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RESEARCH ARTICLE

Effect of interference on Wind loads on Tall buildings

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Abstract

Experimental study was carried out on the models of tall buildings in a wind tunnel, to study the effect of small size building on the wind loads acting on a comparatively larger building when small size building falls on the way of wind hitting the large building perpendicular to its large surface. Building blocks of rectangular corners are made of plywood at a scale of 1: 200. Results of the study are presented in the form of variation of base shear, base moment and twisting moment with spacing between building building blocks. Variation of force Fx, i.e. base shear is almost constant for spacing of 0 to 250 mm and noticed that there is a increase in spacing increases the base shear up to a specific distance and becomes constant afterwards. Variation of My, i.e. base moment is identical to that of Fx and torsional moment decreased rapidly with increase in spacing between the instrumented and interfering building blocks for a distance of 1 m in setups A and B and 500 mm in set up C.

Keywords: Tall buildings, wind loads, interference, rectangular plan, square plan, building blocks.

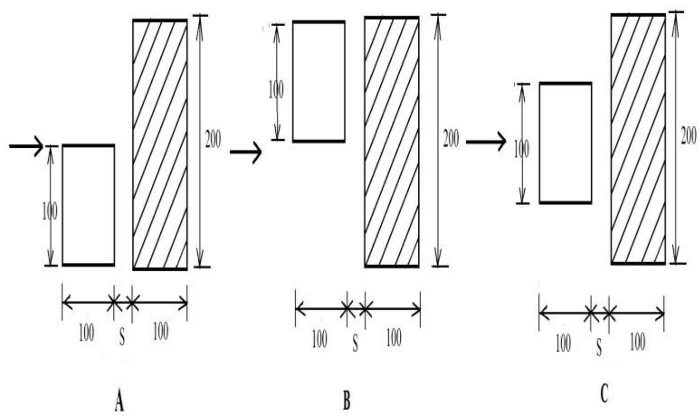
Introduction

Numerous tall buildings are being built all over the world including India. For evaluation of wind loads on such buildings, the structural designers generally refer the relevant standards [AS/NZS: 1170.2(2002), ASCE: 7-02(2002), BS: 63699(1995), EN 1991-1-1 (2005), IS 875 (Part 3) 1987] which suggest the design pressure coefficients and force coefficients for square and rectangular buildings having different side ratios and height for specific wind orientations. A large number of these buildings have non prismatic and irregular shapes. The shape of these buildings makes them more sensitive to wind than those with a regular shape. Wind tunnel testing is generally carried out on the models of such buildings. Review of recent research work also indicates that very little work has been done in the area of effect of L and T-plan shape under wind loads. Stathopoulos and Zhou (1993) examined the wind loads for L-shape plan view as well as for L-shaped cross section (stepped-roof building) through a numerical study. Gomes *et al.* (2005) tested the models of irregular-plan shape (L and U shape) in closed circuit wind tunnel to measure the pressure distributions on 1:100 scale models. Arunachalam *et al*. (2006) investigated the effects of interference on a square tall building model due to the presence of similar building on upstream side. Amin (2008) carried out an experimental study of wind pressures on L and T-plan shape buildings. The authors considered the model with different shape having same floor area and height. Since available information is not enough for the structural designers to make use of it while designing tall buildings with varying plan shape for wind loads, an experimental study has been carried out on the models of one square plan and one rectangular plan shape tall buildings forming L and T-shapes by varying spacing between 2 blocks.

Materials and methods

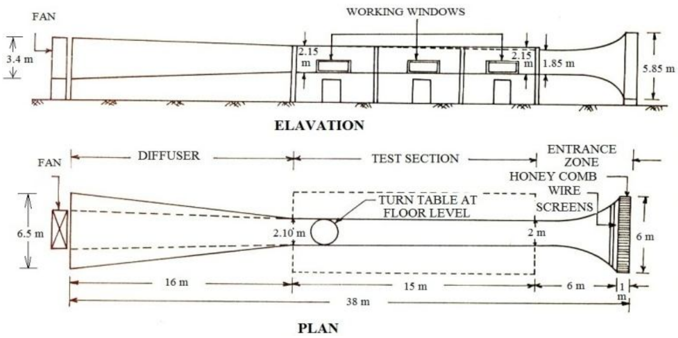
Details of models: The prototype building is assumed to have total floor area of 600 m^2 in which instrumented block has floor area of 400 m^2 (represented by hatched portion) and interfering block has floor area of 200 m^2. Both the blocks have a height of 100 m. Rigid models are made of plywood at a scale of 1: 200. Square plan block has a cross-sectional dimension of 100 x 100 mm whereas rectangular block has 200 x 100 mm cross section (Fig. 1). Both models have a height of 500 mm. Three setups namely A, B and C are considered. In setup A, interfering building is placed on the right-hand side. In setup B, interfering building is placed on the left-hand side. In setup C, interfering building is placed at the centre (T-shape) as shown in Fig. 1. Spacing between instrumented building and interfering building blocks is varied as 0, 25, 50, 75, 100, 150, 200, 250, 500, 1000, 1500 and 2000 mm.

