WELCOME

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Session 1

Wind Load Basics & Applications

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Basics of Wind Load

- Wind means air in motion.
- Winds are produced due to differences in atmospheric pressures which are primarily due to differences in temperatures.
- Forms of Wind

I. Light Air
II. Breeze (Light to Strong)

0 to 17m/s

III. Gales
IV. Thunderstorms
V. Cyclones
VI. Tornadoes

Natural Hazards (17 to 33 m/s & > 33 m/s)

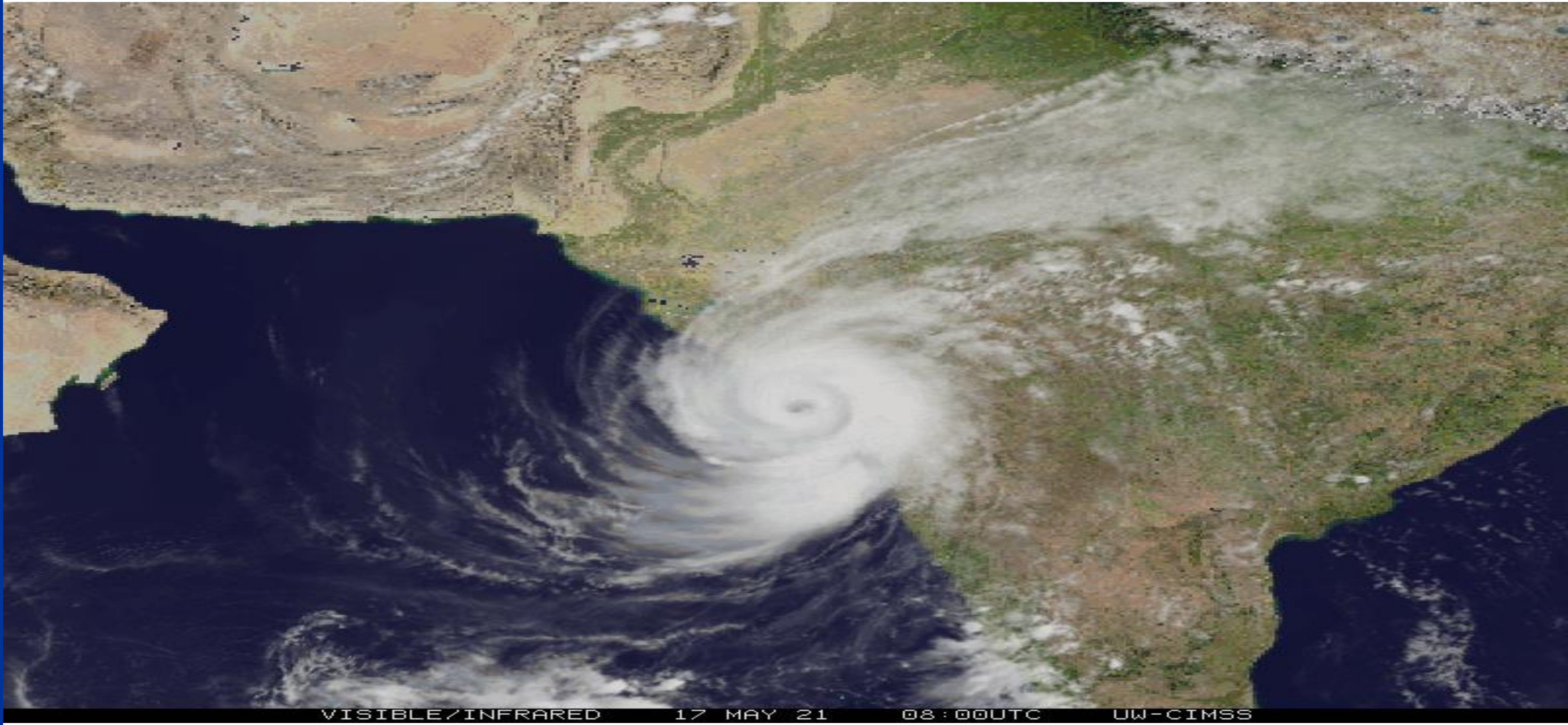
Basics of Wind Load

***Gales:**-wind speed:17 to 20 m/s*

Basics of Wind Load

Thunderstorms:-Wind Speed 9 to 31 m/s

Basics of Wind Load



Cyclone:-Wind speed 30 to 36 m/s

Basics of Wind Load

Tornado:- Wind Speed 75-135 m /s

Basics of Wind Load

TABLE 3.14 Hazard-wise losses due to all disasters for the period 1900–1976 (Krishna, P. et al. 2004)

	Gross loss	Landslides, avalanches, and volcanic eruptions (%)	Cyclones and other windstorms (%)	Floods (%)	Earthquakes (%)
Death	4.85 million	2.93	10.83	28.10	58.14
People rendered homeless	232 million	—	12.07	75.48	12.45
Estimated economic losses	131,200 million US$	7.62	36.43	18.37	37.58

Tornado: Wind Speed 75-135 m/s

Basics of Wind Load

- **Characteristics of Wind**
- Wind loads on structures are function of wind flow and the effect of that flow on the structural system

Wind Flow ↓

I. Basic wind speed
II. Mean recurrence interval of the wind speed
III. Surrounding terrain
IV. Height above ground

Effect of wind flow on structure ↓

Aerodynamics of the structure
Position of the area
Magnitude of the area
Porosity of the structure

Basics of Wind Load

- **Variation of Wind Velocity with height**

- **Gradient Height:-Height at which velocity ceases to increase**

- **Gradient Velocity:-Velocity corresponding to gradient height**

- **Atmospheric boundary layer:-Height through which velocity is affected by topography**

- **Fetch Length:-Distance required to travel for wind over a typical terrain to fully develop the speed profile idealized for that terrain category.**

Basics of Wind Load

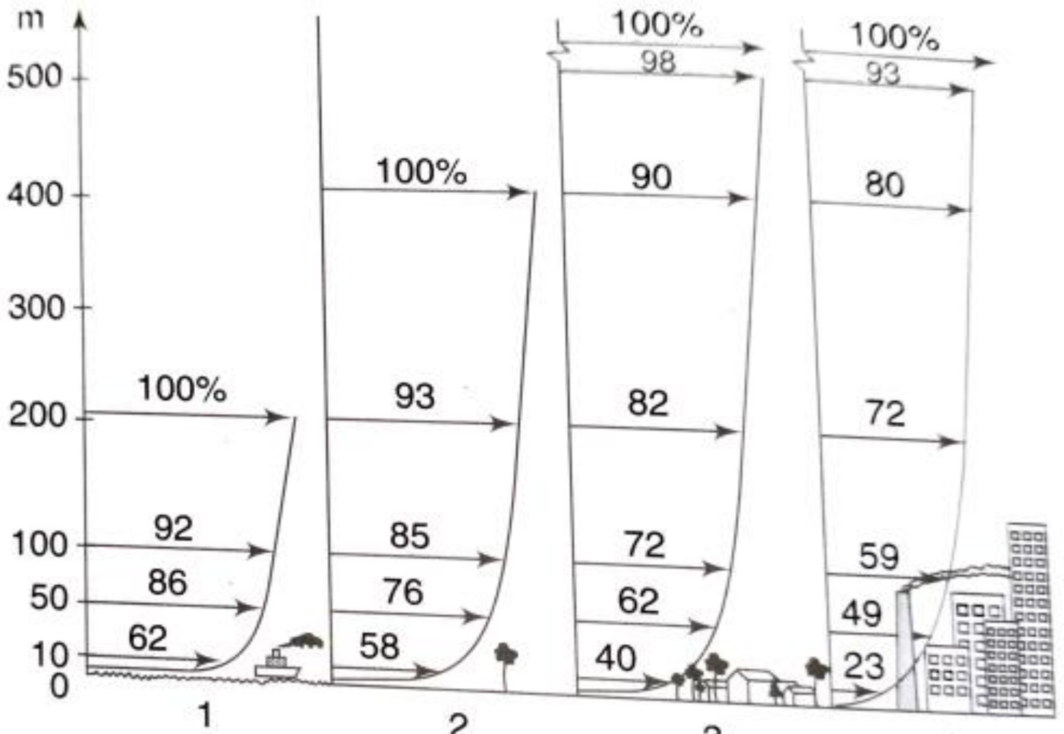


FIG. 3.14 Boundary layer profile for different approach terrains

- **The velocity at 10m above ground level is normally used as the basic value for the design purpose.**

