

International Seminar

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XXIV LSCE 2018 LIGHTWEIGHT STRUCTURES IN CIVIL ENGINEERING CONTEMPORARY PROBLEMS

Monograph from Scientific
Conference of IASS Polish Chapters

Edited by: Marcin Kamiński & Jacek Szafran
Łódź University of Technology

LIGHTWEIGHT STRUCTURES IN CIVIL ENGINEERING

CONTEMPORARY PROBLEMS

XXIV LSCE

2018

Edited by

Marcin Kamiński and Jacek Szafran

Łódź University of Technology
Faculty of Civil Engineering, Architecture
and Environmental Engineering

Łódź, 7th December 2018

DOCUMENTATION & IMPACT FACTOR

The papers herein are published in the form camera-ready and in electronic form as submitted by the authors. All the papers were reviewed by minimum two members of Scientific Committee. The collected opinions were delivered to authors. Finally corrected all papers were accepted for printing and presented by prof. dr hab. inż. Marcin Kamiński, professor of Łódź University of Technology. All papers were reformatted by editors. Additionally, minor changes have been made where obvious errors, faults and misprints were detected. The authors warrant that the papers are their original works and have been never published in their present form. The authors have accepted the full responsibility for the scientific content and opinions expressed in their papers.
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According to Polish law Publisher in law gazette (Dz. U. from 1.08.2012 pos. 877; with actualization in Dz. U. from 2.12.2015 pos. 2015):

Authorship of each chapter in this monograph published in the English language assures 5 points of Ministry of Science and Higher Education.

LIGHTWEIGHT STRUCTURES IN CIVIL ENGINEERING

Proceedings of the Scientific Conference - Local Seminar of IASS Polish Chapters

On Lightweight Structures in Civil Engineering

Łódź, 7th December 2018

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ISBN 978-83-7283-961-9

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Lodz University of Technology

Faculty of Civil Engineering, Architecture and Environmental

Engineering

XXIV LSCE

Łódź, 7th of December 2018



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FOREWORDS



FOREWORD by Marcin Kamiński - Chairman of the Scientific Committee

Lightweight structures attract very much many researchers, scientists and also engineers due to their optimal character, remarkable ratio of their strength to the span as well as application of the new building materials. Usage of optimization methods, uncertainty analysis, reliability tools and modern numerical as well as experimental techniques make this research area very demanding and still challenging. These structures due to their unique and individual character are a good alternative for popular and massive concrete structures. This year problems that will be discussed during LSCE meeting include some general problems like lightweight structures reliability simulation, stability analysis, inelastic constitutive models, topology optimization and dynamic structural response as well as application of composite materials. They include many experiments in various scales, computer simulations, theoretical models as well as engineering studies on prefabrication and management. It is a great opportunity behind us to learn from each other, to discuss interesting topics and, due to a single session, see the entire perspective of modern research in this area.

A majority of the Polish annual IASS Conference is its non-commercial character, which makes it really very unique in the modern science. I would like to mention that it groups many professionals in civil engineering and architecture interested in systematic continuation and development of the same issues concerning lightweight structures and offers peer-reviewed publication of the key results each year. Furthermore, this conference has no comparable national meeting neither in the matter nor in volunteer participation and reviewing process in Poland hosting occasionally some researchers and engineers from abroad. It is evident that this series of conferences could not have happened without personal initiative in 1995, continuous personal engagement, and even hard physical work of prof. Jan Obrębski, who brought all the people interested and possibly interested in this area together. It remains unforgettable that He prepared the 10th anniversary medals for the most active Polish IASS researchers, which had been personally delivered during IASS Symposium in 2005.

This series has appeared to be extremely beneficial for many young researchers who started their serious research careers on IASS Symposia of Polish Chapter. I need to mention that almost all of my past and

present PhD students have started from this level including this Conference Manager, Doctor Jacek Szafran and also myself. There is no doubt that Polish IASS was and still is remarkable promotion of Polish science on the international level and has been appreciated by at least the Presidents of IASS, who permanently annually wish us a great success. Scientific committee groups many people being international authorities in this area, including such countries like Australia, Italy, Denmark, France, Great Britain or United States of America and also the leading technical universities and research institutions in Poland.

Łódź University of Technology hosts this Conference for the second time. Last time LSCE meeting took place in 2011 in the Rectorate of the university and the first historical location of the Faculty of Civil Engineering and Architecture. This year IASS Symposium takes place in Computer Science Department completed recently. Łódź is one of the best locations in Poland for such a symposium because of remarkable lightweight structures, which appeared recently in its heart as renovated center of old power plant *ECI*, Arena convention center, downtown railway station *Łódź Fabryczna*, sport stadiums *Widzew* and *ŁKS* roofs, sport club *Orzeł* brand new stadium and of course central tramway transit center.

