Wind City Buildings

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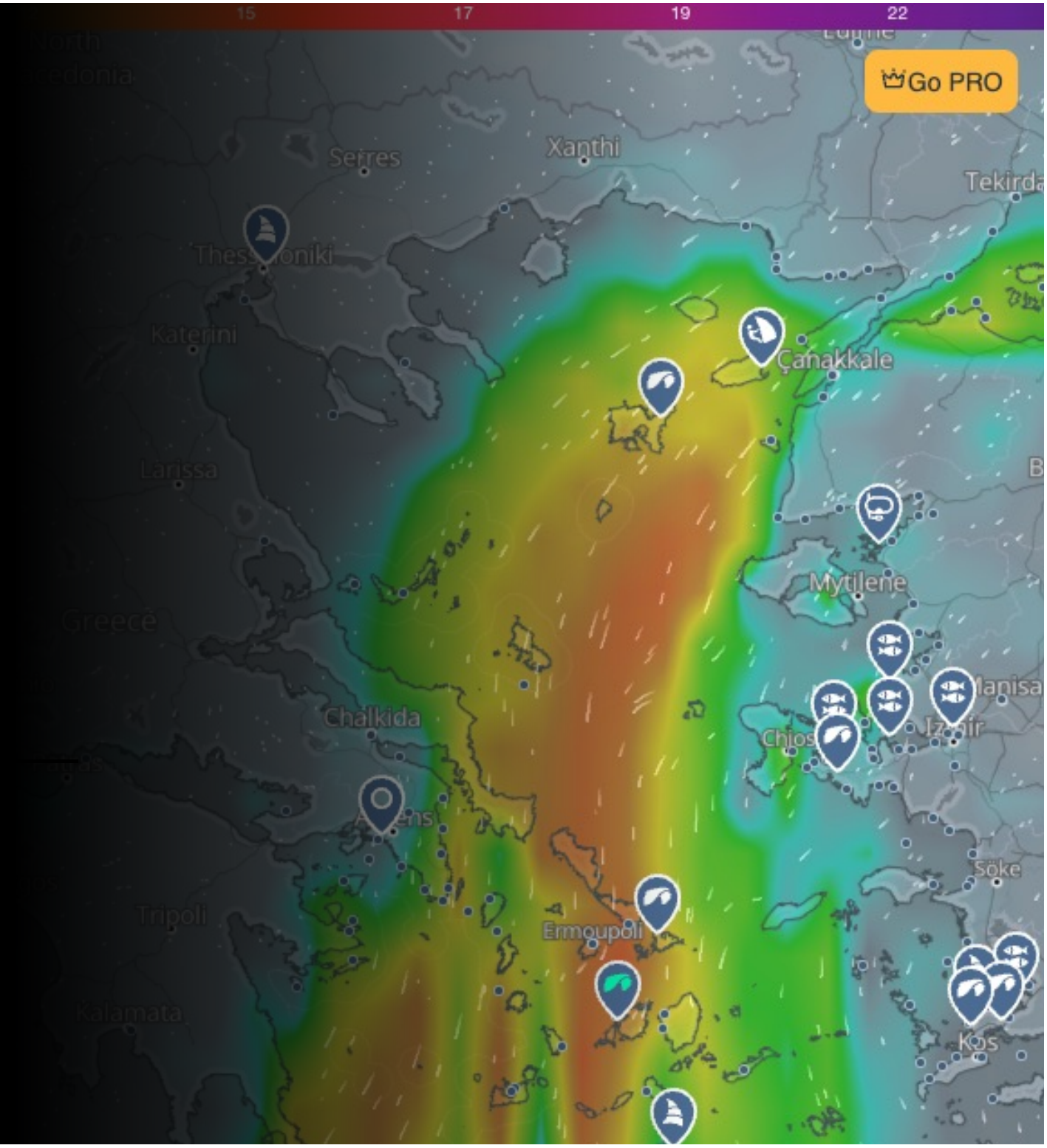
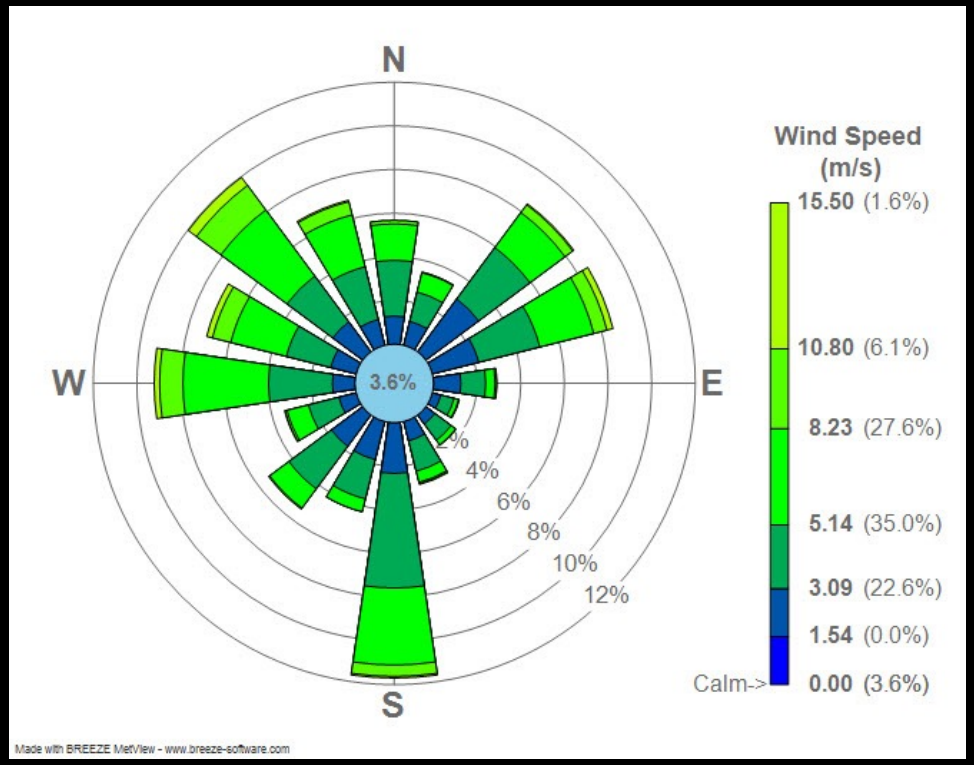
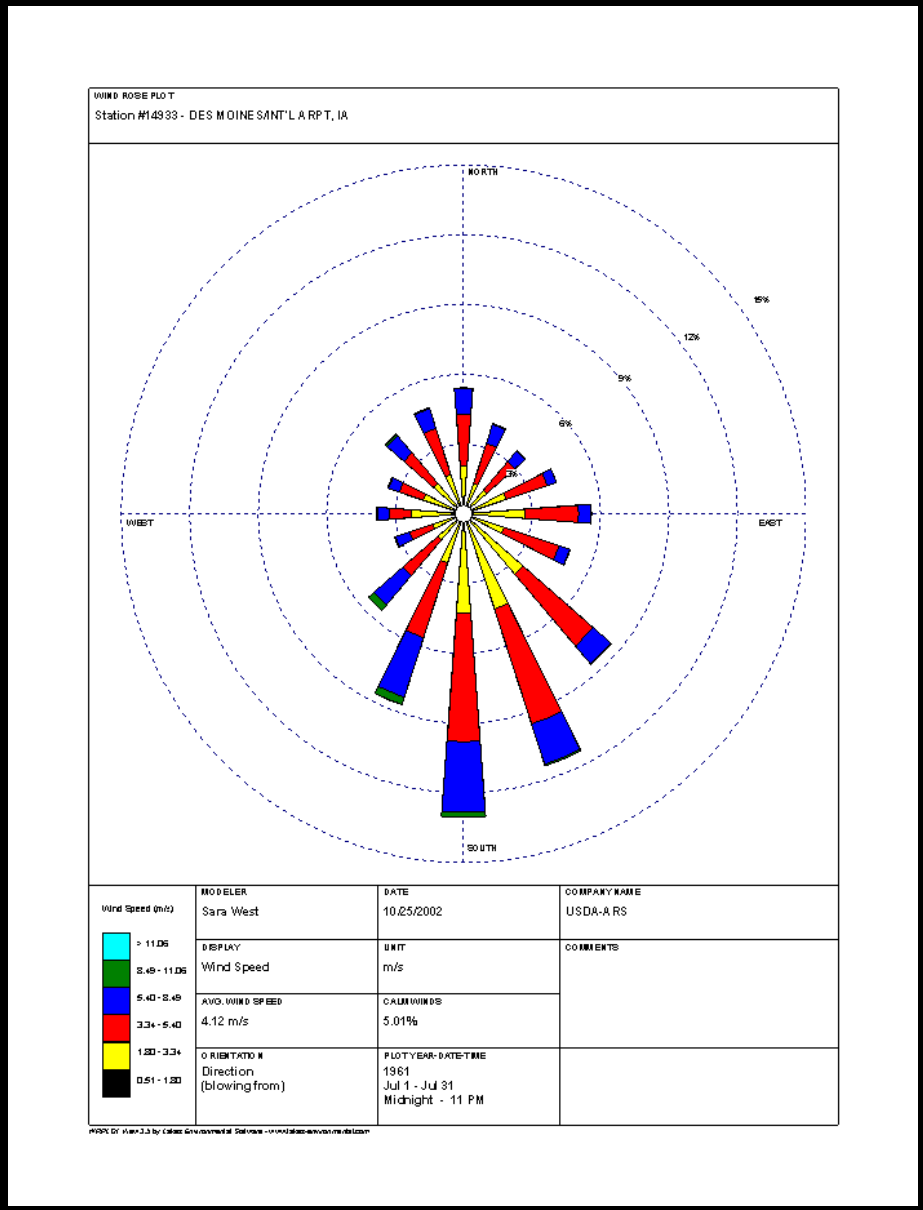


