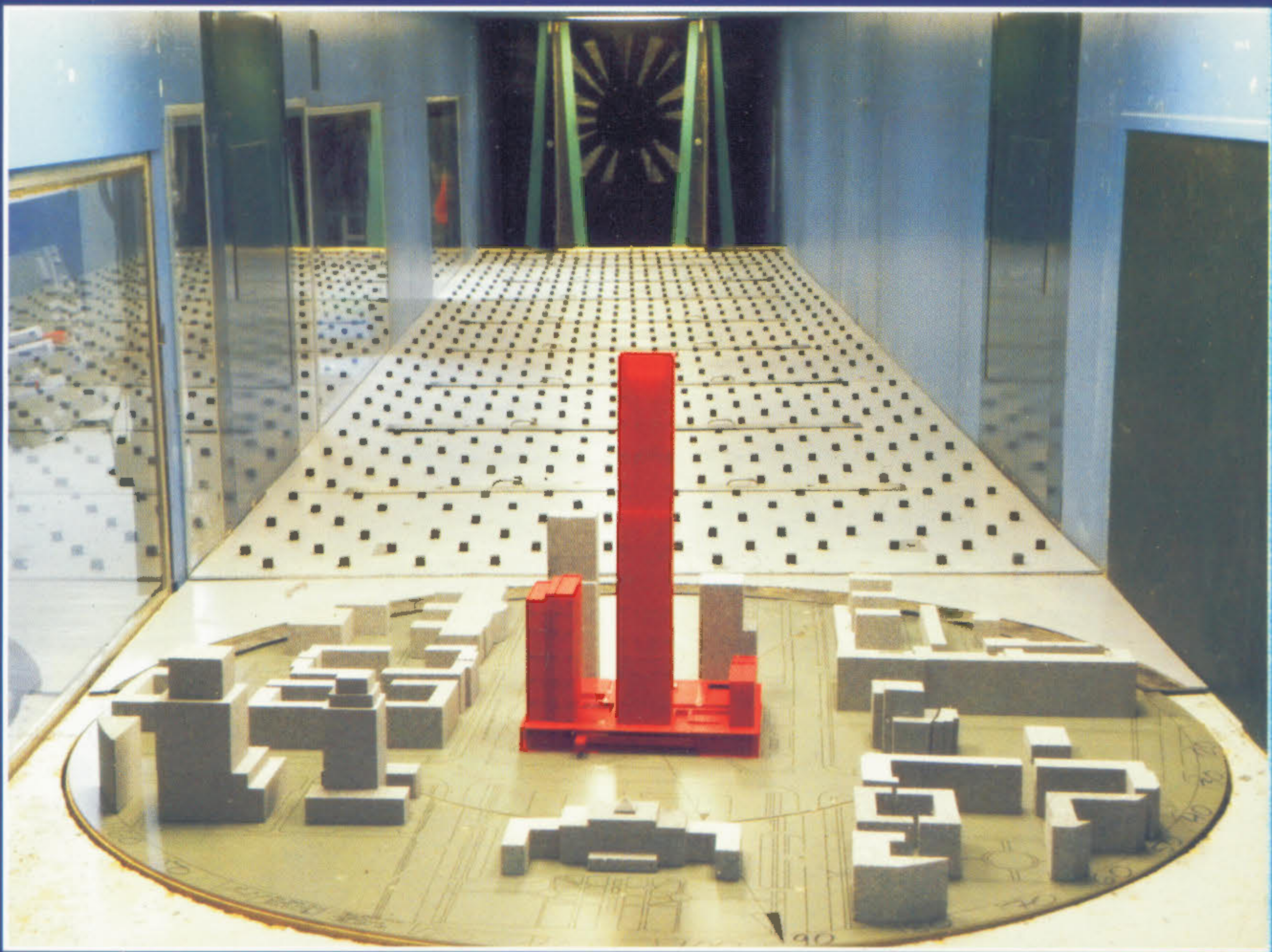
STRUCTURAL ENGINEERING

QUARTERLY JOURNAL OF
INDIAN SOCIETY
OF
STRUCTURAL ENGINEERS

ISSE

VOLUME 13-1

Jan-Feb-Mar-2011



GUIDELINES FOR THE WIND DESIGN OF HIGH-RISE BUILDINGS

(See page 3 inside)

LET US BUILD A STRONG STRUCTURE OF INDIAN SOCIETY

STRUCTURAL ENGINEERING

QUARTERLY JOURNAL OF

INDIAN SOCIETY OF STRUCTURAL ENGINEERS

ISSE

VOLUME 13-1, JAN-FEB-MAR 2011

Head Office : C/O. S G Dharmadhikari, 24, Pandit Nivas, 3rd Floor, S K Bole Marg Dadar (W), Mumbai - 400 028 • Tel. 91-22 24365240 • Fax . 91-22 -2422 4096

• E-mail : issemumbai@gmail.com • Website : www.isse.org.in

Regd. Office : The Maharashtra Executor & Trustee Co. Ltd., Bank of Maharashtra, Gadkari Chowk Gokhale Road (N), Dadar, Mumbai - 400 028

Charity Commissioner Reg. No. E 17940, Mumbai Donations are exempted from Income Tax under 80-G

Contents

Fraternity News

WELCOME TO NEW MEMBERS

(Jan-Feb-Mar 2011)

LIFE MEMBERS

M-1055 Mr. Saravanakumar Nagaswamy
M-1056 Mr. Sunil Bhimrao Thakare
M-1057 Mr. Giridhar Narayanrao Narule
M-1058 Dr.Satishkumar shahajirao Kashid
M-1059 Mr. Mahesh Girmallappa Kalyanshetti
M-1060 Mr.Sanjay Shivaji Kadam
M-1061 Mr.Iftekhar Ahmed Mohiyuddin Nadaf
M-1062 Mr. Sangappa Gurusiddappa Dhorigol
M-1063 Mr. Bhushan Harish Ballal
M-1064 Mr. Atul Vasant Joshi
M-1065 Mr. Navnath Tukaram Chavan
M-1066 Mr. Ranjit Rajaram Hande
M-1067 Mr. Shrinivas Laxmanrao Karanjikar
M-1068 Mr. Ravindra Yeshwant Bansode
M-1069 Mr. Amol Haribhau Joshi
M-1070 Mr. Kamal Nagraj Rao
M-1071 Mr. Bhushan Shashikant Joshi
M-1072 Mr. Bhaskar Shantaram Kolte
M-1073 Mr. Dyaneshwar Ashok Surse
M-1074 Mr. Raghunath Gopal Vartak
M-1075 Mr.Rajesh Baliram Vargantwar
M-1076 Mr.Rahul Balwantrao Bhoite
M-1077 Mr.Satyajit Ramchandra Marathe
M-1078 Mr. Salil Deoram Thakare
M-1079 Mr. Mohan Damodar Keskar
M-1080 Mr. Swanand Balkrishna Kulkarni
M-1081 Mr. Sanjeeva Iswarappa Yadahalli
M-1082 Mr. Senthimal Kumar Palanisamy
M-1083 Rema Surendran
M-1084 Mr. Harshavardhan Shripad Deshpande
M-1085 Mr Mahesh Nandlal Varma

ORGANISATION MEMBER

OM-17 Vidya Pratishthan's Engineering College
OM-18 Rushabh Consultant

REVISED STRENGTH AS ON 31-3-2011

Patrons : 29
Organisation Members : 18
Sponsors : 8
Members : 1085
Junior Members : 9

TOTAL STRENGTH : 1149

AIMS & OBJECTIVES

1. To restore the desired status to the Structural Engineer in construction industry and to create awareness about the profession.
2. To define Boundaries of Responsibilities of Structural Engineer, commensurate with remuneration.
3. To get easy registration with Governments, Corporations and similar organisations all over India, for our members.
4. To reformulate Certification policies adopted by various authorities, to remove anomalies.
5. To convince all Govt. & Semi Govt. bodies for directly engaging Structural Engineer for his services.
6. To disseminate information in various fields of Structural Engineering, to all members.

