

SEPTEMBER 2022

VIEWPOINT

OFFICIAL QUARTERLY MAGAZINE OF CEAI

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tall Buildings in India





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About CEAI

Consulting Engineers Association of India (CEAI) is the apex body of consulting engineers in India having membership of organisations as well as individuals. The membership represents large, medium and small consultancy companies/ organisations both in the private and public sector and eminent individual consultants. EPC organisations are also members of CEAI since they have planning and design engineers, apart from construction management consultants.

CEAI is the Member Association, of the International Federation of Consulting Engineers, commonly known as FIDIC, the acronym for Fédération Internationale Des Ingénieurs-Conseils, representing the Consulting Engineering Fraternity in India. FIDIC has membership of more than 100 Member Association of various countries and is headquartered in Geneva.

CEAI was incorporated in 1996, with the merger of two leading national associations Association of Consulting Engineers (India) {ACE(I)}, incorporated in 1960 and National Association of Consulting Engineers {NACE}, incorporated in 1976. Thus, CEAI has, behind it six decades of accumulated knowledge and experience.

- CEAI promotes the interest and works to enhance the status of the consulting engineering profession in India
- CEAI advocates global networking and co-operation
- CEAI's activities include:
 - Quality development of Consultants.
 - Productivity enhancement.
 - Promotion of ethical practices.
 - Facilitation and interaction with government and other authorities/ bodies to streamline and improve the system of engagement of consultants.
- Regional Centres in Jaipur, Bengaluru, Kolkata and Mumbai to broad base activities.

Aims & Objectives

- Promote the professional interest and establish the rights and privileges of the status of consulting engineering profession in India
- Represent the consulting engineering profession within India and abroad. Connect the members locally and globally.
- Disseminate among the members information on all matters pertaining to engineering, especially knowledge and information related to consulting engineering profession by way of holding Conferences, Seminars, Courses, Workshops, Field/ Site Visits, etc. and thus assist in Continuing Education for the Professional Development of Members.
- Act as the principal champion for consulting engineering profession through constantly informing and educating the public and lawmakers about key engineering issues and making it possible to have the voice of the profession heard by the policy makers.
- Promote adoption of equitable forms of contracts and other documents used in consulting engineering practice.

Vision

- To represent, promote and enhance the status of consulting engineers in India as an honoured and dignified profession for nation building and propagate Indian engineering consultancy globally.

Mission

- Promote interests of the consulting engineering profession nationally and internationally.
- Promote sustainable, safe and sound engineering practices.
- Upgrade engineering knowledge and skill.
- Propagate code of professional ethics, safety, health and environment.

Values

- Commitment with tenacity to high ethical values, integrity, professionalism and achieving technical excellence and inclusive development.

Code OF Ethics

- CEAI has adopted a Code of Ethics, to which all members must abide. It is not just for the quality of the jobs they work on, but for the safety and well-being of the public at large.
- CEAI is the profession's most respected voice on the practice of ethical engineering.
- The code specifies the responsibilities of Consulting Engineers towards the society as well as the profession, to refrain from performing services unless competent to do so, to act in the legitimate interest of client, to be impartial, to maintain ethical relations with other consultants.

Engineer's Day

The World is realising the importance of Engineers - the builders of nations.

It is also dawned on the powers that be that Nature is Supreme.

Man must abide by the Laws of Nature.

Build and live in harmony with Nature.

Any alteration of Mother Earth should take in to account the long term effects so that Future generations can also live off the bounty of Nature.

Sir Mokshagundam Visvesvaraya was one such engineer who always had the welfare of the people in mind and for that he conceived, planned and executed pioneering projects. Today the nation pays homage to Sir Visvesvaraya on his 162nd birth anniversary.

We Engineers must solemnly affirm that:

We will serve the nation,

Do what is right and sustainable,

With honesty and integrity,

For the benefits of the people in all strata of society,

For the Nation to grow and prosper.

Pledge that as an Engineer our shibboleth will be

"Engineer to Build Sustainably"



Dr. Ajay Pradhan
President



Message from Chief Editor

Dear Fellow Consulting Engineers & Readers,

In keeping with the saying ‘Sky is the limit’, habitable buildings around the globe are soaring higher and higher, setting new records. The trend set off in India way back around 1960s with a 15 storeyed one and is now a part of all the metropolises and major cities; reaching to around 90 storeys. Areas with old structures which have outlived their usable life are being redeveloped and tall buildings are redefining the skylines.

The last few decades have demonstrated the capabilities that are in India for conceptualizing, planning and executing tall buildings – for their foundations, sub-structure and super structure, architectural aspects & features, electro-mechanical systems, tele-communication, safety, surveillance & security, BMS and allied systems, etc. Construction capabilities also kept pace with the needs. Maintainability and Asset Management are getting tested as the buildings rise higher. Indian codes and standards are also being framed and revised to meet the needs and address the challenges of the unknown future.

Over the years Warranties & Guarantees will be tested and so will Responsibility and Accountability of every professional who has been associated. Tall Buildings are vertical towns and hence needless to add that the warranties & guarantees would cover every aspect of the building right from the foundations, the basement, waterproofing, the structure per se, the architectural features, especially façade (ease of cleaning, maintenance, avoidance/ prevention of bird collision deaths), the services, safety, surveillance & security, etc.

To address all the above in their entirety, the design life of each of the different components of the built facility and their inter play needs to be kept in mind and so also the sustainability aspects as applicable to each of them. A multi-dimensional and integrated approach is a paramount requirement to address sustainability requirements and also the climate ones. Robust and resilient designs are essential for those. Reliability is to be ensured for all critical facilities (structures, plants & equipment) by providing proven failsafe monitoring devices using the Internet of Things (IoT); reliability of internet is questionable hence satellite connected systems could also be provided wherever redundancy is crucial.

Newer, bigger, larger, taller structures and systems call for planning and designing beyond the realms of the codes and standards. In all such cases it is imperative that each and every aspect be critically reviewed and examined and a reliability analysis done. They must also address possibilities of multi-pronged disasters (wind, hurricanes, floods, earthquakes, tsunamis, landslides, blasts, aircraft engine falling, aircraft crash, etc.) and how to avoid losses under those conditions. Predictive analytics such as Catastrophe Modelling could be used for some not only from an insurance point of view but in an endeavour to link to reliability analysis. All this is easier said than

done but they have to be fully catered for in all disciplines of work that the project demands. The mere use of a software does not absolve or shift the responsibility from the professional; the professional and the organization concerned remain wholly and solely responsible and accountable.

All those requirements take one to the realm of professionalism. Who can be called a Professional? Does merely having a degree transform a person overnight to be called a Professional? Far from it. By just walking through a cotton field a person does not come out wearing a garment. There are a number of steps involved from sowing the seed, to picking cotton, converting that to a thread, weaving a cloth, cutting to shape and size, stitching the cloth, etc. Similarly, the real Professional training begins only after one earns a degree and not acquires one. To be able to conceptualize and convert that into a meaningful workable and sustainable solution takes a few years of learning and hard practice to develop the mental faculties and simultaneously the physical abilities. Becoming a Professional involves deploying one's mental abilities, hard labour and trials to get to an acceptable solution. Inter-disciplinary requirements must be considered and coordinated correctly in a proper systematic manner. Then comes the field test which is at many times preceded by lab tests. The trainee professional to be, MUST undergo the rigors of all those so as to develop a rounded perspective and be able to think and act holistically.

It is for these reasons that the professional engineering association have been pursuing for legislation for the profession of engineering. It is only then that each one of them will appreciate and realize that there is responsibility and accountability inseparably tagged to the profession. Such a body should comprise of professionals who have demonstrated strong and consistent ethical standards in their work and businesses and who have the courage of conviction to be able to voice their concerns. Only then would that body not be subservient or dependent on the professionals who are to be monitored.

The setting up of such a body would also demonstrate the professionalism that is there in the system and help Indian consulting firms to bid for works in other countries where finding suitable trained and experienced manpower is becoming a problem. India stands a very good chance of being able to help other countries in fulfilling their need for hard core engineering services.

In this issue, professionals have penned down some of their experiences on Tall Buildings that have come up in India. There are other articles too, equally interesting. We are sure our readers will find all of them to be useful.

***A fortnight back the Engineering fraternity celebrated the
Engineers Day and rededicated itself to nation building –
let's resolve to live by that***

Happy Reading & Learning



A P Mull



Message from Guest Editor

Dwellings have grown from simple huts housing a family to skyscrapers housing many families. The transformation of course took centuries but it also kept changing human aspirations for living in comfort. Taller a building the more complex is its planning, design, construction and maintenance. The last need necessitates that the material used be long lasting and those on the outside be able to withstand the natural elements with as little maintenance as possible, albeit keeping economy in mind

Moving on to the interiors, where human beings spend all their time, it's the buildings services that go to make their living comfortable. Thus, they also need very careful consideration so that they function properly 24x7. It's easier said than done. For the services to be truly available 24x7 their provision has to be incorporated at the initial planning stage itself so that a coordinated facility is developed. BIM has made this coordination a lot easier and IoT has provided the ease for automating the controlling and coordination of all the various services. Keeping a check on Safety & Security with Access Control to various areas in tall buildings, right round the clock is also remotely done now. However, all the features that need to be incorporated in a Tall Building must be defined at the concept stage itself so that proper provisions can then be made for space, routing, fixing, operation and maintenance. All these are challenges but at the end they become worth all the sleepless nights that the different teams have to spend to get the final facility read for use.

With Climate Change causing disruption across the board it is essential that Sustainability requirements be fully provided for. Water and Power consumption must be optimized for all usages. Surely, no one would like that the future generations are devoid of a Green Mother Earth.

Professionals, have shared their experiences in this View Point, which the readers would find informative.

I wish the readers good learnings and look forward to their feedback.

Girish Chandra Mishra

Principal Consultant & Director

SAVIRAM Engineering Consultants Pvt. Ltd.

Germany introduces world's first hydrogen-powered trains

ET Online and Agencies|

Updated: 27 Aug 2022, 11:13 AM IST



1/6

Hydrogen-powered train

Germany has launched the world's first fleet of hydrogen-powered passenger trains in the state of Lower Saxony.



2/6

Green train

According to reports, 14 trains with hydrogen fuel cell drive - produced by French manufacturer Alstom - are to replace diesel trains.



3/6

Cost

The total cost of the project is around \$92 million.



4/6

Why hydrogen?

These trains will save 1.6 million litres of diesel fuel a year.



5/6

Speed

According to train manufacturer Alstom, each train will have a range of 999 kilometres (621 miles) with speeds touching 140 kilometres per hour (87mph).



6/6

Routes

The routes will be operated by regional rail company LNVG and will serve the towns of Cuxhaven, Bremerhaven, Bremervoerde, and Buxtehude.

Read more on

Source: <https://economictimes.indiatimes.com/industry/transportation/railways/germany-introduces-worlds-first-hydrogen-powered-trains/hydrogen-powered-train/slideshow/93813401.cms>

Tall Buildings – Integrated Design, Construction and Operations – Standards and Regulatory Framework



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Context

1. The new millennium is witnessing major demographic growth the world over and shift to urbanization in different degrees. From 6.2 billion population in 2000, it is expected to expand to 9.3 billion by 2050. With 7.8 billion population on date more than 50 % live in cities and towns and in developed countries; that has even touched 80% plus. India itself has grown from 320 million at the time of Independence to nearly 1.4 billion by the 75th year of Independence. The rural urban shift from 16% is reaching 40%. The Indian Urban population is likely to be 600 million by 2030. Cities are engines of growth contributing to over 70% of GDP through expansion in manufacturing, services and tertiary sectors. India is the fifth largest economy and will be a 5 trillion \$ economy by 2025. The requirements of the increased population and growing economy and employment creation, puts a major demand for the built environment- namely housing, buildings of all asset classes and related utility, social and economic infrastructure.
2. India would need to create over 6.5 billion sqm (70 billion sqft) of buildings in the next two decades. The intensity and density of development has been seeing a great rise and tall buildings have become the order of the day in all mega cities, metro cities and Municipal Corporation cities and leading tier 2 cities. The last three decades have clearly shown the shift from 20 to 25 storeyed buildings towering up to 100 storeys. The world over, tall buildings have changed the skylines of the top fifty cities.
3. With such large development needs for creation of tall buildings it is essential that all concerns of safety - structural, fire, health, electrical, environment, public, and life, are fully considered. The operating building regulatory framework with Building Regulations and Development Control Rules have been gearing up to deal with all concerns, albeit at a much slower pace than needed. The Bureau of Indian Standards, the National Standards Body has been continuously keeping track of the changing development needs and reflecting these in the Indian Standards and the Building Code over the last five decades. These covered the needs of design codes for all external and internal loads, forces and actions. India needs these more to cater to the seismic zonewise needs, and the wind pressure and cyclonic impact for over 6000 km of coast line. The needs of building and plumbing services to deal with the three-dimensional spaces at different heights pose many challenges. The building materials and technologies and products for various services also have to take care of safety, security and assured functional performance. The National Building Code of India brought out in 1970 and revised in 1983, 2005 and 2016 has been able to deal with the challenges in development for tall buildings, solidly backed up with timely upgrades

in the base standards. This has helped most of the operating building regulations and special rules of local bodies and services regulating agencies.

4. Tall Buildings are complex in nature with multi-disciplinary inputs from various professional groups like Architects, Planners, Urban Designers, Civil Engineers, Geotechnical Engineers, Structural Engineers, Mechanical, Electrical, Plumbing, Fire Protection, Communication and Vertical Transportation (MEPFCVT) Professional Engineers and AFM (please give full form) groups. Coordination and Integration of inputs from each of the professional groups are the keys for successful planning, design, execution and completion, commissioning and occupancy of spaces on various floors for the building to perform effectively, efficiently and economically. The climate change concerns and SDG 2030 goals dictate the larger needs of sustainable development attributes and savings and efficiencies in resources like water, energy, waste and materials all leading to reduced carbon footprint. The operating environment also has multiplicity of agency beyond urban local bodies and development authorities dealing with all services including water supply, sewerage, gas supply, electrical and lift inspectorates and fire authorities. Mobility is yet another critical area for vehicular needs of various options and using Electric Vehicles (EV) and special parking, additional energy charging and storage needs. The environmental protection authorities have a larger role in the coming years with the climate change action plans being adopted with 2030, 2050, and 2070 time horizons. The nature of tall buildings being developed would, therefore, have to deal with a kaleidoscope of requirements, rules and regulatory frame work. This paper attempts to give a larger vision on these many inter-connected aspects.

Instruments For Building Regulation

A Building Code in any country of the world is evolved under the principles of the four pillars of Safety namely structural safety, fire safety, health safety and public safety. In India, the land and building development

activities are predominantly governed by the various urban local bodies through their building byelaws which in turn refer to the National Building Code of India 2016 (NBC 2016) which enshrines the various facets under its 33 chapters (as Part/Section/Subsection – refer its Annex A). NBC 2016 in turn provides the necessary minimum requirement which are applicable to the planning, design, construction, operation and maintenance of all buildings including the tall buildings. Specific provisions have been incorporated in NBC 2016 on structural safety, fire safety, vertical transportation and other building services. Multi-disciplinary professional inputs, as needed in the codes and regulations of multifaceted Authorities, dictate the use of zero defect products and project options. Part 0 of NBC rightly emphasizes the need for holistic coordination and integration among the specialist Professionals dealing with structural, non-structural, finishes and services components.

The administrative requirements associated with the regulatory aspects of such tall buildings are also covered and special requirements can be arrived from separate Indian Standard such as IS 16700 on safety of tall concrete buildings, IS 1893 (Part 6): 2022 on base isolated buildings, etc.

Structural Safety

- 1 Analysis, design and construction of tall buildings generally follow the provisions given in the Part 6 Structural Design of NBC 2016 and additionally to those in the following Indian Standards:

IS no.	Title	Amd. no.
IS 875 (Part 3): 2015	Design Loads (other than Earthquake) for Buildings and Structures — Code of Practice: Part 3 Wind Loads (<i>Third Revision</i>)	2
IS 1893 (Part 1): 2016	Criteria for Earthquake Resistant Design of Structures: Part 1 General Provisions and Buildings (<i>Sixth Revision</i>)	2

IS 456: 2000	Plain and Reinforced Concrete — Code of Practice (<i>Fourth Revision</i>)	5
IS 13920: 2016	Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces — Code of Practice (<i>First Revision</i>)	2
IS 16700: 2017	Criteria for Structural Safety of Tall Concrete Buildings	1
IS 800: 2007	General Construction in Steel — Code of Practice (<i>Third Revision</i>)	1

2. The structural safety aspects of tall buildings are ascertained depending on the height of the building, the base dimensions, aspect ratio, type of structural system and its integrity to resist the dominant effects of wind (*see Annex B*) as well as of seismic forces (*see Annex C*), type of foundation, etc. One of the ten types of structural systems (such as structural wall, framed tube, tube-in-tube, hybrid system, etc.) has to be adhered by any building towards compliance in line with IS 16700. Towards arriving at a robust foundation system, the standard stipulates geotechnical investigation through boreholes (to the extent of 30 m maximum spacing, minimum of 3 bores per tower, having depth 1.5 times the estimated width of foundation). Even the minimum embedment depth (height/15 for raft OR height/20 for piled or pile-raft foundation) has been suggested. The use of Non-Structural Elements (NSE) whilst advantageous in limiting the self-weight, pose an equal challenge towards their secured fitment to the principal structure. Detailed design guidelines for the NSEs which classify under one of the three systems (acceleration sensitive OR deformation sensitive OR acceleration-&-deformation sensitive) also needs to be ensured. Towards obtaining the direct response of tall buildings and to suitably make any required interventions, instrumentation in tall buildings is essential; particularly tri-axial

accelerometers, anemometers & accelerometers, and permanent settlement markers & pressure pads. The Internet of Things (IoT) has enabled remote monitoring of all these.

Fire Safety

1. Unlike the low vulnerability of spread of fire in low rise buildings, tall buildings pose a significant challenge in terms of fire safety. All the aspects namely fire prevention, life safety and fire protection require considerable attention. With respect to fire prevention, the materials used in the construction of tall buildings, be it on the periphery or within, need to have an extended rating requirement in terms of fire resistance. Leaping fires and movement of smoke and fire through shafts and conduits needs proper attention in terms of blind walls and smoke sealing respectively having similar fire resistance rating. The Code (NBC 2016 – Part 4 Fire and Life Safety) in particular, advocates the use of only Type I or Type II construction to this effect; and suggests the expected duration of fire-resistant rating. As regards life safety, adequate number of redundancies need to be provided to enable safe evacuation of the building inmates of diverse age groups and differentiated mobility capabilities. Those are particularly achieved through compartmentation, fire fighting shafts, fire lifts, refuge area, etc. The most important aspect of fire protection which is necessary to enable that the fire be fought from within a building is achieved through the fire fighting installations which include main risers, sprinkler system, automatic detection and alarm systems, under and above ground water head tanks, pumping requirements, etc. In addition, to address the special challenges associated with the fire safety requirements for high rises, a special treatment in the Part 4 of NBC 2016 is provided by way of ample guidelines in its Annexes D and E. Some of the special requirements are:

- a) Alarms and drills;
- b) Signs & Plans – stair/ lift identification signs, floor numbering signs, stair re-entry signs;

- c) Fire safety plan – building information form, formats, roles & duties of fire safety director, warden/ deputy wardens, evacuation supervisors, etc.;
 - d) Fire command centre;
 - e) Egress & evacuation strategy;
 - f) Refuge area & horizontal exits;
 - g) Fire safety requirements for lifts;
 - h) Electrical services – separate shaft of 120 min fire resistance rating for routing the cables, redundant transformers, etc.;
 - i) Static storage tanks at higher heights (around 160 – 180 m) having atleast half the water as in the underground tank;
 - j) Helipad requirement for buildings above 200 m in height;
 - k) Fire & life safety audit by third party auditors.
2. The recent fires in tall buildings have clearly established the direct link between structural safety and the fire resistance capability of members. The 9/11 disaster opened up the need to protect the structural members for ensuring ‘structural integrity’ of building frames exposed to high temperatures during fire and avoid progressive collapse. These requirements are well covered in NBC’s Part 4 and Part 6, and in IS 456. The covers for various elements of concrete structures are determined more from fire resistance capabilities requirement so as to protect the reinforcement. In case of structural steel and composite construction, provision of additional protective shield is a must for ensuring long term durability.

Vertical Transportation

1. Vertical transportation throws an exciting opportunity to the lift specialist to overcome the unique demands of tremendous usage, lifts of adequate number, size, capacity, location, etc. NBC
2. Fireman’s lift need to specifically have dual power supply with automatic changeover switch to have redundancy in operation at call by the Firemen. Such Fireman’s lifts, although they can be used by occupants during normal times, at the call of operation by Firemen using the toggle switch, they cease the normal operation mode and enter into the operation control mode [in 2 phases – (1) return to evacuation floor and (2) car-controlled operation]. Further, supplementary evacuation lifts for buildings over 200 m in height (a suggested additional requirement in NBC 2016) ensures systematic evacuation of persons using these lifts during emergencies in a building, which people had earlier generally been advised to avoid. The 9/11 incidence changed that thinking.
3. Lift Shafts and Guide Rails play equally important role, to avoid the spread of fire and smoke and structural sways due to horizontal forces from wind

addresses even the planning and design aspects considering the quality and quantity of service, lift configuration options, special facilities (for residential, hotel, office, retail occupancies) and even basement service. Lift speed, quite operation, civil, structural and electrical requirements including safety & security are also crucial. All these have been addressed in the Part 8 Building Services, Sec 5A in the chapter on Lifts in NBC 2016. Passenger lifts and Fireman’s lifts and their operational aspects are distinct and both are required in tall buildings. Detailed visual and functional checklists, provided in NBC, for the installation of lifts are with a view to ensuring that the safety aspects of lift design are executed in the building projects. The screen sensor (typically provided for full length) is one such device which enables reopening of doors when the invisible light rays are cut, such as when one tries to enter or exit the lift car. Also, the door safety edge enables immediate reopening when it hits any object, while closing. Non-compliance of such aspects can even lead to fatalities thus strict enforcement with zero deficiency tolerance are crucial in tall buildings.

and seismic effects affecting the very functioning and movement of lift cars.

Building and Plumbing Services

1. Performance of any building and more so tall buildings, depend on the standards and levels of various functional requirements to the built environment, be it lighting, ventilation, air-conditioning, vertical transportation, acoustics and sound insulation, and degree of ICT embedded infrastructure. Equally important are the life sustaining needs of water supply, sanitation, plumbing systems for hygiene, waste management and gas supply options. These are amply covered in Part 8 Building Services (Sections 1 to 6) and Part 9 Plumbing Services (Sections 1 to 4). In tall buildings, performance of these critical utility services installations has to ensure 24x7. Continuous service and right performance parameters including pressure are therefore crucial. Hence, in tall buildings and more so in Super Tall Buildings [beyond 250 m], there is a need for “Zoning” locations of services for generation and distribution and creating additional Services Floors after certain heights. This has become a necessity for input and output services.
2. Architects, Civil and Structural Engineers have to work in tandem with the Mechanical, Electrical, Plumbing, Fire Protection, Communication and Vertical Transportation, Sustainability and other specialists to achieve all the above.
3. With India’s commitments to SDG 2030, it is absolutely essential that all the goals are rightly addressed in the development of tall buildings. Optimum and efficient use of all resources, be it land, water, materials and energy and conservation and efficient use including use of renewables and reuse of all wastes of all forms dictate special attention to Green Building Development needs. Part 11 of NBC gives a clear road map to deal with the approach to sustainable built environment development.

Maintenance Management

1. As in normal buildings, periodic maintenance and preventive maintenance of buildings and their various services are crucial to achieve continued operation. Maintenance of the building fabric is also important and proper attention, right from the conceptualization of the choice of material and design is required. Representative of the Building Maintenance team should play a significant role right from the time when a tall building idea is conceived, planned, designed and constructed. Continued operation and maintenance of all the facilities including lifts, escalators, HVAC system, fire fighting system, plumbing and drainage system, electrical installations and security system in a coordinated way should be achieved by Facility Managers. That is an essential activity to not only keep up the building duly under functioning stages but also aid in periodic renewal of fitness assessment during occupancy. Part 12 of NBC 2016 gives guidance on this important facet of Asset and Facility Management during the life cycle of Buildings. Building Management System (BMS) facilities have to be incorporated as part of Building Information Management (BIM) system right at the start itself. That is the only way forward.
2. Maintenance of tall building elements is a continuous challenge. External Façade protection and maintenance calls for additional safety and secure arrangements through safety of hoist platforms and Personal Protection Equipment (PPE) for maintenance teams working at heights would need special protection measures for aggressive external climate and other concerns. Building Maintenance Unit [BMU] - Restraining System suspended generally from roof top periphery with right anchorages call for special attention.

Implementation of Standards & Building Code

1. To address the aspirations of buildings which exceed those covered by the code, the standard IS 16700 provides a 2-stage process namely, review

by a structural design reviewer, and review by an expert review panel. All entities involved in the building development at planning stage, design stage, scrutiny stage, approval stage, construction stage, occupancy permit stage, and maintenance stage have to be involved directly; and also, the authority having jurisdiction have an important role in each of these crucial phases of a construction project's conceptualization through to its execution. This is all the more needed as consulting professional services and professionals are drawn from India and abroad with experience and expertise in tall building development. The related professionals are required to adhere to these common minimum benchmarks and are expected to even surpass depending on the requirements of the project proponents. Similar considerations have to be also applied to all other features and services for the proposed building.

2. Many State Governments and City Authorities have constituted High Powered Multi-Disciplinary Specialist Advisory Groups with experts drawn

from Industry, Academia, IITs, Engineering Colleges, R & D Institutes, Fire Service authorities, to enable specialized review and vetting of Tall Building proposals with particular attention to any complexities that may be present, in a holistic manner. These are good signs for a positive development process.

Conclusions

The growing tall buildings and related infrastructure, in the country is a sign of both economic and technical prosperity. Keeping in line with the commitments towards disaster resiliency under the Sendai Framework, and the UN Sustainable Development Goals, and Climate Change Action Plan, it is imperative that tall buildings also need to be planned, designed, built and maintained for at least 100 years akin to life lines structures. The role of every professional is crucial in addressing the solutions to urbanization by way of demonstrating tall buildings as strong, safe, and secure pillars of development.

