

Vasant Matsagar *Editor*

# Advances in Structural Engineering

Dynamics, Volume Two

 Springer

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# Foreword

Earthquake Engineering and Structural Dynamics is a major subject of teaching and research in the present decade. This is evident from the size of publications taking place in different themes of the subject in recent years. The number of committees formed, the conferences organised and the special courses offered on the subject is also large. Therefore, it is natural that the number of papers received in this area is large for the Structural Engineering Convention (SEC 2014). As a result, a strict criterion has been adopted to review the papers for the inclusion in the conference proceeding to be published by Springer. The papers cover a wide range of topics, namely structural control, offshore dynamics, dynamic soil-structure interaction, seismic hazard analysis, retrofitting of structures for lateral loads, dynamic behaviour of structures and the like. The papers have been peer-reviewed for acceptance.

Like previous Structural Engineering Conventions, SEC 2014 has drawn the interest of all researchers in different academic institutes in India. It is heartening to see that a large number of researchers are working in the area of Structural Dynamics and Earthquake Engineering. Certainly, the conference venue will provide them an excellent platform to meet and exchange ideas on various topics of recent interest. The conference proceedings will be a good reference material for them. Further, the conference proceedings being published by an international publishing house will reach international readers. All these together make SEC 2014 an eventful congregation of researchers in the area of Structural Dynamics and Earthquake Engineering.

The trend of recent researches has numerical orientation because of the availability of standard software. Therefore, solution of application problems forms the core of majority of papers in the conference volume. In this context, the importance of the materials presented in this volume lies in exploring the response analysis of a variety of both models and prototypes of real-life structures. The excitations to the structures constitute a number of important dynamic loadings such as earthquakes, wind, wave, blast and moving loads. The structures include bridges, buildings, chimneys, offshore platforms, specialty structures, foundation structures and other types of civil amenity structures. The response analysis provides the values of

response parameters that describe the dynamic behaviour of structures. In certain cases, extensive parametric study is conducted to evaluate the effects of parameters that predominantly influence the response.

In earthquake engineering, a major thrust of the papers is on earthquake resistant design of structures. Both steel and concrete structures are considered. Post-yield or inelastic analysis is carried out in most cases to verify the adequacy of the earthquake resistant design. Performance-based design and seismic retrofitting form another set of interesting papers in which several issues related to the topics are thoroughly discussed. Some of the retrofitting strategies use a seismic design philosophy, e.g. they use structural control devices for retrofitting.

Two other areas of research are adequately covered in the conference volume, namely structural health monitoring and structural control. Both topics deal with a number of current research areas such as semi-active control, hybrid control and passive control applied to bridges and chimneys. Extensive parametric studies are presented to investigate the reliability and effectiveness of different control strategies. The effects of various uncertainties existing in the seismic structural control on the responses are brought out through interesting examples. In structural health monitoring, system identification including damage state evaluation forms the topics of discussion. Different types of health monitoring strategies are also presented in the papers.

This proceedings goes as a compendium of interesting research papers on topical themes on Structural Dynamics and Earthquake Engineering. Readers of the conference volume will find them useful for both profession and research. Certainly, it has the standard of an archive value.

Prof. T.K. Datta  
Emeritus Professor  
Department of Civil Engineering  
Indian Institute of Technology (IIT)  
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# Preface

I am delighted that the Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi has hosted the eagerly awaited and much coveted 9th Structural Engineering Convention (SEC2014). The biennial convention has attracted a diverse range of civil and structural engineering practitioners, academicians, scholars and industry delegates, with the reception of abstracts including more than 1,500 authors from different parts of the world. This event is an exceptional platform that brings together a wide spectrum of structural engineering topics such as advanced structural materials, blast resistant design of structures, computational solid mechanics, concrete materials and structures, earthquake engineering, fire engineering, random vibrations, smart materials and structures, soil-structure interaction, steel structures, structural dynamics, structural health monitoring, structural stability, wind engineering, to name a few. More than 350 full-length papers have been received, among which a majority of the contributions are focused on theoretical and computer simulation-based research, whereas a few contributions are based on laboratory-scale experiments. Amongst these manuscripts, 205 papers have been included in the Springer proceedings after a thorough three-stage review and editing process. All the manuscripts submitted to the SEC2014 were peer-reviewed by at least three independent reviewers, who were provided with a detailed review proforma. The comments from the reviewers were communicated to the authors, who incorporated the suggestions in their revised manuscripts. The recommendations from three reviewers were taken into consideration while selecting a manuscript for inclusion in the proceedings. The exhaustiveness of the review process is evident, given the large number of articles received addressing a wide range of research areas. The stringent review process ensured that each published manuscript met the rigorous academic and scientific standards. It is an exalting experience to finally see these elite contributions materialise into three book volumes as SEC2014 proceedings by Springer entitled “Advances in Structural Engineering”. The articles are organised into three volumes in some broad categories covering subject matters on mechanics, dynamics and