GUIDELINES FOR THE WIND DESIGN OF HIGH-RISE BUILDINGS

K. Suresh Kumar

WIND

1. DESIGN PHILOSOPHY

The importance of "Wind Engineering" is emerging in India ever since the need for taller and slender buildings came into picture. Considering the ever increasing population as well as limited space, horizontal expansion is no more a viable solution especially in metropolitan cities like Mumbai, New Delhi, Kolkata. The structural design of high-rise buildings is indeed a challenge technically as well as economically. As buildings grow taller and more slender, wind loading effects become more significant in comparison with earthquake effects. The is because whilst the wind overturning moment will typically increase as height cubed, the elastic seismic base moment is unlikely to increase at more than height raised to the power of 1.25 (Willford et al. 2008).

Note that a wind engineered building is not all about precise loads for design. One of the most important issues when the buildings grow taller is serviceability related to comfort. So the design criterion with respect to wind is dual fold:

(a) Strength based
(b) Serviceability based

2. WIND ENGINEERING STUDIES

Wind engineering is a niche field under the umbrella of Civil Engineering. Many times, wind engineering is being misunderstood as wind energy in India. On the other hand, wind engineering is unique part of engineering where the impact of wind on structures and its environment being studied. More specifically related to buildings, wind loads on claddings are required for the selection of the cladding systems and wind loads on the structural frames are required for the design of beams, columns, lateral bracing and foundations. Without doubt, the wind loads are combined along with other types of typical loads such as dead load and live loads using load combination procedures.

Wind engineering can be studied in many different ways and they are shown in Figure 1, which is briefed below:

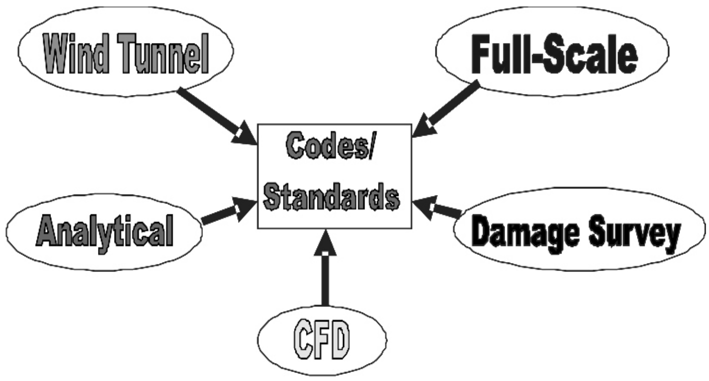


Figure 1 Different ways of wind engineering studies

Wind Tunnel: In wind tunnel studies, scaled models of structures are subjected to scaled atmospheric wind in a controlled laboratory set-up. Then sensors installed on the model can measure the physical quantities of interest such as shear, moment, pressure etc. Later in the analysis, these model scale quantities are converted to prototype using model scale laws. Most of the complex architectural and structural innovations are being confirmed through wind tunnel tests. Outside of India, wind tunnel tests are being done for almost all buildings above approximately 100 m. Even low buildings are being tested for places like Miami, Florida where severe wind conditions are expected.

Typical model scales are in the range of 1:300 ~ 1:500. Since the response of the structure is significantly influenced by its geometry, utmost care has to be taken in modelling the exact shape of the structure including all the external architectural ornaments such as fins, balconies etc. Typically, all elements more than 1ft can get modelled with the typical scale range noted above. However, certain simplification of the external architectural features is allowed at the modelling stage by wind tunnel experts.

A wind tunnel is shown in Figure 2. Note that fan behind the spires is used to blow the wind through the test section. The upwind spires and appropriate floor roughness elements are used to generate the full-scale wind characteristics (i.e., mean and turbulence profiles). Surrounding buildings for a half kilometre radius around the study building are also modelled and placed in the disk (in grey colour) during the test in order get the influence of immediate surroundings. Further, the disk is rotated at every 10 degree in order to subject the building to various angles of attack similar to full-scale.

Full-Scale: With full-scale studies, actual buildings already built will be used to get instrumented and put into test in natural wind flow for several months in order to get decent measurements. The time consumption in full-scale study is one of the issues; many times one has to wait for the wind to blow from the directions that you need since you don't have an opportunity to rotate the building like in a wind tunnel. Full-scale studies are good to improve our understanding of the science as well as the simulation in the wind tunnel. But these types of studies are not practical in day-to-day life.

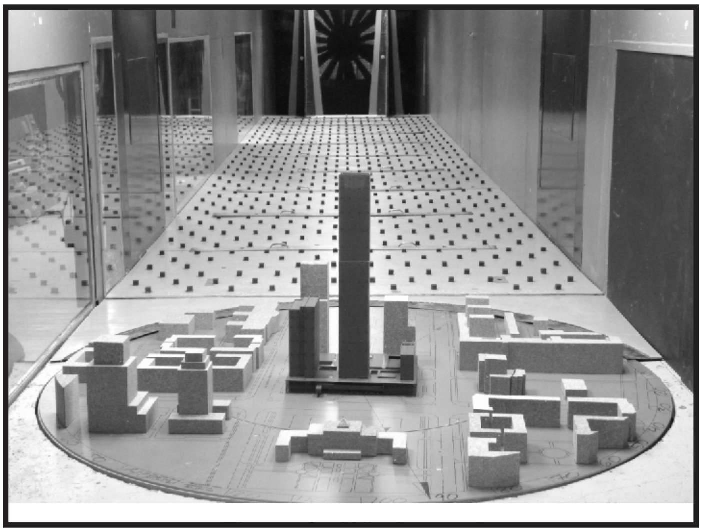


Figure 2 Wind tunnel

Analytical: With analytical studies, the structures are modelled in structural dynamic sense and the wind flow is modelled as stochastic time series and thereafter, the response of the structure is obtained by random vibration techniques. This is a very useful tool in research since parametric studies can be easily carried out. For any analytical study, a few parameters have to be determined through wind tunnel tests.

CFD: In Computational Fluid Dynamics (CFD) studies, like in analytical studies, the structures are modelled in structural dynamic sense. But the wind flow is modelled using basic fluid dynamic equations such as continuity, energy and momentum equations. Thereafter a specific turbulence model is used and the equations are solved using numerical techniques and the responses are obtained. This technique is becoming popular and quite widely used in studies such as pedestrian level wind flow, internal flows for air quality, pollution studies, topographical studies etc.

Damage Survey: This is a rather new science emerged in the last two decades. Once the damage has occurred, pool of experts visit the location and tries to investigate how it happened. Through this we try to relate the extent of damage with the wind speed. They may carry out some simple laboratory tests as a part of this.

Codes/Standards: Codes/standards are being widely used in India for determining wind loads for design. Certainly this is sufficient for preliminary design. However, considering the numerous non-typical geometries of the structures, complex surroundings and complex structural design which are not covered by the codes/standards, for final design other established means such as wind tunnel tests are required at times to confirm the preliminary design.

3. PRELIMINARY DESIGN USING IS:875 PART 3 (1987)

Indian code IS: 875 Part 3 1987 is recommended for the preliminary design of tall buildings. It would also be useful to refer other International codes of practice such as Australian/New Zealand Standard (AS1170.2 2002), American Standard (ASCE7-05 2005), Canadian Code (NBC 2005) and Eurocode 1 (1991) not only to verify the calculated loads but also to obtain information on cross-wind loads as well as acceleration response which are not covered in our Indian standard. As a note of caution, please carry out appropriate conversions when mixing information between codes.

Most of the existing international codes and standards for wind loading on structures clearly show their limitations and recommend detailed studies by other established means when required. As a result of this, in the past two decades, wind tunnels have been widely used to reliably predict the localized wind loads on the cladding/glazing as well as the overall structural wind loads on the frames of tall buildings. Similar to other codes/standards, the Indian wind loading standard also clearly shows its limitations and warrants detailed studies.

