1. Parameter validation from comparison with tunnel experiment

To ensure reasonable definition of parameters used in the numerical simulation, a number of error impact analysis were taken between the results of CFD and of the reference tunnel experiment. Four main groups of parameters are considered, which include domain scale (geometry), mesh, boundary condition, turbulence models and solution method.

To evaluate the outcome of different values for the selected principal parameters, two indicators are chosen, respectively, **E/U_0** the average percentage of error in portion of the reference velocity from CFD data and that of tunnel, the smaller the better, and **P** the number of test points with better approching CFD data than a fixed case as reference, the bigger the better. Note that all the velocity data analysd here are in vector X while the inlet is in X direction. Besides, the judgement is more focused on the vertical section performance while for our project the object is for the wind energy, which appears in higher level rather than the pedestrian's.

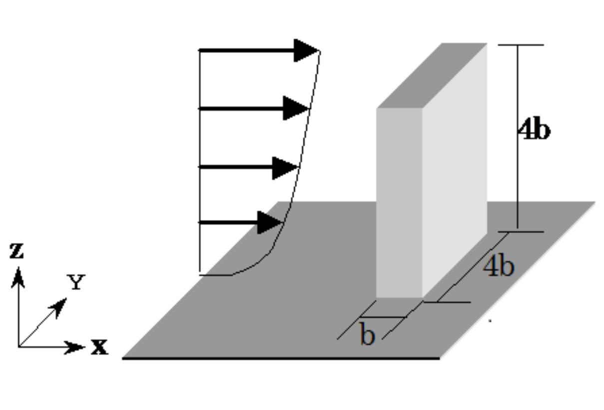

Fig. 01 Schematic view of tunnel test model

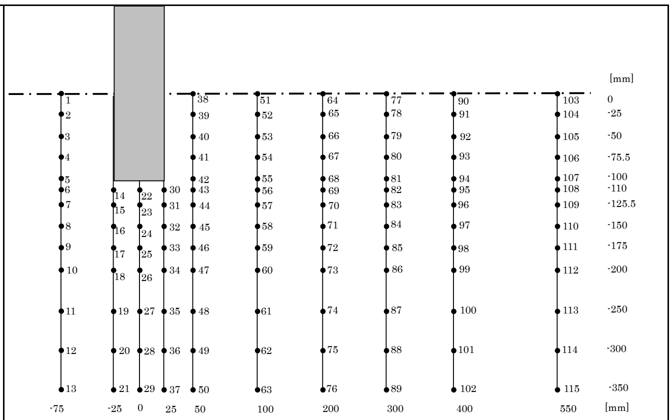

Fig. 02 Horizontal section (pedestrian's level Z=1,25m) and its 115 test points

b=5m,
Rs=1:100 for tunnel test
Inlet flow data can be simplified as a power law:

$$U = U_0(Z/100)^{\alpha}$$

(U is the inlet velocity in the height of Z)
U_0=7,84m/s (H=100m)
$\alpha = 0,25$

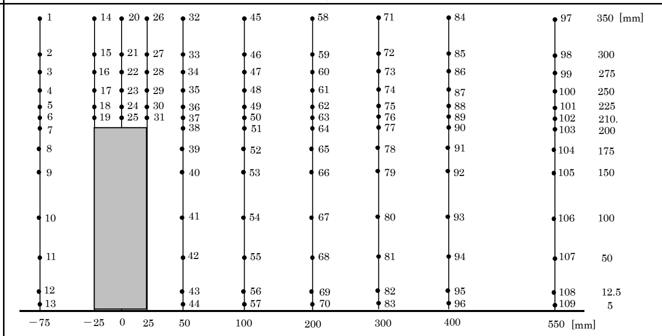

Fig. 03 Vertical section (Y=0m) and its 109 test points

Table 5.1 Error Impact analysis of the parameters for CFD

			E_{hor}		E_{ver}	
			E/U_0	**P**(/115)	**E/U_0**	**P**(/109)
Domain Scale	B	K-e Standard (R=250m)	0.253	46	0.072	70
	Ba	R=150m	0.251	50	0.073	65
	Bb	R=170m	0.252	44	0.078	59
	Bc	R=200m	0.248	54	0.070	71
	Bd	R=300m	0.257	47	0,069	71
Mesh	A	L=0.8m, N=10, T_g=0.3m, r_g=1.1, T_b=0.08m, r_b=1.2, Advanced size function: proximity and curvity, RC (Relevance Centre): Medium, Smoothing: Medium, Q=1.84*10^4	0.270	37	0.099	64
	A1a	L=0.6m, Q=2.26*10^4	0.263	39	0.095	66
	A1b	L=1m, Q=1.46*10^4	0.259	43	0.097	66

