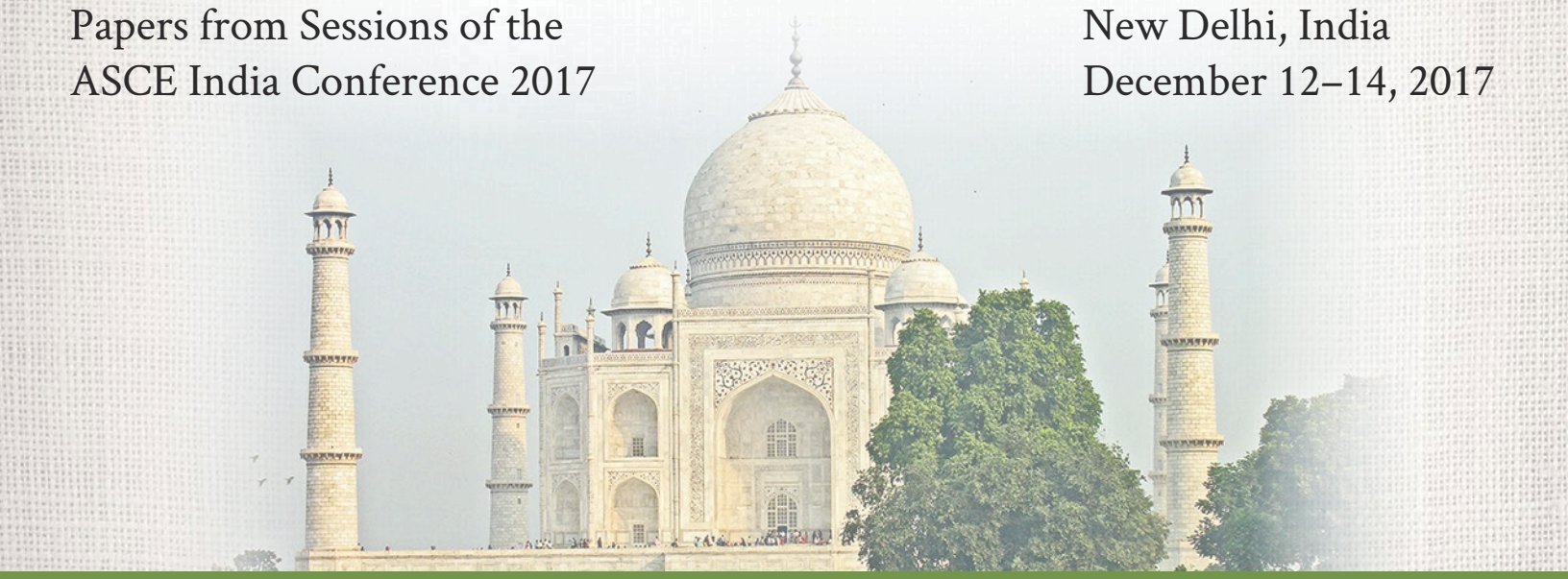
Urbanization Challenges in Emerging Economies

Resilience and Sustainability of Infrastructure

Papers from Sessions of the
ASCE India Conference 2017

New Delhi, India
December 12–14, 2017



Edited by
Udai P. Singh and

ASCE

URBANIZATION CHALLENGES IN EMERGING ECONOMIES

Resilience and Sustainability of Infrastructure

SELECTED PAPERS FROM THE ASCE INDIA CONFERENCE 2017

December 12–14, 2017
New Delhi, India

ORGANIZED BY
American Society of Civil Engineers

CO-SPONSORED BY
Indian Institute of Technology Delhi
Institution of Engineers (India)

EDITED BY
Udai P. Singh
G. L. Sivakumar Babu

Published by the American Society of Civil Engineers

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/publications | ascelibrary.org

Errata: **Errata, if any, can be found at https://doi.org/10.1061/9780784482032**

ISBN 978-0-7844-8203-2 (PDF)
Manufactured in the United States of America.

Preface

By the end of the last century the world transitioned from predominantly rural to equal rural-urban living. Many estimates predict that by year 2050 two thirds of the world's population will live in cities due to rapidly increasing rural to urban migration. This rapid and unplanned migration is having most impact on metropolitan areas in emerging economies, and is threatening the quality of life for its residents. Infrastructure in these cities, a key ingredient in quality of life, is not keeping up with the growth of population.

