B&SE_Volume 46_Number 4_December 2016

The Bridge & Structural Engineer

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JOURNAL OF THE INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE & STRUCTURAL ENGINEERING

Challenges Facing the Civil & Structural Engineering Industry

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The Bridge & Structural Engineer

Indian National Group of the International Association for Bridge and Structural Engineering

Contents : Volume 46, Number 4 : December 2016

CONTENTS

Editorial

Special Topic : Challenges Facing the Civil & Structural Engineering Industry

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The Bridge & Structural Engineer

JOURNAL OF THE INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE & STRUCTURAL ENGINEERING

March 2017 Issue of the Journal will be a Special Issue with focus on

BRIDGE ENGINEERING

SALIENT TOPICS TO BE COVERED ARE :

1. **Aesthetics in Bridge Construction**
2. **Composite Deck Systems**
3. **Fatigue and Fracture Critical Bridge Inspection**
4. **Floating Bridges**
5. **Service Life Predictions for Reinforced Concrete Bridges**
6. **Accelerated Bridge Construction to Rehabilitate Aging Highway Structures**
7. **Efficient Methods for Upgrading or Reinforcing Existing Bridges**
8. **Future of Bridge Designs**

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The Bridge & Structural Engineer

JOURNAL OF THE INDIAN NATIONAL GROUP OF THE INTERNATIONAL ASSOCIATION FOR BRIDGE & STRUCTURAL ENGINEERING

June 2017 Issue of the Journal will be a Special Issue with Focus on

URBAN TRANSPORT STRUCTURES

SALIENT TOPICS TO BE COVERED ARE :

1. **Urban Transport Planning**
2. **Sustainability Issues**
3. **Mass Rapid Transport Systems**
4. **Accelerated Bridge Construction Techniques**
5. **Traffic Management Issues in Urban Areas**
6. **Use of ITS in Urban Planning**
7. **Case Studies**

Those interested to contribute Technical Papers on above themes shall submit the abstract by 31st March, 2017 and full paper latest by 15th April, 2017 in a prescribed format, at e-mail id : ingiabse@bol.net.in

B&SE: *The Bridge and Structural Engineer, is a Quarterly journal published by ING-IABSE. It is one of the oldest and the foremost structural engineering Journal of its kind and repute in India. It was founded way back in 1957 and since then the journal is relentlessly disseminating latest technological progress in the spheres of structural engineering and bridging the gap between professionals and academics. Articles in this journal are written by practicing engineers as well as academia from around the world.*

Front Cover :

Top Left : Erection of Full Span PSC Box Girder in progress. Special Launching gantry in use for erection.

Top Right : Group of Engineers discussing strategies near a building site.

Bottom Left : An animated sketch to demonstrate how constructions have changed the face of maximum city.

Bottom Right : Two Engineers discussing a blue print of drawing near a construction site.

Published:

Quarterly: March, June, September and December

Publisher:

ING-IABSE

C/o Secretary, Indian National Group of the IABSE

IDA Building, Ground Floor (Room Nos. 11 and 12)
Jamnagar House, Shahjahan Road
New Delhi-110011, India
Phone: 91+011+23388132 and 91+011+23386724

E-mail: ingiabse@bol.net.in, ingiabse@hotmail.com, secy.ingiabse@bol.net.in

Submission of Papers:

All editorial communications should be addressed to Chairman, Editorial Board of Indian National Group of the IABSE, IDA Building, Ground Floor, Jamnagar House, Shahjahan Road, New Delhi-110011.

Advertising:

All enquiries and correspondence in connection with advertising and the Equipments/Materals and Industry News Sections, should be addressed to Shri R.K. Pandey, Secretary, Indian National Group of the IABSE, IDA Building, Ground Floor, Jamnagar House, Shahjahan Road, New Delhi-110011.

The Bridge & Structural Engineer, December 2016
Journal of the Indian National Group of the International Association for Bridge & Structural Engineering

From the Desk of Chairman, Editorial Board

Civil engineering can easily be construed as the earliest and most earthy profession which brought about a differentiation between humans from other species on the planet. Everything that Civil Engineers do, has a direct impact on the development and well-being of society and the environment. The construction industry, to which Civil Engineers (CEs) are directly associated, is the largest consumer of natural resources on the planet and second largest in the country after agriculture, in terms of manpower deployment. Thus it makes a significant contribution to the national economy and provides employment to large number of skilled & unskilled population of the country. CEs are the key leaders of the planning, design and construction team, often working alongside other professionals. Together they create all kinds of structures from housing, multi-storey buildings, theatres, sports stadia, hospitals, bridges, oil rigs, power stations, e.g. hydro, thermal & nuclear and space satellite launch stations. CEs make a difference and shape the built environment in its entirety.

Despite all of these, it is unfortunate that there is a fatal discrepancy between the image of a Civil Engineer and their unsung role in society. In the public opinion Civil Engineering is neither high-tech nor creative, though in fact, it is both, as much, if not more, than any other profession. What is the root cause of this discrepancy between our deeds and our image as Civil Engineers? Is there a cultural disconnect of Civil Engineers with the society at large? Are we Civil Engineers geared up for the upcoming challenges of the profession?

I believe that, without question, the future for Civil Engineering profession is bright in India, considering the tremendous growth potential ahead of us. There are, however, many demanding challenges ahead of us to resolve, in order to connect with the masses and to establish our rightful and dignified position in society. It is well known that the nature of engineering, or at least engineering performance, is changing dramatically with challenging new technologies to be deployed in increasingly demanding environments. In order to cope with this fast changing scenario and also in order to be in the forefront, the leaders of the industry today, must invest time and energy to devise strategy for preparing the next generation of civil engineers well, so that they are capable of taking the seat of leaders in future.

Our next generation of Civil Engineers should be able to manage and integrate globally constituted, multi-cultural teams that design and procure equipment, materials, and services internationally. The leaders of today in our profession must help young engineers to develop skills to have the ability to see the big picture in front of us rather than get bogged down to only micro issues. This will enable us to successfully manage extremely large and complicated engineering and construction projects and other complex developments anywhere in the world.

So how do we address these complex issues? How do we prepare our next generation for this new broader role? How do we make them not only technically competent, but also effective communicators, especially cross-culturally? How do we ensure that they have acquired interdisciplinary knowledge? What are the challenges facing present and future civil/structural engineers in the country?

In order to address all these issues, the editorial board of this journal thought it prudent to bring out this special issue on the theme of **"CHALLENGES FACING THE CIVIL & STRUCTURAL ENGINEERING INDUSTRY"**.

For this special issue, we are privileged to have Er P. Surya Prakash, Founder Director of M/S Satya Vani Projects and Consultants Pvt. Ltd., as our Guest Editor. Er. P. Surya Prakash is an eminent Engineer, Consultant and a Mentor who is young, energetic and has made significant contribution to Civil Engineering Profession. He is also the Founder and Mentor of Smart Infr-EST, a trust dedicated to the Civil Engineering to enhance employability and employment. He was President ACCEI (2013-15) and is Founding President of PSI since 2013. Er. Surya Prakash is a FIE, FACCE (I), MICI.

We in ING-IABSE editorial board are highly indebted to Dr E Sreedharan, the Metro Man, who, despite his extremely busy schedule, has kindly agreed to share his views regarding the challenges faced by Civil Engineers in this special issue.

We are also privileged to have Mr Raju Gogia, a Governing Council member of IAStructE and a very active member of EAG (Engineers Action Group) on board as the Co-Editor for this important issue of the journal. He has immensely contributed in bringing this issue to this shape, by not only reviewing each and every paper in this journal, along with the guest editor, but also contributing an article for this issue.

I hope readers will find this issue thought provoking and interesting !

Happy Reading !

(ALOK BHOWMICK)

From the Desk of Guest Editor

The economic development is indicated by the GDP growth. Major contributor to GDP in any developing country is construction sector and thus the industry. Construction sector is largely managed by the Engineering Professionals. Quality of these professionals would determine the effectiveness of spending in Built Environment, Infrastructure and the Industry. In India, the employability of the Graduates produced is found to be only 10%. Even among those employed the Continuing Professional Development is only 10%. No professional or the organization, employing the Engineer, would spend time and money unless it is made mandatory.

India is a country subjected to more natural calamities due to its geographical and geological position and needs more attention on quality professionals and Professional development. The magazine publishers have identified the severity of the problem and the need to invite the who's who in Indian Construction scenario to express their views on different issues being faced by the professionals and the need for the regulation of the profession.

The topics addressed starting from Engineering education, Higher education, Need for promulgation of Engineers Act, Regulation and accountability of Engineers, Sustainability of the Built Environment etc.

The 11 papers received for this special issue focusses broadly on multiple issues highlighting the huge responsibility bestowed upon the Civil Engineering Fraternity by the society at large and identifies various challenges that the fraternity is facing in working for a sustainable built environment, which is in the best interest of our profession as well as the interest of future generations.

Dr. E. Sreedharan and Prof. Mahesh Tandon have presented some of the statistics on the current situation in the engineering global importance and they mention that economic growth is undoubtedly dependent upon engineering profession. It discusses about the importance of getting a statutory recognition to the engineers and how it will affect the people's safety. They suggested that, this is the time to give the professional engineers a statutory recognition because several schemes implemented by Prime minister require professional engineering skills. They mentioned the importance of enacting engineer's bill by discussing some of the major issues faced by the professional engineers. They finally discuss about some of the institutions in India and their significant role in professional engineer's career.

Ms. Sayona Philip in her paper discusses about the challenges that are faced by the consulting engineering fraternity in India. She mentioned, how the engineering education in India is changing and their significant impact on the industry and consulting. It discusses about the younger and less experienced profile, how to retain the younger talents. It also discusses about how the engineering profession will change and the complexities that are going to occur in the design field.

Mr. Manoj Mittal in his paper presented brief statistics on the current engineering students chance to enter the institutions like IITs, NITs, IIITs etc., It mentions that engineer's bill is in a continuously torturous journey in the legislative process by the Government. It suggests that there is no official regulatory authority to give a statutory recognition to the professional engineers.

Mr. Alok Bhowmick in his paper emphasized the need for training the Young Brigade coming out of the college by the industry. The paper highlights the leadership crisis in the profession and the challenges ahead.

Mr. Amitabha Ghoshal in his paper mentioned about the threat to the domestic consultants due to increasing entry of multinationals and foreign investment etc. It discusses the challenges and operational issues in industries. It suggested that united action is the call of the day.

Mr. Ajit sabnis paper discusses about India's vision 2030. It shows various statistics related to the future issues that may occur. It also discusses how to solve those issues by implementing the opportunities.

Dr. N. Subramanian Narayanan in his paper mentions about the role of civil and structural engineering in building the sustainable environment. It discusses about the environmental threats and their solutions for today. It mentioned the challenges that may occur in the future.

Mr. R. Gogia in his paper mentioned that initiatives such as "Make in India", "Housing for all by 2022" etc. require a very high level of civil engineering technological skills, engineering innovation. It also mentions that the study of the civil engineering is currently not regulated by engineers themselves, but by administrators. It highlights vision 2025 by mentioning civil engineers as leaders in safe planning, designing, and constructing the built environment, must continue to position themselves at the helm of multi-disciplinary, global, collaborative teams that carry out successful projects.

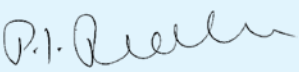
Mr. Rajendra Gill and Ms Alpa Sheth in their paper mentioned the engineering teaching methods and the need for changes by making it more broad based with a lot more humanities subjects to be included in the curriculum. it also discusses about the issues between engineers and architects.

Mrs. Sangeeta Wij mentioned about the professional ethics which should be followed by the engineering professionals and it also suggests that structural engineers should be entrusted by society to create the safe and sustainable built environment for the people.

Mr. Sudhir Dhawan paper discuss about the constraints in forwarding the draft of engineer's bill for getting the legislative approval. He has mentioned the major draw backs of not having the engineer's bill.

I trust that the articles published in this volume shall provide an insight of the various perspectives and interpretations of "Challenges faced by Structural Engineers" as perceived by some of the stalwarts of our fraternity.

I am thankful to ING-IABSE for giving me this opportunity to guest edit this very important and special issue of the journal. It is hoped that the papers in this special issue would help the civil engineering fraternity to review the current state of practice, reflect on its deficiencies and consider the ideas expressed by various experts to set the correct course for a sustainable future.



(P SURYA PRAKASH)

Brief Profile of Mr. P. Surya Prakash

Er. P. Surya Prakash is an eminent Engineer, Consultant and a Mentor who has made significant contribution to Civil Engineering. Er. Surya Prakash obtained his Bachelor's degree in Civil Engineering from JNTUK in 1986. He did MS in Structures in 1990 from IIT, Madras. After working for 5 yars as Design engineer, in 1994, he established M/s SatyaVani Projects and Consultants Pvt. Ltd. He is also the Founder and Mentor of Smart Infr-EST, a trust dedicated to the Civil Engineering to enhance employability and employment. He was President ACCEI (2013-15) and is Founding President of PSI since 2013. Er. Surya Prakash is a FIE, FACCE (I), MICI etc.

He Authored a Book on "Design and Implementation of Communication Towers". Er. Surya Prakash was the Guest Training Faculty to CERI, ESCI, and Hyderabad on CAD of Transmission Line Towers. He was Chief Resource Person for LEAP Lecture in 56 topics for Smart Infr-EST. The CABFADD software developed by him won the ACCE-CDC Best Software award in 2007. He was the Organizing secretary for WISE-2004. He organized Workshops on PEPSCon-2013, '14,'15 A3C2010, MecCON2007, EiA (2003), IS: 456-New Vistas, Seismic design of Buildings, IS-1996, ISIS-1999. He was a Member of the Expert Committee for Categorization of Seismic damaged structures. Er. Surya Prakash is involved in the successful conduct of several International Conferences, viz. Como-Italy 2011, SEWC, Seoul - South Korea, IASS 2012, and Pre Cast -2014 Moscow and SEWC-2015, Singapore. He guided Projects for M.Tech and B.Tech Students of Engineering colleges IITM, JNTUH, NITW. He was also involved in the training of Engineers.

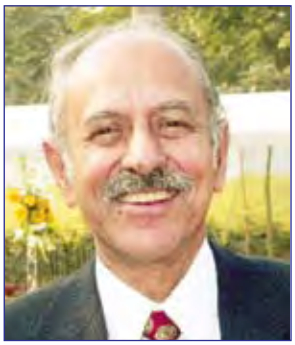
Er. Surya Prakash handled several prestigious projects during the past three decades. Some of the projects he undertook include: Affordable Housing, Buildings – Residential, Commercial, Office, IT, Industrial, Hospitals, Hotels, Infrastructure- Roads, Bridges, Metro Rail, Runways, Hangars, Logistic Parks, Leisure Theme Parks, Stadiums, Transmission Line Towers, FM, TV, Microwave and Cellular Towers providing Architecture, Engineering and Project Management Services. The Prestigious Clients include Ministry of Defence, Il&FS, Tech Mahindra, GVK, GMR, BSNL, Idea, AirTel, TATA, Saket, Manjeera, Janapriya, Ashoka etc.

CHALLENGES FACING THE CIVIL & STRUCTURAL ENGINEERING FRATERNITY IN INDIA

Elattuvalapil SREEDHARAN

Principal Advisor
Delhi Metro Rail Corp. Ltd.,
Ponani, Kerala, India
dmrcpon@gmail.com

Dr. Sreedharan, (IRS) who retired as 'Member Engineering', Railway Board (1989-90) is affectionately known as the "Metro man" of India, having done pioneering work in DMRC as its first Managing Director (1997-2011). Recipient of Padma Shri (2001), Padma Vibhushan (2008), Légion d' Honneur, France (2005) and several prestigious awards and honours. Currently Advisor to most metro constructions in various cities across India. Credited with changing the face of Public Transport in the Country.



Mahesh TANDON

Managing Director
Tandon Consultants Pvt. Ltd.,
New Delhi, India
tandon@tcpl.com

Prof Mahesh Tandon received his Bachelor degree in Civil Engineering IIT Roorkee & Masters from University of Hawai, USA. He was appointed Distinguished Visiting Professor at the IITs @ Kanpur, Roorkee & Gandhinagar (2005-2015) by the Indian National Academy of Engineering (INAE) and the ALL India Council for Technical Education (AICTE). Currently President, Indian Association of Structural Engineers.

1. Introduction

Many challenges face the engineering profession in India. Two mountains which have sprung up in our path concern the "un-employability" of a large percentage of our engineers and lack of statutory recognition of our profession. By seeking divine intervention to remove these mountains from our path would not be the appropriate "engineering approach". The objective of this paper is to examine their contours and make an attempt to cut a path across them.

2. History

A Committee under the chairmanship of S. G. Barve was set up by the Planning Commission in February 1966 to study the problems relating to technical consultancy services. The Committee's Report submitted in 1970, recommended that "in order to develop the profession on healthy lines and to avoid undesirable elements/practices there should be an All India Institution/Association on the lines of the Indian Institute of Chartered Accountants to lay down proper standards of education, experience, capability, capacity etc". The Chartered Accountants Act had already come into being in 1949. The Report further recommended that "legislation could be undertaken to make it (the Institution) a legal entity parallel to the Institute of Chartered Accountants".

It is a sad commentary that even after half a century this important piece of legislation has not seen the light of day.

We cannot ignore the fact that India has a high vulnerability profile from the point of view of natural disasters like earthquake, cyclones and floods. To complete the profile we must add man-made disasters, such as pollution, unsafe buildings, haphazard planning and over-crowding in cities and road accidents (400 fatalities per day in 2015). These calamities threaten India's economy, the safety and security of its population as well as its sustainable

development. Engineers, by education, training and experience are well-equipped to make a significant contribution to ameliorate these hazards.

After the Kutch earthquake on 26th Jan 2001, the State of Gujarat felt the need of for regulation of Engineers and as a consequence the Gujarat Professional Civil Engineers Act, 2006 came into being. The need of the hour is to have a similar, but improved, enactment on a national scale, to ensure the safety and security of the general public as well as the physical assets of the nation.

3. Some Statistics

In most countries, e.g., Australia, Canada, Japan, Malaysia, New Zealand, Pakistan, Sri Lanka, South Africa, Singapore, Tanzania, USA, etc. professions such as Engineers are invariably governed by an Act of the Government. In India too, some professions, like that of Chartered Accountants, Doctors and Lawyers are indeed governed by Acts of Parliament, while the Architect's Act is for governing the 'TITLE'.

The engineering population in India has reached an estimated 7.5 million and is increasing at the rate of 1.5 million per annum. While the Government brought Acts of Parliament after Independence for the regulation of other professions like Chartered Accountants, Doctors and Lawyers. The ratification of regulation for Engineers by Institution of Engineers (India), established though Royal Charter in 1935, seemed to have been inadvertently over looked. Incidentally, the total numbers of Chartered Accountants, mentioned by the Barve Report are but a small fraction of numbers of Engineers, i.e., 240,000 out of which only about 50% are in practice.

The first ever Global report commissioned by the *Queen Elizabeth Prize for Engineering* makes some startling revelations. While just 20% of 16 to 17 years old from the UK and 30% from the USA are interested in an engineering career, in India the rate is as high as 80% - the highest in the world. India also has the distinction of having closed the gender gap (85% men and 79% women) for engineering aspirants in 2015.

A Research Report titled "Real Estate and Construction Professionals in India by 2020" published by the Royal Institution of Chartered Surveyors (RICS) mentions that the Built Environment contributed 18.9 % of GDP of US$ 756 billion in the year 2008-2009. The GDP is forecast to reach US$ 2080 billion in 2015-16 and the demand for Civil Engineers in the same year would exceed 4 million as against the meager supply of 640,000 thereby resulting in a huge shortage of Civil Engineers.

From the above discussion it can be concluded that

- Engineering, undeniably tops the list of professions seen as most vital for economic growth.
- Given the potential of a "knowledge economy" our country must develop in an organised fashion to absorb the young but growing talent pool.

Coming to the quality of engineers, the position in worse.

Based on the National Employability Report – Engineers: Annual Report 2016 available on the website of "Aspiring Minds" less than 20% engineering graduates are employable. The Report is based on survey of 150,000 engineering students from 650 engineering colleges across the country.

Considering non-IT jobs in the "Core Engineering" category such as mechanical, electronics/electrical and civil engineers the employability comes down drastically to a mere 7%.

Technical (including engineering) education comes under the purview of AICTE, which has been set up by the Government of India. This statutory body has the objective of the coordinated development of the technical education system as well as the regulation of its quality.

Worried about quality, AICTE is reported to be considering the reduction of seats in engineering by one million, from the existing capacity of 1.67 million seats. This is a good move to prevent "fly by night" operators who set up shop without proper facilities and staff. However, some of the established courses like AMIE run by the Institution of Engineers should be encouraged.

4. Why Now ?

The Prime Minister's initiatives have resulted in the launching of several schemes for a safe and sustainable environment like 'Smart and Amrut cities', 'Make in India', 'Housing for all by 2022','Swach Bharat Abhiyan' and the target of constructing National Highways at the rate of 42 km/day and supplementing them with inland waterways . We can add to this the long list of cities where Metro project constructions

are in progress or are in an advance planning stage, as well as high speed train corridors and development of ports. The inevitable conclusion is that never before in India have such ambitious investments in construction and infrastructure been envisioned. Such projects require skills of the highest order from Civil Engineers and those from other engineering disciplines. These schemes need big ideas, ideas that will make a difference, ideas that will open doors and result in breakthroughs. We need an organised work force which can visualize a better world beyond the status quo, which will need new levels of technical excellence. To exploit the inherent inventiveness of engineers for these schemes we require a cohesive and cogent planning at a national level by the Government and an active commitment which will come only by a statutory stamp.

5. The Need For Engineers Bill

The need for Engineers Bill is best answered by asking if there is an authorised body (association or institution) which has the legal mandate to:

- Take up issues concerning engineers with any Authority?
- Uniformly decide across the country on the qualification, competency and experience requirements of engineers for a particular work.
- Grade engineers based on their qualifications, competency, experience and demonstrated capability and certify them?
- Direct and monitor that each and every engineer continuously updates knowledge and skills?
- Bring in accountability and responsibility and lay down Code of Ethics
- Regulate entry of foreign professionals and also have reciprocal arrangement for acceptance of Indian engineers in other countries?
- Restrict the usage of the title and style of "Engineer"?
- Initiate a mentoring program for the next generation of engineers?
- Lay down rules for election to the Council?

The answers to all these question is NO!

6. Road Ahead

There is a dire need to regulate the profession of Engineering, an Engineering Council needs to be set up that can then eventually be made "a legal entity parallel to the Institute of Chartered Accountants" as suggested in the Barve Report.

In the interim, an existing Institution such as the Institution of Engineers (India), IEI, which was established by Royal Charter in 1935 could be made *de facto* the legal entity. IEI has approximately one million members in 15 engineering disciplines in 125 centres or chapters located in India and overseas; it is the world's largest multi-disciplinary engineering professional society. They also hold examinations for Sections A&B of AMIE (in all the 15 disciplines) which is considered equivalent to an Engineering Degree. The IEI represents India at the International Professional Engineers Agreement (IPEA) which provides for recognition of equivalency of standards and quality assurance systems used to establish the competency of engineers for independent practice in most parts of the world. Given its extensive reach and diversification IEI is well suited for the role. It can also be given the primary responsibility of Registration of Professional Engineers.

Other Institutions like Consulting Engineers Association of India and Engineering Council of India have also started the process of Registration of Professional Engineers. These are symptoms that are indicative of the dire need felt by the fraternity for a regulatory and registration mechanism. However, before these energies dissipate in various directions, all institutions need to come under a single umbrella for this common cause. Failure to do so on a previous occasion does not justify the pessimism surrounding the futility of another whole-hearted attempt.

Coming to the quality of engineering education, which is one of the main reason for the large number of engineers being "unemployable", AICTE seems already seized of the problem as indicated earlier. The 1.5 million engineering graduates being released into the job market every year, could become a major sociological issue apart from hindering development of country.

Atleast part of the answer lies in making the education more "job centric" in some respects, and, more importantly, work with AICTE to have vigorous academia-industry interaction and engagement. This would be possible more easily once the profession of engineering has a regulator with statutory status.

ROLE OF CIVIL AND STRUCTURAL ENGINEERS IN SUSTAINABLE BUILT ENVIRONMENT

Subramanian NARAYANAN
Consulting Engineer,
Gaithersburg, MD 20878
USA
drnsmani@gmail.com

Dr. N. Subramanian earned his PhD from IIT, Madras in 1978. He worked in Germany as Alexander von Humboldt Fellow during 1980-82 and 1984. He has 40 years of professional experience which includes teaching, research, and consultancy in India and abroad. Dr. Subramanian has authored 25 books and more than 240 technical papers, published in International and Indian journals and conferences. He has won the Tamil Nadu Scientist Award, the Lifetime Achievement Award from the Indian Concrete Institute (ICI) and the ACCE(I)-Nagadi best book award for three of his books. He also served as the past National Vice-President of ICI and ACCE(I). He is also in the editorial/review committee of several journals.

Summary

Significant challenges are posed to the civil and structural engineers in the 21st century and the main challenge among them is do design and develop systems that will result in sustainable environment. The population growth coupled with increased urbanization and dwindling resources, has resulted in several environmental threads such as increased ambient temperature, decreased air quality, increased water run-off, loss of aesthetic beauty/character of the community, reduction in farm lands and subsequent food shortage, and deforestation. As we have the commitment to provide adequate resources for future generations, there is an urgent need to consider sustainability in all our projects. Though structural steel and concrete are preferred by structural engineers, they have an appreciable environmental impact. In order to fulfill the reduction in greenhouse gas emissions, committed by the Nations of the world, engineers should use techniques and materials which will have profound impact on sustainability. Some of the techniques and solutions that have been developed, such as life cycle assessment, life cycle costing, increasing the design life of RC structures, use of sustainable materials like wood, gypsum, and glass, use of recycled and waste materials, previous concrete and zero energy/zero carbon buildings are discussed. The challenges for the future are briefly discussed with suggestion for improvements in structural engineering practice, research and education.