Basics of Wind Load

- **Turbulence nature of wind**

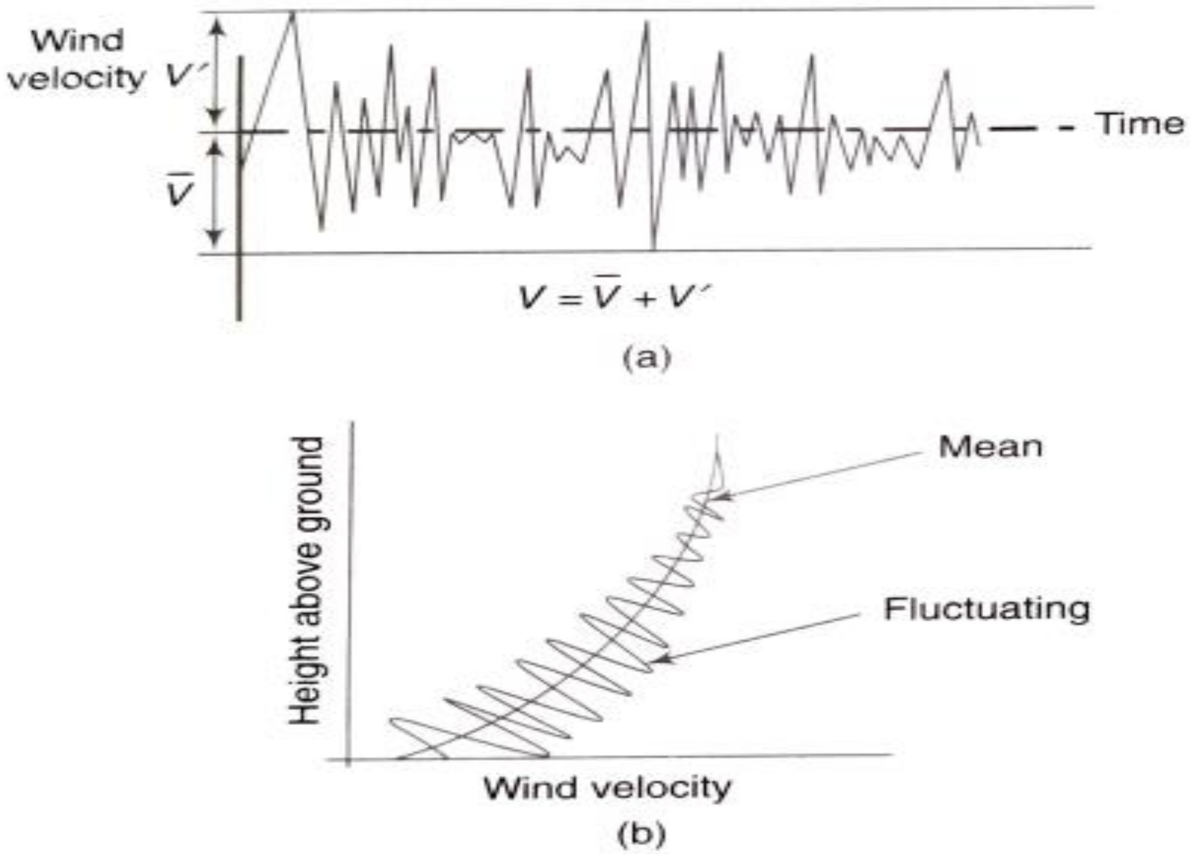


FIG. 3.15 Variation of wind velocity with (a) time and (b) height

Basics of Wind Load

- **Turbulence nature of wind**
- Wind speeds greater than 0.9 to 1.3 m/s are turbulent in nature.
- $V_t = V + V'$
- Rapid bursts in the velocity of wind are called as “Gusts”.
- Due to random nature of wind the properties of wind are studied statistically by obtaining the required mean or the average.
- As wind speed changes constantly, different averages are obtained by using different averaging times.(2-3 sec, 10 min & 1 hour)

Basics of Wind Load

- **Return Period**
- **Probabilistic approach to determine the wind load**
- **Intensity of wind is function of return period (Duration recurrence interval)**
- **Return period 50 years of wind speed 44m/s means on average structure will experience wind speed of 44m/s within 50 years**
- **Probability of occurrence within a year (P_a) 1/50=0.02 or 2%**
- **For design life of 50 years probability of exceedance of design wind speed will be 64%.(P_N=1-(1-P_a)^n)**
- **The probability level of 64% is normally considered sufficient for the design of structures.**

Basics of Wind Load

- **Static Effects**
- **For rigid structures consideration of equivalent static wind is adequate.**
- **Wind blowing past a body is diverted in 3 mutually perpendicular directions.**
- **In structural applications generally winds are considered in two directions**
- **Along Wind → Drag Force**
- **Transverse Wind → Cross Wind**

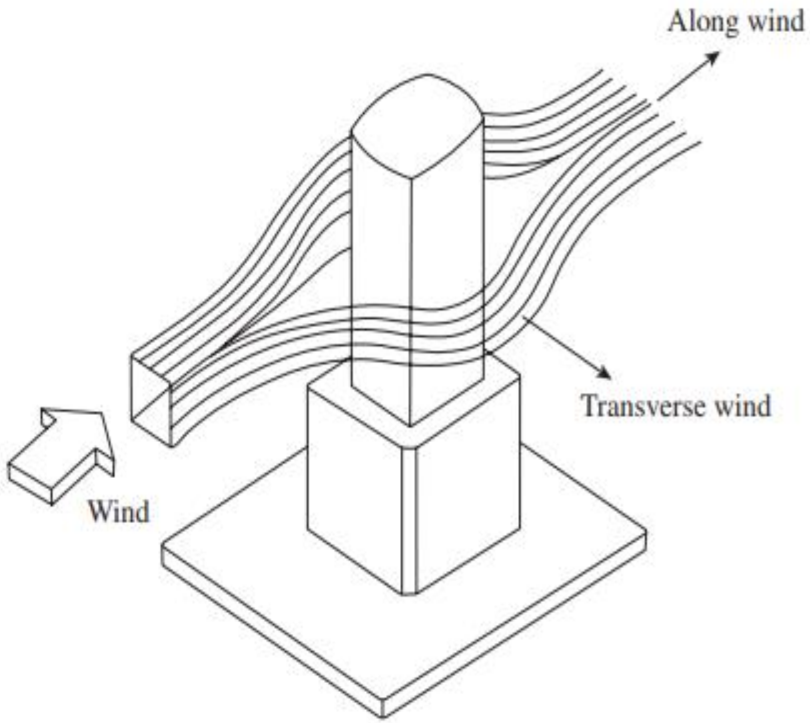


FIG. 3.7 Simplified two-dimensional flow of wind

- **Dynamic Effects**
- **Flexible structures having fundamental natural frequency less than 1Hz are sensitive to dynamic part of wind.**
- **Vibrations are set up in structures in along and across wind directions**

a) **Limited amplitude Vibrations** → **Serviceability discomfort**

b) **Divergent amplitude Vibrations** → **Structural Catastrophe**

- **Buffeting Vibrations (Along Wind)**
- **Vortex Induced Vibrations (Across Wind)**