As per **IS:875 Part 3 1987** (Page 5), "*Note 1 – This standard does not apply to buildings and structures with unconventional shapes, unusual locations, and abnormal environmental conditions that have not been covered in this code. Special investigations are necessary in such cases to establish wind loads and their effects. Wind tunnel studies may also be required in such situations. Note 2 – In the case of tall structures with unsymmetrical geometry, the designs may have to be checked for torsional effects due to wind pressure. (Page 48) Note 9- In assessing wind loads due to such dynamic phenomenon as galloping, flutter and ovalling, the required information is not available either in the references of Note 8 or other literature, specialist advise shall be sought, including experiments on models in wind tunnels.*"

3.1 Points to remember while using IS:875 Part 3

Please note that the current Indian Wind code IS:875 Part 3 has numerous typographical errors as well as omissions of important sections. In recent studies by Bhami et al. (2009) and Suresh Kumar (2011), local cladding as well as structural loads predicted by IS code have been compared against other international codes as well as wind tunnel results.

The results of this study indicate that concerning the cladding loads predicted by IS:875, the pressure values on edges stand much lower than the tunnel tested and ASCE values. Therefore, IS:875 predictions for cladding design should be used with caution and it is strongly recommended to look at other international codes at the preliminary design stage. Also, it is necessary to revamp the tabular values for external pressure coefficients provided for local cladding design at the earliest. As an initial step, it is recommended the pressure coefficient to be increased to -1.8 from the current value of -1.2 at least for an edge zone of 20% building width. For the central region, one can use the same pressure coefficient of -1.2 currently in the code. The practitioners can use the load calculation procedure in IS:875 with minimum risk (r=0.63, life of 50 years) by using the above recommended pressure coefficients.

The structural load comparisons indicate that IS:875 is indeed good enough for preliminary structural load predictions in the absence of across-wind response domination. However, the necessity of including a basic estimation procedure for across-wind response is clear which will help practitioners accounting this phenomenon in early stage of the design itself. Note that design of a traditional text book type square shape structure may get underestimated if done using IS:875 Part3 considering the fact that these structures are prone to higher cross-wind loading which is not covered in the code.

There is no provision on the IS: 875 Part 3 for torsional wind loads. As an initial step, one can estimate the torsional loads from the estimated shear forces. It is recommended to determine the torsional load by multiplying the maximum shear by 15% of the maximum width.

When wind is blowing from any direction, the structure will be subjected to simultaneous orthogonal and torsional loadings due to aerodynamics and fluctuating nature of the wind flow. Therefore, simultaneous application of sway forces and torsional loads with suggested combination factors should be included in the code. Based on our wide experience in the subject matter, 100% of any individual primary force (Fx, Fy or Mz) can be considered with 60% of secondary forces (Fx, Fy or Mz) as an initial step.

4. DETAILED DESIGN USING WIND TUNNEL TEST

4.1 When to get Expert Advice and do Wind Tunnel Test

Interestingly enough mostly, nowadays developers and architects are coming up with unconventional building shapes with offsets, setback, various corner shapes, balconies, fins etc. Further, the buildings are mostly located in complex surroundings along with other structures. These conditions were not covered or addressed in any of the international codes and standards. In addition to this, the effect of building response due to its orientation with respect to the wind directionality of the site is not covered in detail in any of the International codes. All the codes and standards are based on box like shape buildings in isolated condition. In general, Code analytical methods are helpful for preliminary design and for simple situations, but provide conservative wind loads in most cases; underestimating in others. Presently, wind tunnel model studies offer the best estimate of the wind loading acting on a building for cladding as well as structural frame design. In addition to the potential cost savings and accurate results, wind tunnel studies confirm that the architect's vision can be safely built and elevate litigation protection (Suresh Kumar et al. 2006, Suresh Kumar 2007).

Further to the issue of unconventional geometry, complex surroundings and wind directionality being not covered in codes and standards, complex structural interaction as well as cross wind response which are important for tall buildings are not covered generally in codes and standards. Many times, complex structural properties would alone be the reason for higher wind-induced response. For instance, modal coupling is a common result of a complex structural design. There are different types of couplings and the typical ones would be the coupling between torsion and sway modes and the coupling between sway modes. On the other hand, cross-wind responses of buildings are mainly influenced by the geometry and immediate surroundings. The effects of these cannot be codified considering the numerous possible geometries and surroundings that we are encountering in real life. Therefore, site specific wind tunnel tests have to be carried out for determining loads on buildings.

The results from wind tunnel tests can be lower than code predictions due to unconventional geometry, complex surroundings as well as wind directionality. However, some allowance for possible future changes in surroundings has to be provided. Therefore, finally a minimum load need to be derived and recommended for design based on wind tunnel results and code predictions. This recommended load supersedes code predictions and should be used for design. Note that wind tunnel testing is a proven methodology for the prediction of building response and this technology has been under use for the last few decades and most high-rise buildings are constructed and safely serving occupants for many decades around the world.

In summary based on Indian wind conditions, it is recommended to get expert advice when buildings are above 30 storeys (or 100 m above grade) and/or slenderness ratio (height/width) exceeds 5, where the width is equal to the smallest average width in orthogonal direction. Later, the expert's review will suggest whether to carry out a wind tunnel test or not. When the external geometry gets crystallized and that is the right time for wind tunnel testing. Note that any minor geometry changes after the tunnel tests can be reviewed and the effects of which can be assessed by an expert in the field without going through a full blown retest. On one hand wind tunnel test may be required to confirm the loads and accelerations which can be very different (lower or higher) than predicted by codes/standards in some cases. But with a positive note mostly wind tunnel tests come up with lower loads and hence significant savings in construction cost is a reality.

4.2 Common Wind Tunnel Model Studies

Common wind tunnel model studies and their typical results are shown in Table 1

Table 1 Common Wind Tunnel Model Studies

No.	Type of Test	Type of Results
1	**Local Pressure Test:** Local pressure measurements on scaled static models instrumented with pressure taps	Mean, fluctuating and peak external pressures Wind-induced internal pressures Peak net pressures on cladding
2	**High Frequency Force Balance (HFFB) Test:** Measurement of overall wind loads on scaled high frequency static models using balance	Base loads (sway moments, torsional moment and shear forces) Floor-by-Floor Loads (shear forces and torsional moment) Load combination factors Accelerations and torsional velocity at top occupied floor
3	**High Frequency Pressure Integration (HFPI) Test:** Simultaneous pressure measurements on scaled static models I nstrumented with many pressure taps and subsequent spatial or time averaging of simultaneously acting local pressures to obtain overall wind loads	Same results as HFFB would provide The decision with regard to the type of test(HFFB or HFPI?) will be taken by the expert depending on the geometry, scope and instrumentation challenges.

5. INFORMATION REQUIRED FOR WIND TUNNEL TEST

For modelling the study building, the following information is required in electronic format: (a) the most up-to-date architectural drawing files (all floor plans, elevations, roof plans, site plan showing north) and (b) 3-D CAD model if available.

For modelling the surrounding structures, all available information regarding the surroundings within a 600 m radius of the site is required. This may be either in the form of footprints marked with height on CAD drawing or site photographs taken from an adjacent tall building.

The above said information is all that required for cladding studies. But for structural studies, the following dynamic properties of the building are required at the analysis stage: (a) floor ladder used in the structural model – i.e., floor-to-floor heights and elevations above grade, floor labels in the structural model, (b) mass properties for each floor/storey, including mass, mass moment of inertia and location of the center of mass of each floor, (c) mode shapes (modal deflections at each floor) and corresponding natural frequencies associated with each of the modes of vibration, and (d) a drawing showing the origin of the structural model co-ordinate system to an architectural floor plan of a typical floor and sign convention of the x and y coordinate system.

Note that the lumped mass at each floor/story used in the dynamic analysis should account for the full self-weight of the floor's structural system (i.e. slab, beams, columns, walls, bracing), superimposed dead loads, and a live load allowance (typically about 30% of the nominal value). Some programs provide diaphragm masses as well as assembled point masses and both information would be useful for the analysis. Mode shapes and natural frequencies information can be extracted from the dynamic analysis results of the structural model. Typically, for buildings, the first two sway (translational) modes and the first torsional modes are required.

In complex cases such as connected twin towers, higher order modes are also required for the analysis. The effects of higher order modes are also simulated in most of the aeroelastic tests. In addition to the above information, for aeroelastic tests, sway as well as torsional stiffness of each floor is also required for modelling purposes.

