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Natural Ventilation in a Smart Building

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Abstract— The design of non-domestic buildings which adopt a purely natural ventilation strategy is now commonplace in many parts of the world, and increasingly this strategy has been shown to be viable in city centers as well as 'green field' locations. However, the adoption of natural ventilation in tall buildings is less common. This is not surprising in view of the potential risks to a successful design. This paper explores the basic principles strategic options for natural ventilation of tall buildings, Base Isolation, and refers to prominent examples which have adopted a 'mixed mode' approach. The prospect of purely naturally ventilated tall buildings is considered in terms of the envelope design. The paper concludes that in terms of designing the envelope and its openings, the challenges for tall buildings are greater than for low rise, primarily because the potential magnitudes of the driving forces become greater and their relative magnitudes can vary over a wider range. Segmentation offers the least risky approach for envelope design of non-residential tall buildings provided the aerodynamic effects can be reliably accounted for. Tall buildings may also lend themselves to some forms of innovative envelope.

Keywords: Seismic, Stability, Analysis, Earthquake, Wind

I. INTRODUCTION

The potential energy savings and other benefits of natural ventilation are as valid for tall buildings as they are for low-rise non-domestic buildings, perhaps more so. However there are few, if any, non-residential tall buildings (25 storeys or more) that rely solely on natural ventilation. There are several notable buildings that have been designed with a natural ventilation system, but they also have some form of mechanical system so they are strictly mixed-mode (or hybrid) designs. This is an understandable approach, since it reduces the risks associated with a purely natural system. However it means that the full benefits of a natural system (reduced capital and running costs; carbon reductions) will not be achieved.

The mechanical systems that are employed in a hybrid system and the benefits that would be accrued if a reliable and purely natural system were feasible.

The primary objective of a natural ventilation system is to allow the occupants (and/or a control system) to achieve envelope flow rates such that the occupants can remain comfortable under most conditions. A particular problem with tall buildings is that they are often prestigious buildings that are air-conditioned to give close control of the internal environment under all conditions. These high expectations put more emphasis on achieving a natural system that gives as much control as possible, which is a major challenge.

The construction of base-isolated structures in Japan began about 20 years ago, during the 1980s. At the base-isolated structures, most of energy input from an earthquake is mainly absorbed by the base isolation devices. So the base isolation system can minimize the damage of superstructures and maintain the buildings' functions even after severe earthquakes. However, up to our proposal, this excellent system had been applied only to the low-rise buildings with natural period shorter than 1 second, and has been regarded as ineffective to the high-rise buildings. In the study of the high-rise buildings with the base isolation system, the authors faced the following design problems.

The response reduction effect of the base isolation on the high-rise buildings was not clear.

The base isolation system in the high-rise buildings might make the habitability worse in the case of strong winds.

II. BASIC MECHANISMS

The physical mechanisms for natural ventilation of tall buildings are of course the same as those for other buildings i.e. pressure differences are generated across openings in the building envelope, leading to ventilation.

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The wind pressure difference can be expressed in the form

$$\Delta P = 0.5\rho U^2 \Delta C_p$$

Where U denotes the wind speed measured at the height of the building, ρ the air density and ΔC_p is a pressure coefficient which depends on such factors as building shape and wind direction. Wind pressures on tall buildings can be relatively large due to the increased value of U and the exposed nature of the building leading to high ΔC_p. From the viewpoint of natural ventilation design, this means that the system will need to operate over a wider range of wind pressures and this can exacerbate control difficulties. An overall measure of the buoyancy pressure is

$$\Delta P = \Delta T \rho g h$$

Where-ΔT denotes the temperature difference, g the gravitational constant and h the height over which the temperature difference acts. Clearly the buoyancy pressures can also be large, if the temperature difference acts over the whole building height, H.

Examples of the pressures that can be generated by these mechanisms can be found in Daniels et al, 1993. This is perhaps one of the earliest and most comprehensive design exercises published for a tall building. It gives a good indication of the importance of building aerodynamics to such designs.

III. OVERALL DESIGN PROCESS

The design of any naturally ventilated building can be a lengthy process involving several stages, which are likely to be iterative. CIBSE AM10 2005 is probably the most comprehensive design guidance available for non-domestic buildings and in principle can be applied to tall buildings.

In very simple terms, the design process can be divided into four stages, as shown in Figure 1. The feasibility of natural ventilation for a tall building will ultimately depend on the acceptability of the design to the client and the building's occupants. Feasibility will also depend on the urban context. For example, the geometry of the surrounding buildings, and their relationship to the prevailing wind and street pattern, can have a significant effect on wind velocities and the pattern of air movement at different levels. Microclimate mapping of cities is being used by planners in Germany in assessing the impact of major new developments, and will be used increasingly at the feasibility stage. However, in this paper, our concern is with Stages 2 and 3, which are concerned with the building envelope and are crucial to a successful design. The aim of Stage 2 is to choose a ventilation strategy i.e. the flow pattern that is required, which is basically concerned with where fresh air enters the building. There may of course be more than one strategy for different times of the day or year.