	A1c	L=1.25m, Q=1.195*10^4	0.258	41	0.090	65
	A1d	L=1.5m, Q=1.076*10^4	0.268	44	0.096	63
	A2a	N=8, Q=1.85*10^4	0.269	38	0.103	65
	A2b	N=12, Q=1.84*10^4	0.266	39	0.103	64
	A2c	N=14, Q=1.85*10^4	0.270	43	0.093	58
	A3a	T_g=0.2m, Q=1.87*10^4	0.277	37	0.106	63
	A3b	T_g=0.4m, Q=1.81*10^4	0.270	39	0.098	67
	A4a	T_b=0.1m, Q=1.78*10^4	0.277	38	0.111	57
	A4b	T_b=0.06m, Q=1.91*10^4	0.267	37	0.098	62
	A5a	r_b=1.1, Q=1.942*10^4	0.268	37	0.097	61
	A5b	r_b=1.25, Q=1.777*10^4	0.268	38	0.101	65
	A6a	RC: fine, Q=2.96*10^4	0.269	41	0.102	64
	A6b	RC: corse, Q=1.44*10^4	0.262	44	0.113	55
	A7a	Smoothing: high, Q=1.836*10^4	0.267	37	0.103	68
	A7b	Smoothing: low, Q=1.834*10^4	0.268	40	0.096	64
	B	L=1.25m, N=10, T_g=0.5m, r_g=1.13, T_b=0.08m, r_b=1.25, Advanced size function: proximity and curvity, RC (Relevance Centre): Medium, Smoothing: low, Q=1.146*10^4	0.252	39	0.082	68
	B1a	T_g=0.3m, r_g=1.1, r_b=1.2, Q=1.193*10^4	0.258	42	0.093	69
	B1b	T_g=0.4m, r_g=1.1, r_b=1.2, Q=1.164*10^4	0.250	45	0.096	56
	B1c	T_g=0.4m, r_g=1.15, r_b=1.2, Q=1.193*10^4	0.250	43	0.096	63
	B1d	T_g=0.4m, r_b=1.15, Q=1.171*10^4	0.252	42	0.091	63
	B1e	T_g=0.4m, r_b=1.2, Q=1.164*10^4	0.250	43	0.096	69
	B1f	r_b=1.2, Q=1.146*10^4	0.252	41	0.084	66
	B1g	r_b=1.15, Q=1.146*10^4	0.250	41	0.087	68
Boundary contition	A	Ks=1m, Cs=0.99, I=10%, L=1m	0.270	37	0.099	64
	Aa	Ks=0m	0.286	37	0.104	60
	Ab	Ks=0.1m	0.271	37	0.100	63
	Ac	Ks=0.5m	0.270	37	0.099	64
	Ad	Ks=0.8m	0.270	37	0.099	63
	Ae	Ks=1.2m	0.270	37	0.099	64
	Af	Ks=1.5m	0.270	37	0.099	64
	Ag	Cs=0.5	0.273	36	0.100	62
Turbulence Model and Solution	A	K-e realisable, 2 precision, Scheme: Simple, Discretization: 2 order (pressure), Quick (momentum, k, e).	0.270	37	0.099	64
	A1	Discretization (momentum, k, e) 2 order	0.270	37	0.099	64
	A2	k-e RNG	0.297	37	0.139	46
	A3	RSM	0.255	44	0.105	63
	A4	k-e Standard	0.260	42	0.079	65

Note:

E_{hor} : horizental section (Z=1,25m) velocity in vector X ;

E_{ver}: vertical section (Y=0m) velocity in vector X;

E/U_0: average error percentage of reference velocity;

P: number of test points better approching tunnel data than a fixed reference case;

R: radius of the domain.