ANNEX A

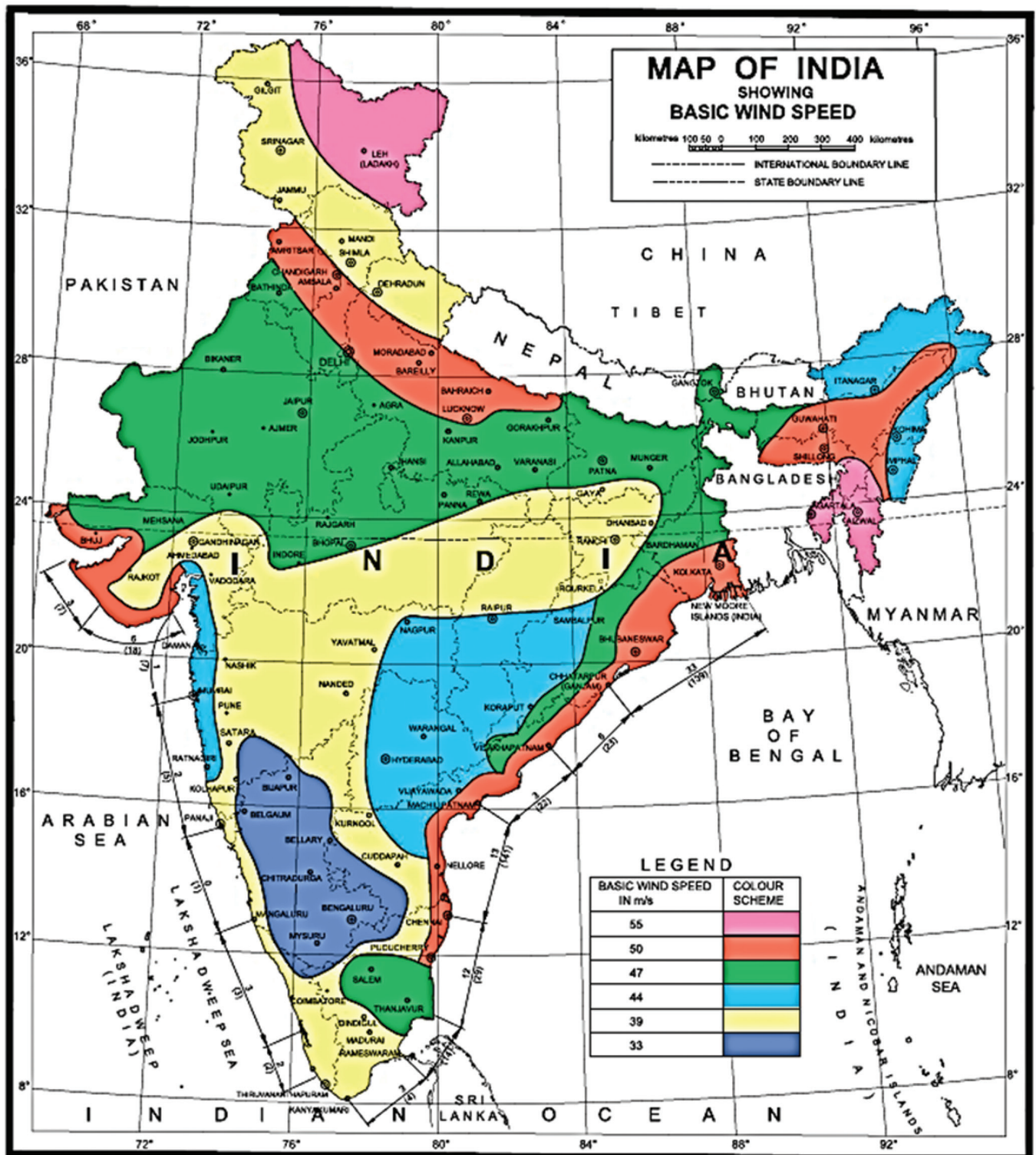
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PART 4	FIRE AND LIFE SAFETY	
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		3A Timber
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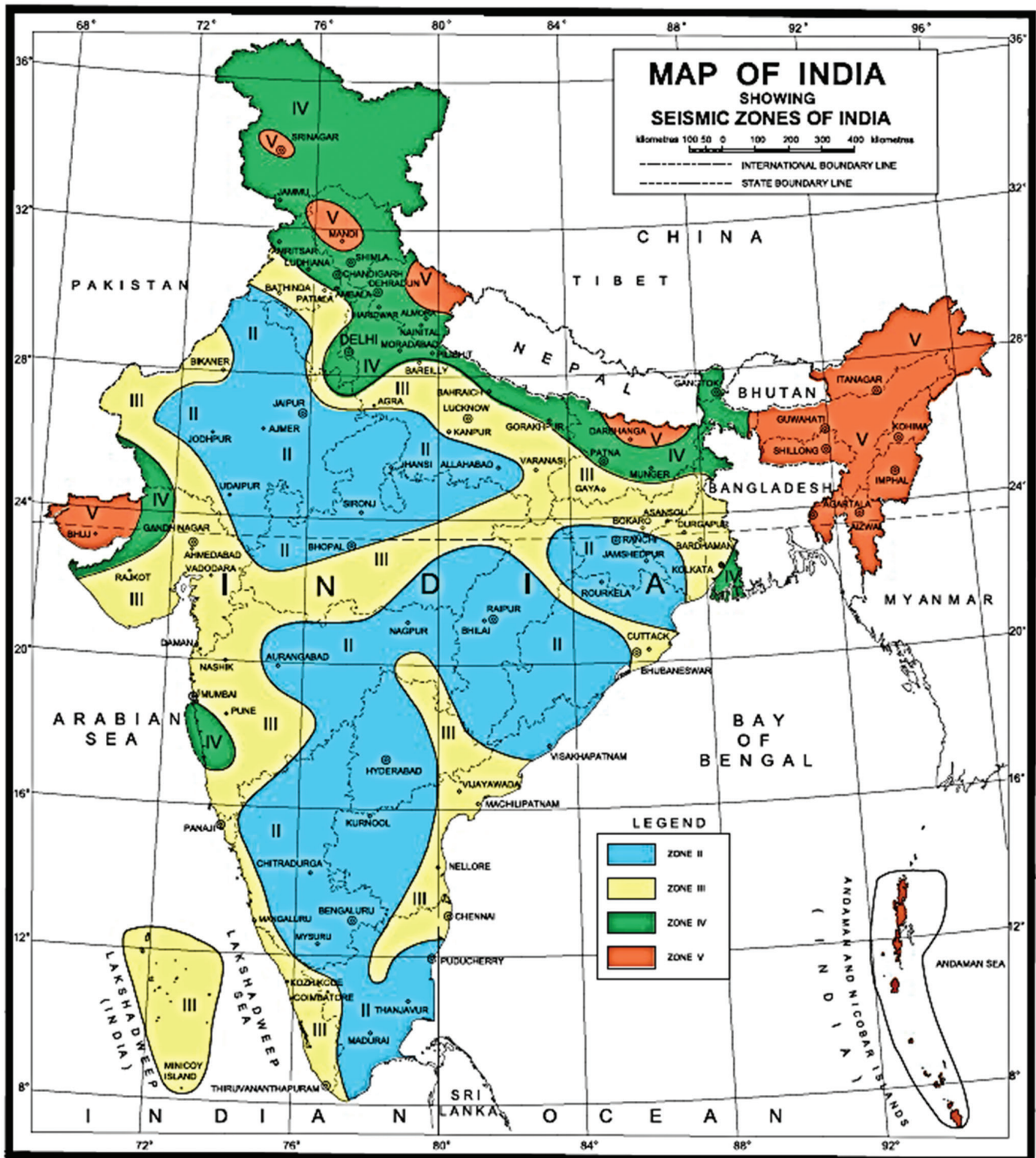
WIND SPEED MAP OF INDIA



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SEISMIC ZONING MAP OF INDIA



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Tall Buildings – do they fit into the gamut of Sustainability



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Introduction

Tall structures have been considered throughout the ages to demonstrate the power of man to reach ever higher. Towers and palaces were used by kings to show the higher position they enjoyed with respect to the common people. Other early tall structures were the house of God to emphasize the desire of human spirit to rise up. Modern tall structures that started in the last quarter of the nineteenth century had a different utilitarian purpose of commercial or residential buildings, primarily in the United States.¹ Along with the special requirements of design safety and construction for tall buildings, there was requirement of providing utility services for comfort and safety of occupants against fire. Though the economic depression caused slowdown in the growth of tall buildings, the trend picked up in the 1950s and spread to other countries, notably the countries in the Middle East and Far-East Asia and metro cities of Europe. Things took a turn in the latter part of the twentieth century when residential accommodations also started to get converted to tall building due to pressure of land availability in urban centres. The most commonly visible façade of tall buildings includes glass facades with the internal atmosphere control managed through mechanical ventilation systems. Thus, by design, tall buildings appear to be hungry power consumers to maintain the required services for operation. That poses the question whether these developments are sustainable.² The question assumes special significance in the context

of climate change and the already manifested drastic climate disasters.

The subsequent sections look at the trends in tall buildings, the drivers for such construction, and aspects of design, construction, and operation of tall buildings from the viewpoint of sustainability and impact on the climate. The article also presents how planners and architects are attempting to incorporate principles of sustainability in tall building development.

Trends in Tall Buildings Construction

Tall buildings impose very high demand on the systems of which it is composed, including both the structure and the services. The embodied energy and operating power required for a tall building is considerably higher than for low rise construction.² However, the continuous and rapid growth of urbanization demands that the spread of building construction be vertical rather than horizontal. Reports by United Nations predict urban population growth from 4.46 billion in 2021 to 6.68 billion in 2050, a growth of about 2.2 billion; and further grow to about 9 billion in 2100. Constraints of land price, land ownership issues, preservation of land, provision of infrastructure, arranging finance, air space rights are factors that are also driving tall building construction. Construction statistics show that since the beginning of twenty first century, 12,979 high rise buildings (height over 100m) have been constructed as compared to the

7,804 built in all previous times. In large and metro cities during that period the construction of 200m+ buildings number 1,361 as against 284 built previously; 150 300m+ supertall buildings as against 24 earlier and 3 mega tall structures (600m+) of which none were constructed in the earlier years.³

Design, Construction and Operation of Tall Buildings

Tall building definition: A building is generally classified as tall when its height exceeds human capacity to walk up to the higher floors, thus requiring mechanical lift transportation. Another criterion used is associated with the requirement of special firefighting equipment. CTBUH, the global authority on tall building defines a minimum height of 50m. Building uses generally vary between office, hotel, residential and mixed use. The construction and operation costs are very high and flexibility in layout design is required for changes in occupancy and use.

Structural systems: The structural systems are designed to sustain both vertical gravity loads and lateral loads due to wind pressure or inertial forces generated in seismic events. Wind pressure causes considerable deflection in the upper region of the building. Shedding of vortices formed by the wind flow cause the building to oscillate perpendicular to the wind flow direction. These phenomena place severe demand on the structure to ensure comfort to occupants in terms of stability, limit lateral deflection and maintain acceleration due to oscillation under perceptible limits (. Seismic performance demands the structure to sustain lateral forces caused by accelerations and provide ductility to the structure to absorb seismic energy without collapse or serious damage. However, the design also needs to be economic, using material strength efficiently. The concept of “premium for height” is generally used to determine the efficiency of the design; this criterion requires that any extra material used should be the least possible over and above that required to carry vertical gravity loads only. Structural configurations employed include rigidly connected frames, shear walls or shear trusses, combination of frame and shear wall/ truss,

tubes with perimeter diagonal bracing and bundled tubes depending on the height.⁴

Enclosures: The most common façade now a days for tall buildings is curtain wall. The high wind pressure and vortex-shedding effects demands user of thicker frames, glazing and special sealants. The large, exposed areas cause thermal movements in addition to movement caused by wind and seismic effects. Special provisions like fixed vertical tracks are required for washing of windows.

Vertical transport: This is a very vital facility in a tall building. While escalators may be used in the lower floor to handle large volume of people, especially when a plaza section is provided, the tower portion uses highspeed elevators. Passenger and Freight elevators of adequate capacity are to be provided.

Life safety provisions: These include stairway shafts, fireproof elevators, fire suppression systems, usually sprinkler systems, fire hoses, pipes and pumps and fire stand posts at street level for operating truck-based pumps. All occupied parts of the building should be covered by the lift safety systems.

Plumbing: The major feature of plumbing is the requirement of pumps and intermediate tanks. Here also, zoning of tall building is done with separate pumps and tanks.

Interior Environment management: Two systems can be used with regard of placement of air handling units – centralized fans catering to about 20 floors moving air through vertical trunk ducts or placing fans for each floor. Central refrigeration plant with cooling tower is used and chilled water is moved by pumps. Cold air in winter is heated by circulating hot water produced in boilers or by radiation using heat produced by electric resistance.

Electrical system: The major difference with low rise construction is the use of HT incoming power due to the high load that requires use of a step-down transformer. The power distribution is like in a low-rise building.

Concept of Sustainability in Tall Buildings

Concept of Sustainability: The Brundtland report, *Our Common Future*, published by the World Commission and Environmental Development (WCED, 1989) defines sustainable design as an effort to “meet the requirements of the present without compromising the needs of future generations by encouraging the wise and prudent use of renewable resources, alternative strategies for energy production and conservation, environmentally friendly design and intelligent building technology”.⁵ This definition addresses needs of comfortable life for all members of society irrespective of economic status while making consistent resource demands on environment, society and technology. It promotes development in a sustainable manner rather than only maintaining the quality of life within the carrying capacity of the ecosystem.⁵

Sustainable Building Design: Architects and planners are accepting the concept of sustainability, but specific guidelines are lacking. Vernacular architecture has been adopted by many as the basis of sustainable building principles like passive climate control system, increased thermal resistance of walls, natural ventilation to replace mechanical ventilation systems. While there has been reasonable success and acceptance of such styles to modern small buildings, extending this technique to scale for modern tall buildings is a challenge and is yet to be applied. Solutions for providing natural light and ventilation to levels required for performing activities in the large free internal spaces of tall buildings are difficult to be derived using principles of vernacular architecture.⁶

Mechanical air-condition systems pioneered by Willis Carrier in 1939 in the United States allowed larger free space in office buildings, but the increased floor depths reduced opportunity of penetration of natural light. The use of fully glazed and sealed curtain walls started by Mies van der Rohe and Skidmore, Owings & Merrill facilitated natural lighting but increased solar gain requiring additional cooling effort. The completely sealed environment has also been found to adversely affect physical and mental health of occupants. Current

thoughts of architects and planners are diverging from this “International Style” which had been applied universally without consideration of local external climate and culture. Tall building design as practiced since the last century has run into a deadlock over adopting sustainable concepts while enabling the benefits of such construction.⁶

Sustainability in building planning and design should respect the interconnection factors like need for accommodation, economic growth, use of land, water and energy, parks and open spaces, transportation, waste recycling. Rick Pruetz describes sustainable planning as establishing a “balanced community where urban centers prosper, natural landscapes flourish, and farming is strengthened as an integral component of our diverse economy and cultural heritage”. In his book ‘The Architecture of Community’, Léon Krier has described sustainable urbanism as “an ethical and civilizing vision of universal stature”.⁷

The three pillars of inclusive sustainability framework include the interlinked aspects of “people” (community/equality), “profit” (economic), and “planet” (environment/ ecology). Sustainable design principles balance these principles on a global scale covering individual habitats, neighbourhood, community, and city extending out to the entire planet. A healthy and comfortable human habitat that is economically viable is the outcome of the application of sustainable building design as shown in Figure-1.⁷

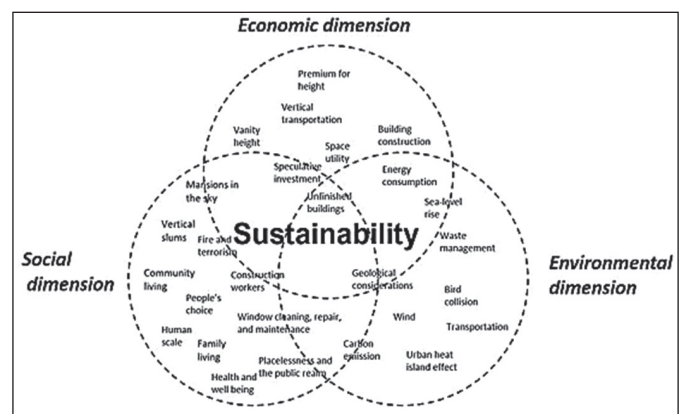


Figure-1: “Sustainability” as a guiding framework to organize the many issues related to tall building developments⁷

Impact of Tall Buildings on Sustainability

Tall buildings create impact on all the three aspects connected with sustainable living. They are imposing structures in an urban skyline and their presence has strong effect in social, economic, and environmental dimensions.

Social dimension: People in high rise communities have many concerns regarding social relationships, family life, raising children, personal behaviour and comfort, safety perceptions, and connection to outdoors. Occupants tend to feel disconnected from nature, city life and neighbour interactions. The major worries are with altered norms of family and community living, disparities in the quality of life, distortion of human scale of perception, creating feeling of being out of place in the neighbourhood, continuous feeling of discomfort from impending fire hazard and terrorist attack. Other complexities include cleaning of windows, maintenance and repair, construction worker's risks management, and non-acceptance of high-rise living style by occupants.

Economic dimension: Tall buildings are costly construction per unit area compared to low-rise houses due to requirements of stronger and more complex structure and foundation systems to offset the higher demands posed environmental loads and performance requirements, see Table-1. Economic parameters used in evaluating design efficiency of tall buildings include

concepts of premium for height (additional material required over that for gravity loads to carry lateral loads), vertical transportation, vanity height (space occupied for services, usually >30% as compared to 20% for low-rise structures), investment risks from unsold/ unrented space, costly mitigation for construction errors and unfinished projects (CTBUH has listed 50 building of 150m or taller).⁷

Environmental dimension: High rise building have large carbon footprint at all stages of life cycle of construction, operation, maintenance, and demolition. The density of population accommodated makes huge demands on infrastructure and transportation system. Microclimate alteration produced by tall buildings include wind tunnelling, turbulence at ground level, shadow zones, obstructing views and hinder natural ventilation. Construction of skyscrapers produce very high carbon emissions and the materials used have high embodied energy and maintaining interior environment also consumes very high energy. High rises also contribute significantly to urban heat island effect. Geological impacts can include increase in settlement problems and depletion of ground water. Waste management requires special and complex designs with mechanical systems of ducts and chutes requiring high maintenance and scope of recycling is non-existent. Other environmental parameters include probability of bird impact, and adverse effect of sea level rise in high rises on coastal areas.

Strategies for Sustainable High-rise Construction

Though there are challenges are concerns with the sustainability aspects of tall buildings, the pressure of increasing urbanisation is making it imperative for policy makers to push for vertical urban development. Drastic climate changes that result in more severe storms, earthquakes and flooding are prompting new sustainable technologies. The “sponge city” model developed on the Green Infrastructure (GI) model uses improved water management principles, rainwater capture and recycling and use of green elements in buildings to absorb effects of expected massive floods.⁷

Skyscrapers are costly buildings		
#	Skyscraper	Billions
1	Abraj Al Bait	\$15.49
2	Marina Bay Sands	\$5.98
3	One World Trade Center	\$3.92
4	Taipei 101	\$2.26
5	Princess Tower	\$2.24
6	Antilia	\$2.17
7	Trump Taj Mahal	\$2.00
8	Bank of China Tower	\$1.81
9	Petronas Twin Towers	\$1.65
10	Burj Khalifa	\$1.63

Table-1: Cost of Tall Buildings⁷

Sustainability design incorporates rules of endurance, resilience, and long-lasting facilities to promote preparedness of the infrastructure to extreme emergency situations reducing harmful effect on people and property. Sustainable design supports adoption of technological solutions to improve building construction methods and performance of the various systems.

Smart technologies for utility features like smart elevators, smart grid, smart parking, smart traffic management systems, smart ventilation systems, smart water management systems can all contribute incrementally to reduce the power consumption and improve operational efficiency resulting in a “greener” facility.³

Sustainable Construction: This principle includes application of the following:

- Reduction in consumption of resources, less use of virgin materials
- Reuse of resources
- Using recyclable resources
- Protect nature
- Eliminate toxics
- Use life-cycle costing

Figure-2 shows the integrated picture of these sustainable principles linked to resource constraints along the development stages of project lifecycle.

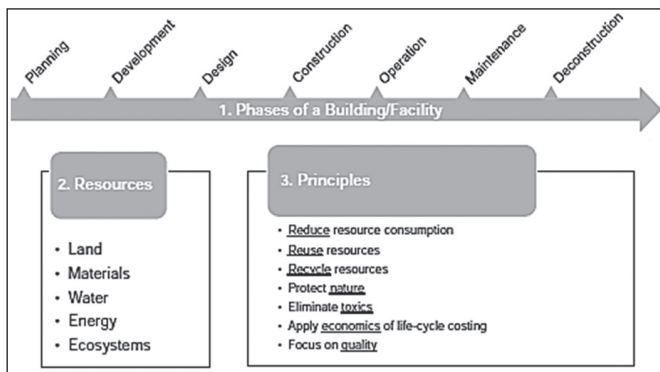


Figure-2: Framework for Sustainable Construction⁸

Embodied energy of materials: Measuring embodied energy of product is associated with the use of power used in extracting raw material, transportation, manufacturing, assembly, installing, dismantling after use and disposal. Both direct energy and indirect

energy consumed in associated process along the lifecycle are measured. In addition, the energy used in maintaining, repairing, refurbishment or replacement of materials during the operation of the facility also comprise the embodied energy of building materials and are dependent on their durability and resilience.⁸ The concept of embodied energy of building materials is depicted in Figure-3. Values of embodied energy for different building materials are provided in Table-2

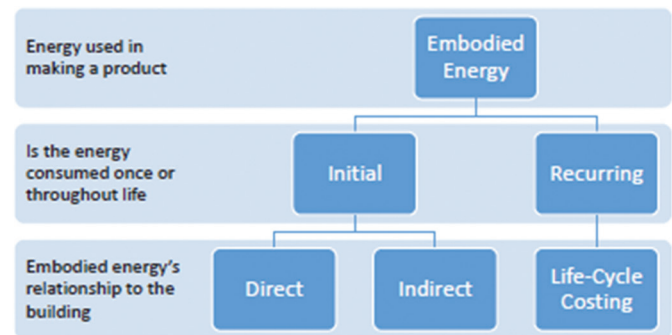


Figure-3: Embodied Energy of materials⁸

Table-2: Embodied Energy of various Building Materials⁸

Material	Embodied Energy	
	MJ/kg	MJ/m ³
Aggregate	0.1	150
Soil-cement	0.4	819
Stone	0.8	2030
Concrete (30 MPa)	1.3	3180
Concrete precast	2.0	2780
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminium (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fibreglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Polystyrene insulation	117.0	3770
Carpet (synthetic)	148.0	84900
Aluminium	227.0	515700

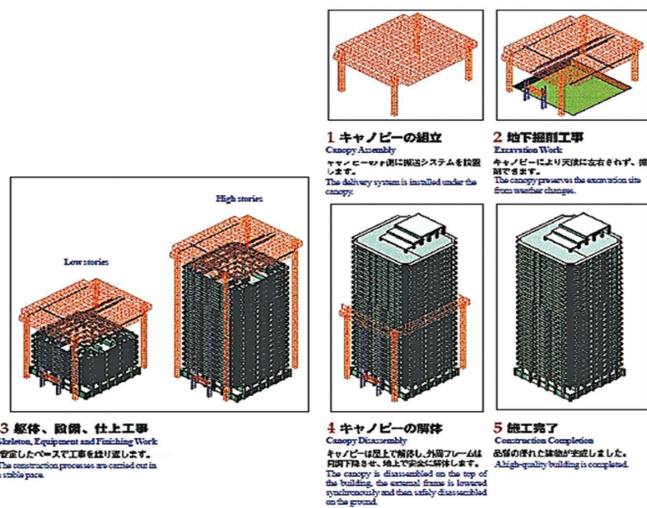


Figure-6: Robotized construction – Big Canopy by Obayashi Corporation⁸

Using Building Information Modelling (BIM): BIM technology provides modelling and simulating performance of building on a digital platform. Full digitalization during design, construction and operation integrates the various functions and improves their productivity. BIM facilitates the implementation of Design for Manufacturing and Assembly (DfMA) concept in construction and modularisation. By allowing digital mock-up, simulation of assembly steps, digitized method statements and plan construction equipment deployment. LEGO-like models using prefabricated components can be created in BIM environment and shared among

all stakeholders from component manufacturers to assemblers. A typical application of BIM framework is shown in Figure-7.

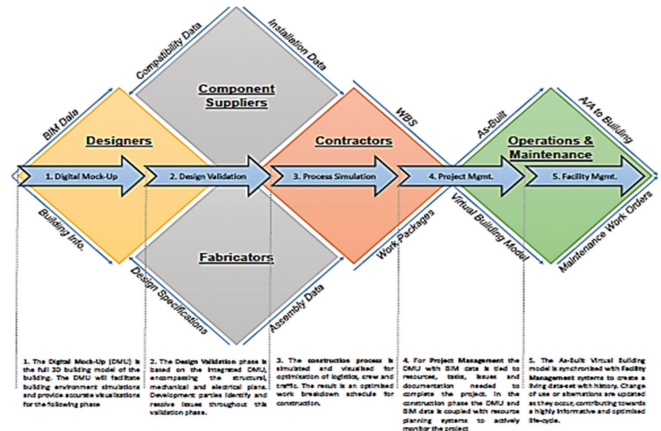


Figure-7: BIM application framework in building lifecycle⁸

Examples of Sustainable Tall Buildings

This section lists few examples of tall building designed and constructed employing principles of green building and sustainability features.