Having chosen the pattern, the aim of Stage 3 is to ensure that the magnitudes of the air flow rates through the envelope openings can be achieved over a range of specified conditions. This basically means determining the positions of the envelope openings and the range of their sizes.

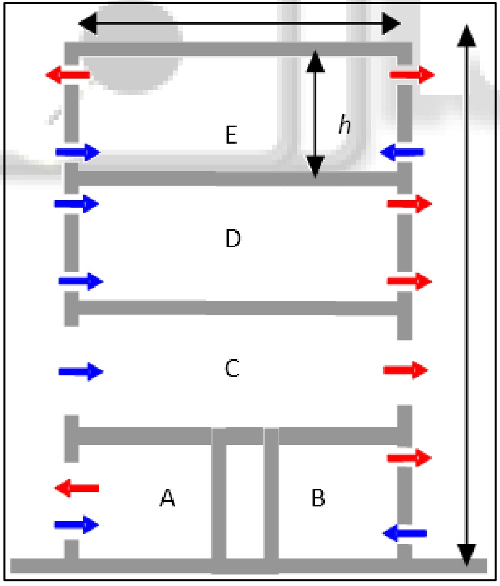
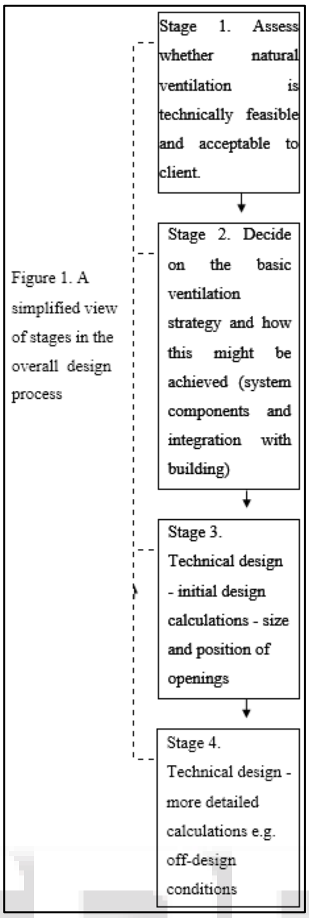


Fig. 1: Ventilation Patterns for Isolated Spaces



Stage 1. Assess whether natural ventilation is technically feasible and acceptable to client.

Stage 2. Decide on the basic ventilation strategy and how this might be achieved (system components and integration with building)

Stage 3. Technical design - initial design calculations - size and position of openings

Stage 4. Technical design - more detailed calculations e.g. off-design conditions

Fig. 2:

IV. VENTILATION STRATEGIES

The more common strategies are identified in the following. It is relevant to divide them into two basic categories (isolated and connected spaces). In all cases the flow pattern is such that fresh (external) air enters each occupied space. This pattern should be maintained under a wide range of conditions. The magnitudes of the flow rates, as distinct from their directions, are involved in Stage 3.

In some buildings the spaces or rooms can be considered as isolated (in terms of air flow) from other parts of the building. For this to be true, the openings to other parts of the building must be small in relation to openings in the external envelope. Figure 2 illustrates such spaces and possible ventilation strategies. Spaces A and B are examples of single-sided ventilation, with a large single opening and two small openings at different heights. Spaces C and D are examples of cross flow ventilation of an isolated floor, again with large and small openings. In both cases the flow pattern is that due to the action of wind alone. Space E shows the flow pattern due to buoyancy alone.

V. BASE –ISOLATION

The tall structure is commonly characterized as one that is taller than the most extreme tallness which individuals are happy to stroll up; it thus requires a mechanical vertical transportation. This incorporates a somewhat constrained scope of building utilizers, principally private condos, inns, and places of business, however at times including retail and instructive offices. A sort that has appeared recently is the blended use of buildings, which contains shifting measures of private, office, lodging, or business space. Tall structures are among the biggest structures fabricated, and their unit costs are generally high; their business and office capacities require a high level of adaptability.

Multi-story structures are utilized for office, unpredictable, private pads, open focuses, and so on. There is requirement for multi-story working due to congestion of urban areas. There multi-story structures can be changed into tall structures so as to accomplish more floor space yet involves less land space. In the plan of tall structures, parallel burdens are wind load and seismic load. There are different parallel burden opposing frameworks, for example, supporting edge framework, minute opposing edge framework, outline bracket cooperating framework, shear divider framework, center and outrigger framework and tubular frame work .The tube is name given where you oppose the horizontal loads (seismic or winds).

A building is intended to act like a three dimensional empty cylinder, cantilevered opposite to ground. The tube frame development was first utilized in the Dewitt-Chestnut Apartment building, Structured by Khan and finished in Chicago in 1963.thus, most of the structures more than 40 stories built since the 1960s are of this basic sort. The most effective impact on building is mainly due to earthquakes in the resent past have given the intention about seismic protection to the building structure. This has given the confinement to different advanced techniques to protect the building structure from the earthquake. The base isolation system is one of the best technique in which base isolators are provided at the base of building which separates the building from ground motion providestiffness to the building in vertical direction and flexibility in horizontal direction.