Keywords: Alternative Materials, Civil Engineers, Design life, Ecological footprint, Energy Efficiency, Environmental Threats, Internal Curing, LEED® rating system, Life Cycle Assessment, Life Cycle Costing, Pervious concrete, Structural Engineers, Sustainability, Tensegritic Structures.

1. Introduction

Significant challenges are posed to the civil and structural engineers in the 21st century and the main challenge among them is do design and develop systems that will result in sustainable environment. Our planet has only finite natural resources (already, we are consuming the equivalent of 1.6 planets' worth of resources to sustain the way we live each year. If everyone on the planet lived like the average American, we would need 5 Earths to sustain our lifestyle). However, due to the ever-growing population and associated built environment, these resources are being consumed at a level, which is not sustainable. Hence, there is an urgent need for our civil and structural engineers to consider environmental as well as economic and social sustainability in their systems and design. To really achieve a sustainable

built environment, engineers must be truly involved at each and every stage of their construction project. A few solutions and directions are given in this paper, which may be divided into three sections:

1. Environmental threats: The trends in the consumption of building materials worldwide shows that the decisions made by civil/structural engineers (hereinafter referred as engineers) in selecting the materials of construction, will have a great environmental impact. Our engineers should consider the greenhouse gases emitted during the production of the materials they are specifying in their projects, and should try to optimize them.
2. Current Solutions: Several solutions are available to the engineers to mitigate the impact of their choices on the environment. Several solutions are already available, which can reduce the environmental impact and result in sustainable constructions.
3. Future challenges: The solutions that exist today to reduce the environmental impact of construction may not be significant in future, and hence the profession should find some holistic solutions. In addition, engineers should not only be knowledgeable in the analysis and design of structural systems, but also about environmental issues in construction. Engineers can achieve the above only if they take up leadership roles by identifying the challenges and finding solutions, thereby fulfilling the needs of future generations.

2 Environmental Threats

The greatest threats to the sustainable development on earth are: population growth and urbanization, energy use and global warming, excessive waste generation and the subsequent pollution of soil, air, and water, transportation in cities, and limited supply of resources. Many of them are interrelated (Subramanian, 2015).

The ecological footprint represents the human demand on the planet's ability to provide renewable resources and ecological services. We currently need the regenerative capacity of 1.6 Earths to provide the goods and services we use each year. Furthermore, the per capita Ecological Footprint of high-income nations dwarfs that of low- and middle-income countries. If current trends continue, unsustainable consumption and production patterns will expand along with human population and economic growth, largely affecting biodiversity and climate (www.footprintnetwork.org). Currently, 80 million people are being added every year in under-developed countries, compared with about 1.6 million in developed countries. Thus, populations are growing more rapidly at places where such growth cannot be afforded. In addition, urban population is increasing at an exponential level, throughout the world. Global proportion of urban population rose dramatically from 29 percent (736 million) in 1950 to 54 percent (3.94 billion) in 2015. It is projected to be about 60 percent (4.96 billion) of the global population by 2030 [Subramanian, 2008].

Population growth coupled with urbanization results in significant impacts on the environment and other problems, which may include [Subramanian, 2008a & 2008b]:

1. Increased ambient temperature,
2. Decreased air quality,
3. Increased water run-off,
4. Decreased quality of run-off water,
5. Altered weather patterns,
6. Loss of aesthetic beauty/character of the community,
7. Reduction in farm lands and subsequent food shortage, and
8. Deforestation (Deforestation is occurring at a rapid rate, with 0.8 hectares of rain forest disappearing every second. Deforestation is linked to negative environmental consequences such as biodiversity loss, global warming, soil erosion and desertification).

Also urbanization results in the migration of rural population to towns thus increases the development of slums, pollution and waste, and also the need to develop infrastructure for housing the masses, educational facilities, roads and highways, health care, and civil supplies.

In addition, population growth and urbanization pose significant challenges for water resources management throughout the world. Water is vital not only for farming and domestic well-being (agriculture accounts for more than 70% of global freshwater withdrawals); it is "fundamental to economic growth". Water scarcity may stall industrial development by squeezing energy supplies, as most energy producing

units such as thermal power plants, nuclear power plants, and hydro-electric plants, cannot function without water. As per World resources Institute, water stress causes pain or suffering to one in four cities worldwide (Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use). In India, there is a serious river water sharing dispute between the states of Tamil Nadu, Kerala, Karnataka, and Andhra Pradesh.

Urban populations also consume much more food, energy, and durable goods than rural populations. The urbanization of the world's populations will increase aggregate energy use. Urban areas reduce the infiltration of water and lower the water tables. This means that runoff occurs more quickly with greater peak flows. Flood volumes increase, as do floods and water pollution downstream. For example, in Chennai there were heavy floods in December 2015; threatening life and property (Chennai recorded a 100 year record whopping 1218.6 mm of rain, which is three times its monthly rainfall. The study by reinsurance company Swiss Re, showed that the economic loss due to this flood alone was $2.2 billion, out of India's total economic loss of $6.2 billion suffered due to disasters in 2015). However, most of this water went unused and drained to the sea. This year, there is scanty rain and Chennai may experience severe water scarcity. It has been reported that over third of China's waterways have been spoiled by industrial effluents and pollutants.

Construction activities require huge amounts of natural resources, and mining for these resources results in several environmental problems such as soil erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, in addition to spoiling ground and surface water by chemicals from mining processes. Moreover, not only the population is growing but also the rate of resource consumption per person is growing, due to the economic growth (By 2050, the world economy is expected to quadruple and the global population to grow from 7 billion today to over 9.2 billion). The amount of materials extracted, harvested and consumed worldwide increased by 60% since 1980, reaching nearly 62 billion tonnes (Gt) per year in 2008 and is projected to reach 100 Gt by 2030 [www.oecd.org/greengrowth]. But our earth has only finite resources. Several materials have been depleted or on the verge of depletion. These include gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. Territories with the highest mineral depletion are Australia, Brazil, Chile and China. Many locations in India have experienced shortage of natural sand (Sand has by now become the most widely consumed natural resource on the planet after fresh water. The annual world consumption of sand is estimated to be 15 billion tonnes). Illegal mining of sand and gravel in most of the rivers of India, can have an impact on flow patterns, change the profile of the riverbed and put embankments at risk. In addition, it may damage infrastructure like bridges and transmission lines, and cause depletion of groundwater tables and degradation of groundwater quality. As per a study, increasing greenhouse gas levels, rising global temperatures, rising sea levels, and dramatic resource depletion have all occurred at increasing rates in the last 30 years [Meadows et al. 2006].

It is also of importance to note that many valuable materials are disposed of as waste and, if not recovered, are lost to the economy. It is estimated that about one fifth of the raw materials extracted worldwide ends up as waste. This corresponds to over 12 billion tonnes (Gt) of waste per year [www.oecd.org/greengrowth].

Realizing these challenges, civil engineers have already started working on providing some immediate solutions. In 1987, the World Commission on Environment and Development adopted the definition of sustainability, as suggested by then Prime minister of Norway, Gro Brundtland, as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [Brundtland report, 1987]. Sustainable development is the application of the available resources to enhance the safety, welfare, and quality of life for all of society. In order to save the world from the disaster of depleted resources, the concept of sustainability has to be adopted as the standard goal by all governments and the global industry. As per ASCE report on vision for Civil engineers in 2025, civil engineers should realize that they must increasingly transform themselves from the traditional role of designers and builders to project life-cycle "sustainers" [ASCE 2009]. According to ASCE, future civil engineers should be master:

1. Planners, designers, and constructors;
2. stewards of the natural environment;
3. innovators and integrators of technology;
4. managers of risk; and
5. leaders in shaping public policy, where "master" implies "leader" in both role and knowledge.

This shift outlines the importance of the relationship between engineers and the natural world. Future engineers should look forward to designing in a planet with has limited natural resources, complex problems with no clear answers, and increasing environmental concerns. It is important for engineers to consider functionally aesthetic designs with construction materials for structure & finishes, that have lower embodied energy, lower greenhouse gas emissions during production, long life, and are recyclable. Note that embodied energy is the energy consumed by all of the processes associated with the production - from the mining and processing of natural resources to manufacturing, transport and product delivery. As shown in **Fig. 1**, embodied energy per unit weight of steel is the highest compared with other materials.

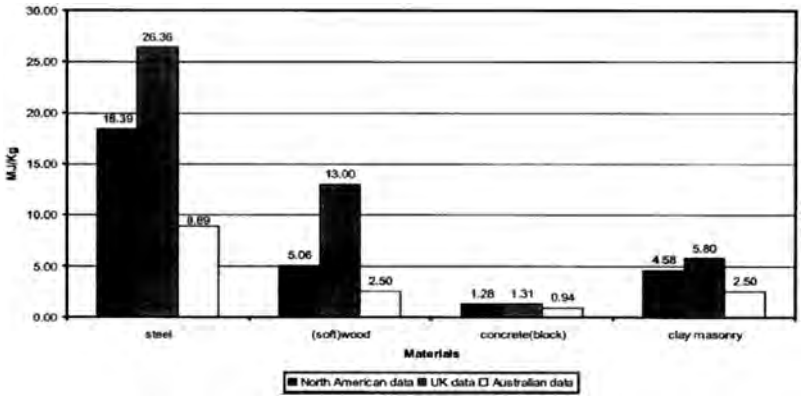


Fig. 1 : Embodied Energy of Materials Per Unit Weight

Currently, steel and concrete are the preferred materials of construction for structural elements and their consumption worldwide has an appreciable environmental impact, as shown in **Fig. 2**. Cement is the main component of concrete and the world cement production was 4.1 billion tons/year in 2015 and it is estimated to reach 5.8 billion tons/year by the year 2050. Each ton of cement is responsible for about one ton of CO_2 emissions and the cement industry alone contributes about 5 to 7% of global CO_2 emissions. As shown in **Fig. 3**, the environmental impact of steel is greatest when compared with other structural construction materials [Lomite and Kare, 2009]. For both concrete and steel there are environmental consequences from open pit mining, and from the fossil fuels used to process the raw materials. However, it has to be noted that steel is completely recyclable.

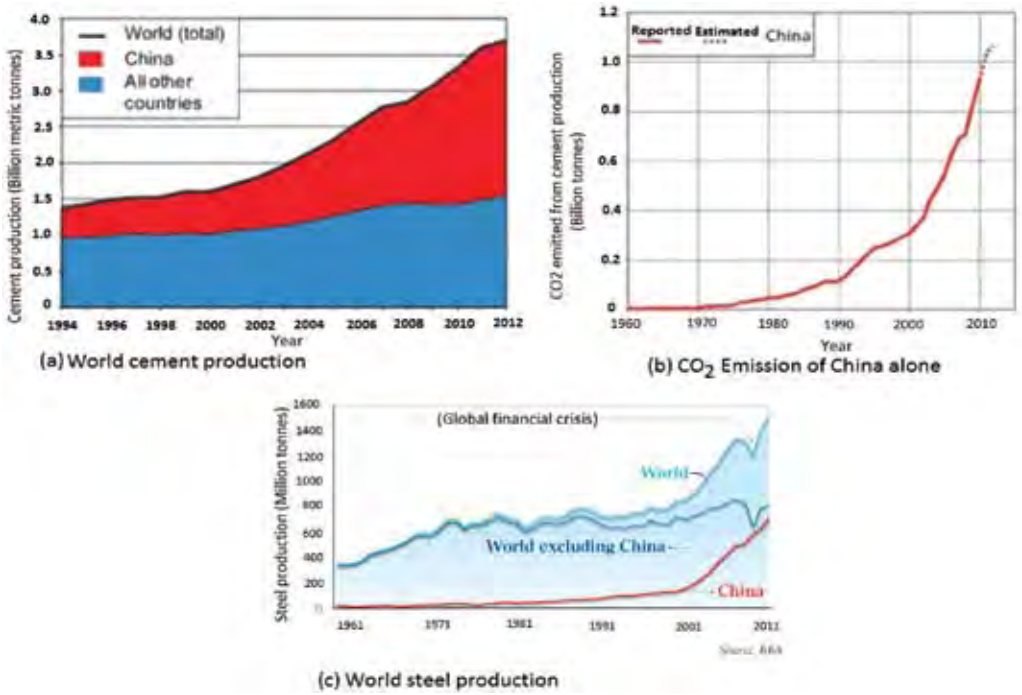


Fig. 2 : World Production of Cement and Steel

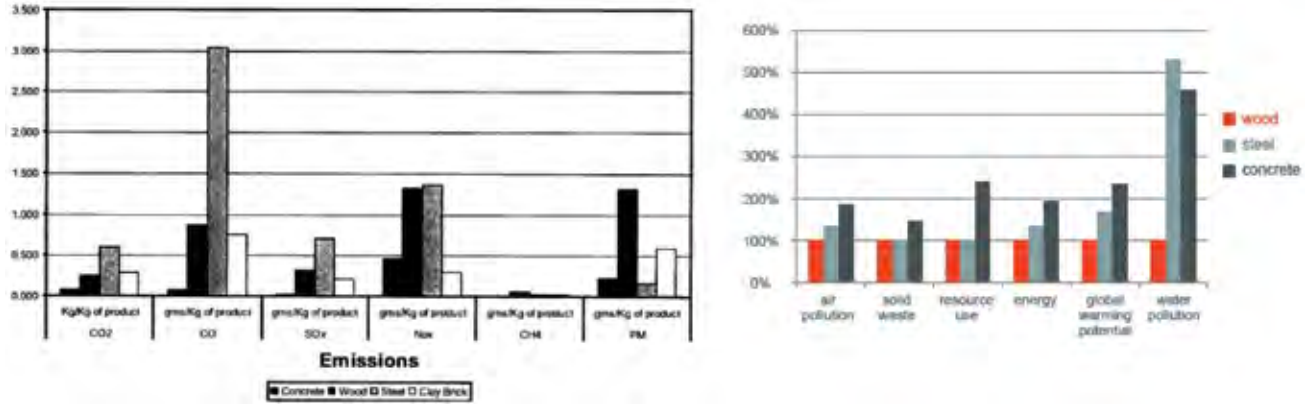


Fig. 3 : Environmental Impact of Different Structural Construction Materials

To limit global warming, governments around the world are taking steps to reduce CO_2 emissions. For example, under the framework adopted by EU leaders in Oct. 2014, EU and its Member states have set the following three key targets for the year 2030:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 27% share for renewable energy
- At least 27% improvement in energy efficiency

It is notable that the total greenhouse gas emissions, including international aviation, in the EU-28 decreased by around 20% between 1990 and 2013. As the construction industry is responsible for a large percentage of total global CO_2 emissions, civil engineers should take up the challenge of improving the sustainability of civil engineering infrastructure seriously and as a priority. In addition, the structural engineering profession currently faces many challenges in areas such as education, licensure, technology, globalization, innovation, and leadership. Those challenges are also avenues of great opportunity (SEI-ASCE, 2013).

3. Solutions For Today

There is a growing demand for engineers who have knowledge about sustainability and environmental issues in construction. The LEED® rating system developed by the U.S. Green Building Council during 1993 has been well established and there is growing demand to obtain LEED® ratings for new as well as old buildings and neighborhood development [USGBC 2016]. LEED® grew from one standard for new construction to a comprehensive system of six interrelated standards covering all aspects of the development and construction process [Subramanian, 2015]. More details of this rating system may be had from its website. Similar assessment systems are available in other countries also [e.g., The British green building rating system called the Building Research Establishment Environmental Assessment Method (BREEAM), The comprehensive Assessment System for Building Environmental Efficiency (CASBEE) of Japan, and Green Star of Australia]. Several other tools and techniques that are available today that can be used to reduce the environmental impacts are presented in this section.

3.1 Life Cycle Assessment and Life Cycle Costing

Life Cycle Assessment (LCA) examines the total environmental aspects and potential impacts of a material or product through every step of its life (i.e. cradle to grave) - from raw material acquisition (e.g. through mining or logging) through manufacture, transport to a store, and use in actual structure to disposal or recycling. LCA can consider a range of environmental impacts such as resource depletion, energy and water use, greenhouse emissions and human health, waste generation and ecological consequences. LCA can be applied to a whole product (e.g., a house) or to an individual element or a process of that product. It is usually complex and the details are beyond the scope of this paper. More details of LCA methodologies may be found in the internationally agreed standard [ISO 14040:2006].

Currently engineers plan and design most structures, such that the initial cost is minimized, rather than considering the life cycle costs. For example, in the case of bridges, the maintenance cost could often exceed the initial cost of construction. By choosing materials which have better life cycle cost than initial cost, engineers can develop structures that are more sustainable and even economical in the long run. For example, the use of stainless steel or weathering steel, (known as COR-TEN steel), will result in high initial cost, but when the life cycle cost is taken into account, it will result in durable and economical structures [Subramanian, 2004].

3.2 *Increasing the Design Life of RC Structures*

Though explicitly not mentioned in codes, structures are often designed for a useful life of about 50 to 60 years. Recent sustainability concerns and the need to conserve depleting resources have resulted in the objective of designing structures, especially bridges, for 100 to 125 years. By selecting an appropriate cover, suitable dense concrete mix, and by using appropriate detailing (e.g., minimizing the exposed concrete surface, by using rounded corners, and by providing adequate drainage), the design life of reinforced concrete structures could be enhanced [Subramanian, 2016]. Other strategies to increase the design life of concrete structures may include: Selection of proper ingredients for concrete, controlling the cement content of concrete, use of supplementary cementitious materials, and by exercising proper care during concrete mixing, placing and compacting [Subramanian, 2016]. Many problems in concrete may also be traced to improper curing. Internal curing, using a variety of materials including pre-wetted lightweight aggregates, pre-wetted crushed concrete fines, super-absorbent polymers, and pre-wetted wood fibers, may be adopted to improve the quality of entire concrete sections [Bentz and Weiss, 2011]. It has to be noted that conventional water curing is applied at the surface and hence influences only the depth to which it can penetrate the concrete (mostly the cover concrete), and improves its quality in that zone. The difference between conventional (external) water curing and internal curing is shown in **Fig. 4(a)**; an internally cured concrete bridge deck covered by wet burlap and plastic sheeting is shown in **Fig. 4(b)**.

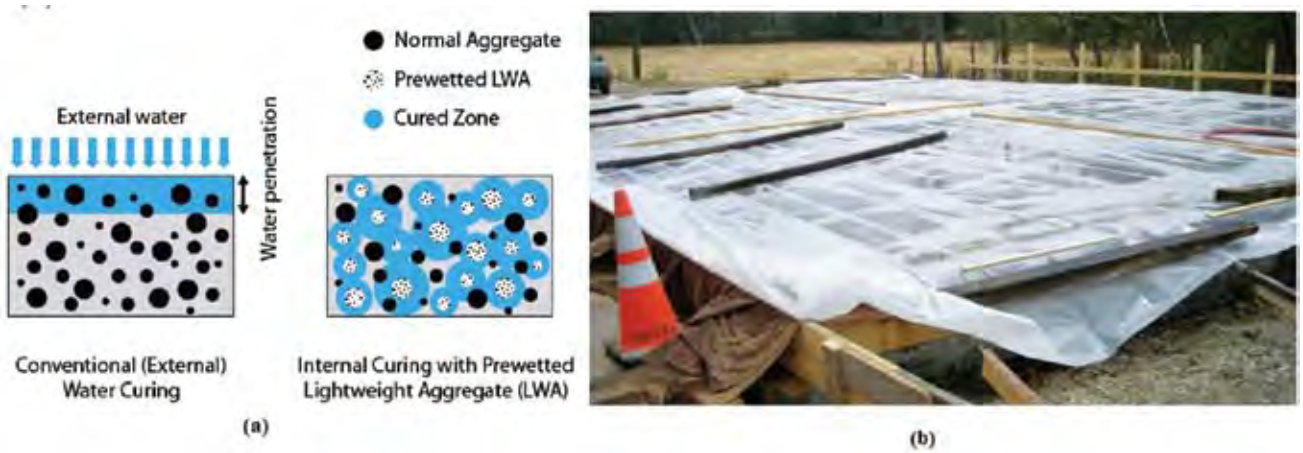


Fig. 4 : Internal Curing: (a) Comparison of Conventional Water Curing and Internal Curing using Pre-wetted Lightweight Aggregates, (b) Plastic Sheeting Covering the Wet Burlap on an Internally Cured Concrete Bridge Deck [Source: Bentz and Weiss, 2011]

Providing stronger concrete/additional thickness in the cover area will avoid corrosion of steel reinforcement, which is the major cause of failure of several bridges. Use of controlled permeable formwork (CPF) systems will result in better quality of concrete covers [Basheer et al., 1993]. The use of fusion bonded epoxy-coated rebars, galvanized reinforcing bars, stainless steel bars, basalt bars, or fiber-reinforced polymer bars in lieu of mild steel deformed bars, will also increase the durability of concrete structures [Subramanian, 2016].

3.3 *Wood as Sustainable Material*

In fact, as seen from **Fig. 3**, wood is more sustainable than steel or concrete, and also more environment friendly. Wood grows naturally and is renewable, and life cycle assessment studies consistently show that wood offers environmental advantages in terms of embodied energy, air and water pollution, and other impact indicators. The manufacturing of wood products also results in less greenhouse gas emissions than other materials. One-to-two-hour fire-resistance requirements are generally provided by fire-rated assemblies that include gypsum sheathing. A wooden building is about quarter of the weight of an equivalent RC structure, resulting in smaller foundations. It also acts as a natural sink for CO_2, as trees lock in carbon from the atmosphere. Tall steel and concrete buildings tend to have larger carbon footprint. Using wood would reduce their carbon footprint by 60-75 %, according to some studies. Wooden structures may also have long life, as is evidenced by the five-storey pagoda of the Temple of the Flourishing Law in the Nara prefecture of Japan, which has withstood wind, rain, fire and earthquakes for more than 1,400 years! Advancements in engineered wood, such as Cross Laminated Timber (CLT) made from layers of timber sections glued together with their grains at right angles

to one another, imparts greater rigidity and strength to wooden structures.

These products have encouraged the use of wood in multi-storied buildings (www.rethinkwood.com). For example, Skidmore, Owings & Merrill (SOM) has recently developed a concrete-jointed timber frame system for tall wooden buildings. This system relies primarily on mass timber for the main structural elements, with supplementary reinforced concrete at the highly stressed locations of the structure, i.e. at the connecting joints. This system utilizes the strengths of both the materials and allows the engineer to apply sound tall building engineering fundamentals. The result is believed to be an efficient structure that could compete with reinforced concrete and at the same time reducing the carbon footprint by 60 to 75%. Similarly, Arup is developing HAUT, the 21 storey, 73 m tall (the highest wooden residential building in the world to date), wooden building in Amsterdam, the Netherlands, which is supposed to receive the highest possible sustainability score from BREEAM.

Traversina Bridge in Switzerland designed by Structural Engineer Jürg Conzett and built in 1996 provides an example of a sustainable timber structure. It was built using small sections of locally available timber (see **Fig. 5**). The key design constraint was to replace any single piece of the structure without providing any auxiliary support. This design resulted in an elegant structure that could be maintained indefinitely using locally grown timber with low life cycle costs and improved environmental performance [Conzett, 1997].

Fig. 5 : Traversina Bridge, Switzerland, Jürg Conzett (1996)

3.4 Steel Tensegritic Structures

Steel structures are usually designed to have continuous compression members (e.g. columns) and discontinuous tension members (e.g. ties). The renowned American philosopher, mathematician, designer, and inventor R. Buckminster Füller suggested that if this system is reversed, i.e., having continuous tension members (which will utilize the full cross-section to resist the forces acting on them) and discontinuous compression members (whose efficiency is reduced by local and global buckling), one can obtain economic and efficient structures and coined the term tensegrity to represent such systems. Such tensegritic systems, are typically made of lightweight rod and cable systems, and result often in delicate-looking structures which can be as strong as it's component material properties allow. Although structurally efficient, for many years only sculptures and small scale structures were attempted because of the need for adjustment/pre-tensioning and the fact that a single structural failure will cripple the system. However, with advancements in construction methods and computational modeling, it is now possible to design and build large scale tensegritic structures. The 470 m long Kurlipa pedestrian Bridge in Brisbane, Australia, opened in Oct. 2009, is the first tensegrity based bridge in the world. Conceived by Cox Rayner Architects and partnered by Arup as Structural Engineers and shown in **Fig. 6**, it reveals the minimum quantity of materials used in its construction.

Fig. 6 : World's First Tensegrity Based Kurilpa Pedestrian Bridge, Brisbane, Australia

3.5 Use Recycled Materials

Traditionally, construction materials are obtained from mining natural resources and processing them into useful products. As natural resources are being depleted, engineers must begin to use alternate materials, which will have similar or

better properties. The best example of such alternate material is the manufactured sand or M-sand, which has also been incorporated into the Indian standard code [IS 383:2016]. Another best way to reduce the consumption of natural resources is to economize the use of these materials, and recycling/reusing them. For example, some studies show that if demand continues at the current rate, materials like indium, platinum, silver and even aluminium will be depleted in about 10, 15, 20 and 80 years respectively. It shows that future generations may have to salvage and recycle these materials that are currently mined from earth. Moreover, World's available landfills are being used up fast due to the exponential rate at which solid wastes are generated (Landfills such as Bordo Poniente in Mexico City, Mexico, Laogang in Shanghai, China, and Jardim Gramacho in Rio de Janiero, Brazil, each receive more than 10,000 tonnes of waste per day). Solid waste management expenditure of above $1 billion per year competes with education, poverty, security and other sustainable initiatives in New York City. These problems of waste disposal should provide economic incentives for recycling and reuse.