Bank of America Tower: Also known as One Bryant Park, this is a 336m high building designed by Cook + Fox Associates and has LEED Platinum Certification from US Green Building Council (USGBC).³

Building information	Green features
Name: Bank of America Tower City: NYC Number of stories: Above ground: 55 Below ground: 3 Height: To Tip: 365.8 m/1,200 ft Architectural: 365.8 m/1,200 ft Occupied: 234.5 m/769 ft Ranking: Worldwide: #60 North America: #10 NYC: #8 Year of completion: 2009 Design: Cook + Fox Architects Function: Commercial Office Certification: LEED Platinum	- On-site cogeneration plant - Ice storage system - Building-integrated photovoltaic (BIPV) system - Air filtration system removes 95% of airborne particulates - Air monitoring system tracks CO₂, CO, VOCs, and small particulates - Curtain wall with low-E glass and heat-reflecting ceramic frit automated dimming system - Water management and recycling system (graywater); harvest rainwater; waterless urinals and low-flow fixtures - A high percentage of the building's materials and furniture come from recycled or locally sourced materials located within 800 km (500 mi) of NYC - Building's steel was made from 87% recycled materials, and the concrete was made from cement containing 45% recycled materials - Interior materials are low-VOCs, sustainably harvested, manufactured locally, and recycled wherever possible 91% of all construction and demolition waste was recycled or otherwise diverted from going to landfill (Ali and Moon, 2007; Al-Kodmany, 2014)

One World Trade Center: The 105 floor One World Trade Center is the tallest in North America reaching height of 541m, designed by Skidmore, Owings, and Merrill (SOM).³

Building information	Green features
Name: One World Trade Center City: NYC Number of stories: Above ground: 94 Below ground: 5 Height: To Tip: 546.2 m/1,792 ft Architectural: 541.3 m/1,776 ft Occupied: 386.5 m/1,268 ft Ranking: Worldwide: #6 North America: #1 NYC: #1 Year of completion: 2014 Design: Skidmore, Owings, and Merrill LLP Function: Office/Hotel/Retail Certification: LEED Gold	• Twelve hydrogen fuel cells, which generate 4.8 megawatts of power, partially power the tower • Waste heat output from the fuel cell system is recycled and used for hot water and heating • Central Chiller Plant • The building draws as much as 70% of its power from green energy sources • A water management system that collects rainwater and recycles graywater, which is used to cool the building, irrigate the landscape, and provide fire protection. • Low-flow plumbing fixtures • Curtain wall with insulated glazing units and ultra-clear Glass • Automatic dimming devices • Over 3,000 monitoring stations within the building were linked to air handling software to provide fresh air when necessary. • Building's structural materials contain a minimum of 75% recycled materials • Used "Green Concrete" • Fifty percent of all wood products installed in the tower were certified by the Forest Stewardship Council • The building does not contain VOCs or chemicals that leach in a gaseous form (Tsang, 2014; Ilgin, 2018)

Shanghai Tower: The Shanghai Tower is the tallest building in China, a 121-story mixed use supertall rising to a height of 632 m. The tower has received LEED Platinum certification.³

Building information	Green features
Name: Shanghai Tower City: Shanghai, China Number of stories: Above ground: 128 Below ground: 5 Height: To Tip: 632 m/2,073 ft Architectural: 632 m/2,073 ft Occupied: 583.4 m/1,914 ft Ranking: Worldwide: #2 China: #1 Shanghai: #1 Year of completion: 2015 Design: Gensler Function: Hotel/Office/Retail Certification: LEED Platinum	• The tower is divided into nine vertical neighborhoods with 12-to-15-story-tall sky-gardens, which act as buffer zones between the inside and the outside and form DSF • The tower's form aims to resist the typhoon-level winds by embracing multiple strategies, including asymmetry, tapering, rounded corners, and a reduced floor plate as the tower rises • Advanced lighting controls • Efficient Central Plant • Wind turbines • Natural gas-fired cogeneration system • Rainwater collector • Graywater recycling system • Mixed-use tower (Goncalves, 2010; Al-Kodmany, 2017)

Table-13 of the article in reference 3 lists the various green features based on LEED rating system and connects them with the three key pillars of sustainability. The data can be used for planning and design of sustainable tall buildings.

Conclusions

Though tall buildings have traditionally been designed, built, and used without real concern for sustainability

aspects in past, there is now an increasing awareness among both architects, engineers and occupants to move towards sustainable buildings. That is giving rise to the "fifth generation" skyscrapers that are energy efficient and carbon neutral. Tall buildings designed as "vertical garden cities" are more habitable and provide occupant friendly environment while using space and resources more efficiently. Some of the innovative green features being included in tall building planning include renewable energy production and use, solar

shading, double-skin facades, natural ventilation, use of high thermal mass, landscaped atriums, underground heat sinks, rainwater collection and ground recharging, linear induction lifts. The 33 story, 167m high PNC Plaza in Pittsburgh uses standout features like natural ventilation, optimal solar orientation, water recycling and waste diversion.

Though it may prove difficult to adopt sustainability aspects in tall buildings some basic rules of simple and logical planning, using new forms, incorporating modern technological solutions, preserving, and connecting with local culture and natural environment can generate cost-effective solution for sustainable tall buildings.^{3, 7}

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The Vital Tech Behind Monitoring Concrete Cylinders

How specialized wireless remote monitoring solution and rugged sensors allows civil engineers the ability to keep observation on concrete samples.

September 22, 2022 Jonathan Kozlowski MultiTech Systems Inc.

The concept and practice of the Internet of Things (IoT) has been around for a while, but the impact in the modern concrete construction site has only broken the surface. Project managers and foremen alike have found benefits from IoT with apps providing intuitive solutions that range from inventory management, change documentation, office forms, and more.

Also benefiting from IoT on the jobsite are environmental technologies providing construction professionals with smart, actionable data. These solutions are capable of capturing data on the outside weather, report on interior air quality for jobsite safety, and embedded sensors in concrete that can survive long enough to transmit curing temperatures. One less noticed, yet vital, area also benefiting from sensor technology: the monitoring of concrete cylinders and core samples.

Source: <https://www.forconstructionpros.com/concrete/equipment-products/technology-services/article/22432213/multitech-systems-inc-multitech-sensors-and-red-wireless-help-monitor-concrete-core-cylinders>



Dr. V V Nori

Chairman
Shirish Patel & Associates Consultants Private Limited

Mumbai has for decades been symbolic of Highrise buildings and now the Tall ones with the change in the development rules over the years. This paper features two buildings that incorporated unique design concepts– architecturally and structurally.

Kanchanjunga Apartments (1972-1973)

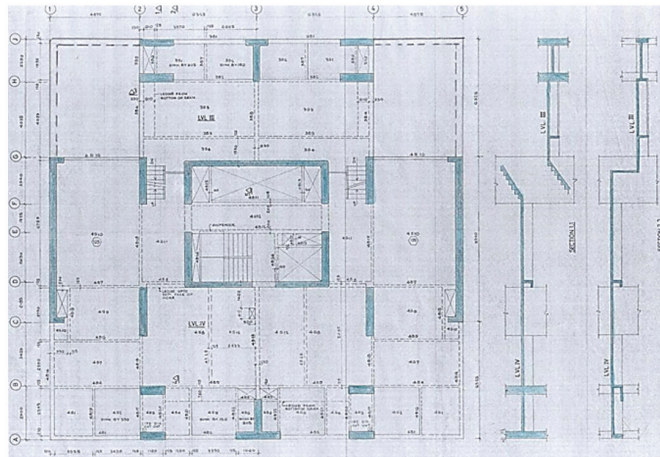
Conceived as a 32- storied reinforced concrete structure apartment building, with plan dimensions of 21.6m x 22.4m, it ultimately ended as a 27-storied structure because of height restrictions imposed by the Airport Authority. The central core of 7.8m x 6.9m houses the elevators, staircases, and other services. The structure rests on open foundations.

An unusual feature of the floor framing is that it had to accommodate three levels so that rooms could look across double-height terraces.

That entailed 6.32m span cantilever balconies. The lateral loads are resisted by shear walls as well as the central core and also to a lesser extent by the frames. The cantilever balconies were also analysed by the Finite Element Method with a view to verifying the concentration of stresses at the junction of the cantilever and the shear wall.

The 6.32m cantilever balconies support two floors. The large cantilever balconies were well integrated into shear walls.





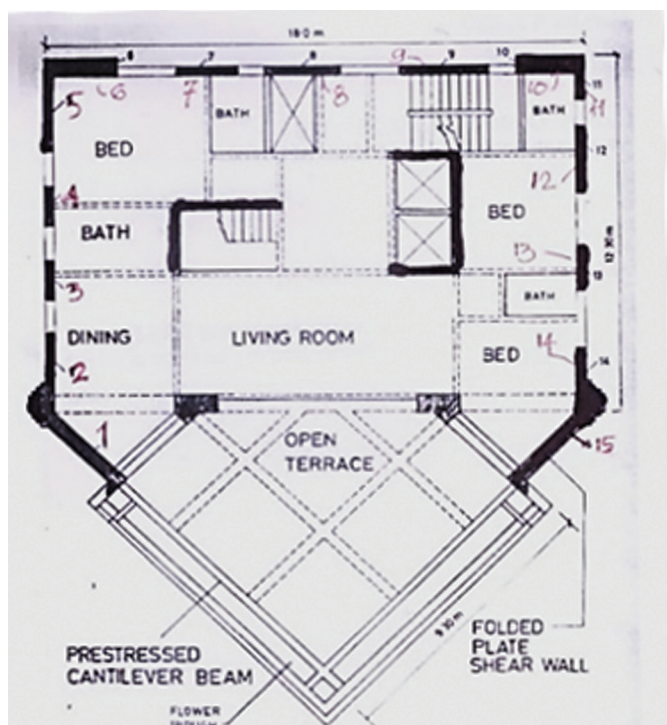
In order to reduce the construction time, the Contractor suggested that the central core be constructed by slip-forming technique. Circular curves were introduced at the corners to facilitate the technique. Slip-forming progress, at the rate of 12.5cm per hour was achieved using twenty jibs including 4 positioned in 4 corners. Block-outs were incorporated in the central core at floor levels for facilitating the construction of floors which commenced soon after the central core had reached a height of three stories.

Charles Correa was the Architect, Pravina Mehta was the Associate Architect and Engineering Construction Corporation Ltd. (now L&T Construction Group Ltd.) were the contractors. In a few years, the building became an iconic architectural and structural masterpiece.

Kashmir House at Nepean Sea Road, Mumbai (1985-1988)

The building for the Government of Jammu



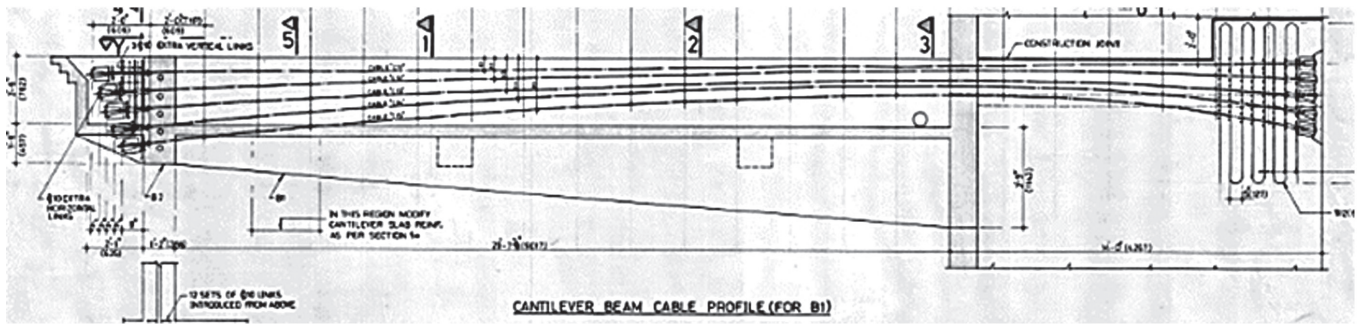


and Kashmir is a twenty-five-storied apartment building, with large open terraces and gardens on every alternative floor, which are kept open with minimum obstruction to the view. It was accomplished by providing 9.6m long prestressed concrete cantilevered beams anchored in the peripheral shear walls.

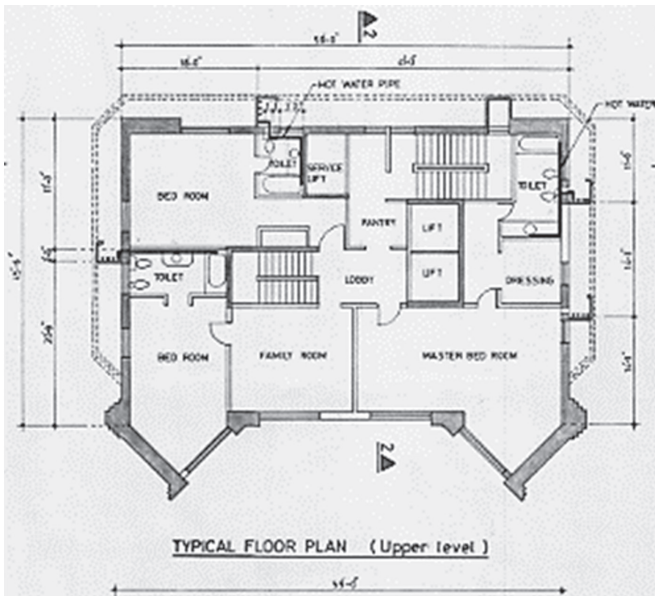
The outer shell was used as a shear wall to brace the building for lateral loads due to wind and earthquakes. For the preliminary design, the shear wall was assumed to be pierced thin-walled folded plate with floor slabs acting as rigid diaphragms. The structure was also analysed on a DEC 10 mainframe computer at the Tata Institute of Fundamental Research (TIFR) using SAP IV space frame program.

AXIAL LOADS OCCURRING ON VARIOUS COLUMNS OF THE FOLDED PLATE SHEAR WALL						
COLUMN NO	DEAD LOADS + LIVE LOADS INCLUDING THE EFFECTS OF CANTILEVERS		EARTHQUAKE		WIND	
			NORTH SOUTH		EAST WEST	
	MANUAL	FEM	MANUAL	FEM	MANUAL	FEM
1	1716	1685	446	451	-340	-380
2	648	603	122	84	27	46
3	254	274	18	7	62	69
4	249	246	-18	16	100	93
5	405	385	-106	-101	279	270
6	697	669	-266	-268	530	491
7	288	287	-108	-93	98	92
8	353	369	-133	-110	13	18
9	418	441	-158	-136	-174	-136
10	696	736	-266	-254	-541	-511
11	134	144	-43	-50	-209	-194
12	191	418	-55	-50	-209	-194
13	317	324	15	4	-72	-73
14	544	533	105	65	-83	-91
15	1710	1750	446	441	348	375

The post-tensioned cantilever beams are subject to fairly large loads due to the terraced lawn and the flower beds. The dispersion of the vertical loads including the effect of the overturning moment was worked out using the folded plate method. That was another major challenge.



Vibration analyses indicated the natural period of vibration of the structure in the first mode to be 1.4 seconds in the North-South direction, and 2.4 seconds in the East-West direction.



TRANSVERSE DIRECTION EAST-WEST

The building is founded on rock that was encountered at a shallow depth

Earthquake forces govern in the longitudinal direction, whereas the wind load govern in the transverse direction. It was heartening to see a reasonably close agreement between hand calculation and the SAP IV output.

Earthquake and Wind forces are reversible. It was heartening to see a reasonable agreement between simple manual calculations and the finite element method (refer table).

The building is a good example of how structural solutions evolve gradually and merge with the functional requirements of the project. Since the building was slender in the longitudinal direction, its response from the point of view of comfort to the occupants under wind loads was investigated. It was found that on the uppermost floor the displacement was on the threshold of being noticeable but would not cause discomfort.

I M Kadri was the Architect and Talib- Shamsi Constructions were the Contactor. This building also became iconic for its spacious balconies offering an unobstructed view.

CRESCENT BAY, Parel, Mumbai



Anuja Sawant
Principal
SSA Architects



*We shape our buildings
and thereafter they
shape us...*



Crescent Bay is one of Mumbai's finest landmark comprising of 6 residential towers, aligned to form a moon-like crescent shape when viewed from afar. Each tower is built on an elevated podium with panoramic views of the city skyline and the Arabian Sea as the backdrop making it picture perfect.

Situated in Parel, a fast-developing residential locality of Mumbai, which is also known for its prime commercial business centre and office spaces. As it is located in central Mumbai, it offers excellent connectivity with other parts of the city via numerous modes of transportation.

The locality also has reputed schools, hospitals, banks



together with luxury retail stores, renowned shopping malls, premium entertainment hubs within minutes which further eases the standard of living of the residents.

Besides its proximity to some of the largest retail and commercial hubs in the city, Crescent Bay also connects with business hubs like Nariman Point as well as BKC with a few minutes away by road, thereby the commute to work takes very little time. It enjoys railways connection from the two lifelines of Mumbai - the Central and Western lines, plus it has close proximity to bus depots and monorail ensuring easy commute to and from all areas of Mumbai. With excellent connectivity to the Eastern Express Highway, the Eastern Freeway and also the proposed Nhava Sheva Sea Link, life at this residential project in Parel, is a complete joyride not just within Mumbai but also boosting connectivity with the outskirts.

Crescent Bay is a marquee residential complex that offers a perfect setting for an extraordinary life and is rich of what meets the heart.

The design of each residential building ranging from a height of 181.95m to 238.86m arranged in a Crescent form showcases a blend of aesthetics, functionality, and efficiency. The triangular form of buildings with apartments arranged along its periphery and the central core proved to be the most effective structural scheme for a residential building. Each building allowing uninterrupted views while keeping the sense of privacy intact, is a feast for the eyes in a dense city like Mumbai. The blend of the indoors and the outdoors, with the clubhouse sitting at the centre of the crescent enhances community living thereby ensuring a perfect setting for a family living.

Spacious apartments ranging from 780 sft (72.5 sqm) to 2700 sft (250 sqm) carpet area and façade with a play of balcony and window wall which ensure optimum level of light and ventilation. In addition, having a deck in every room encompassed the outside to being one with nature. High-rises being the need of the day, the sky bridge at Crescent Bay ensures human interaction and connectivity with rejuvenating spaces vertically. The happiness quotient of people has been the prime focus of this complex, with a product mix of 2BHK, 3BHK and 4BHK apartments totalling to 1490 apartments, catering to a population of approximately 7000 people, just like having a home in the sky!

As one moves through the buildings, one experiences not only continuous changes of perspective but also discrete transitions from one space to another. The apartments in Crescent Bay are strategically constructed keeping in mind the best of architecture both from inside as well as outside.

Crescent Bay is designed to improve liveability through enhanced internal and external apartment amenity, including better layout, apartment depth and ceiling heights, natural ventilation and visual privacy. Individual apartments with 8feet (2.43m) decks enable enjoying the outdoors along with uninterrupted views within the living domain generating an inside-out concept. Similarly, just like the outdoor spaces provide a sense of vertical neighbourhood within the complex, the harmonious planning of apartments provides a sense of

dynamism and comfort inside, thereby making it a home. It's these thoughtful touches that come together to create the perfect setting for a life less ordinary.

The site per se was earlier an inactive quarry land on which slum dwellings had mushroomed. Hence, the design process was a journey from challenges to the joy of sold inventory with optimum construction speed. Architecturally the challenge lay largely in the capacity to give something back to communities and add value to the city and individuals occupying the planned development. Taking the contoured land under the SRA scheme, Crescent Bay seized a comprehensive look at the three dimensions, the environment, economy and society. Additionally, extensive discussions with all the stakeholders worked towards a unified goal of human comfort and wellbeing. The Crescent Bay project received the IGBC Green Home - Silver precertification for embodying sustainable design principles and encourages conservation and optimal utilisation of natural resources.

Overall, although the complex is located in the off heart of the city, easy connectivity to various avenues, makes Crescent Bay as the new heart of the city with easy commuting not only on a daily basis but also to outskirts of the city. From being one with nature and being one with self, Crescent Bay has led to an overall socio-economic development within as well as in its neighbourhood, giving a new dimension to residential living in the densely populated city of Mumbai.

High points of design are:

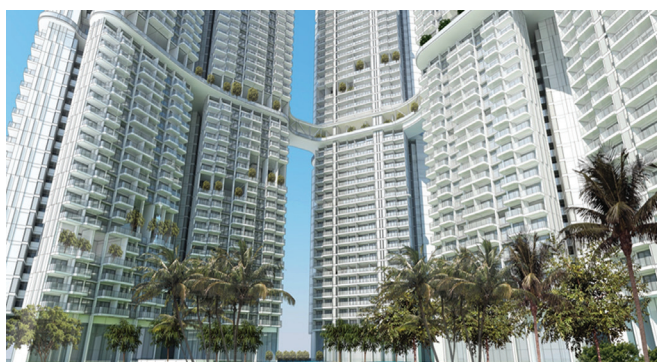
- Inside outside concept
- Sustainable façade
- Biophilic nature
- Breathing spaces – balconies and terraces, offering stupendous views

Emergence of design

Design Essential

- Staircase design
- Traffic analysis
- Elevators

- MEP space allocation
- Vaastu compliance



- Difference in Residential core & Commercial core
- Lighting design
- Sustainability
- Efficiency/Ratios
- Construction to FSI
- Saleable to Construction
- RERA Carpet to Construction
- MOEF/ CFO/ Civil aviation

Structural attributes

- Tie between the core & flats/office

- Wind engineering
- Link beam connection for stability

MEP & Services

- FHC Provision
- Pressurisation Shaft
- Ventilation
- L.V./Electrical shaft
- Vertical transportation
- Safety/Security

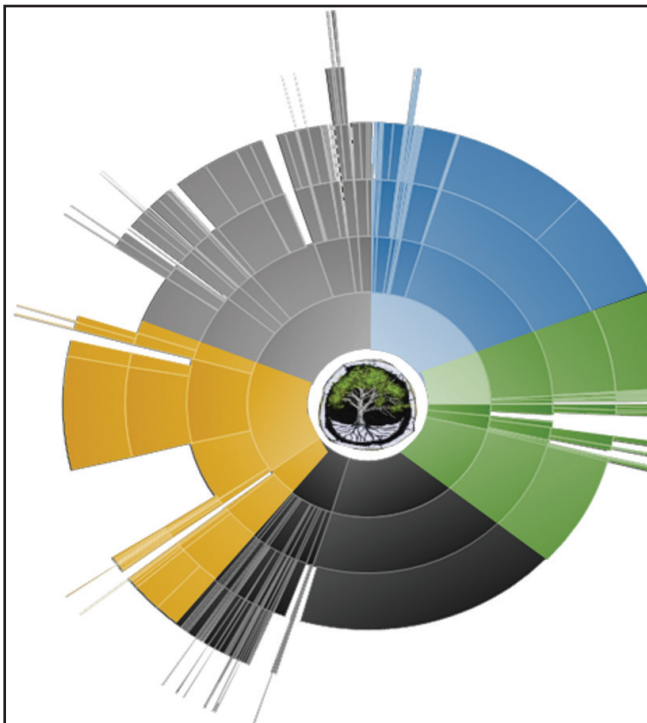
Project Management

- Formwork efficiency
- Budget and timelines
- Construction quality control & commissioning
- Advanced technologies

Every mega high-rise project is a journey by itself and requires great leadership from all concerned - client, consultants, contractors.

Highrise's are complex entities and need to be dealt with accordingly. Embodying new technologies. while designing its extremely important to understand sustainability and evolve the design accordingly and then execute keeping constantly in the mind the condition in the future of such projects, how occupiers would be maintaining them. Such projects are the biggest learning curve for all the stake holders.

Before closing it is pertinent to record that it was a long journey – of a decade, which definitely helped the team grow as a responsible designer (Architect) and enabled me in making every project aspect a bench mark – from human centric designs, technology, sustainability, cost efficiency, execution and maintenance perspectives.



Tall Buildings— Some Structural Solutions



Aamir Chowdhary
Vice President (Audit)



Girish Dravid
Managing Director
STERLING Engineering Consultancy
Services Private Ltd.

High-rise buildings, small a footprint roof area but a large façade, have the potential to decongest urban sprawl as they can deal with high-density issues and lack of available land for development.

Knowledge, technology and construction materials are constantly evolving and so is the ambition for constructing higher buildings. However, it does not go without some challenges and issues. First of all, the vertical loads increase with the height of the building. There is also the large effect from horizontal wind-load on the building. The buildings behaviour under the lateral loading can be seen as a cantilever fixed at the ground. If the wind is assumed to have a uniform distribution the base-moment increases quadratically with the height. However, the real shape of the wind pressure with increasing heights, results in even greater base-moment. One of the main tasks when designing high-rise buildings is its ability to withstand the horizontal forces and to transmit the resulting moment to the foundation. One way to effectively achieve that are coupled load-bearing vertical walls. However, that would lead to tensile stresses in the concrete walls on the windward side. In order to minimise these stresses, the self-weight of slabs, etc. are made to bear on the walls to get compressive stresses.

The higher a building is, the more important it is to consider the choice of cross sections, materials and structural systems as well as the demands on

functionality. Factors that need to be considered are deflections and accelerations from horizontal loading that mainly occurs from unexpected deflections, wind or earthquakes. Unexpected deflections may arise when imperfections in the elements occur during the manufacturing or if the foundation is uneven due to an heterogeneous site. Any unexpected deflection causes additional lateral forces and must be considered. Horizontal loading from wind may also cause sway in the building and hence they are susceptible to oscillation. The wind should therefore not only be seen as a static load but also as a dynamic load. To determine how the building responds to wind-loads, wind tunnel experiments are often performed. The oscillation affects the building in several ways and the people inside could perceive the sway and the maximum horizontal deflection that arise.

The approach towards the construction of a high-rise building is challenging and therefore requires consideration of critical factors. Some of the challenges related to architectural, structural and services designs and construction for a few projects are discussed in this article.

Palais Royale

Palais Royale (pronounced as pa-lai ro-yaal) in French means a Royal Palace, is situated at Worli Naka, Mumbai has a height of 295 m above the ground level. The total structural height is 325 m from the bottom of the foundation to the top of the architectural feature.



A Graphical View of Palais Royale

Structural Systems

The configuration of structural system for the typical residential floor was adopted as conventional column, beam and solid slab.

In order to achieve precise load-path till foundation level without disturbing the architectural and functional need, transfer girders were provided at +76 m level. These are RCC girders 9 m deep and their widths vary from 1200 mm to 1500 mm as per the design and bearing requirements.

Due to heavier loads and longer span, the Structural system below the transfer girder level predominantly comprises of Post Tensioned Flat Slabs and few necessary post-tensioned beams wherever needed.

A raft foundation system was adopted as per the Geotechnical consultant's recommendations.

During the excavation for the deep foundation shoring piles were installed with inclined pre-stressed rock anchors. The base dimensions of the octagonal prismatic building are 84 m x 86 m.

The construction area of the building is over 279,000 sqm (three million sft) with 88 slabs.

Computer Model

Static and Dynamic structural analyses for gravity loads and lateral forces of earthquake and wind were carried out using the ETABS software.

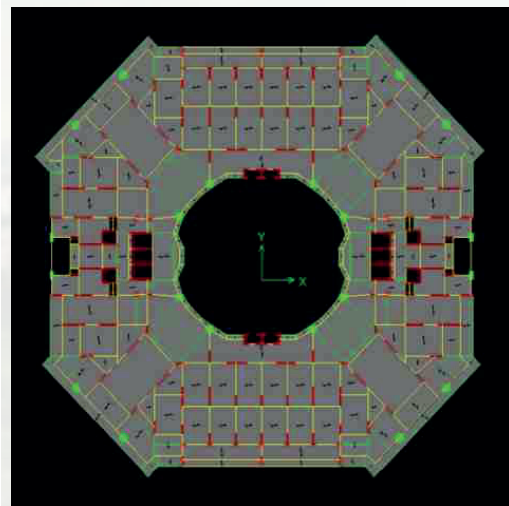
A combination of shell diaphragm and membrane diaphragm were chosen to simulate framing conditions of the structure.

The flat slabs at the parking and amenity levels were treated as shell elements contributing to the lateral stiffness.

At the residential levels, the lateral resistance was derived from the beam-column frame action. Hence, the diaphragm was modelled as a membrane. Cracked section properties were assigned in accordance with the codal recommendations.