6. STRENGTH DESIGN

6.1 Cladding Loads

This study addresses the local wind pressures that act on the exterior envelope of the building. Predictions of these loads are required in order that the cladding system can be designed to safely resist the wind loads. Wind tunnel results in the form of local pressure distribution can be utilized by the curtain wall consultants for selecting the right thickness of glass to resist the expected wind loads. The technique that is used to make these predictions consists of conducting a wind pressure study. The basis of this approach is to instrument a rigid wind tunnel model of the building with pressure taps that adequately cover the exterior areas exposed to wind. The mean, root-mean-square, maximum and minimum pressures are measured at each tap. The measured data are converted to prototype values using scaling laws. This procedure would lead only to external pressure. A typical cladding wind tunnel model is shown in Figure 3, where the black dots represents the pressure tap locations and the complex tubing inside the model is also shown.

Internal pressures are also critical to the design of cladding systems. In strong winds, air leakage effects dominate the internal pressures. Other factors that influence internal pressure include operable windows, window breakage due to airborne debris in a windstorm, and less significant stack effect and mechanical ventilation systems. Influence of internal pressures due to an opening on the façade can be studied using wind tunnel tests. Finally, the recommended design pressures are a combination of exterior and internal pressures. In case where the cladding elements exposed to wind on opposite surfaces such as parapets, balcony, fins etc., net pressures are measured by putting taps on both surfaces.

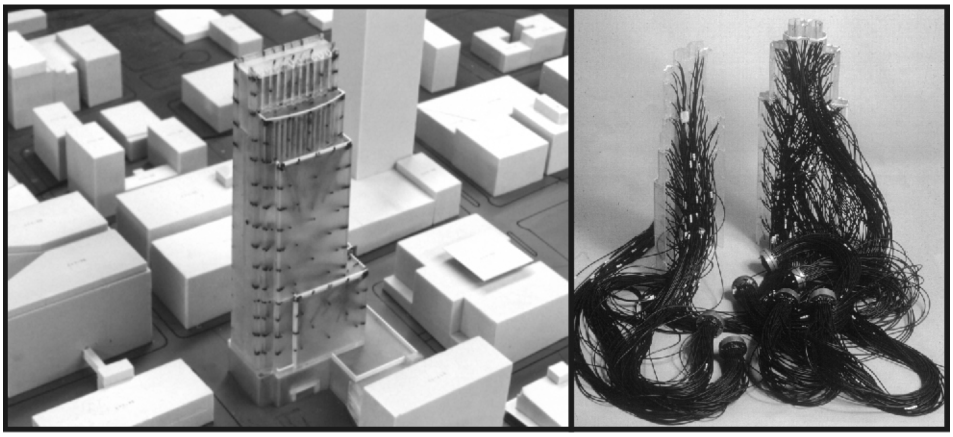
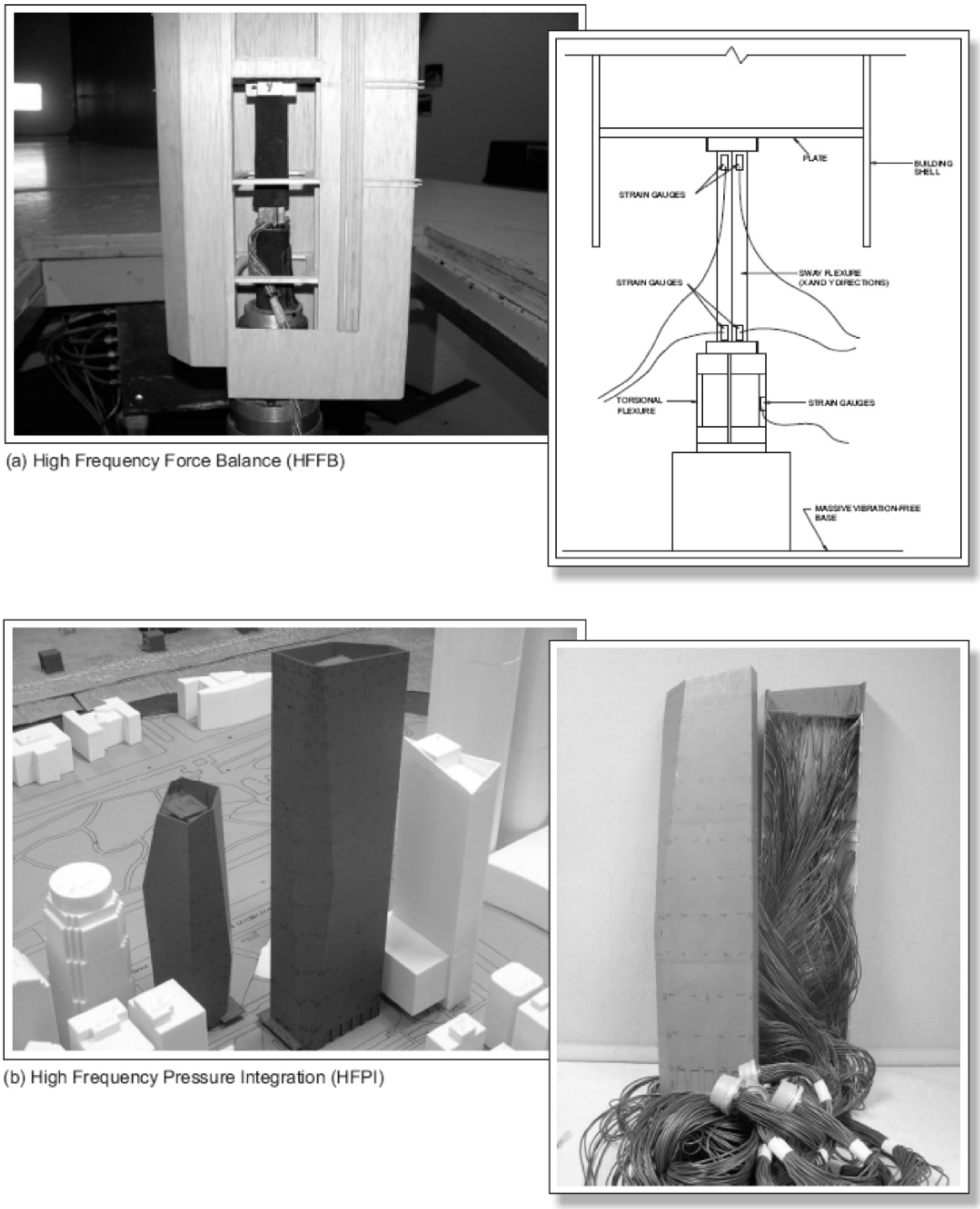


Figure 3 Cladding wind tunnel model

6.2 Structural Loads

6.2.1 High Frequency Force Balance (HFFB)

The High Frequency Force Balance (HFFB) method is based on measuring the overall wind-induced forces acting at the base of a rigid model, using a high frequency force balance (see Figure 4 (a). To allow predictions of the dynamic responses of the structure to be made, the model must be light and stiff (i.e. nominally rigid) so that the measurements reflect the fluctuations in the applied wind loading only, and not the vibrations of the model itself. The requirement for a light, stiff model is in contrast to an aeroelastic model, which would be carefully designed to vibrate as the actual structure would. The HFFB method, when it was first introduced, allowed a simple model to be constructed and tested, generating data with which various sets of structural dynamic information (e.g., mass, stiffness and damping) could be analysed without altering the model and repeating the wind tunnel tests. For this reason, the HFFB method has proven to be a cost-effective tool (Calin et al. 2006).



(a) High Frequency Force Balance (HFFB)

(b) High Frequency Pressure Integration (HFPI)

Figure 4   Measurement techniques for the prediction of wind-induced structural responses (RWDI (2000)

Inherent in the HFFB approach is the fact that only the total loading at the base is known. The prediction of the dynamic response to wind requires knowledge of the wind-induced generalized forces, which are related to the pressure distribution over the height of the building. For a building with a linear mode shape, it is possible to use the base moments directly to represent the generalized forces. For the general case of non-linear mode shapes, various refinements are possible, both in the physical test set-up as well as in the analysis.

Note that HFFB method always measures overall responses. To generate effective load distributions over the height of the building requires similar assumptions to those discussed above. This appears to be adequate in many cases of practical significance; however, there are obvious limitations should the designer wish to focus on individual structural elements higher up in the building. On the other hand, HFFB method offers the advantage that the total loading on complex geometries will be reflected in the measured base loads.