Construction and Demolition (C&D) waste is a major waste stream, the quantum of which is increasing as a result of increasing construction, maintenance, retrofitting and demolition activities in several countries of the world, especially in China and India where there is a boom of construction activities. Recycling of concrete is a relatively simple process. It involves separation from C&D debris, breaking, removing, and crushing existing concrete into materials of specified size and quality. Some amount of washing may also be necessary. Already, recycled aggregates, fly ash, and other waste products are being used and replacing natural virgin aggregates and Portland cement. Codes such as IS 383:2016 have provisions for recycled aggregate use. Designers should be aware of these provisions and try to accommodate such materials in their design and thus minimizing the use of virgin materials. Steel Recycling Institute estimates that 95% of the structural steel is been recycled.

Stansted Airport Terminal in England, designed by M/s Foster and Partners and Ove Arup provides an excellent example of a building constructed with recycled materials that offers maximum flexibility (see **Fig. 7**). The long spans provided by the steel modules allow for great interior flexibility and also allow changes in the layout of the building for expansion/ contraction as per future demands. It is designed in such a way that the different modules could be disassembled and reused in another building, in case Stansted terminal ceases to exist. Reusing of any structure is far more preferable to recycling. Reuse eliminates the energy required for recycling or for producing virgin steel, and also CO_2 and other environmental problems associated with the mining and manufacturing processes of steel (One ton of recycled steel saves 1,133 kg of iron ore, 450 kg of coal and 25 kg of limestone. In addition, it saves 642 Kwh of energy, 1.8 barrels of oil, and 3 cubic meters of landfill space). An additional advantage is that the possibility of waste going into the landfill is reduced. Already some industries, such as the agricultural sector, commonly reuse steel structures and cladding components. Structural engineers should look out for opportunities to reuse existing structures, wherever possible.

Fig. 7 : Stansted Airport, England, by Foster and Partners and Ove Arup (1991)

Gypsum products are amongst the very few construction materials where "closed loop" recycling is possible. It has to be noted that closed loop recycling is different from "down-cycling" of some other construction materials such as waste concrete and bricks, where the materials are merely recovered for reuse in low strength applications, such as aggregates in road construction. In closed loop recycling the waste can be used directly to make the same product again. Furthermore, a major advantage of gypsum is that it is eternally recyclable. In addition, the use of Synthetic gypsum (commonly called as FGD gypsum), which is obtained from equipments in the smoke stacks of coal-fired electrical utilities, while removing sulfur dioxide from flue gases, reduces the rate at which natural gypsum reserves are exploited.

3.6 Use Alternative Materials

As already stated, structural engineers, throughout the world, use mainly structural steel and reinforced concrete in their designs. Unfortunately, both these materials require considerable amounts of energy

to produce and are responsible for very high CO_2 emissions (see **Figs. 2 and 3**). These two materials will be used considerably in future also, due to their inherent advantages. However, it is imperative that engineers should explore the possibility of using alternative materials in their structures, especially those with lower environmental impact. An innovative example is the 72 m long, 35 m wide and 15.5 m high Japanese Pavilion at the Hannover Exposition built in 2000, which is a grid shell made of recyclable paper tubes, which took only three weeks to assemble [Ochsendorf, 2005]. As the German authorities refused to allow a structure made only of pressed paper tubes (held together at the joints with tapes), a previously curved wooden structure was placed in position and connected to the main structure of the tubes. According to the architect Shigeru Ban, the wooden reinforcement was absolutely not necessary. The structure was then covered with a translucent membrane. This remarkable structure, shown in **Fig. 8**, was jointly designed by the architect Shigeru Ban and Frei Otto and the engineering firm of Buro Happold and Prof. Stefan Polonyi. In addition to the creative use of structural cardboard, the foundation consisted of boxes made of steel frames and lugs, filled with sand to allow for easy reuse later. Such alternate materials should be explored by structural engineers, especially for temporary structures, to achieve efficiency and economics, and at the same time reducing the environmental impact of construction.

Fig. 8 : Japanese Pavilion at the Hannover Expo by Shigero Ban and Buro Happold

Another promising material is the shape memory alloy that allows designing "elastic" bridge connections that would offer complete shape recovery after experiencing large strains, energy dissipation through hysteresis response, excellent resistance to corrosion, high fatigue resistance, and high strength. Using rebars made of shape memory alloy in the plastic hinge zones of RC structural elements will not only protect them during earthquakes, but also result in durable structures.

3.7 Utilize Waste Plastic Economically on Roads

Dr R Vasudevan, a chemistry professor and Dean at the Thiagarajar College of Engineering in Madurai, through trial and error, came up with the invention of plastic tar roads made with a discarded, low-grade polymer. This idea of sprinkling shredded plastic waste over hot gravel and coating the stones in a thin film of plastic and then adding the plastic-coated stones to molten asphalt was patented in 2006. Every kilometer of this kind of road uses the equivalent of 1m plastic bags, saving around one tonne of asphalt and costing roughly 8% less than a conventional road. This technology was first tried on Jambulingam Street, in the Nungambakkam area of Chennai, in 2002. Till now, it has not developed any cracks, potholes or craters that typically show up after rains. Today, there are more than 33,800 km of plastic roads in India, and roughly half of them are in the southern state of Tamil Nadu. A modified version of the road which adds road scrap to plastic-coated gravel was tested out recently on a highway connecting Chennai with Villupuram. It was the first time plastic road technology was used for a national highway. It is expected to reduce construction costs by 50%.

3.8 Pervious Concrete Pavement Systems

Unlike rural roads, urban roads are paved with asphalt or concrete, which seldom provide percolation of rain water. Moreover the platforms of these roads are also covered with concrete slabs. The latest trend is to cover most of the areas around dwellings with concrete interlocking blocks, since they may add visual appeal to a building. This means that runoff occurs more quickly in urban areas with greater peak flows. Flood volumes increase, as do floods and water pollution downstream. A few State Governments (e.g., Tamilnadu) imposed compulsory rain water harvesting systems for individual house owners, which proved to be successful in increasing the underground water table. However such systems have to be maintained properly in order to be successful in the long run.

In the past, engineers have dealt with issues connected with water runoff by designing gutters, permanent storm water retention/detention ponds, slope protection, or grass strips, and by providing

temporary sediment traps, silt fences, and diversion trenches. All the above methods may help reduce runoff pollution.

The latest in runoff control is pervious concrete, though its earliest application dates back to 1852. Pervious concrete has a 15-25% void structure, allowing for 120- 320 liters of water per minute to pass through each square metre, with typical flow rate of 3.4 mm/s (200 L/m^2/min) or more (see **Fig. 9**). This flow rate is greater than that generated during any rain event, allowing water to flow through it. Majority of first-flush pollutants are removed by the pervious concrete system. This prevents the pollutants from entering storm water collectors and being conveyed to local surface waters (Note that pervious pavements may not be appropriate where inorganic pollutants are found). Hence, the U.S. Environmental Protection Agency (EPA) has designated pervious pavement as a best management practice for storm-water runoff. Pervious concrete can contribute to the following LEED categories: Sustainable Sites, Water Efficiency, Materials and Resources, and Innovation in Design. More details of pervious concrete and its applications may be found in Subramanian, 2008b.

Fig. 9 : Pervious Concrete Pavement Systems

3.9 Wind as Energy Source in Tall Buildings

In current building designs, buildings are oriented in such a way that the effects of wind are minimized. But in future, wind will not only be treated as an obstacle to overcome, but as a source of energy to be harnessed. Several skyscrapers have been constructed recently, which have integrated large wind turbines into their design (see **Fig. 10**). The 50-story Bahrain World Trade Center in Manama, Bahrain was the first to include such a wind turbine. Three 225-kilowatts, 29 m diameter wind turbines hang from separate walkways connecting the identical, sail-shaped towers. Together, these turbines supply about 15 percent of the towers' electricity, the equivalent of the energy needed to power over 300 homes. The unique shape of the building directs wind gusts towards the turbines; increasing wind speeds and creating an artificial wind tunnel between the two towers (see **Fig. 10a**).

Wind can also provide skyscrapers with natural ventilation, which along with lighting, heating and cooling systems, represents major energy expenditure in most buildings. Some advanced building façades, such as that in Pearl River Tower, Guangzhou, China, have a system for regulating natural airflow into the building (**Fig. 10b**). In such façades, vents in the building's "skin" are used to provide energy-efficient ventilation, powered by prevailing winds outside (Frechette, and Gilchrist, 2008).

Fig. 10a *Fig. 10b*

Fig. 10(a) : Bahrain World Trade Center, (b) Pearl River Tower, Guangzhou, China

3.10 Energy Efficient Glass Façades

Glazing can help builders achieve the best energy performance, minimize overall environmental impact and provide a comfortable and desirable

place for occupants. Glass facades containing high-performance glass such as low-e insulating glass can keep warmth in, and solar-control glass, which reflects unwanted heat away, can help reduce energy consumption. Solar-energy glass helps enhance the production of renewable sources of energy. Glass generates minimal environmental impact, and hence a product of choice for sustainable buildings. For example, the total CO_2 emitted during the manufacture of an energy efficient double glazing unit can be offset by the energy savings realized in only 3 to 10 months of its use, compared to the same building equipped with inefficient glazing. In addition, glass is usually made of non-polluting raw materials; its manufacturing process is highly energy efficient, requires low levels of water, and generates little waste. In fact, recent life-cycle studies have shown that windows represent a very minor share of any building's environmental impact from the cradle to the construction phase. Moreover, the vast majority of glass products for buildings are recyclable at the end of their lives. Better use of efficient glass products alone has been estimated to reduce Europe's CO_2 emissions by 100 million tonnes annually [www.buildup.eu].

A comparative analysis of three different types of façades, located in three different climatic zones, which will reduce the energy requirements, is provided in **Table 1**.

Table 1 : Comparative Analysis of Three Different Types of Façades [Dewidar et al., 2010]

Applying various façades techniques on large scale office buildings		**Council House 2 (CH2) Melbourne, Australia** 	**Pearl River Tower Guangzhou, China** 	**Masdar Headquarters Abu Dhabi, United Arab Emirates** 
Ventilation High performance double skin façades		- Blinds in the upper and lower part of the façade. - External plants on the northern façade. - Double glazing in the western façade. - Low conductor timber facades.	Consists of a double glazed façade with integral spandrel panels and cavity space for air cooling	High-thermal mass exterior glass cladding blocks direct solar radiations and decreases the internal cooling load
Shading	Glass Louvers	-	A motorized perforated venetian blind is in the east and west double facade	Roof and façade with PV cells in order to reduce the solar gain
	Wood Louvers (Recycled materials)	Western façade is shaded by shutters made of recycled timber	-	-
Energy efficiency Natural lighting		Visible light transmittance glazing. - Lighting shelves. - Glare Control	Integrated glass façade to provide visual transmissions, enhancing daylight and to reduce artificial lighting	Staggered cones bring daylight in addition to side facades
Façade Effect		Energy is 65% less	Energy is 44% less	Energy is 61.5 % less

In the twin 25 storey Al Bahar towers, Abu Dhabi, taking inspiration from a traditional Islamic motif, an innovative and visually interesting external automated façade shading system has been designed and implemented for achieving privacy while reducing glare (reduced by 50%) and solar gain. As the sun moves, 2,000 umbrellas open and close to reduce interior thermal energy by 50 percent. The shades are each individually controlled by linear actuators that are programmed to react to the sun as it sweeps across the sky. At night, all of the shades fold up to resemble the Mashrabiya, a patterned wooden lattice characteristic of Arabic architecture. It is seen that such energy efficient systems require a synergy of architecture and advanced levels of engineering.

Fig. 11 : The Twin 25 Storey Al Bahar Towers, Abu Dhabi

4. Challenges For The Future

Since energy consumed by the buildings throughout its lifetime will be much more than the energy used in the construction, the ultimate aim would be to construct building with zero net energy consumption and zero carbon emissions. Such buildings are termed as Zero Energy Building (ZEB) and Zero Carbon Vuilding (ZCB), respectively (In 2015, about 40% of total U.S. energy consumption was consumed in residential and commercial buildings, or about 1.143 × 1010 MWh. Most of the energy used goes towards conditioning the space, which is often more affected by the size of the building than the number of occupants. Heating, cooling, and lighting equipments are still the largest energy consumers in buildings, despite increased energy efficiency of these equipments). The critical issues in engineering and architecture, the important factors affecting the feasibility, and also some of the pilot ZEB/ZCB projects in the world are reviewed by Hui, 2010. The Pearl River Tower, Guangzhou, China, mentioned earlier, is one of the examples of such ZEB buildings. It has to be noted that complete sustainability will be achieved only when whole cities are made sustainable. A few sustainable cities like the Masdar in Abu Dhabi and Dongtan in China are under development. Such zero carbon initiatives require holistic approach and require the collaboration of different kinds of engineers and architects.

In addition, the structural engineering profession currently faces many challenges in areas such as education, licensure, technology, globalization, innovation, and leadership. Those challenges are also avenues of great opportunity. To meet these future challenges structural engineers should take up a leadership role and the profession of structural engineering must consider the challenges in three key areas: practice, research and education. The above results are possible only if civil and structural engineers decide to be project leaders.

4.1 Practice

The practice of structural engineering faces significant challenges in the effort to improve the sustainability of construction. As mentioned earlier, the construction industry currently considers constructions on the basis of initial cost, rather than life cycle costs. This leads to buildings and bridges with higher life cycle costs and higher environmental impact. Spending on maintenance of bridges and buildings could be drastically reduced by selecting materials of construction based on life cycle costs. It is important for practicing engineers to update their knowledge about sustainable materials and techniques, by attending continuing education programs, webinars, conferences, or talk by experts. They should also adopt innovative techniques in their designs which will promote sustainability. Future structural engineers may need to consider the carbon footprint of new construction, efficient use of materials, and de-constructability. Creative reuse of existing buildings offers huge opportunities for structural engineers to mitigate the impact of construction on the environment. In addition, there is a need for government policies and building standards to approve the kinds of materials and techniques, that result in sustainability. Structural engineers should get themselves licensed through a program similar to that of the ANSI-approved NCEES Model Law Structural Engineer, with a continuously evolving examination that properly evaluates the skills, as those skills evolve over the years; this will minimize failures and also material wastage due to wrong designs. They should commit to developing and implementing uniform and meaningful requirements for professional licensure, continuing education, quality control, and training of the next generation of engineers.

The structural engineer of the future will require more organizational and management abilities. Structural engineers of the future will spend their technical skills toward innovation; they will develop substantially different frameworks for developing intuition about structural systems; and they will make engineering judgments on a considerably different input stream. The education of engineers capable of bridging this gap must focus on discovery, validation, exploration, and conceptual design rather than the small deterministic tasks that are prevalent today.

Performance-based design would increase the importance of sound engineering judgment in the design process, rely on better technical knowledge, require the use of more sophisticated technology in problem solving, result in more efficient structures, and place the structural engineer in a better position to drive technological change. Structural engineers should be fully conversant on matters of financing, land use, construction costs, constructability, and means and methods.

4.2 Research

Structural engineering is a mature field in comparison with other emerging areas of research. As a result, research in structural engineering, especially in USA, will be focused on existing structures (rather than new construction), rehabilitation, reuse of existing infrastructure, and sustainability. It is evidenced by the development of several Non-Destructive Testing (NDT) methods. Research into the development of sensors and systems should help to monitor and diagnose structural problems before they result in catastrophe. Tools should also be developed that are suited to the task of rehabilitating, retrofitting, or extending existing infrastructure. The structural engineering community is already improving the sustainability of the built environment by increasing the life of existing structures rather than constructing new structures. However, in order to drastically improve the sustainability of the built environment, research in structural engineering must produce new options for practice. Above all, there is a need for new materials which can utilize waste products to build new structures with lower environmental and economic costs. Ideally, the built environment would help to absorb CO_2 and would utilize waste products from other sectors of society. In addition, the goal of a more sustainable built environment will require new cooperation between government, practice, and universities, as well as a broader outlook. Structural engineering research must engage with policy, design, economics, and social impacts, in addition to conventional research in mechanics and engineering science.

4.3 Education

The educational system has not changed much in the past several decades and, therefore, new graduates entering the profession today are not ideally prepared [Subramanian, 2011]. Additionally, there is palpable concern that the best and brightest young people are becoming less interested in structural engineering as a career. As per SEI-ASCE report, 2013, nearly two-thirds of senior structural engineers have no knowledge of any academic programs beyond their own personal experience. This disconnect is further exacerbated by the research mission at top universities that has distanced the research frontier from mainstream professional practice and has left undergraduate curricula largely unchanged for decades [SEI-ASCE report, 2013]. Civil engineers today get an excellent grounding in the fundamental technical tools, but civil engineering practice will continue to change dramatically in the future. This future change may be necessitated because of globalization; sustainability requirements; emerging technology; and increased complexity with the corresponding need to identify, define, and solve problems at the boundaries of traditional disciplines. Many tasks that we consider civil engineering today will no longer be performed by professional engineers in the future but, with the aid of computer technology, by technicians and technologists. Civil engineers should apply innovative technologies and information management tools to create enhanced solutions in the built and natural environment. Civil engineers must surcharge their education and subsequent practical experience with environmental awareness. The future civil engineer should envision, adapt, and integrate new technologies within and across projects [Dritsos, 2011].

To produce the future leaders of structural engineering, educators must be visionary. As with other academic fields, engineering education should promote critical thinking, where assumptions are questioned and students must solve open-ended problems with many possible solutions. Professors with the knowledge of sustainability are wanted in many universities. More technical books on sustainability and other related subjects is also a necessity. Moreover, education of structural engineers in the workplace is limited. Most structural engineering consulting firms do not have internship programs, and most focus on recruiting

rather than training. Very few firms have formal mentoring programs. While younger engineers wish to have more mentoring, their leaders do not provide it. Some firms do offer training, especially in-house training, but this is focused almost entirely on technical skills related to production of the firm's work. Very few firms offer training in soft skills like business, communications, and leadership [SEI-ASCE report, 2013]. Universities must go well beyond conventional structural analysis and teach design, as well as the broader thinking required to address the challenges of sustainable design, including the social and environmental impacts of structural design (Ochsendorf, 2003).

Conclusions

Civil engineers of the future will be entrusted by the society to help achieve a sustainable world and raise the global quality of life. In order to achieve this, they should be master planners, designers, and constructors; stewards of the natural environment; master innovators and integrators; managers of risk; and leaders in shaping public policy. Existing engineering design solutions of using certain materials and systems have environmental implications and do not minimize life cycle costs. To improve this situation, future engineers must develop a more holistic view of engineering design, with emphasis on sustainability. Achieving more sustainable design will require concerted efforts and inputs from practitioners, researchers, and educators. Sustainable engineering design should aim to reduce material consumption, provide economic and durable solutions, preserve natural resources for future generations, and reduce energy requirements and pollution. A number of solutions have been suggested and some of them are already in use. Civil engineers should learn to lead and become motivated to initiate, communicate, negotiate, and participate in cross-professional efforts to envision societal changes that shape the quality of life. Future engineers should think of holistic designs, which will solve the problems of depleted resources, and provide long lasting solutions. The above results are possible only if civil and structural engineers decide to be project leaders.

Acknowledgements

The inspiration to write this paper came after reading the paper by Prof. Ochsendorf of Massachusetts Institute of Technology; some of the examples of sustainable structures quoted are also from that paper (Reference 15). In addition, several images have also been extracted from various sources in the internet.

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CIVIL/STRUCTURAL ENGINEERING EDUCATION & PROFESSIONAL PRACTICE IN INDIA : AN INTROSPECTION

Manoj MITTAL
Civil & Structural Engineering Consultant,
Vice President (N) IAStructE,
ACCE (I) & Convener EAG.
manoj_shelter@yahoo.com

Mr Manoj Mittal graduated in Civil Engineering from BITS Pilani in 1985. He also earned his M.Sc. & MS degrees from the same Institute. He is practicing as Consulting Civil & Structural Engineer and has an experience of over 30 years in the field of Civil & Structural engineering Consulting. He also has expertise in structural retrofitting and rehabilitation of structures in distress. He also has keen interest in the field of green & sustainable design of built environment.

He is member of several professional bodies e.g. IEI (I), IAStructE, ICI, CEAI, CDC, ACCE (I), ACI-India Chapter, IBC and IOV. At present he is Vice President (North) IAStructE & ACCE (I). He is also convener of EAG (Engineers Action Group). He is also member of various BIS committees e.g. CEDC, CED-29, and CED-54 & CED-46: P11 & P1. Presently he is also affiliated with SPA-New Delhi as visiting faculty. He was honored with "Outstanding Concrete technologist of the year 2012" award by ICI-Ultratech.

We very proudly say that India has around 65-70% population below the age of 35. We have the largest talent pool of skilled manpower in the world. At a time when many developed western countries are ageing fast and most have a negative population growth rate, India is in an advantageous position. However, I sometimes wonder if we really are so blessed.

It is a hard fact that most students in India join engineering courses not because of interest or passion, but for better job prospects. Looking for job prospects is not wrong but that should not be the primary criterion to join or pursue a course of study. After schooling everyone, parents and students, talk about placement packages and hence, choose universities and programs which perform best in this domain only. It is not surprising to find that majority of them want to join computer science/IT based programs. Why? Simply because they offer a much higher compensation and better working conditions. Consequently, Civil Engineering moves to lower priority.

All India Council of Technical Education (AICTE) data indicates that 14.5 lac students appear for the Joint Entrance Examination (JEE-main entrance tests) every year. Many more appear in other state/private entrance tests as well. Interestingly, we have more than 4000 engineering colleges in India accounting for the intake of approx. 16.7 lac students (2015). Of these 50,000 seats are in IITs, NITs, IIITs and CFTI's. We may consider another 35,000 seats in reputed state and private institutions (having ranks in top 120 or so in India). Then where do the remaining aspirants take admissions?

On the other hand, large number of seats in engineering colleges remains vacant. Colleges have applied to

close down and AICTE has decided to cut down UG engineering seats by as much as 40% over the next few years by allowing some colleges to close down and/or by reducing the student intake. Does this not indicate the poor state of affairs in our engineering education system? Why engineering institutions with poor infrastructure and in-experienced faculty are being allowed to operate when they are simply churning out graduates without any thought about their future? AICTE urgently needs to involve practicing engineers while finalizing course contents and related credits for each stream of engineering.

Even so, India is producing 15 lac engineers each year. It may be surprising to note that it is more than the total number of engineers produced by USA and China combined together. As per NASSCOM, only 17.5 % of these were employable. Employability also varies from 12 to 42 % in different states. Only 7 % were found to be fit for core engineering jobs. Only 11 % find job in knowledge intensive sectors (74 % due to language issues and 58 % due to poor analytical and quantitative skills). 90 % of engineering graduates want jobs in mechanical, electrical, electronics and civil but only 7.49 % were employable in these sectors. In non-tech roles most engineers find employment in BPOs. Only 11.5 % engineers qualify for business analyst jobs. Several engineers end up working as sales executives. While the rest are not fit for engineering employment at all, and may end up as supervisors. This results in a colossal waste of the country's resources and loss of self-esteem by technocrats who are officially qualified as 'engineers' but do not find gainful employment as such. Often, this is the primary reason for them going astray, in early years of their career.

At present, majority of graduating engineers have inadequate preparation in the domain area. 90% of computer/IT engineers and 60% in other branches fall short of domain knowledge. They lack ability to apply basic principles to real world problems. There is gap in teaching and learning pedagogy being followed in majority of colleges. Added to this, there is hardly any research or innovation environment in our institutions which is evident from the number of papers published in peer reviewed journals, citation index and patents. As a result, we don't figure in top ranked institutions across the world. Very few consider doing a masters degree, or opt core engineering jobs. They prefer other high paying options. Even if they think of doing masters or doctorates they prefer universities abroad. Further survey indicates that very little return back to work in India. Majority of students doing masters in top institutions in India are graduates from tier 2 or 3 colleges. There is severe shortage of competent faculty in academic institutions. Even old IITs are struggling with faculty shortage (Kharagpur 42 %, Bombay 39 %, BHU 53 %, Roorkee 42%, Delhi 33 % and Guwahati 26 %.)

These deplorable numbers and the large percentage of unemployable but qualified candidates, is a sure recipe of disaster and social instability which poses a great danger for society who suffer for no fault of theirs. Hence the Quality of engineering education and of engineers needs tremendous improvement. Enhanced interaction between Academia and the Industry is absolutely essential so that we can produce "employable" engineers.

In this context, a recent observation made by Sunder Pichai, CEO, Google, holds much significance: "The current education system in India is made in such a way that students have to follow set rules. I think it is more important to try different things, take more risks".