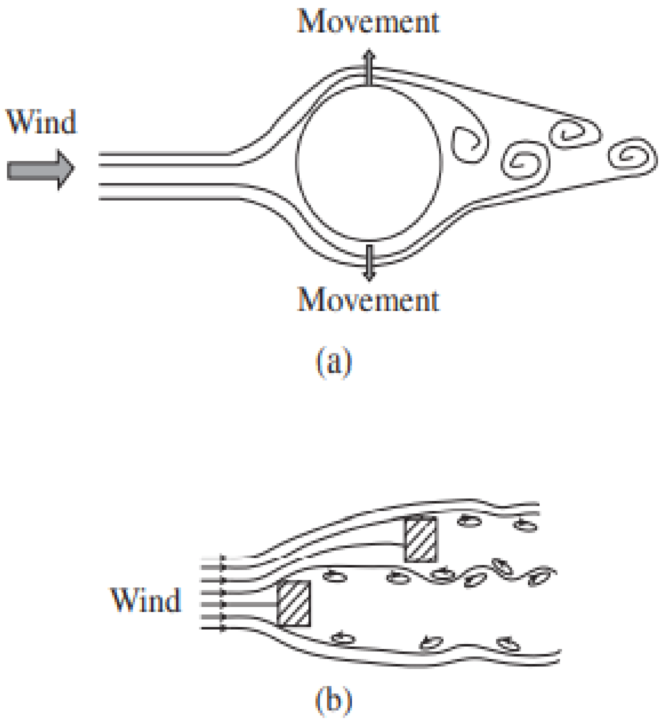
} a

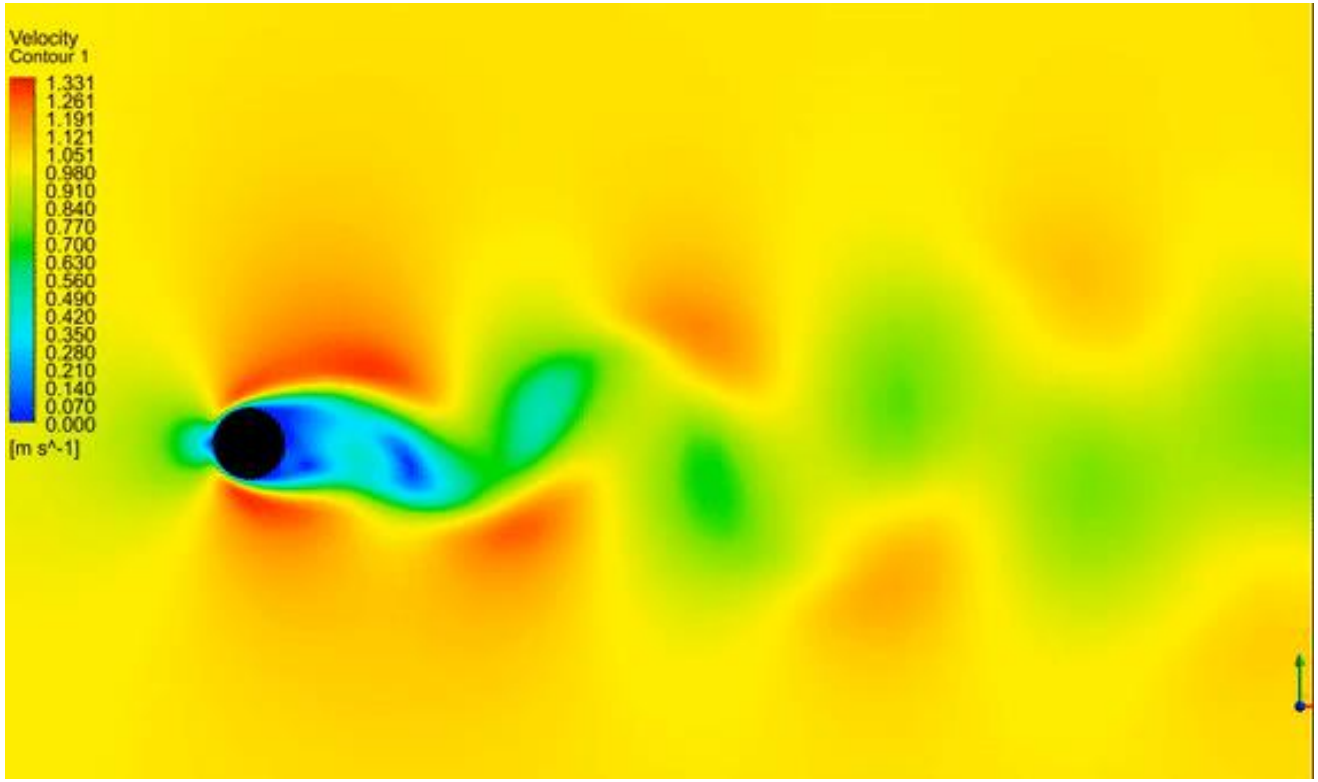
- **Galloping**
- **Flutter**
- **Ovalling**

} b

Basics of Wind Load

- **Vortex Induced Vibrations (Across Wind)**
  - Spiral Vortices due to separation of air flow
  - At higher wind speed vortices shed alternatively from one side to other side of structure
  - Shedding frequency f=SVd/b





Basics of Wind Load

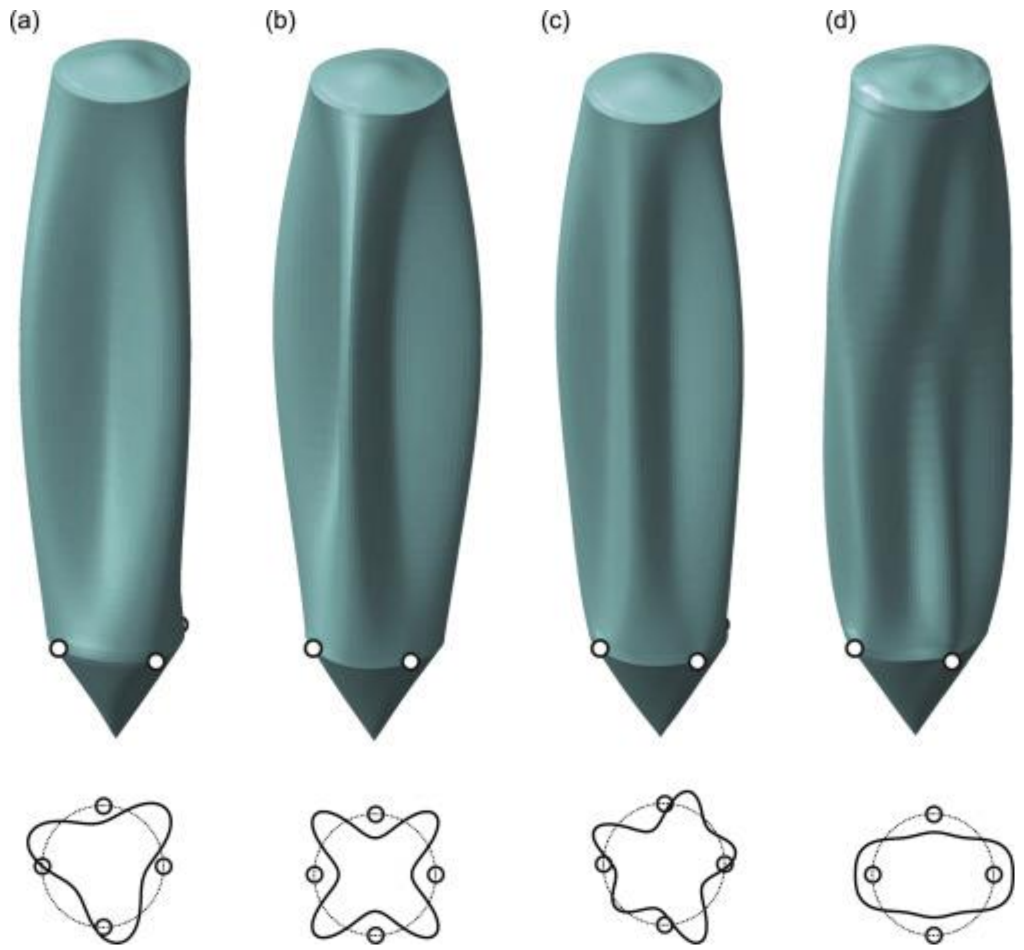
- **Galloping:** Movement induced self excited periodic oscillation in perpendicular direction to the flow with amplitudes much larger than cross section dimensions of structure.