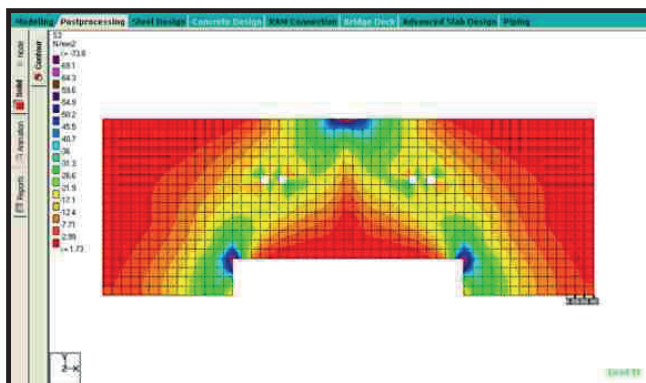
The foundation raft was analysed in SAFE, using the reactions obtained from the ETABS analysis.

Considering the overall maximum lateral deflection of the building being only 300 mm at the top level, the general performance of the building was well controlled.



Plan View of Palais Royale

The transfer girders were analysed by Solid Finite Element Method. Both individual girder models and integrated layout model involving all girders and the three floor levels within the girder depth were assembled in STAAD-Pro. The stress patterns clearly indicated that the girders acted in conformity with strut-tie model corresponding to deep beam action. In-depth research was carried out to design the girders, which are probably the largest transfer girders being constructed in the world.



Principle stress S3 pattern for dead and live load in a girder.

Concrete Information

M:80 and M:60 concretes have been used for columns, & shear walls and the beams & slabs respectively. With the help of an elite team of concrete experts, concrete manufacturers, admixture vendors, contractor's engineers and batching plant operators, a number of trial mixes were tested for various performance criteria and the best one was selected.

Construction Methodology: The Design Engineers were actively involved in the finalization of the construction methodology and in selecting high performance equipment from vendors all around the world apart from providing structural designs. M:80 concrete, use of self-compacting concrete, using surface retarders, introduction of retarded concrete to avoid cold joints, column cages, compulsory use of couplers for rebar splicing, Automatic Climbing System for Walls and cores, etc. were some of the salient aspects of the construction method.

Mock ups

Based on the experience from the project, it has been made a practice to insist on setting up true scale mock-

ups to study the veracity of the systems. For example, two mock foundation blocks of 3.5 m depth with reinforcing bars as per the actual design requirement were cast, cured and monitored for the formwork system, study the feasibility of using SCC, the temperature variation, thermocouple working, segregation characteristics, characteristic strength curve and E-value. The mock-ups were tested two months in advance of commencing the actual foundation concreting. Similarly, the bottom chord of 2 m depth of the overall 9 m deep transfer girder with all the rebars and other embedment was successfully cast.



Pre-engineered formwork



Automatic climbing formwork for cores

Residence Antilia

Introduction

Located at Altamont Road, just off Pedder Road in South Mumbai, Residence Antilia is an extraordinary high-rise building, constructed as a private residence. The structure rises 160 meters above ground level and has two basements. The general floor plan dimensions are about 47 meters x 43 meters. The total built up area is about 42,000 sqm.

Since the residential floors begin above 109 meter level, they enjoy panoramic views of the city in all directions.

The original structure was conceived as a structural steel-framed building and was designed by M/s. Arup from their UK office. However, the structural steel members required as per design were very heavy and almost impossible to fabricate, transport through the city to the site and to erect in position - even with the best available resources. Besides, joining the fabricated pieces by carrying out butt welding at site was seen as impractical and unreliable. Hence, after careful review, it was decided to convert the design into an RCC framed structure.

Sterling then shouldered the responsibility of producing the revised structural design. Perkins & Wills - the Architects from Chicago, USA - were pleased to see that their original architectural intent was kept intact even after the conversion. There was no significant increase in sizes of the structural members.

Planning

The grand entrance canopy on the eastern side provides a clear headroom of 5.2 meters with an impressive overhang of 11 meters. The canopy is covered with glass to permit natural light. The entrance leads to the Grand Ballroom located at the upper basement level. The magnificent Ballroom is 44 meters long and 13.5 meters wide. The lower basement has water tanks, pump rooms, telecommunication room, electric sub-station, etc. Above the ballroom level, there are six parking floors over which there is an entire mechanical floor. That is followed by an entertainment floor with a plush home theatre. The main garden level is planned at 45 meters level. Twenty two meters above this level is a service floor followed



by two Health Club floors with a swimming pool and associated facilities. Next, there are two guest floors with apartments for resident guests. Finally, the four residence floors rise above 109 meters level. Above those is a mechanical floor with a void in between to isolate noise and vibrations from the upper floors. Above that floor is an observatory floor and library at 141 meters. Finally, there is a helipad at 159 meters level. In all, there are three refuge floors and three mechanical plant floors at different levels in the building. A service core comprising

of nine elevators, two stairs and service shafts is located on the eastern face of the building. Some of the external walls have been designed as vertical hanging gardens.

Structural Scheme

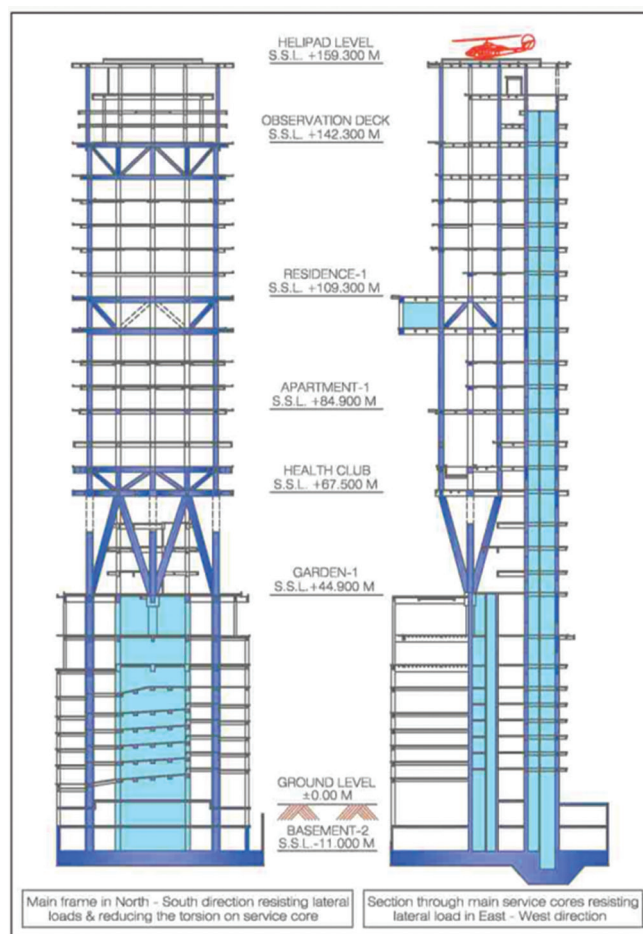
Very hard rock stratum was encountered at the lower basement level. The building has a 3 meter thick RCC raft foundation designed by M/s. Arup. In order to provide column free space for the ball room, directly under the tower block, the main columns were pushed back towards the core. That also enabled the architects to achieve column free car parking floors above the banquet hall. The banquet hall has a clear height of 10.5 meters and the ceiling has been fitted with chandeliers weighing about 25 tonnes, suspended from a steel platform, which in turn is suspended from the first parking floor.

As a structural scheme, the elevator and stair cores form the main spine of the building. However, the service core is eccentrically placed. The remaining areas are supported on suitable column grids which are about 7 meters x 5 meters. For the purpose of the structural analysis, a space frame model was prepared using STAAD-Pro software. Apart from conventional gravity loading, special attention was given to seismic parameters. Although Mumbai is located in Zone III as per current IS Codes, the owners decided to adopt the parameters of Zone IV as an abundant precaution. Similarly, considering the unusual structural irregularities in this building, the response reduction factor “R” was taken as 3 to obtain conservative results. This factor was further reduced to 2 after deliberations because it was found to be better to rely on strength than on ductility. Wind tunnel tests were conducted by BMT Fluid Mechanics Limited at London, UK. The tests were used to assess both the design wind loads and the acceleration arising from wind induced motions.

Construction challenges

When the structural design was revised from steel to concrete, most of the columns had to be heavily reinforced in order to retain the original cross-section. The stress levels in these columns were significantly higher compared to those in the thick shear walls of the service core.

The computer analysis revealed the non-uniform elastic



deformation of these load bearing elements and indicated significant tilt of the structure towards the west under dead-load condition. The service core was therefore, constructed with a carefully calculated “tilt” towards the east so that, under fully loaded condition, it would come back to a nearly vertical position.

Above the main garden at 44 meters level, each “mega column” was split into 4 tapering circular columns forming an inverted pyramid. The free-standing height of these tilted columns is 22 meters. The construction of these 1600 mm diameter columns posed a challenge. Two piece, semi-circular steel forms were specially fabricated for each and every column. These forms were rigidly supported on well designed staging and the entire staging was kept in position till the upper floor tying all these inclined columns was cast and cured.

The second mechanical plant floor at 101 meters level, as well as the first residential floor at 108 meters level,

cantilevers by about 9 meters beyond the front row of columns. Therefore, a special well braced staging of about 56 meter height was erected to support the formwork exclusively for these cantilevered floors. The formwork was kept in position for over two months while the superstructure construction advanced.

There are two extraordinary helical stairs within the residence for internal communication. Since the designs for these stairs were not finalized at the time of construction of the residence floors, suitable cut-outs were provided in the floor slabs. Subsequently, elaborate fabricated structural steel stairs were erected and anchored into the RCC floors.

The challenging design of RESIDENCE ANTILIA stretches the boundaries of architecture and engineering. With its high level of complexity and the innovations required to accommodate them, it is an excellent example of modern day revolutionary skyscraper design.

Sunshine Tower

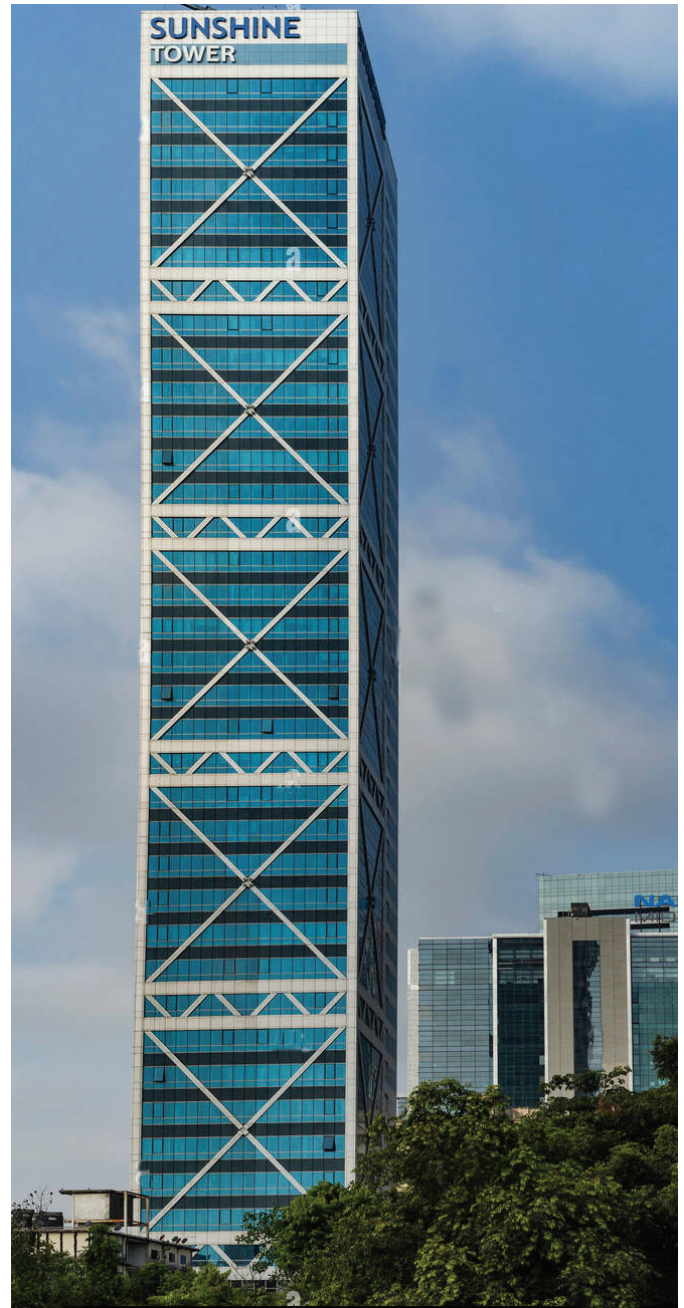
It is the tallest Commercial Steel-framed building in India

Introduction

Until recently, developers in India were rather sceptical about using structural steel on a large scale for their projects and RCC was the preferred choice. However, due to availability of suitable structural steel sections manufactured to international standards and advancement in fabrication and erection facilities, steel-framed buildings are emerging as viable alternatives to RCC structures. One recent example is the construction of Sunshine Tower, the tallest commercial steel-framed building in India – located on Tulsi Pipe Road, Dadar, Mumbai.

Architectural Planning

The plot of land available for construction was about 3,000 sq.m. of which 15% area was consumed by the narrow approach road itself. The overall dimensions of the tower in plan are 21 m x 27 m with a total height of 161m above the ground and 5 m below. Hence, construction of a very tall and slim building was inevitable. Considering the space constraints, it was decided to minimize “in-situ”



work and fabricate most of the building components away from the site. That led to selection of a steel-framed building covered with structural glazing and aluminium composite panels. The service core comprises of elevators, fire escape staircases, toilets and air-handling units.

The tower comprises of a basement, Entrance Lobby at the Ground Floor, 5 parking floors and 35 office floors

including refuge floors at different levels. The office space, measuring 21 m x 16 m, is completely column free. All the services are accommodated in the basement along with a mechanical car parking facility. The car parking floors above are accessed by a 6 m wide ramp. The entire parking block is designed as an RCC structure, attached to the tower block.

Structural Scheme

The structural scheme comprises of RCC slabs supported on steel beams which in turn span 15.6m from the service core to the peripheral columns. The depth of these beams was restricted to 686mm, and they are designed as composite sections utilizing the compressive strength of the concrete slabs. The beams are directly supported on square hollow steel columns (measuring 500mm x 500mm). The plate thicknesses of these sections vary from 36mm at the bottom to 16mm at the top.

Traditionally, the lateral loads due to earthquake and winds are resisted by providing a strong, centrally located service core. However, in this case, the plan dimensions of the RCC core were restricted to 11m x 21m only and the core was eccentrically placed. It was too weak to provide lateral stability for this 180m tall building. Hence it was decided to utilize the strength of the steel columns on the periphery of the building. Although 500mm x 500mm steel columns can carry large axial loads, they have very low stiffness to resist lateral loads. Hence, lateral deflections were brought under control with the introduction of diagonal bracings

- rectangular hollow steel sections of 500mm x 300mm. The concept of having bracings also appealed to the Architects for its aesthetic advantages and honesty of expressing the structural concept. The six storey high diagonal bracings resist significantly large tensile forces and reduce lateral deflections. Besides, the steel columns are filled with concrete to increase their stiffness as well as to improve their resistance to fire.

In addition to that, the structural framing system at every service floor was specially designed to function as a “Floor Deep” Spandrel Truss along the periphery of the building. Its major contribution is to utilize the axial load carrying capacity of the steel columns on the periphery and further reduce the lateral deflections at the top.

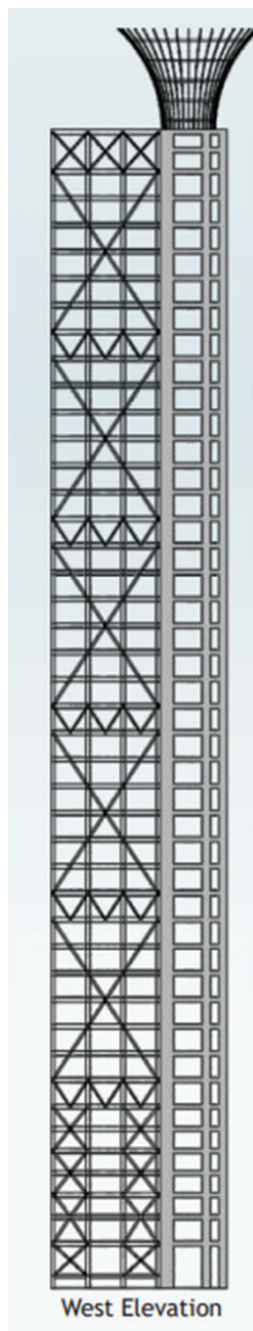
As per the geo-technical report, a suitable stratum with a Safe Bearing Capacity of 150 t/sqm., was available at a depth of 7m to 8m below the natural ground level. As only one basement was required in the building, the option of using Pile Foundation was ruled out. Hence shore piles were provided to facilitate deep excavation without endangering the adjoining buildings.

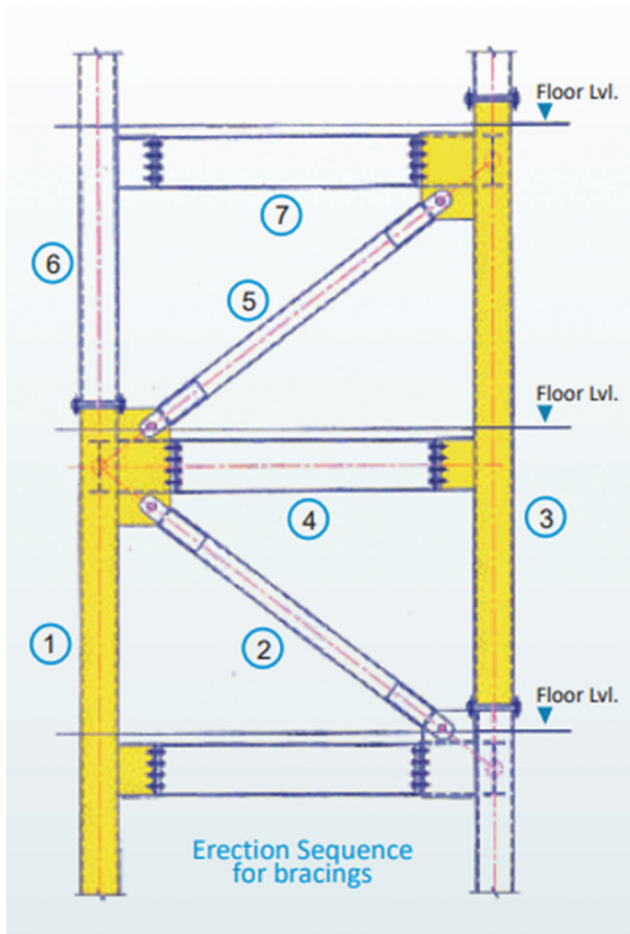
The roof of the lift-machine room rises more than 6 m above the terrace level. A steel truss of the same height, along the periphery of the building, conceals the façade cleaning system mounted on rails as well as the lift machine room and staircases.

A specially designed architectural feature – resembling a fountain – is supported above the roof of the lift-machine room. This feature is expected to be illuminated at night. The feature is over 15m high, with an upper and lower diameter of 16m and 6m respectively. It was modelled using ETABS software. The feature along with an access ladder and maintenance walkways was fabricated using MS tubular sections. The design was optimized and the total weight of the whole unit is less than 25 tons.

Construction Sequence

While the contractors were busy excavating for the basement in the restricted plot area, the owners imported all the special steel sections sourced through CORUS from Japan, Taiwan and UK, since they were not rolled in India. These sections were transported directly to Pratibha Industry’s modern fabrication facilities in Wada





90 kms away from Mumbai. The fabrication was carried out with utmost care and accuracy. As soon as the raft foundation was concreted, the lowest sections of the steel columns (complete with 100mm thick base plates) were brought to the site by special trailers. A heavy duty crane – capable of lifting 5 metric tons at 185m was erected in the north east corner of the tower block. Similarly,

to expedite construction of the concrete core, pre-engineered aluminium formwork was used. That ensured dimensional accuracy as well as speed.

All the diagonal steel bracings in the tower block were installed in the same plane as the peripheral columns and beams. Thus, eccentric connections were avoided. However, the erection sequence of the columns, beams and diagonal bracings had to be worked out very carefully to avoid delays. The accompanying diagram shows the erection sequence that was successfully adopted. It can be seen that the junction of columns was staggered specifically to simplify erection and the bolted connections between columns and beams were moved away from the main grids. The diagonals were connected by using single pins and all other joints were “bolted” connections. Thus, welding at site was practically eliminated.

Conclusions

Technological innovations used in high-rise buildings can be manifested in many areas: geometric forms, construction, materials, vibration damping systems and energy efficiency. The development of computer technology has facilitated the design of high-rise buildings with complicated structural forms and functional requirements. Increased computing power has allowed the creation of more advanced engineering programs, which are able to simulate the actual behaviour of a structure. That can especially be seen in high-rise buildings constructed in the past decade or so. Modern designs have broken the stereotypes of high-rise buildings in terms of history and tradition. The challenges and excitement of Tall Buildings has just begun.



TAK Mathews

Director

TAK Consulting Private Limited

Introduction

From one building of 4 - 5 floors at the turn of the last century to 45 floors no longer sounding tall, the Indian landscape has changed dramatically through the first two decades of this century. The Bureau of Indian Standards recognized the dramatic change and released the revised National Building Code of India (2016) [NBC 2016] in two volumes. The earlier NBC 2005 was just one volume.

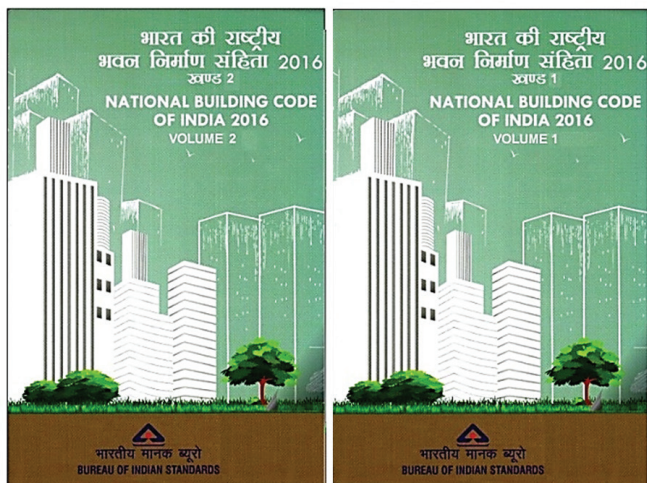


Figure-1: NBC 2016 (the majestic two volumes)

From the elevator and escalator perspective, the clear objective was to put together codes that facilitate going tall. The new codes for elevators and escalators were totally rewritten. The first differentiator from NBC 2005 was the separation of escalators and moving walks as

a separate part (Part 8 Section 5B) from the elevators which is covered under Part 8 Section 5A.

NBC 2016 Part 8 Section 5A Codes for Lifts

The section on Lifts has been rewritten with a significant emphasis on taller buildings and the special require-

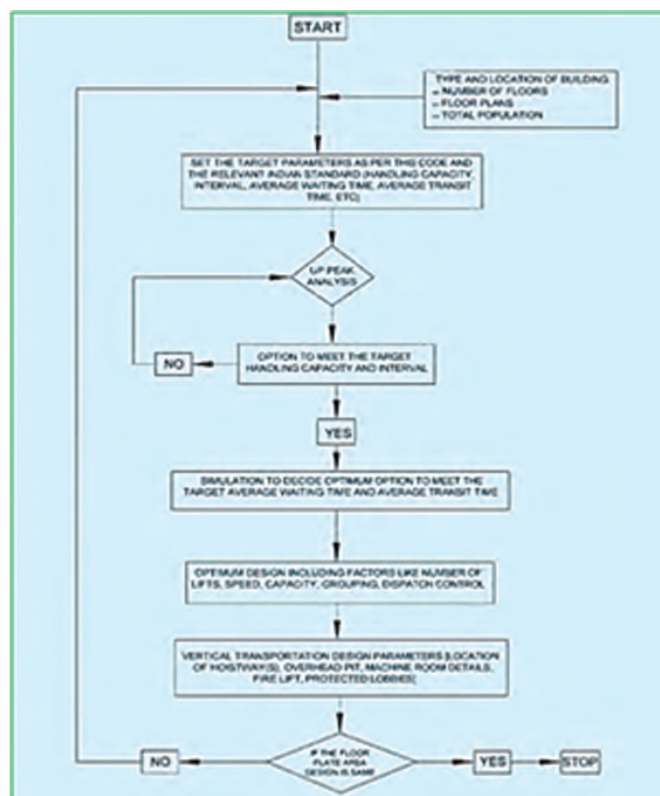


Figure 2: Typical Flowchart on Preliminary Design of Lifts (Ref NBC 2016, Part 8, Section 5A)

ments. The chapter on Planning and Design had more elaboration than NBC 2005 and provided a robust design process flow chart.

The recommended quantity of service and quality of service for residential buildings has been segregated to reflect the difference in requirements depending on the class of building. NBC 2005 had a flat 7.5% handling capacity for all class of buildings and an open-ended range for quality of service.

The planning dimensions were expanded to include for more capacities and for speeds up to 10m/s. They were also expanded to differentiate between machine room elevators and machine room less elevators, different door types as well as applications like hospital bed lifts and automobile lifts.

Chapter 7 was devoted to Fire Protection requirements with clear recognition that firefighters, in case of taller buildings, are dependent highly on elevators for firefighting and assisted evacuation. Accordingly, the minimum capacity of the fireman's lift buildings beyond 60m has been increased to 1000kgs (15 passengers) from the previous 544kgs (8 passengers). The new requirements also recognizes that for taller buildings, it might not be possible to have a single lift serving all the floors and has provided for zoning, which itself provides an additional level of safety for firemen.

Chapter 7.2 introduces a radical change to the *"Do not use Lifts in case to fire"*. The committee recognized that elevators could provide additional support for building evacuation to the time-tested evacuation via the staircase, particularly for the people with special needs and the elderly. Clear guidelines and standard operating process has been defined for evacuation lifts with two very clear riders – first, that *lifts may be planned only as a supplementary means to staircases* and second, that *dependency on lifts instead of staircases may increase the evacuation time*.

Chapter 9.5 of Part 8 Section 5A also considers impact of seismic forces and provides guidance how to provide the required protection for elevators and users.

Chapter 11.0 has been introduced in the lift section detailing the Special Technical Requirements for Super High-Rise Buildings. It brings to attention impact of piston effect on ride comfort and quality. It provides for the elimination of imperforate partition walls or provision of vents between hoistways to reduce the impact of piston effect. Impact of building sway is also covered.

The above effectively covers the best part of elevating in a taller India.