If we delve into the situation for Civil/Structural Engineering we will realize that most students who join Civil Engineering are not motivated enough to pursue it as a profession. Further they leave it during masters or the first job level as soon as a better opportunity is available. Most of our engineering institutions are not doing enough and also they are not equipped to produce good quality skilled Civil/Structural engineers. Civil Engineering is also very broad based. Curriculum includes courses in basic sciences, applied science, application oriented courses, engineering skill courses, disciplinary courses in structures, surveying, construction practice, airports, highways and railways, hydraulics and fluid mechanics, water supply, waste water treatment, building planning/estimating, soil mechanics and foundation engineering etc. Apart from these some humanities and computer courses are also included. Some colleges have one semester industry training which practically leaves only 7 semesters for course work. It is very difficult to do justice with each

one in just four years. I wonder if it is time to have civil engineering as 5 year course with 5th year being optional mainly devoted to specialization of students' interest. It may also include an internship, project or thesis. Some of the courses from earlier semesters may be shifted to 5th year. If someone wants to pursue a Masters Degree then it should be allowed by spending an additional year. Such a system will be useful for those students who have clear idea about their career path. Others who are not very clear about it can leave the college after 4 years to join the industry for exploration. Such students can join masters course later if they so desire. Such courses can be designated as B.Tech. , B.Tech (hons) and M.Tech respectively. Academicians can take a call on it. It will add more flexibility in the curriculum and we will get better prepared engineers. It is said that Civil Engineering has been known to mankind from time immemorial. It is also the earliest known branch of Engineering. Civil Engineering practice invariably brings them into direct contact with the public. Most Civil Engineering projects directly affect the lives of a large number of people and hence frequent contact with the users will always be prevalent. It is therefore essential that the curriculum of Civil Engineering must include few credits to enhance the awareness, interpersonal and soft skills of students.

The proposal by AICTE to now mandate outcome norms for those qualifying as Engineers takes cognizance of some of the above issues and proposes a method which may ensure a minimum level of technical expertise on graduation. However, I would like autonomy, initiatives, flexibilities & innovativeness of institutes & their programs not to be compromised in the name of regulation.

Majority of our engineering organizations also do not have a structured way of preparing these fresh engineers for the job. We need to create an enabling environment for proper training, up gradation of skills and knowledge. Before induction each organization must carry out training and conditioning of fresh engineers. All seniors must mentor newly inducted civil/structural engineers. It must be considered as an investment not only for organization but also for the profession.

The Engineering profession is grappling with several professional issues particularly related to qualification, competence, registration and regulation. We do not have any standard definition of "Engineer." Every local body, department has its own definition of engineers. Title of Engineers is not protected. Anybody with any qualification can use the title of 'Engineer'. Architect's Act is being misused to make civil engineering subservient to architects. The Civil Engineering fraternity of our country has been adversely affected by some of the direct and indirect actions of the Council of Architects (COA). Empowered by the Architect Act 1972, which was meant only for TITLE ,COA has been assiduously trying to usurp the " Profession of Architecture " which never was the intent of the Architect's Act, refer The Prefatory Note – Statement of Objects and Reasons (Note no. 3) :……..' The legislation protects the title "Architects" but does not make the design, supervision and construction of buildings as an exclusive responsibility of Architects. Other professionals like engineers will be free to engage themselves in their normal vocation in respect of Building Construction works provided that they do not style themselves as Architects '…..

At present engineering profession has no legal backing in the absence of Engineers act. Engineering is in fact not considered a profession as per legal terminology. Building bye-laws and policies affecting engineers are being framed without consulting practicing engineers. These building bye-laws are generally biased in favor of Architects which results in poor status of Civil and Structural engineering consultants in the society. Civil Engineers are generally not practicing as lead consultants in most built environment projects. A Civil/Structural Engineer is required to register at each municipality to practice and each one has a different set of requirements. You are even not sure of your own eligibility. How can Civil engineering grow in such a state of uncertainty? Can we attract talent to Civil/ Structural engineering in such an environment? The entire ecosystem of Civil engineering professional practice is not at all conducive for the development of this profession in India. The Engineers Bill is in a continuously torturous journey in the legislative process by the Government. An institutional mechanism must be in existence to ensure that engineers adhere to best ethical standards, and opportunities are provided for their career and professional knowledge development.

This is not only in the interest of the engineers but it is required for the safety and welfare of the society as a whole.

Civil Engineers are the largest body of professionals with no official Regulatory Authority. The Institution of Engineers formed by Royal Charter in 1935 & Engineering Council of India formed by joining hands by various professional bodies much later in 2002, seem to be doing many things but are not regulating the profession of Engineering. As a result, many Civil Engineers Associations have mushroomed all over the country, thus diluting the purpose of their existence, without much benefit to the core practicing engineering professionals. Most of these associations/ institutions are not focusing on these important issues of competence and educational course content. Isolated efforts are being made by some enthusiastic and concerned engineers. One year ago the Engineers Action Group [EAG] has been formed with the support of some of these associations, to address and follow up such professional issues. But it is a gigantic task before EAG. To me, unity, focus, strategy and sustained follow up are key for the success. It is high time to act on all fronts, be it education or professional practice standards.

We cannot imagine development of our country without focus on quality of engineering education, training, professional development and regulation of the engineering profession. It requires gearing ourselves for a major shakeup. We also need to put adequate and sustained pressure on the government to act fast. Civil/Structural engineering has a glorious past and I am hopeful it will be so in future again.

(NOTE: The article has been written primarily with the focus on civil/structural engineering in India. All facts and data have been taken from published AICTE/ NASSCOM & various newspapers surveys. Even if we consider some variations in data, facts remain the same).

CHALLENGES FOR THE CONSULTING ENGINEERING FRATERNITY

Sayona PHILIP
Civil Engineer,
New Delhi, India
sphilip@tce.co.in,
president@ceai.org.in

Sayona Philip, received her Bachelor's degree from the Indian Institute of Technology and her Master's degree from the Asian Institute of Technology. She is President of the Consulting Engineers Association of India and Head, Govt Relations in TATA Consulting Engineers. Her career spans over 30 years , of which 25 years have been in urban infrastructure.

Summary

This article enumerates the challenges that the consulting engineering fraternity in India faces and suggests that some solutions may require interventions by the Government of India, in addition to proactive action by the fraternity to improve their lot and stay on top of the game. Whilst this may be applicable to all engineers, being the predominant discipline- it would be most relevant to civil engineers.

Keywords: Talent, experience profile, design complexity, sustainability, asset management, resource optimisation.

1. Introduction

Engineering has been central to civilisational progress since the discovery of the lever and the invention of the wheel. Engineering which is applied science has even enabled untold advances in medicine, thereby boosting modernisation and improving the quality of our lives.

2. The Engineering Professional

2.1 Engineering Education in India

At the time of India's independence in 1947, there were 36 engineering institutes with an output of 2500 engineers per year. Today there are 7200 institute churning out 1.5 million engineers per year - that is a mind boggling increase in engineers, whilst our population has increased only 3.5 times. It may speak well of an aspirational young population with an aptitude for science and technology, whilst our counterparts in the West struggle to enthuse their younger generation to choose the STEM option - but that again is another story.

Should we be content to just produce the numbers and not focus on the quality of those engineers? Certainly not. From all accounts, experts have claimed that the employability of a majority of these engineers (80%) is questionable and is not commensurate with the numbers graduating. A matter of grave concern, that Government after Government has not come to grips with. Reams have been written by concerned educators and the intelligentsia about the need to upgrade the quality of our educational system including engineering, to improve employability, instead of opening new institutions or giving a carte blanche to private institutions to do so - but nary a thought has been given to this crucial issue.

2.1.1 Impact on consulting

The surplus engineering graduates and the consequent unemployment due to inadequate number of job opportunities to match their capabilities, has resulted in a situation, which could have been obviated with more holistic, end to end planning. Engineers' salaries are not commensurate with their qualification and some would even describe them as amongst the most underpaid professionals, resulting in - except for the most committed and zealous - a significant percentage of the talent deciding to switch careers midstream and moving on to more remunerative options with better growth prospects.

This is a major cause for concern to the Consulting Engineering Profession, arguably that which requires the higher end of engineering professionals, to cater to the challenging task of design engineering and project implementation, from concept to commissioning and, thereafter, even operation and maintenance of what is created.

2.1.2 Impact on industry

This is true of the non-Consultancy driven engineering industry also. The Government needs to take cognizance of this. A serious study to review the number of engineering graduates and the quality of engineers churned out by the numerous institutions need to be undertaken and steps taken to rectify and upgrade before continuing to open institutions at the same pace. It is believed that this thought process is already in place with plans to have a more

appropriate combination of engineering/technological institutions with skill development institutes/poly technics to produce quality engineers, designers and technicians.

2.2 Matters for Organisations to Cope with

2.2.1 A younger and less experienced profile

Unlike the IT sector where a younger age profile suffices, due to the nature of the job content, the hard core engineering consultancy profession requires a combination of youthful zest and experience; who together are better able to turn dreams into reality. Hence, the need for the tech savvy young engineer, the experienced middle level, as Project leads, and the Senior level professional in the leadership, who mentors and reviews all that is done by the other two.

With the consultancy business becoming highly competitive, with challenging top lines but shrinking bottom lines, companies, unfortunately, are turning to a younger age profile. That is resulting in senior experienced experts following their own path. Thus, the youngster overnight becomes the middle level engineer and the middle level engineer starts to occupy leadership positions and the gradual process of mentoring the youngster through exposure on projects does not happen. Besides, design review takes a back seat.

2.2.2 Engineering strength

Companies suddenly realise that their engineering strength lacks depth. Clients wanting to get the cheapest inputs, are the original cause for this decline. It is only when it reflects on the project implementation process, that everyone wakes up. By then it's too late to salvage the situation and the client gets only what natural justice ordains. The Project owners bemoan the loss of quality of engineers and engineering but like to distance themselves from the root cause.

Then there is also the situation where Clients/ Project Owners insist on project teams being deployed at the project office in the vicinity of the site, inspite of lesser infrastructure than at the Consultant's home offices, limited access to resources, reference material, consultation and brain storming with seniors and specialists, document management systems - all leading to a sub optimal work environment.

Much of the above, in the final analysis, can be attributed to inadequate remuneration for the Engineering Consultants and consequently their staff. The impact of the L1 system of job award which is the most prolific, is often not comprehended by Clients in their zeal to reduce costs. The L1 system of job award has resulted in very unrealistic remuneration for engineering Consultancy services resulting in Consultants not qualified for a job being appointed. Eventually starts the cycle of compromises in resource allocation, and their resultant effects. Changes are happening, but not fast enough, and a gradual shift is visible to a Quality and Cost based system for job award. Compensation needs to be commensurate with the type of job and that would go a long way in resolving the issues being faced by Consultants.

2.2.3 Retaining talent

Companies need to go the extra mile to prevent attrition and retain talent that has been trained and nurtured over the years - not only in terms of project experience, but also in absorbing the company ethos, culture and several other intangibles. When senior engineers leave the company's work force, a lot of the engineering time is spent in duplicating what's already been done in the past, primarily due to absence of awareness of the knowledge bank that exists in the company and lack of documentation of tacit knowledge because the person that had that knowledge has separated.

A similar new resource, probably hired at a higher salary, or a resource recruited at a lesser experience level takes that much longer to settle in with much of the person's time consumed in things that aren't really productive. That results in a reduction - both from the company's top line and bottom line.

All of this has its consequences. Hands on engineers with an innate sense of, and gut feel for engineering seem to exist less and less. There was a time when a majority of senior engineers, in case of even the most complex problems involving engineering judgement and instinct could tell when something was not right - without even reviewing those lengthy calculations or taking a run of the software. Today, that is a rare exception rather than the rule. This can be attributed to a large extent to inadequate on-the-job training, dependency on software, lack of appropriate mentoring, especially in the initial phases of an engineer's career.

The need to start from first principles and understand the basics, by doing manual calculations or making spreadsheets, is less important now than being able to run that latest version of a software - before a young mind begins to comprehend, much less master, the basics of design. Or the even more exciting 3D and 4D modelling. The end result is that due to this

process, a young engineer minus the technological software and tools, winds up being not up to the design responsibilities thrust upon him/her.

Inputs from contemporaries in various organisations suggest that this is especially true of structural engineering. Some attribute it to the poor quality of teaching in engineering colleges, both at the undergraduate and the post graduate levels. The deteriorating standard is exacerbated with the proliferation of engineering colleges, as mentioned earlier. The resultant shortfall in qualified and capable teaching faculty is another major factor. When selecting teachers, teaching merit becomes a casualty and one ends up picking a teacher without a natural aptitude for that most noblest of the professions.

However, this seems to be a problem, the extent of which has not been fully comprehended. I once asked a Professor in a premier engineering institute, how they managed to get appropriate teaching faculty with a virtual overnight increase in the number of engineering institutions. Surprisingly, he did not think getting suitably qualified faculty was a problem – but acknowledged that infrastructure definitely was an issue. One would have thought that finding the right teachers with the right attitude and dedication was a more serious and fundamental problem as is evident from the engineering graduates that are coming out every year.

2.2.4 Collaboration

One possible solution for educational institutions and their students to benefit would be to foster collaboration between practitioners of engineering Consultancy and academia. This is already happening in some institutions but, mainly, the premier ones. A structured collaborative effort between industry and academia would be to the benefit of both. This would also enable curricula to be designed to match the industry requirement.

Reportedly, many educational institutions are doing consultancy jobs. If that is the case then what needs to be ensured is that the teaching faculty is not unduly burdened so that their primary task of teaching is affected. It is also reported that very often the assignment is got done from the students. While that does help to develop the student, the question remains as to how reliable the output would be, unless a 100% per cent review is done by a senior faculty.

2.3 Project Execution Challenges

Over the past decade or so, the importance of project management, scheduling and SHE during project execution has become less foreign to the country's work culture and very much part of the jargon. Yet, the general consensus is that on the construction front, high quality workmanship has taken a step backward. The time pressure, sometimes with unrealistic deadlines and a lackadaisical attitude tends to overlook quality requirements and very often bypasses even safety requirements. The reports of failures in the media, stand testimony to that.

In the field of structural steel it is very difficult to get good fabricators. Sometimes, due to inadequate basic structural knowledge, the art of structural erection seems not to exist anymore and most contractors do not know the sequence of erection. This leads to the structure going out of plumb, improper jointing, etc., sometimes even leading to failures.

Each project is unique, often involving remote sites with accessibility problems. The project implementation process is, therefore, not predictable. There is high potential for encountering unforeseen conditions, geological & geotechnical surprises and difficulty in applying automation. Such adverse conditions result in costs varying significantly and end up becoming difficult to manage, due to pressure on supply of resources and other utilities.

2.4 Challenges For The Future

2.4.1 The future engineer

The aptitude to take risks, venture into new, uncharted territories and take up challenging works is reducing. Most new engineers are more comfortable in dealing with familiar areas which their software can solve. For the country to progress and grow, the future Consulting engineer should be even more prepared to take risks, take up the gauntlet of new challenges, exhibit better leadership and continuously develop and update oneself in newer engineering materials, technologies and skills.

In the consultancy business, a post graduate is more often than not, a must for affirmation of your suitability for the job. The need for strong analytical skills, practical ingenuity and a creative innovative thought process cannot be over emphasised. Good communication skills, team work and ethical values are a given along with professionalism and the willingness to be a lifelong learner. An engineer who hesitates to say he doesn't know and is too embarrassed to learn has reached his/her level of incompetence.

In consultancy, which is the high end of engineering, one cannot be a single discipline civil or structural

engineer anymore. To make a coordinated effort towards project design and execution, one needs to understand the multi-disciplinary nature of the job. It is not too tough, since there are equivalences in most disciplines. For e.g. where a power project has power generation, transmission and distribution, in a case of a water supply system the generation is at the treatment plant followed by transmission/ conveyance and water distribution respectively. With a willingness to learn and hard work, it takes a short time to come up to speed with a new sector.

Engineering students, for some time now, have had the option of taking advantage of flexible accreditation criteria in their curricula and can, therefore, endeavour to get the necessary exposure to multiple, related skills or subjects. What needs to be ensured is that the core subjects are compulsory.

2.4.2 Complexities in design

It is expected that over the next decade there will be prolific use of pre engineered and pre-fabricated buildings by 3D printing, use of precast aerated concrete blocks, etc.,.

Aspirational projects stretching the threshold of our imagination and the power of our engineering skills would demand advanced analytic skills. For mega sized projects the demand for speedy implementation, overriding study of alternative solutions, would need cautious calculated approaches but not at the cost of sustainability.

Design Codes would need to provide for changes in parameters of design due to several factors -the climate change impacts resulting in increased intensities and frequencies of natural disasters like floods, cyclones, earthquakes, etc. as well as man-made disasters and their consequent effects.

Flexible solutions would be considered a necessity and a challenge - for suitability at widely variable end conditions, without compromising on design.

2.4.3 Asset management

Project Owners would hand over projects for comprehensive asset management which would imply project life cycle management over the life of the asset. This would call for a balanced approach with adequate time for planning, designs and use of technologies for holistic modelling and simulation. Expending more time in planning and designing, considering techno-economically viable solutions would enable better execution over a shorter time frame and reduce project life cycle costs and subsequent liabilities.

2.4.4 Sustainability

Sustainability would be the principal basis for all solutions and cannot be compromised. From conceptualisation to project delivery, use of advanced analytic tools and design solutions which are environment friendly, intelligent and energy efficient are key to sustainability. Also the use of local material with adequate strength to promote green engineering and conserve natural resources.

The role of an engineer has become more critical to devise green solutions which are a part of project life-cycle and cost-benefit analyses.

All of the above imply that the engineer would be entrusted by society to achieve a sustainable world and raise the quality of life universally and would need to have the heft to influence public policy. This entails need for mastery in key areas related to:

- Planning, design engineering, construction, operation and maintenance
- Innovation and integration of technology
- Environmental management
- Risk Management
- Financial Planning & Monitoring

2.4.5 Resource optimisation

Because of the many complexities involved in engineering a project, access to information and similar work is important if one is not to end up doing what's been done before (reinvent the wheel?) or duplicating it at the cost of money and effort. Companies investing in efficient document management systems, will allow resources to be optimally utilised to analyse and innovate for out of the box solutions – rather than on mundane routine tasks.

As the engineering profession moves towards the goals of Vision 2025, the composition of the engineering team will undergo changes as well. The Project leader would need to integrate technology and resources. With the ever increasing sophistication of engineering software, many of the routine engineering tasks in future projects could be performed more economically by non graduate engineers under the guidance of engineer leaders. That would result in strategic allocation of professional engineering graduate/post graduates, diploma holders and technicians

The Consulting engineering fraternity needs to plan for this change.

CIVIL ENGINEERS – ESTABLISHING THEIR ROLE

R. GOGIA

Principal Consultant,
Engineering Projects Consultants,
N. Delhi
rgepc12@gmail.com

Mr. R. Gogia is a B. Tech from MANIT (erstwhile MACT) Bhopal, in 1978. He has over thirty five years experience in Civil and Structural Engineering Consultancy.

He started his career in 1979 by working in various Consultancy offices e.g. Engineering and Development Consultants, Bhargava (Paper Factory) Consultants and Consulting Engineering Services (now JACOBS), followed by Partnership Company for about 8 years. He is currently practicing as a Structural and Civil Engineering Consultant office from last 25 years in Delhi.

Memberships: Governing Council member : IAStructE, & earlier for CEAI & ICI, Delhi chapter.

Synopsis

It is said that Civil Engineering has been known to mankind from time immemorial being the earliest known branch of Engineering. It is also well known that Civil Engineering Projects consume the largest amount of natural resources, which, if not utilized judiciously, can create an unsustainable environment for any country and create social upheaval among its citizens. The world must now realize that Civil Engineers, by virtue of their environmental stewardship, are intrinsically "entrusted by society to help achieve a sustainable world and raise the global quality of life".

Keywords: environmental stewardship, entrusted by society, sustainable, global quality of life, natural resources, built environment, infrastructure, managers of risk,

India is now poised at the cusp of an upward trajectory in terms of Growth and progress. Recent pronouncements by important world leaders and Financial Institutions have pegged Asia, particularly India, as having the potential to be the fastest growing economy of this century. Growth and progress are primarily driven by Technology and infrastructure. History is witness to the fact that Developed countries have acquired their present status by judicious application of Technology and Innovation, while their infrastructure was already in place much earlier.

The Government's initiative of START - UP INDIA is likely to create opportunities for entrepreneurs so that an organic spurt in employment is generated at a rapid pace all over the Country. Initiatives such as 'Make in India' and 'Housing for all by 2022' will surely benefit the Country in the long run especially in the Construction Industry, which provides large scale employment for skilled/unskilled manpower with collateral generation of employment opportunities in manufacturing sector for construction and finishing goods. Civil Engineers will obviously need to spearhead this movement.

Need for high quality Civil engineers is essential when the Government is looking for Innovative technology applications and approach to tackle the challenges in developing World class infrastructure, Amrut and Smart Cities, Waterways transportation and National highways constructions. All these sectors shall require a very high level of Civil Engineering Technological skills for establishing and maintaining such installations. Projects such as construction of Metro Networks, Chenab Rail Bridge, Worli Sea Link, Signature Bridge, etc. would have been done much earlier in a time bound manner at much lesser cost, with proper education & exposure of Civil Engineers, if the expertise had been available at home.

The Government's recent decision to construct an impregnable wall on more than 3300 kms of our

international borders, in a short period of time in the near future, is a case in point. The difficult terrain & working conditions shall need a very high level of engineering innovation, to build & to maintain, cost effectively, for the next few decades.

The Central Government's agenda of 'Housing for all by 2022' actually translates to 'Safe, Secure and Sustainable housing for all'. This again involves reliable Civil Engineering skills. While it needs only a few years to construct a Building & infrastructure – its use for the next fifty years or more, depends solely on the sustainability factor which is completely driven by Civil engineering innovation. In fact, by now, environmental stewardship should have become an integral part of Civil Engineering education and research.

The Study of Civil Engineering is Currently not Regulated by Engineers Themselves, but by Administrators, Many of them, Non – Engineers.

The result is that many internationally and highly qualified Civil Engineers, who have been involved in some of the most complex Infrastructure Projects, are not eligible to certify Engineering Designs of Structures, in many parts of the Country !

India being a developing country, needs to scale up its infrastructure at a rapid pace, which is likely to have far reaching impact on green house emissions, sustainability, and cross border climate change . On account of our vast population, diverse ethnic, cultural and socio economic strata, the need of location specific infrastructure often necessitates original thinking for similar projects but located in geographically or culturally differing locations. Such projects necessitate out of the box methods of design and construction thus requiring a high level of continued innovation. Moreover, the use of local materials in remote and currently under-developed areas, needs an incisive mind for attaining the required results.

It is therefore obvious that the Epicenter of Engineering involves Design as an integral part of its manifestation followed by the required processes being put in place.

We should not wait to be given an opportunity, instead ask for it by building our own strength and developing our own leadership style. We must lead by example if we want to make a real difference. We must take out time to think about our personal and professional goals, by having a sense of purpose.

A sure recipe for success in such an endeavor is by building networks, of both mentors and peers who are in a similar career stage, with a strong internal locus of control. For many, this tectonic shift may involve stepping out of their comfort zone, to seize the opportunities, without overanalyzing.

The new crop of Civil Engineers must stand outside the patriarchy and engage with the profession on their own terms, thus creating their own DNA. They must not be influenced by archaic rules laid down by the old boys club. In today's times – everybody needs the fighter gene to succeed. Resilience plays a very crucial role in attaining success – if we learn to leverage the diverse perspectives. Life is a long term game – we need to have the courage to make our own choices and the perseverance to stand by them.

In this backdrop, the "ASCE vision 2025" document for Civil Engineers, published in 2007, aptly captures the holistic role of Civil Engineers as follows:

Entrusted by society
to create a sustainable world and
enhance the global quality of life,
civil engineers
serve competently, collaboratively, and ethically as master:

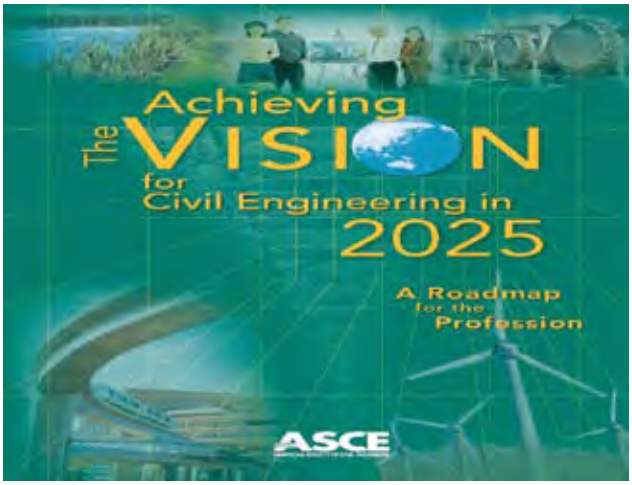
● planners, designers, constructors, and operators of society's economic and social engine—the built environment;

● stewards of the natural environment and its resources;

● innovators and integrators of ideas and technology across the public, private, and academic sectors;

● managers of risk and uncertainty caused by natural events, accidents, and other threats; and

● leaders in discussions and decisions shaping public environmental and infrastructure policy.



The above document is available on ASCE website www. asce.org

It would be beneficial for all Civil Engineers to read, analyse and imbibe the same, early in their careers, so as to sow the right seeds for incubation and furtherance of their profession.

In order not to reinvent the wheel, few relevant excerpts for vision one and two, are reproduced below (interspersed with my personal views to suit the present and domestic scenario), from the above referred document.

Leaders of civil engineering organizations around the globe are expected to move the civil engineering community toward the Vision which may be construed as a "roadmap" for civil engineers to shape their own future and grasp a bold vision for their profession. It is time that today's leaders realize that leadership is not about delivering a few good projects, but fostering a whole new generation of leaders, for the benefit of society. If the fraternity loses a few years of dynamic leadership, it creates a vacuum for a few decades.

"Vision 2025" sets a target for the global state of affairs:

That Civil engineers must shoulder the belief that they are entrusted by society to help achieve a sustainable world and raise the global quality of life. Civil engineers, as a body of professionals, must exercise their learnings, as master :

1. planners, designers, and constructors;
2. stewards of the natural environment;
3. innovators and integrators of technology;
4. managers of risk; and
5. leaders in shaping public policy,

where "master" implies "leader" in both role and knowledge.