Civil engineers throughout the world regularly face challenges in building infrastructure in our quest for sustainable solutions to quality of life issues. The American Society of Civil Engineers (ASCE), a global leader in sustainable practices in civil engineering infrastructure, organized a conference "Urbanization Challenges in Emerging Economies" on 12 to 14 December 2017 in New Delhi, a rapidly expanding metropolitan area, to facilitate policy, technical, and scientific discussions and exchanges on these challenges in emerging economies. This conference of civil engineers, urban architects, policy makers, technology experts, and related professionals provided a showcase for the latest developments and advancements in design, construction, technology, and policy related to sustainable infrastructure and offered a forum to discuss and debate future directions for emerging economies. The goal was to help these societies move towards resilient sustainable cities and infrastructure.

Approximately 400 abstracts were received and reviewed by the conference steering committee and other reviewers. Of these, about 250 technical papers were presented at the conference. A Book of Abstracts was published and distributed at the conference. Each full paper underwent peer review by two or three reviewers. As a result, 151 papers were accepted for publication in the Proceedings. The Proceedings has been published in two volumes. This volume includes 70 papers, while the other volume has 81 papers. While some papers present successful case studies and examples of sustainable infrastructure, others share latest advances in urban infrastructure planning, design, and construction. In addition, several papers showcase new tools and latest research to support sustainable urban infrastructure.

The Proceedings contain peer-reviewed papers from several continents, including from the west as well as from emerging economies, especially from India. This volume covers the topic of Resilience and Sustainability of Infrastructure in a Changing Environment for the Next 100 Years. The papers presented here cover a diversity of topics, such as sustainable building materials, transport infrastructure, seismic resilience, lifecycle assessments, sustainable infrastructure ratings and tools, innovative technologies, smart cities, cyber-physical systems, climate change considerations, tools and methodologies, emerging paradigms in urban resilience, etc. Sustainability is a common thread in this publication.

The need to use innovative and sustainable solutions and to efficiently use, protect, and manage our existing resources is paramount to improving quality of life in the urban environment, especially in emerging economies around the world. We hope that this publication will be of assistance and use in this effort. Publication of the peer-reviewed Proceedings has been a team effort. We express our sincere appreciation to all who made it possible (please see the Acknowledgements page). In addition, special thanks are due to the India Section of ASCE and to Indian Institute of Technology Delhi as well as Institution of Engineers (India) for co-organizing the conference and actively assisting ASCE in the publication of the Proceedings.

Dr. Udai P. Singh, Environmental Consultant, Moraga, California, USA

Prof. G. L. Sivakumar Babu, Professor, Indian Institute of Science, Bangalore, India

Acknowledgments

Conference Chair and Lead Editor

- Dr. Udai P. Singh, Moraga, California, USA

Track Chair and Editor

- Prof. G. L. Sivakumar Babu, Bangalore, India

Reviewers of Technical Papers

- Prof. G. L. Sivakumar Babu, Bangalore, India
- Prof. Rajib Mallick, Worcester, Massachusetts, USA
- Prof. Ananth Ramaswamy, Bangalore, India
- Prof. Bharathi Ganesh, Bangalore, India
- Prof. Edward H. Wang, Xinfeng, Taiwan
- Dr. Anjaneyappa, New Delhi, India
- Prof. K. Chandrashekhar Iyer, New Delhi, India
- Prof. K.S. Nanjunda Rao, Bangalore, India
- Dr. Vilas S. Mujumdar, Vienna, Virginia, USA
- Dr. B. Munwar Basha, Hyderabad, India
- Er. Satish K. Vij, New Delhi, India
- Dr. Ajit Sabnis, Bangalore, India
- Prof. Amit Srivastava, Gurgaon, India
- Er. Sughosh P., Bangalore, India
- Er. Chaitra Purushothama, Bangalore, India
- Prof. Meera Raghunandan, Mumbai, India
- Prof. Prathima Bhat, Bangalore, India
- Prof. M. R. Pranesh, Chennai, India
- Er. Aravind Salecha Chetan, Bangalore, India
- Prof. L. G. Santosh, Bangalore, India
- Prof. Sireesh Saride, Hyderabad, India
- Prof. D. Nagesh Kumar, Bangalore, India
- Dr. Udai P. Singh, Moraga, California, USA

ASCE Staff

- Ms. Angie Lander, Reston, Virginia, USA
- Ms. Meggan Maughan-Brown, Reston, Virginia, USA

Contents