The rest of the paper looks at how India is approaching the two most critical prerequisites for tall buildings from a codal perspective – first, **Elevator Planning and Design** approach to establishing the required elevators and second, the issues related to **Fire and Elevators**

Note: Through the paper, the terms Elevators and Lifts are used interchangeably

Elevator - Planning and Design

Almost a decade back, the author's recommendation on elevators for a building were not considered. That was despite the whole project team's concurrence with the explanations and recommendations. The question was who would bell the cat and inform the owner and the architect that slabs had to be cut and elevator hoistways added. The project manager who saw the folly, in sheer frustration had predicted, *"only disasters and financial loss will make people learn"*. Sure enough, on commissioning the building had and continues to have major problems with inadequate elevating. However, it is doubtful whether the project manager's prediction has any chance of coming true.

So how is a taller India approaching the elevator planning and designing? The author's contention is that there are more under elevated buildings coming up or being planned than before NBC 2016 was issued.

Matching the Building to proposed Elevators

Where a Design Basis Report (DBR) does exist for a building (which is not the case for many buildings), there is a high probability that the recommendations of NBC

2016 are being adequately achieved due to adoption of two techniques to achieve the results theoretically.

I. Averages, Creative Probability & Statistics

At a workshop on traffic analysis the trainer narrated a story – *A 6 feet tall man who did not know to swim drowned trying to cross a river that was on average 3 feet deep*. What the average and statistics did not reveal was that at the deepest point, the river was 20 feet deep.

In many ways that is how many approach elevating decisions. It is not uncommon for to consider that there is nothing wrong with a 45 second average waiting time for a commercial building without recognizing that averages do not tell the whole story or that lunch time peaks is a very different scenario. Incidentally, NBC 2016 recommends less than 25 seconds for a premium building and between 25 to 35 seconds for a regular commercial building.

Considering a single 5-minute period to establish averages without recognizing that the average of a single number is the number itself is a fallacy that needs to be set right.

II. Designing the Population to the Elevators

Calculating the Round-Trip Time (RTT) which forms the basis for the interval calculations and the *absolute* 5-minute handling capacity number does not have the building population as an input. Barring some tweaking of enhanced acceleration/ deceleration rates, faster door operation, and faster passenger ingress/ egress timings, the round-trip time would remain the same for most traffic analysts. Of course, sometimes the probable number of stops is not properly accounted for and that yields an erroneous improved RTT.

It is when the handling capacity is converted into percentage terms that the building population number first comes as the denominator into the traffic analysis equation. At this stage, often the elevator traffic population is not correctly considered and hence the result is again incorrect and the Handling

Capacity percentage meets the set target or values prescribed by NBC 2016. Another common error is to consider elevator designs for office buildings based on absenteeism factors as high as 40% or even 50% - *effectively meaning the average elevator traffic is reduced to 50%*. Thus, when the building is finally occupied the morning peak would be very bad, while lunch time traffic would be a disaster.

Similar approaches are adopted for residential buildings on the plea that the building would never be fully occupied. That again is not the correct reasoning, as in time either the owners could have moved-in or investors could have leased out their apartments.

If the population to be considered for traffic analysis becomes a function of the available elevator capacity i.e., the *input becomes the output*, then that again is incorrect

With the above considerations the viability of the building is questionable!

High-Rise Committee, DCRs and Municipal Byelaw

Beyond the structure, what makes a high rise building viable are the elevators – the buildings life line, a fact which must be acknowledged.

However, there is no statutory compulsion to ensure the adequacy of elevators since no Development Control Rules (DCR) or Byelaw lays out the verifiable conditions for elevator adequacy. While Mumbai Metropolitan Region Development Authority (MMRDA) does ask for a validation, however it is more of a formality. The only reference to elevators is for Fireman's Lift and in recent times the Fire Evacuation Lift (which is a misnomer and discussed later); that too, driven by the Chief Fire Officer's (CFO's) office.

To the best of this author's understanding, the High-Rise Committee also does not have any requirement or check for the adequacy of the elevators.

Without a statutory compulsion or mandate for elevator adequacy, costs become the driving and deciding factor

for elevating. The provisions of NBC 2016 are taken as just a recommendation and are not correctly adhered to.

In one instance, while reviewing the elevating provisions for a tall commercial building, it was clear that the elevator provisions were without a DBR. The elevator provisions were established for other considerations. The Handling Capacity was less than 5% against the minimum of 10% called for by NBC 2016. With a metro at walking distance from the building, the morning average waiting times are expected to be close to 4 minutes.

2.0 Fire & Elevators

The author's involvement with fire and elevators started in 2009 after the tragic death of 6 firemen in an elevator at the Tarangan Housing Society. It was ironical that the incident happened on the eve of Diwali. As everybody was celebrating with firecrackers and diyas, 6 families lost their breadwinners and loved ones. Six brave men, who were colleagues and friends to many were lost.



Figure-3: Tarangan CHS Elevator (post incident)

On investigation of the incident, it was concluded that the elevators were installed prior to NBC 2005 and therefore were not expected to meet those norms. Some of the potential issues were that the elevators had multiple fireman's switches, the door opening wasn't as per phase 2 defined in NBC 2005 and NBC 2016 and the hall call buttons were not being deactivated. The investigations and studies were expanded to address the question, "How could this tragedy been prevented?"

The observations and conclusions gathered since 2009 are discussed below.

Collaboration between constituent stakeholders

The first issue identified was the very little collaboration and understanding between the various constituent stakeholders – the fire-fighting fraternity, fire experts, consultants, architects, developers, and the elevator industry.

Within months a workshop, a first of its kind, was organized with representatives from the fire fraternity from around the country and the others.

Since then, the author has been advocating the cause of proper planning and designing of elevators and has addressed audiences on numerous platforms around the country. Others from the elevator industry too have taken up this issue.

Awareness

A glaring and most dangerous issue is and continues to be, that many from the fire fraternity and most laymen carry the notion that "Fire Lifts" mean that these lifts are fireproof. It is essential that all concerned, recognize that the term *Firelift* is a short form for Fireman's Lift or Firefighter's Lift. The official statutory documents, including the Unified Development Control and Promotion Regulations of Maharashtra (UDCPR – 2020), use this short form. Therein chapter 9.28.8 is titled 'Fire Lift'. That needs to be corrected to convey the correct intent. Hence, it is recommended that, to avoid confusion or misunderstanding, the short form 'Fire Lift' whether verbal or written be removed from the vocabulary especially of codal and statutory documents.

Standard Operating Process (SOP)

Due to limited understanding and collaboration, the standard operating processes were varied and somewhat vague.



Figure-4 Recommended reading for PG course in Fire & Life Safety Audit

David M McGrail in his detailed book “Firefighting Operations in High-Rise and Standpipe-Equipped Buildings”, PenWell Corporation, Oklahoma, USA has provided detailed and very clear SOP. Some of the points mentioned therein are:

- Never take an elevator below grade
- Never take an elevator directly to a reported fire floor
- Stop two floors below the reported fire floor

The book is part of the recommended reading list for the post graduate diploma in Fire & Life Safety Audit offered by the Guru Gobind Singh Indraprastha University. It is recommended that it should be made a compulsory reading material for all firemen and the other stakeholders.

Standards and Codes

While many issues and shortcomings came up during the February 2010 workshop, one particular issue was the discovery that the prevailing Indian standard for elevators (IS 14665) was silent on the requirements for fireman’s lift, however, NBC 2005 (Part IV and Part VIII Section 5) had detailed requirement for fireman’s lifts. BIS’ ET 25 Committee immediately sprang into action and on priority issued an amendment to correct the anomaly.

During the drafting of NBC 2016, the CED 46: P16 Committee ensured that any section on Fire and Elevators would be based on collaboration with domain experts and the fire fraternity. Many including Mr. S K Dheri and Mr. Santosh Warrick extensively contributed their time and counsel to the committee.

However, the problem remains as many jurisdictions tend to issue their own adaptations, often with requirements which are technically impractical or in contradiction to the standards and codes and sometimes even dangerous. There has been very little appetite to study and understand the provisions and requirements for Evacuation Lifts, instead new provisions which are technically impossible or in violation of prevailing standards and codes are being introduced. Even the critical NBC 2016 provision where the Fireman’s Lift for buildings above 60m should have a minimum capacity of 1000kgs (15 persons) is often not provided.

References to International Standards and Codes

Documents issued by statutory authorities sometimes refer to international standards and clauses. These references though based on inputs from experts, are not properly incorporated to convey the correct meaning or context as intended.

A few examples:

- i. Some jurisdictions refer to paragraphs from Annexure B of National Fire Protection Association (NFPA) 101 as mandatory requirements. However, Annexure B starts with the statement, “*This annex is not part of the requirements of this NFPA document but is included for information only*”.

The understanding is that devices mentioned in Annexure B could be considered as *supplemental* evacuation methods. Unfortunately, the emphasis laid out is on the supplemental methods and not the primary requirements.

- ii. A CFO document mandates a controlled lowering device for evacuation as defined by NFPA 101 as approved by CFO. NFPA 101 in its *not mandatory* section defines a Controlled Descent Device as “*A system operating on the exterior of a building or structure that lowers one or two people per descent, each wearing a rescue harness, at a controlled rate from an upper level to the ground or other safe location.*” Discussions with persons concerned revealed that they understood it to be something else.
- iii. A recent circular has a requirement that Fire Evacuation Lifts should have a “Conformité Européenne” (CE) certification. There are three issues with this requirement.

First, the two standards defined for fireman’s and evacuation lifts by the European Committee for Standardization CEN (Europe) are

- EN 81-72 (2015) Safety rules for the construction and installation of lifts – Particular applications for passenger and goods passenger lifts – Part 72: Firefighters Lifts, European Committee for Standardization.
- EN 81 – 76 (2011) Safety rules for the construction and installation of lifts – Particular applications for passengers and goods passenger lifts – Part 76: Evacuation of disabled persons using lifts, European Committee for Standardization

There is nothing like a Fire Evacuation Lift either in Europe or anywhere else in the world.

Second, without a requirement for Fire Evacuation Lifts, Europe does not have a standard for Fire Evacuation Lifts and hence does not have a CE certification process for this newly created local

requirement. The CE certificates that this author has seen as having been submitted for equipment supposedly complying to the Fire Evacuation Lifts requirement, refers to a Fire Evacuation System and not an elevator. The certificate also does not refer to any CEN requirement (EN81 – 20, 50, 58, 72 or 76) for elevators.

Third, CE certification indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area (EEA). India does not have a CE certification body and does not recognise a CE certificate

Conclusions

that the provisions of NBC 2016 for elevators must be correctly incorporated in the planning and design of buildings which embodies the collective wisdom of over 2 dozen experts with combined and varied experience of close to 1000 years. Trying to reinvent the wheel, has serious consequences from the perspective of safety, viability and sustainability of any building, let alone tall buildings. The sooner that is recognized and corrected the better it would be for all the stakeholders.

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Tall Buildings – Overview of Design Issues



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Abstract:

With the increasing demand on land in urban areas, the buildings have been naturally growing in the vertical direction. Development of design and construction technology is resulting in building taller and efficient buildings. This paper discusses the design issues associated with Tall Buildings.

The world over, in large cities, where land availability is restricted and thus at a premium, tall buildings have become the order of the day. To keep space with that, there have been tremendous developments in the planning, analysis, design and construction and maintenance methodology of buildings as they soared towards the sky. New building materials, construction technology also developed together with the advancement of technology for providing water, electricity, plumbing, HVAC, elevators, communication and monitoring systems, fire safety and fire-fighting measures all to make the tall buildings more safe and secure. The stone and brick masonry buildings whose height were restricted to eight to ten story height are becoming a thing of the past.

The definition of ‘Tall Buildings’ (i.e., which building could be called a tall building) has evolved over the years. What was called a tall building or even a skyscraper are now, after a few decades merely referred to as multi-storied building. The 54m tall LIC Building in Chennai was the tallest building in the country in 1960 and now



it is one of the many multi-storied buildings. The tallest building in the country at present is the 88-storied Palais-Royale Building in Mumbai which stands 320m tall. As per the current version of IS:16700 (Structural Safety of Tall Concrete Buildings) a ‘Tall’ building has to be more than 50m high, although this definition varies where the lower limit is considered as 100m or even 150m.

The practice of constructing modern Tall Buildings started in North American cities like New York City and Chicago in the second half of the 19th century. It coincided with the availability of structural steel products and the



development of electrically operated safety elevators. Structural Steel frames with riveted connections replaced the thick masonry load-bearing walls and allowed the engineers to build taller structures. Masonry walls were used only as curtain walls. The availability of elevators made climbing higher stories feasible. Over the years, the height of the buildings increased from ten stories to twenty stories culminating in the 380m tall 102-storied Empire State Building in New York City in 1931. After the gap created by the Second World War, the pursuit of taller and lighter structure continued not only in North America but also in major Asian cities besides Europe. Tall Buildings are usually situated in city centers where the price of land is high, and where it makes economic sense to build upward so as to minimize the cost of the land vis-à-vis the total floor area of a building. They provide a high ratio of rentable floor space not just for commercial usage but also for residential purposes per unit area of land. Hong Kong has very restricted land to build on, hence, it now has more than 500 buildings that are taller than 150m. Mumbai at present has more than two hundred such tall buildings and many more are being constructed.

Planning, Design & Construction

The planning, design and construction involve creating safe, secure, habitable spaces in structures that must support their weight, resist wind and earthquakes, and protect occupants from fire and other natural elements. Yet they must also be conveniently accessible, even on the upper floors, and provide utilities and a comfortable climate for the occupants. The problems posed in planning and design are considered among the most complex encountered given the balances required between economics, engineering, and construction management. The major planning and design issues are:

- Planning
- Geotechnical Design
- Structural Design
- Elevators/ Vertical Transportation
- Services like Water Supply, Sanitation, Plumbing, HVAC, Electrical, Communication, etc.
- Fire Safety & Fire Fighting
- Energy Conservation

For Life Cycle Planning and Design, two issues should also be considered during the initial planning and design stage.

- Disaster Mitigation – Safe evacuation of occupants in case of a rare event of explosion or catastrophic damage.
- Dismantling at the end of usage life – a possible safe method of dismantling of the building without any damage to neighbouring structures.

Loading

The load a tall building experiences is largely on account of the building materials themselves. In most building designs, the weight of the structure is much larger than the weight of what that has to support. In technical terms, the dead load, i.e., the load of the structure, is larger than the live load, the weight of things in the structure (people, furniture, etc.). As such, the amount of structural material required at the lower levels of a tall building will be much larger than the material required at higher levels.

This is not always visually apparent. For masonry (Brick or Stone) buildings the wall thickness required to support just the vertical loads on lower floors becomes too large. Hence a masonry building taller than eight or ten stories becomes practically infeasible. The normally adopted framing system of tall buildings can be categorized as steel frames, concrete cores, tube within tube design, and shear walls.

Buildings are usually subjected to static loads, such as occupants' weight, equipment, furniture, and the weight of the structure per se. However, two important environmental loads that are different in nature may act on the buildings during their lifetime— they are the forces imposed by Wind and Earthquake, which are different from the static load. Even if they could be expressed as equivalent static loads, tall buildings and flexible structures may amplify the internal loads resulting in additional inertia loads which can affect the serviceability and the comfort of the people inside, or even lead to a complete collapse. When it comes to dynamics and load-structure interaction, inherently low damping in buildings is a key parameter that can be used to control the behaviour of a structure under such dynamic loads. In addition, the building's orientation change can result in wind response and reduction of wind forces acting on it.

Developments in structural materials and design technology in engineering have led to designs that satisfy strength requirements but often result in a very flexible structure which can cause unfavorable vibrations when the structure is subjected to wind or earthquake loads. These vibrations may lead to serious structural damage and affect the comfort of the occupants. The dynamics of buildings greatly depend on the characteristics of the external excitation as well as the physical properties of the building in terms of generalized masses, frequencies, and damping. Wind loads are characterized by low frequencies while earthquakes usually contain higher frequency force components. Tall Buildings have a fundamental frequency range of 0.1 to 0.3 Hz which is close to high values of spectra of crosswind excitation. While low rise buildings generally have a fundamental frequency range of 1 to 5 Hz that often matches the high

values of the seismic spectra. Most of the dynamics associated with damage and discomfort in buildings are referred to as excitations close to the first few modes. In super tall buildings, however, first modes are likely to have low frequencies which make them mostly affected by wind loads rather than earthquakes. On the opposite, short buildings are more likely to be affected by dynamics-associated damage under earthquake loads which are likely to occur at the dominant frequencies of these type of structures. In order to control the swaying of tall buildings different approaches are sometimes employed. One such approach is installing Tuned Mass Dampers (TMDs) at the top level.

Wind Loads

Wind can be low, moderate, strong, and extremely destructive. While low and moderate winds are beneficial for pollution dispersion and electric power generation, extreme wind events can cause devastating effects on the infrastructure. Extreme winds may cause damage to low-rise buildings viz. windows damage, roof loss, or even complete collapse of timber structures. In tall buildings, however, both cladding loads and the dynamics of the structure become a concern. High-rise buildings are amongst the more wind-sensitive structures. The lateral wind load imposed on super-tall structures is generally the governing factor in the structural design. It is inevitable that the response to wind would be of concern to structural engineers and attract the interest of early experimenters, both in the wind tunnel and in full-scale testing. Wind loads and the associated structural responses are a governing factor in the design of the steel framing system of many high-rise buildings. Wind load capacity is also a key factor in determining the overall strength of towers. In addition, the design of high-rise buildings should take into account the comfort criteria due to wind-induced vibrations.

Wind-induced response to the loading on structures depend, among other factors, on:

- 1) Terrain or mean wind velocity profile and turbulence characteristics,
- 2) Building's aerodynamic shape,

- 3) Wind speed (which should not be always very high to cause damage),
- 4) Wind direction, and
- 5) Structural properties that may magnify wind loads at resonance.

Not only the wind approaching buildings is a complex phenomenon, but the flow pattern generated around buildings is also complicated too. The flow pattern is distorted by the mean flow, flow separation, the formation of vortices, and the development of the wake. Large wind pressure fluctuations due to these effects can occur on the surface of a building. As a result, large aerodynamic loads are imposed on the structural system and intense localized fluctuating forces act on the façade of such structures. Under the collective influence of these fluctuating forces, a building tends to vibrate in rectilinear and torsional modes. Along-wind loading and response of buildings due to buffeting can be assumed to consist of a mean component due to the action of the mean wind speed (the mean hourly wind speed) and a fluctuating component. That is the basis of the so-called ‘gust-factor’ approach, which is treated in many design codes. The mean load component is evaluated from the mean wind speed using pressure and load coefficients. The fluctuating loads are determined separately by a method that makes an allowance for the intensity of turbulence at the site, size reduction effects, and dynamic amplification. The dynamic response of buildings in the along-wind direction can be predicted with reasonable accuracy by the gust factor approach, provided the wind flow is not significantly affected by the presence of neighboring tall buildings or surrounding terrain.

Cross-wind oscillations can be very significant especially if the structural damping is small. The most common source of cross-wind excitation is that associated with ‘vortex shedding’. Tall buildings are bluff (as opposed to streamlined) bodies that cause the flow to separate from the surface of the structure, rather than follow the body contour. The asymmetric pressure distribution, created by the vortices around the cross-section, results in an alternating transverse force as these vortices are shed. If the structure is flexible, oscillations

are transverse to the wind. The conditions for resonance would exist if the vortex shedding frequency coincides with the natural frequency of the structure. Such a situation can give rise to very large oscillations and possibly failure. In buildings experiencing wind motion problems, objects may vibrate, doors and chandeliers may swing, pictures may lean, and books may fall off shelves. If the building has a twisting action, its occupants may get an illusory sense that the world outside is moving, creating symptoms of vertigo and disorientation. In more violent storms, windows may break, creating safety problems for pedestrians below. Sometimes, strange and frightening noises are heard by the occupants as the wind shakes elevators, strains floors and walls, and whistles around the sides.

A vital part of the design of modern tall buildings is the prediction of wind-induced motion and the assessment of its effects on occupant comfort. One of the primary purposes of wind engineering research is to predict wind-induced forces on structures. Wind-induced forces are dependent on structure shape, location of the structure, and the characteristics of wind (such as wind speed and angle of attack). Traditionally, wind loading on buildings can be evaluated analytically using some codes and formulas. However, these standards provide little guidance for the critical cross-wind and torsional loading. This is partially attributed to the fact that the crosswind and torsional responses, unlike the along-wind, result mainly from the aerodynamic pressure fluctuations in the separated shear layers and the wake flow fields, which have prevented, to date, any acceptable direct analytical relation to the oncoming velocity fluctuations. Also, these methods have some limitations especially when some other tall structures exist in the vicinity of the building under consideration. Moreover, the evaluation process depends on many assumptions. To alleviate these problems, wind tunnel tests and full-scale measurements of wind are used to provide more reliable wind loads on buildings. Despite recent advancements in computational fluid dynamics, wind tunnel simulation of a scaled model is still the most common tool used to predict wind loading. Ideally for a cluster of tall buildings, multiple analyses are required to assess the wind forces during different stages of construction.

Seismic Loads

When the ground shakes, buildings respond to the accelerations transmitted from the ground through the structure's foundation. The inertia of the building may cause shearing of the structure which can concentrate stresses on the weak walls or joints in the structure which could result in its failing or perhaps total collapse. The type of shaking and the frequency of shaking depend on the structure. Tall buildings tend to amplify the motions of longer periods when compared with small buildings. Taller buildings also tend to shake longer than short buildings, which can make them relatively more susceptible to damage. Fortunately, many tall buildings are constructed to withstand strong winds and some precautions have been taken to reduce their tendency to shake. They can be made resistant to earthquake vibrations too.

Preparing structures (either new or old) for earthquakes is expensive and the level of investment is a social and political decision. The choice of building design is a compromise between appearances, function, structure, strength, and of course, cost. Standards are instituted through the establishment of Building Codes, which regulate the design and construction of buildings. Most of the building codes are designed to protect first the building occupants, and second the building integrity. Building codes are usually drafted to meet the demands of the expected shaking in a given region that are summarized by seismologists and earthquake engineers in hazard maps (e.g., IS:1893). Hazard maps are constructed by examining:

- The earthquake history of the region to estimate the probability of an earthquake,
- The expected shaking intensity produced by the earthquake (often expressed as a peak acceleration),
- The frequency of the shaking, the distance from the fault, and
- The regional geology and site conditions.

Thus, rigorous analyses for estimating the response to the expected wind and seismic excitations are a requirement for the safety of the occupants and the structure. It has been found that generally tall buildings designed for wind may be safe under moderate earthquake loads.

Structural Framing

The first structural steel framed building was constructed in Chicago in 1885. It was a ten storied 42m high building. The architect, Major William Le Baron Jenney, created a load-bearing structural frame. In this building, a steel frame supported the entire weight of the walls, instead of load-bearing walls carrying the weight of the building. This development led to the 'Chicago skeleton' form of construction. In addition to the steel frame, the Home Insurance Building also utilized fireproofing, elevators, and electrical wiring, key elements in most high-rise buildings today. Even the tall 102-storied Empire State Building was built on this concept. It was almost the limit of such a type of structural framing reaching the limits of column spacing and size on the lower floors.

This constraint was overcome by Bangladeshi-American Architect/ Engineer Fazlur Rahman Khan in the early 1960s with his concept of framed tubes. He is considered to be the father of modern skyscrapers. The framed tube structure is defined as "a three-dimensional space structure composed of three, four, or possibly more frames, braced frames, or shear walls, joined at or near their edges to form a vertical tube-like structural system capable of resisting lateral forces in any direction by cantilevering from the foundation". Closely spaced interconnected exterior columns form the tube. Horizontal loads (primarily wind) are supported by the structure as a whole. Framed tubes allow for fewer interior columns, and so create more usable floor space, and about half the exterior surface is available for windows. Khan's concept was that the building's external envelope could – given enough trussing, framing, and bracing – be the structure itself. This made buildings even lighter. The 'bundled tube' meant buildings no longer need to be boxlike in appearance: they could become sculptures. Tube structures cut down costs, at the same time allowing buildings to reach greater heights. The tubular systems are fundamental to tall building design. Most buildings over 40-stories constructed since the 1960s now use a tube design derived from Khan's structural engineering principles.

Khan pioneered several other variations of the tube structure design. One of these was the concept of



X-bracing, or the trussed tube, first employed for the John Hancock Center. That concept reduced the lateral load on the building by transferring the load onto the exterior columns. The John Hancock Center was designed in 1965 and completed in 1969. One of the most famous buildings of the structural expressionist style, the skyscraper's distinctive X-bracing exterior is a hint that the structure's skin is indeed part of its 'tubular system'. The idea is one of the architectural techniques that building have used to climb to record heights - the tubular system is essentially the spine that helps the building stand upright during wind and earthquake loads. The John Hancock Center was far more efficient than earlier steel-frame structures. Where the Empire State Building (1931), required about 206 kilograms of steel per square meter, the John Hancock Center required only 145 kg/ sqm.

The development of the Tube concept led to many

advancements and variations in the concept of framing ultra-tall buildings which are:

Bundled tube: An important variation of the tube frame is the bundled tube, which uses several interconnected tube frames.

Tube-in tube: Tube-in-tube system takes advantage of core shear wall tubes in addition to exterior tubes. The inner tube and outer tube work together to resist gravity loads and lateral loads and to provide additional rigidity to the structure to prevent significant deflections at the top.

Outrigger and belt truss: The outrigger and belt truss system are a lateral load resisting system in which the tube structure is connected to the central core wall with very stiff outriggers and belt trusses at one or more levels.

Concrete tube structures: Khan also adopted concrete as a material of construction instead of steel and built tall buildings as concrete tubes.

Shear wall frame interaction system: Khan developed the shear wall frame interaction system for mid-high-rise buildings. This structural system uses combinations of shear walls and frames designed to resist lateral forces; the sharing is based on their relative stiffness. Most of the tall buildings in India are built with this concept, with the elevator and staircase shafts acting as shear walls.

Elevators

The invention of the elevator was a precondition for the development of tall buildings, given that most people would not (or could not) climb more than a few flights of stairs at a time. The elevators in tall buildings are not simply a necessary utility, like running water and electricity, but are closely related to the design of the whole structure: a taller building requires more elevators to service the additional floors, although the elevator shafts consume valuable floor space. If the service core, which contains the elevator shafts, becomes too big, it can reduce the profitability of the building. Architects must therefore balance the value gained by adding height against the value lost to the expanding service core.

Various non-conventional elevator arrangements have been adopted especially super tall buildings to alleviate this problem.

Services

Planning and design of HVAC, Water Supply, Plumbing, Waste Disposal, Electrical, Communication, and Fire Fighting of tall buildings are often quite different from that of low-rise buildings and energy intensive.

For example, potable water supply in a 30 storied building would call for pumping water to 100m height. The capacity of such a pump or the wall thickness of the pipe will become highly economical. The usual practice in such buildings is to place a series of interconnected break tanks at different levels to supply potable and fire fighting water to all levels. Even for disposal of waste water or rain water from such heights, the designer has to make proper arrangements. Similar issues are there for operating central air conditioning in tall buildings. The system design and equipment for services in Tall Buildings are quite different from normal low-rise buildings and requires careful planning and execution.

