Wind pressure distribution on rectangular plan tall building due to variation in height of interfering buildings

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1. INTRODUCTION & OBJECTIVE

The growing popularity of tall buildings amongst the architects due to the limited area of land and ever increasing population is vividly evident in the present era. But, with increase in height of the buildings, concern of the structural designer for wind loads also starts to grow. These wind loads are greatly affected by the presence of other closely spaced buildings as shown by different research studies. Various codes of practice on wind loads (AS/NZS: 1170.2 (2002), ASCE: 7-02-2002, EN: 1991-1-4-2005, IS: 875 (Part-3) 2015) provide guidance limited to isolated cases only. Many wind tunnel studies have been carried out in the past to study the effect of interference (Khanduri et al. 1998, Xie and Gu 2004, Amin 2008, Zhao and Lam 2008, Kim et al. 2011, Kushal 2013, Pandey 2013, Mara et al. 2014, Yan and Li 2016). However, no studies could be found for the effect of interference on wind pressure distribution on tall buildings having rectangular plan shape due to the presence of two other interfering buildings having similar plan shape, but of varying height.

An attempt has been therefore made to study the effect of interference on wind pressure distribution on a rectangular plan shape tall building due to the presence of two other closely spaced tall buildings having similar plan shape (Fig. 1). Models of three rectangular plan buildings are arranged in an I-shape pattern in plan, keeping the principal building model (hatched) in the center. To study the effect of height variation of the interfering buildings, the heights of the interfering building are varied in two different manners namely (i) height of both the interfering building models is reduced simultaneously and (ii) height of only one of the interfering building model is reduced. The height of interfering buildings is varied with respect to the height of principal building and the wind pressure distribution on the principal building in interference condition is compared to that for isolated condition.

Wind tunnel experiments are conducted in an open circuit boundary layer wind tunnel to study the interference effect. Rigid models are made using perspex sheet for principal building model and plywood for interfering building models, at a geometric scale of 1:200 to the corresponding prototype, having width to length ratio of 1:3 and width to height ratio of 1:5. The assumed prototype for the instrumented tall building considered in this study is of rectangular shape in plan having plan dimensions of 60m x 20m (i.e. 1200 m^2 area in plan) and having height of 100m. Similarly, the prototype considered for the interfering tall buildings in the study are also of rectangular shape in plan having plan dimensions of 60m x 20m (i.e. 1200 m^2 area in plan) but having variation in heights as 100m, 80m, 60m, 40m and 20m. Principal building model has 35 pressure points on both Face A and Face C, while Face B and Face D has 21 pressure points each (Fig. 2).

The testing is undertaken in isolated as well as interference conditions. Going through the literature, it is found that the effect due to interference for wind loads are maximum when the interfering building is present in close proximity of the instrumented building (Khanduri et al. 1998). Therefore, the distance between the principal building and the interfering buildings, is kept zero and effect of height variation of interfering buildings is studied by varying it with respect to the height of principal building for the arrangement as shown in Fig. 1.

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Pressure measurements are conducted by placing the principal building model of rectangular cross-section on top of the turntable. Experiments are carried out under free stream mean wind velocity of 11.4 m/sec under the mean wind velocity profile of the approaching flow corresponding to power law exponent of 0.3. Wind pressure at each tapping point is measured with the help of pressure transducer for 60 seconds.