Wind Rose (charts)





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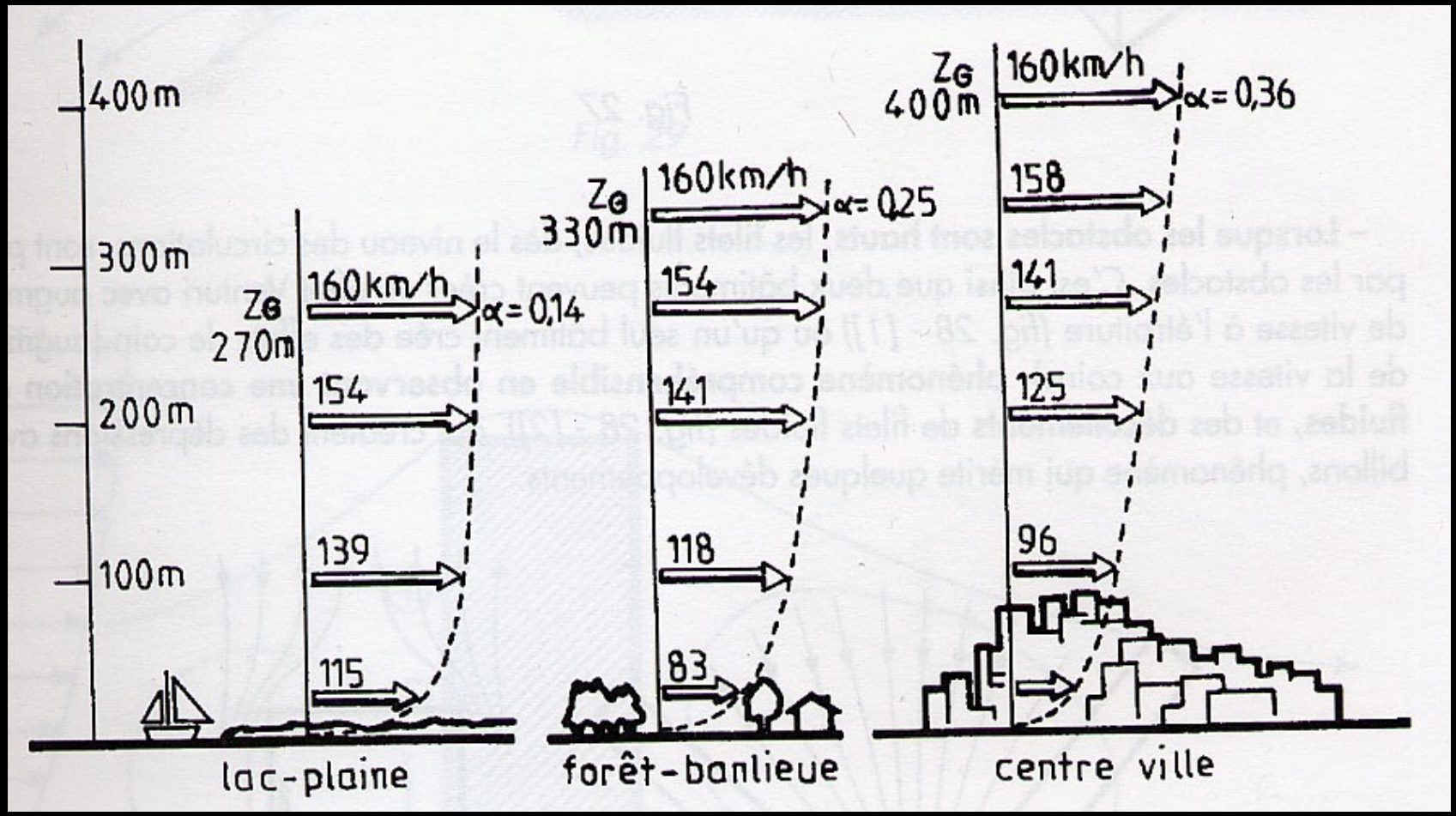
The wind phenomenon on an urban scale