Note that HFFB test measures mean as well as fluctuating loads not including inertial response. In this study, the inertial or resonant loads are calculated from measured wind force spectra. Estimates of the wind-induced accelerations are made analytically after the forces are determined.

6.2.2 High Frequency Pressure Integration (HFPI)

The HFPI method is based on the simultaneous measurement of pressures at several locations on a building (see Figure 4 (b)). If pressure taps are installed at a fine enough resolution over the building surfaces, then integrating the data should provide the same output as an HFFB test. In fact, the measurement of the generalized forces is greatly improved as assumed pressure distributions based on measured base forces are replaced with instantaneous pressure distributions over the entire building surface. This method also allows for flexibility in isolating components or substructures for which loads can be determined in detail. The measurements also allow higher modes to be considered.

A practical benefit is that such pressure measurements are typically required to begin with, for the prediction of cladding loads. Therefore, some testing time may be saved. It is worth noting that the ability to sample pressures simultaneously, at the hundreds of locations required for this task is a relatively recent development. The current state of data storage as well as pressure scanning technology has virtually eliminated this obstacle.

In general HFPI approach is more labour-intensive with respect to the determination of tap tributary areas, moment and torsion arms, as well as the physical installation of the pressure taps. Again, advances in graphics and modeling technology continue to help this process.

There remain some physical constraints with conducting HFPI studies. Slender structures provided limited space in which to run the instrumentation from the building face and out to the data acquisition system. Close proximity to nearby buildings seemingly requires more taps to deal with the complexity of the flows compared to those affecting an isolated building. Installation of pressure taps on balconies and architectural façade details may be difficult or impossible. Frames, trellis work or other kinds of screens pose similar challenges. Addressing such details requires engineering judgement usually in assigning tributary areas and pressures to such features. Alternatively, this is often justification for using the HFFB technique where one can be certain that the integrated effect of such details will be embedded in the measured base loads.

Similar to HFFB test, using HFPI method, inertial loads as well as wind-induced accelerations are estimated analytically. More details on HFFB and HFPI methods can be found in Calin et al. (2006).

6.2.3 Aeroelastic Model Studies

In aeroelastic studies, the building mass, stiffness and damping will be appropriately modelled. Typically, a central metal spine system is selected to represent the scaled down stiffness of the building in case of sway dominance. More complicated frame spine system is warranted in case torsional stiffness needs to be simulated. The outer shell connected to the spine represents the geometry of the building. Spine and shell together represent the scaled mass of the building. The damping is induced through simple magnetic or viscous damper.

In aeroelastic test, strain gauges fixed at the spine system at various heights are typically used to measure loads. These measured loads represent total loads including the resonant component. There is no need of estimating resonant loads analytically like in rigid model tests. Over and above, accelerations can be measured directly using accelerometers or lasers. Note that aeroelastic models can move in air, so these moving models can interact with air and any change in force due to the movement of the model relative to the wind flow will be captured in measurements. These motion-dependent or 'aeroelastic' forces are not experienced by rigid stationary models used in HFPI or HFFB tests.

However, aeroelastic forces seem to be minimal and need not be considered for design in majority of the building cases. Typical buildings are not too tall and slender and they are massive as well, where aeroelastic effects are negligible. In such cases, less expensive HFFB and HFPI tests can be utilized to obtain wind-induced response for design. When the building become too slender of the order of h/b>10, or too tall above 500 m or too light and tapered with steel as the medium, then one would have to consider aeroelastic tests if there is enough information warrant the test after a simple desktop study or HFFB/HFPI initial test.

6.2.4 Typical Results - Loads

Typically results are provided in the following format:

(a) Base loads: Orthogonal sway moments, torsional moment as well as orthogonal shear forces.

(b) Floor-by-Floor Loads: Effective static wind loads that correspond to the predicted overall moments and shears are provided on a floor-by-floor basis.

(c) Load combinations: To account for the simultaneous action of the sway and torsional components provided, wind load combination factors are provided.

The provided structural wind loads are typically used by the structural engineers for checking their preliminary design. Further, they should be using the provided loads for optimising their structural system if the wind tunnel results are lower than their preliminary design loads. If otherwise, they need to rework on their design to resist higher loads.

Please do not use wind tunnel results just to verify the preliminary design. If the wind tunnel results are lower than the preliminary design loads, then the structural system can be optimised which will result in significant savings to the owner. Of course time is a constraint in this trial and error process and therefore, wind tunnel tests should be carried out early in the process. Also there is a tendency not to wait for the results and continue with piling and building foundation systems and this should not be practiced.

7. SERVICEABILITY DESIGN

7.1.1 Serviceability Criterion (RWDI 2000)

All buildings are expected to move to some degree under wind action. When buildings grow taller and slender, such motions can be noticeable to their occupants and pose concerns. This happens when the magnitude of movement becomes significant and/or their frequency of occurrence is excessive. Note that tolerable acceleration levels are subjective to some degree since they are dependent on many physiological factors of occupants. Similar to wind loading, acceleration is also a fluctuating quantity. The acceleration is generally described in literature either using root-mean-square (RMS) value or the peak. Research indicates that people first begin to perceive accelerations when they reach about 5 milli-g (where milli-g is 1/1000 of the acceleration of gravity).

As far as codes and standards are concerned, National Building Code of Canada (NBCC) was the first building code to provide guidance on building motions. It suggested that 10-year return period accelerations in the range of 1.0% to 3.0% of gravity (10 to 30 milli-g) were acceptable, with the upper end of the range being appropriate for office buildings and the lower end for residential buildings. NBCC also indicated that peoples' sensitivity to motion becomes less as the natural frequency of the building becomes lower though this dependence is not reflected in the NBCC criteria.

On the other hand, the International Organization for Standardization (ISO) provided an acceleration criteria as a function of frequency. The ISO Criteria generally have used shorter return periods than 10 years. In the new ISO standard (ISO 10137:2007(E) – Annex D) on building serviceability, the acceleration criteria are expressed as peak values at the 1-year return period. The expression for building frequencies ranging from .06 Hz to 1 Hz (which is the range of interest for high-rise buildings) is as follows:

where f is the building frequency in Hz, and the constant is 6.12 for office buildings, and 4.08 for residential buildings.

$$1\text{-Year Peak Criterion in milli-g} \quad \text{constant} \quad f^{-0.445}$$

In addition to the NBCC and ISO guidelines, acceleration criteria were developed based on a consensus between design teams, developers, and the wind engineering community's experience with many towers constructed and wind tunnel tested during the 1980's and 1990's. The Council on Tall Buildings and Urban Habitat (CTBUH) recommends 10-year accelerations of 10 to 15 milli-g for residential buildings and 20 to 25 milli-g for office buildings (Isyumov 1993). Based on discussions between RWDI and the designers of numerous high-rise towers, RWDI have found it desirable to relax the residential criteria to a range of 15 to 18 milli-g, noting that the consequence of higher accelerations is an increased likelihood of occupant discomfort, rather than an issue of life safety. After numerous studies using this less stringent criteria, RWDI is not aware of any complaints of building performance (Irwin and Myslimaj 2008). It should be noted that these criteria, which are not expressed as functions of frequency, may not be appropriate particularly for buildings with unusually high or low frequencies.

Similar to translational motion, torsional motion is also equally important to be assessed in connection with occupant comfort. Torsional motions will create visuals cues among the occupants and they are assessed in the literature using peak torsional velocity in milli-rad/sec. The Council on Tall Buildings and Urban Habitat (CTBUH) have suggested torsional velocity limits of 1.5 milli-rad/sec and 3.0 milli-rad/sec corresponding to 1- and 10-year return periods respectively (Isyumov 1993). Note that these guidelines are tentative and based on limited research which is still ongoing.

7.1.2 Typical Results - Accelerations

Typically, wind tunnel tests can provide individual peak acceleration components (x, y and torsion) as well as combined total peak acceleration at the highest occupied level on a building. Further, torsional velocity at top occupied level can also be obtained. By directly comparing the predicted values with the criterion, the comfort of the building can be assessed. In case, the accelerations or torsional velocity exceeds the perception levels, it would be desirable to reduce the chance of occupant complaints by improving the response of the building. This may be achieved through modifications to the shape or by increasing any or all of the stiffness, mass or damping of the structure.