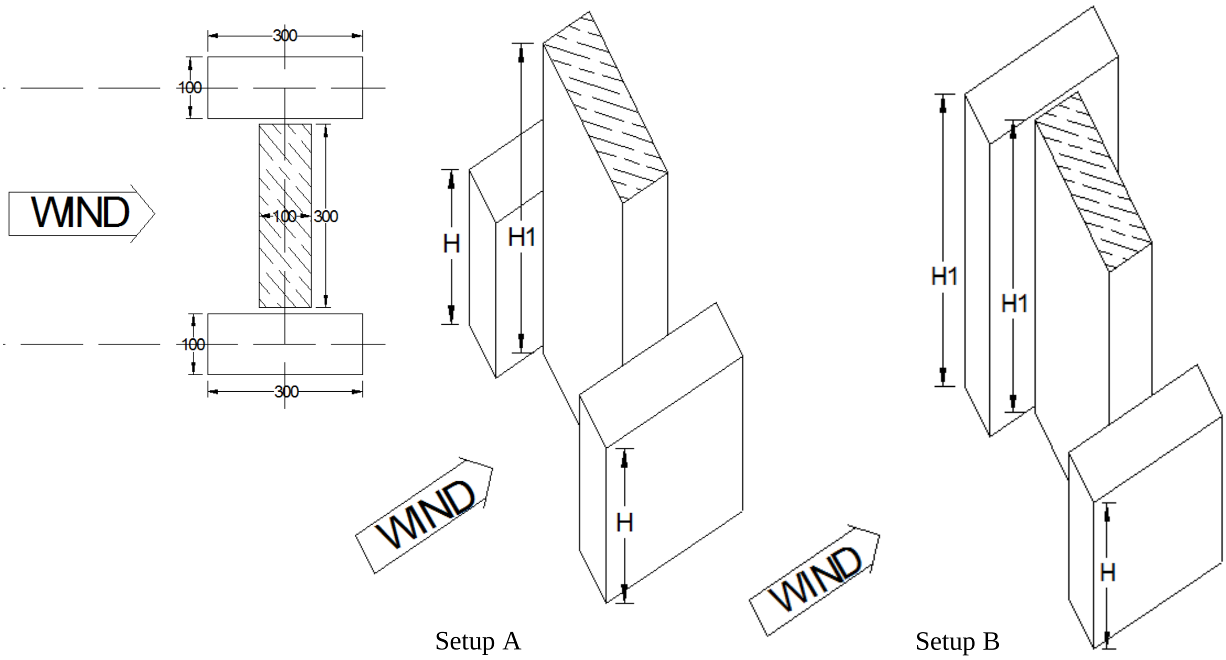

Figure 1. Plan and isometric view of the different arrangements for experimentation (All Dimensions are in mm). [H/H1=1.0, 0. 6, 0.2, 0.0]

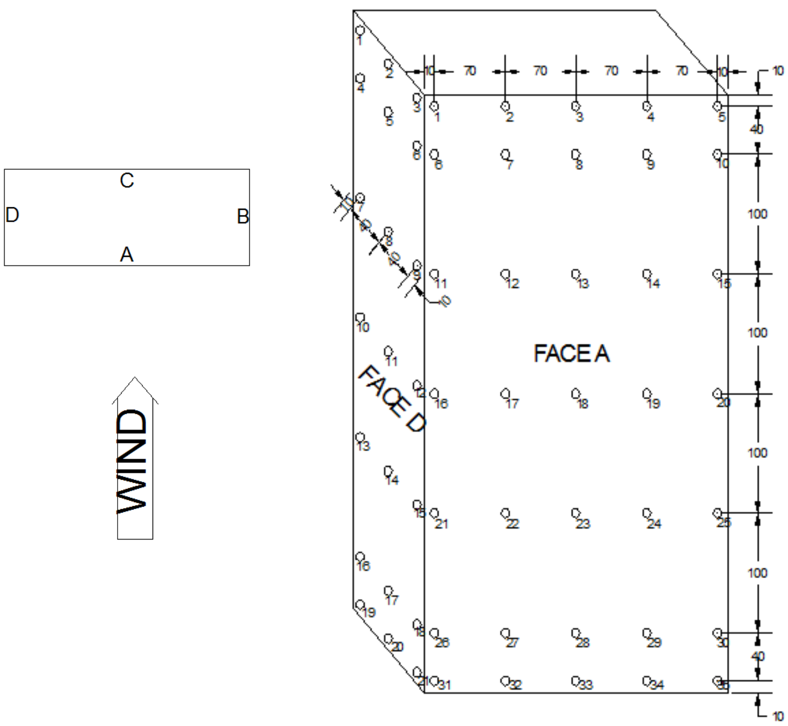

Figure 2. Plan and isometric view of principal building showing the location of pressure tapping points. (All Dimensions are in mm)

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

Values of wind pressure coefficients are calculated from the values of mean wind pressures measured at different faces of the principal building and are reported in the form of contours. It is observed that wind pressure distribution on the faces of the principal building is highly influenced by the arrangement as well as the height of the interfering building (Fig. 3). The value of torsional moment in the principal building is seen to increase with increase in the height difference of the two interfering buildings.