To achieve the first Vision outcome, Civil Engineers as leaders in safe planning, designing, and constructing the built environment, must continue to position themselves at the helm of multi-disciplinary, global, collaborative teams that carry out successful projects. In their role as master builders, they must practice a new, more expansive body of knowledge, provide ethical guidance, attract a diverse workforce, and define the knowledge and responsibilities for each member of a well-defined hierarchy of professionals and paraprofessionals. In addition, civil engineers must educate their colleagues, partners, and the public on what civil engineers bring to the table, and become knowledgeable, vocal advocates of sustainable economic growth through infrastructure renewal.

Civil engineers must enter 2025 having long recognized the imperative for sustainable practices and the urgency for social equity in the consumption of resources. In the present scenario, policies and government funding not only encourages but often mandatorily requires sustainability and resilient approaches. Civil engineers must apply new technology, techniques, and financial methods in place for sustainable planning, design, construction, operation, and maintenance in carrying out their vital role. In addition, civil engineers must routinely encourage owners to adopt new environmental technologies and techniques to improve the quality of life.

As master innovators and integrators of technology, civil engineers must define the strategic research direction for leading-edge technologies in the built and natural environment and serve as active participants and partners in the research process. This involves a variety of efforts, including identifying and prioritizing emerging technologies and innovations, fostering civil engineering inputs into strategic research planning, influencing and bolstering funds for research, promoting faster application of new technologies and multi-national knowledge exchange, championing diversity and inclusion in the profession, and accelerating the integration of technology through spirited partnerships among diverse sectors.

To achieve the managers of risk outcome, civil engineers must show their mettle in assessing and managing risk by forging new tactics for reducing the incidence and effects of natural and man-made

disasters. Civil engineers must lead enterprise-wide risk management efforts and routinely make project-specific risk decisions, communicating risks and mitigation options to project colleagues, clients, government agencies, and the general public. At the same time, they must advance new approaches to balance business risk and reward. To have an impact, risk management must become part of every civil engineering project, a step as basic as scheduling and budgeting, and a key ingredient of all communication channels.

Thus, if, through the efforts of civil engineers, policy-makers and the public will understand the hard-wired link between infrastructure and the quality of life, then civil engineers will have shaped their professional stature and remained the force behind their own destiny.

That is what the "Vision 2025" put before the global civil engineering community, a motivation for civil engineers to shape their own future rather than sitting back passively as world events and forces shape it for them.

With the advent of powerful computer technology and the trend toward increasing specialization, civil engineers' roles often limit their leadership opportunities. Vision 2025 calls on civil engineers to reclaim some of the roles that they once held and to expand their influence as leaders to better serve society through their unique and valuable expertise.

Of course, accomplishing Vision outcome one goes well beyond the basics of technical study. To lead and execute complex projects that involve many and varied stakeholders and meaningful collaboration, civil engineers will have to command the multi-disciplinary, multi-cultural, team-building, and leadership aspects of their work. This broad union of civil engineering technical and non-technical knowledge will put more weight behind society's recognition of civil engineering as a learned profession. Civil engineering should be known for its comprehensive, energetic acquisition and creative application of knowledge and experience. Putting these skills to work in a global economy represents another neon signpost on the Vision 2025 Roadmap. Civil engineers should have language and cultural skills, and they must avail opportunities for targeted learning and for gaining a practical footing on the global stage. They must also endeavour to be universally recognized as representing a respected and diverse body of dedicated professionals who maintain high ethical standards in the varied procurement processes that quilt the world.

Civil Engineers in India are fortunate to have had several such luminaries in the past e.g. Mahadeva Iyer Ganapati, Ghananand Pande, T. Samynada Pillai, Anumolu Ramakrishna, many others and the contemporary Dr. Anoop Kumar Mittal of NBCC, and Dr. E. Sreedharan, better known as "The Metro man".

Dr. E. Sreedharan

Dr. Anoop Kumar Mittal

This kind of professional leadership would garner sufficient societal recognition for the value of civil engineers, along with the appropriate rewards. Such leadership will also require an identification of each engineering team member's competencies and the proper role for outsourced talent on global teams. What is more, to ensure public health, safety, and welfare, civil engineers will have to drive the establishment of worldwide civil engineering standards adaptable to local cultures and environments. In the end, for civil engineers to achieve the Vision, they must ensure that civil engineering is recognized as a vital profession that creates the infrastructure that drives sustainable economic growth and development.

Contrary to some popular stereotypes, civil engineers have always interacted with nature. Early definitions of civil engineering practice might be paraphrased like this: the art of directing nature's great sources through the application of physical and scientific principles for the use and convenience of humankind. During the last 150 years, civil engineers have arguably affected the health and life-span of more people than have medical professionals. Civil engineers have done it by providing clean water for our taps, sanitation for our cities, safe transportation infrastructure for our relationships and trade, and durable shelters that we can call an office or a home.

Yet some of that remarkable progress came at a cost. These efforts sometimes resulted in impacts on the environment and natural resources that were not fully understood, evaluated, or regulated. Either in reality or in perception, civil engineers have not always effectively carried the natural environment banner, so it is time for environmental stewardship to become the watchword and the stamp of civil engineers worldwide. Civil engineers must raise the bar in how they help protect the planet (read achievements of young Indian origin civil engineer, Rajan Jha, recently felicitated by ASCE).

To achieve this second Vision outcome, civil engineers must surcharge their education and subsequent practical experience with environmental awareness. They must then channel that energy and perspective to policy-makers and the public, including how civil engineering solutions affect resource consumption and social equity. Civil engineers must break out as leaders and help enact new government and private-sector policies to encourage or require that sustainability and resilient practices be considered in the planning, design, construction, operation, and maintenance of the built environment.

Through the efforts of the global civil engineering profession, policy makers and the public have already recognized and understood the reality of shrinking resources, the necessity for sustainable practices, design, and life-cycle financial support; and the need for social equity in the consumption of resources.

The baton is in the hands of each and every Civil Engineer and even more so, their leaders. It remains to be seen whether they harness the inertia and hit the ground running !!!!!!!!

Reference

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LET'S CONTINUE TO PRACTICE WITHOUT LEGISLATION FOR ENGINEERS

Sudhir DHAWAN

CEO, Aether Engineering Solutions Pvt. Ltd., Immediate Past President, Consulting Engineers Association of India (CEAI)
sudhir.dhawan@aetherengg.com

Mr. Sudhir Dhawan did his engineering from IIT, Delhi and MBA from Faculty of Management Studies (FMS), Delhi University. He has long experience (more than 40 years) in different sectors engineering covering consultancy for infrastructure, railways/metro rail, chemicals and petro-chemicals, gas pipelines, LNG/LPG terminal, thermal and hydro power projects.

He has been very active in development of development of consultancy profession in India. Presently, he is Chairman of President's Council of CEAI. He was President of CEAI for year 2015-16, President of National Association of Consulting Engineers and Vice President of Consulting Engineers Association of India, former Vice Chairman of Consultancy Development Centre, Former Member of National Council of CII, former Governing Body Member of F.I.E.O. He was also on the panel of WTO formed by Ministry of Commerce relating to Consultancy sector.

An apparently controversial topic but that's the reality since with the present mood of the Government and non cooperation amongst engineering associations/ institutions, practising engineers may not get legislative support for years to come. There is therefore a need to workout an alternate system whereby the impediments due to lack of legislative support could be addressed.

In this article the main issues of the legislation for Engineers vis-à-vis an alternate recourse which would need to be pursued to achieve the objectives of the profession, are analysed.

1. Constraints in Legislative Approval

There have been many constraints in forwarding the draft Engineers Bill in the government. The major one being lack of cooperation, nay distrust amongst various engineering associations/institutions, which has lead to the repeated failures to push the Draft of the legislation for Engineers at the government level. Some in the Institution of Engineers (India) (IEI) are of the opinion that since IEI has a Royal Charter, it serves the purpose and hence there is no need for any new legislation. There have been differing legal opinions on this view in IEI.Be what may be the legal verdict on that, IEI cannot forbid a qualified engineer who is not their member from practicing as an engineer.

The Government is being cautions after facing major problems with some of the other professional councils such as the Medical Council of India (MCI), The Bar Council of India (BCI), The Institute of Chartered Accountants of India (ICAI)& The Council of Architects (meant for protection of 'TITLE'), et al. Due to their adverse experience, the Government is of the opinion that there is no need to constitute new councils and that each profession should regulate its activities on its own. This recent development has thrown cold water on the efforts for legislation for Engineers. It's all very easy to for the Government to propose this view. However, what remains unanswered is that how can any association or institution prohibit

or even restrain in any manner, an engineering graduate from practicing engineering when they have no statutory authority.

However, all is not bleak. There are some in the Government and the political sphere who appreciate the issue of unbridled practice by a person who may have a qualifying degree but not the experience and demonstrated capability to be one. They appreciate that safe and sound designs are essentialin view of the large scale investments in new infrastructure projects with state of the art engineering and to address sustainability issues. For the legislation to materialise all major engineering associations/ institutions need to make a concerted effort, jointly. Their first task would be to explain to non- engineer Ministers and Members of Lok Sabha and Rajya Sabha the need for the legislation.

2. Major Drawbacks of not Having Engineers Bill

There are quite a few drawbacks in not having Engineers Bill. The major ones are:

- Anyone can start engineering consultancy practice without proper background, experience and demonstrated capability.
- Foreign engineering consulting organisations/ individuals can start business in India without any approval. However, Indian engineering consultants do not have reciprocal advantage in foreign countries. Each Indian company has to take approval from the local engineering bodies/ departments before starting business, which in some countries involves getting their individual engineers certified and registered.
- Designs, construction supervision, operations and maintenance are being done by inexperienced engineers leading to unsafe and unsound structures/systems/plant & equipment. Major failures, blasts and disasters that have been occurring are mostly attributable to inadequate designs and/or poor construction and/ or maintenance stemming from lack of appreciation of the issues involved.

3. Registration of Professional Engineers/ Consulting Engineers

The draft for legislation for Engineers had the provision of registering engineers and engineering companies. To overcome this, Consulting Engineers Association of India (CEAI) and the Engineering Council of India (ECI) have started the process of registration of engineers. Even though this registration has no legislative backing, it will at least help in registering those engineers who have proven track records of rendering good professional services. Both CEAI and ECI have formed screening committees to ensure that engineers registered meet the criteria. The registration will be renewed on a periodic basis with due consideration of the work done by an engineer during the intervening years.

4. Suspension of Member

The draft for legislation for Engineers also had a provision by which the membership could be suspended or revoked due to well defined reasons. There is a provision in place in CEAI, as per its Code of Ethics which are to be followed by its members. In case of any professional shortcomings, the Ethics Committee has the powers to propose suspension or cancellation of the membership based on proper evidence. It has been seen that in general CEAI members tend to follow proper processes and procedures and abide by codes and standards while carrying out their work.

Based on the above and the manner in which engineers have been practising all these years sans any regulation, they can continue to practice even if there is no legislation for managing the engineering profession. As a professional body the need is to promote and ensure the following:

- Clients adopt and follow a proper procedure for engagement of engineering consultants. Fortunately due to the interactions by the consulting engineers associations and Government departments/PSUs, they are following guidelines for engaging engineering consultants.
- Due to efforts of many associations and international funding institutions such as The World Bank, Asian Development Bank, et al many Clients have adopted the QCBS (Quality and Cost Based Selection) for engagement of engineering consultants.
- Where the Lowest Fee criteria still prevails, efforts have to be made at various levels to educate members to quote fees/rates that are adequate to meet all the costs need to be entailed by the engineering consultant in performing the assignment plus a suitable mark up.

- CEAI has published the"Guidelines for Selection of Consultants and Professional Compensation Structure". This document should be promoted with the Clients.
- Clients should also be advised to appoint a third party agency for Proof Checking of the designs, especially where state of the art engineering and technology are to be incorporated.

5. Professional Development

India still lacks training towards development and enhancement of professional engineers. Even young engineers are not trained properly before being assigned on a job.

CEAI has been conducting training courses which have been well received by its members as well as other participants. However, lack of interest by engineering companies in training their personnel is worrisome at times. In some countries the Government has made it compulsory for the personnel to be trained.

Consulting Engineering companies should expose their engineers to new software, new materials of construction, impact of mechanised construction on engineering designs, construction, operation and maintenance.

*****Views expressed in this article are personal and not of CEAI.***

ENGINEERING DESIGN SERVICES IN INDIA - CHALLENGES AHEAD

Amitabha GHOSHAL

Chief Advisor to Board of Directors,
STUP Consultants Pvt. Ltd.

Mr. Amitabha Ghoshal started his career with the Construction Industry and continued to be involved in design, planning and construction of projects for 23 years.

He joined STUP Consultants Pvt. Ltd., In 1980, has served them as Director for ten years, and still continuing to serve as Chief Advisor to Board of Directors.

He has been responsible for export of Consultancy services to eighteen countries and to many for the first time for Indian Consultants.

Preamble

Engineering design, during colonial days, was very limited in nature and was invariably handled by the captive design offices in government departments. Whatever little design demand was there in the private sector, used to be assigned either to Consultancy organisations abroad or handled by individuals trained abroad. Major projects like Howrah Bridge, Port complexes in Mumbai, Kolkata and Chennai were all handled in Britain by respective specialist Consultant organisations, who would also send their representatives for overseeing site operations.

After Independence, the design units in Government departments were strengthened and dedicated units, like CDDO (Central Design and Development Organisation) created in Steel sector and PDIL in Fertiliser sector.

Indian Consultancy units were formed by entrepreneurial individuals like Dr M N Dastur (Dasturco), Sadhan Dutt (DCPL, inherited from Kuljian Corp), Mahendra Raj, C R Alimchandani (STUP) and others, each with focus on specific sectors. With increasing thrust on developmental programmes in Infrastructure and Industry, more Consultancy organisations like TCE (TATA Consulting Engineers), CES (Consulting Engineering Services) and ICT (Inter Continental Technocrats) developed and started operating successfully.

Changes set in, as India embarked in the adventurous journey towards dynamic growth with foreign funding. The government departments could no longer depend on their design section for timely delivery of project design, as demanded by the funding agency, and had to look for external agencies for design work. The sectoral Engineering Design offices set up in the public sector like MECON in Steel sector, EIL in Petroleum, Gas and Port sector, RITES in Railway sector were not able to cope with the sudden rise in demand with the ambitious growth plans. Such organizations started to outsource most of the detailed engineering works in fragments, to private consultants and moonlighting engineers in the industry, while retaining the overall co-ordination.

The Engineering Services Organisations in Private and Public sector had to embark on rapid expansion. More and more new organisations entered the field with inadequate experience, manpower and technological base.

Both these developments cast shadow on the quality of deliverables. Simultaneously, the recession across the globe prompted Multinational organisations to enter Indian market with long term plans. These changes in the Engineering Consultancy and services sector have created issues that are not familiar to Indian professionals and merit close examination.

This paper intends to address some of the challenges faced and seeks the way forward.

Effects of Change

One of the major changes, that was ushered in with the rising foreign investment, and particularly through funding agencies like DFID, ADB, JICA, WORLD BANK, was that the selection process for service providers became through the FIDIC based QBS

(Quality Based Selection) and QCBS (Quality and Cost Based Selection) process, as against the earlier Least Cost basis (LCB) as was prevalent.

Preference for public sector organisations in selection of agencies was largely done away with. Some Transparency in selection process was established and this levelled the field for private sector agencies considerably. This method has now been partially adopted, first by bodies like NHAI, Urban Development Ministry, and then by some large units responsible for development works.

Engineering Services got linked with non engineering disciplines, like Finance, Sociology, Economics and Environment, for making development funding beneficial to the society at large. Benefit Monitoring and Evaluation (BME)on completion of projects has become standard protocol. Engineering consultancy and service providers had to augment their expertise base, to include soft sector capabilities along with multi disciplined technical expertise, and automatically increased their Band Widths.

FIDIC based contract conditions, with a little tweaking, are somewhat accepted as a norm for both Construction and Consultancy service providers. This has created a healthier environment in development projects, by reducing arbitrary decision making and cut down on uncertainties faced during execution-bidders are now able to make more realistic offers.

Large Indian Service providers succeeded in closing the gap in quality of submission with International agencies and export of services to Asian and African countries grew steadily. With growth in client base, and better cash flow, the consultancy organizations and service providers started enlarging their operations systematically.

The professional and financial prowess of large Indian Consultancy organisations grew steadily.

Challenges and Operational Issues

Manpower

The demand for soft sector professionals grew very fast in a market where paucity of demand had never encouraged individuals to practice as professionals. Even with the growth of demand, the professionals in some disciplines were not required on continuous basis, and therefore, consultancy organizations and service providing agencies were not able to take such professionals on regular pay roll. Absence of guilds or associations, made procurement of right professionals, and fixing their remuneration, difficult. Projects suffered for non induction of quality professionals at the right time, matching with the project demand.

In the technological field, the sharp growth of demand for manpower, of appropriate qualification, resulted in deployment of personnel with inadequate capability, by manipulation of their Curricular Vitae, and this reflected in the quality of delivery.

This problem was further accentuated with inexperienced clients making unwarranted demands of educational qualification and expertise, not compatible with the task demands, for the professionals.

Growth in demand for professionals led to sudden expansion of student input in technical institutions, which resulted indirectly in poor quality outputs. Inadequate number of teaching faculty further added to the low quality of output.

Consultants, and Service providers took recourse to in house training program and started using the few continuing education courses operated by professional Institutions. Only large agencies could impart such value to their staff and the benefits to service users were limited.

Integrity

With the steady growth of demand, number of Consultants and service providers have seen unbridled rise, with the induction of organisations with no professional integrity. To meet the strict qualifying demands set in the RFP, produced by clients, misinformation is being provided for fulfilling the experience requirement of organisation, as also individual professionals, to be deployed. Certificate for educational attainments are provided from nonexistent or ill provided Institutions and same are getting accepted with the help of corrupt officials of the client.

Assessment of Technical Bids is being influenced by submitting false experience certificates and by avoidance of checking with referred ‘clients’.

Clients like NHAI have introduced websites, for uploading CV and project information, to avoid award based on false claims. Submission of bids are done by uploading on security protected web sites. Despite such precautions, the scourge of award to incapable organisation continues, - and that tarnishes the image

of all Consultants and Service providers, bringing disrepute to the Industry as a whole.

Contractual Issues

Some authorities have been including unworkable conditions, while preparing Bid Documents, that are affecting systematic execution of projects and pushing up the costs due to introduction of multiple uncertainties, - just the opposite of the philosophy guiding FIDIC based contracts.

Payment clauses are being framed to negatively affect cash flow of Consultants and service providers. For consultancy contracts, a major part of payment is being linked with actual execution of the project at site, which often gets inordinately delayed due to various reasons, beyond the control of the design consultant.

Similarity part of payment of executing agencies are being linked with the performance of the project, way beyond the normal Defects Liability period of one year. Cash content is not being released on offer of Bank Guarantee for equivalent amount.

Non release of Expired Bank Guarantees, even after the Defects Liability period, is another problem faced by service providers.

In many contracts, the total amount withheld under different clauses become a very high percent of the total dues--separate deductions are being made towards Security Deposits and Performance Guarantee.

Very high value Professional Indemnity Insurance, linked to cost of the project (and not fees amount), valid for long years beyond completion of Defects Liability Period, is being demanded from Design Consultants, rendering them disabled for proper technical performance.

Many clients like the Railways are not reimbursing Service Tax (which is a Tax payable by service receivers as envisaged by Government) to the Consultants and are urging them to include same in Bid Price-- and then not paying the increased liability when the Tax rates are increased by Budget proposal. In many running contracts, the Tax rate has increased from 10.3 percent to 15 percent already.

Consultants are being pressurised to submit, to the design checking group, software used for design work, and they are non returnable. Even standard widely used softwares like Staad and Autocad are being demanded to be provided.

What is more unfair, is that consultants are being forced to part with Excel program's developed in house at great cost and over long periods - together with source codes in many cases.

Contract documents are providing for summary rejection of proposal, if any unfair clause is objected to, citing noncompliance with tender conditions, and thereby making them work like bonded labour.

This situation is being aggravated, with provisions in Bid Document (and sometimes in pre qualification documents) that any bidder, who has ever been 'Terminated' or ' Debarred' by ANY authority (however motivated or biassed), will not be eligible to Bid and/ or his Bid will be summarily rejected. Such draconian stipulations are stifling the Industry and making them subservient to the Authorities, that are often vengeful and and nurturing ulterior motives.

Multi National Agencies

The prospect of long term growth in Industry, together with recessionary pressure in the Global market, has prompted many Multi National organisations to set up units in India. This is, by its nature, an welcome move, as it allows local units to upgrade themselves to International standards, and help them improve the quality of deliverable. This expectation of the Indian Industry, has however been belied, with the way some of these agencies are working.

Some of these organisations have set up office in India with entirely commercial objective and manned them with professionals hired from local sources. They are not positioning any experienced technical senior professional as can train the team employed locally, but are using the references earned abroad as proof of their organisational capability, for scoring high marks in Technical Bid assessment. After obtaining the project, they are providing local professional service only, thereby denying any Technology Transfer, as is the expectation of the host country authority. Our deep seated, respectful, mindset towards foreign technology, blinds the Authorities against the fallacy of the situation. The country gains nothing, and at the same time local Industry loses out.

Many of the organisations work as PMC, and therefore get the opportunity to check the design prepared by local consultants. They use the unprofessional contract clause that empowers them to seek all

custom prepared software, including their source code, and work sheets. Some of them often harass the local agency, and present a sordid picture of local capability, to convince the client of their superiority.

Many of them use the opportunity, to identify the best trained and capable staff belonging to the local organisation, and poach them with offer of higher pay. This helps them build up their capability and simultaneously render the local unit vulnerable to pressure.

Unfortunately, no clauses are included in PMC contracts, whereby they are debarred from offering employment to employees of the agency reporting to them - as is the professional practice in many countries. Such practices need to stop, to save the local Industry from decay.

WAY OUT

It is pertinent to mention that, one after another established Consulting organisations, that had been built and nurtured with care, and contributed immensely to the growth and development of the country's engineering infrastructure, are falling into distress, unable to counter the challenges. In most cases, the units on decline are being acquired by the MNCs, thereby adding to their strength. Today, very few, strong and thriving Indian agencies are in the field.

Industry associations need to organise themselves and make united effort to address these issues.

With live case studies, the issues need be explained to authorities and redressal sought. Government need be made aware, of the danger to the growth and survival of the Industry, that had been serving the country effectively and been partner of the development agenda. Government also has to be convinced that with elimination of local competition, the country will pay heavy price by having the same services at a much higher cost, as had happened to many developing countries like Indonesia.

United action is the call of the day.

CHALLENGES FACING STRUCTURAL ENGINEERS & ENGINEERING ORGANIZATIONS

Alpa SHETH

Str. Engineer + Managing Director
VMS Consultants Pvt. Ltd.,
alpa_sheth@vakilmehtasheth.com

Alpa Sheth chairs the Academic Council at Kamla Raheja Vidyanidhi Institute for Architecture (KRVIA), Mumbai. She is Founding Trustee of Structural Engineering Forum of India (sefindia.org).

She holds a post-graduate degree in engineering from University of California, Berkeley

Rajendra GILL

Director,
VMS Consultants Pvt. Ltd.,
rajendragill@vakilmehtasheth.com

Raj Gill has been a career banker for over two decades in the treasury function before which he was Officer in the Tata Administrative Services (TAS).

He holds a post-graduate degree in Economics

Summary

This opinion paper examines the past and current dynamics of relationships between various stakeholders in the structural engineering consulting industry. It reviews the present state of affairs and surmises that the existing state is not tenable for the long term survival and growth of the profession. It further suggests a way forward for reform.

Keywords: Ecosystem, human mind, digital mind, leadership, accountability, performance based design.

1. Introduction

Looking back over the past two decades…

Structural engineering consulting profession has a diverse set of players- Consultants who design infrastructure (which has further specialisations from bridge engineering to design of roads and airport terminals, metros and so on, industrial consultants, and consultants who cater to the world of "buildings" and real estate (commercial and residential structures and occasionally public buildings). The majority of structural engineering firms and designers belong to the latter category. While the observations made herein are mostly applicable to this set, they would find correspondence in other segments of the industry.

Over the past two decades, until as recently as 2012, the real estate industry was a seller's dream market. There was a consistent and accelerated realty price appreciation (except for a temporary reversal between 1997-1999) with capital values staying way ahead of retail inflation. Real estate was hailed as the asset class that generated maximum returns. There was no incentive for the real estate developer to deliver a good quality product in the promised time. The buyer seemed satisfied with accepting a deficient product with limited or no warranty. The steady rise in capital value made up for all deficiencies. Focus of the developer was on more land acquisition coupled with managing the regulatory process and exploiting it to ensure maximum profit. There was no accountability on part of the developer as there were no consequences for breach of contract. Another factor that added to this state of affairs was that the buyer was often not the end user. The investor-buyer accounted for a larger percentage of the purchases. The situation created an environment where everybody who was part of the delivery ecosystem – the developer, architect,

structural engineer became complacent and lazy. Almost everything sold, regardless.