Basics of Wind Load

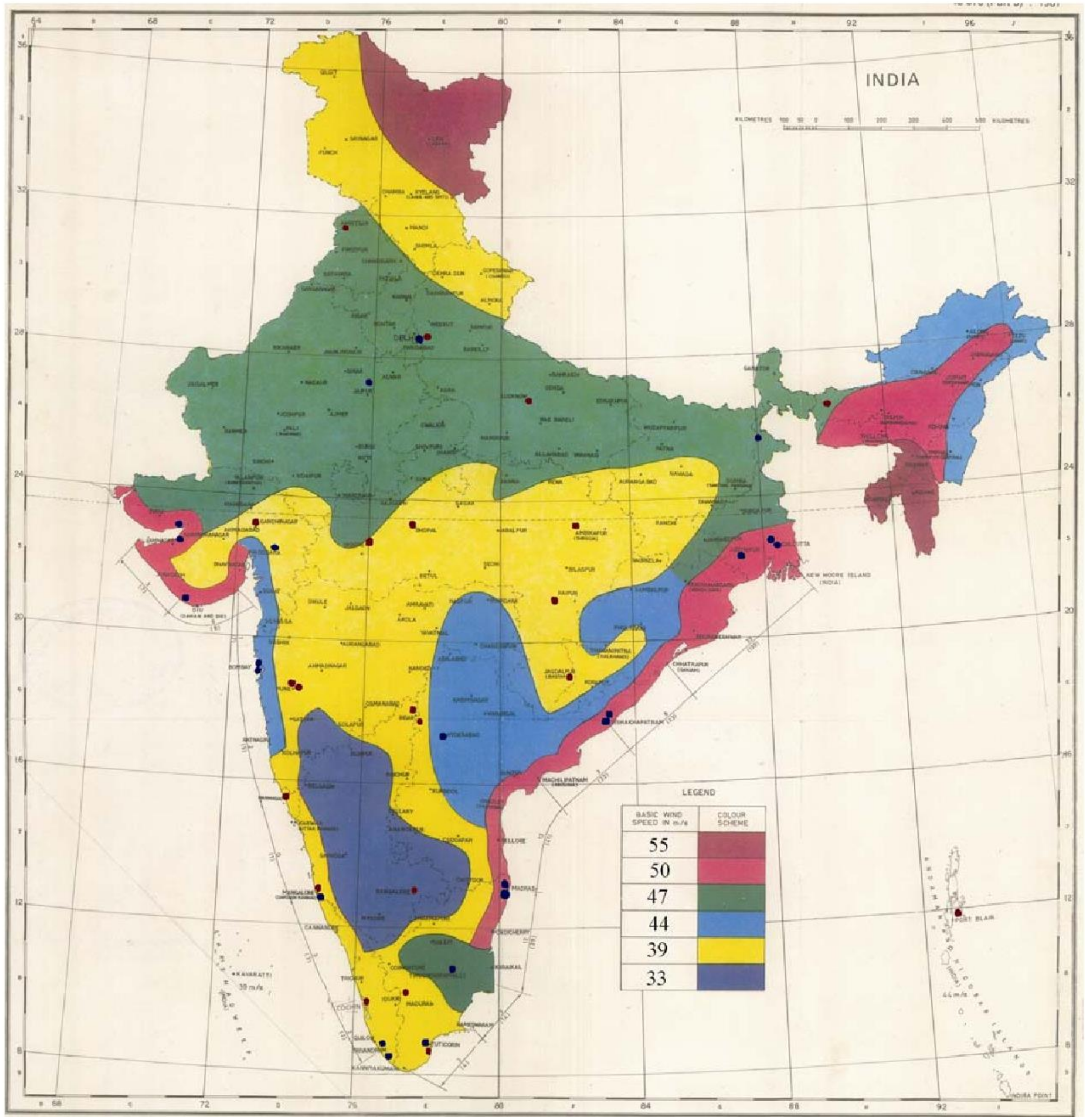
- **Flutter:** Unstable oscillatory motion due to combined bending and torsion which occurs in flexible plate like structures

Basics of Wind Load

- **Ovalling**: Cross wind induced oscillation in which a thin circular cross section deforms in the shape of an oval without significant bending in longitudinal direction



Determination of Wind Load as per IS 875 Part 3



- **Basic Wind Speed (V_b) averaged over 3 Sec and return period of 50 years at a height of 10m above ground level.**
- **Terrain Category:-Open (2)**

Determination of Wind Load as per IS 875 Part 3

- **Design Wind Speed (V_z)**
- Is obtained from basic wind speed after modifying it to include
  - Risk level
  - Terrain roughness
  - Height & Size of Structure
  - Local Topography

k1 = risk coefficient (probability factor)
k2 = terrain roughness and height factor
k3 = topography factor
k4 = importance factor for the cyclonic region

$$V_z = V_b\, k_1\, k_2\, k_3\, k_4$$

- **Risk Coefficient (k1)**

Table 1 Risk Coefficients for Different Classes of Structures in Different Wind Speed Zones

(*Clause* 6.3.1)

Sl No.	Class of Structure	Mean Probable Design Life of Structure in Years	k_1 Factor for Basic Wind Speed m/s					
			33	39	44	47	50	55
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	All general buildings and structures	50	1.0	1.0	1.0	1.0	1.0	1.0
ii)	Temporary sheds, structures such as those used during construction operations (for example, formwork and false work), structures during construction stages and boundary walls	5	0.82	0.76	0.73	0.71	0.70	0.67
iii)	Buildings and structures presenting a low degree of hazard to life and property in the event of failure, such as isolated towers in wooded areas, farm buildings other than residential buildings	25	0.94	0.92	0.91	0.90	0.90	0.89
iv)	Important buildings and structures such as hospitals communication buildings/towers, power plant structures	100	1.05	1.06	1.07	1.07	1.08	1.08

Determination of Wind Load as per IS 875 Part 3

- **Risk Coefficient (k1)**
- **The k1 factors given in the Table above is estimated using the equation given below.**

$$k_1 = \frac{X_{N,P}}{X_{50,0.63}} = \frac{A - B\left[In\left\{-\frac{1}{N}In(1-P_N\right\}\right]}{A+4B}$$

- **N=mean probable life of structure in years**
- **PN=risk level in N consecutive years (probability that the design wind speed is exceeded at least once in N successive years, nominal value=0.63 XN,P=extreme wind speed for given values of N and PN**
- **X50,0.63=extreme wind speed for N=50 years and PN=0.63**

Determination of Wind Load as per IS 875 Part 3

- **A and B**
  coefficients have following values for different basic wind speed

Zone	A	B
m/s	m/s	m/s
33	23.1	2.6
39	23.3	3.9
44	24.4	5
47	24.4	5.7
50	24.7	6.3
55	25.2	7.6

Determination of Wind Load as per IS 875 Part 3

- **Terrain, Height Factor (k_2)**
- **Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness as given below**
- **Terrain Category 1:-**

Exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5m.

(open sea-coasts and flat plains without trees:- z0,i=0.002m)

Determination of Wind Load as per IS 875 Part 3

- **Terrain, Height Factor (k_2)**
- **Terrain Category 2:-**

Open terrain with well scattered obstructions having heights generally between 1.5m and 10m.

(airfields, open park lands and u ndeveloped sparsely built-up out skirts of towns and suburbs. Ope n land adjacent to sea coast :- z0,i=0.02m)

Determination of Wind Load as per IS 875 Part 3

- **Terrain, Height Factor (k_2)**
- **Terrain Category 3:-**
  Terrain with numerous closely spaced obstructions having the size of structures up to 10m in height with or without a few isolated tall structures.

(wooded areas, and shrubs, towns and industrial areas full or partially developed:- $z_{0,i}$=0.2m)

Determination of Wind Load as per IS 875 Part 3

- **Terrain, Height Factor (k_2)**
- **Terrain Category 4:-**

  Terrain with numerous large high closely spaced obstructions. This category represents large city centers, generally with obstructions above 25m.

