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A Comparative Study on Interference Factors of Buildings Depending Upon the Size of Control and Interfering Buildings

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Abstract: Wind forces and moments on each building in a row are measured with the base balance under different wind incidence angles and different separation distances between buildings. Many researchers have investigated shielding and interference, but each looked at a different small subset of large number of possible variables and configurations. There are many factors which govern interference factor including the size of the control as well as interfering building. The present paper looks into the change of interference factors depending upon the length-wise change in size of control as well as interfering building spaced at a particular distance from each other in a row.

Keywords: Interference Factor, Shielding Factor, Building Size-variation

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I. INTRODUCTION

Wind interference is caused by modification in the wind characteristics produced by the obstruction caused by an object or a structure in the path of the wind.A multiplication factor known as interference factor (IF) has been introduced to be applied to the design wind force.

$$\mathrm{IF} = \frac{\text{Force on a building with interfering buildings present}}{\text{Force on an isolated building}}$$

The wind effect may be mean drag force, lift force, base overturning moment, rms torsional moment etc. Here the interference factor is calculated from the wind force on isolated building as well as control and interfering building by Computational Fluid Dynamics simulation in ANSYS. The simulation is done in 2D computational fluid domain. The control building and interfering building size is varied from B, 2B, 3B and 4B and the change in force and corresponding interference is calculated. The basic wind speed used in this simulation process is 60 m/s and the turbulence model used is standard k-€ turbulence model.

II. CONFIGURATIONAL DESCRIPTION OF SIMULATION

At first the wind force is calculated for a single isolated building of square shape having length of one side(B) of 40m. The reference is of this side length is taken from data of experimental arrangements of Xie&Gu(2006). Then the simulation is done in two steps. In first step the length of one side of control building is increased in the ratio of 2B, 3B and 4B and while the size of the interfering building is kept constant and the corresponding wind force on the control building is calculated. The next step is done by varying the size of the interfering building in the same ratio as mentioned before,keeping the size of the control building constant also the force on control building is calculated.