Environmental Issues

Constructing a single tall building requires large quantities of materials like steel, concrete, and glass, and these materials represent significant embodied energy. Tall Buildings are thus material and energy-intensive buildings. They have considerable mass, requiring a stronger foundation than a shorter, lighter building. In construction, building materials must be lifted to the top of a tall building during construction, requiring more energy than would be necessary at lower heights. Furthermore, a Tall Building consumes much electricity because potable and non-potable water has to be pumped to the highest occupied floors, Tall Buildings are usually designed to be mechanically ventilated, elevators are generally used instead of stairs, and electric lights are needed in rooms far from the windows and windowless spaces such as elevators, bathrooms, and stairwells. In the lower levels of a Tall Building a larger percentage of the building floor area must be devoted to the building

structure and services than is required for lower height buildings:

- More space for the structure – because it must be stronger to support more floors above.
- The elevator conundrum creates the need for more lift shafts—everyone comes in at the bottom and they all have to pass through the lower part of the building to get to the upper levels.
- Building services – power and water enter the building from below and have to pass through the lower levels to get to the upper levels. The solid and liquid waste disposal systems, etc. also have to be planned and provided.

The building sector accounts for approximately 50% of greenhouse gas emissions, with operational energy accounting for 80-90% of the building-related energy use. Operational energy use is affected by the magnitude of conduction between the interior and exterior, convection from infiltrating air, and radiation through glazing. The extent to which these factors affect the operational energy varies depending on the microclimate of the tall building, with increased wind speeds as the height of the building increases, and a decrease in the dry bulb temperature as the altitude increases.

The embodied energy associated with the construction of Tall Buildings varies based on the materials used. With embodied energy quantified per unit of material, Tall Buildings inherently have higher embodied energy than low-rise buildings due to the increase in the material used as more floors are built.

Like with all other buildings, if special measures are taken to incorporate sustainable design methods early on in the design process, it is possible to obtain a green building rating, such as a Leadership in Energy and Environmental Design (LEED) certification. An integrated design approach is crucial in making sure that design decisions that positively impact the whole building are made at the beginning of the process. Because of the scale of Tall Buildings, the decisions made by the design team must take all factors into account, including the impact of the building on the surrounding community,

the effect of the building on the direction in which air and water move, and the impact of the construction process, must also be taken into account. Several design methods could be employed in the construction of a tall building that would take advantage of the height of the building. The microclimates that exist as the height of the building increases can be taken advantage of to increase the natural ventilation, decrease the cooling load, and increase daylighting. Natural ventilation can be increased by utilizing the stack effect, in which warm air moves upward and increases the movement of the air within the building. If utilizing the stack effect, buildings must take extra care to design for fire separation techniques, as the stack effect can also exacerbate the severity of a fire. Tall Buildings are considered to be internally dominated buildings because of their size as well as the fact that a majority are used as some sort of office building with high cooling loads. Due to the microclimate created on the upper floors with the increased wind speed and the decreased dry bulb temperatures, the cooling load will naturally be reduced because of infiltration through the thermal envelope. By taking advantage of naturally cooler temperatures at higher altitudes, tall buildings can reduce their cooling loads passively. On the other side of this argument, is the lack of shading at higher altitudes by other buildings, so the solar heat gain will be larger

for higher floors than for floors at the lower levels of the building. Special measures should be taken to shade upper floors from sunlight during the overheated period to ensure thermal comfort without increasing the cooling load.

Sustainable design of Tall Buildings is a major issue and should be seriously taken into account at the conceptualization stage well before the structural design of the building commences.

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ACI UPDATES

Upcoming Webinar - President's Series: Assessment and Repair of a Mid- and High-Rise Building Using ACI 562

This Oct. 4 webinar, presented by ACI Past President Randall Poston, will focus on the evaluation and repair of two high-profile concrete buildings using ACI 562 - the Courthouse Square mid-rise building complex in Salem, Oregon, and the Austonian high-rise residential tower in Austin, Texas.

Source: <https://mail.google.com/mail/u/0/?tab=rm&ogbl#inbox/FMfcgzGqQmSFMMxrWSZwvQrghRtKZljt>



Dr. Prem Krishna
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Introduction

Buildings have already crossed the ceiling of 800m in height, and will, in all probability, cross the 1000m mark in the near future. One can describe buildings as tall, on the basis of their height, though different ranges will be seen to have been assigned in the literature. In a recently issued Indian standard [1] on tall buildings, the focus is on the height range of 50m – 250m. Ostensibly, it implies that buildings higher than 50m are treated as tall. Another way to view this issue, particularly in the context of this paper, would be to define wind-sensitive buildings that are expected to exhibit significant dynamic response to wind, say with a period of oscillation of more than 1 second, as being tall. All such buildings involve big financial outlays, and are occupied by large numbers of people, thereby implying particularly the need for taking all measures to ensure safety and comfort of the inhabitants. Besides, a number of parameters, which dictate the design of a tall building, two natural hazards are important amongst those which act upon the structure – earthquake and wind. Both primarily cause lateral forces. Generally, wind tends to become more significant as one traverses in height from shorter to taller buildings, but no threshold value can be assigned. Despite wind being the dominant lateral load for most cases, it is a dichotomy, that there is less awareness amongst engineers about wind compared to that about earthquakes. It is worth therefore to address the salient features of this phenomenon.

Phenomena of Wind

Wind is an unavoidable natural hazard resulting from flows, whose generation is on account of atmospheric pressure differentials, and manifests itself into various forms of storms, such as Cyclones (on the coasts), Monsoonic & other storms, such as dust storms, thunderstorms, downbursts, tornados, which occur inland. The mandate of Engineers & Technologists is the safety of the Infrastructure against these storms. In the Indian context it is noteworthy that monsoonic and dust storms cover large regions and occur frequently, whereas other inland phenomenon are in a rather narrow band and are infrequent. The latter therefore constitute a lower level of risk, despite being lethal in themselves when they do strike. Cyclones, which occur on the coasts (more on the East coast than the West) cover large areas and are characterized with high circulatory wind speeds and heavy rainfall, have the highest destructive potential. It is important for the designers of building to understand that whatever the nature of the storm, despite structural differences amongst them, wind is a random dynamic phenomenon with speeds varying in time as well as space, as represented in Figure-1. The boundary layer flow shown therein forms the basis of codal provisions worldwide, almost without exception. Wind velocity is seen to be fluctuating in time as well as space. It is convenient to reduce the velocity into a mean component and a fluctuating one, which represents the turbulence or gustiness in the flow. Understandably,

the value of the two components varies with the time interval chosen for averaging.

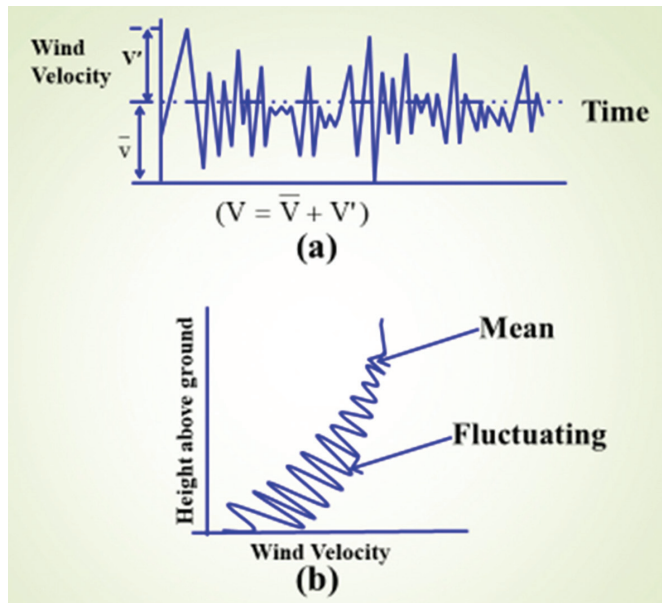


Figure-1. Variation in Wind Velocity (a) with time, and (b) with height

Intrinsically, wind evokes a dynamic response from all overground structures, which obstruct its flow. For short stocky structures the response can be treated as quasi-static, with the dynamic component being often insignificant. For slender, flexible structures like tall buildings, the dynamic response is significant.

Design Wind

Design wind velocity varies according to geographic location, averaging time chosen, height above ground (see fig. 1), approach terrain, topography, directionality, size of the structure, design life, etcetera. IS 875 part 3 [2], gives values of basic wind velocity at a height of 10m above ground, obtained with 3 second as the averaging time, for different regions of the country. The code also specifies the multiplying factors, related with the variables that affect the wind velocity, such that the design wind speed can be obtained from the basic value. It is very important to be able to get as realistic a value of V as possible, since pressures, forces and reactions on the structures, as can be seen from the Eq.1, are in proportion to its square.

$$\text{Force exerted by wind, } F = C \cdot p \cdot A \quad (1)$$

where

- $p = 1/2 \rho V^2$
- $\rho = \text{Mass density of air}$
- $V = \text{Design Wind velocity}$
- $C = \text{Typical coefficient}$
- $A = \text{Reference area of exposure}$

Much design information, such as for the coefficients C , is covered in Codes, Standards, Guidelines & relevant literature, for many types of structural forms. It is important to note these values are given for structures in the *stand-alone* condition (though this is hardly ever the case on ground). Also, the coverage is generally for conventional geometries only. Structures with *Unusual geometries*, which are seen to occur frequently, are not covered. Furthermore, the effect of *interference* from other structures in the vicinity of the structure in question is rarely addressed, though reference 2, gives values of *interference factors* for a limited number of cases.

Response of Buildings

As mentioned already, it is convenient to reduce the wind velocity into a mean component and a fluctuating one, which represents the turbulence or gustiness in the flow. For a tall building wind acts upon it primarily in the lateral direction. The building responds by deflecting in the direction of wind flow, as seen in Figure-2 – the mean component corresponding to the mean wind (or quasi-static wind), and the oscillations corresponding to the gusts. The along-wind response increases with the velocity of wind, and its peak is reached at the highest value of velocity under consideration as can normally be expected, or, the design wind velocity.

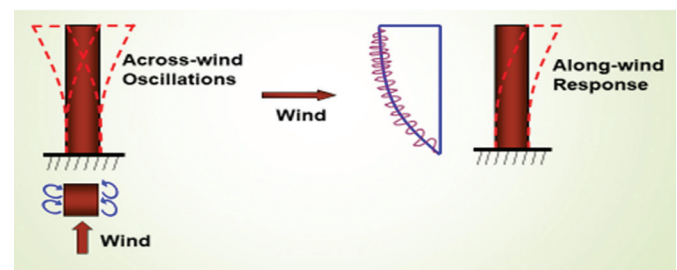


Figure-2. Typical Aerodynamic Response of a Building

Interestingly, a flexible building attracts less seismic force, but higher wind induced forces and vice versa. Buildings also undergo oscillations in the direction transverse to the flow of wind. This occurs due the unsteady transverse force created by the shedding of vortices. The peak across-wind oscillations occur when the vortex shedding frequency matches with the frequency of oscillation of the building. Such a condition can be experienced at velocities lower than the design velocity, which can reach dangerous levels. Naturally, this has to be avoided through appropriate design measures mentioned later in this paper. A building can also experience torsional oscillations. The reasons for this lie in possible asymmetry of wind loading itself, but rather more so in the buildings having unconventional geometries, such as those shown in Figure-3.



Figure-3. Some Typical Tall Building Images of Unconventional Geometry

Though the Indian wind loading code [2] gives the procedure to deal with the along- as well as across-wind response, there is only a mention yet of torsional responses, wherein it limits the fundamental torsional period to 0.9 times the fundamental lateral translational period in any of the two orthogonal directions. It is worthy of mention that there are limitations to what the codal provisions yield. Firstly, as mentioned earlier too, the stipulations are for buildings in the *stand-alone* situation, which is hardly ever the case in practice (the scenario is more akin to that in Figure-4). Furthermore, the theoretical background for obtaining the along-wind response comes from a paper [3], wherein the theory was developed for a line-like structure, whereas a large number of tall buildings do not comply with that description (a couple of such examples are seen in Figure-3). For across wind response, stipulations are based on pioneering works (carried out by renowned scientists) such as the one described in reference 4, and further developments of the same. The stipulations given in the code for obtaining across-wind effects are however

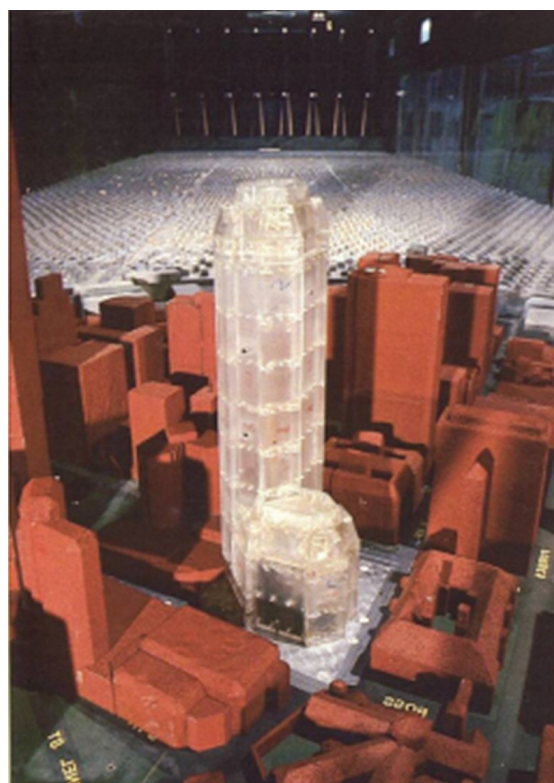


Figure-4. A tall building surrounded with many other shorter buildings

quite limited in scope and lack generality. It is therefore quite likely that the results based on the current Indian codes may differ from the reality, even for *stand-alone* buildings. More elaborate provisions for across wind effects are elaborately mentioned in IS 4998 – 2015 [5] covering the design of tall chimneys which are also tall structures with, usually, circular shape. Across - wind aspect can be better understood from Figure-5.

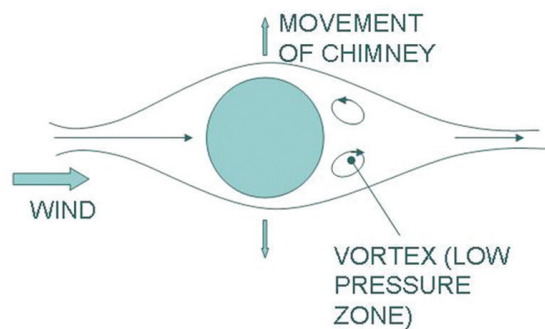


Figure-5: Illustration of Across Wind Effects on a Tall Structure

Whereas the evaluation of aerodynamic response is required to ensure that the stresses as well as deformations in the building remain within prescribed limits, it is equally important to ensure that the accelerations satisfy the criterion for human comfort. IS 16700 [1] indicates requirements to meet human comfort and façade safety. For this purpose, inter-story drift should be limited to $H/500$, fundamental translational lateral period in any of the two horizontal directions should be limited to 8 sec, vertical natural frequency of any floor should be limited to 3 Hz and vertical acceleration (in m/sec^2) of any floor should be limited to 0.05 for residential and office floors, and 0.18 for mercantile floors.

Basics of wind-resistant design

The basic requirements for structural design of buildings under the action of wind are, ensuring economy and safety, keeping a control on deformations and oscillations to ensure that standards for comfort are met. The overall approach for this is briefly mentioned in the sub-sections that follow. Broadly it consists of reducing the loads as much as possible, adopting appropriate design framework to resist the same and control of oscillations if still required.

Reduce Response

One obvious approach to reduce wind loads is by making the exposed area, A , smaller if architectural design permits creation of openings in the envelope, and the other is to choose a cross section which gives a lower value of the wind coefficient, C (Eq.-1). In the context of the latter, the square shape has the largest value of C and a circular section the least (see also a mention of this later). Some tweaking of plan shape of building can be done as for Taipei tower, shown in Figure-6. This change of the plan shape resulted in a reduction of about 25% in the wind loads.

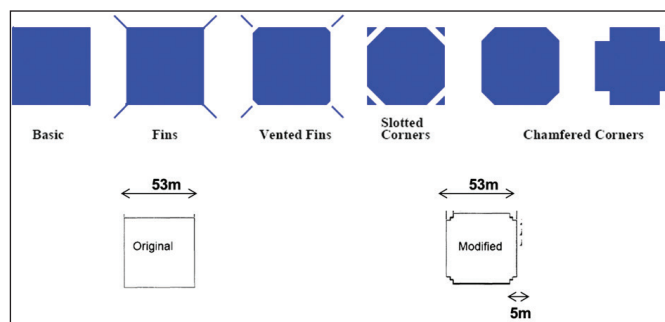


Figure-6: Modifications of Plan Shape of Building leading to Significant Reduction of Wind Loads (Taipei 101 Tower)

Control of Oscillations

If despite measures described above, the oscillatory response of the building is beyond acceptable limits, in terms of deformations or accelerations, there are measures that can be adopted, as given in Table-1. Extensive studies were carried out by Yukio Tamura and his associates [6-9] through wind tunnel testing on a large number of models. The geometrical variations tried included corner cutting or chamfering of the cross section. This was shown to reduce the wind effect, particularly the across-wind oscillations. Creation of openings in the wall reduced the forces. (See also Figure-6 which gives the example of Taipei Tower and indicates similar findings). Other important variations tried were, (i) to vary the number of sides in the cross-section from 3 to 12 and (ii) to create a helical twist of varying degrees about the vertical axis of the building. Both these also generally have a beneficial effect in reducing response to wind. It is possible that different measures to introduce geometrical variations, though

beneficial in reducing the aerodynamic effects, may not always fit into the architectural scheme of things. Control of oscillations then is also quite effectively

possible through the use of various kinds of damping devices. Indeed, there would be hundreds of buildings which have incorporated this arrangement.

Table 1. Auxiliary Means of Improving Aerodynamic Performance of a Tall Building

Means	Type	Method & Aim	Remarks
Aerodynamic Design	Passive	Improving Aerodynamic Properties to Reduce Wind Force	Corner Cutting, Chamfering, Openings
Structural Design	Passive	Increasing Building Mass, Increasing Stiffness or Natural Frequency	Massive Materials, Bracing, Walls, Thick Members
Auxiliary Damping Device	Passive	Adding Material, Increasing Building Damping, Adding Auxiliary Mass System	
	Active	Generating Inertia Effects to Minimize Response, Changing Stiffness to Avoid Resonance	

Structural Arrangements

The code [1] indicates some of the structural systems for tall buildings. These include Core & Outrigger system, Core, Outrigger & Belt-wall system, Framed Tube system (for tall buildings with comparatively small height), Tube in Tube system (for tall buildings of larger height) and Multiple Tube system for even taller buildings. Primary objective of choosing these solutions is to take care of lateral loading. Choice of the system depends upon the height of the building in question and wind intensity to which it is likely to be subjected.

- i. Core & Outrigger system comprises core elements and peripheral columns known as outrigger columns connected at discrete levels to core elements through outrigger beams for integration and carrying larger lateral forces.
- ii. Core, Outrigger & Belt-wall system is an extension of the system in i) above, but it also comprises connections of outrigger columns with adjacent columns through deep link beams (known as belt truss) typically at the same levels as the outrigger beams to enhance the lateral stiffness for taller buildings.

- iii. Framed Tube system comprises closely spaced peripheral columns connected through deep beams (forming a tube) in combination with internal core or columns.
- iv. Tube in Tube system is an extension of the system in (iii) above except that the internal vertical elements are also connected with deep beams forming another line of tube.
- v. Multiple Tube system is an enhancement of the system in (iv) above having several such tubes to further enhance the lateral strength of the system for larger heights of building and higher wind intensities.

Figure-7 shows a typical Core Outrigger Belt-wall system. Figure-8 shows a possible Framed Tube system. Figure-9 shows one possible arrangement of Tube in Tube system. The famous engineer Fazlur Khan is known for his work in developing tube systems. Provision of bracings at the periphery makes the structural system stronger to take larger quantum of lateral forces; Figure-10 depicts one such example.

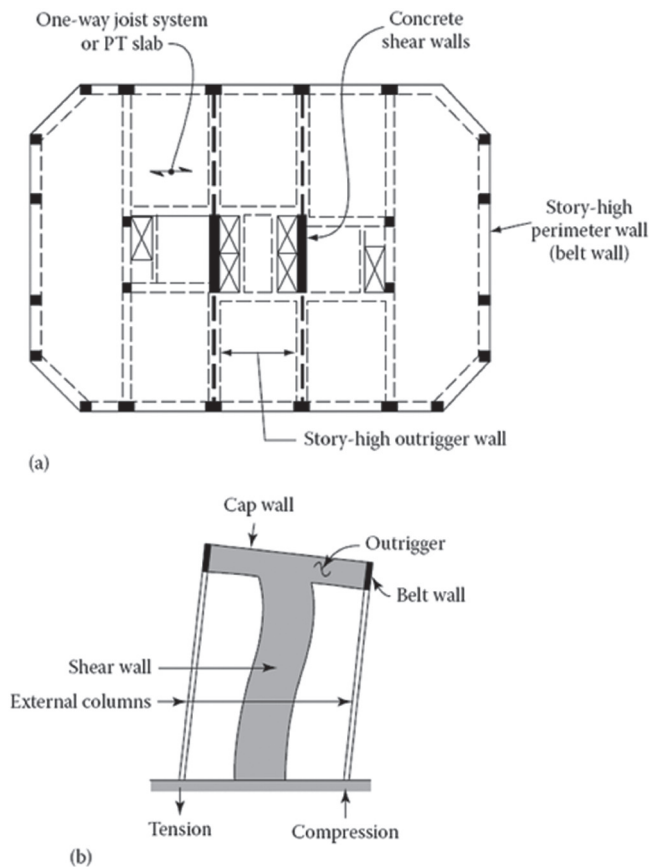


Figure-7: Typical Core Outrigger Belt-wall System

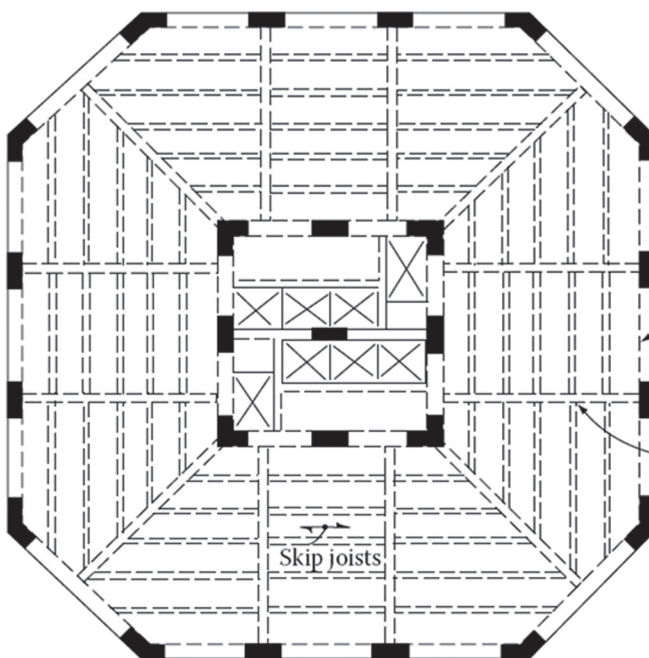


Figure-8: Framed Tube System

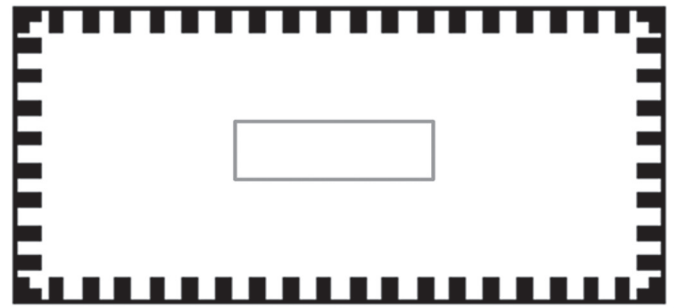


Figure-9: Tube in Tube System

In tall buildings, shear walls tend to support the structural frame laterally at the lower levels, but the behaviour reverses at higher levels. This happens because a shear wall acts as a vertical cantilever fixed at its base and cantilevering towards the top. The shear wall is stronger towards the base due to its fixity and large moment of inertia, but it becomes weaker than the frame at higher levels due to its cantilevering effect, see Figure-11.

Some other Issues

It has been pointed out earlier in this paper too that, interference effects on the wind experienced by a structure are rarely quantified in the codes. The reason for this is not difficult to understand. The variability of situations that one meets in practice is enormous and thus generalisations are almost impossible. Likewise, another wind related issue of importance for tall buildings is to assess the podium level flow conditions, which can often cause discomfort to the pedestrians and can sometimes be dangerous. There is not much theoretical back-up available to tackle these issues.

Another issue of concern for tall buildings arises from the increasing practice of using large panels in the façade. These become vulnerable to puncture under high wind loading, even more so in cyclone affected regions because of wind-borne debris acting as missiles. Indian standards on both these aspects are currently being drafted to help designers in detailing the façade panels appropriately and cater for *missile impact*.

With increase in the height of buildings, façade design becomes more critical for two reasons. One of the well-



Figure-10: Bracings at Peripheral Facade

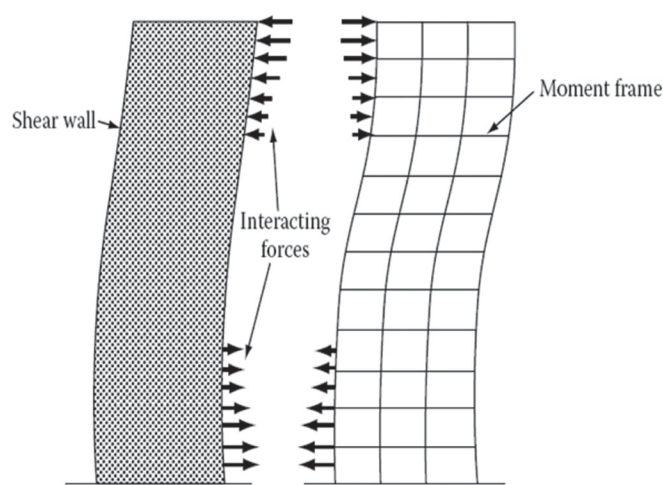


Figure-11: Shear Wall – Frame Interaction

known reasons is that wind loads are higher at higher levels. Secondly, the local wind pressures can be much larger than the average wind pressures on a panel, requiring adequate design of façade material and its connections with the main frame.