I am happy and proud to deliver to your hands the new LSCE Conference proceedings because they have been printed out by Łódź University of Technology press and also because many articles have the term "lightweight" in their titles. My special personal thanks are directed to Doctor Jacek Szafran, my first PhD student, who has organized the 24th Conference of Polish IASS Chapter, managed very well all the submissions, who has helped me to manage the review process and who was responsible for preparation of this year Conference Proceedings. They could not have appeared without very careful editorial help of Mrs. Klaudia Juszczyk, our PhD student professionally entirely devoted to the stochastic structural response of modern lightweight structures.



FOREWORD by Romuald Tarczewski - Member of IASS Executive Council, Chairman of Permanent Organizing Committee of IASS PCs

This is already the twenty-fourth annual meeting organized under the auspices of Permanent Committee of Polish Chapters of the

International Association for Shell and Spatial Structures (IASS), next year we will celebrate the silver jubilee. Initiated in 1995 by prof. J.B. Obrębski cycle of LSCE seminars has already become a well-established tradition. This proves the importance of these seminars not only for Polish members of the IASS but for the entire engineering community. This is certainly due to the fact that the subject matter of the seminars focuses on issues that are rarely present in the programs of other scientific events. Above all, it is a wide spectrum of issues concerning lightweight spatial structures and related: lattice spatial structures, tensile structures, shells and many others. However, it is not limited to this scope. Number of previous publications in the framework of LSCE, rank of their authors and the number of countries they represent are impressive. It is an accomplishment but also heritage and a tradition that requires respect and continuation. Therefore, it is optimistic that a significant part of the seminar participants are now younger colleagues, whose scientific career began when the LSCE seminars had already an established reputation.

The world in which we live and carry on our activities, both scientific and engineering, changes very quickly. This applies not only to new technologies, materials and methods of analysis that allow the construction of objects that several years ago we could think in terms of the distant future. Equally variable is the environment of the academic life. New ways of communicating and changes in the evaluation of scientific achievements are a challenge that needs to be addressed to ensure the further development of the LSCE initiative. This positive evolution is evident in the topics of submitted papers that follow the latest global trends. It will probably be necessary to adjust also the formula of seminars to these changes. Who does not go forward, goes backwards.

I would like to congratulate the organizers of this year's seminar on very effective work and many interesting initiatives that will remain the permanent achievements of the LSCE seminars. I am convinced that all participants of this year's meeting will be satisfied both with its organization and substantive level.



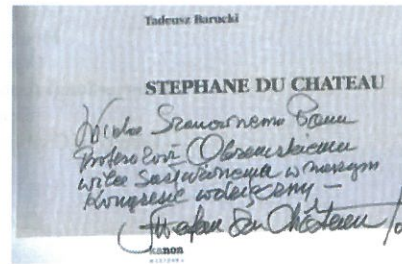
FOREWORD by J.B. Obrębski - Member of IASS since 1989; Member of IASS Executive Council 1996-2002; Member of IASS Advisory Board since 2002, Honorary Member of IASS since 2014.

This annual LSCE meeting has number XXIV and is organized in Łódź. Many thank for Prof. Marcin Kamiński and dr Jacek Szafran for invitation me, to write Foreword and paper about history of LSCE to these proceedings.

So, the series of different size scientific conferences on Lightweight Structures in Civil Engineering reach the number XXIV. It is serious, real achievement. It permits on certain summary of efforts performed by many organizers, authors and participants. Among them were very outstanding scientists and engineers domestic and foreign. In this place I wish to express my cordial thanks for all of them. Without of theirs support, the series of up to now LSCE meetings can be not possible.

It is occasion also, to look back on this series of these just 24 LSCE conferences with its proceedings and on history of IASS Polish Chapters (see chapter "Short history of IASS Polish Chapters and LSCE conferences", printed in this book). Really it is phenomenon in scale of famous engineer's organization as it is IASS, founded in 1959 by Edwardo Torroja, and first of all in Poland.

Coming to the beginnings it is worthy, the best, to remember a few quotations from texts published in previous LSCE books.



Personal dedication in the book about S. Du Chateau; at app.27.09.1995

Two fragments of forewords by Prof. S.J. Medwadowski – founder of IASS national Chapters:

(LSCE 2004) "It was with great personal pleasure that I learned of the plans for a conference on *Lightweight Structures in Civil Engineering (LSCE)*, to be held in Częstochowa later this fall. It will be the tenth Polish conference on this topic – *LSCE* – during the last decade, thus underscoring its importance to modern society.

It is particularly fitting that this year's Conference is dedicated to the memory of Stefan du Chateau, widely recognized as one of the pre-eminent pioneers in the field of space structures. A strong supporter of *LSCE*, he was one of the keynote speakers at the first Warsaw *LSCE* Conference in 1995". Prof. Dr. Stefan Medwadowski; Oakland, California, October 2004.