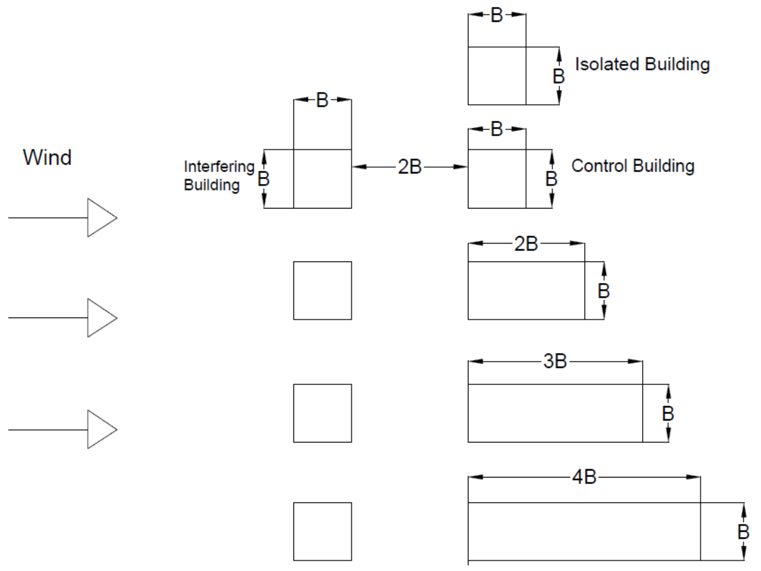

Fig: Changing Control Building Configuration

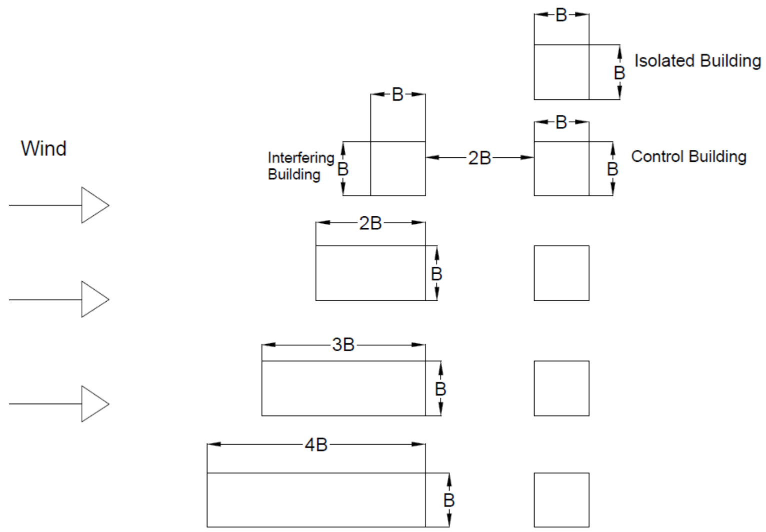

Fig: Changing Interfering Building Configuration

III. CALCULATION OF INTERFERENCE FACTOR

The interference factor is calculated by force on a building with interfering building present divided by force on an isolated building of similar shape with similar boundary conditions present. When varying the shape of the control building, in each step similar simulation is done in ANSYS taking only an isolated building and corresponding force is calculated. While varying the shape of interfering building, the shape of the control building is constant.

IV. COMPUTATIONAL FLUID DOMAIN SIZE FOR ANALYSIS

The computational fluid domain size have been chosen according to T Yang et al(2006).For the development of turbulent flow fully and to avoid any disturbance to inlet velocity profile the distance from the wall of the domain and the control building as well as interfering building was set to 5B and the distance from the upstream building was also set to be at 5B and from the downstream building it was set to be at 10B.

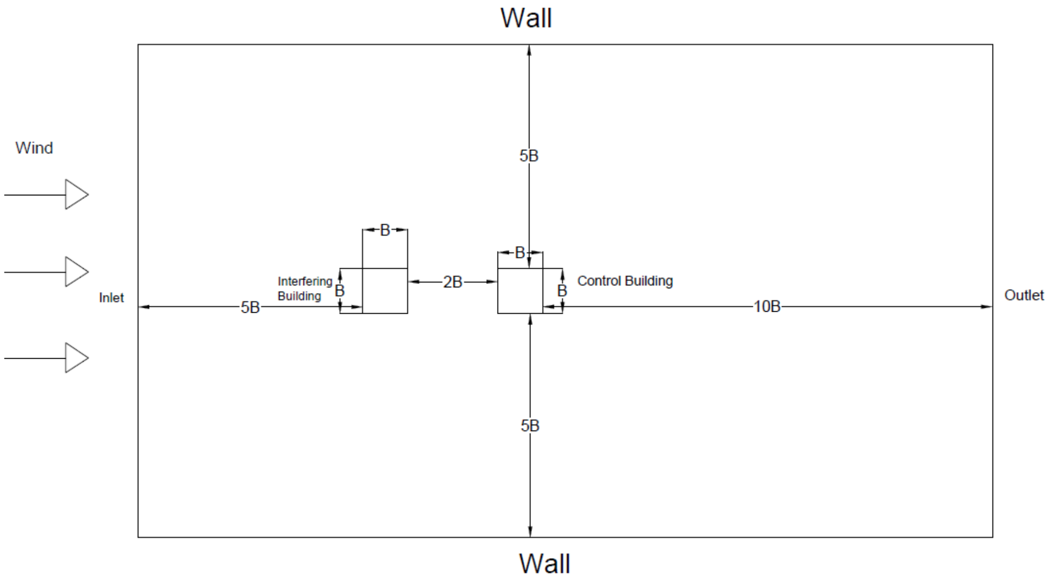

Fig: Typical CFD domain size

V. SIMULATION VARIABLES

The turbulence model used in this simulation process is Standard k-€ turbulence model.
For turbulent kinetic energy,

$$\frac{\partial(\rho k)}{\partial t} + \frac{\partial(\rho k u_i)}{\partial x_i} = \frac{\partial}{\partial x_j}\left[\frac{\mu_t}{\sigma_k}\frac{\partial k}{\partial x_j}\right] + 2\mu_t E_{ij} E_{ij} - \rho\varepsilon$$

For dissipation,

$$\frac{\partial(\rho\varepsilon)}{\partial t} + \frac{\partial(\rho\varepsilon u_i)}{\partial x_i} = \frac{\partial}{\partial x_j}\left[\frac{\mu_t}{\sigma_\varepsilon}\frac{\partial \varepsilon}{\partial x_j}\right] + C_{1\varepsilon}\frac{\varepsilon}{k}2\mu_t E_{ij} E_{ij} - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k}$$

Where

u_i represents velocity component in corresponding direction

E_{ij} represents component of rate of deformation

μ_t represents eddy viscocity

$$\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$$

For standard k-€ turbulence model the adjustable constants are,

$$C_\mu = 0.09 \qquad \sigma_k = 1.00 \qquad \sigma_\varepsilon = 1.30 \qquad C_{1\varepsilon} = 1.44 \qquad C_{2\varepsilon} = 1.92$$

Each simulation process is done by 100 numbers of time steps and 10 numbers of iterations per time step. Basic wind speed=60m/s (Constant)

The meshing was done by triangular meshing method with a more uniform and smaller meshing grid at all over the side of the building. The initialization process was set to be hybrid initialization process. For calculation process number of time step was set to be 100 and maximum number of iteration per time step was set to be 50.