8. MITIGATION OF RESPONSE – GENERAL REMEDIAL MEASURES

8.1 Aerodynamic Modifications

Since wind-induced response is influenced by the geometry of the building, modifications to the shape have the potential to reduce the response. Vortex excitation caused by alternate shedding of vortices from both sides of the body is common in all bluff bodies including buildings. In case of buildings, this type of excitation is heavily mixed with buffeting type vibrations. Geometry also plays crucial role in inducing vortex excitation. For instance rounded corners or step corners on a sharp-edged cross sections can reduce the intensity of vortex shedding and can reduce across-wind response. Balconies, fins, screens and other various types of aerodynamic features can potentially reduce the wind-induced response.

At the very initial stage of the design Owners as well as Architects do have significant influence in the shape of the structure. If the structure is taking a very slender shape and the plans for a high tower, then obviously much warranted attention should be given in the overall plan form shape of the structure. Wind loading on structures is very much influenced by its shape and through simple corner treatments, the loading can be decreased substantially.

8.2 Raise Natural Frequencies

By raising the natural frequencies of the structure, generally the inertial response of building is reduced. The natural frequency depends on the stiffness and mass of the structure. Adding material to increase stiffness leads however to increased mass, so that the end effect on the frequencies is quite small. Thus, this is not a very practical approach. On the other hand, with appropriate positioning of the internal structure could raise the frequencies without adding mass. Note that the role of stiffness may sometimes be altered depending on whether loads or accelerations are important. For the case of vibrations caused by longitudinal turbulence, increasing stiffness is always beneficial to reduce loads and accelerations; however, in case of vortex shedding, increasing stiffness will worsen the situation unless the increase is sufficient to raise the critical speed to a value well beyond the design speed.

Flexible buildings (with low natural frequency) will typically attract more wind loading in comparison with stiff buildings. In certain buildings, the shaft core is in the middle with little shear walls towards the outer area. This is specifically done to get unobstructed outside view. But this will result in a torsionally weak system due to lack of shear walls on the periphery. Appropriate distribution of shear walls is warranted in order to stiffen the structure not only in sway directions but also in torsional direction. Further, outrigger wall/truss systems can be used to stiffen the structure when buildings grow taller.

8.3 Raise Mass Density

Note that lower mass towards the top would attract much higher accelerations. For example, steel structural system towards the top could move a lot in comparison with concrete structural system. By increasing the mass density, especially towards the top of a tall building, one may increase the generalized mass of the building and this is universally beneficial in reducing building accelerations. Similar to stiffness, the role of mass may sometimes be altered depending on whether loads or accelerations are important. For instance, increasing mass can reduce accelerations caused by longitudinal turbulence but not loads. On the other hand, increasing mass is always beneficial for reducing loads and accelerations due to vortex shedding.

8.4 Raise Damping

Increasing the damping is one of the most effective ways of suppressing wind-induced response of buildings. Several techniques have been successfully used on other existing structures, including tuned mass dampers, viscous (oil) dampers, visco-elastic dampers and tuned liquid column dampers. It should be pointed out that increase in damping capacity is always beneficial for reducing loads and accelerations irrespective of the type of loading or phenomenon causing it.

9. REFERENCES

ASCE7-05 (2005). “Minimum Design Loads for Buildings and Other Structures”, Published by the Structural Engineering Institute of ASCE, Reston, VA.

AS/NZS1170.2 (2002). “Australian/ New Zealand Standard, Structural Design Actions, Part 2: Wind Loads”, Standards Australia/ Standards New Zealand.

Bhami Mohammed, Cini, C. and Suresh Kumar, K. (2009), “Wind Loads: Where does our code of practice stand”, Proceedings of the Fifth National Conference on Wind Engineering, Surat, November, 2009.

Calin Dragoiescu, Jason Garber and K. Suresh Kumar (2006). “A Comparison of Force Balance and Pressure Integration Techniques for Predicting Wind-Induced Responses of Tall Buildings”, ASCE Structures Congress, May 18-21, St. Louis, Missouri USA.

Eurocode 1 CEN TC 250 (1991). “Actions on Structures – Part 1-4: General actions – Wind actions”, European Standard.

Irwin, P.A and Myslimaj, B.M. (2008). “Practical Experience with Wind-Tunnel Predicted Tall Building Motions”, IABSE Congress, Chicago, USA.

IS:875 Part 3 (1987), “Code of Practice for Design Loads (Other than Earthquake) For Buildings and Structures, Part 3 wind Loads”, Indian Standard.

Isyumov, N. (1993). “Criteria for Acceptable Wind-Induced Motions of Tall Buildings,” International Conference on Tall Buildings, CTBUH, Rio De Janerio.

NBC2005 (2005). “User's Guide – NBC 2005, Structural Commentaries (Part 4)”, Issued by the Canadian Commission on Building and Fire Codes, National Research Council of Canada.

RWDI (2000). “Overview of Wind Tunnel Procedures for the Prediction of Wind-Induced Structural Responses,” Appendix-A, Canada.

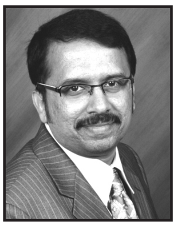
Suresh Kumar, K. (2007), “A Consultant's perspective on the Need for Wind Engineered High-Rise Buildings in India”, Proceedings of the Fourth National Conference on Wind Engineering, SERC Chennai, October 30 – November 1, 2007.

Suresh Kumar, K. (2011), “Commentary on the Indian Standard for Wind Loads”, To be published in the forthcoming 13th International Conference in Wind Engineering, Amsterdam, The Netherlands, July 10-15, 2011.

Suresh Kumar, K., Irwin, P.A. and Davies, A. (2006), “Design of Tall Buildings for Wind: Wind Tunnel vs Codes/Standards”, Proceedings of the Third National Conference on Wind Engineering, Kolkata, January 5-7, 2006.

Willford, M., Whittaker, A. and Klemencic, R. (2008), “Recommendations for the Seismic Design of High-Rise Buildings”, Draft for Comment-1, 21 February 2008, Council on Tall Buildings and Urban Habitat.

Author :



K. Suresh Kumar, Ph.D., P.Eng., M.ASCE Principal/ RWDI (India)
Managing Director RWDI India,
Email: suresh.kumar@rwdi.com
www.rwdi.com

DRAFT OF SUBMISSION TO HIGH RISE BUILDING COMMITTEE BY STRUCTURAL ENGINEER.

Municipal Corporation of Greater Mumbai (MCGM) wants structural engineers to submit their proposals for high rise buildings to the High Rise Building Committee.
The information to be submitted to the High Rise Building Committee is given for reference of structural engineers. - EDITOR.

(A) CHECK LIST FOR THE MAIN STRUCTURAL CONSULTANT

The main structural consultant is required to submit following information.

1) Provide **Design Basis Report** as per the document **HRC/DBR/V1.0.**
2) Provide description of Sub-structure and Super- structure as per the format given in the **Appendix** enclosed.
3) Provide brief Description of structural system with sketches, image of drg. Etc. with specific focus on 'Lateral load resisting system'
4) Provide brief note on modeling, software used etc. Clearly mentioned whether infill/ partion wall is idealized as part of lateral load system?
5) Provide following EQ loading details.
   - a) Zone Factor =
   - b) Importance factor =
   - c) Response Reduction factor =
   - d) Soil Type =
   - e) % LL considered in seismic =
   - f) Time Period in the horizontal X-direction (from formula in code) =
   - g) Time Period in the horizontal Z-direction (from formula in code) =
   - h) Total Seismic weight (Sw) of building (in kN) =
   - i) Static Base-shear in X-direction (as % of Sw) =
   - j) Static Base-shear in Z-direction (as % of Sw) =
   - k) Table of distribution for static base shear =
   - l) Max. deflection at roof level. =
   - m) Max. inter storey drift. =
6) Provide following Wind loading details.
   - a) Category of building =
   - b) Class of building =
   - c) Basic wind speed in m/sec. =
   - d) Maximum wind pressure =
   - e) Force coefficient =
   - f) Wind Base-shear in the horizontal X-direction =
   - g) Wind Base-shear in the horizontal Z-direction =
   - h) Gust factor calculations (if Gust- wind applied) =
   - i) Details of wind –tunnel force data (if applicable) =
   - j) Estimate magnitude of wind induced vibrations =
   - k) Max. deflection at roof level. =
   - l) Max. inter storey drift. =

7) Provide following data from Dynamic Analysis.