1- Wind, boundary layer and roughness



Cf. Chatelet et alii

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Formula

In turbulent flow, the force applied by the wind on the sleeve is expressed as follows:

No worries, we'll explain all the parameters below:

- r is the air density = 1.292 kg.m-3
- v is the speed in m.s-1
- S is the surface area of the sleeve = 18 * 10 cm2
- Cx is the drag coefficient = 1.1
- F is the force expressed in Newton

$$F = \frac{1}{2} * \rho * v^2 * S * C_x$$

We want to calculate the wind load that will be exerted on a wooden construction of 3.00 x 5.00 m with a wall height of 3.00 m. The construction is located in the Ardèche department at an altitude of 800 m. The maximum wind speed is 150km/h.

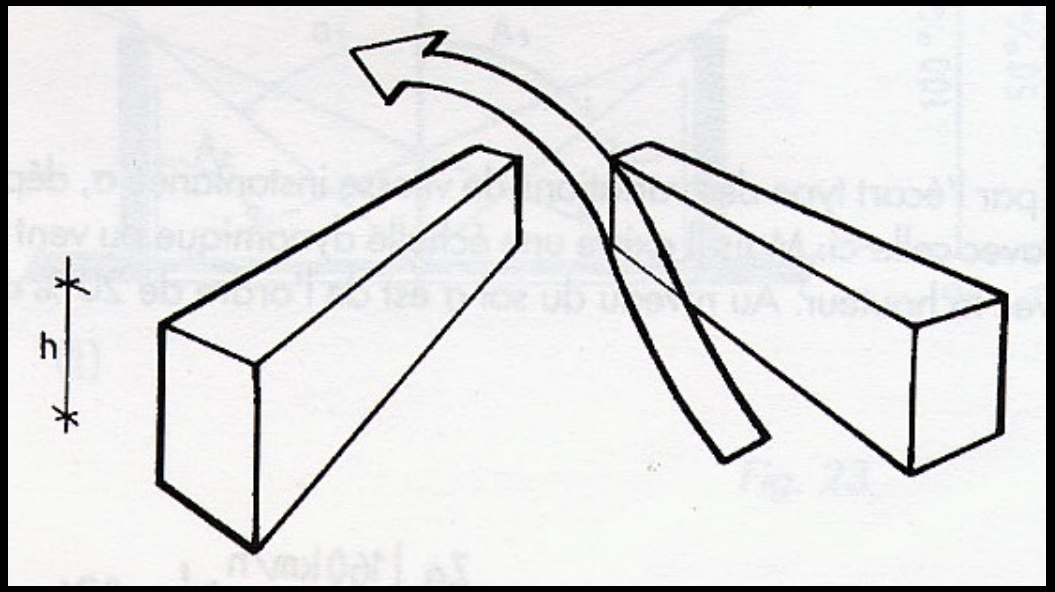
A. Density calculation
According to the formula, we must find P and t°. At an altitude of 800m, we have an atmospheric pressure of 92,078 Pa (value obtained on the internet) and a temperature of:
15 - (800 x 6.4) / 1000 = 9.88 °C or 283.03 °K
The density is therefore equal to:
(92078 x 28.9644) / (8314.32 x 283.03) = 1.133 kg/m3
B. Wind speed calculation
150/3.6 = 41.67 m/s
C. Application area calculation. 5.00x3.00 = 15.00 m²
D. Wind load calculation
0.5 x 1 x 1.133 x 41.67² x 15 = 14754.96 N or 14.75496 kN
Therefore, we can conclude that the load of the wind exerted on our construction is of the order of 14.75 kN or 14 750 N

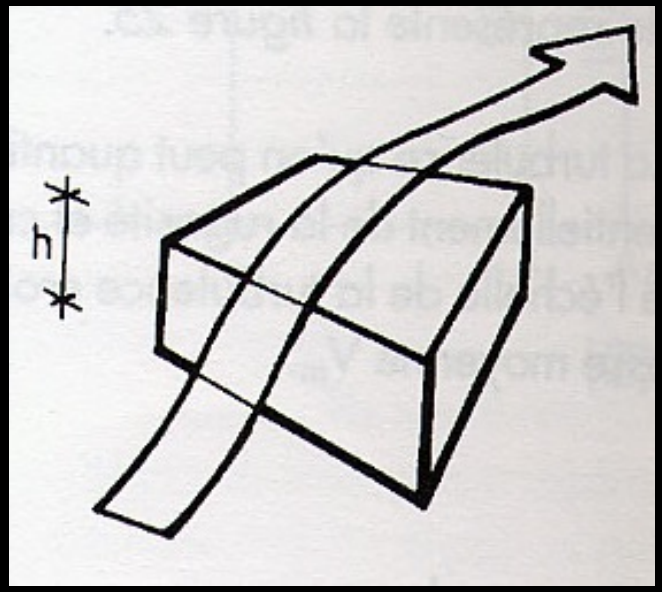
This construction will therefore have to withstand a force equal to 14.75 kN.@

The wind phenomenon on an urban scale

. To have low wind speeds on facades and pathways, it is in your interest to build low-rise buildings in rough areas.