VI. CFD SIMULATION DATA VARYING THE SIZE OF CONTROL BUILDING

Size Of Control Building	Force On Control Building	Force On Interfering Building	Force on Isolated Control Building	Interference Factor
B	125765 [N]	109742 [N]	133115[N]	0.944
2B	123157 [N]	101099 [N]	140638 [N]	0.875
3B	122325 [N]	109111 [N]	136219[N]	0.898
4B	122570 [N]	105088 [N]	131231[N]	0.934

VII. CFD SIMULATION DATA VARYING THE SIZE OF INTERFERING BUILDING

Size Of Interfering Building	Force On Control Building	Force On Interfering Building	Force on Isolated Control Building	Interference Factor
B	125765 [N]	109742 [N]	133115[N]	0.944
2B	127666 [N]	109720 [N]	133115[N]	0.959
3B	120934 [N]	106007 [N]	133115[N]	0.908
4B	125085 [N]	104315 [N]	133115[N]	0.939

VIII. VALIDATION OF RESULTS

Size Of Control Building	Interference Factor	IF According to Khanduri et al. 1998 (Drag on Upstream Building)
B	**0.944**	**0.818**
2B	**0.875**	**0.878**
3B	**0.898**	**0.907**
4B	**0.934**	**0.923**

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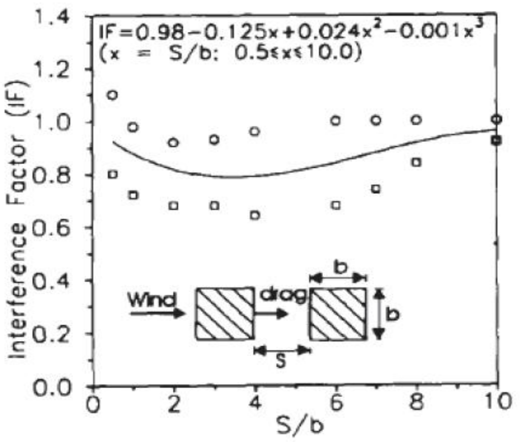


Fig-a

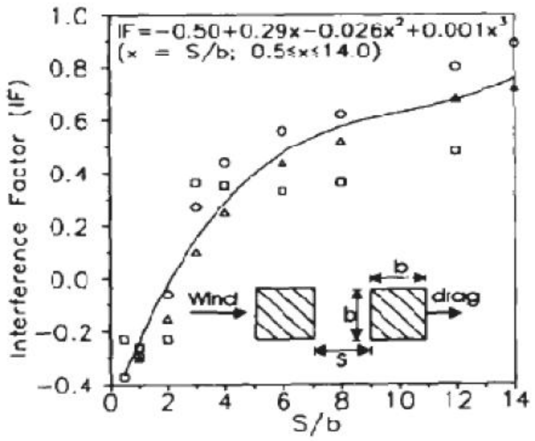


Fig-b

(a) mean-drag interference factors for upstream model (b) mean drag interference factors for downstream model (Khanduri et al. 1998)