(well-developed in dustrial complexes: -z0,i=2m)

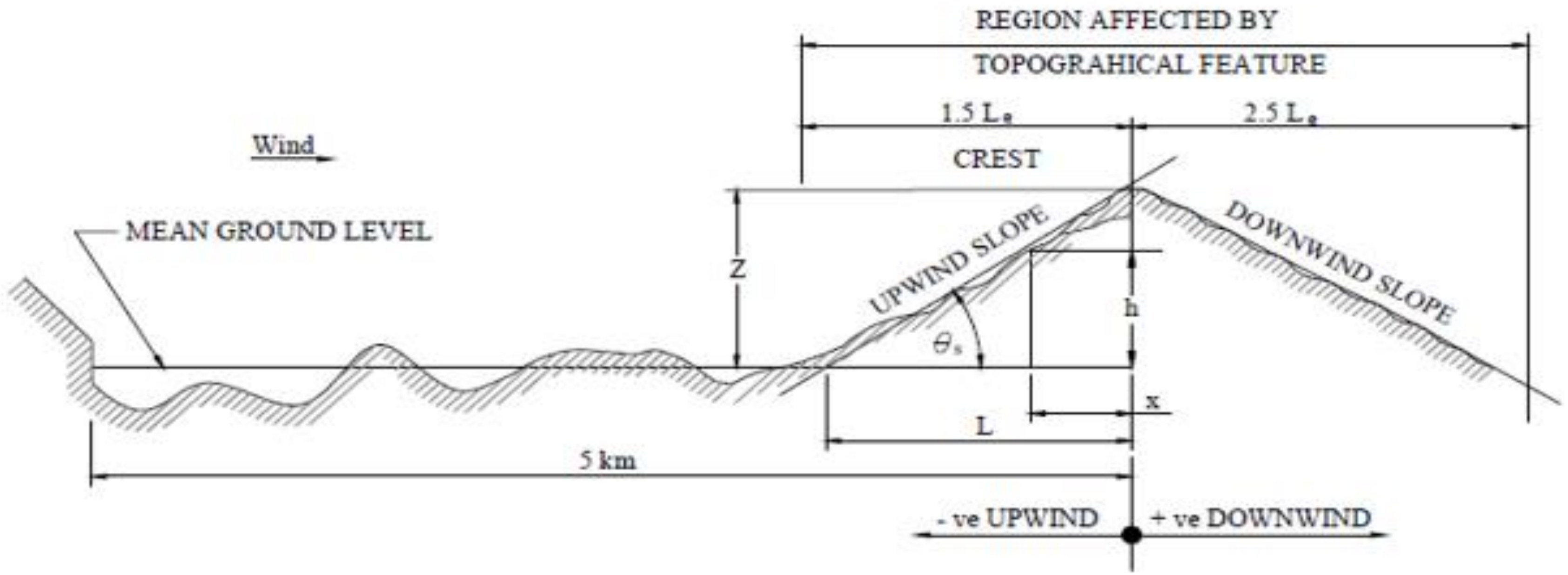
Determination of Wind Load as per IS 875 Part 3

Table showing k2 Factors to obtain Design Wind Speed

Sr. No.	Height (z)	Terrain and Height Multiplier (k_2)			
	M	TC 1	TC 2	TC 3	TC 4
i)	Up to10	1.05	1.00	0.91	0.80
ii)	15	1.09	1.05	0.97	0.80
iii)	20	1.12	1.07	1.01	0.80
iv)	30	1.15	1.12	1.06	0.97
v)	50	1.20	1.17	1.12	1.10
vi)	100	1.26	1.24	1.20	1.20
vii)	150	1.30	1.28	1.24	1.24
viii)	200	1.32	1.30	1.27	1.27
ix)	250	1.34	1.32	1.29	1.28
x)	300	1.35	1.34	1.31	1.30
xi)	350	1.35	1.35	1.32	1.31
xii)	400	1.35	1.35	1.34	1.32
xiii)	450	1.35	1.35	1.35	1.33
xiv)	500	1.35	1.35	1.35	1.34

Determination of Wind Load as per IS 875 Part 3

- **Topography Factor(k3)**
- This takes into account of local topography features such as hills and valleys.
- Hills ⟶ Accelerates Wind
- Valleys ⟶ Decelerate Wind



Determination of Wind Load as per IS 875 Part 3

- **Topography Factor(k_3)**
- Annexure C of IS 875 gives the method to calculate k_3
- For level ground or when upwind slope < 3 degree k_3 = 1
- For slope > 3 degree k_3 varies from 1 to 1.36.
- The topography factor k_3 is given by the following:

$k_3 = 1 + C\, S_0$

where C has the following values:

Slope	C
$3^\circ < \theta s \leq 17^\circ$	1.2(Z/L)
$\theta s > 17^\circ$	0.36

Determination of Wind Load as per IS 875 Part 3

- **Importance Factor for Cyclonic Regions(k_4)**
- For greater safety of structures located within 60km wide of the east as well as the Gujarat coast where wind speed > 70 m/s during cyclones following values of k4 are given based on code IS 15498.
- Structures of post cyclone importance (Hospitals, power plants etc) = 1.3
- For industrial structures = 1.15
- For all other structures = 1.0
- Non cyclonic regions = 1.0
- **Off Shore Wind Velocity**
- For offshore structures situated at a distance of up to 200 km off the coast the wind speed may be taken 1.15 times the value on the nearest coast in addition to factor K_4.

Determination of Wind Load as per IS 875 Part 3

- **Design Wind Pressure(Pd)**
- The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:

$$P_z = 0.6V_z^2$$

- Where Pz= wind pressure at height z, in N/m2;
  and Vz= design wind speed at height z, in m/s
- The design wind pressure is obtained as
- Pd = KdXKaxKcxPz (should not be less than 0.7Pz)
  Kd = Wind directionality factor
  Ka = Area averaging factor
  Kc = Combination Factor

Determination of Wind Load as per IS 875 Part 3

- **Wind directionality factor(Kd)**
- Takes account of randomness in the directionality of wind
- For circular and near circular sections Kd = 1.0
- Cyclonic regions Kd = 1.0
- For all other buildings, solid or open signs, trussed towers Kd = 0.9

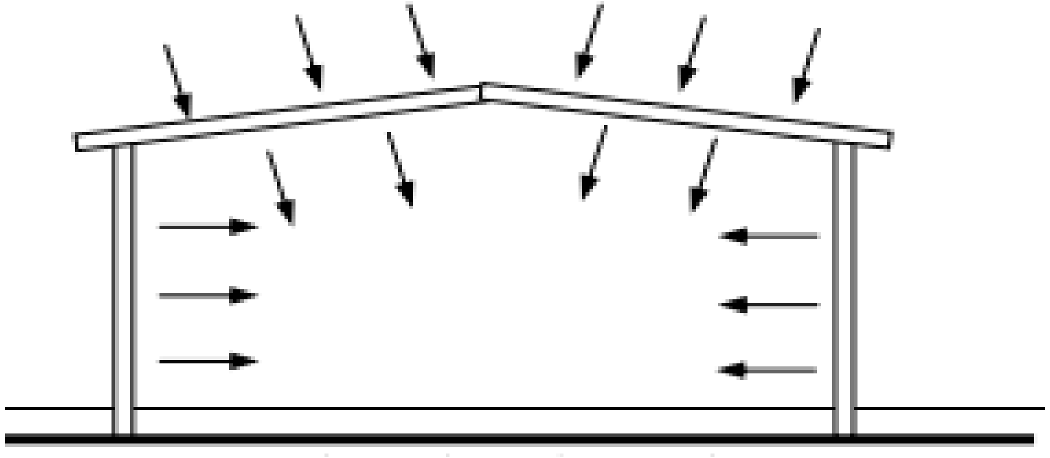
- **Area Averaging factor(Ka)**
- Pressure coefficients are results of averaging the measured pressure values over a given area.
- As the area increases the correlation of values decreases and vice versa.
- The decrease in pressure values due to larger areas is taken account by this reduction factor Ka.

Table 4 Area Averaging Factor (K_a)
(*Clause* 7.2.2)

Sl No. (1)	Tributary Area (A) m^2 (2)	Area Averaging Factor (Ka)* (3)
i)	≤10	1.0
ii)	25	0.9
iii)	≥100	0.8

* Linear interpolation for intermediate values of a is permitted.

- **Combination factor(K_c)**
- **When taking wind load on clad buildings it is reasonable to assume that pressure or suctions inside or outside the structure shall not be fully correlated.**
- **Thus when taking combined effect of wind load reduction factor K_c=0.9 may be used when roof is subjected to pressure and internal pressure is suction.**



Determination of Wind Load as per IS 875 Part 3

- **Pressure Coefficient (Cp)**
- The wind load acting on the surface is obtained by multiplying area of the surface, wind pressure and the pressure coefficient (Cp)
- The pressure coefficients are obtained from measurements on models in Wind Tunnel Test
- When calculating wind load on individual structural units such as roofs and walls pressure differences on opposite faces of units need to be considered.
- Then Wind Load F is given as

$$F = (C_{pe} - C_{pi})\, A\, p_d$$

where

C_{pe} = external pressure coefficient,

C_{pi} = internal pressure coefficient,

A = surface area of structural element or cladding unit, and

p_d = design wind pressure.