Fig. 1. Details of setups A, B and C.



Flow characteristics: In this study, the models are tested under the boundary layer flow in an open circuit wind tunnel with a cross-section of 2 m (width) x 2 m (height) and the length of the test section as 15 m as shown in Fig. 2. Floor roughing devices namely vortex generators, barrier wall, cubical blocks of size 150 mm, 100 mm, 50 mm are used on the upstream end of the test section to achieve the mean wind velocity profile corresponding to terrain category 2 as per Indian standard on wind loads. The model of rectangular plan building block is placed on force balance at a distance of 10.5 m from the upstream edge of the test section, and is tested under free stream wind velocity of 9.78 (Approx. 10) m/sec measured at 1m height above the floor of the tunnel.

Fig. 2. Line diagram of open-circuit boundary layer wind tunnel.



Measurement technique: Rigid model of the rectangular building block is placed on five component load cell with square plan building block on upstream side causing interference (Fig. 3). The base shear, base moment and torsional moment acting on the model for wind incidence angle shown in Fig. 1 is recorded for spacing (s) of 0, 25, 50, 75, 100, 150, 200, 250, 500, 1000, 1500 and 2000 mm between instrumented building block and interfering building block. Base shear, base moment and torsional moment values are recorded for 1 min at an interval of 1 sec and average values are calculated.

Fig. 3. Wooden models of tall buildings inside the wind tunnel.

Setup- A Setup- C

Results and discussion

Variation of base shear, base moment and torsional moment measured on three setups namely A, B and C as a function of spacing between instrumented building block and interfering building block as shown in Fig. 4 to 6.

Fig. 4. Variation of base shear with spacing between blocks.

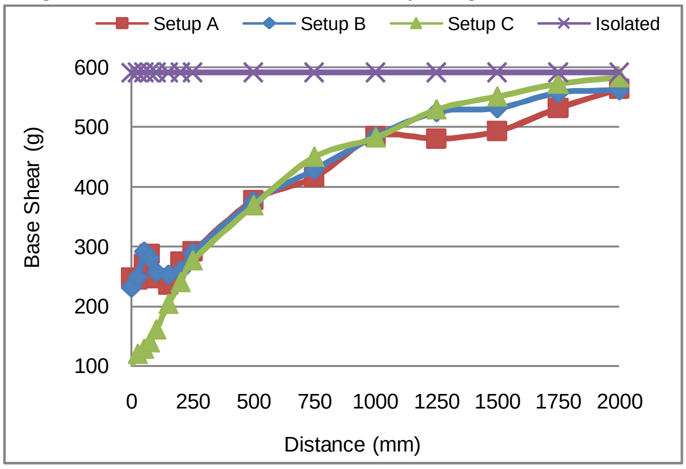


Fig. 5. Variation of base moment with spacing between blocks.