IX. ISOLATED BUILDING CFD SIMULATION :

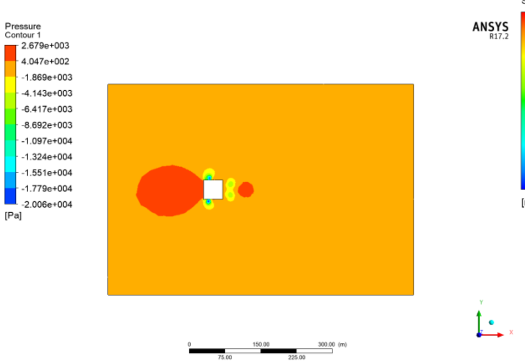


Fig: Pressure Contour

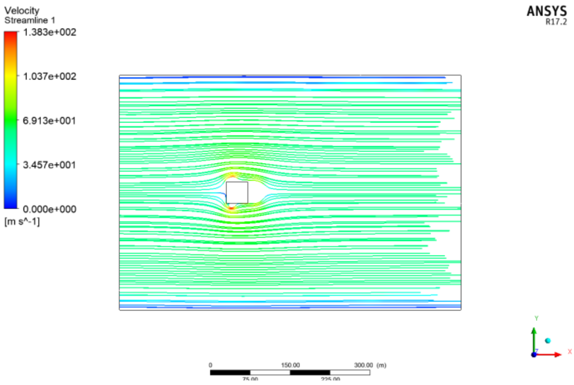


Fig: Streamline

X. CONTROL BUILDING OF SIZE B CFD SIMULATION:

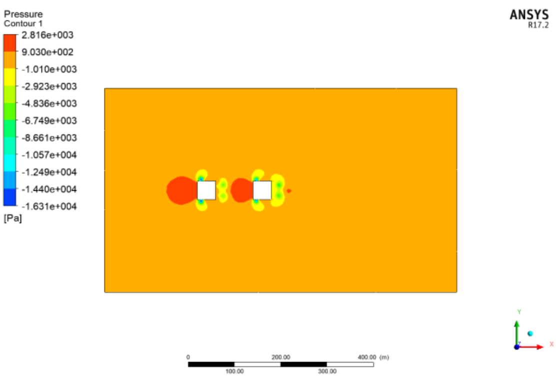


Fig: Pressure Contour

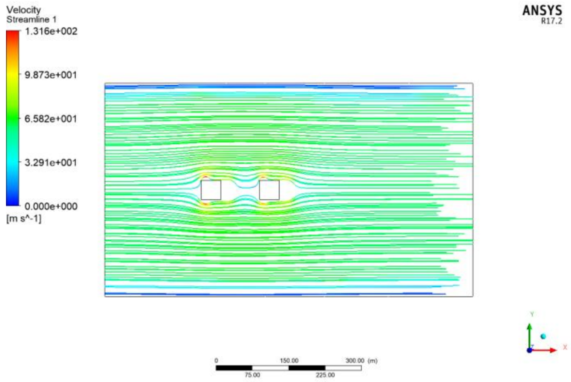


Fig: Streamline

XI. CONTROL BUILDING OF SIZE 2B CFD SIMULATION:

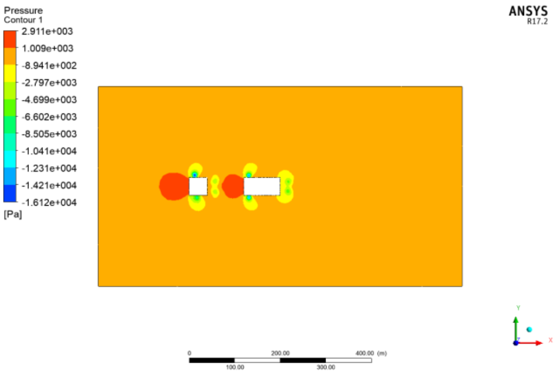


Fig: Pressure Contour

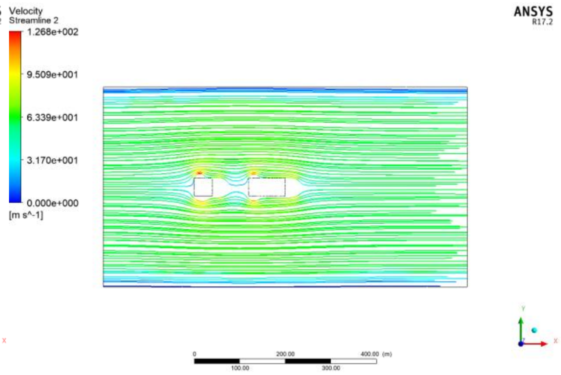


Fig: Streamline