Determination of Wind Load as per IS 875 Part 3

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Determination of Wind Load as per IS 875 Part 3

- **Internal Pressure Coefficient (Cpi)**

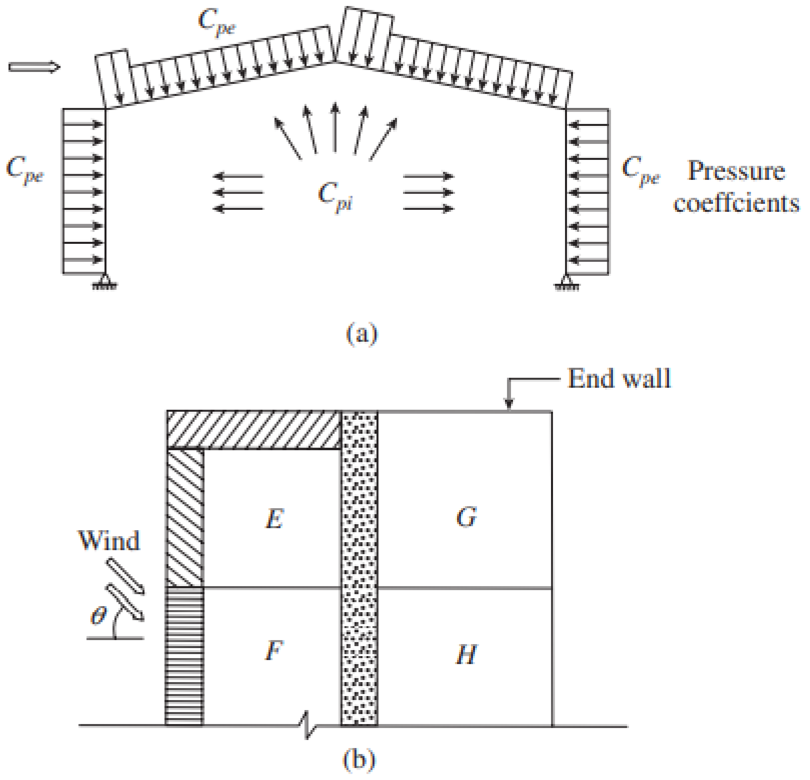
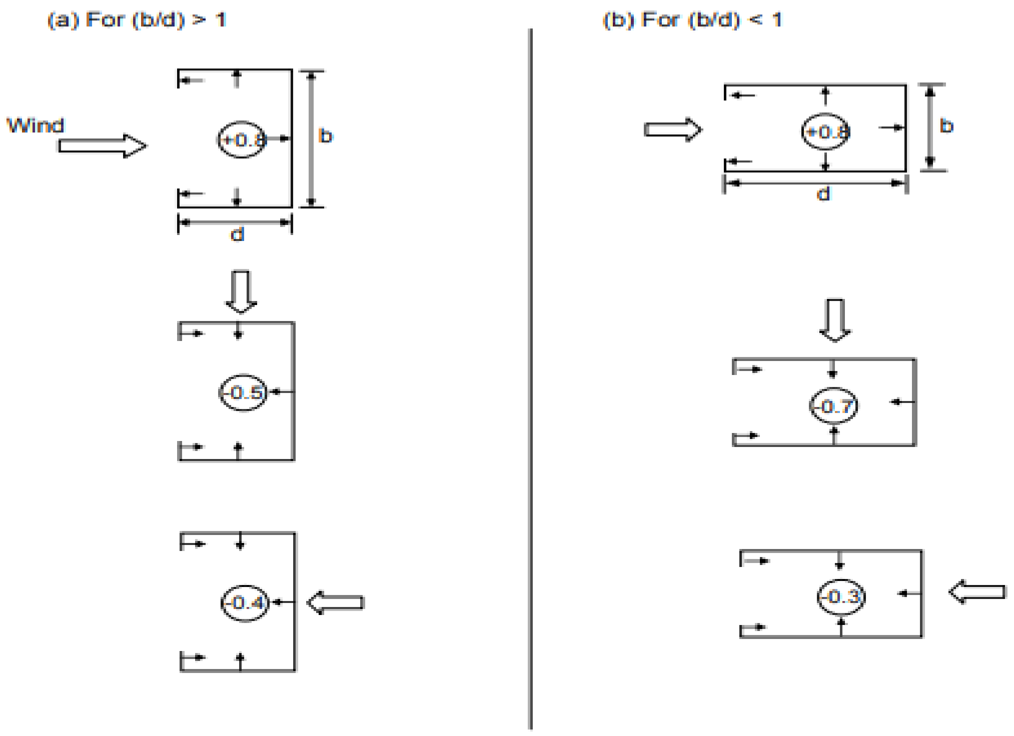


FIG. 3.6 Typical industrial building elevation along with the wind pressure coefficients (a) Typical elevation with wind pressure coefficients C_{pe} and C_{pi} (b) Half plan

TABLE 3.6 Internal pressure coefficient C_{pi}

S. No.	Type of Building	C_{pi}
1.	Buildings with low permeability (less than 5% openings in wall area)	±0.2
2.	Buildings with medium permeability (5–20% openings in wall area)	±0.5
3.	Buildings with large permeability (openings in wall area > 20%)	±0.7
4.	Buildings with one side large openings	See Fig. 3 of code

- Internal Pressure Coefficient (Cpi)



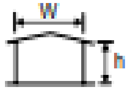
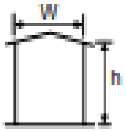
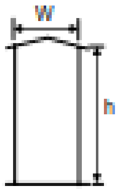
(c) For (b/d) = 1, use average values
Arrows indicate direction of wind.

Figure 2: Large opening in buildings (values of coefficients of internal pressure) with top closed *[Clause 6.2.2.2]*

Determination of Wind Load as per IS 875 Part 3

- ## External Pressure Coefficient (Cpe)(Roofs)

Table 6 External Pressure Coefficients (C_{pe}) for Pitched Roofs of Rectangular Clad Buildings *(Clause 6.2.3.2)*

Building Height Ratio		Roof Angle α	Wind angle θ 0°		Wind angle θ 90°		Local Coefficients			
		Degrees	EF	GH	EG	FH	(diagonal hatch)	(reverse diagonal hatch)	(horizontal lines)	(dotted)
$\frac{h}{w} \le \frac{1}{2}$		0	-0.8	-0.4	-0.8	-0.4	-2.0	-2.0	-2.0	—
		5	-0.9	-0.4	-0.8	-0.4	-1.4	-1.2	-1.2	-1.0
		10	-1.2	-0.4	-0.8	-0.6	-1.0	-1.4		-1.2
		20	-0.4	-0.4	-0.7	-0.6	-0.8			-1.2
		30	0	-0.4	-0.7	-0.6				-1.1
		45	+0.3	-0.5	-0.7	-0.6				-1.1
		60	+0.7	-0.6	-0.7	-0.6				-1.1
$\frac{1}{2} < \frac{h}{w} \le \frac{3}{2}$		0	-0.8	-0.6	-1.0	-0.6	-2.0	-2.0	-2.0	—
		5	-0.9	-0.6	-0.9	-0.6	-2.0	-2.0	-1.5	-1.0
		10	-1.1	-0.6	-0.8	-0.6	-2.0	-2.0	-1.5	-1.2
		20	-0.7	-0.5	-0.8	-0.6	-1.5	-1.5	-1.5	-1.0
		30	-0.2	-0.5	-0.8	-0.8	-1.0			-1.0
		45	+0.2	-0.5	-0.8	-0.8				
		60	+0.6	-0.5	-0.8	-0.8				
$\frac{3}{2} < \frac{h}{w} < 6$		0	-0.7	-0.6	-0.9	-0.7	-2.0	-2.0	-2.0	—
		5	-0.7	-0.6	-0.8	-0.8	-2.0	-2.0	-1.5	-1.0
		10	-0.7	-0.6	-0.8	-0.8	-2.0	-2.0	-1.5	-1.2
		20	-0.8	-0.6	-0.8	-0.8	-1.5	-1.5	-1.5	-1.2
		30	-1.0	-0.5	-0.8	-0.7	-1.5			
		40	-0.2	-0.5	-0.8	-0.7	-1.0			
		50	+0.2	-0.5	-0.8	-0.7				
		60	+0.5	-0.5	-0.8	-0.7				