Low obstacle (h<15m) ... the wind passes over it





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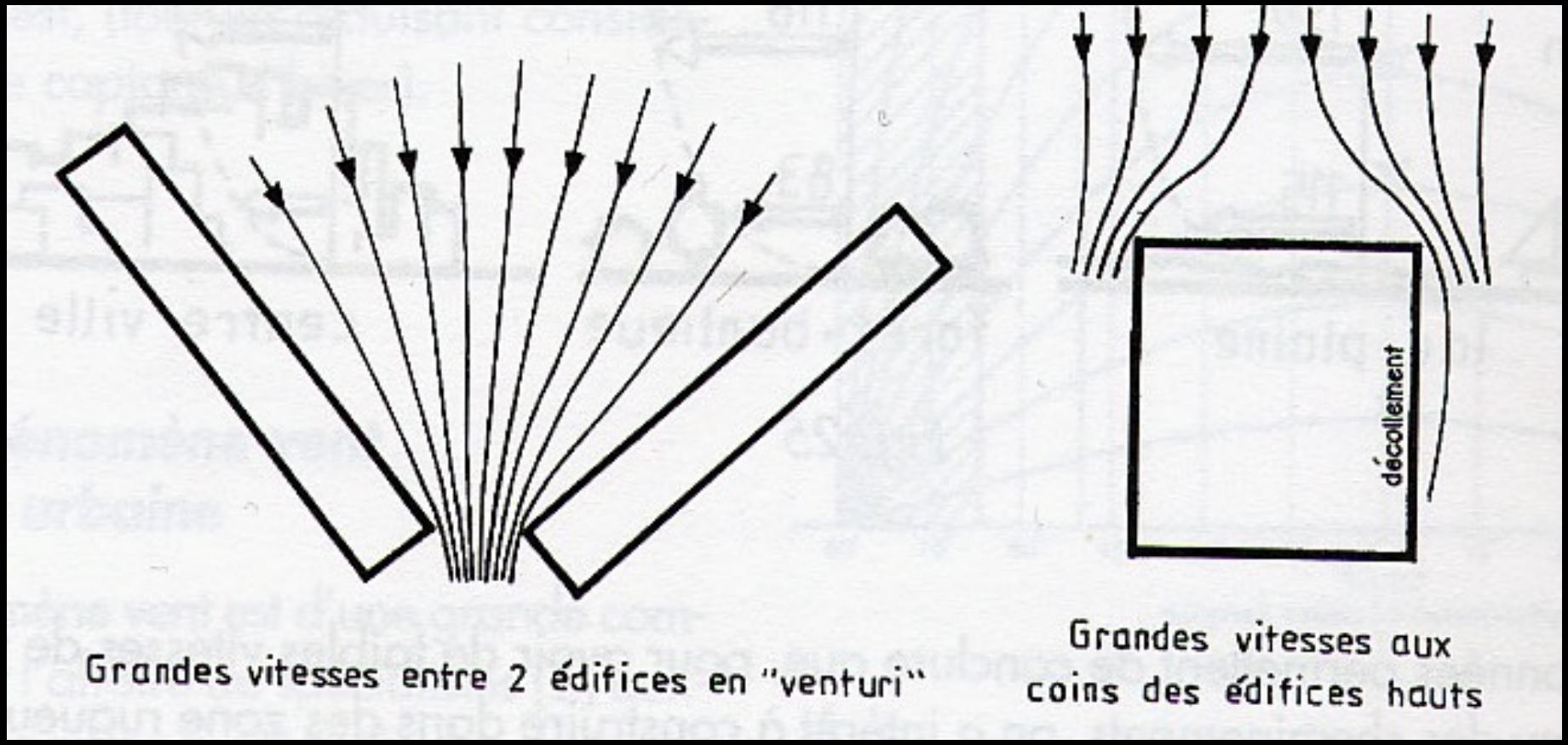
High obstacle (h>15m) = Venturi effect creation = concentration of fluid threads + detachment



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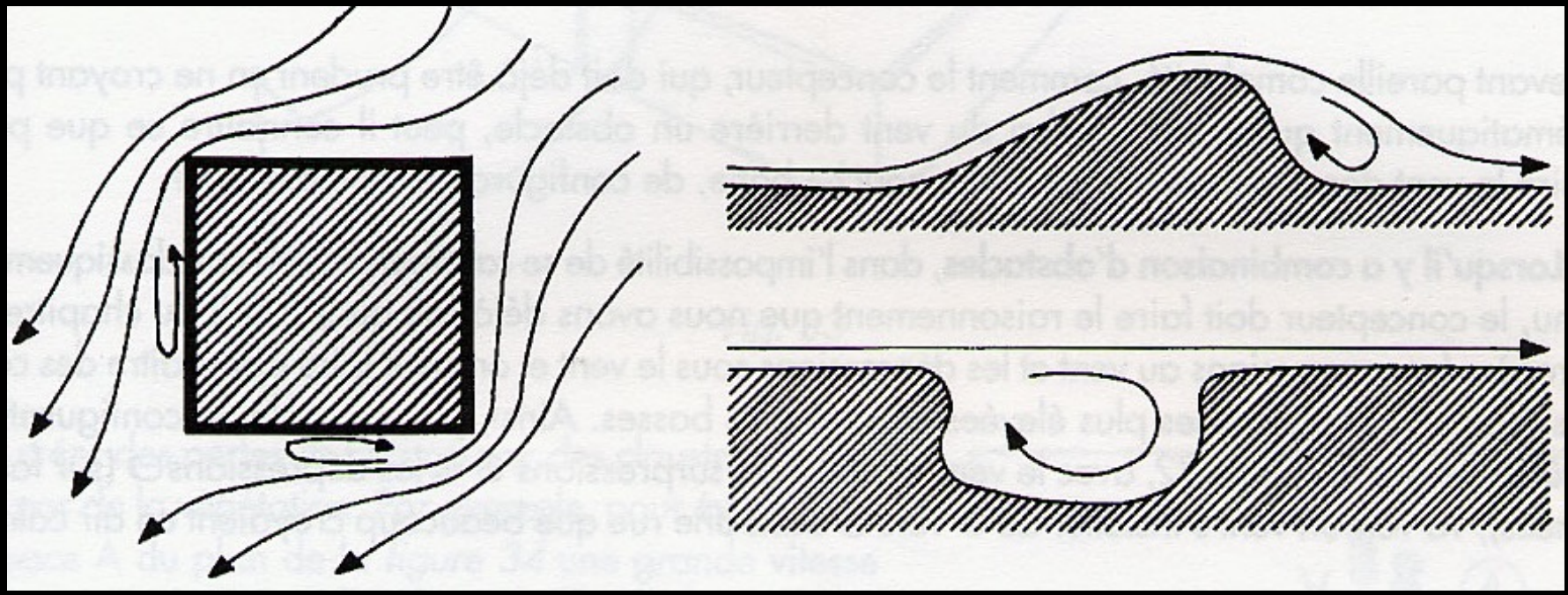
Rapid variation in the profile of the obstacle = Fluid thread detachment + vortex creation