XII. CONTROL BUILDING OF SIZE 3B CFD SIMULATION

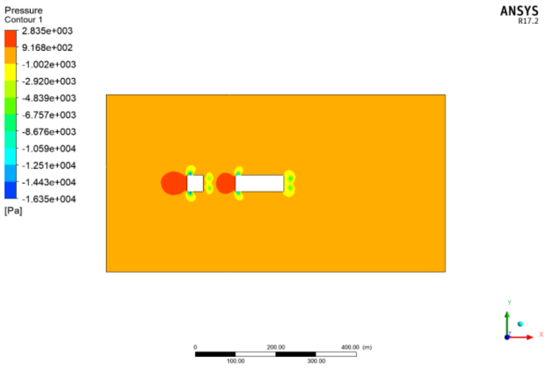


Fig: Pressure Contour

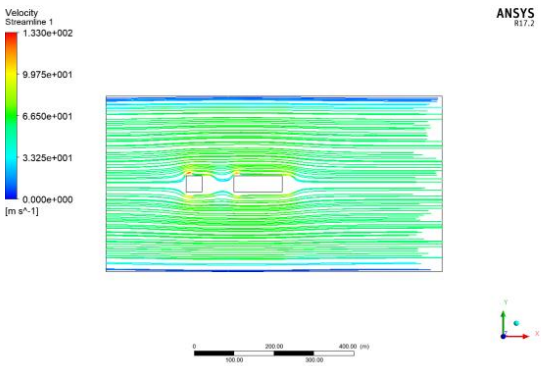
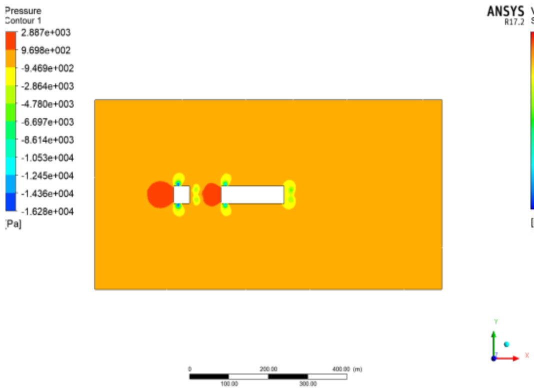


Fig: Streamline

XIII. CONTROL BUILDING OF SIZE 4B CFD SIULATION



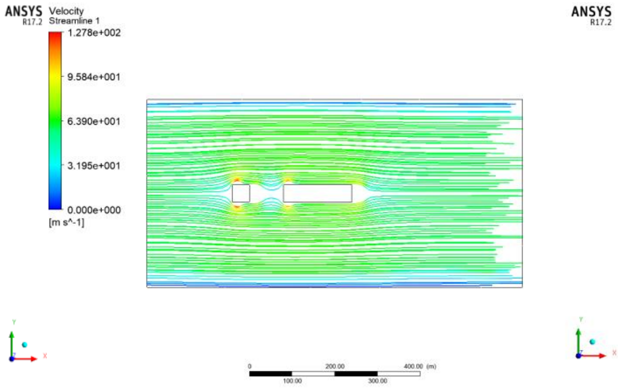
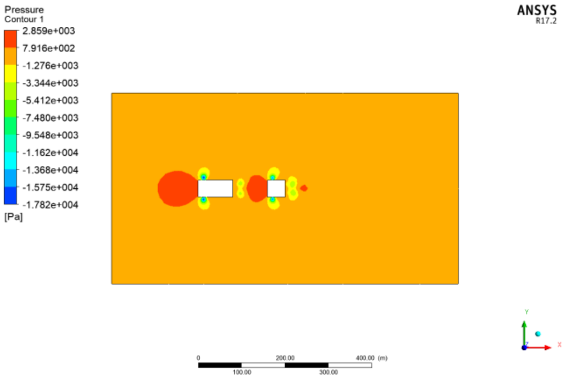


Fig: Pressure Contour **Fig:** Streamline

XIV. INTERFERING BUILDING OF SIZE 2B CFD SIMULATION



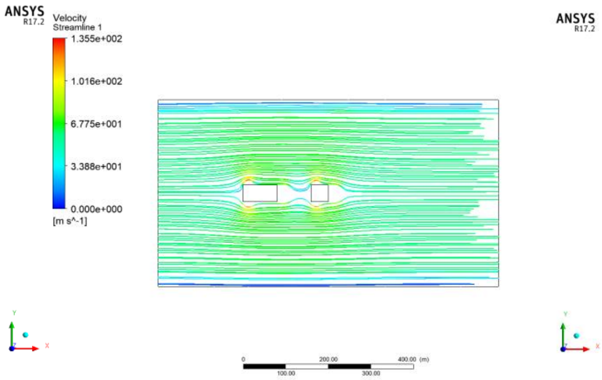
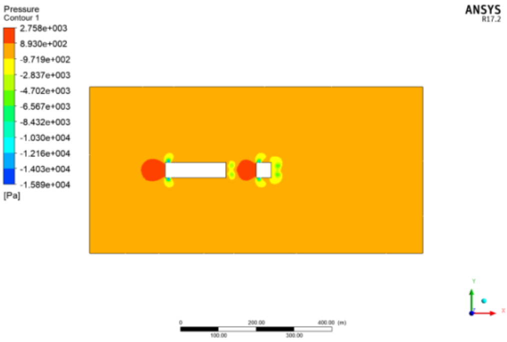