2. The Changing Ecosystem

Various macro and micro economic, social and political changes since 2012 have transformed the ecosystem quietly and swiftly. A new government at the centre (2014) has ushered in powerful instruments for ensuring better governance in the real estate industry such as RERA (The Real Estate Regulation And Development Act, 2016) and the Benami Transactions (Prohibition) Amendment Act, 2016. The former is an enabling Act to ensure that developers invest the money collected on a project for that project and deliver the product as per the agreed terms of contract in a time bound manner. The focus will now be on adherence to terms of contract between the buyer and seller. This will constrain the developers from running what have essentially been Ponzi schemes of real estate development till date wherein money collected from new launches was funnelled into older projects that were sorely short of liquidity or to buy new land parcels. The two Acts together will change the profile of the buyer. There would be more genuine end user-buyers, and the number of investor-buyers in the fray will reduce significantly. It could launch an era which one had not dreamed was possible in India- A robust regulatory framework supported by an implementation mechanism that would create a transparent system where all approvals are obtained legitimately and before the construction has commenced with little manoeuvrability for any of the stakeholders to "manage" the system, and where accountability to the consumer of the product will be the rule rather than the exception. In such an environment, there is likely to be much compression, mergers and acquisitions in the developer segment. Many developers are possibly building their last independent project as we see it in 2017. Consolidation is being imposed on a reluctant industry which still continues to be in denial. Going forward, only those developers who have a long-term view and run their businesses professionally are likely to survive. Willy-nilly, the industry will have to fall in line with other manufacturing industries with returns of 10-20% on effective production and reliable product delivery that is backed with a warranty.

But even before all the above comes into full effect, what is now fairly evident is the rising growth of a strident consumer class who have taken it upon themselves to assert their rights and enforce contracts. They have been aided by an active and sympathetic judiciary who, having watched the excesses of the industry for many decades, have now stepped in to provide reasonably quick and stern redressal to the aggrieved parties – usually the buyer.

The third macroeconomic change that has caused a seismic shift in the industry is the current global and national economic scenario. The sluggishness in markets which has been in the works for a long time and that does not seem to be going away any time soon has also caused stalling of appreciation in value of properties and the weakening of the investor buyer market for whom it is no longer wise or profitable to invest in an illiquid asset such as property. Further, overbuild and overprice have been a double whammy for the industry, causing a huge build-up of inventory. In areas like the National Capital Region, there is an oversupply of affordable housing (within a price ticket of Rs. 2.5 to 5 million for two to three bedroom homes) and in areas like the island city of Mumbai, there is oversupply of highly overpriced super-luxury housing. To put things in perspective, in 2017 Mumbai city is staring at more than 10,000 unsold apartments (built or under construction/planning) in the ticket category of Rs. 50 million or more. That such a supply exists in a single city in a country where less than 50,000 people declare an annual income of over Rs 10 million is a telling indictment of the grossly skewed environment that has existed for long in the country.

Where do Structural engineers come into all of this?

The ecosystem as it existed for the past three decades co-opted the structural engineering industry into the way business was conducted by its client- the developer. It encouraged structural engineers to become lackadaisical. If one looks back at the past three decades in terms of new systems and technologies in the industry, the report card is dismal. There simply have not been any significant earthshaking inventions nor many innovative technologies. Structural design in the past decade was primarily reduced to a regime of technicians delivering software-generated output. One had imagined that software, supported by increasingly powerful computing machines would provide an opportunity for the engineer to free himself from the drudge of number-crunching and mind-numbing calculations and let his "thinking mind" delve un-distracted into the realm of engineering creativity and innovation. Alas, the engineer appears to have resigned himself to be enslaved by the computer

which instead of freeing his human mind, roboticised him into an obedient servant of the "digital mind". The developer client caught on to this situation early on and successfully bargained down fees of structural engineers ("All you do is invest in a computer and software and a technician/computer operator- how expensive can that be?") to the point that oftentimes structural engineers are being paid less than what they were paid a decade ago. Adjusting for inflation in real terms, structural engineering profession experienced a downward fee spiral of up to 50 % in a decade. Structural consultants added to this situation by beating each other down in fees, in a literal race to the bottom. In lieu of providing better services and commanding better fees, consultants were seemingly agreeable to providing "blue-collared" engineering services and being paid likewise. Consultancy rates reflected sub-par design skills. Structural consultants were focused on output, not outcomes. And the remuneration they received reflected this bias. As long as the structural consultant was delivering on time, nobody was bothered on the quality of the product being delivered because the client believed that all consultants used the same software and thus would have the same assembly-line design output. Basic issues such as new learning, creativity and innovation, contribution to professional journals, a nuanced interpretation and understanding of codes, exposure to international state-of-art engineering or interaction with academia was absent. An intellectually charged environment that is conducive to absorbing and producing new engineering inventions was non-existent. Lack of depth in understanding ancillary but important allied areas such as material technology which has seen more innovations than the core structural engineering field and construction technology plagued the industry. However, as long as the client could not discern a "thinking" consultant (or we may call him a "white-collared" consultant) from a software driven technician consultant (a blue-collared consultant), all was fine.

Change is Around the Corner….

But things are set to change. Like the developer-client segment, the structural consultancy business will see much shrinkage. There are simply too many blue-collared structural engineering consultancy firms out there. They will increasingly find it difficult to survive as they face even more competition and pressure to reduce fees. As mentioned earlier, only the more discerning developer will survive, and they will demand not just output but outcome from the structural engineer. It will be incumbent on the designer to prove to a client how he has added value to the project –beyond the computer generated design and drawings. There is no reluctance on part of the client to pay more to his consultant if he is convinced of a better product. After all, the structural engineer's fees are too insignificant for the client in the larger scheme of things. The fact that he is reluctant to pay even the pittance he earlier used to, is a reflection of the contempt he seems to hold the structural engineer in.

Consolidation at client end will thus be mirrored in consolidation of structural consultants. Only those consultants will survive who have developed the wherewithal to skill and re-skill the mediocre set of technicians (with engineering degrees) on an ongoing basis. (The quality of graduating civil engineers will be discussed later). The emphasis will not be on efficiency (timely delivery alone) but on effectiveness. Work will go to those who have an institutionalized delivery platform which ensures delivery of effective outcomes instead of efficient output. Offices where creativity and innovation are fostered and main streamed into every day work will be the ones most likely to do well. This will require extending beyond the software-produced assembly line design of structural engineering and participating and collaborating closely with clients to create performance based design which is fully code compliant but also completely up to speed with changes in state-of-art construction and design innovations across the world and responds to a client's specific needs in a highly demanding and challenging environment rather than a purely prescriptive-based design approach (blind application of codes using software).

Capacity Building of Young Structural Engineers

The elephant in the room is the increasingly poor quality of engineering talent that the structural engineering profession is able to attract. The industry as mentioned elsewhere has not seen much innovation in the past few decades and is thus not viewed as a "happening" field. The first choice of most engineering students is not civil engineering. It is usually information technology, followed by electrical, mechanical and at the bottom of the rung is civil engineering. So when a student enters the portals of a civil engineering college, he has already made his first compromise. And then the next four years of college are a systematic attempt to disengage him from his love of the core field of engineering.

It would seem that the world plots against the poor lad- uninspiring and disinterested teachers, insipid teaching methods, endless amounts of time invested in seemingly outdated tools and technology which a student is hard pressed to make sense of or comprehend its applications. The situation has been compounded by two phenomena- On one side is the plethora of civil engineering colleges that have mushroomed across the country, with poorly qualified faculty and inadequate infrastructure. The entry bar for joining a civil engineering college has been lowered so much in the past decade that anyone can now become a civil engineer, irrespective of whether you possess the acumen or the aptitude to pursue the field. There is tremendous pressure on colleges to graduate a student, even though he may not be technically or mentally ready for the outside world, just to keep the inflow coming and the juggernaut rolling. On the other side is the pressure on premier engineering colleges like the IITs to spew out more "well-rounded" graduates- which is another way of saying that while the student may get a civil engineering degree, there is more than an 80% probability that he will not be pursuing the field, so we equip him with skills to switch to information technology or finance or management. "We teach him to learn" is the refrain of the IITs. We already now have IIT civil engineering students who graduate with just one or two core courses in analysis and design against seven to eight courses in earlier times.

The typical civil engineering student graduates with poor subject knowledge and poor communication skills, and zero exposure to the outside world of architecture and engineering. Their aesthetic sensibilities are not honed nor are their observation skills sharpened. This puts them at a distinct disadvantage vis-à-vis other professionals. Therein develops their innate sense of subservience to others such as planners/ architects. Time and again, the structural engineer is unable to convey what is important for the building stability, safety and serviceability and what constitutes good behaviour. His solutions may seem boring, droll and uninteresting not because they are necessarily so but because he is a poor communicator. The planner/ architect switches off midway and dismisses the poor engineer with a "do as I say". The engineer needs to learn a few important skills- sketching, model-making and language skills if he is to interact one-on-one with the clients/planners/ architect. And of course the most important ability- that of imagination.

Teaching methods in architecture and engineering colleges could not be more different. Engineering students can graduate giving just one presentation in the first year and one during final year. Other than that he is not required to open his mouth except for the odd viva. A large cross-section of engineering students enter college without the ability to string a sentence in English. So do many architecture students. The difference is that engineering students graduate with a degree without still being able to form an English sentence while the architecture student, subjected as he is to all kinds of stress tests where he is made to explain and defend his work- in juries, presentations, vivas, projects and so on comes out extremely articulate and confident. The battle lines get drawn at that very stage. More importantly, the studio concept of learning in architecture schools trains the student to "ideate", to think in the abstract and to convert such abstractions into tangible forms. Architecture curriculum has a good balance of design, some technology and humanities. Engineering curriculum on the other hand has little other than technology, encouraging creation of tunnel-visioned individuals. Civil engineering curricula needs to be more broad based with lot more humanities subjects included in the curriculum, without diluting core technical subjects but whilst jettisoning antiquated subjects, which should be moved from mandatory to elective subjects.

The basic objective of education must not be lost. Schools and colleges are meant to be crucibles of learning and knowledge, not skills. Teaching skills is the job of a vocational institute or an office. Unfortunately, most colleges are now into the business of imparting skills which they claim is the demand of the industry. Computer Aided Design is not just one of the many courses students take, it is a subject in which one can specialize and attain a post-graduate degree. But what is missed out is that the world out there is fickle and skills required to navigate it will constantly change. Rarely in the career of a human being will he not be required to learn new skills. If the college is successful in teaching a student "how to learn" and kindle the "what" and "why" in him, it would have been successful in its mission of education. Sadly this is being followed only in its breach.

On the Turf war between Architects and Engineers…

The incessant territorial fight between engineers and architects has its roots in the traditionally adversarial relationship between architects and structural

engineers. Earlier on, the relationship was based on a set hierarchy in which the architect was the lead consultant, lording as it were, over the engineer and all other consultants on the project. Things are however changing rapidly. Architect is no longer the lead on most projects and his role has been appropriated by the client's in-house management team or a consultant project management team which engages one-on-one with architects and structural engineers as independent service providers. As the real estate industry pie shrinks on one hand, while the number of professionals in the architectural and engineering feeding off it increases on the other hand, (the number of graduating architects in India each year is over 5,000 and increasing) battle lines for dominance are sharply drawn. The Architecture profession which till date had not been very aggressive in protecting its turf is now introducing more barriers for engineers to perform architectural functions. This is a reflection of the desperate situation the architecture profession finds itself in. They see themselves peeping into a bottomless abyss as jobs continue to shrink at an alarming rate – This has happened already in Europe and North America. Engineers on their part need to have the nuanced ability to understand the difference between structural engineering and architecture and not strut about pretending (and demanding) to practice what they have not been trained to do competently. There is enough work in structural engineering if one wants to do a good job (and one needs resources of the human mind and not the digital mind to do a good job). The structural engineering community seems to be responding in a predictable but naïve way to the backlash from architectural fraternity. They are attempting to bring in their own protectionist barriers – through engineering councils and other such means. Both architecture and engineering professions appear to be demonstrating typical ostrich behaviour, completely oblivious to the disruptive ecosystem out there. It is foolish to try to protect oneself against disruption- because it is simply not possible to do so. Both professions are looking the wrong way- They need to look within. One needs to be ready for impending disruption. It will come from the most unlikely sources- be it information technology industry or elsewhere.

Engineers & Architects need to break from their decades long slumber and look the world straight in the eye. The comfort world of loyal clients and customers who took anything you gave them as long as it was cheap is over and done with. It is now the new age of effective outcomes, not efficient output. If engineers & Architects will find their mien- they will find their answers.

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ETHICS AND STRUCTURAL DESIGN OF BUILDINGS

Sangeeta WIJ
Managing Partner
SD Engineering Consultants LLP
Email:sangeetawij@gmail.com

Mrs. Sangeeta Wij is a renowned Civil Engineer from Delhi College of Engineering with M.Tech from IIT Delhi. She is Managing Partner, SD Engineering Consultants, a 20 year old Consultancy firm carrying out Engineering designs , Architecture and Project Management in India. She has worked as DGM in Rail India Technical and Economic Services (RITES) before starting her Consultancy firm SDEC. She has also worked as Director (Technical) at AECOM for a couple of years handling prestigious high rise assignments. She is a member of Women in Engineering (WIE) Committee of WFEO and on the Board of Directors, INWES. She is President, Women in Science and Engineering (WISE India) and also on Governing Council of Indian Association of Structural Engineers (IAStructE). She is a Fellow and Chartered Engineer, Indian Institution of Engineers, member Indian Buildings Congress and, Consulting Engineers Association of India.

Synopsis:

What are the possible reasons for this state of affairs of our noble profession especially in this country? How is it that the Internationally considered blue collar profession of "Structural Engineering" (the comprehensive version, as per National Building Code) has been reduced to the level of unorganized sector or a cottage industry without any lower bound parameters in our country? This article shall attempt to present my point of view with the diagnosis & prognosis, and I shall be glad to receive any constructive feedback from the readers, if it can be offered without malice or being judgemental.

Having worked in the Buildings Industry as a Structural Design Engineer since 1982, I have seen the industry evolve from a slide rule and manual analysis scenario to the internationally acceptable parameters of Computer Aided Design (CAD), though I am not confident enough to claim that quality of designs and quality of construction in general, has evolved to globally acceptable standards. Many a times, the poor standard of design is attributed to poor fees that is generally accepted by the Structural Consultants in India, or the lack of proper agreements not demanded by them or their late stage of involvement, when the structural consultant has practically no say in general layouts and planning of judicious geometry with engineering sense of equilibrium, leading to enhanced life cycle & safety for the structures. It may be of interest to some of the readers that the Central Designs Office (CDO) of Central Public Works Department (CPWD) had recognized this anomaly as far back as 1993, and had there after immediately issued a circular saying that they will not design or proof check any structure for which they have not been involved from planning stage itself, refer CPWD Circular no CDO/SE(D)/G-293 Dated December 1993, (reproduced below).

CENTRAL PUBLIC WORKS DEPARTMENT
CENTRAL DESIGNS ORGANISATION

No. CDO/SE(D)/G-293 Dated, New Delhi, the Dec. 1993

CHECKING DESIGNS CARRIED OUT THROUGH OUTSIDE CONSULTANTS

Of late, certain instances have come to our notice wherein Chief Engineers have approached CDO for undertaking the checking of structural designs carried out through Consultants after finalising the plans by the Architects and in some cases after approval by local bodies also. Since CDO looks at the designs from various angles of concepts, economy, accommodation of civil, mechanical and electrical services, maintainability etc., considerable interaction is required with the Architects, Service Engineers and other Consultants before a viable structural system is evolved. In the process, often basic changes are called for on the initial proposals prepared by the Architects. Thus, approaching CDO for checking the designs at later stages after the plans are frozen will lead to re-evaluation of the system, necessitating changes and consequent delays and embarrassment.

To avoid such situations, wherever CEs require CDO either to undertake the design or check the same, they should approach CDO in the beginning itself so that interaction with the Consultants can start at the stage of conceptual planning itself. This will ensure economy and structural safety in the best possible manner.

In instances where the above procedure is not followed, CDO may reserve its right not to undertake such projects for structural design/checking.

(K.S. GANGADHARAN)
ADDL. DIRECTOR GENERAL (TD)

To All Chief Engineers
in C.P.W.D./P.W.D. (DA)

The biggest enemy of our professional growth are some of us within our own fraternity, who have allowed our role to slide and to become subservient to other Professionals. We have miserably failed to rise to the occasion and lead the multi disciplinary teams required to successfully plan and execute a Project from inception to completion. A Structural Engineer is technically more qualified than any other team member to perform the Team Leader's role to perfection and we must aspire to be team leaders. Most mega Projects are generally bagged by Planning & Architectural firms without carrying any responsibility for operational safety, sustainability, life cycle & workability of the project (all subjective components of a Built environment project), with specialist sub consultants engaged for different disciplines of work, each carrying specific responsibility for their respective scope of works, (all objective and numerically/mathematically challengeable components). In fact, we, as Structural Engineers (comprehensive version), could be that "Main/Prime Consultant" and engage the required sub consultants/professionals of other disciplines to complete the project specific assignment as and when required. Recognizing this aspect, CPWD has taken a lead to issue a Circular to this effect, refer CPWD Circular No. F.No. 2/4/2015-WII (DG)/Vol.-I/606 dated 02/07/2015 (reproduced below).

DIRECTORATE GENERAL
CENTRAL PUBLIC WORKS DEPARTMENT
NIRMAN BHAWAN, NEW DELHI
E-Mail:- cepwacpwd@gmail.com, dirpwacpwd2008@gmail.com

F. No 2/4/2015-WII (DG)/Vol.-1/606 **Dated 2 /07/2015**

OFFICE MEMORANDUM
Circular No. DG/P&WA/56

Sub:--Inviting bids for comprehensive architectural and engineering services.

It has been observed that field units sometime invite offers from architects for comprehensive architectural and engineering consultancy jobs for various projects. Registration of the architects with the Council of Architect is sometimes kept as a prequalifying condition in some of the expression of interest (EOI)/request for proposals/(RFP)/bid documents (NIT) for such consultancy jobs whereas pure engineering jobs have little or no role of Architects in such consultancy assignments. Appropriate Engineering experience is absolutely necessary to render such consultancy services.

It has now been decided that EOI/RFP/NIT for comprehensive Architectural and Engineering consultancy jobs shall clearly lay down eligibility criteria compatible with components of the consultancy assignments. Registration of Applicant/Bidder with Council of Architect shall not be a mandatory condition in such combined Architectural & Engineering Consultancy jobs. Any firm/consultant (whether titled as an Architectural firm or an Engineering firm or a joint venture thereof) which fulfils the laid down eligibility criteria in the EOI/RFP/NIT shall be permitted to take part in the bidding process. Engineering firms shall be permitted to engage Architects registered with Council of Architect and with requisite experience to fulfil eligibility criteria and to take part in the bidding process. Likewise Architectural firms shall be permitted to engage Engineers of appropriate qualification and experience to fulfil eligibility criteria and to take part in the bidding process.

This substitute circular No. DG/P&WA/55 dated 24/06/2015.

This issues with the approval of the DG, CPWD.

(Nirmal Goel)
Director (P&WA)

To
1. All SDGs and ADGs, CPWD.
2. Engineer-in-Chief, PWD, Govt. of Delhi.
3. All other CPWD/PWD officers through CPWD website.

That is the model of working professed in the developed world, (refer California bye-laws below) where safety is considered paramount. In the high seismic state of California, building bye-laws have limitations for all other professionals but contain NO LIMITS on competency for Planning & Design by Structural Engineers. A detailed reading of The National Building Code of India also professes similar competencies, but alas, our specialist structural engineers (the truncated version) have opted to play second fiddle to planners, by becoming unsung heroes and performing only the number crunching services, while carrying the albatross of safety around their necks, during the service life of structures.

It has been my personal experience that the Lead Consultant's role is far more gratifying for any Engineer, than the role of a sub consultant which is only tantamount to being a cog in the wheel. It is extremely satisfying and also financially rewarding to execute a Mega Project as a Main/Prime Consultant.

B-36

TECHNICAL BULLETIN

PERMIT AND RESOURCE MANAGEMENT DEPARTMENT

2550 Ventura Avenue, Santa Rosa, CA 95403
(707) 565-1900 FAX (707) 565-1103

Plans Requiring Design by Licensed Architect or Engineer

BUILDING DESIGN LIMITATIONS

Architects may design any building, including engineering elements, of any type except:

- structural portion of a hospital

  Applicable statues: H&SC Section 129805; B&PC Sections 5500.1 & 6737

Civil Engineers may design any building, including architectural elements, of any type except:

- hospitals
- schools

  Applicable statutes: H&SC Section 129805; B&PC Sections 5537.5, 6731, 6735; Education Code Section 17302

Structural Engineers may design any building, including architectural elements, of any type:

- no limitations

  Applicable statutes: B&PC Sections 5537.1, 6731, 6736

Secondly, it is important to get hired by the Owners directly and not through any other Consultant/s, especially a mere planner, and your fair share of responsibility, remuneration & scope of work has been officially contracted before start of work. It is obvious that Owners would always have a greater emphasis on safety than any other third person who may be interested only in external aesthetics to further their personal or other pursuits so as to get the project featured in a magazine for further mileage at the cost of Owner. A direct hiring by the Client ensures exposure, honour & respect for our profession in relation to other professionals involved in the project. It may not be out of place to state that for any changes affected, or for any increase in scope of works, the remuneration is almost always enhanced on pro-rata basis by the owners. The payment received as a Sub Consultant is more often than not, barely enough to cover survival costs of a Sub-Consultant's office. Mostly, it works on a one-way trust equation, no work orders may ever be issued and payments are released arbitrarily. In my experience, when you ask for a Work Order for a Project under design (or maybe nearing completion), you may be shown the carrot of yet another Project and we enthusiastically and willingly jump on board! Thus we almost never get paid as per mutually agreed payment terms, and may not get the last few payments at all! As a Sub-consultant, one may never be able to stand up and protest when the Planner (& paymaster) suggests (read commands) that we design highly Irregular Geometries, or provide hidden beams, or flat plates or floating columns or a stilted parking or a Transfer Girder in a high rise structure in highly seismic areas like NCR. As a Structural designer, one has to always follow Safety First as the golden epic rule, which however is not easily understood by Planners, who are almost always obsessed with a esthetics, facades and finishing. Does the lack of remuneration subdue the voice of one's conscience? Yes, it does, and not only that, it probably slowly kills one's passion and commitment to produce the highest quality of design through an assertive dialogue with the Planners/Client and put in the desired level of sincere efforts and innovation.

One may question my over emphasis to get paid a decent fee, as some of us are driven by our love for the profession and have gotten used to slogging and can go on working for ever and ever without even sending reminders for due payment. We feel shy and even embarrassed asking for our dues, and fall painfully short where marketing skills are concerned and fail to admit this shoddy treatment meted out to us as a fraternity in any open platforms. So what does it all lead to? It might lead to a set of underpaid and de-motivated team members, use of pirated and often old

computers, obsolete design softwares and sometimes even part-time design engineers, reducing the chances of any brilliant or innovative design being produced in such an establishment. We have all heard stories of design personnel not being paid for months altogether in many design offices, or of senior employees being fired at short notice, and such heartbreaks are obviously a result of extremely poor cash flows in structural engineering consultancy (in the case of truncated version only) profession generally. Needless to mention here, that many old engineering stalwarts running prestigious Consultancy firms in India, have given up hope of revival and sold out to bigger MNC firms or simply closed shop and disappeared.

So how does one infuse ethics and revive the competence level of designers in general? Is lack of regulation a good old excuse and we should wait till our Government finally wakes up and accepts our long overdue demand for a Civil Engineers' Bill? Well the answer, my dear friends, is to look inside and introspect. I personally feel that we must provide our services and engage only with Owners, follow a Code of Ethics and stick to diligently performing our role with commitment once we have accepted an assignment; the due diligence about the Scope, deliverables, fees and payment terms must precede the acceptance and we must focus on every important aspect of our engagement before taking it up. I feel Engineering Associations like IAStructE can play a stellar role in establishing and implementing this Code of Ethics through an ETHICS Committee responsible for accepting complaints/reviewing and reporting on them within a stipulated time frame. This will surely give more credibility to our profession and raise the standard of our designs to a Globally acceptable one.

Here I would like to share one of my recent experiences as a Review (Proof) Consultant for a multistoried Housing Society Project with an open stilted parking and Flat Plates being provided as the only means of Lateral Load Transfer. The slab thickness provided was grossly inadequate and failed in carrying the induced moments, and there were no column capitals or Column drops provided. A Report was presented to the Client, listing out the above and the other short falls in the analysis/design and the well meaning Client could be made to see reason, after a few joint meetings with the Main Consultant Design Consultant. While our recommended options for a retrofit were being debated and discussed with the Clients' Technical team, another Structural Engineering firm entered the scene and gave a clean chit to the previous design, also getting them a Certificate from an Engineering Institution of repute.

This certainly was an unexpected development, as to this date I cannot believe that the Client has been misled by another so called professional structural engineer; they have unknowingly agreed to compromise the safety of structures. The customers don't know that their life's savings has gone into buying a house which is not designed for earthquake and is in fact safe only to carry vertical loads. I can, without sounding pretentious, mention that the society buildings will fail whenever a Zone IV Earthquake (as per IS:1893) strikes close to the region and I wonder who will reconstruct them in the aftermath of such an unfortunate occurrence? The Builder shall have walked out by then (RERA not withstanding), and the survivors of such a disaster will be devastated enough; so who goes for Local authority approvals and gets the reconstruction done? And at whose cost? And who is more responsible morally and legally, in such a case the developer or the second review Consultant who has assisted him with a sham Structural Stability Certificate, probably due to lack of professional awareness of BIS codes?

I would like to leave you with this food for thought and do hope the article will make all of us introspect and see what measures need to be taken to improve Quality of designs being done by us. At a recent interaction with delegates after a lecture at a high profile seminar, I was surprised to hear from a large number of structural engineers that they were not aware of any special enhanced force application for lateral load analysis in the case of stilt buildings! The thought is not too far-fetched if I say that some such unsafe condominiums may be bought and occupied by our own family members and/or friends. May be we would like to install latest versions of engineering software's in office, send our engineers for skill up-gradation, and encourage them to read the Revised and Under revision BIS codes 1893, 13920, Draft 10639, NDMA guidelines for Hospitals etc.