VI. REGULAR TYPES OF STRUCTURAL SYSTEM IN TALL BUILDINGS

1) Unbending frame system
2) Braced casing framework
3) Shear wall system
4) Coupled wall system

VII. HIGH SHAPE FACTOR-HIGH SHEAR MODULUS BEARINGS

A. *Background Information*

The high shape factor-high shear modulus bearings are made of a high damping high shear modulus rubber compound. They have a high shape factor value of 24. The bearings were designed and constructed as "dowelled" bearings to avoid tension in the rubber. Purchased sixteen (16) bearings for the joint ANL/Shimizu program. Eight bearings were shipped to Japan for installation at the Sendai test facility and for performance of laboratory tests at Shimizu Corporation; four bearings were sent to EERC for testing to determine their static and dynamic characteristics; two bearings were sent to ETEC for dynamic tests; and two bearings were retained by ANL for archival purposes.

VIII. DESCRIPTION OF BEARINGS

In the configuration of the Sendai bearing, the overall diameter of the bearing, including a 3/4 inch protective cover layer, is 20 inches. The bearing has 1 inch thick end plates located at its top and bottom with four drilled holes in the top plate used for dowel pins.

IX. TEST PLAN

The ANL test program at EERC was specifically designed to replicate in situ field tests conducted in Japan on the full size building after the bearings were installed. The bearings were tested in the Large Scale Bearing Test Machine at EERC. The Sendai seismically-isolated test building weighs a total of 255.4 metric tons and is supported by six bearings. It is estimated that the four corner bearings carry a load of 37.8 metric tons each, and the two middle bearings carry 52.3 tons each. These loads correspond to 83.2 kips and 115.1 kips, respectively. The four bearings were placed in the test machine with the vertical load set to 83.2 kips. Each horizontal displacement cycle (±3.15%, ±6.25%, ±12.5%, ±25%, ±50%, +75% - 50% shear strain) was repeated three times and data collected for all three cycles. The vertical load was increased to 115.1 kips and the test sequence repeated. The bearings were then deformed to displacement cycles of ±100% and ±125% at the larger vertical load. It was observed that one bearing was showing signs of distress at this point. This bearing and its partner on that side of the test machine were immobilized by a strong-back, and the testing was continued with displacement cycles corresponding to ±150%, ±200% shear strain. No further evidence of damage was visible, and it was concluded that the two tested bearings performed satisfactorily to ±200% strain. (The distressed bearing was cut in half after the test and it was found that the bond between the rubber and the top end plate had failed.)

A. *Tests on Tensile Property of Rubber Bearing*

In the design of the slender high-rise building, the uplift due to overturning and vertical forces during a large earthquake might act on the isolators especially at the corner. However, the property of large size rubber bearings subjected to the tensile force was unknown. In order to understand the tensile properties of the large rubber bearings, the tensile loading tests were carried out on the test specimen with the diameter of 1200mm. There is a large difference of the safety limit between the small and the large size rubber bearings.

X. CONCLUSION

A purely naturally ventilated building is a major challenge to the designer even for conventional buildings. In terms of designing the envelope and its openings, the challenges for tall buildings are greater, partly because the potential magnitudes of the two driving forces (pressures due to wind and buoyancy), become greater and their relative magnitudes can vary over a wider range. The high exposure of a tall building to wind means that means that building aerodynamics becomes particularly important. Furthermore, the sheer number of openings means that the permutations of envelope configurations are greatly increased.

Segmentation offers the least risky approach for envelope design of non-residential buildings, provided the aerodynamic effects can be reliably accounted for. The potential for innovative envelopes (e.g. porous walls and ventilated facades) is increased, by virtue of pre-fabrication and high quality construction.

1) The authors applied the base isolation systems to the high-rise buildings as a pioneer, getting out of the conventional ideas.
2) The several actual design problems have been resolved for the applicability of the base isolation system to the high-rise buildings.
3) Using the high strength materials and the long span structure systems, Sendai MT building and Thousand Tower possess not only high seismic performance, also the flexible planning in design.
4) The recorded data of the seismographs and the analyses show that the base isolation system acted effectively in Sendai MT building, when the Off -Miyagi earthquake occurred in May 26, 2003.

REFERENCES

[1] International journal of civil engineering and technology (IRJET)
[2] Council on tall building and urban habitat (CTBUH)
[3] International Advanced School “Wind effects on buildings and urban environment”, Tokyo Conference Centre March 5 – 9, Tokyo Polytechnic University, Tokyo.
[4] KATZSCHNER, L. (2000) urban climate map: a tool for calculation of thermal conditions in outdoor spaces. Proceedings PLEA 2000, Architecture, City, Environment, James and James London.
[5] FORD, B.H. and SCHIANO-PHAN, R. (2005) Double Skin Facades – improving performance and reducing cost. Proceedings PLEA 2005, Beirut