the Organizing Committee of the 13th ICMS and would like to express at this point the gratitude to Professor

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Tadeusz Kuczyński, Editor-in-Chief of CEER for his kind approval for the idea of this special issue.

The papers of this issue cover a wide range of topics and create the overview of trends in recent scientific investigations observed during the ICMS'2016 conference presentations. In opinion of the guest editor these articles should be interesting for researchers and civil engineers acting in the field of structural engineering in general and for all those who specialize in metal structures in particular.

All fourteen invited papers were positively evaluated by two reviewers, unquestioned experts in the field of steel and composite structures. Short characteristics of all contributions included in this issue are presented below.

Authors of the paper [1] present an innovative solution of transition zone between steel beam and concrete part of the composite steel-concrete structure and discuss the results, with emphasis put on the transition zone structural response in term of bending capacity, failure model and force distribution on the connection length. The article includes results of the destructive experimental test made on beam in which the innovative connection was applied.

Authors of the paper [2] consider some aspects of bracing of truss roof girders. They discuss recommendations which are included in EN 1993-1-1 and propose some modifications free of drawbacks revealed in Eurocode provisions. The formulas for an equivalent stabilizing forces of restrained roof girders with parabolic variability of axial force, have been proposed. Obtained results have been discussed and illustrated on selected examples.

Authors of the paper [3] present some alternative approach to existing in Eurocode 3 provisions. The application of consistent Ayrton-Perry analytical formulation is presented for steel I-section members subjected to compression and monoaxial bending about the major axis. Advantages of the proposed formulation are as follows: a) easy graphical interpretation, b) only one design condition for checking the beam-column resistance instead of two buckling resistance conditions and one section resistance condition postulated in Eurocode 3, c) elimination of the necessity of equivalent uniform moment factors to be involved in interaction design criteria. The proposed Ayrton-Perry design strategy is similar to that utilized in the steel Eurocode 3 for design of beams and columns but not used so far for the beam-column design.

The paper [4] deals with the method to identify internal (residual) stresses in two-dimensional, steel members. Steel members were investigated in the delivery stage and after assembly, by means of electric-arc welding. In order to perform the member assessment two methods to identify the stress variation were applied. The first is a non-destructive measurement method employing local external magnetic field and to detecting the induced voltage, including Barkhausen noise. The second method, essential in the paper, is a semi-trepanation Mathar method

of tensometric strain variation measurement in the course of a controlled void-making in the material. It was applied in cases presented in the paper to verify correctness of the nondestructive method based on Barkhausen noise effect.

The paper [5] presents experimental and numerical studies leading to determination of the equivalent second moment of area of the uniform torsion of the two-chord steel single laced members. The stiffness of uniform torsion of this kind of columns allows to the determine the critical loads of the spatial stability. Experimental analysis was supplemented by numerical simulations carried out by ABAQUS and SOFiSTiK systems. The purpose of the latter was determining parametrical formulas for calculation of the second moment of area of uniform torsion required for determination of the buckling resistance of such kind of structural elements.

The paper [6] deals with the buckling resistance assessment of pressurised steel spherical caps.

The new procedure was presented as an alternative to existing European provisions. All steps of the procedure leading to the assessment of buckling resistance of pressurized steel, spherical shells were presented in this work. The elaborated procedure is consistent with provisions of Eurocode EN 1993-1-6 and with recommendations inserted in Europeans Design Recommendations published by ECCS. The proposed capacity curves were compared with existing recommendations for three different fabrication quality classes. In this work also comparisons of author's proposals with experimental results obtained by other authors were presented.

In some quite typical cases positive eccentricities appear in the truss nodes what induce additional forces in the truss chords. The paper [7] considers such a case and Authors examine problem using experimental and numerical analyses. All details of the test rig were prepared carefully and tested before the actual experiments started. The paper presents all stages leading to the adjustment of the stand according to preliminary assumptions. It is an example how difficult and laborious are experimental test in domain of slender metal structures.

The paper [8] refers to a rotational capacity assessments of semi-rigid joints. Current design codes, including Eurocode 3, do not contain procedures enabling designers to obtain the value of rotational capacity. In the paper the calculation procedure of the rotational capacity for stiffened bolted flush end-plate beam-to-column connections has been proposed. The analysis was performed with the use of finite element method (ANSYS), based on the assumed numerical, experiment plan. Power function was proposed to describe available rotational capacity of the joint. Influence of the particular components on the rotational capacity was also investigated. A general procedure for determination of rotational capacity was proposed in the paper.