Determination of Wind Load as per IS 875 Part 3

- **External Pressure Coefficient (Cpe)(Walls)**

Table 5 External Pressure Coefficients (C_{pe}) for Walls of Rectangular Clad Buildings
(*Clause* 6.2.3.1)

Building Height Ratio	Building Plan Ratio	Wind Angle θ (degrees)	C_{pe} for Surface A	B	C	D	Local C_{pe}
$\frac{h}{w} \le \frac{1}{2}$	$1 < \frac{l}{w} \le \frac{3}{2}$	0	+0·7	−0·2	−0·5	−0·5	−0·8
		90	−0·5	−0·5	+0·7	−0·2	
	$\frac{3}{2} < \frac{l}{w} < 4$	0	+0·7	−0·25	−0·6	−0·6	−1·0
		90	−0·5	−0·5	+0·7	−0·1	
$\frac{1}{2} < \frac{h}{w} \le \frac{3}{2}$	$1 < \frac{l}{w} \le \frac{3}{2}$	0	+0·7	−0·25	−0·6	−0·6	−1·1
		90	−0·6	−0·6	+0·7	−0·25	
	$\frac{3}{2} < \frac{l}{w} < 4$	0	+0·7	−0·5	−0·7	−0·7	−1·1
		90	−0·5	−0·5	+0·7	−0·1	
$\frac{3}{2} < \frac{h}{w} < 6$	$1 < \frac{l}{w} \le \frac{3}{2}$	0	+0·8	−0·25	−0·8	−0·8	−1·2
		90	−0·8	−0·8	+0·8	−0·25	
	$\frac{3}{2} < \frac{l}{w} < 4$	0	+0·7	−0·4	−0·7	−0·7	−1·2
		90	−0·5	−0·5	+0·8	−0·1	
$\frac{h}{w} > 6$	$\frac{l}{w} = \frac{3}{2}$	0	+0·95	−1·85	−0·9	−0·9	−1·25
		90	−0·8	−0·8	+0·9	−0·85	
	$\frac{l}{w} = 1·0$	0	+0·95	−1·25	−0·7	−0·7	−1·25
		90	−0·7	−0·7	+0·95	−1·25	
	$\frac{l}{w} = 2$	0	+0·85	−0·75	−0·75	−0·75	−1·25
		90	−0·75	−0·75	+0·85	−0·75	

NOTE — h is the height to eaves or parapet, l is the greater horizontal dimension of a building and w is the lesser horizontal dimension of a building.

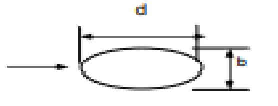
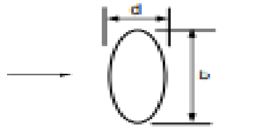
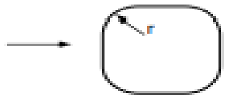
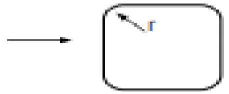
- **Force Coefficient (C_f)**
- The total wind load for a building as a whole is given by the code as follows:

$$F = C_f A_e p_d$$

- Here, F is the force acting in the specified direction, C_f the force coefficient of the structure, Ae the effective frontal area, and P_d the design wind pressure.
- Code gives force coefficient values for clad buildings of uniform sections, buildings of circular shapes, free standing walls and hoardings, unclad buildings and frameworks(flat sided members, circular sections, wires and cables, single frames, multiple frames and lattice towers)

- **Force Coefficient (Cf)**

Table 20: Force coefficients C_f for clad buildings of uniform section (acting in the direction of wind) [*Clause 6.3.2.1*]

Plan Shape		$V_z b$ m^2/s	C_f for Height / Breadth Ratio ≤ 2	10	≥ 20
	All Surfaces	< 6	0.7	0.9	1.2
	Rough or with projections	≥ 6			
	Smooth	≥ 6	0.5	0.5	0.6
	Ellipse b/d = 1/2	< 10	0.5	0.6	0.7
		≥ 10	0.2	0.2	0.2
	Ellipse b/d = 2	< 8	0.9	1.1	1.7
		≥ 8	0.9	1.1	1.5
	b/d = 1 r/b = 1/3	< 4	0.6	0.8	1.0
		≥ 4	0.4	0.5	0.5
	b/d = 1 r/b = 1/6	< 10	0.8	1.0	1.3
		≥ 10	0.5	0.6	0.6
	b/d = 1/2 r/b = 1/2	< 3	0.3	0.3	0.4
		≥ 3	0.2	0.3	0.3
	b/d = 1/2 r/b = 1/6	All values	0.5	0.6	0.7

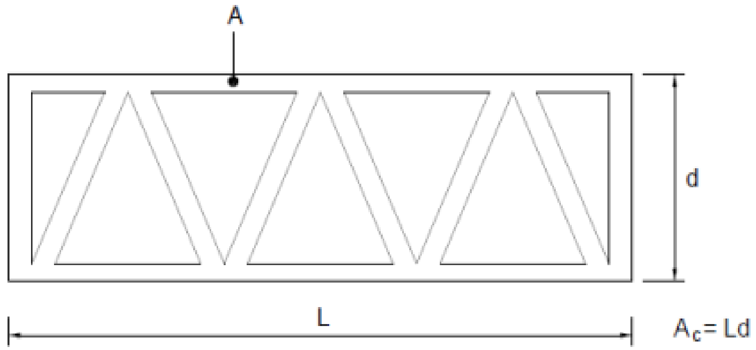
Determination of Wind Load as per IS 875 Part 3

- The wind pressure/Force coefficients depend on the following factors:
- 1. Shape of the building or roof or cross section of member
- 2. Slope of the roof
- 3. Direction of wind with respect to building
- 4. Zone of the building
- 5.Solidity ratio
- The solidity ratio (Ø) is given by Expression

  $$\text{Ø} = \frac{A}{A_c}$$

  Where A is the sum of the projected areas of the members

  Ac is the overall envelope area Ac =l.b



Determination of Wind Load as per IS 875 Part 3

- **Dynamic Wind Response**
- Dynamic effects need to be studied if
  1. Buildings and closed structures with a height to minimum lateral dimension ratio of more than 5.0 (h/b > 5.0)
  2. Buildings and close structures whose fundamental natural frequency (first mode) is less than 1.0 Hz
- Hourly mean wind speed is used as a reference wind speed to be used in dynamic wind analysis.
- For calculation of along wind loads and response (bending moments, shear forces, or tip deflections) the Gust Factor (GF}method is used.

- **Hourly Mean Wind Speed**

The hourly mean wind speed at height z, for different terrains can be obtained as

$$\overline{V}_{z,H} = \overline{k}_{2,i} V_b$$

where

$\overline{k}_{2,i}$ = hourly mean wind speed factor for terrain category

$$= 0.1423 \left[\ln\left(\frac{z}{z_{0,i}} \right) \right] (z_{0,i})^{0.0706}$$

The design hourly mean wind speed at height z can be obtained as:

$$\overline{V}_{z,d} = \overline{V}_{z,H} k_1 k_3 k_4$$
$$= \overline{V}_b k_1 \overline{k}_{2,i} k_3 k_4$$

- **Design Hourly Mean Wind Pressure** $\overline{P}_Z = 0.6 \overline{V}_{z,d}^2$

Determination of Wind Load as per IS 875 Part 3

- **Gust Factor**
- For calculation of along-wind load effects at a levels on a structure, the design hourly mean wind pressure at height z shall be multiplied by the Gust Factor (GF).
- G = Gust Factor and is given by,

$$= 1 + r\sqrt{\left[g_v^2 B_s (1+g)^2 + \frac{H_s g_R^2 S E}{\beta}\right]}$$

- Gust Factor depends on
  - Level at which forces need to be calculated
  - Turbulence Intensity
  - Terrain Category
  - Fundamental Frequency of the structure
  - Damping in the structure

Determination of Wind Load as per IS 875 Part 3

- **Across Wind Response**
- **The across wind design peak base bending moment Mc, for enclosed buildings and towers shall be determined as follows:**