materials, although given the diverse areas of research reported it might not have been always possible.

SEC2014 has ten plenary speakers, who are eminent researchers in structural engineering, from different parts of the world. In addition to the plenary sessions on each day of the convention, six concurrent technical sessions are held every day to assure the oral presentation of around 350 accepted papers. Keynote speakers and session chairmen for each of the concurrent sessions have been leading researchers from the thematic area of the session. The delegates are provided with a book of extended abstracts to quickly browse through the contents, participate in the presentations and provide access to a broad audience of educators.

A technical exhibition is held during all the 3 days of the convention, which has put on display the latest construction technologies, equipment for experimental investigations, etc. Interest has been shown by several companies to participate in the exhibition and contribute towards displaying state-of-the-art technologies in structural engineering. Moreover, a pre-convention international workshop organised on “Emerging Trends in Earthquake Engineering and Structural Dynamics” for 2 days has received an overwhelming response from a large number of delegates.

An international conference of such magnitude and release of the SEC2014 proceedings by Springer has been the remarkable outcome of the untiring efforts of the entire organising team. The success of an event undoubtedly involves the painstaking efforts of several contributors at different stages, dictated by their devotion and sincerity. Fortunately, since the beginning of its journey, SEC2014 has received support and contributions from every corner. I thank them all who have wished the best for SEC2014 and contributed by any means towards its success. The edited proceedings volumes by Springer would not have been possible without the perseverance of all the committee members.

All the contributing authors owe thanks from the organisers of SEC2014 for their interest and exceptional articles. I also thank the authors of the papers for adhering to the time schedule and for incorporating the review comments. I wish to extend my heartfelt acknowledgment to the authors, peer-reviewers, committee members and production staff whose diligent work put shape to the SEC2014 proceedings. I especially thank our dedicated team of peer-reviewers who volunteered for the arduous and tedious step of quality checking and critique on the submitted manuscripts. I am grateful to Prof. Tarun Kant, Prof. T.K. Datta and Dr. G.S. Benipal for penning the forewords for the three volumes of the conference proceedings. I wish to thank my faculty colleagues at the Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi, and my Ph.D. Research Scholars for extending their enormous assistance during the reviewing and editing process of the conference proceedings. The time spent by all of them and the midnight oil burnt is greatly appreciated, for which I will ever remain indebted. The administrative and support staff of the department has always been extending their services whenever needed, for which I remain thankful to them. Computational

laboratory staff of the department had handled the online paper submission and review processes, which hardly had any glitch therein; thanks to their meticulous efforts.

Lastly, I would like to thank Springer for accepting our proposal for publishing the SEC2014 conference proceedings. Help received from Mr. Aninda Bose, the acquisition editor, in the process has been very useful.