L: the cell size for the faces of the building;

N: layers number of inflation for both ground and building;

T_g: first layer thickness from the ground inflation;

r_g: ground inflation transient ratio;
T_b: first layer thickness from the building inflation;
r_b: building inflation transient ratio;
Q: quantity of cells element for the mesh.
Ks: roughness height (m) for wall function;
Cs: roughness constant for wall function;
I: tubulent intensity (%).

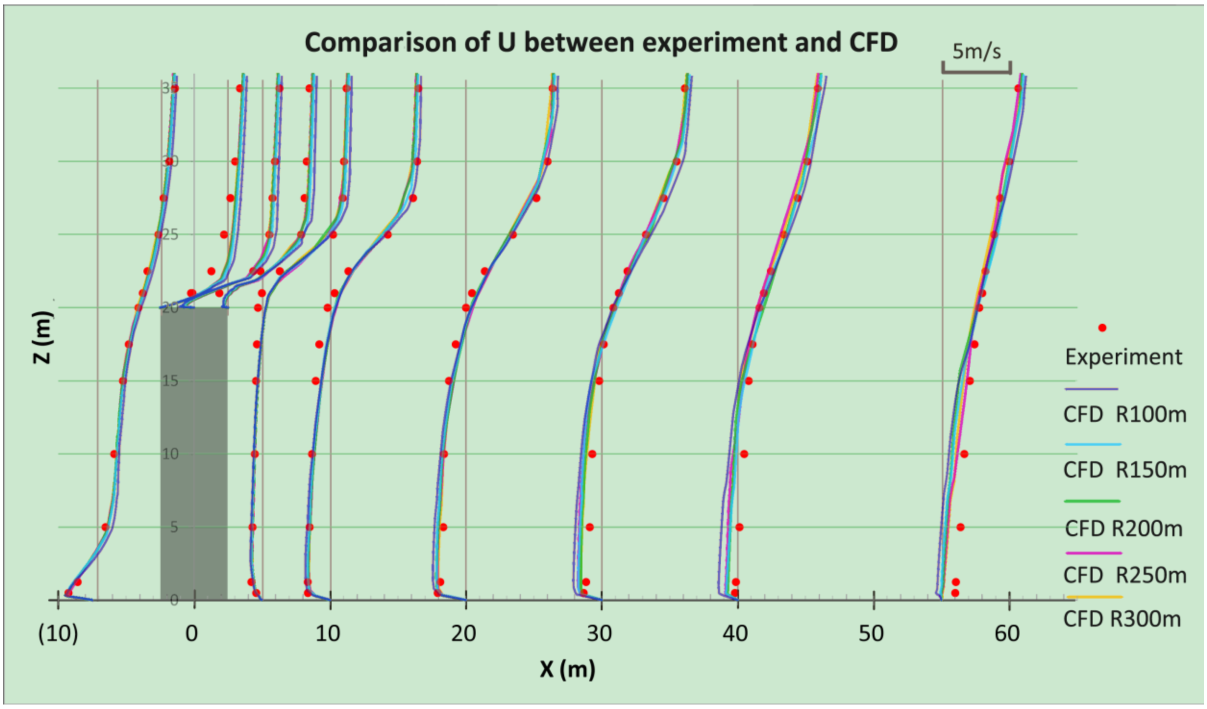

Fig. 04 Comparison of results CFD with model in different domain scales

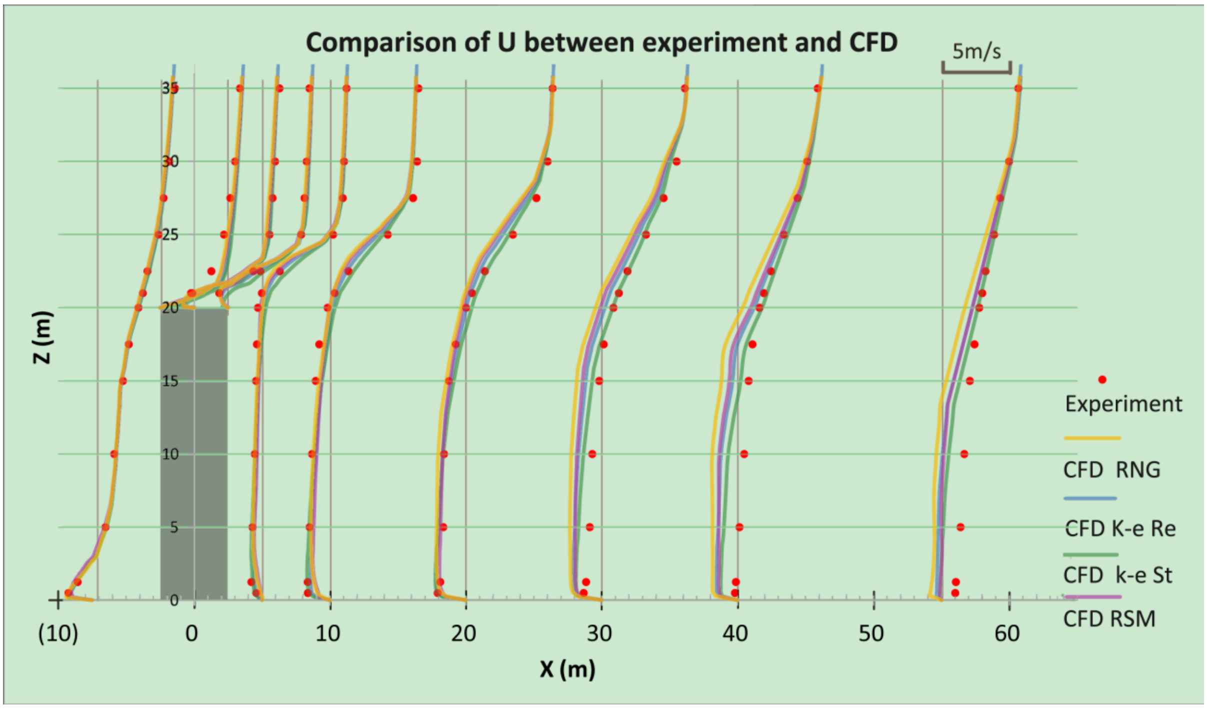