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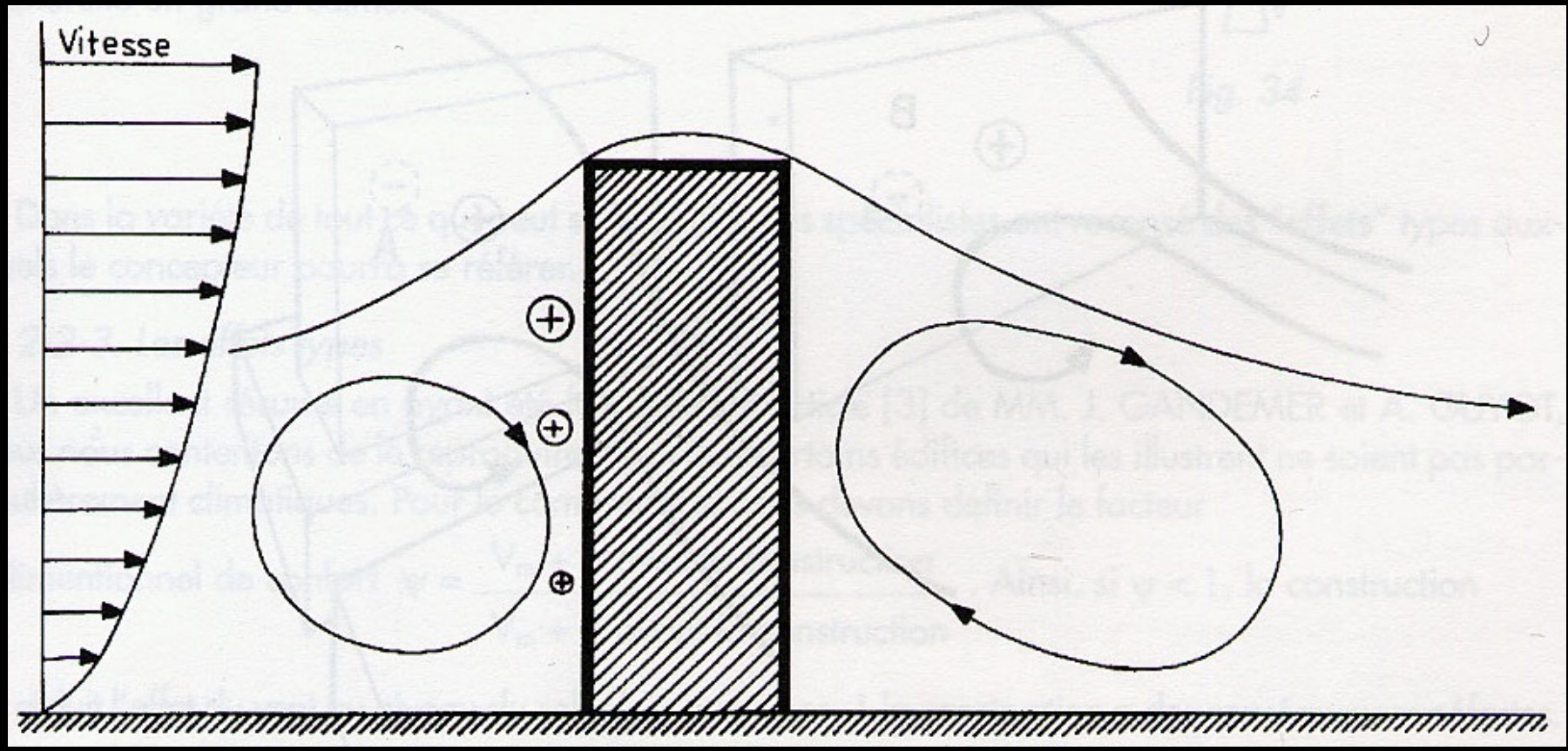

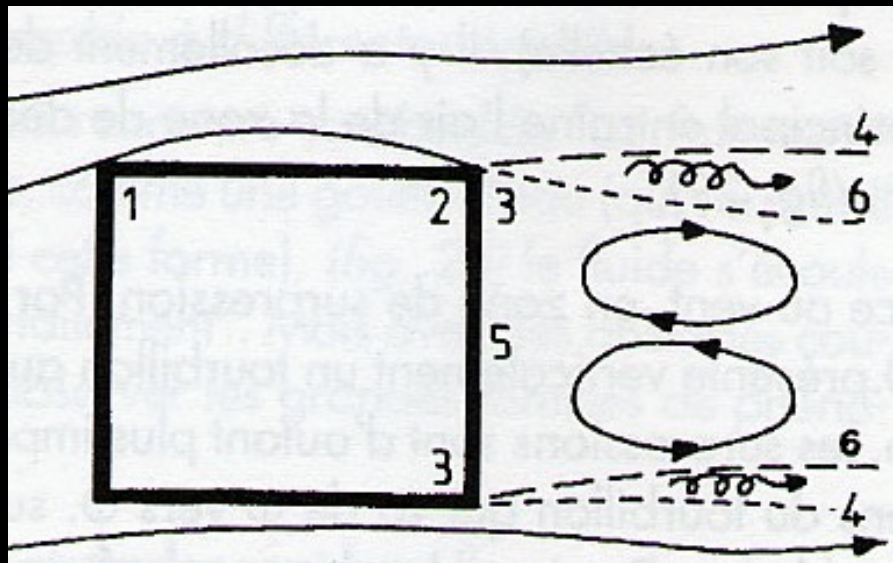

1-2 : zone de décollement
3-4 : ligne de séparation
5 : sillage et circulation tourbillonnaire
6 : épaississement des limites entre sillage et écoulement (principal)