Practicing Structural Engineers need to crawl out of their cocoons to become leaders and devote time to nation building by taking active part in the formulation stages of various BIS codes as also spreading awareness of their applications. **It is high time we realize that Structural Engineers have been entrusted by society to create A SAFE & SUSTAINABLE BUILT ENVIRONMENT FOR HUMANITY & LEAD THE DESIGN TEAMS.**

INDIA'S VISION 2030
WHAT ENGINEERS & TECHNOLOGISTS CAN DO?

Ajit SABNIS
President, ACCE(I)
CMD- InCiCon AG
ajitsabnis57@gmail.com

Mr. Ajit Sabnis, graduated in Civil Engineering from BMS College of Engineering, Bangalore 1979, post-graduated from IIT, Madras 1981, has to his credit a number of major design projects in India & overseas. In his illustrious career spanning 35 years, he has made significant contributions in the field of Civil and Structural engineering, by sharing his expertise and experience. He is the CMD - InCiCon AG, an Innovative Civil Engineering Conclave and also Partner- Inci-Retrofit- Company involved in Retrofit and Structure Rehabilitation. He is also holding the post of President of Association of Consulting Civil Engineers [ACCE(I)], Editor-in-Chief-Built Constructions, monthly publication dedicated to Civil Engineering and Architecture.

Synopsis

It is time now for us to shift gears and surge ahead realizing the tremendous responsibility on our shoulders as true nation builders. We have challenges galore! How do we collectively and effectively engage ourselves in achieving this endeavor?

New role of a civil engineer extends beyond what we learn within the four walls of our class rooms. An integrated approach with a solution to the ever increasing environmental crisis cannot be ignored. Development of a sustainable society by adopting innovative sustainable construction techniques goes beyond what is taught. A sense of national pride, respect to other living beings, co-existence are the vital parameters to be understood by the engineers and architects as true nation builders. Example, we cannot design a town without understanding the cultural diversity that exists in a particular region. Let us take a step forward in this direction.

Niti Aayog has decided to do away with conventional Five year Plans and instead come out with Vision India-2030. This laudable decision comes in the wake of India's commitment to the global community under the auspice of United Nations, during the recently held summit (COP 21) at Paris in September 2015, where 195 countries participated. Highlight of this summit was-every country is legally bound to the commitments made to the global community. One of the important decisions taken during the said summit is to strive hard to hold global temperature rise below 1.5 degree C till 2100. Emerging trends show that this threshold level of 1.5 degrees would be staring us by 2030, if not addressed now.

Every country was expected to indicate its INDCs (Intended Nationally determined Contributions). India has expressed its intentions in terms of 17 macro goals comprising of about 170 sub-goals. Developed nations acknowledged the need of developing nations to grow and promised financial support with relevant inputs in terms of research and technologies. It is on the shoulders of developing nations to strike balance between Development and Sustainability and to protect the limited natural resources.

In view of this, Sustainability becomes the fulcrum on which all our engineering actions should balance. For Civil Engineers, the focus is on the impact of Built Environment on Natural Environment. Built Environment circumscribes all that is built for human comfort.

INDIA'S VISION 2030
WHAT ENGINEERS & TECHNOLOGISTS CAN DO?

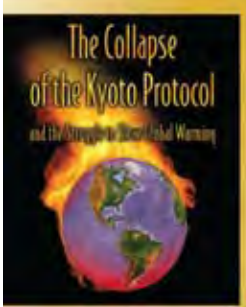
November 28, 2016
India International Centre, New Delhi

Ajit Sabnis
President, ACCE(I)

It all began at the Rio, Brazil, Earth Summit In 1992. The Convention included the adoption of the UN Framework on Climate Change.

THIS CONVENTION SET OUT A FRAMEWORK FOR ACTION AIMED AT STABILIZING ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES (GHGS) TO AVOID " DANGEROUS ANTHROPOGENIC INTERFERENCE WITH THE CLIMATE SYSTEM."

FOLLOWED BY:



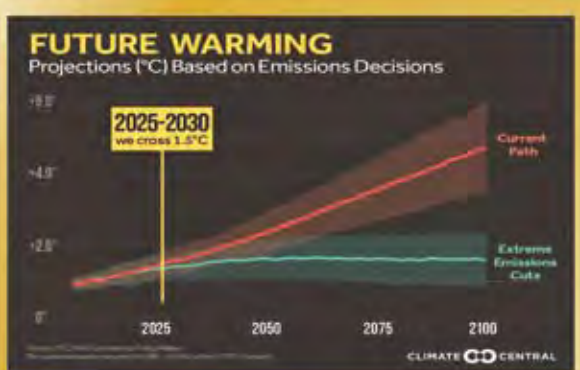
- **Kyoto Protocol (COP3) Kyoto, Japan, 1997. Setting internationally binding emission reduction targets.**
- **Placed a heavier burden on developed nations, being responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity**

THEN CAME :
COP 21, THE PARIS SUMMIT, 2015

- **INDIA PLAYED A MAJOR ROLE.**
- **195 COUNTRIES PARTICIPATED**
- **DEVELOPED NATIONS PLEDGED**
- **FINACE OF 100 B-USD**
- **STRIVE HARD TO HOLD GLOBAL TEMPRATURE RISE BELOW 1.5 DEG**
- **COUNTRIES WERE BOUND BY INDCs**

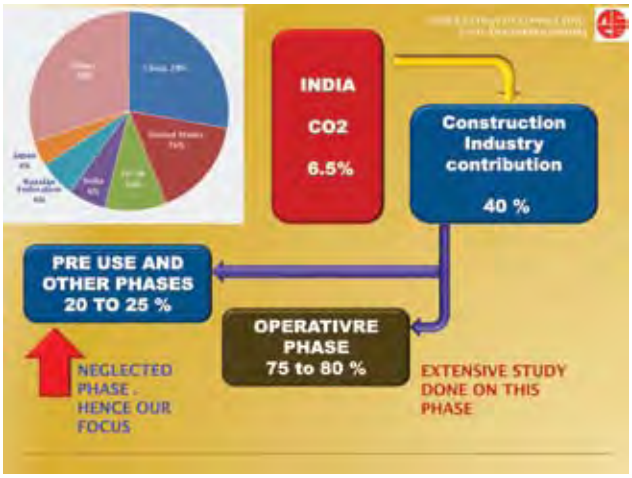
INDC : Intended Nationally Determined Contributions

WHAT FOR ?



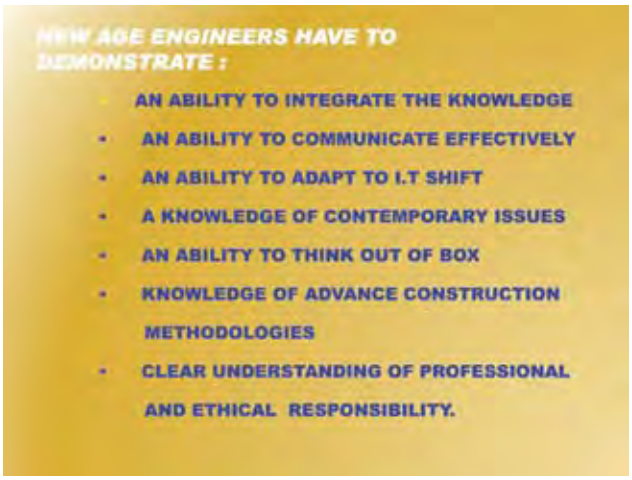
India's Intended Nationally Determined Contributions (INDCs)

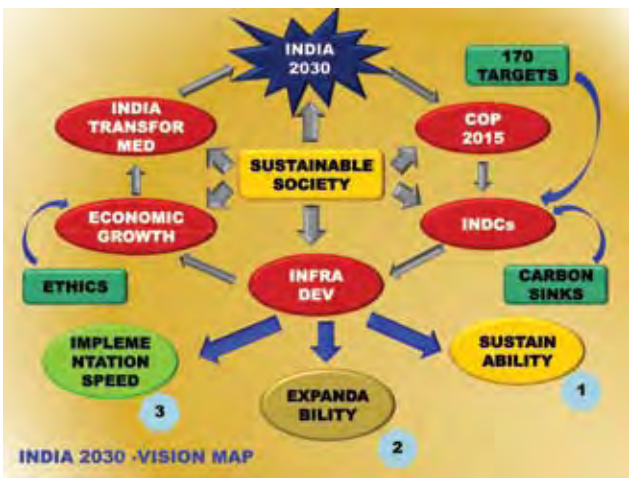
- **Annually, 220 billion rupees of CSR money is to be spent on environmental initiatives.**
- **Propagate Sustainable Living**
- **Adopt Eco-friendly Paths / Mechanisms**
- **Reduce GHG emission by 35% by 2025**
- **Generate 40% of the total power required using renewable energy technologies.**
- **Create additional carbon sink of 2.5 to 3 billion tonnes by 2030.**
- **In addition to this India has strategized many GHG reduction measures.**


INDIA
CO2
6.5%
Construction Industry contribution
40 %
PRE USE AND OTHER PHASES 20 TO 25 %
OPERATIVRE PHASE 75 to 80 %
NEGLECTED PHASE . HENCE OUR FOCUS
EXTENSIVE STUDY DONE ON THIS PHASE

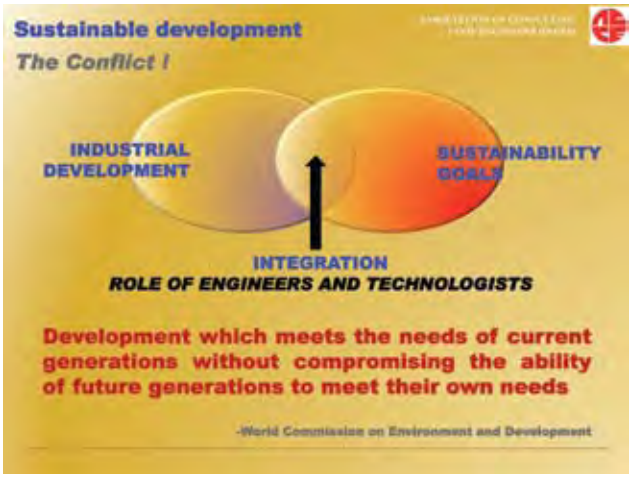

FUTURE DEMANDS
ENERGY SCENARIO IN INDIA
• 16% OF GLOBAL POPULATION APPROXIMATELY
• INSTALLED CAPACITY – 160000 MW
• PROJECTED CAPACITY BY 2030 – 800000 MW
• CAPITAL INVESTMENT NEEDED - 1 TRILLION USD
• 66% OF INDIA'S COMMERCIAL BUILDINGS REQUIRED BY 2030 NOT YET BUILT
NO OTHER COUNTRY IN THE WORLD WOULD HAVE ENCOUNTERED THIS KIND OF A GROWTH IN DEMAND.

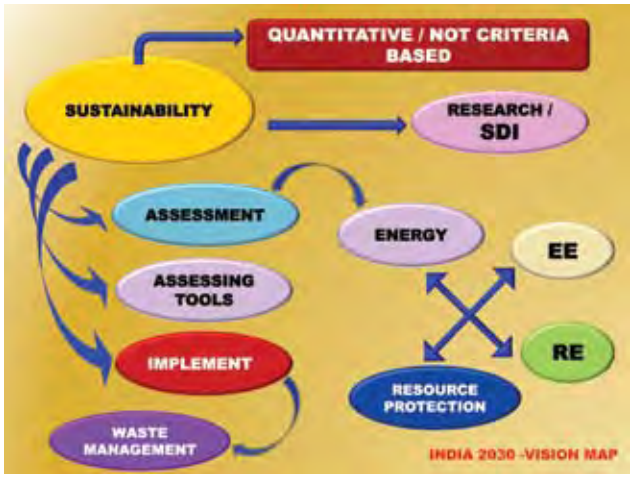

FUTURE BUILDING REQUIREMENTS
Should be :
Energy Efficient - Blend with nature - Self sufficient in terms of water and Power – Floor to ceiling windows - No curtains - Auto chromatic - Biomimicry accepted - Self secured – Smart and Intelligent - Wall panels to store Energy Roof Insulation - Sensitized Flooring - Waterless Urinals and Closets - Recycled Materials - Minimum Manpower – Minimum Cost - Maximum Technology Most Functional – Appealing - Construction time say 72 hrs. And So on.....

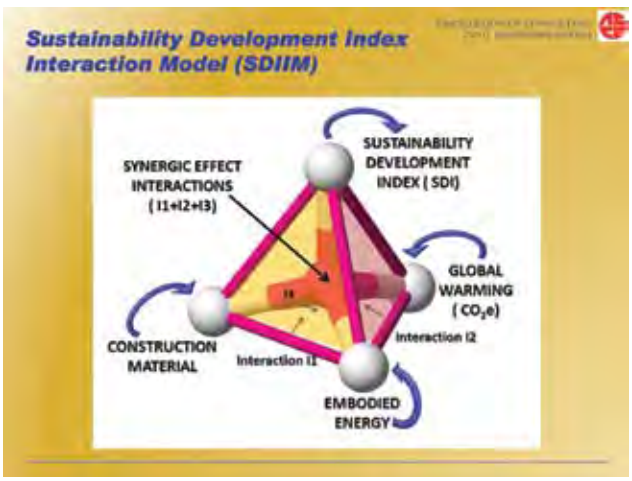

NEW AGE ENGINEERS HAVE TO DEMONSTRATE :
• AN ABILITY TO INTEGRATE THE KNOWLEDGE
• AN ABILITY TO COMMUNICATE EFFECTIVELY
• AN ABILITY TO ADAPT TO I.T SHIFT
• A KNOWLEDGE OF CONTEMPORARY ISSUES
• AN ABILITY TO THINK OUT OF BOX
• KNOWLEDGE OF ADVANCE CONSTRUCTION METHODOLOGIES
• CLEAR UNDERSTANDING OF PROFESSIONAL AND ETHICAL RESPONSIBILITY.

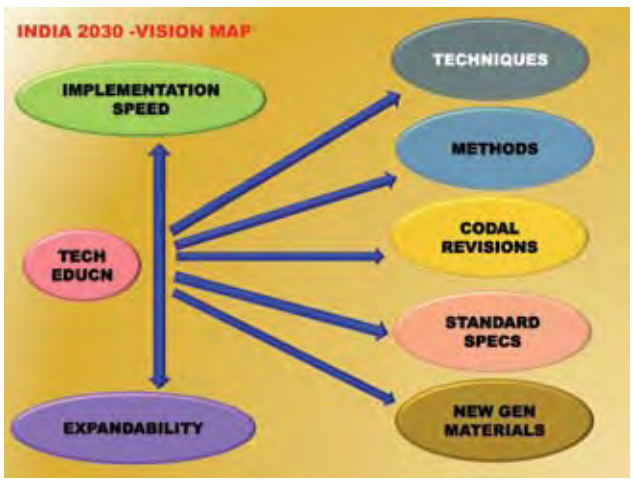

INDIA 2030
170 TARGETS
INDIA TRANSFOR MED
COP 2015
SUSTAINABLE SOCIETY
ECONOMIC GROWTH
INDCs
ETHICS
INFRA DEV
CARBON SINKS
IMPLEME NTATION SPEED
3
EXPANDA BILITY
2
SUSTAIN ABILITY
1
INDIA 2030 -VISION MAP


SUSTAINABILITY IN TRUE SENSE
Social Environment
SUSTAINABILITY
Natural Environment
Economic Environment
Holistic Integration of all the three independent environmental entities.
Engineers focus on the sphere of Natural Environment.

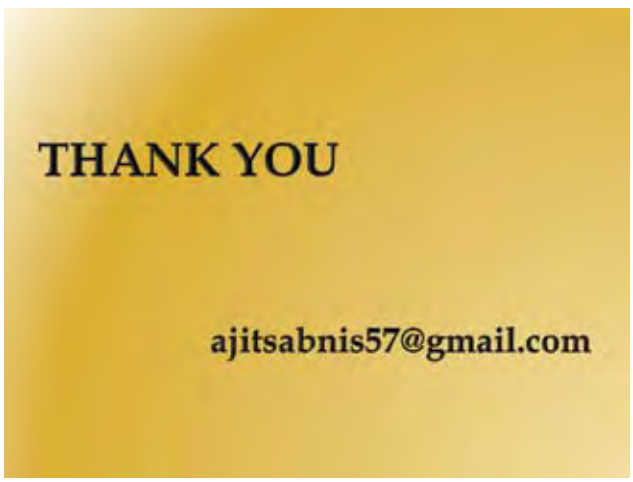

Sustainable development
The Conflict !
INDUSTRIAL DEVELOPMENT
SUSTAINABILITY GOALS
INTEGRATION
ROLE OF ENGINEERS AND TECHNOLOGISTS
Development which meets the needs of current generations without compromising the ability of future generations to meet their own needs
-World Commission on Environment and Development


QUANTITATIVE / NOT CRITERIA BASED
SUSTAINABILITY
RESEARCH / SDI
ASSESSMENT
ENERGY
EE
ASSESSING TOOLS
IMPLEMENT
RE
RESOURCE PROTECTION
WASTE MANAGEMENT
INDIA 2030 -VISION MAP


Sustainability Development Index Interaction Model (SDIIM)
SUSTAINABILITY DEVELOPMENT INDEX (SDI)
SYNERGIC EFFECT INTERACTIONS (I1+I2+I3)
GLOBAL WARMING (CO_2e)
Interaction I2
CONSTRUCTION MATERIAL
Interaction I1
EMBODIED ENERGY


INDIA 2030 -VISION MAP
IMPLEMENTATION SPEED
TECHNIQUES
METHODS
CODAL REVISIONS
TECH EDUCN
STANDARD SPECS
NEW GEN MATERIALS
EXPANDABILITY


OPPORTUNITIES...
PROJECT ENGINEERS
FORENSIC ENGINEERS
CONCRETE TECHNOLOGIST
GREEN CONSULTANTS
EQUIPMENT CONSULTANTS
PROJECT MANAGERS
CONTRACT EXPERTS
FORMWORK SPECIALISTS
NANO TECHNOLOGISTS
DEMOLITION EXPERTS
WATER CONSERVATION
PC/PEB EXPERTS
WATER PROOFING
NEW GEN MATERIAL EXPERTS
BUILDING AUTOMATION.


THANK YOU
ajitsabnis57@gmail.com

DEVELOPING THE NEXT GENERATION OF CIVIL ENGINEERS – A CHALLENGING TASK AHEAD

Alok BHOWMICK
Managing Director,
B&S Engineering Consultants Pvt. Ltd.,
Delhi
bsec.ab@gmail.com

Mr. Alok Bhowmick, graduated in Civil Engineering from Delhi University in 1981, post-graduated from IIT, Delhi in 1992, has to his credit a number of major design projects in PSC, RCC and Structural Steel in India & overseas. In his illustrious career spanning 35 years, he has made significant contributions in the field of structural engineering, by sharing his expertise and experience. He is an active member of several technical committees of Indian Roads Congress and BIS. He is a 'Fellow' of Indian Association of Structural Engineers and also a member of its Governing Council. He is also a GC member of Consulting Engineers Association of India, Vice Chairman of Indian National Group of IABSE and Chairman of the Editorial Board of this Journal published by ING-IABSE

Synopsis

Civil Engineers in India are currently facing significant challenges. The profession is fast changing globally due to developments such as globalization, energy and sustainability imperatives, scientific advances in automation and technology, economic pressures due to population explosion, depleting natural resources, changes in natural hazards due to climate change … etc. …etc. Civil Engineering profession in India is perhaps not able to cope with this dizzying pace of development. This situation has created challenges and opportunities, to the fraternity. The author is of the view that if we civil engineers are to maintain a vibrant profession, attract the best and brightest Engineers, and remain relevant in the society, we will have to revisit our professional conduct, our curriculum for undergraduates and graduates. We will also have to significantly improve our professional practices in the industry and re-engineer our roles. The civil/ structural engineering fraternity in India has to work hard to formulate strategy, train the next generation of engineers to take leadership role in our profession. Senior engineers must invest their time and energy in this direction for the sake of our future generation. This paper highlights the issues that confronts civil/ structural engineers in the country today and suggests the way forward for developing the next generation of Civil and Structural Engineers.

Keywords: Civil Engineering; Structural Engineering; Continuous Professional Development;

1. Introduction

Civil Engineering is one of the oldest and most noble professions in the world, born out of people's age-old needs. Civil engineering is an umbrella field comprising of many related specialties. The broad categories of fields under civil engineering are:

a. Architectural Engineering & Town Planning
b. Building Materials
c. Construction Technology
d. Environmental Engineering
e. Geotechnical Engineering
f. Hydraulics, Water resources and Irrigation Engineering
g. Remote Sensing and GIS
h. Structural Engineering
i. Surveying
j. Transportation Engineering

It is a high responsibility profession. of paramount concern is the safety of public.

Civil engineers are the custodians of the built and natural environment. They work for the welfare of the public and society at large. They build the essential infrastructure upon which society depends. They help turn engineering knowledge into action. They are the people involved to address pressing global challenges such as Devastating water poverty, Growing urbanization, Energy shortages and climate effects.

Despite being a noble profession, Civil Engineers, instead of receiving public gratitude, often carry a negative social stigma. The lack of respect to this profession in the society is unfortunately growing. Civil Engineers are in news only when there is a failure or a calamity. This hard reality galls many in our profession, especially when compared to the public adulation given to people from other professions (such as Doctors, Lawyers, Scientists, Chartered Accountants, Bolly-wood Actors, Artistes …etc.).

Structural Engineering, which is one of the sub-discipline of Civil Engineering, deals with planning, analysis, design and research in structural systems &components of built environment, to achieve performance goals and ensure the safety and comfort of users or occupants economically. Structural Engineer's work takes account mainly of safety in planning & design, durability, technical, economic and environmental concerns, but they also need to consider aesthetics and social factors.

Civil/Structural Engineering Practice is going through trying times. Some industry giants have already began to call it a 'sunset industry'. The profession today is at critical cross roads. If the engineering fraternity fails to understand this situation and do not act boldly now, I am afraid our stature will become more and more trivialized and this will be a great disservice not only to our future generation in the profession but also to the society at large.

Though there are several reasons for this poor image of Civil Engineers in the society, one of the factor responsible for this is the lack of regulation of the profession of Civil Engineering in the country. This is much unlike the profession of Doctors, Lawyers and Chartered Accountants, which are regulated profession by act of parliament. Further, Civil Engineers mostly seem to be working in the shadow of Architects, Bureaucrats and Politicians. The public at large often confuse between the profession of Architecture and the profession of Civil Engineering, almost always to the detriment of civil engineering profession. For any good work done in the building industry, Architects are hailed. For any successful completion of a mega infrastructure project, politicians are credited. Engineers who work unceasingly in a project to meet the milestones goals and quality, are not even invited and honored at the inauguration ceremonies, after successful completion of the project. In contrast, if there is any failure, Civil Engineers are indicted and put behind bars without even giving them an opportunity of hearing.

Civil Engineering fraternity in India has unfortunately failed to produce leaders, who could provide leadership to bring about the much needed changes for regulating this profession. We need many more role models of the likes of Sir M. Visvesvaraya (1860-1962), a notable engineer and scholar and Dr E Sreedharan (The Metro Man) in the country. Both of them has have proved their mettle with clean image in the society and are revered by the whole nation for their integrity, sincerity, commitment and leadership qualities.

There is an urgent need for Civil Engineers to up the ante and serve more and more in leadership positions in the society. The public perception about our role in the society and about the work that Civil Engineers do needs to change. It is increasingly apparent that there is a deep churn that demands fast action from the Civil Engineering community to set things in the right direction and to bring back the past glory for this profession. All stakeholders (Contractors, Consultants, Academicians, Owners. etc.), including the professional associations like IE(I), IAStructE, ACCE(I), CEAImust join hands and agree for a vision of how they would want civil engineers to be seen in the next 25 years and in what manner they would like to achieve this target ?

The objective of this paper is to understand the present crisis in the profession, to apprise the readers about the new world realities and challenges, to understand the opportunities that these new realities and challenges present to the next generation of civil and structural engineers, to discuss the ways and means by which we should significantly raise the bar by restructuring our roles so as to contribute in a more meaningful and Impactful way and earn back the desired position in the society.