Fig. 05 Comparison of results CFD with different turbulent models

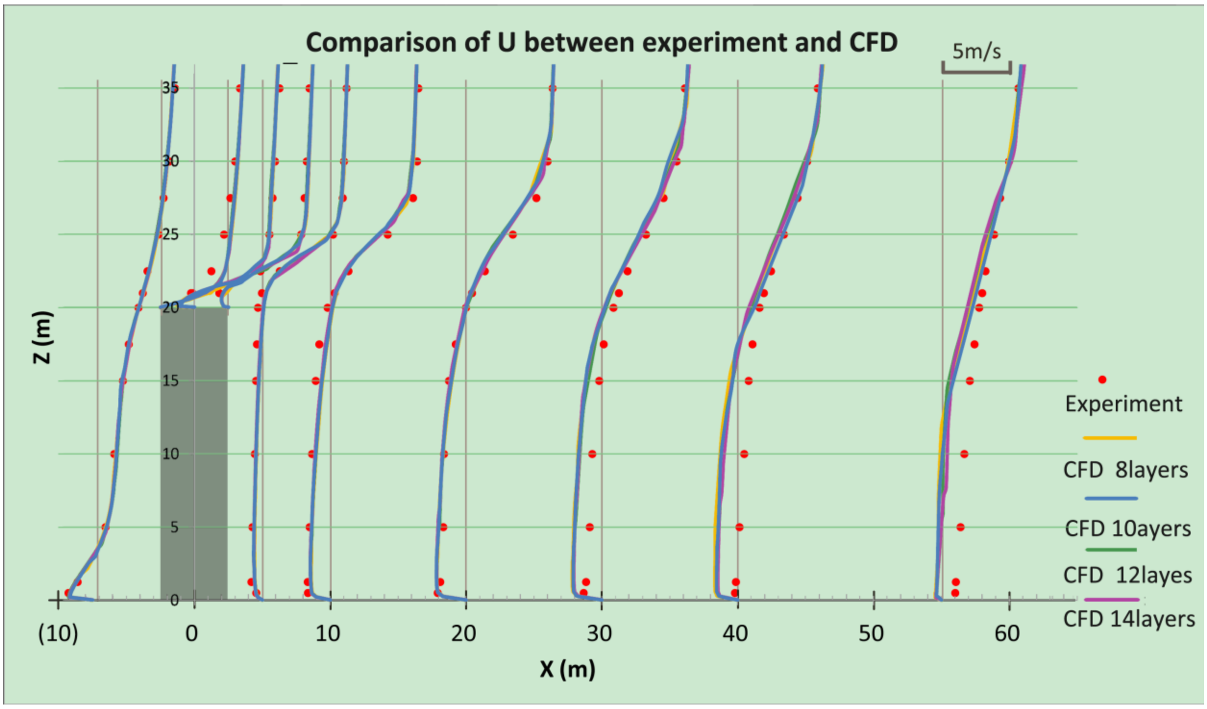

Fig. 06 Comparison of results CFD with meshes of different inflation layer numbers (N)

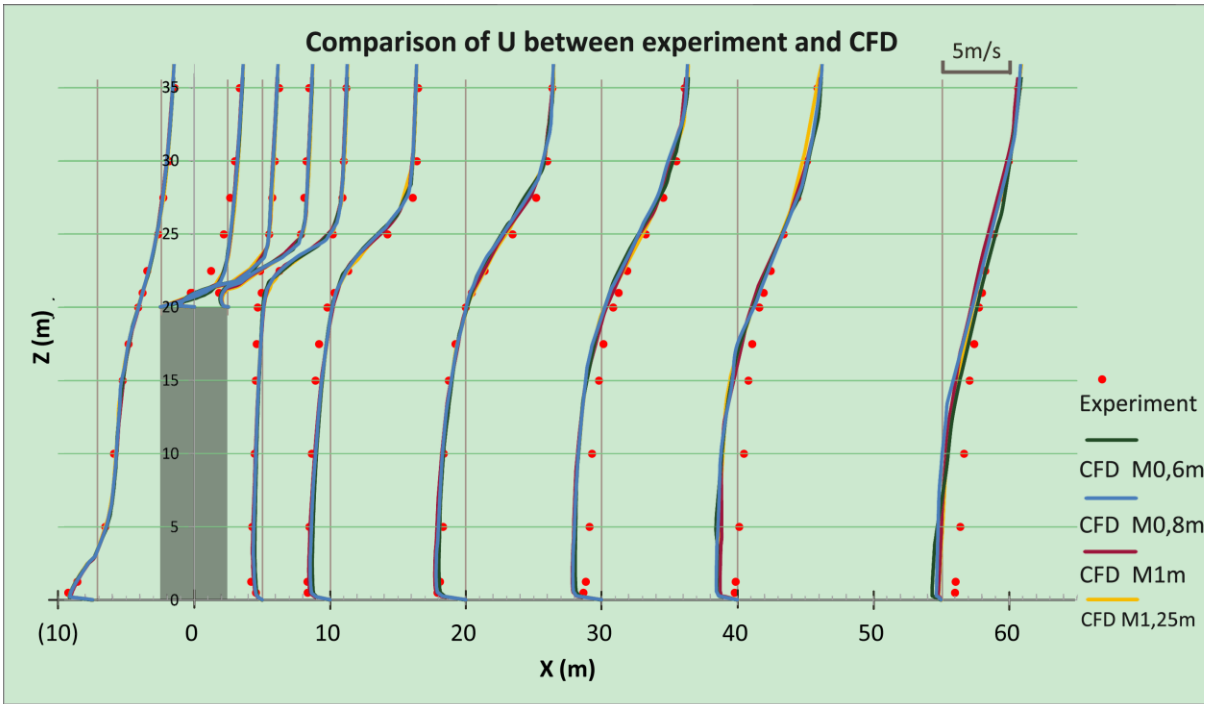

Fig. 07 Comparison of results CFD with meshes of different size precision for the building (N)