- **Mc=** $0.5 g_h p_h b h^2 (1.06 - 0.06k)\sqrt{\left(\frac{\pi C_{fs}}{\beta}\right)}$
- **k = a mode shape power exponent for representation of the fundamental mode shape**

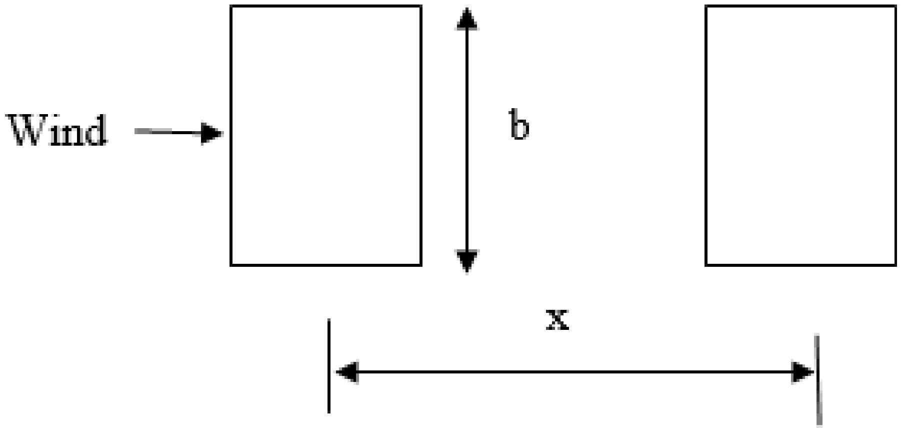
- **The across wind load per unit height**

$$F_{z,c} = \left(\frac{3M_c}{h^2}\right)\left(\frac{z}{h}\right)$$

- Interference Effect
- Wind pressure get significantly modified due to presence of surrounding other structures.
- Due to high turbulence it get enhanced
- This is a complex phenomenon and need to be studied by conducting CFD or Wind tunnel studies.
- For preliminary design estimates Interference Factor (IF) is introduced in the code.

Determination of Wind Load as per IS 875 Part 3

- **Low Height buildings (Height < 50m)**

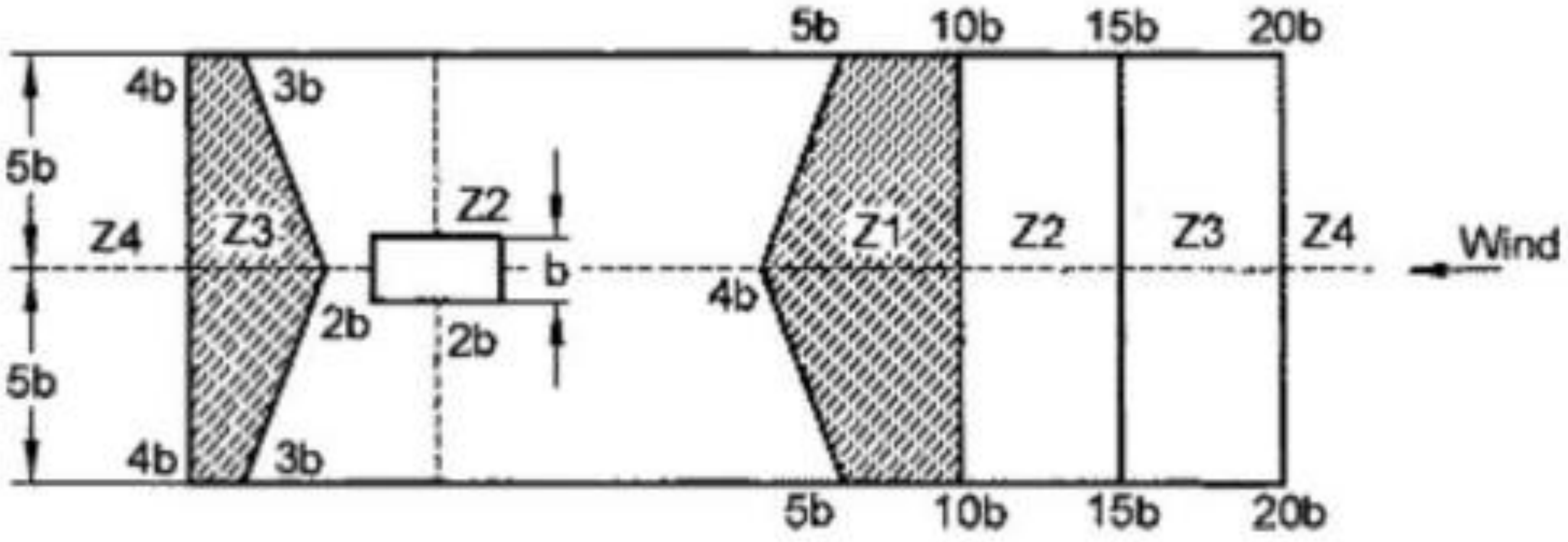


$x \le 0.5b$	IF = 1.00
$2b \le x \le 5b$	IF = 1.25
$x = 10b$	IF = 1.10
$x = 20b$	IF = 1.00

Determination of Wind Load as per IS 875 Part 3

- **Tall buildings (Height > 50m)**

Zone	Z1	Z2	Z3	Z4
IF	1.35	1.25	1.15	1.07



Z1 - Zone of high interference
Z2 - Zone of moderate interference
Z3 - Zone of low interference
Z4 - Zone of insignificant interference

Wind Load provisions in IRC-6 for bridge structures

- **Wind Load clauses need discussion**
- Clause No 209.1

  Applicable for span length up to 150m or pier height up to 100m

  No provision for Dynamic Wind Effects
- Clause No 209.2
- The intensity of wind force depends upon Hourly mean wind speed & pressure
- Only two terrain categories are defined.

Table 12: Hourly Mean Wind Speed and Wind pressure
(For a Basic wind speed of 33 m/s as shown in Fig. 10)

H (m)	Bridge Situated in			
	Plain Terrain		Terrain with Obstructions	
	V_z (m/s)	P_z (N/m^2)	V_z (m/s)	P_z (N/m^2)
Up to 10 m	27.80	463.70	17.80	190.50
15	29.20	512.50	19.60	230.50
20	30.30	550.60	21.00	265.30
30	31.40	590.20	22.80	312.20
50	33.10	659.20	24.90	373.40
60	33.60	676.30	25.60	392.90
70	34.00	693.60	26.20	412.80
80	34.40	711.20	26.90	433.30
90	34.90	729.00	27.50	454.20
100	35.30	747.00	28.20	475.60

Wind Load provisions in IRC-6

- Wind Load as per IRC-6 for bridge structures
- Clause No 209.3.3
- Single Value of 2 is provided for Gust Factor

The drag coefficient for slab bridges with width to depth ratio of cross-section, i.e $b/d \geq 10$ shall be taken as 1.1.

- What d to be taken for calculation of area?
- What d to be taken for calculation of Cd?
- What about b/d<10?

For bridge decks supported by single beam or box girder, C_D shall be taken as 1.5 for b/d ratio of 2 and as 1.3 if $b/d \geq 6$. For intermediate b/d ratios C_D shall be interpolated. For deck supported by two or more beams or box girders, where the ratio of clear distance between the beams of boxes to the depth does not exceed 7, C_D for the combined structure shall be taken as 1.5 times C_D for the single beam or box.

For deck supported by single plate girder it shall be taken as 2.2. When the deck is supported by two or more plate girders, for the combined structure C_D shall be taken as $2(1+c/20d)$, but not more than 4, where c is the centre to centre distance of adjacent girders, and d is the depth of windward girder.

- Applicable for construction stages

Wind Load provisions in IRC-6

- Wind Load as per IRC-6 for bridge structures
- Clause No 209.3.5

209.3.5 An upward or downward vertical wind load F_V (in N) acting at the centroid of the appropriate area, for all superstructures shall be derived from:

- No provision for eccentricity
- Clause No 209.3.7

209.3.7 The bridges shall not be considered to be carrying any live load when the wind speed at deck level exceeds 36 m/s.

- Wind speed whether basic or design?
- Clause No 209.5
- No provisions for Wind Tunnel Test

IRC-6 Wind Load Code :-Draft

THANK YOU