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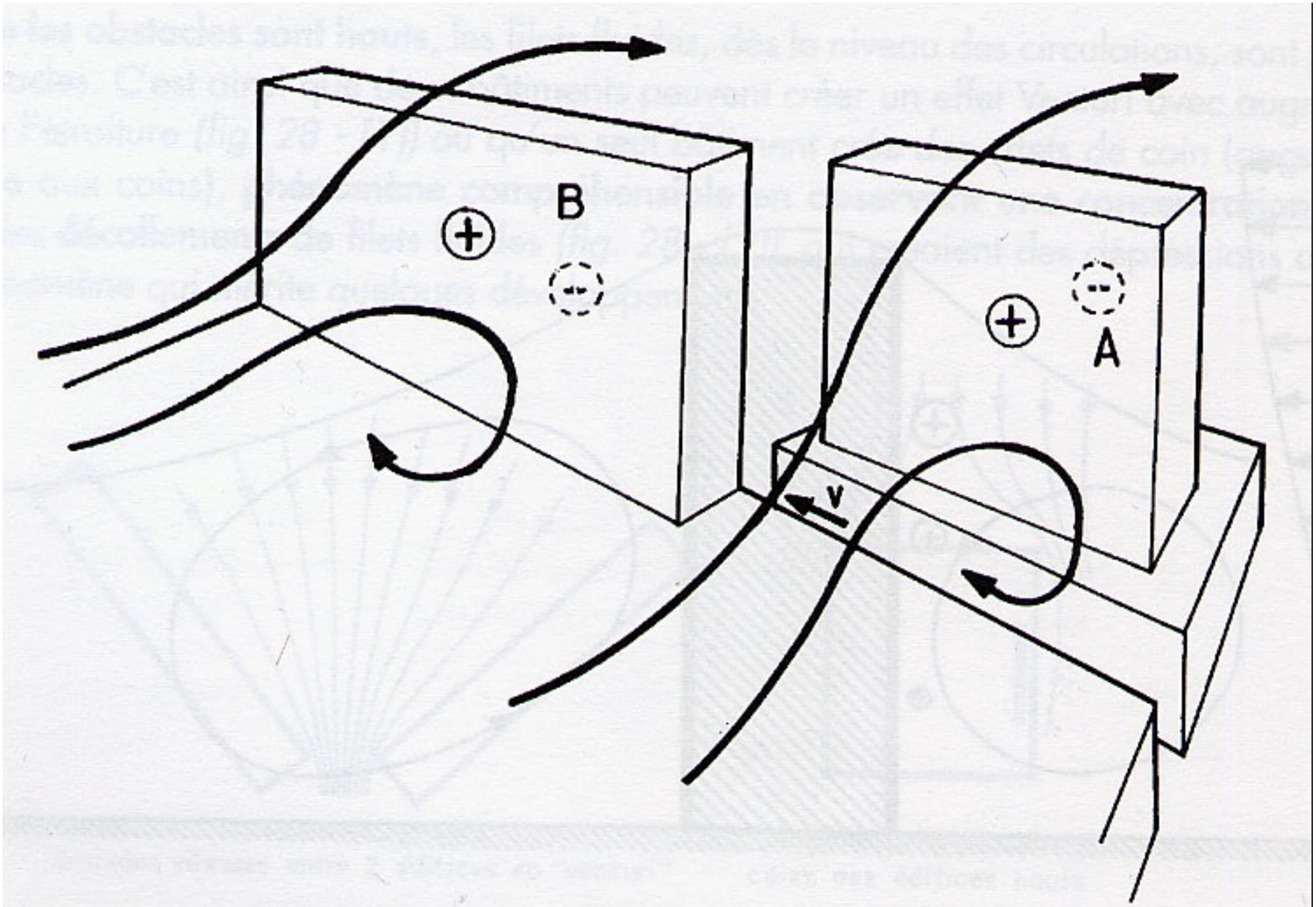