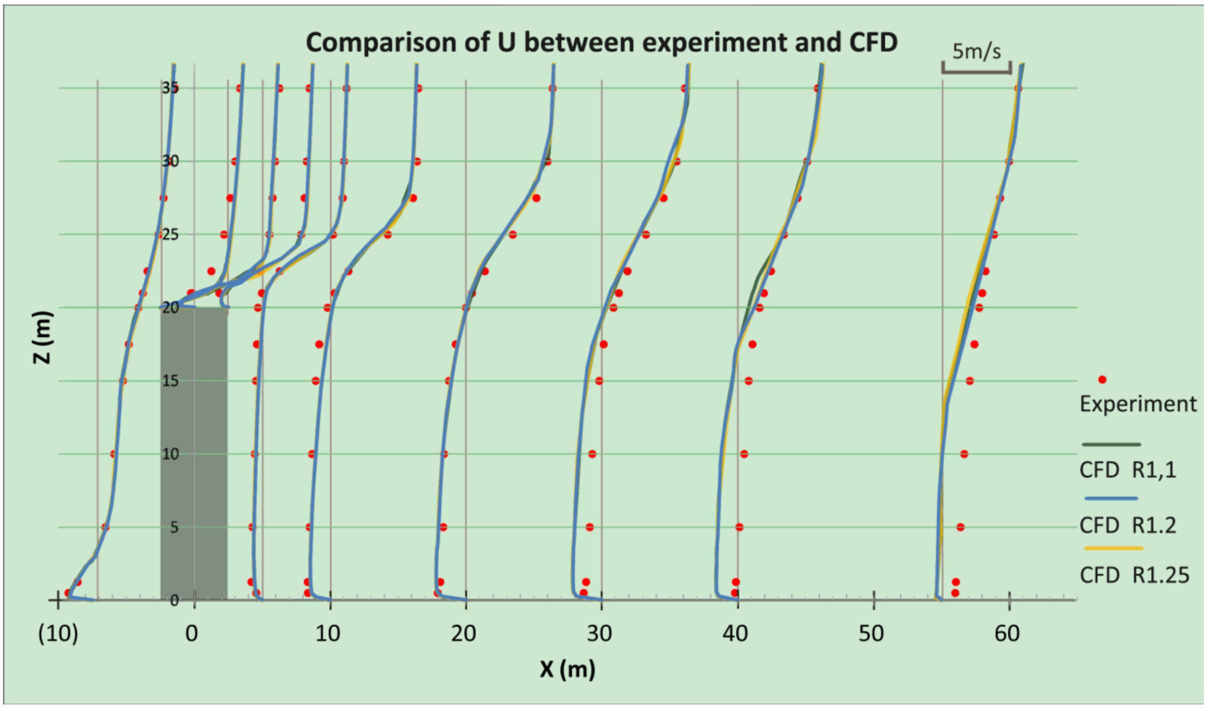

Fig. 08 Comparison of results CFD with meshes of different inflation ratios for the building (r_b)

From the comparison table and plots above we can see that:

1. For the domain scale a radius of 200m can be a best choice, while increase it to 250m or 300m the error has little change.
2. For the mesh:

   a. among different inflation first layer thickness for the building (T_b=0.06m-0.1m), the smaller the size the better the outcome. However with consideration of mesh cell number (Q) a balanced value like T_b=0,08m is chosen;

   b. there is no best number of inflation layers, while the small average error is more often accompanied by a bad number of better approaching points. Hence we take a balanced value: N=10.

   c. among different inflation first layer thickness for the ground (T_g=0.2m-0.5m), 0.5m has the best performance.

   d. among different inflation transit ratio for the ground (r_g=1.1-1.15), 1.13 has the best performance.

   e. among different inflation transit ratio for the building (r_b=1.15-1.25), 1.25 has the best performance.

   f. for the option of general mesh control, Relevance Centre (RC) in Medium, and low in smoothing get a best performance respectively.
3. For boundary condtion in wall function, the roughness height Ks and constant Cs in fact both have little influence over the result. However, a bigger Cs seems a better outcome and when Ks>0.1m the outcome seems to stop changing. Here we take a Ks=1m and Cs=0.99 as the best setting.
4. Among different turbulent models k-e standard shows a best performance.