Vasant Matsagar  
Organising Secretary, SEC2014



## About the Editor

**Dr. Vasant Matsagar** is currently serving as an Associate Professor in the Department of Civil Engineering at Indian Institute of Technology (IIT) Delhi. He obtained his doctorate degree from Indian Institute of Technology (IIT) Bombay in 2005 in the area of seismic base isolation of structures. He performed post-doctoral research at the Lawrence Technological University (LTU), USA in the area of carbon fibre reinforced polymers (CFRP) in bridge structures for more than 3 years. His current research interests include structural dynamics and vibration control; multi-hazard protection of structures from earthquake, blast, fire, and wind; finite element methods; fibre reinforced polymers (FRP) in prestressed concrete structures; and bridge engineering. He has guided students at both undergraduate and post-graduate levels in their bachelor's and master's projects and doctoral research. Besides student guidance, he is actively engaged in sponsored research and consultancy projects at national and international levels. He has published around 40 international journal papers, 60 international conference manuscripts, a book, and has filed for patents. He is also involved in teaching courses in structural engineering, e.g. structural analysis, finite element methods, numerical methods, structural stability, structural dynamics, design of steel and concrete structures, to name a few. He has organised several short- and long-term courses as quality improvement programme (QIP) and continuing education programme (CEP), and delivered invited lectures in different educational and research organisations.

Dr. Matsagar is the recipient of numerous national and international awards including "Erasmus Mundus Award" in 2013; "DST Young Scientist Award" by the Department of Science and Technology (DST) in 2012; "DAAD Awards" by the Deutscher Akademischer Austausch Dienst (DAAD) in 2009 and 2012; "DAE Young Scientist Award" by the Department of Atomic Energy (DAE) in 2011; "IBC Award for Excellence in Built Environment" by the Indian Buildings Congress (IBC) in 2010; "IEI Young Engineer Award" by the Institution of Engineers (India) in 2009; and "Outstanding Young Faculty Fellowship" by the Indian Institute of Technology (IIT) Delhi in 2009. He has also been appointed as "DAAD Research Ambassador" by the German Academic Exchange Programme since the academic session 2010.

# About Structural Engineering Convention (SEC) 2014

The ninth structural engineering convention (SEC) 2014 is organised at Indian Institute of Technology (IIT) Delhi, for the first time in the capital city of India, Delhi. It is organised by the Department of Civil Engineering during Monday, 22nd December 2014 to Wednesday, 24th December 2014. The main aim towards organising SEC2014 has been to facilitate congregation of structural engineers of diverse expertise and interests at one place to discuss the latest advances made in structural engineering and allied disciplines. Further, a technical exhibition is held during all the 3 days of the convention, which facilitates the construction industry to exhibit state-of-the-art technologies and interact with researchers on contemporary innovations made in the field.

The convention was first organised in 1997 with the pioneering efforts of the CSIR-Structural Engineering Research Centre (CSIR-SERC), Council of Scientific and Industrial Research, Chennai and Indian Institute of Technology (IIT) Madras. It is a biennial event that attracts structural engineers from India and abroad, from both academia and industry. The convention, as much as it did in its history, is contributing to scientific developments in the field of structural engineering in a global sense. Over the years, SEC has evolved to be truly international with successive efforts from other premier institutes and organisations towards the development of this convention.

Apart from the 3 days of the convention, an international workshop is also organised on “Emerging Trends in Earthquake Engineering and Structural Dynamics” during Saturday, 20th December 2014 to Sunday, 21st December 2014. Eleven experts in the areas of earthquake engineering and structural dynamics delivered keynote lectures during the pre-convention workshop. The convention includes scholarly talks delivered by the delegates from academia and industry, cultural programmes presented by world-renowned artists, and visits to important sites around the historical National Capital Region (NCR) of Delhi.

# Composition of Committees for SEC2014


## Structural Engineering Convention 2014

1<sup>st</sup> Biennial Event Under the Auspices of Indian Association for Structural Engineering (IASE)

Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi



### Organizing Committee

Patron	<div></div> <div>R.K. Shevgaonkar Director, IIT Delhi</div>	<div>Areas of Interest: Fiber Optic Communication, Photonics, Nonlinear Fiber Optics, Antennas, Image Processing, Radio Astronomy.</div> <div>E-mail: rks@ee.iitd.ac.in director@admin.iitd.ac.in Phone: +91-11-2659-1701</div>
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Mentor



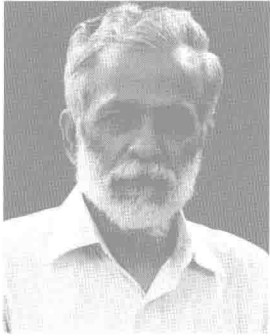

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