Approach to Final Design

It is clear from the aforesaid explanations that use of

codes can help to obtain design parameters for a *stand-alone* tall building, but this has its limitations. Another possibility is the use of *Computational Fluid Dynamics (CFD)*, a slowly developing field for analyzing wind engineering problems. This again is rather limited at present but, may provide useful results for preliminary design. Also, interference effects and *near ground* flow patterns can at best be assessed, but to a limited degree of accuracy. It is thus necessary that a tall building project takes recourse to wind tunnel model testing programme. This is an approach which has the benefit of almost 75 years of experience and has by now developed to be a well-honed art. Developments in electronic instrumentation, computer-based data acquisition and processing have further aided wind tunnel testing capabilities. An industrial wind tunnel, capable of replicating target boundary layer wind flows, with cross-sectional dimensions close to 2m and length of 10-12m, in which a model scale of around 1:400 can be accommodated, should normally suffice in the majority of cases. Besides the model of the building to be tested, the surrounding installations also need to be modelled. Good professional wind engineering outfits have the capability to deliver soft copy version of results which can be hooked directly to the designer's analysis software, in up to 12 weeks. Considering the expected volume of tall building activity in India in the upcoming future, there is a need to add new wind tunnel facilities operating on a commercial basis.

Concluding Remarks

As the world appears to recover from the *Covid* gloom, India is set to see again a boom in its infrastructure construction industry. This should include tall buildings to cater for various requirements. Although building heights are still moderate compared to those attained internationally, in India too buildings have been trending to be taller. Consideration of wind loading will thus assume greater importance. This paper briefly touches upon the various aspects involved in the design of tall buildings to be safe and comfortable under wind loads. It is brought out as to how wind loads and effects can be reduced through appropriate design measures. Whereas adequate background information is available to the designer in codes, standards and literature to

produce a good preliminary design, for which CFD can also be a useful tool, it is recommended that recourse be taken to wind tunnel model testing for finalizing the design of any major tall building project.

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Engineering 360

Video: Are pneumatic clothes a gamechanger for the mobility impaired?

Kevin J. Harrigan | September 02, 2022

Video link: https://youtu.be/GAIGReu_fJk

Mechanical engineers at Rice University's George R. Brown School of Engineering believe that small pneumatic actuators made from textiles could provide a major benefit to disabled or mobility impaired patients. To demonstrate, they have developed a jacket hood that slips over the wearers' head for thermoregulation; an estimated 10% of the population have limited overhead mobility.

The team notes that similar attempts to support these patients with motion control components requires bulky electronics and presents a power supply challenge. By replacing those systems with fluid power, many components can be miniaturized and sewn into apparel.

The researchers implemented digital fluid logic to control valves in the system to enable high or low pressure. Those valves are a better option than a controller, as they can be laundered, are highly resilient and are rated for up to 20,000 on-off cycles. Those 1 in2 valves are laminated into textiles and can be mass manufactured with existing equipment.

Power for the system is made possible by a compressed gas canister, although the Rice team has plans to develop a kinetic replenishment system.

To contact the author of this article, email kharrigan@globalspec.com

Source: <https://insights.globalspec.com/article/19246/video-are-pneumatic-clothes-a-gamechanger-for-the-mobility-impaired?uid=451890&uh=cba3b5&md=220913&mh=1a7805&Vol=Vol22Issue37&Pub=1&LinkId=211150-9&keyword=link%5F2111509&itemid=380978&frmtrk=newsletter&cid=n1>

Innovatively Engineered GMRT- Refurbished



A V Ashitkar



D Satyanarayana



M G Pendse



M K Lokhande



MKS Yogi



P K Murthy



S V Bharambe



Vinayak Kawatekar

All formerly with Tata Consulting Engineers

This is the story of innovation and achievement by Indian Engineers; of conceptualisation, design development, operation, maintenance and refurbishment of the large size dish antenna for the Giant Metrewave Radio Telescope (GMRT).

The National Centre for Radio Astronomy (NCRA) of the Tata Institute of Fundamental Research (TIFR) had established two world renowned facilities viz. the Ooty Radio Telescope (ORT) in 1970 at Ooty and the Giant Metrewave Radio Telescope (GMRT) in 1996 at Khodad near Narayangaon about 90 kms from Pune. Tata Consulting Engineers (TCE) were the consulting engineers for both the unique projects, which were first of their kind in the country.

The GMRT comprises 30 identical steerable 45 metre diameter parabolic dish Antennas, spread

over 25 sq.km. of area. The reflector surface of the dish is formed with unique concept called SMART (Stretched-wire Mesh Attached to Rope Trusses). The SMART dish concept was approved and accepted for implementation by Prof. Govind Swarup, the father figure of Radio Astronomy in India. He had been the moving force being the concept and the setting up of the GMRT. The former TCE Engineers had the privilege to directly connect with him in the early days.

The 30 Antennas work in unison through a centralized control – all indigenously designed, engineered, fabricated, erected, operated and maintained. Of the 30 antennas in the GMRT array, 12 antennas operate in a central cluster and the remaining 18 antennas on three Y shaped arms with 6 in each arm. The dish back-up structure is made from mild steel tubes of various diameters and it

supports the stretched stainless steel wire mesh through rope trusses forming the paraboloidal reflector surface of the antenna. The work on construction of the GMRT started in 1991 and the first antenna (viz C03) was erected in 1992. The fabrication and installation of all the 30 antennas was completed in the year 1996 and since then all the antennas have been working seamlessly 24 x 7 all 365 days for over a quarter of a century. GMRT is a very versatile instrument for investigating a variety of radio astrophysical problems ranging from nearby Solar system to the edge of observable Universe. A few years ago, NCRA upgraded the electronics and since then the facility is known as **uGMRT**.

In November 2020, GMRT became **the third Indian scientific facility to be awarded international recognition by the Institute of Electrical & Electronics Engineers (IEEE) Milestone Achievement for its novel engineering, advanced technology and scientific contributions made in the field of Radio Astronomy. A special accolade for a very special telescope, the GMRT - designed, built and operated by Indian scientists and engineers.** It is used by radio astronomers from across the world to study our Universe. It is one of the largest and most sensitive fully operational low frequency radio telescopes in the world today. For details visit [Giant Metrewave Radio Telescope \(tifr.res.in\)](http://tifr.res.in)

NCRA over the years of operation found that the antenna dish structure need refurbishing – especially replacing the corroded members. To do that the antenna dish needed to be brought down to ground from the Sky Position and raised to Sky Position again after refurbishing. Since the whole operation needed to be done in a planned and synchronised manner plus it required very carefully handling so as not to damage any other members and the reflecting wire mesh, in May 2021, NCRA contacted a retired engineer from the

former TCE team who had been involved with the GMRT project for possible technical assistance. The engineer traced the key engineers from the original team of TCE [now superannuated] who were involved in the GMRT design and were aware of the intricacies of the antenna. Though, they were spread across many countries, each and every one of them whole heartedly pitched in and helped achieve **success a second time around**. The interactions of TCE engineers with the NCRA Team, from May 2021 to June 2022, led to the finalisation of the procedures and equipment to be used for doing the in-situ refurbishment work.

The Antenna Dish (viz. C03) which was the first one that had been constructed and erected was brought down to the Ground Position from its working position in the sky on 17th June 2022. After carrying out structural repairs, replacement of members, certain other modifications and painting, it was raised back to its working position in the Sky by a team of engineers at NCRA, on the 2nd September 2022 in a record time of 2½ months.

It was a proud moment for the former TCE engineers who had originally worked on the project and who a quarter century later again got together to advise the client - NCRA. The NCRA site team guided by Mr. H.S. Kale and team members of the Mechanical engineering team at GMRT were encouraged and supported by Prof. Yashwant Gupta – Distinguished Professor and Centre Director NCRA; all of whom worked with great zeal and dedication.

GMRT reflects the daring and ambition of Indian Engineers and Scientists who came up with the SMART dish concept, and implemented an optimised structure under stringent budgetary constraints. TCE engineers had developed a light but sturdy structural concept vis-à-vis other contemporary Radio telescopes around the world. There were a lot of innovative approaches in instrumentation and communication for achieving synchronous operation of the 30 antennae. This was

done in the years when internet was in its infancy and data of other projects was not readily or even easily available – libraries, journals and individual knowledge were the only sources.

time contribution to science, engineering and service above self by both the teams for achieving their goal successfully.

The extra ordinary project exemplified life

Cheers for Indigenous Engineering and Radio Astronomy Science in India!



Fully steerable C03 Antenna in Sky Position since April 1992 - being used for Radio Astronomy Observations.

Antenna Dish weighs about 40 tonnes.



Antenna Dish lowered to the Ground Position on 17th June 2022



Refurbished Antenna Dish raised to the Sky-Position on 2nd September 2022

NCRA Team is seen in the foreground

IBEF INDIA BRAND EQUITY FOUNDATION News

Nearly 60 startups register with ISRO since opening of Indian space sector

IBEF July 13, 2022

Union Minister of State (Independent Charge) Science & Technology; Minister of State (Independent Charge) Earth Sciences; MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space, Dr. Jitendra Singh stated that over 60 companies have registered with ISRO since Prime Minister Mr. Narendra Modi's recent "unlocking" of the Indian space industry, with many of them working on space debris control initiatives.

He highlighted that private actors' and creative start-ups' ardour will complement the Department of Space's role in preserving India's interests in space by creating all-around capabilities in the sectors of space transportation, debris management, infrastructure, and applications. He inaugurated ISRO System for Safe and Sustainable Operation (IS4OM) at ISRO Control Centre, in Bengaluru on July 11, 2022. According to him, the IS4OM capability would help India achieve its SSA (Space Situational Awareness) goals by providing users with complete and timely information on the space environment. This multi-domain awareness platform will provide timely, accurate, and efficient information on on-orbit collisions, fragmentation, atmospheric re-entry danger, space-based strategic intelligence, hazardous asteroids, and space weather forecast.

The Minister went on to say that the IS4OM facility can support all routine operations such as safeguarding Indian space assets, mitigating collision threats from space objects via specific collision avoidance manoeuvres, the information needed for strategic purposes, and research activities in Space Debris and Space Situational Awareness.

Disclaimer: This information has been collected through secondary research and IBEF is not responsible for any errors in the same.

Source: <https://www.ibef.org/news/nearly-60-startups-register-with-isro-since-opening-of-indian-space-sector>

Landfill Management - How to Remediate Leachate & H₂S Emissions



Arvinder S Brara
Chairman & Managing Director
Mantec Consultants Pvt. Ltd.

Brief

Though most landfill concerns focus on Methane (CH₄) production, collection and remediation, Hydrogen Sulfide (H₂S) can be a significant component to address in certain situations. It is most often produced from the prokaryotic breakdown of organic matter in the absence of oxygen, such as in swamps and landfills.

At lower concentrations, the gas has a strong, unpleasant odour that is similar to that of rotten eggs. At higher concentrations, local populations can be subject to serious health risks such as respiratory problems, dizziness

and even fatality in extreme circumstances. For this reason, any landfill sites where off-site gas migration is detected need to take corrective action within 60 days to mitigate the problem. This paper discusses the different remediation methods as well as the benefits and uses of each process.

Overlooking Communities & the Environment

Most commonly found in wastewater treatment facilities and municipal solid waste landfills, leachate generation



occurs almost wherever a landfill is present. By definition, leachate is produced any time water or liquid passes through a permeable material. In most communities with a temperate or tropical climate, leachate production is unavoidable. The only way to not produce leachate in these areas is to achieve what is known as “zero waste.” Unfortunately, this is a feat that only a handful of communities have accomplished.

For most of the population, an actively operating landfill in the community is necessary. Regardless of how many resources landfill operators put toward generating zero waste, it continues to be a necessary evil.

To make matters worse, leachate is one of the biggest contributors to H_2S production. The gas is highly soluble and tends to dissolve in landfill leachate and becomes an emissions source when the leachate collections are exposed to air. H_2S emissions can be problematic for local communities due to associated health risks, noxious odors, damage to landfill gas collection piping and equipment.

At lower concentrations, H_2S gas has a strong, unpleasant odor that is similar to that of rotten eggs. This odor can be detected at concentrations as low as 1.0 ppm. At higher concentrations of 10 ppm or more, local populations can be subject to serious health risks. Inhalation of H_2S vapors at low concentrations can affect the respiratory system and cause irritation, difficulty breathing, headaches and fatigue. Slightly higher concentrations can lead to severe irritation, dizziness and extreme headaches and nausea. Higher concentrations of 600 to 800 ppm can cause shock, unconsciousness and even fatality within a few breaths.

H_2S Cleanup

Phase 1: Assessments

Groundwater

Available groundwater data needs to be assessed and evaluated to determine its condition. Groundwater wells would also have to be assessed to determine if they are functioning properly and providing data representative to the aquifer in which they are located.

For each well, construction records, field notes, and a historical review of water quality would all be used to determine a well's condition. Following the evaluation of available data, a field review would be necessary so that the well's condition could be assessed and any necessary maintenance scheduled.

Surface Water

Historical data provided by the landfill operator has to be reviewed and a field study of surface water bodies performed. Based on the results of those evaluations, additional sampling may be necessary if there is not enough available data for a proper analysis.

Leachate Seeps

Existing leachate seeps and the corrective actions that have been taken thus far would have to be reviewed. With the help of the landfill operator, any visible, known or suspected sources of leachate leaks within the landfill or along the perimeter of the property could be evaluated. Telltale signs of leakage would include iron staining and unidentified sources of liquid flow. Recommendations for short- and long-term corrective actions could be made after the evaluation.

Landfill Gas

A review of existing landfill gas monitoring as well as well boring construction logs would have to be viewed in relation to regulatory compliance and the need for new gas monitoring wells along the landfill perimeter. Documentation of the survey could then be given to the landfill operator so that installation of new gas monitoring wells could be got approved and included in the gas monitoring plan.

Phase 2: Design - Remediation methods for landfills

Excavation to Recover Recyclable Material

The goal of landfill excavation is to process waste and recover recyclable materials, cover soil and combustible waste to free up empty landfill space. The waste is excavated by being filtered through a series of screens and sorted into categories. The amount of waste that is recovered depends on a variety of factors including:

- Physical and chemical properties of the waste material
- Technologies used, and
- Efficiency of technology

In some cases, recovered materials may be contaminated or partially decomposed. Landfill excavation is most effective when the waste has been fully decomposed and stabilized.

Capping

The use of temporary landfill caps can increase landfill space pushing down the waste with a synthetic membrane. These caps are often used in combination with leachate recirculation and gas extraction systems. Temporary landfill caps are advantageous because they can be easily removed, do not occupy much space, and increase landfill capacity. Landfill capping involves three separate layers:

- An upper vegetative layer
- A drainage layer
- A low permeability layer

In addition, the cap must be made thick enough to prevent cracking and erosion that can happen when temperatures fluctuate or when earthquakes or subsidence occurs.

Air Sparging and Soil Vapour Extraction

Air Sparging and Soil Vapour Extraction are two separate techniques that are frequently used together to remove harmful vapours from contaminated soil and leachate plumes. Two types of wells are installed near the landfill area:

Extraction wells	Air injection wells
These are used to draw vapours to the surface so they can be easily extracted from the landfill.	These pump air into the ground to encourage growth of aerobic bacteria that speed up decomposition.

Both techniques are safe and reliable, but can take several years to reach peak effectiveness depending on the extent

of pollution, soil type and amount of contamination. However, they are still much quicker than natural decomposition.

Pump-and-Treat

Leachate plumes can also be managed by pumping out the liquid and either treating it on-site or sending it to a wastewater treatment plant. Municipal wastewater treatment typically utilizes oil water separators and/or activated carbon to remove pollutants and suspended solids from the liquid leachate. Once authorized by a local environmental agency, the water can be discharged into a nearby sewer or aquifer.

Compliance

In most cases, landfill remediation efforts would need to be monitored by the Pollution Control Boards or another regulatory agency to ensure that landfill operations remain compliant with established criteria. These regulations typically fall into one of three areas:

1. Clean Air

If off site gas migration is detected, corrective action would need to be taken within 60 days. That means the landfill operator would have to develop emergency plans as well as long-term corrective measures. For example, an emergency solution may involve constructing barriers to contain the gas while a long-term solution would be installing a gas extraction system.

Particular jurisdictions may require ongoing air monitoring and quality testing to identify the concentration and composition of landfill emissions. In these cases, a series of monitoring stations will be placed in areas directly upwind and downwind of the landfill as well as known areas where vapors collect.

2. Clean Water

Groundwater monitoring regulations prohibit the migration of landfill contaminants into the groundwater and require groundwater monitoring systems to be installed at all landfills. A groundwater

monitoring system is designed to collect water samples from nearby wells and analyze them for potential contamination. They work by comparing samples from unaffected water to samples from the monitoring wells to determine if any contaminants have migrated into the aquifer.

However, natural variations in groundwater chemistry could sometimes be the cause of discrepancies between samples, rather than landfill pollution. That means that a thorough understanding of the monitoring system, as well as the site's hydrogeology, would be necessary to accurately gauge the impact on the groundwater quality.

3. Resource Preservation

Properly designed landfill covers create several opportunities to preserve resources and cut back on utility expenses by harnessing solar or wind power. The Environmental Protection Agency (EPA) recommends that landfill cap designs take into consideration the weight of solar power equipment, wind or snow forces and maintenance requirements in order to preserve natural resources and reduce energy usage.

In addition to reducing energy consumptions, properly covered landfills offer numerous other possibilities for beneficial land use including:

- Recreational green space for wildlife populations
- Agricultural use
- Seed harvesting for revitalizing other landfill sites

Landfill operators can also consider recycling onsite waste as a way of reducing pollution and creating economic and environmental benefits of the land.

Appointing a Consultant

Due to the scale and complexity of landfill remediation projects, landfill operators would benefit by appointing a consultant to perform assessments, design and construction and ongoing monitoring. The purpose of ongoing evaluations and monitoring is to ensure that contamination is being contained, there are no environmental hazards present, and to develop a plan for closure. The consultant to examine the site and groundwater conditions, must have the experience of conducting test borings and water quality analyses to identify and monitor environmental impacts and also be accredited with National Accreditation Board for Education and Training (NABET) and Ministry of Environment, Forest and Climate Change (MOEF &CC).

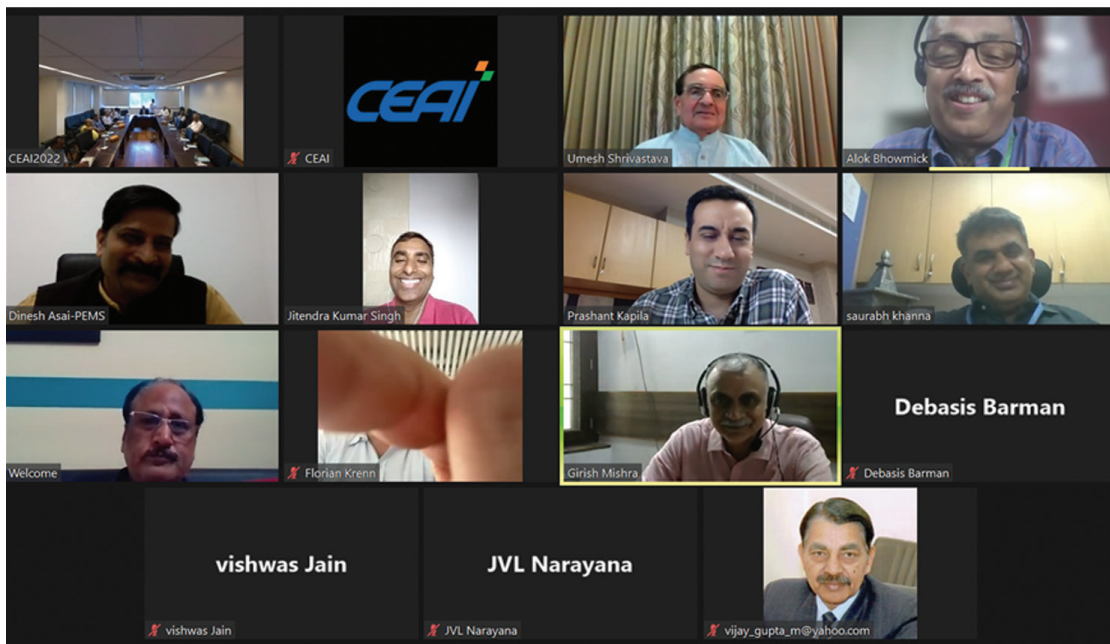
CEAI NEWS

Extra Ordinary General Meeting

An Extra-Ordinary General Meeting (EGM) of the Consulting Engineers Association of India was held on 27th July 2022 at 3:00 pm at CEAI Centre, Pocket 9, Sector B, Vasant Kunj, New Delhi 110070, to consider additions, amendments and/or deletion in

the Memorandum of the Association and Rules of the Association of the Consulting Engineers Association of India.

The EGM discussed the amendments as recommended by the Governing Council and approved the same with some modifications.



Life Member (Individual) – Revised Rules

During the Extraordinary General Body Meeting of CEAI held on 27th July 2022, the revised rules for Membership were approved. For becoming a Life Member (Individual) the revised rule is reproduced below:

Member (Individual) who has been on the roll of the Association for 1 year and his/ her subscription is not in arrears and is of the age of 35 years, or above, may opt to become a Life Member (Individual) after paying one-time subscription as under:

	Age of member	Subscription
a	upto 44 years	15 times annual subscription
b	45 to 59 years	10 times annual subscription
c	60 to 69 years	5 times annual subscription
d	70 years and above	2 times annual subscription

Technical Talk on “Urban Transportation in India - Making it Affordable & Sustainable”

CEAI organised a technical talk on “*Urban Transportation in India – Making it Affordable & Sustainable*” on 12th August 2022.

Dr. Ajay Pradhan, President CEAI, welcomed the Speaker and the participants to the technical talk delivered by Mr. Alok Jain, CEO & Managing Director, Trans-Consult Ltd, Hong Kong. Mr. Jain focused on the traffic congestion in India and also presented ideas for making transportation in the urban areas not only affordable but also sustainable for personal and public use plus the haulage of goods.

Mr. A P Mull, Past President CEAI moderated the technical talk.



Mr. Alok Jain described India as one of the fastest growing economies in the world, achieving an annual growth rate of more than 10% per annum and added that a well-functioning transport system is an essential element to maintain those high

growth levels. Urbanization in particular and growing population in general, has created many urban mobility issues such as congestion and poor air quality. India is working hard to transform itself over the next few decades. By 2070, India aspires to achieve carbon neutrality. For a country with a billion-people, it is not a small task and would require a multi-pronged effort from all sectors and stakeholders.

Among the urban problems that world is facing, climate change is becoming starkly evident. About a quarter of the world's CO₂ emissions comes from Transportation sector. Emerging economies, like India, could be at the forefront of leading the change and create an outsized impact on the solution landscape. A billion people country can also hold billions of ideas that could be innovative as well as transformative.

Major towns and cities in India, that offer huge opportunities for the people and businesses, and act as hubs for neighboring small cities soon become a victim of traffic congestion, increased carbon emission, bad air quality. Traditionally, these cities were created for the people, walking and moving on non-motorized transport. They were scaled for humans. Unfortunately, the western model of personal vehicle ownership, which has been adopted as a status symbol, is causing many of these problems. Thankfully, the personal vehicle ownership levels in India are still just a fraction of what is observed in the so-called developed countries. Majority of the country still moves through walking, cycling or on Public Transport. The entire world is now talking about new urbanism and scaling of urban landscape with “15-minute cities”, which has traditionally existed in Indian cities. These traditional city planning concepts need to be brought back into India's planning landscape.

A successful urban mobility framework works fairly and efficiently only when the inhabitants make smart and sustainable choices. Here, India must elevate the bar to harmonize with the global standards and practices of incorporating zero-emission and green fuel technologies in majority of the transport sector. Most of the public transport sector is managed and operated by the public sector which presents India a big opportunity

to drive change through policy levers. Government of India's Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME I) and FAME II schemes were ambitious policy steps in that direction and have proven to be extremely successful. However, the EV adoption as compared with other mature markets, such as China and Japan, emerging Asia and Europe, is particularly lagging in India and perhaps more needs to be done. The supporting infrastructure is an obvious reason for more widescale adoption but with the new policies, industries and vendors are given quite attractive incentives to invest into this sector of industries and hopefully in a few years' time, this bottleneck would be resolved.

Many of the states have joined the EV bandwagon and have announced their own state level EV policies; India must look forward in adopting a standardized framework country wide to make the acceptance smoother, and interoperable. By 2030, India is projected to become the second largest E2W markets in the world after China. India also has the potential to become a huge battery supplier as its land is rich in graphite, Iron Ore, Aluminum, Titanium and Magnesium. EV ecosystems may take several years to build, but conditions are shifting at a rapid pace. There is a real and urgent need for India to participate in green business building. The opportunities for building green businesses, particularly in EV, are more attractive than ever. Asian players—both established firms and start-ups—should seize the moment and apply the lessons learnt globally to build tomorrow's EV ecosystem. EV ecosystem is still in its infancy and ripe for innovation, all the way from chemistries of energy storage systems to drivetrain efficiencies. With the scale that India presents, it has the potential to be a breeding ground for home-grown innovation. It can even redefine the entire zero-emission vehicle market globally.

YouTube Link: <https://www.youtube.com/watch?v=ta34F15vVjg>



Webinar on “Indian Cities and the Race to Zero”

Cities are the loci for economic growth so much so that according to the World Bank, 80% of the global GDP is generated in cities. Over the years, the expansion of cities as the engines of growth has been accompanied with rapid urbanisation-placing irreconcilable burden on existing natural resources and catalysing the occurrence of extreme climatic events. While the world seems to treat this issue in an over simplified manner, the nuances and dynamics involved in curbing climate change in an economically growing world demands critical thinking and constant dialogues between different players including the government, private sector, NGOs, think tanks, academia amongst others. Towards that, one such effort was made by the Consulting Engineers Association of India, (CEAI) in organising a webinar titled “*Indian Cities & the Race to Zero*” in association with Mott MacDonald as the knowledge partner on 25th August 2022. During the event, esteemed guests from different backgrounds shared their insights and knowledge on how cities can achieve the net zero goal, role of state actors and other stakeholders, use of data and digital tools, importance of urban planning, amongst many other crucial aspects. Some of the key pointers cited by speakers during the webinar are highlighted below:

Mr. S S Acharya - Managing Director – South Asia, Mott MacDonald



While the world continues to urbanise incessantly, continents such as Asia and Africa continue to be the frontrunners with a country like India itself estimated to account for an urban population of 800 M by 2050. Such spike in numbers is exposing mega cities across the world to bear the brunt of adverse impacts of climate change. These events are being realized in different forms, be it rising temperatures, increasing sea levels or extreme weather events such as floods, droughts, storms, or heatwaves. While these incidents have gained momentum in the

recent years, the severity and frequency of such climatic events are only estimated to intensify-impacting basic services, physical and social infrastructure, human livelihoods, and health and more so among vulnerable communities. Thus, this situation calls for cities and urban areas to be recognised as important stakeholders in the fight for climate change, with adoption of a systems approach which holistically looks at the services and the interdependency of systems operating with cities. Towards that, Mott MacDonald has undertaken several programmes contributing to increasing resilience, including the Sustainable Urban Transport Project, Climate Resilient Cities for Shared Prosperity programme, Climate Risk and Resilience for Indian Cities or the UK Government's 2050 carbon calculator programme.