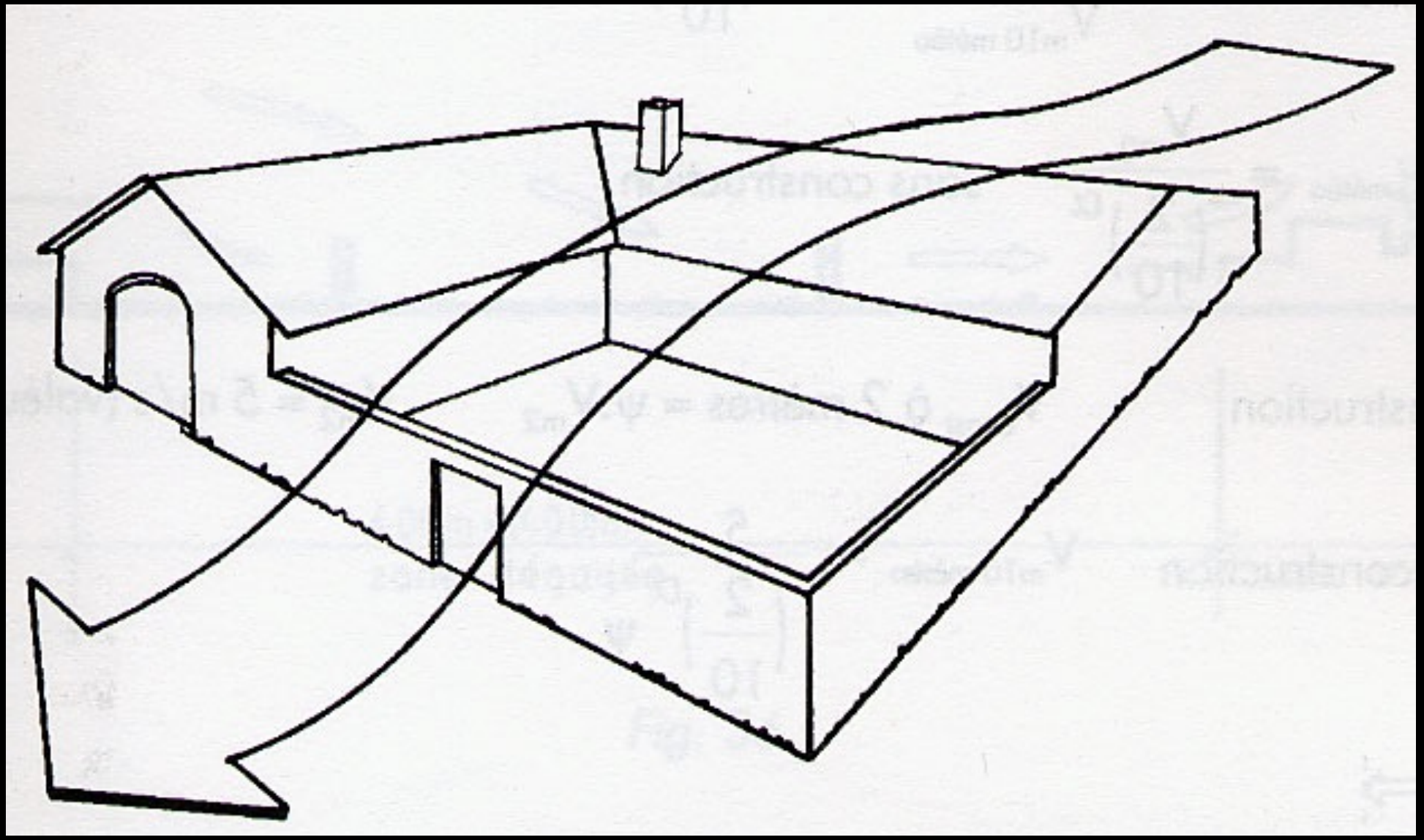
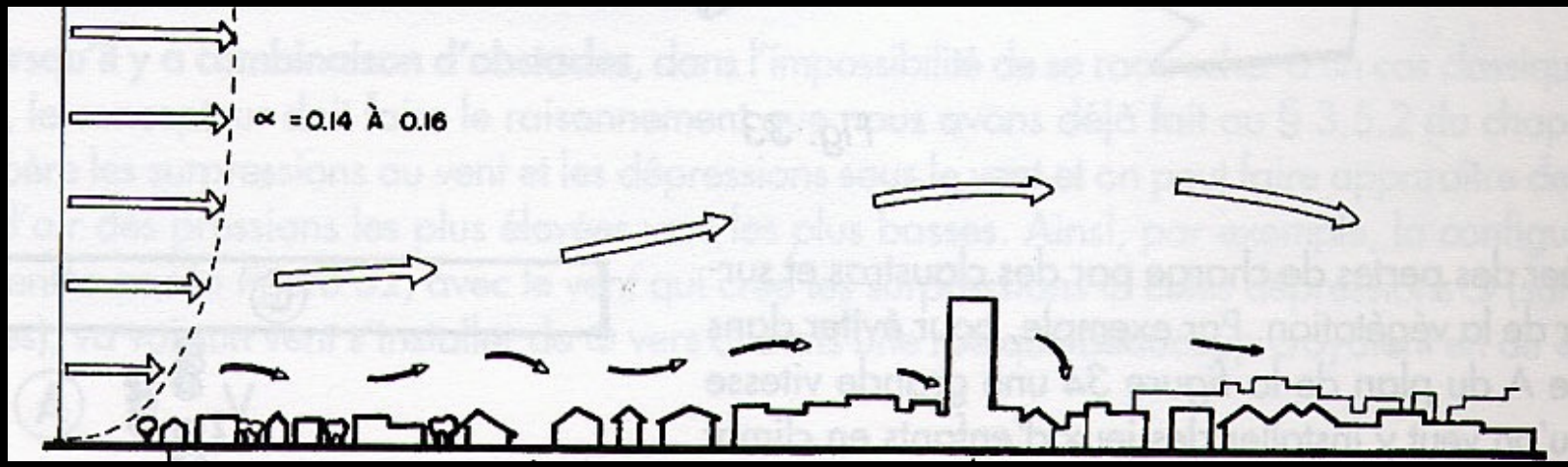
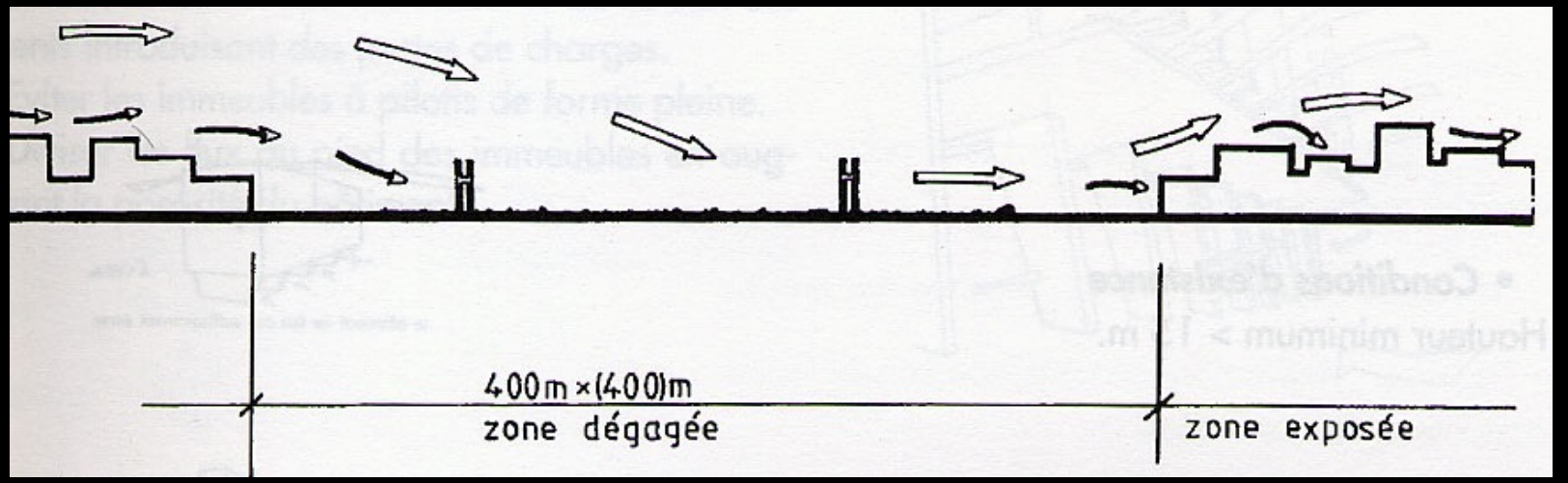