Modes	Frequency	Time Period	X-participation	Z-participation
Mode 1				
Mode 2				
Mode 3				
Mode 4				
Mode 5				
Mode 6				
Mode 7				
Mode 8				
Mode 9				
Mode 10				
	Summation			

8) Provide Table for lateral deflection at Terrace Level in the following format.

Load Case	Dx-max	H/Dx	Drift-x	Dz-max	H/Dz	Drift-Z
DL						
DL + LL						
EQx						
EQz						
Wx						
Wz						

9) Provide Table for Torsional irregularity (along x-direction) in the following format.

Load Case	Corner- 1	Corner-2	Corner-3	Corner-4	Avg-x	% Max./Avg
Eq-x						
Wi-x						

10) Provide Table for Torsional irregularity (along z-direction) in the following format

Load Case	Corner- 1	Corner-2	Corner-3	Corner-4	Avg-z	% Max./Avg
Eq-z						
Wi-z						

11) Provide acceleration values in the following format.

Eq-x (Static)	Eq-z (Static)	Eq-x (dyn)	Eq-z (dyn)	WL-x	WL-z

12) Provide following data regarding Vertical Elements.

a) Size of maximum loaded column =
b) Gravity load on max. loaded column =
c) Axial stress in max. loaded column (Gravity loads) =
d) Grade of max. loaded column =
e) Axial settlement in max. loaded column =
f) Axial settlement in min. loaded column =
g) % Base-shear resisted by all columns along X (static) =
h) % Base-shear resisted by all columns along Z (static) =

13) Provide, if applicable, following data regarding Floating Columns.

a) Total gravity load on floating column (provide table if there are multiple floating columns) =
b) Size and span of Girders supporting floating columns =
c) Number of floors supported by floating columns =
d) Deflecting of Girders under column (from model) =
e) Deflecting of Girders under column (from s/s action) =
f) Specific details about floating columns on cantilever Girders (Refer Table below)

Column	Supporting Girder		Deflecting Values		Floors Above	Total Load in Column
	Size	Span	Model	S/S Action		

- S/S denotes the simply supported.

14) Provide, if applicable, following data regarding soft story effect.

a) Stiffness of lower floor (in deflection/KN) =
b) Stiffness of upper floor (in deflection/KN) =
c) Relative stiffness ratio (upper/ lower) =
d) Level of soft story =
e) Number of floors above soft story =

15) Provide, if applicable data for each cantilever.

a) Cantilever span =
b) Structural system =
c) Nature of usage =
d) Maximum elastic deflection under gravity loads =

16) Provide stability calculations for uplift and overturning (model extract in case of model)

17) Typical design calculations for footings

18) Typical design calculations for RCC columns (Or Composite Columns)

19) Typical design calculations for RCC walls

20) Typical design calculations for RCC beams (or Steel Beams)

21) Typical design calculations for RCC Girders (Or Steel Girders/ Trusses)

22) Typical design calculations for Steel Bracings

23) Wind tunnel studies shall be conducted for any HRB with total height beyond normal ground level exceeding 250 mt. Wind tunnel study shall include modeling of all surrounding obstacles in the area. The report from study should be submitted.

24) Provide a note on special provisions suggested for the building (like dampers etc.)

25) Soft copy of model including input and output.

26) Soft copy of Power point presentation including all above points.

27) Items 1 through 26 on CD.

APPENDIX

I) DESCRIPTION OF SUB-STRUCTURE

NO. OF BASEMENT		
Minimum clearance between outermost basement retaining wall and compound wall		
Has a shoring system been installed? Submit sectional detail of the shoring system		
Give details of methodology used to resist uplift pressure due to ground water for tower portion as well as the portion outside the tower.	Bottom Level of Raft w.r.t. ground level in mts. Total downward load of self weight of raft + Counter weight over raft + Rock Anchors if any(for raft spanning between columns) Whether level assumed for uplift calculation	
Description of the foundation for the tower block		
Nature of Foundation	Piles, Spread Footings, Combined Raft, Piled Raft, etc.	
SBC assumed T/sq.mt.		
Sub-grade Elastic Modulus		
Flooring system of the Basements		
Retaining wall types & Sequence of backfilling	Whether propped cantilever, Cantilever Supported between Buttresses / Counter forts, etc.	

Intended Use of basements		
If rock anchors are used, are they grouted after installation and stressing?		
Is structural steel used in the construction of the sub-structure?		
If yes, what are the measures taken for its fire proofing and corrosion resistance?		
Whether Expansion/Separation joints provide? Whether expansion joint/separation joint continues through basement? If yes, detail at Basement level & retaining wall junction		

II) DESCRIPTION OF STRUCTURE

No. of Floors	
Shape Of Building, Plan, Elevation whether Symmetric in Elevation	
Maximum plan dimension in either direction in mt.	
Ratio of plan dimension	
Typical Floor to floor height in mt. Maximum floor to floor height in entire height of building in mt.	
Aspect ratio (Height of building till Terrace/ Minimum Dimension of Building)	
Type of floor slab	
Average thickness of floor slab in mm.	
Whether column are RCC, Composite or In structural steel	
<u>Lateral System</u> Whether the Geometry of Building is Symmetric	

Whether the lateral load resisting system is symmetrically placed in Geometry	
Use of floor at different levels (Residential / Commercial / industrial)	
Is there any Transfer level? If yes, depth of Transfer Girder	
Whether Expansion joint is provided? If yes, what is the maximum plan dimension in mt.	
Whether separation gap is sufficient joint is provide?	
Maximum cantilever projection in mt.	

(B) PEER REVIEW

(Draft of peer review to be submitted by proof consultant)

Name of the Project	Main Structural Engineer	Architect	Geotech Consultants
Proposed Redevelopment of ----- Building on plot bearing C.S. No. - - - - f - - - Division “ ? ” Ward Situated - - - - - - Marg & Known As “ ---------------			

S No.	Description	Remarks
1	Does the DBR contain all the points mentioned in document entitled `HRC/DBR/V1.0: DESIGN BASIC REPORT?	
2	Are the loading parameters in the DBR as per relevant IS Codes?	
3	Is model consistent with GA drawings?	
4	Are there any deviations in the model compared to GA drawings? If Yes, then would they impact general behaviour or are they negligible?	
5	Is the behaviour of building in dynamic analysis satisfactory?	
6	Are the time periods of modes and mode shapes acceptable?	
7	Are the lateral and vertical deflections within acceptable limits?	

8	In your opinion, what is the class of the performance of the Structure – Collapse Prevention / Immediate Occupancy / Operational ?	
9	Are the accelerations within acceptable limits?	
10	Do you think the accelerations will be comfortable for the occupants?	
11	Is there a possibility of substantital differential settlement Under vertical loads? If yes, what is your suggestion to overcome the problem?	
12	Is there a soft – storey in the structure? Are the design Calculations for such elements consistent with the provision of soft – storey?	
13	Is torsional effect checked and applied?	
14	Are the Stability calculations for uplift and overturning safe?	
15	Typical Design Calculations – Are they as per IS Code? -For footing -For RCC Foundation -For RCC Wall -For Composite Column -For RCC Beam	
16	Are there any peculiar structural elements? If such specific Elements are used, have they been analyzed and detailed satisfactorily?	
17	Are the ductility details incorporated properly?	
18	Are any specific precautions required during construction? Have they been documented effectively? Would you like to suggest any special precautions and sequence of construction?	
19	Are the general parameters like, grade of concrete, covers. Typical detailing as per relevant provisions of code and as per ` Good Engineering Practice'?	
20	Are any special provisions suggested for the building (like dampers, etc)? Would you like to propose any additional performance improvement technique?	
21	Are there special any structures close to this building separated by expansion joint? If yes, is the width of expansion joint sufficient? Is the location of expansion joint suitable and acceptable?	