Ms. Sushma Chaudhary – Cities Practice Lead, South Asia Mott MacDonald



While the world continues to address the two faced issue of urbanisation and climate change in a stop-gap manner, what is essentially needed is to underscore urban planning with the concepts of climate change, adaptation, and mitigation strategies – particularly to support post covid urbanism. That necessitates the repivoting of focus on long term planning needs with evolving perspectives of developing compact, sustainable, and resilient cities having effective city planning, good governance, reduced life cycle costs of asset creation and management, and improved service delivery to citizens. That can be done by adopting pandemic response strategies, integrating surge capacity planning through adoption of adaptable building design and use of modern construction technology and digital tools, effective supply chain management planning leveraging data portals, planning pandemic resilience for infrastructure, and preparing for city emergency services. Beyond these short term goals, considerations should also be given to futuristic strategies vital for sustainable urban planning and development to make cities resilient. These strategies should be based on the

climate risks faced by individual cities and tailored to the state's demand. A way in which that could be achieved is through the demonstration of resilience projects to cities to generate interest amongst ULBs and other decision makers, rely on multi-sectoral information and building synergy between the national institutions and private sector.

Ms. Sharla McGavock – Principal Hydrologist, Mott MacDonald



In today's day and time, one of the frequent incidences faced by cities relates to stormwater flooding which not only has an impact on daily traffic situations, but also severely impacts health and economic conditions of the cities and its citizens. While

several predictive mechanisms have been developed across the world to successfully forecast such occurrences, the unpredictable nature of these urban floods both in terms of its time and place, make such predictions challenging. Mott MacDonald has worked on developing a solution to avoid such events by way of developing a Flood Management Decision Support System which uses the machine learning to create hydraulic modelling for flood forecasting. Through this digital intervention the idea is to provide the cities with extra lead time, enabling them to cope with urban floods. The case study clearly demonstrates how the digital frontier can open ways and means to better decision making that not only aims to protect lives from the vagaries of climate change but also better deliver climate positive outcomes.

Mr. Anurag Satpathy – South Asia International Hub Lead, Mott MacDonald



Cities face a number of pressing challenges today. These range from increase in the number of slum dwellers to the high levels of energy consumption and concerns around ever increasing pollution levels. In fact, the cost of poorly planned urbanisation

can be seen in some of the huge slums, tangled traffic, green-house emissions, and sprawling suburbs all over the world. That creates the urgency to act sustainably – providing quality life to citizens, forming a part of the city’s productive dynamic and creating shared prosperity and social stability without harming the environment. SDG 11 of the UN’s 17 SDGs focuses on ‘Sustainable Cities & Communities’ and promotes inclusive and sustainable urbanisation. That involves investment in public transport, creating green public spaces, and improving urban planning and management in participatory and inclusive ways. While SDG 11 expands on the relevance of sustainable communities, it is equally important for businesses to adopt SDG 11 as well, since historically, businesses have been the core of development of cities, livelihoods, and services to urban populations. That also relates to India’s commitment to net-zero emissions by 2070 which depends heavily on the ability of its cities to transition to low-carbon systems. Thus, it is not an option but imperative for cities to plan their interventions and develop business cases for their projects mainstreaming aspects of sustainability, inclusivity, and resilience. In that regard, the Five Case Business Model (5CM) tool provides decision makers and stakeholders with a proven framework for structured ‘thinking’ and assurance of economic and social co-benefits and the

fact that climate change and economic growth can be decoupled for a green growth driven future.

Panel Discussion

Dr. Dev Niyogi – Professor – Dept. of Geological Sciences, Jackson School of Geosciences and Professor – Dept. of Civil, Architecture and Environmental Engineering, Cockrell School of Engineering

With cities acting as growth engines, a better matrix is needed to measure climate footprint which moves beyond just emissions. That calls for expanding the definition of climate footprint that considers aspects such as the use of alternative fuels, localised issues, localised best practices that can be scaled up and also replicated. In addition, with the rapid scale of urbanisation, a paradigm shift is needed in the manner in which urban planning is done, particularly with an apex agency instituted to drive common climate goals in a coordinated manner. As the world continues to become more digital, several tools have also been developed to enable cities achieve their net zero ambition. Nevertheless, while these tools are useful, they may not be entirely usable since most of them do not take local government participation, local stakeholder consultations or even customisation to



address local vulnerabilities into account. That means that while availability of such tools is appreciable, what is lacking currently is the access to their more customised versions, capacity building of urban actors to put such tools into use and the overall awareness of the applicability and relevance of such tools.

Prof. Saswat Bandyopadhyaya – Project Director, Centre of Urban Planning and Policies (CEPT) and Professor – Faculty of Planning, CEPT University



Urban development is mostly a state subject and the municipal building bye laws and urban regulations are largely limited to the concept of buildings and often fails to take the surroundings into consideration. Meanwhile, due to the constant

focus on urban development, a city is burdened by the presence of multiple plans and strategies that end up putting unreasonable pressure on the city authorities to put plans into practice. That, therefore, necessitates strengthening a statutory form of planning, with state policies and regulations being relooked for spatial

planning and re-engineering how planners are trained. That essentially means planning a city envisaging how good it can be for the climate while customising available solutions based on vulnerability analysis and other critical assessments.

Mr. Subhabrata Haldar – Technical Lead, Climate and Urban Planning, Mott MacDonald

Cities today are plagued by several structural/ institutional barriers including the involvement of multiple agencies in setting climate change objectives, lack of awareness of internationally accepted tools and processes and the most critical issue of climate change being considered as a voluntary action. Therefore, to mainstream climate action, necessary mandates need to be in place to drive adoption of low carbon interventions. That could be realised through change in the way Master Plans/ Development Plans are drafted in India, creation of unified institutional mechanism at an apex level to drive a common climate change goal across all organisations and use of procurement as a tool to stimulate low carbon interventions.

YouTube Link: <https://www.youtube.com/watch?v=8pQvJKhxWhs>



Conclave on “Exploring Business Opportunities Abroad for Construction & Design Engineering Consultancy, Engineering, Architecture & Environmental Services”

Consulting Engineers Association of India (CEAI) and Service Export Promotion Council (SEPC), Ministry of Commerce and Industry, Government of India, and Council of Architecture organized a conclave on 2nd September 2022 at Hotel Le-Meridien, New Delhi to create an action plan to make it easier for Indian companies working in Construction & Design Consultancy, Engineering, Architectures & Environmental services to work in foreign countries and thus also increase exports from India. The export of professional services especially in the construction field is a sector still not fully explored though it has huge potential as 3 % of global GDP is invested in Infrastructure development.

Officials representing the CEAI Governing Council and other Members drew attention to the large pool of Indian Engineering professionals and experts working worldwide and have experience and the expertise to deliver world-class projects. During the conclave senior officials from the Ministry of Commerce, Ministry of External Affairs, Indian High Commissioner from Singapore and Tanzania and the Ambassadors from Brazil, Japan and Uzbekistan outlined the opportunities for Indian service providers to export services to those geographies. It was suggested that India should become a Member of the Inter-American Development Bank (IADB) for opening up opportunities for Indian companies to secure business contracts funded by the IADB in the vast and unexplored Latin American Market. Indian service export companies have some presence in the Middle East, Africa, CIS countries, and Asia but these markets could be developed much more for the export of professional services with the support of the Indian Missions. They also highlighted the challenges that Indian companies could face. Overall, they advocated that increased trade in this sector would further enhance and strengthen bilateral trade relations between India and these countries. DG

SEPC, Dr. Abhay Sinha informed that SEPC would be taking a delegation to CIS countries in November 2022 to increase services trade with the region in all the champion sectors.

CEAI officials pointed out that consultancy services in the infrastructure industry always require to meet certain Pre-Qualifications (PQ) criteria to participate in the global bidding process. They drew attention and stressed on the fact that Indian companies do not meet the criteria set in the PQ so as to be able to compete with other multinational companies who are able to demonstrate previous experience working on similar projects abroad or even in India. Due to this practice the Indian companies which do not have prior experience and the stipulated experts are unable to bid. Hence, they were of the opinion that unless steps are taken at the government level to encourage Indian companies to participate in Indian infrastructure development projects, it would be very difficult to build enough credentials for Indian companies to go global and compete with foreign companies which can satisfy higher PQ criteria since, such services are hired based on the technical score where the Indian companies are not at par with other MNCs. It was therefore necessary that they be given an opportunity to participate and build their credentials, experience and expertise.

In most of the bids invited by governments, boards and authorities in India, the PQ criteria and conditions are restrictive. For example, in METRO, Oil & Gas construction projects only a few International companies are dominating the Indian market due to the conditions stipulated such as no JV allowed or each JV partner should have completed similar projects or demand of very high turnover, all of which create a situation and carry the message that there is no room for Indian consulting companies. It was suggested unless Indian companies are not promoted in India, the dream to have a strong presence at a global level would be very difficult.

It was pointed out in the conclave that most MNC who qualify and secure the projects in India based on their extra edge of prior experience, execute the

projects using only local Indian professionals. The government needs to take a policy decision to promote Indian companies within India so as to enable them to build their credentials and thus help to fulfill the dream of Atamirbhar Bharat and increase the export of engineering services.

Dr. Ajay Pradhan President CEAI expressed that the Indian consulting engineers were confident to deliver any kind of complex project anywhere in the world. If they can build a Nuclear power plant and also reach out into space all based on indigenous technology development, then why should projects like consultancy for the construction of drains and sewer lines in India be led by MNCs? In Metro rail construction after completing 20 years of successful journey, the authorities still frame bids that pre-empt Indian companies from participating and leave only international companies in the fray. CEAI demanded fair competition and equal opportunity.

Directives issued by the Ministry of Finance that bids in the service sector up to Rs. 200 crores be only through the national bidding process would be more fruitful if the definition of Indian companies is made as those whose ultimate beneficiary are Indian nationals. In the case where the project demands technology that is not available in India, the Request for Proposal (RFP) should call for a JV with a local Indian company and also stipulate smooth technology transfer to Indian professionals of the Indian companies.

Another matter that was highlighted at the conclave was the urgent need for registration and monitoring of professional engineers. That was being demanded by other countries so that they could be assured that only qualified, capable and experienced professional would be deputed for the work in their country. It was also highlighted that this has been pending for a very long time with the concerned ministry.

The Government officials present assured full support to initiate necessary steps and admeasures to promote and strengthen Indian companies to increase their capabilities and export of their services.





Report on Annual FIDIC Global Infrastructure Conference in Geneva: 10th -13th September 2022

The annual conference of FIDIC was held at Fairmont Hotel, Geneva, Switzerland, as the '**2022 International Infrastructure Conference**'. The official delegation of CEAI was led by Dr. Ajay Pradhan, President, CEAI, and included Mr. Prashant Kapila, MD of ICT, and Mr. M Padmakumar, MD of Pems Engg. Another CEAI member who joined the conference was Mr. K. K. Kapila. The conference was quite well attended with over 400 delegates, internationally.

The Directors and Secretaries (DNS) meeting was held between 09.00-13.00 hrs. on 10th September 2022 in which CEAI was represented by Dr. Ajay Pradhan and Mr. Prasant Kapila. It is a very important annual meeting for discussing current policy initiatives and functioning of FIDIC and lays down the base for the Board to consider towards making FIDIC more responsive and effective for the members' needs. The meeting was chaired by Mr. Chris Campbell of South Africa (FIDIC DNSAC) and co-chaired by Mr. John Gamble from Canada. The current initiatives and actions were presented. Dr. Nelson Ogunshakin, CEO, of FIDIC, who mentioned that a new strategy was being adopted for the functioning of various

YouTube link: <https://youtu.be/UPKkrs8mGao>

committees during the pandemic and that new work culture and restructuring done. With the new office at China, the FIDIC Academy are considered for making FIDIC more efficient and effective for the engineering consultancy fraternity and the MAs.

The DNS was followed in the afternoon by the FIDIC President's meeting, which was, in a way, the sequel to the DNS meeting. In the evening a reception was hosted for the Directors, Secretaries and Presidents of MA's at the Fairmont Hotel.

On 11th September 2022 morning, FIDIC Chairs Committee meetings were held, and option given to Presidents of selected MA's to join. Concurrently, the Future Leaders meeting and presentation were held in the parallel hall.

On 12th September 2022, the Inaugural Session of the Conference commenced at 08.45 hrs. with a local cultural show for 20 minutes.



The two-day Conference was well structured, with distinguished speakers to cover diverse but connected topics. Amongst the guest during the inaugural, the Secretary of Economic Affairs of the Government of Switzerland, Chief of UNO Geneva, and CEO of World Economic Forum addressed the delegates. The social program of the Gala Dinner on the evenings of the 12th and Local Color Night on the 13th was attended by most of the delegates. Welcome Reception was held at the President Hotel very close to Fairmont Hotel.

On 13th September 2022, GAM was held at 5.00 pm, which Dr. Ajay Pradhan, Mr. Prashant Kapila, and Mr. K K Kapila attended as CEAI's representatives. Voting for the two positions on the Board, in place of the two retiring members had been done earlier and the result was announced at the GAM. Mr. Manish Kothari from the USA and Mr. Alfredo Ingletti from Italy got elected. At the end of the GAM, Ms. Catherine Karakatsanis from Canada, who was the Vice President was named as its new President-Elect.



Overall, the Conference was very well organized and provided a high level of networking opportunities with key members of the stakeholder authorities and industries.



MEMBER NEWS

CEAI partner in “Business Opportunities Seminar” (Bos) with the Asian Development Bank

ADB funded projects in India and other countries, offer many business opportunities for Indian business community. The Government of India and ADB are keen to support participation of good quality contractors, consultants and suppliers in ADB financed projects both within and outside India, to facilitate successful implementation of the projects.

In order to disseminate information on business opportunities available in ADB funded projects in India, ADB conducted a **“Business Opportunities Seminar”** (BOS) on 21st July 2022 at the Taj Palace Hotel, New Delhi.

The seminar mainly focused on:

- access to ADB’s business opportunities through an online demonstration of ADB website;
- presentations by Government agencies implementing ADB funded projects on business opportunities available in their respective projects; and
- presentation of case studies on how to bid successfully in ADB funded projects.

The seminar also provided an opportunity for participants to interact with ADB’s Procurement Specialists.

ADB had invited Dr. Ajay Pradhan, President CEAI as a partner organization to present the views as one of the main stakeholders for ADB-funded projects. Dr. Pradhan presented the capabilities of consulting engineers and their strength in supporting projects being funded in India and ADB member countries. He also discussed the diversity of priorities, funding, and solutions with respect to the Sustainable Development Goals of the UN (SDG) in addressing Environmental Social and Governance (ESG). He stressed and explained the very important role of consulting engineers in implementing and achieving the desired goals.



CEAI Annual National Awards for Excellence in Engineering Consultancy Services 2021

Engineering consultancy services play a major role in the development of a Nation and its infrastructure. It is the primary engine that drives or enables the project execution process and forms the basis for further contracting/ construction activities.

Recognising the important role played by engineering consultancy, the Consulting Engineers Association of India or CEAI (Member Association of the International Federation of Consulting Engineers or FIDIC), instituted the **CEAI Annual National Awards for Excellence in Engineering Consultancy Services**.

A. Lifetime Achievement Award

The Lifetime Achievement Award is conferred on Individuals on the basis of their track record of over 35 years at national/ international levels in engineering/ consultancy and exceptional service to the country for technological, economic or social development. Selection is made on the recommendations of a Search Committee.

The Search Committee was headed by Mr. Umesh Shrivastava, Executive Chairman, Holtec Engineering as its Chairperson, and the members were:

- Mr. K K Kapila, CMD, ICT
- Mr. Sudhir Dhawan, CEO Aether Engineering, all three of whom are Past Presidents of CEAI and the other members were
- Mr. Girish Mishra, CEO, Saviram Engg, and
- Ms. Harshita Jain, Director- CEG.

The Lifetime Achievement Awards for 2021 were conferred on

- Mr. Amitabha Ghoshal, former Advisor, STUP Consultants Pvt. Ltd.
- Mr Arun P Mull, Former CEO & MD, TCE Consulting Engineers Limited for their extraordinary contribution to the engineering consultancy profession.



Mr. Amitabha Ghoshal receiving the Life Time Achievement Award



Mr. Arun P Mull receiving the Life Time Achievement Award

B. Excellence Awards for Organisations and Individuals

CEAI's endeavour is to recognise excellence in engineering services, in order to inspire and motivate its practitioners. CEAI invited applications from both engineering consulting organizations and individual consulting engineers to participate in the competition.

CEAI appointed an External Jury of eminent persons and experts to select the awardees. The Jury comprised:

- Mr. D Bhalla, Former Secretary, Lok Sabha & Advisor – Government of Nagaland – Chairperson of the Jury
- Mr. D K Sharma, Chairman, Himachal Pradesh Electricity Regulatory Commission (HPRC), Former CMD-Bhakra Beas Management Board (BBMD) and Former Head of Engineering, L&T Engineering
- Dr. MR Ravi, Professor, Department of Mechanical Engineering, Indian Institute of Technology Delhi
- Mr. I K Pandey, Former Director General Road Development and Special Secretary, Ministry of Road Transport & Highways (MoRTH)

National Awards in Engineering Excellence awarded for different categories were:

1) Organisations

Category A: Project Engineering

Group 1: Turnover less than 50 crores

Tandon Consultants Pvt. Ltd., Delhi

Project Title - Chennai Metro Rail Project – Consultancy Services for Design and Construction of Underground Stations and Associated Tunnels

Group 2: Turnover above 50 crores

a. Consulting Engineers Group Ltd., Jaipur

Project Title - Consultancy Services for Rajasthan Road Sector Modernization Project (RRSMP) funded by the World Bank under IDA credit

b) Mott MacDonald Pvt. Ltd., Noida

Project Title - Engineering Services for SRF State-of Art Chemical Complex at Dahej, Gujarat

c) WAPCOS Ltd., Gurgaon

Project Title - Extension of Lake Victoria Pipeline from Tabora, Igunga and Nzega Towns, Tanzania



*Tandon Consultants Pvt. Ltd.
receiving the Award for Organisation Category A,
Project Engineering - Group 1*



*Consulting Engineers Group Ltd.
receiving the Award for Organisation Category A,
Project Engineering - Group 2*



*Mott MacDonald Pvt. Ltd.
receiving the Award for Organisation Category A,
Project Engineering - Group 2*



*WAPCOS Ltd.
receiving the Award for Organisation Category A, Project
Engineering - Group 2*

Category B: Engineering Innovation

Group 1: Turnover less than 50 crores

Chempro Expertise Pvt. Ltd., Mumbai

Project Title - Detailed Engineering of the CSP Expansion Project at Nagpur

Group 2: Turnover above 50 crores

Reinforced Earth India Pvt. Ltd., Delhi

Project Title- Rehabilitation of landside location with slope protection and drainage improvement at Tindharia on NH-110 in Darjeeling, West Bengal



*Chempro Expertise Pvt. Ltd.
receiving the Award for Organisation Category B:
Engineering Innovation - Group 1*



*Reinforced Earth India Pvt Ltd
receiving the Award for Organisation Category B:
Engineering Innovation - Group I*

2) Individual

Category: Engineering Innovation

Mr Satyam Gupta, B&S Engineering

Project Title - Construction of ROB at Railway KM 1429/6-8 between Ghaziabad and Maripat Railway Station on NH-24 at KM 20.213 (Part of Delhi-Meerut expressway package-II)

The awards ceremony was held on 2nd September 2022 at Hotel Le Meridien, immediately after the SEPC CEAI Conclave. The awards were distributed by Dr. Ajay Pradhan, President CEAI, Mr. CA Sunil Talati, Chairman SEPC, Dr Abhay Sinha, DG SEPC, Mr. I K Pandey, Former Director General Road Development and Special Secretary MoRTH, Government of India, Ms. Sayona Philip, Past President and Chairperson of Awards Committee CEAI.



*Mr Satyam Gupta, B&S Engineering
receiving the Award for Individual Category Engineering
Innovation*

Other News, Views & Notes

Mr. Vineet Lochan Gupta Life Member of CEAI and CEO of SAVE TECHNO ENGINEERS received the 1st Runner-up 'Greenpreneur Award' – Building Construction Category on 3rd September 2022 at Centre for Environment Education (CEE), Ahmadabad in recognition of outstanding contribution to the Green initiative, effectively promoting the concept and to encourage professionals to adopt sustainability to make the world better and greener.



The Award is conceived and initiated by Vyapaarjagat.com and aimed to encourage and facilitating the achievers towards green, sustainability, environmental, waste management, recycling, and up-cycling concept and to effectively promote this concept and also to strengthen collaborations and networks in this domain, aiming and recognizing green entrepreneur i.e., Eco-Minded-Green, Environment Friendly, Climate-Friendly Business owners or Startup Founders or Project Leaders. Vyaparjagat.com has collaborated in "Azadi Ka Amrit Mahotsav" and in promoting "Aatma Nirbhar Bharat" as a National mission.

ViewPoint

Technology and Engineering have turned the world into a kaleidoscope and in their wake have also opened areas and scenarios which need to be carefully knitted so that the products that result are made in a sustainable manner to aid and abet a circular economy. It is to present all the perspectives that emanate from the march of technology and suggest the way forward. Accordingly, the theme for the December 2022 issue

is ***“Technology/ Engineering for Sustainability and Circular Economy”***.

Dr. Prasad Modak, Executive President, Environmental Management Centre LLP; Director, Ekonnnect Knowledge Foundation has kindly consented to be the Guest Editor for this issue.

Professionals are invited to share their views and case studies of how they addressed the challenges faced, practical issues experienced and the solutions to those, etc. Photographs, charts, diagrams, drawings, etc. would benefit readers for better appreciation of the issues encountered and the manner in which they were addressed.

The themes for the issues of ViewPoint for 2023 will be decided by the Publication Committee 2023-2024.

The articles for an issue need to reach CEAI at least 3 weeks prior to the end of the month of the View Point issue.

Articles need to be in Times New Roman 12 with single line spacing with before and after 6 pt and normal margin, on A4 size. A recent clear and bright passport size photograph of the author(s) is to be sent

along with the article. For details of formatting please refer to *“Format for Articles for CEAI Viewpoint”* on CEAI’s website, under ‘Publications’.

Advertisement in ViewPoint

ViewPoint is circulated to all CEAI Members, FIDIC, Ministries of the Government of India, Public & Private Sector Undertakings, Construction Firms, Contractors, Consultants, Foreign Missions and Funding Institutions in India and other organisations related to or dealing with the engineering profession. Thus, all stakeholders partnering development and progress are its readers.

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Support from CEAI members and stakeholders are sought for increasing the number of advertisements, so that View Point gains in its stature as a unique Technical Publication for the fraternity and the public at large to spread information of how consulting engineers are helping society for improving the quality of life and doing so sustainably.

The rates for advertisements in ViewPoint are given below.

Item	Rate Per issue* (Rs)	Discounted rate at 20% for 4 consecutive issues* (Rs)
Back Cover	25,000/-	80,000/-
Inside Front Cover	15,000/-	48,000/-
Inside Back Cover	15,000/-	48,000/-
Full Page	10,000/-	32,000/-

**GST @ 5% or as prescribed will be added to the above rates.*

The above rates are valid only till December 2022.

Tech Quiz

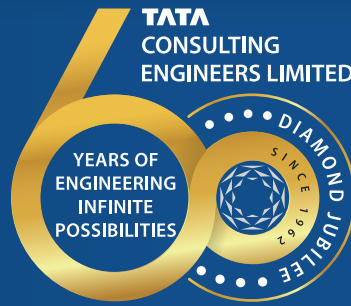
1. **Which was the first residential/ commercial Tall Building in the World?**
 - a. Flatiron Building
 - b. Empire State Building
 - c. Singer Tower
 - d. Home Insurance Building
 - e. Metropolitan Life Insurance Company Tower
2. **What construction material was used for the structure of the first skyscraper?**
 - a. Steel
 - b. Concrete
 - c. Cast Iron & Wrought Iron
 - d. Reinforced Cement Concrete
 - e. Composite Steel & Timber
3. **What material was used for the façade in the early skyscrapers?**
 - a. Stone
 - b. Granite
 - c. Brick
 - d. Glass
 - e. All the above
4. **What is the tallest temple in India?**
 - a. Ranganathaswamy Temple
 - b. Murdeshwara Temple
 - c. New Vishwanath Temple
 - d. Annamalaiyar Temple
 - e. Chaturbhuj Temple
5. **Which of these cities has the best founding strata?**
 - a. Ahmedabad
 - b. Chennai
 - c. Delhi
 - d. Mumbai
 - e. Kolkata
6. **What was the material used for waste pipes in the early bronze age civilization in India?**
 - a. Vitrified clay
 - b. Baked clay
 - c. Circular bricks
 - d. Cast iron
 - e. Hollow timber
7. **In which Asian country was a tall building first built?**
 - a. Japan
 - b. China
 - c. Hong Kong
 - d. Malaysia
 - e. India
8. **Where was glass first made?**
 - a. Mesopotamia
 - b. Harappa
 - c. Egypt
 - d. Cyprus
 - e. Greece
9. **Around when was wootz steel invented?**
 - a. 13th century BC
 - b. 3rd century AD
 - c. 6th century BC
 - d. 11th century BC
 - e. 18th century AD
10. **What is the biggest solar power capacity installed on tall buildings in India?**
 - a. 1000 kW
 - b. 65 kW
 - c. 20 kW
 - d. 525 kW
 - e. 100 kW

The first person who mails the correct answers to CEAI ceai.ceai@gmail.com will get a congratulatory mail and will be acknowledged by publishing the persons photograph in the next issue..

Contributed by A P Mull

Answers to Tech Quiz June 2022 issue

1. (d), 2. (b), 3. (e), 4. (c), 5. (a), 6. (d), 7. (b), 8. (c), 9. (a), 10. (e)



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14– 15 November 2022 | 9:30 am to 5:30 pm | PHD Chamber of Commerce and Industry, New Delhi

Management of Claims and Disputes Resolution

16– 17 November 2022 | 9:30 am to 5:30 pm | PHD Chamber of Commerce and Industry, New Delhi

The training will be imparted by FIDIC faculty Mr Bogdan Oprea

Registration Fee

CEAI Member - Rs.25,960/- (Including GST) for each module

Non Member - Rs.29,500/- (Including GST) for each module

- 5% Discount would be extended if there are 4 or more participants from one organization
- FIDIC Certificate will be issued by CEAi to those who complete the two day training program





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