(LSCE 2005): The Polish Chapter of the IASS was called into being in 1995, during the International Conference on Lightweight Structures in Civil Engineering – *LSCE* – held in Warsaw. Thus this year's *LSCE* 2005 Conference marks the 10th anniversary of the Chapter.

In the intervening decade, members of the Chapter held seven National Seminars and three international (1998, 2002, 2005), each resulting in a permanent record in the form of printed Proceedings. In addition, members of the Chapter participated actively in all *LSCE* Conferences, the most recent one held in Częstochowa in 2004. Altogether, the hundreds of contributions have covered the whole field of shells and space frames: form finding, analysis, design, and realizations.

Fragment of handwritten letter: Professor Z.S. Makowski "Ingleside" Ealing, London. 5 listopada 2004; Drogi kolego, (...)

Cieszę się że ten tak pięknie zaplanuje
 że sprawa jest kontynuacją przedsięwzięcia,
 ale to oczywiście trochę by było by mi
 bardzo coś pomóc w związku z
 przygotowaniami przez Pana konferencjalni.
 Proszę mi wybaczyć ale jestem pewien że
 ten przebieg nie sformułuje.
 Wszelkie pytania w konferencjach
 może oddać
 ZS Makowski

Two fragments of forewords by Prof. M. Kawaguchi:

(LSCE 2004) It is a great pleasure for me to write a foreword for the Proceedings of the *LSCE 2004* to be held in Częstochowa with Professor W. Przybyło as the Organizer. I am glad to say that the IASS Polish Chapter has been extremely active, holding almost every year a local seminar on *Lightweight Structures in Civil Engineering (LSCE)* since 1995. Out of the ten seminars held so far the two in 1995 and 2002 were celebrated in Warsaw together with the IASS Annual Symposia. Those symposia as well as a series of local seminars in Poland were organized or strongly lead by Professor Jan B. Obrębski, an active member of the IASS Advisory Board and the general chair of the Polish Chapter. October, 2004; Mamoru Kawaguchi; President of IASS

(LSCE 2005): The IASS, our Association, is quite unique among other similar organizations of structural engineering in that it aims at not only development of theory and practice of structural engineering but also aesthetic satisfaction of built environments. This task can only be accomplished by frequent exchange of ideas and opinions of

researchers, structural designers, architects, and those working in the field of realization of buildings. In this context I am very pleased to observe that the Polish Chapter of IASS has been very actively holding its seminar or local colloquium almost every year since 1995, presenting a forum for all those who are working in the field of lightweight structures to present the results of their researches and design efforts, to discuss the common subjects, and to exchange their ideas and thoughts on lightweight structures. The present Proceedings are the tenth book of a series of issues that have been published solely by the IASS Polish Chapter. *Mamoru Kawaguchi; IASS President.*

----- o o o -----

Professor S.J. Medwadowski has born at 1924 in Poland. So, nowadays He is just 94 years old. Many thanks for Him. It is worthy to mention His brief biographical data (see LSCE 2005, too): Vice President of IASS, 1983-91; President IASS, 1991-2000; Past President 2000-. Here are listed more important His distinctions: □ Elected Fellow ASCE, and Fellow ACI; □ Eduardo Torroja Medal of IASS in 1990. □ Listed in Who's Who in Engineering and in Who's Who in America. □ Honorary Member of IASS given during IASS Symposium in Nagoya, Japan, at the 9 October 2001. □ Pioneer of Distinguished Contributions in the Field of Space Structures. Awarded during the Fifth International Conference on Space Structures, by Space Structures Research Centre of the University of Surrey, UK, at 21 August 2002. □ Honorary

Professor of University of Warmia and Mazury, Olsztyn, Poland, at 25.04.2003. □ Honorary Member of IASS Polish Chapter with the membership certificate given at 12.09.2005. □ Commemorative Medal in occasion of the XI th anniversary of LSCE from 1995 to 2005 & Ten Years of IASS Polish Chapter founded and given by Prof. Jan B. Obrębski. Warsaw, 12 September, 2005.

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Prof. Dr. Hab. Eng. Jan B. Obrębski

Retired Full Professor, Faculty of Civil Engineering, Warsaw University of Technology, POLAND

Chairman of Permanent Organizing Committee of IASS PCs (2011)

Also member of:

- Polish Association of Building Engineers and Technicians 1970;
- Chapter of Experimental Mechanics of the Mechanical Committee of Polish Academy of Sciences since 1999;
- International Association for Bridges and Structural Engineering (IABSE) since 1994.

Member of Editorial Boards of the:

- International Journal of Space Structures (IJSS) England 1998;
- International Journal of IASS (IJ IASS) 2006;
- International Journal of Structural Stability and Dynamics (IJSSD) Taiwan, Singapore, USA since 1999;
- International Journal of Architectural Technology (IJAT) Tehran, Iran, since 2010.