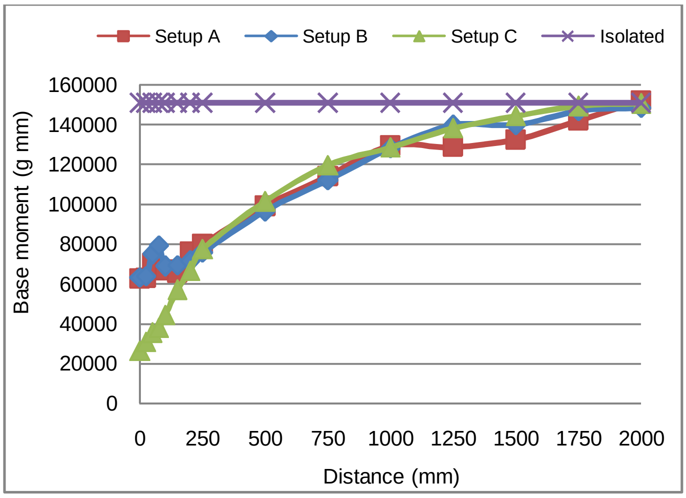
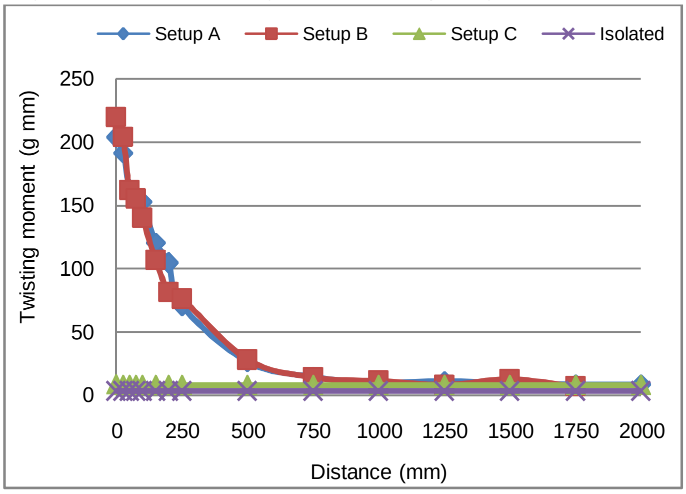


Fig. 6. Variation of twisting moment with spacing between blocks.



It is noticed from Fig. 4 that the variation of force Fx, i.e. base shear is almost constant for spacing of 0 to 250 mm. It increases suddenly for spacing 250 to 1500 mm and becomes almost constant beyond 1500 mm for setups A and B. In case of setup C, base shear increases up to 1500 mm and becomes constant thereafter. Further setup C is subjected to nearly equal force like setup A and B for spacing beyond 250 mm. Thus, it is noticed that increase in spacing increases the base shear up to a specific distance and becomes constant afterwards. Variation of My, i.e. base moment is identical to that of Fx (Fig. 5). Torsional moment decreases rapidly with increase in spacing between the instrumented and interfering building blocks for a distance of 1 m in setups A and B and 500 mm in set up C. It becomes constant thereafter. Also torsional value is much more for setups A and B as compared to setup C up to a spacing of 1 m (Fig. 6).

Conclusion

The following conclusions are drawn from the study presented herein.

1. Wind force on rectangular building block is maximum under isolated condition.
2. Interference effect vanishes when the spacing between building blocks becomes almost 20 times the dimension of the interfering building block in the direction of wind.
3. Twisting moment decreases rapidly with increase in spacing between the instrumented and interfering building blocks up to a specific distance and becomes constant thereafter.

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References

1. Amin J.A. 2008. Effects of plan shape on wind induced response of tall buildings. Ph. D Thesis, Dept. of Civil Engg., IITR Roorkee, Roorkee, India.
2. Arunachalam, S., Lakshmana, N., Babu, G.R., Rajan, S.S. and Selvam, R.P. 2006. Wind Induced interference studies on a square buildings model. Proc. of National Conference on Wind Engineering, Kolkata, India.
3. AS/NZS: 1170.2. 2002. Structural Design Actions, Part-2: Wind Action.
4. ASCE: 7-02. 2002. Minimum Design Loads for Buildings and Other Structures.
5. BS: 63699. 1995. Loading for buildings: Part 2-Code of Practice for Wind Loads.
6. EN 1991-1-4. 2005. Euro code 1: Actions on Structures: Wind Actions.
7. Gomes, M.G., Rodriques, A.M. and Mendes, P. 2005. Experimental and numerical study of wind pressures on irregular-plan shapes. *J. Wind Engg. Indus. Aerodynam*. 93: 741-756.
8. IS 875 (Part-3). 1987. Code of Practice for Design of Wind Load (other than earthquake) for Buildings and Structures, BIS, New Delhi.
9. Stathopoulos, T. and Zhou, Y. 1993. Numerical simulation of wind induced pressures on buildings of various geometrics. *J. Wind Engg. Indus. Aerodynam.* 46/47: 419-430.