22	Are the non-structural elements like cladding, façade, etc, connected effectively to structure?	
23	In your opinion, do the submitted documents and scrutiny of the same indicate a safe and stable structure?	
24	Any additional remarks on important observations in model / analysis / design / construction?	

Structural Engineer for Peer Review

Name of Structural Engineer
MCGM Regd No -- STR / …. / …..

Indian Society of Structural Engineers

In Association with

Institution of Engineers (India)

Maharashtra State Centre

Cordially invite you For

An Evening Lecture On

"FM Global's Approach to Safe Design Practice to Limit Property Losses"

By Mr.Robert Azimi

Head for Global Operations, Sans N. America of M/s. FM Approval.

Safety in Building Design and Limiting property losses is the main consideration for Insurability of buildings. Every structural designer and Architect in the country is faced with challenges of meeting globally acceptable norms for building envelope design demanded by multinational clients directly or by clients servicing end use of multinational companies.

Lecture will be followed by presentation by Lloyd Insulations (India) Limited, the leading Design + Build agency for Pre-engineered Buildings who specialist in FM Approved roofing and Wall Cladding Systems.

Programme will be sponsored by Lloyd Insulations (India) Limited.

Date : 11th MAY, 2011

Time : 5.30p.m.to 8.30 p.m Followed by Dinner

Venue : The Institution of Engineers (India), AC Auditorium
15, Haji Ali Park, K Khadya Marg, Mahalaxmi, Mumbai: 400 034

No Registration Fee

For Registration please contact our centers office no.

Tel.(022) 2436 5240 / 2422 1015 / 2431 4445 Email: issemumbai@gmail.com

Tea & registration between 5.00 p.m to 5.30 p.m.

Congratulations !

ISSE member Dr. M.A.Chakrabarti (Head Sturctural Engineering Department VJTI), has been nominated to high rise building committee of MCGM.

- Editor

Congratulations !

Our Joint Editor & Advisory Trustee Mr. Hemant S. Vadalkar had written series of articles on Structural Engineers, Earthquake resistant structures in local Marathi news paper **"Loksatta"** during month of February & March 2011.

We expect more structural Engineers to come forward and write in the print media.

- Editor

Indian Society of Structural Engineers

In Association with

Institution of Engineers (India)

Maharashtra State Centre

Is Organizing

ONE DAY WORKSHOP ON

"WIND AND EARTHQUAKE LOADS ON STRUCTURES"

Date: - 21st MAY, 2011, Time 10.00 a.m to 5.30 p.m

Venue : The Institution of Engineers (India) AC Auditorium 15, Haji Ali Park, K Khadya Marg, Mahalaxmi, Mumbai: 400 034

About the Workshop

"To have an exposure to the intricacies of wind engineering applicable to the structural response of tall buildings, understanding of provision of IS:875 Part3, 1987 Indian Standard for Wind Loads and significance of wind tunnel testing of tall buildings, wind induced motions of cloud structure and key elements for structural design is necessary."

Presentation will be made by……. Dr.K. Suresh Kumar (Managing Director RWDI India)

"***To Understand the seismic load calculation as per ISI 893 – 2002 and response spectrum analysis in particular will be discussed for tall buildings."***

Presentation will be made by ..Dr.Mrs. M.A. Chakrabarti (Head Structural Engineering Department, VJTI)

Practical application of Response Spectrum using STAAD will be presented by Hemant Vadalkar

Participation fees

Rs.700/- per delegate for ISSE and IE (I) members and students. Rs.900/- for non-members. The registration fees include lunch and tea/coffee. Cheque / DD to be drawn in favour of "**Indian Society of Structural Engineers**" payable at Mumbai.

For Registration please contact our centers office no.:

Tel.(022) 2436 5240 / 2422 1015 / 2431 4445

Email: issemumbai@gmail.com

WEB SITE OF INDIAN SOCIETY OF STRUCTURAL ENGINEERS (ISSE)

We are very happy to announce that our ISSE web site work is almost complete and site will be operational shortly. Now you can get information about ISSE, History, Aims & objectives, Management bodies, Centers, Membership, Publication, Quarterly Journal, Past & fourth coming Seminar, Lecture, One day workshop etc. You can also down load membership form & complete your registration. You can give your advertisement through internet for web page or for our journal.

ALL members are requested to send their correct contact details for updating our records.

For more information contact on

E-Mail :- issemumbai@gmail.com

Web Site :- www.isse.org.in

Publications available at ISSE head office

Title	Donation amount Rs.
Publications :	
Design of Reinforced Concrete Structures for Earthquake Resistance	800
Professional Services by Structural Design Consultant - Manual for Practice	200
Proceedings :	
National Conference on Corrosion Controlled Structure in New Millenium	400
Workshop on ISO-9001 for Construction Industry	200
Brain Storming Session on Use of Speciality Products in Structures	250
Workshop on Software Tools for Structural Design of Buildings with CD	550
Workshop on Structural Audit	200
Workshop on-Seismic Design of Building	200
Workshop on Effective Use of Structural Software.	200
Workshop on Effective Use of Structural Software - CD	150
Workshop on Shear Walls in Highrise Buildings	200
Seminar on Innovative Repair Materials / Chemicals	250
Seminar on Foundations for Highrise Buildings	200
Seminar on Structural Detailing in RCC Buildings	250
Workshop on Pile Foundations	200
Seminar on Pre-engineered Structures	200

BE AN ISSE AUTHOR

Articles and technical papers are the heart of a technical journal. We invite you to write technical articles and papers for publication in the ISSE Journal. You may write about:

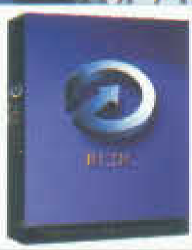
- An innovative concept or approach
- Proposed theoretical, computational or practical improvement on an existing concept
- An experimental study
- Guidelines and standards developed
- Compilation of rare/scattered information on the latest technological advances
- A case study: Challenges in design and construction
- Your viewpoint on current professional practices

While submitting your article for publication, please follow the guidelines given below:

- Page size: A4, Top, Bottom, Left and Right margins: 1”, Font: Arial, 10 pt
- Max length of article: 5 pages including tables and figures
- The manuscript should contain the title of article and names, qualifications, designations, addresses and email addresses of the authors along with photograph.
- The matter should be relevant to the subject and should be organized in a logical flow. It may be divided into sections and sub-sections, if necessary.
- While, sketches and drawings should preferably be in Corel-draw, other appropriate formats are also acceptable. Photographs should be sharp and clear.
- Figures, photographs and tables should be numbered and should have captions.
- Notations, if used, should be clearly defined.
- Article should be sent by email to issemumbai@gmail.com

Articles may be reviewed and edited before publication.

Edited and published by N K Bhattacharyya for ISSE, C/o S G Dharmadhikari, 24 Pandit Niwas, 3rd floor S K Bole Marg, Dadar (W), Mumbai 400 028. Tel 91-22-24365240, Fax-91-22-24224096, e-mail issemumbai@gmail.com Web (www.isse.org.in) for private circulation and printed by S L Bengali, Bensan Printers, 15, Pandit Niwas, S K Bole Road, Dadar, Mumbai 400 028



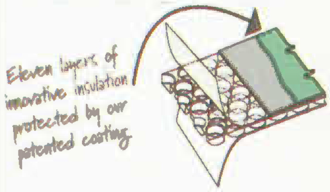
Reflecta-Range™

Leading the way in protection against oxidisation and corrosion

Green Insulation

THE INTELLIGENT SOLUTION

The product Structure



The **REFLECTA-RANGE™** of Products

- **REFLECTA-SHIELD™**
- **REFLECTA-CELL®**
- **REFLECTA-GUARD™**

Green Insulation™ products are suitable for
Residential • Commercial • Industrial Building applications

✓ Energy Saving ✓ Lasting Comfort ✓ Safe and Green

Authorised Distributor :

Roofex

Suite No.19, 1st Floor,
Plot No. 3A, Udyog Nagar,
Goregaon (W), Mumbai - 400 062.

Tel.: 91-22-2876 6563 / 2876 8881
Fax : 91-22-2876 3244

E-mail : hitesh@roofex.in
Web : www.roofex.co.in