2. Issues Confronting Civil Engineers

Listing below some of the crucial issues confronting Civil Engineers in India today, in respect of their

roles, responsibilities and their position in the overall construction industry as well as in the society at large.

a. **Mushrooming Engineering Colleges producing unemployable Engineers:** India at present has 6,214 engineering and technology institutions with 2.9 million students enrolled. According to the Ministry of Human Resources & Development (MHRD), 1.5 million engineers pass out every year in India (1). But the quality of engineering graduates in India is woeful. Recent statistics shows that only 18.43% of the total engineers who graduate every year are employable in the IT sector. Only 7.49% are employable in core engineering jobs like mechanical, electronics and civil engineering.

b. **Developing Population Growth:** The current world population is 7.4 billion, which is projected to reach 9 to 10 billion by the year 2050. India with current population of 1.29 billion is likely to overtake China as the world's most populous nation by 2022, with an estimated population of 1.45 billion (as per UN report). The country requires huge number of competent professionals in the coming decades to deal with the growth demands. While this is a huge responsibility entrusted by the society, little effort is being made by the Government and other stake-holders to keep them battle-ready.

c. **Lack of Regulation & Empowerment:** Civil Engineers are the largest body of professionals in India with no official Regulatory Authority. The Institution of Engineers formed by British Charter in 1935 & Engineering Council of India formed by Govt. of India much later in 2002, seem to be doing everything EXCEPT regulating the profession of Engineering. As a result, a surfeit of professional associations have mushroomed all over the country, working at cross-purposes, with little benefit to the profession and to the core practicing engineering professionals.

d. **Ill's of Technology:** Profession of structural engineering is becoming more and more commoditized as computers and software's are doing more of our work. Young Engineers are becoming more and more computer operators and thinking less about the structural behavior and flow of forces. Speed of R&D in software technology is tremendous, and its relevance has also increased exponentially by mass availability. However, with this technological advancements in computing techniques, the curriculum for engineering undergraduate also needs to change rapidly to keep pace with the technological developments, so that engineers focus on understanding of the concepts and flow of forces. Unfortunately this is not happening and we face the threats of global outsourcing and competition.

e. **Lack of attraction to the best and the brightest:** Retaining the best and brightest to this profession of Civil Engineering is becoming increasingly difficult. Low fees, fierce competition, lack of regulations, rampant corruption in the system, poor image of this discipline in society are some of the reasons for this situation. This is a real crisis. But it is also an opportunity for the present leaders in this profession - a chance to change the practice of structural engineering in a profound way.

f. **Knowledge Exchange and Global Competition:** It is clear that the global engineering workforce will be levelled in future. Indian engineers already face offshore competition from multi nationals, much of it high in quality. For Indian engineers to compete internationally, for getting jobs, they must become more competent, more mobile and more willing to improve their knowledge base. A globally flattened market means that engineers of the future will need breadth, both in technical and soft skills, to operate in many diverse locations and cultures. Perhaps most importantly, the engineers need to be adept at collaborating on teams with members scattered around the globe.

g. **Increasing Complexity of Codes and Standards:** Our codes are becoming increasing complex and the practicing engineer's finds it difficult to keep pace with this complexity. Very little support is given by the industry for Continuous Professional Development (CPD) of the engineers.

h. **Lack of Professional Ethics in the industry:** The construction industry is a "perfect" environment for ethical dilemmas, with its low-price mentality, fierce competition, and paper-thin margins. Unethical behavior is increasingly taking a toll on the reputation of the Civil and Structural Engineers. Lack of regulation of the engineering promoting unethical practices profession is proving to be a catalyst in further promoting unethical practices & lowering the image of this profession.

3. The Way Forward & Leadership Transition

As current leaders/senior professionals in the discipline approach the end of their professional careers, it is increasingly important for them to train and prepare the young professionals to take on the baton. Leadership transition plays a vital role in the profession and therefore it is extremely important that the young professionals are motivated and persuaded to take active measures to step into the leadership role. Training and mentorship is required at all levels to encourage young professionals to develop quality work, gain confidence in the work they do and eventually step into management roles themselves.

Following actions are envisaged by the author for civil engineering industry and various professional associations to facilitate this process of leadership transition :

a. Increase familiarity with Codes and Standards: Codes and Standards set a minimum safeguard to the profession. However as codes are becoming more and more complex, they become increasingly susceptible to misinterpretation and misapplication. Young practicing engineers need to develop familiarity with the dense volume of codes, for which many a times, little help is available from the senior engineers in the team (as they themselves are not so well aware). This may involve a nationwide drive by professional associations for professional training at various levels for increasing the understandability of codes and standards for design and construction.

b. Train young professionals how to lead: Consulting firms, contracting firms and Owner client should provide professional training for leadership to the young professionals involved with them. It is necessary to inculcate and develop the managerial skills from early age. Young professionals must be given opportunity for taking up leadership role within project teams, guiding clients and architects towards cost saving and creative solutions.

c. Involve young professionals in various technical code committees: Codes and Standards committees in Indian Roads Congress and in Bureau of Indian Standards should actively seek out for the involvement of young professionals in the age group of 30 to 40 years. Bright young engineers should be encouraged to attend these committee meetings. Even if they are not given the core membership of the committee, they can be invited through invitation from the core committee members. Such practice will give opportunity to the young professionals tolearn the origins of code provisions by simply listening to the conversations in the meeting, to meet the industry stalwarts and to prepare themselves to lead future committees. This will be a great motivating factor for young engineers.

d. Pursue vigorously for the regulation of engineering profession: In the interest of public safety, the entire industry must join hands and pursue vigorously for bringing in Engineers Bill through act of parliament. Engineers Bill should lay down the criteria for the process of registration of practicing Engineers and provide necessary statutory framework for the same. This is long overdue. A Central Act is necessary to regulate all disciplines of engineering. Just one registration by an engineer would then suffice for practicing throughout India. The Engineers Bill has been in the offing for years, but still has to see the light of day. It is only this legislation which will bring in accountability, ethical dealing and professionalism in the profession.

e. Work for Continuous Professional Development (CPD): Continuing professional development (CPD) is the systematic maintenance, improvement and broadening of knowledge and skills, together with the development of personal qualities, necessary for the execution of professional and technical duties throughout a practitioner's working life.Civil Engineering is a highly technical profession, where lot of the learning takes place on the job. If the employer is conscious about the importance of CPD and gives a structured guidance and regular performance appraisal for the engineer, these can provide good CPD documentation, and will take place within the framework of the training support in the organization itself. However, author is of the view that there are very few professional organizations in India, who follows this culture of training. Bulk of the organizations do not have the provision in their set-up for regular on-the-job training and performance assessment for young engineers. For the industry, an extremely important step for bringing young engineers

to the mainstream is to device mechanism to ensure that the young engineers are given on the job training at various levels to continuously upgrade their engineering as well as managerial skills, matching the requirements.

Professional associations and the industry giants must come forward to promote the CPD and provide necessary funds, in the larger interest of the society. The CPD programs should be organized in a manner, such that the consultancy organizations are not burdened too much in case they wish to sponsor their engineers to attend these CPD courses. It should be also designed in a manner that the young professionals can afford to sponsor themselves for their own development and not depend on the sponsorship from the organization they are working for.

f. **Restructure engineering education:** The academicians alone cannot be expected to develop comprehensive technical educational program, reflecting the fast growing and changing needs of industry. Academicians, industrialist, administrators and professional institutions like the National Academy of Engineers and the various professional associations must sit together and chalk out a viable system of technical education. Ministry of Human Resources Development (MHRD) must take lead in this direction.

g. **Increase effort from industry to adopt new technology and methods:** In the years ahead, the construction industry in India has to overcome various challenges - be it with respect to housing, environment, transportation, power or natural hazards. Technocrats associated with the Indian construction industry need to employ innovative technologies and skilled project handling strategies to overcome these challenges.

h. **Foster collaboration between academicians and practitioners:** Collaboration between practitioners and academicians can lead to quicker adoption of new technology and methods developed through research, which will be motivated by the immediate needs of the structural engineering profession.

i. **Increase public awareness about the profession of Civil and Structural Engineering:** Civil Engineers makes headlines only when something catastrophic occurs, and far too little recognition is given to some of the greatest accomplishments of civil engineers in the public domain. Quite often the work of Engineer is hidden behind an extravagant Architect. It is extremely important to bring the civil engineering profession to the forefront of society in a positive light. We need to have more political leaders with civil engineering background. Civil engineers should be more visible in societal activities. There is a need for increased advocacy on national issues by civil engineers such as ageing infrastructure, earthquake resistant design of structures, role of structural engineers in sustainable development …etc., to draw attention of the public on role of civil engineers to solve these issues.

4. Conclusion

Globalization is changing the civil engineering profession. Engineering services are increasingly expanding into international markets, providing both incredible opportunity and significant challenges for the civil engineering profession.

It is imperative that the profession hone its skills at bringing some order into the rapidly falling image of this noble profession immediately. This will require political will and enormous collaboration involving several professional associations, societies, educators, government and other members of the construction industry. It is hoped that the future generation of civil and structural engineers will be better leaders than the present and will play a significant role in shaping the future of this noble profession.

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HIGHLIGHTS OF THE ING-IABSE SEMINAR ON "URBAN TRANSPORT CORRIDORS" HELD AT VISAKHAPATNAM (ANDHRA PRADESH) ON 21ST AND 22ND OCTOBER 2016

The Indian National Group of the IABSE successfully organized a two day Seminar on "Urban Transport Corridors" at Visakhapatnam on 21st and 22nd October 2016 in cooperation with Government of Andhra Pradesh, Transport, Roads and Buildings Department duly supported by Ministry of Road Transport and Highways. The Seminar was also supported by the other Public and Private Sector organizations in India.

The mission of this Seminar was to highlight the opportunities for the development of urban transport structures in India and discuss the key challenges in this segment. It also showcased the latest technology, best practice and noteworthy projects.

The Seminar covered the following three Technical Sessions:

Technical Session-I	Policy and Planning
Technical Session-II	System and Engineering
Technical Session-III	Financing and Case Studies

In all, 23 papers were published in the Seminar Report brought out on this occasion. Selection of the papers was done by the Scientific Committee constituted for the seminar.

Out of these, 22 papers were presented during the Seminar by the following eminent experts.

	21st October, 2016	**Session-I - Policy and Planning**
1	Dr BC Roy	Urbanization in India: Mass Transit System
2	Mr AV Sinha	Presenting a Perspective on Transport Planning for Delhi
3	Mr PRK Murthy	Hyderabad Karimnagar Ramagundam/Hyderabad Narsapur Medak-Elevated Corridor
4	Mr C Sankralingam	Challenges and Innovations in the Construction of Mass Rapid Transport System
5	Mr Alok Bhowmick	Role of Civil Engineers in Sustainable Urban Infrastructure Planning, Design and Construction
6	Mr N Srinivasa Rao	The New Capital City in Andhra Pradesh - Amaravati
7	Dr Mahesh Kumar	Transit Oriented Development and Landuse Planning
		Session-II - System and Engineering
8	Dr Ankit Gupta	Emergency Management System for Tier-II Indian Cities using GIS
9	Dr BS Singla	Personal Rapid Transit (PRT) System - An Innovative Solution of Urban Transport
10	Mr VM Naidu	Study of Travel Parameters over City Population
	22nd October, 2016	**Session-II - Continued.....**
11	Mr Puneet Singh Bindra	ITS for Safety of Traffic Operations in Urban Corridors
12	Mr Deepak Saxena	Use of ITS - Coordination, Efficiency, Monitoring, Safety & Security in Urban Transport
13	Dr Lakshmy Parameswaran	SHM for Structural Health Assessment of Elevated Road Corridor

		Session-III - Financing & Case Studies
14	Mr Lalit Kumar Joshi	Financing of Highways
15	Mr Amitabha Basu	Developing Transport Corridor through PPP & Regional Cooperation
16	Mr Alkesh Sharma	Innovative Financing for Urban Transit Corridor
17	Mr Amit Chakraborty	Metro Construction Begs Innovative Solutions - Few Case Study
18	Mr Probal Kundu	Design and Construction of an Underground Metro Railway Station in Rocky Strata with Hybrid Construction Methodology at New Delhi
19	Mr Milind Madhusudan Bhoot	Flyover Structures in a Congested Urban Conditions
20	Mr N Subramanian	Challenges and Innovations - Hyderabad Metro - A Case Study
21	Mr S Naveen Reddy	HKR and HNM Elevated Corridor
22	Mr Rakesh V Varadkar	Innovative Solution for Building Urban Transport Corridor using Precase Segmental I Girders

The Seminar Report (236 pages) in CD can be ordered (e-mail: ingiabse@bol.net.in; ingiabse@hotmail.com) at Secretariat of the Indian National Group of the IABSE at New Delhi.

The Seminar was inaugurated by Shri Sidda Raghava Rao, Hon'ble Minister Transport, Roads and Buildings, Andhra Pradesh and Shri Ghanta Srinivas Rao, Hon'ble Minister for Higher Education, Andhra Pradesh by lighting the traditional lamp. Other dignitaries, Shri D.O. Tawade, Chairman, ING-IABSE, Shri AD Narain, Chairman, Scientific Committee, Shri B. Sam Bob, Special Chief Secretary, R&B Department, Govt of Andhra Pradesh, Dr Harshavardhan Subbarao, Vice President of IABSE, Shri M Gangadharam, Engineer-in-Chief, R&B Department, Govt of Andhra Pradesh, Shri Ninan Koshi, Honorary Member of IABSE and Shri R Gopalakrishna, Chief Engineer, NH & R&B also graced the occasion. On this occasion, Chief Guest of the Seminar also released the Souvenir.

The Concluding Session was held on 22nd October, 2016. Shri AD Narain, Chairman, Scientific Committee gave the Valedictory Address in the presence of Shri D.O. Tawade, Shri B. Sam Bob and Shri M Gangadharam as well as other dignitaries. The delegates for participation in the deliberations of the Seminar mentioned that the subject matter of the Seminar on "Urban Transport Corridors" is very timely.

Eminent experts from various fields took part in the deliberations. The Seminar was attended by over 200 participants from various Govt Departments as well as other private and public organizations.

A cultural programme was orginized in the evening of 21st October 2016 for the participants who rejoiced the evening.

The Seminar was a great success.

A view of the Dais during the Inauguration

Shri D.O. Tawade, Chairman, ING-IABSE
Delivering his address

Shri A.D. Narain, Chairman, Scientific Committee
Delivering his address

Souvenir released by Shri Sidda Raghava Rao,
Hon'ble Minister of Transport, Roads and Building,
Andhra Pradesh

A view of the audience during the Inauguration

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TO THE VICE-PRESIDENT OF INDIA
नई दिल्ली/NEW DELHI - 110011
TEL.: 23016422 / 23016344 FAX : 23012645

MESSAGE

The Hon'ble Vice President of India is happy to learn that the Indian National Group of the International Association for Bridge & Structural Engineering, New Delhi had organized a Seminar on 'Urban Transport Corridors' on October 21 – 22, 2016 at Visakhapatnam, Andhra Pradesh.

The Vice President extends his greetings and congratulation to the organizers and the participants for organizing the Seminar.

(Anshuman Gaur)

New Delhi
25th October, 2016.

प्रधान मंत्री कार्यालय
नई दिल्ली - 110011
PRIME MINISTER'S OFFICE
New Delhi - 110011

MESSAGE

The Prime Minister is happy to learn that Indian National Group of The International Association for Bridge & Structural Engineering is organising a Seminar on 'Urban Transport Corridors' on 21st- 22nd October, 2016 in Visakhapatnam and publishing a souvenir to mark the occasion.

On this occasion, best wishes to the organisers and participants.

(P.K. Sharma)
Under Secretary

New Delhi
October 20, 2016

सुरेश प्रभु
SURESH PRABHU

सत्यमेव जयते

स्वच्छ भारत

रेल मंत्री
भारत सरकार, नई दिल्ली
MINISTER OF RAILWAYS
GOVERNMENT OF INDIA
NEW DELHI

18 OCT 2016

MESSAGE

I am glad to know that Indian National Group of The International Association for Bridge & Structural Engineering (IABSE) is organizing seminar on "Urban Transport Corridors" on 21st & 22nd October, 2016 at Visakhapatnam.

It is really praiseworthy that the IABSE has been continuously working for planning, design, construction, operation, maintenance and repair of civil engineering structures. These types of seminar would bring engineers and professionals from both the public and private sector as well as from Research and Academic Institution, where they would meet and exchange their knowledge and experiences.

I wish the event a grand success.

(Suresh Prabhu)

239, रेल मंत्रालय, रेल भवन, नई दिल्ली–110001
239, Ministry of Railways, Rail Bhawan, New Delhi-110001
Tel. : 011-23381213, Fax : 011-23387333
sureshprabhu@rb.railnet.gov.in, sureshprabhu@gov.in

HIGHLIGHTS OF THE ING-IABSE WORKSHOP ON "CODE OF PRACTICE FOR CONCRETE ROAD BRIDGES IRC:112:2011" HELD AT MUMBAI ON 18TH AND 19TH NOVEMBER, 2016

The Indian National Group of the IABSE in co-operation with Govt of Maharashtra, PWD and Maharashtra State Road Development Corporation (MSRDC) successfully organised a two day Workshop on "Code of Practice for Concrete Road Bridges IRC:112:2011" at Mumbai on 18th and 19th November, 2016. The Workshop was well attended by more than 200 delegates from various Govt Departments as well as other private and public organizations.

The aim of the workshop was to provide a unique opportunity to the Engineers of the State PWD, the practicing engineers and the students to interact with experts for dissemination of knowledge and experiences relating to the latest techniques in design of bridges and other structures using the "Code of Practice for Concrete Road Bridges IRC:112:2011". Participation of delegates in floor intervention and discussions was very encouraging.

The Workshop was inaugurated by Shri Chandrakant Dada Patil, Hon'ble Minister of Public Works Department, Maharashtra by lighting the traditional lamp in the presence of Shri D.O. Tawade, Chairman, ING-IABSE, Shri Ashish Kumar Singh, Principal Secretary, Public Works Department, Govt of Maharashtra, Shri S.B. Tamsekar, Secretary (Roads), Shri C.P. Joshi, Secretary (Works), Prof Mahesh Tandon, Managing Director, Tandon Consultants Pvt Ltd., Shri P.S. Mandpe, Joint Managing Director, Maharashtra State Road Development Corporation Ltd and Dr Harshavardhan Subbarao, Chairman, Scientific Committee as well as other dignitaries.

Shri Ashish Kumar Singh, Principal Secretary, Public Works Department, Govt of Maharashtra extended warm welcome to the participants of the Workshop. Shri D.O. Tawade, delivered his address during the Inauguration. Shri R.K. Jawanjal, Suptd Engineer, PWD proposed Vote of Thanks.

The Workshop on "Code of Practice for Concrete Road Bridges IRC:112:2011" was addressed by the following eminent experts covering the following themes who were either involved in the preparation of the Code or have used in extensively since its publication.

	18th November, 2016		
1	Dr Harshavardhan Subbarao	-	Overview & Scope Basis of Design
2	Prof Mahesh Tandon	-	Material Properties and Design Values
3	Shri DA Bhide	-	Action and Load Combinations
4	Shri Umesh K Rajeshirke	-	Ultimate Limit States
5	Shri Vinay Gupta	-	Serviceability Limit State
6	Shri VN Heggade	-	ULS of Induced Deformations & SLS
7	Shri Alok Bhowmick	-	ULS of Shear, Punching Shear & Torsion
	19th November, 2016		
8	Shri Alok Bhowmick	-	Detailing Aspects
9	Shri Nirav Mody	-	Case Study 1: Design of I Girders
10	Dr AK Mullick	-	Durability, Quality control & workmanship
11	Shri PG Venkatram	-	Case Study 2: Design of Integral Bridge
12	Shri Aditya Sharma	-	Case Study 3: Design of Box Culverts, CD Work, Abutments, Retaining Walls

The concluding remarks of the Workshop were presented by Dr Harshavardhan Subbarao, Chairman, Scientific Committee on 19th November, 2016. He expressed the hope that the outcome of the Workshop would have enriched the delegates. The delegates who attended the Workshop mentioned that the subject matter of the Workshop is very timely. Shri P.S. Mandpe, Joint Managing Director, MSRDC proposed Vote of Thanks.

A light music with dinner was organized in the evening of 18th November, 2016 for the participants who rejoiced the evening.

The Workshop was a great success.

Shri Chandrakant Dada Patil, Hon'ble Minister, Public Works Department, Maharashtra lighting the traditional Inaugural Lamp along with high dignitaries

Shri D.O. Tawade, Chairman, ING-IABSE Delivering his address

Shri Chandrakant Dada Patil, Hon'ble Minister, Public Works Department, Maharashtra Delivering his address during Inaugural Function

Hon'ble Minister presenting a cheque of Rs10.00 lakhs to Chairman, ING-IABSE during the Inaugural Function

A view of the audience during the Inauguration

INDIAN NATIONAL GROUP OF THE IABSE
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Persons represented ING on the Executive Committee and Technical Committee of the IABSE

8. Dr. Harshavardhan Subbarao, Vice President & Member, Technical Committee of IABSE & Chairman and Managing Director, Construma Consultancy Pvt. Ltd.,

Past Member of the Executive Committee and Technical Committee of IABSE

9. Prof. S.S. Chakraborty, Past Vice-President, IABSE
10. Dr. B.C. Roy, Past Vice President & Member, Technical Committee, IABSE

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11. Shri R.K. Pandey, Member (Projects), National Highways Authority of India

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14. Shri A.V. Sinha, Former Director General (Road Development) & Special Secretary
15. Shri G. Sharan, Former Director General (Road Development) & Special Secretary
16. Shri R.P. Indoria, Former Director General (Road Development) & Special Secretary
17. Dr. Lakshmi Parameswaran, Chief Scientist, Bridges & Structures Div., CSIR-Central Road Research Institute
18. Shri Ashwinikumar B. Thakur, Group Engineer, Atkins India
19. Shri Sarvagya Kumar Srivastava, Engineer-in-Chief (Projects), Govt of Delhi
20. Dr. Mahesh Kumar, Engineer Member, Delhi Development Authority

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23. Shri K.B. Sharma, Under Secretary, Indian National Group of the IABSE

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Rule-9 (a): A representative of the Union Ministry of Road Transport and Highways

1. Shri D.O. Tawade, Chief Engineer (Coordinator-II), Ministry of Road Transport & Highways

Rule-9 (b): A representative each of the Union Ministries/Central Government Departments making annual contribution towards the funds of the Indian National Group of IABSE as determined by the Executive Committee from time to time

2. CPWD - nomination awaited
3. NHAI - nomination awaited
4. Ministry of Railways - nomination awaited

Rule-9 (c): A representative each of the State Public Works Departments/Union Territories making annual contribution towards the funds of the Indian National Group of IABSE as determined by the Executive Committee from time to time

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6. Govt of Arunachal Pradesh – nomination awaited
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8. Govt of Bihar – nomination awaited
9. Govt of Chattisgarh – nomination awaited
10. Shri Sarvagya Kumar Srivastava, Engineer-in-Chief (Projects), Govt of Delhi
11. Govt of Goa – nomination awaited
12. Govt of Gujarat – nomination awaited
13. Govt of Haryana – nomination awaited
14. Govt of Himachal Pradesh – nomination awaited
15. Govt of Jammu & Kashmir – nomination awaited
16. Govt of Jharkhand – nomination awaited
17. Govt of Karnataka – nomination awaited
18. Shri K.P. Prabhakaran, Chief Engineer, Govt of Kerala
19. Govt of Madhya Pradesh – nomination awaited
20. Dr. D.T. Thube, Chief Engineer, Govt of Maharashtra
21. Shri O. Nabakishore Singh, Additional Chief Secretary (Works), Govt of Manipur
22. Govt of Meghalaya – nomination awaited
23. Shri Lalmuankima Henry, Chief Engineer (Buildings), Govt of Mizoram
24. Govt of Nagaland – nomination awaited
25. Govt of Orissa – nomination awaited
26. Govt of Punjab – nomination awaited
27. Govt of Sikkim – nomination awaited
28. Govt of Tamil Nadu – nomination awaited
29. Govt of Tripura – nomination awaited
30. Govt of Uttar Pradesh – nomination awaited
31. Govt of Uttarakhand – nomination awaited
32. Govt of West Bengal – nomination awaited
33. Shri Mukesh Anand, Chief Engineer, Union Territory Chandigarh

Rule-9 (d): A representative each of the Collective Members making annual contribution towards the funds of the Indian National Group of IABSE as determined by the Executive Committee from time to time

34. Major V.C. Verma, Director (Mktg), Oriental Structural Engineers Pvt.

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37. Shri AV Sinha, Former DG (RD) & Special Secretary
38. Shri R.P. Indoria, Former DG (RD) & Special Secretary
39. Shri. Atul D. Bhobe, Managing Director, S.N. Bhobe & Associates Pvt. Ltd.

40. Shri N.K. Sinha, Former DG (RD) & Special Secretary
41. Dr. Lakshmi Parameswaran, Chief Scientist, Bridges & Structures Div, CSIR-Central Road Research Institute
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Rule-9 (f): Four representatives of Bridge and Structural Engineering Firms

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48. Vacant

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Rule-9 (h): Four representatives of Consulting Engineering Firms

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54. Shri Alok Bhowmick, Managing Director, B&S Engineering Consultants Pvt. Ltd.

Rule-9 (i): Honorary Treasurer of the Indian National Group of IABSE

55. The Director General (Road Development) & Special Secretary to the Govt of India

Rule-9 (j): Past-Chairman of the Society, for a period of three years, after they vacate their Chairmanship

Rule-9 (k): Secretary of the Indian National Group of IABSE

56. Shri R.K. Pandey

Rule-9 (l): Persons who have been awarded Honorary Membership of the Parent Body

57. Shri Ninan Koshi
58. Prof. S.S. Chakraborty

Rule-9 (m): Persons represented ING on the Executive Committee and Technical Committee of the IABSE

59. Dr. Harshavardhan Subbarao

Rule-9 (n): Past Members of the Executive Committee and Technical Committee of the IABSE

60. Prof. S.S. Chakraborty
61. Dr. B.C. Roy

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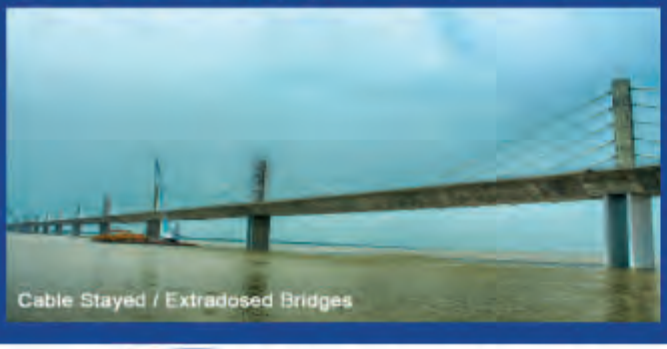
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CORPORATE OFFICE:
47, Sector - 9, Panchkula- 134113
Ph: 0172-2571595, 2570440, 2563209
Fax - 0172-4620941
Email : - spscpkl@gmail.com
www.spsingla.com