The paper [9] deals with full scale, destructive test of huge, steel lattice tower. The main objective of the paper was to discuss chosen lattice tower joint behavior under structure ultimate load. Joint numerical modelling considerations are enriched with comparison to the full-scale tower pushover test results. Numerical model adopted in the analysis has been calibrated after full-scale test structural responses such as displacements and stresses. It helped to create the numerical model of joint with application of the forces taken directly from entire tower FE model. And the model calibrated in this way was used to examine behavior of some joints due to chosen load cases. Some important conclusions were drawn on the basis of the performed analyses.

The scope of application of steel, thin walled elements is bigger and bigger. Authors of the paper [10] consider built-up members composed with light gauge used for studs of shear wall. The flexural buckling resistance of such structural members are subject of detailed considerations. In this paper, full scale testing of light gauge built-up members are presented. From the test results, it was shown that current Japanese Standard overestimates the buckling strength. Authors derived a modified effective slenderness ratio for light gauge built-up member. The validity of the proposed, modified effective slenderness ratio was shown with test results.

Steel scaffoldings are equally important structures as structures themselves. The paper [11] deals with the Movable Scaffolding System (MSS) used for casting situ of concrete bridge decks.

The main structure of MSSs may be potentially exposed to fatigue, usually characterized by low number of cycles with significant stress amplitude. Fatigue may be prevented through adequate design; judicious selection of materials; demanding quality control and implementation of robust inspection and maintenance plans. The detailed fatigue analysis of the MSS in which all possible loading cases were taken into account was presented.

The structure must be save not only during the exploitation but also during erection. Steel, cylindrical tanks before assembly their roofs are vulnerable to damage due to pressure exertion of the wind. This problem is considered in the paper [12]. Authors have carried out investigations on open thin-walled tanks made of austenitic and duplex stainless steels under wind load to study a possible economic advantage which might be gained from the consideration of the elastic postbuckling behaviour. The paper presents not only experimental and numerical results but also first recommendations regarding the range of possible buckling reduction factors which might be incorporated in future revisions of EN 1993-1-6 and EN 1993-4-2.

In all cases in which cyclic loadings occurs not only the fatigue must be taken into account but also the shakedown phenomenon. The paper [13] deals with the earthquake analysis of composite steel-concrete frames. The optimization

problem of the shakedown analysis in which the nonlinear properties of materials were taken into account was formulated and solved. The considered structures were equipped with systems bearing structures of various elastic-plastic and brittle elements absorbing energy of seismic actions. A mathematical model of the problem was presented on the base of limit analysis theory with partial redistribution of self-stressed internal forces. The illustrative example in which this model was used, was presented.

It is obvious that during the designing process of any kind of structures also optimization aspects are taken into account. Classical optimization problems of metal structures is usually confined mainly to 1st class cross-sections. In the paper [14], a new mathematical model for defined shakedown optimization problem for metal structures, which elements are fabricated from 1st to 4th class cross-sections, under variable quasi-static loads is presented. With the help of mathematical programming theory and extreme principles the structure optimization algorithm is developed and justified with the numerical example for the metal plane frames.

Papers presented in this issue are just examples of research carried out on a large scale in the field of steel and composite structures. Papers from this field are usually published in journals devoted exclusively to these domains, but one should positively assess the fact of publishing of these several papers in the special issue of Civil and Environmental Engineering Reports. It will definitely contribute to the dissemination of readily available knowledge on chosen problems of metal and composite structures.

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O PEWNYCH INTERESUJĄCYCH TRENDACH W BADANIACH KONSTRUKCJI STALOWYCH I KOMPOZYTOWYCH

S t r e s z c z e n i e

Referat stanowi wprowadzenie do specjalnego numeru czasopisma CEER poświęconego konstrukcjom metalowym i kompozytowym. Zebrano w nim prace zamówione wcześniej u Autorów uczestniczących w Międzynarodowej Konferencji nt. Konstrukcji Metalowych ICMS'2016, która odbyła się w Zielonej Górze w 2016 roku. Doboru autorów i tematyki zamawianych referatów dokonano we współpracy z sekcją Konstrukcji Metalowych Komitetu Inżynierii Lądowej i Wodnej Polskiej Akademii Nauk. W referacie krótko omówiono każdą z prac włączonych do tego specjalnego numeru CEER.

Słowa kluczowe: Konstrukcje stalowe i kompozytowe, kierunki badań, referaty zamówione

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