Fig: Pressure Contour **Fig:** Streamline

XV. INTERFERING BUILDING OF SIZE 3B CFD SIMULATION



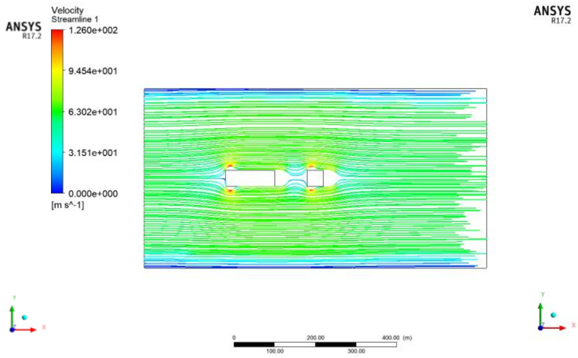


Fig: Pressure Contour **Fig:**Streamline

XVI. INTERFERING BUILDING OF SIZE 4B CFD SIMULATION

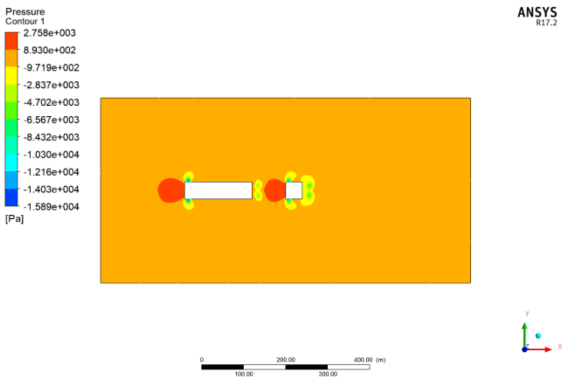


Fig: Pressure Contour

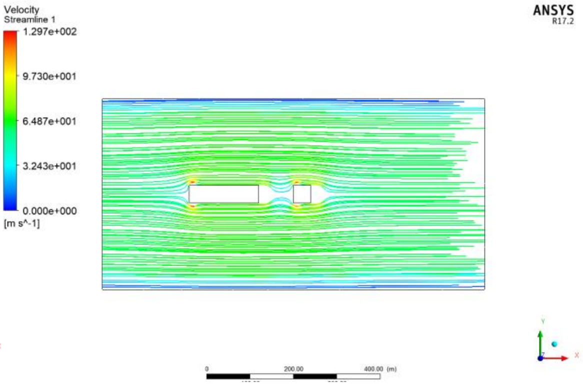


Fig: Streamline

XVII. MESHING PROCESS

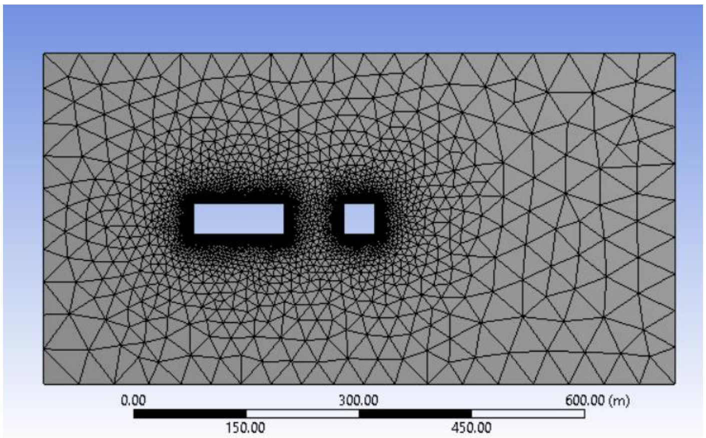


Fig: Typical meshing grid including control and interfering building(3B)

XVIII. CONCLUSIONS

There are wide variability of interfernce factor depending upon several cases. We can see in validation of results the interfence factor is almost same as Khanduri et al(1998) while the change in the shape of control as well as interfering building does not so much affect the interference factor suggested by Khanduri et al(1998). This present paper evaluated the change in interfernce factor due to lengthwise change in the control as well as interfering building. These interference factors may vary due to change in the boundary conditions or change in the turbulence model for analysis.

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