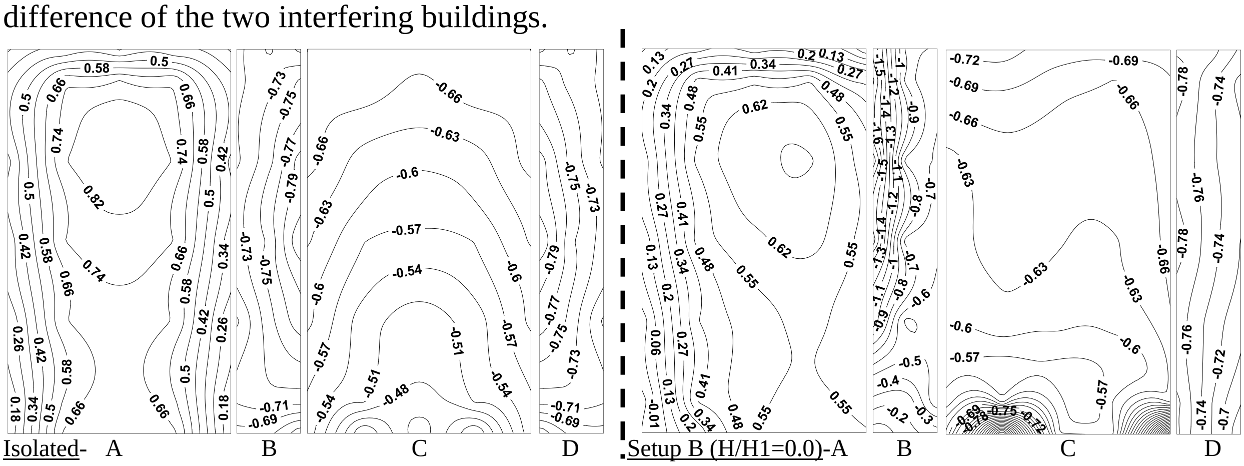

Figure 3. Contour diagrams for distribution of mean wind pressure coefficients.

REFERENCES

1. AS/NZS: 1170.2-2002, *Australian/New Zealand standard: Structural design actions part-2: wind actions.*
2. ASCE: 7-02-2002, *American society of civil engineers: Minimum design loads for buildings and other structures.*
3. EN: 1991-1-4-2005, *Euro Code 1: Actions on structures – wind actions.*
4. IS: 875 (Part-3) 2015, *Code of practice for design loads (other than earthquake loads), for building and structures– Wind loads.*
5. A.C. Khanduri, T. Stathopoulos and C. Bédard, "Wind induced interference effects on buildings - a review of the state-of-the-art", *Engineering Structures* **20**, pp. 617–630, 1998.
6. Z.N. Xie and M. Gu, "Mean interference effects among tall buildings", *Engineering Structures* **26**, pp. 1173–1183, 2004.
7. J. Amin, *Effects of plan shape on wind induced response of tall buildings*, Ph.D. Thesis, Department of Civil Engineering, Indian Institute of Technology Roorkee, India, 2008.
8. J.G. Zhao and K.M. Lam, "Interference effects in a group of tall buildings closely arranged in an L- or T-shaped pattern", *Wind and Structures* **11**, pp. 1-18, 2008.
9. W. Kim, Y. Tamura and A. Yoshida, "Interference effects on local peak pressures between two buildings", *Journal of Wind Engineering and Industrial Aerodynamics* **99**, pp. 584–600, 2011.
10. T. Kushal, *Effect of plan shapes on the response of tall buildings under wind loads*, M.Tech. Thesis, Department of Civil Engineering, Indian Institute of Technology Roorkee, India, 2013.
11. S.C. Pandey, *Influence of proximity on the response of tall buildings under wind loads*, M.Tech. Thesis, Department of Civil Engineering, Indian Institute of Technology Roorkee, India, 2013.
12. T.G. Mara, B.K. Terry, T.C.E. Ho and N. Isyumov, "Aerodynamic and peak response interference factors for an upstream square building of identical height", *Journal of Wind Engineering and Industrial Aerodynamics* **133**, pp. 200–210, 2014.
13. B. Yan and Q.S. Li, "Wind tunnel study of interference effects between twin super-tall buildings with aerodynamic modifications", *Journal of Wind Engineering and Industrial Aerodynamics* **156**, pp. 129–145, 2016.