B
A
v

protect a yard from high wind speeds at ground level







The wind only drops if it finds an open area of about 400 m x 400 m

Le phénomène vent à l'échelle urbaine

3- Wind effect due to buildings

. Free areas of the order of 160,000 m2 (sports field) cause the wind to fall

. Sets of "seed" towers produce virtually no roughness effect due to their high height and wide spaces between them.

. Old city centres, by their density and low height, create a protective effect. However, aerodynamic accidents can occur in this type of fabric at the foot of large elements

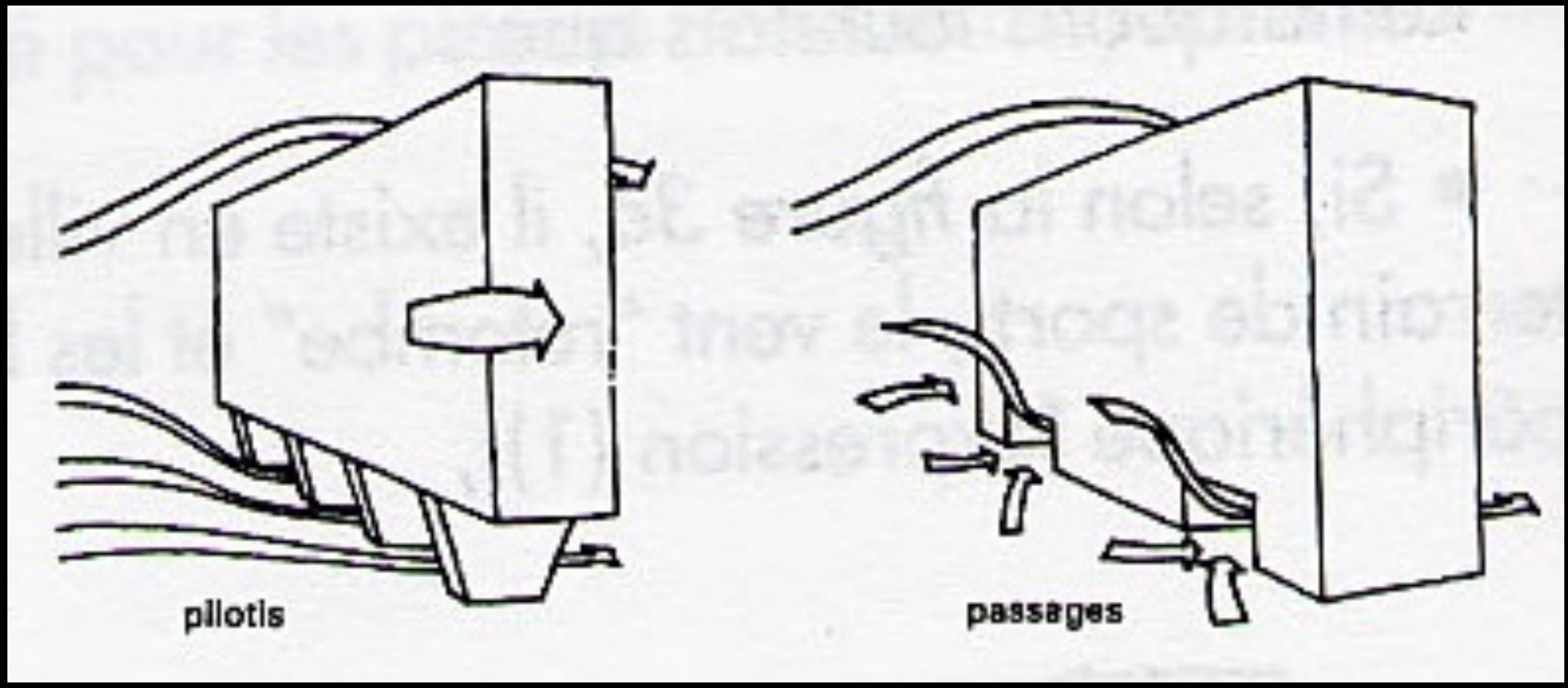
. The effect of a building construction on the wind is defined by a coefficient for a given height.

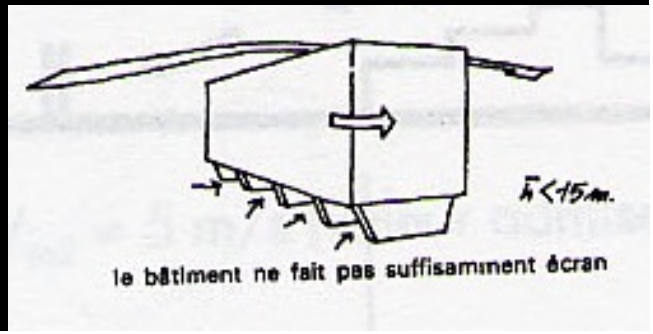
Ψ = (wind speed with construction) / (wind speed without construction)

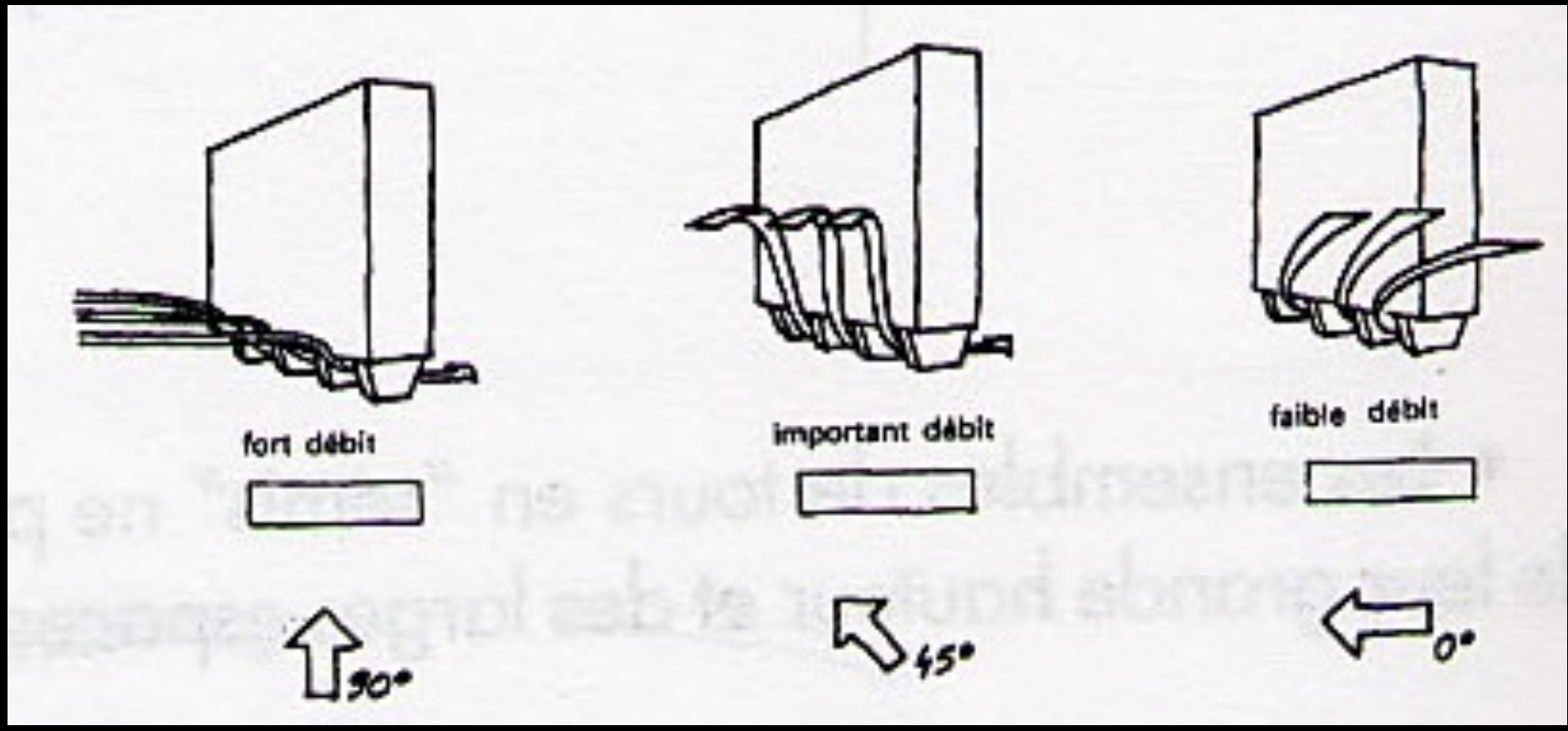
. If $\psi < 1$, then the construction reduces the effect of wind at ground level

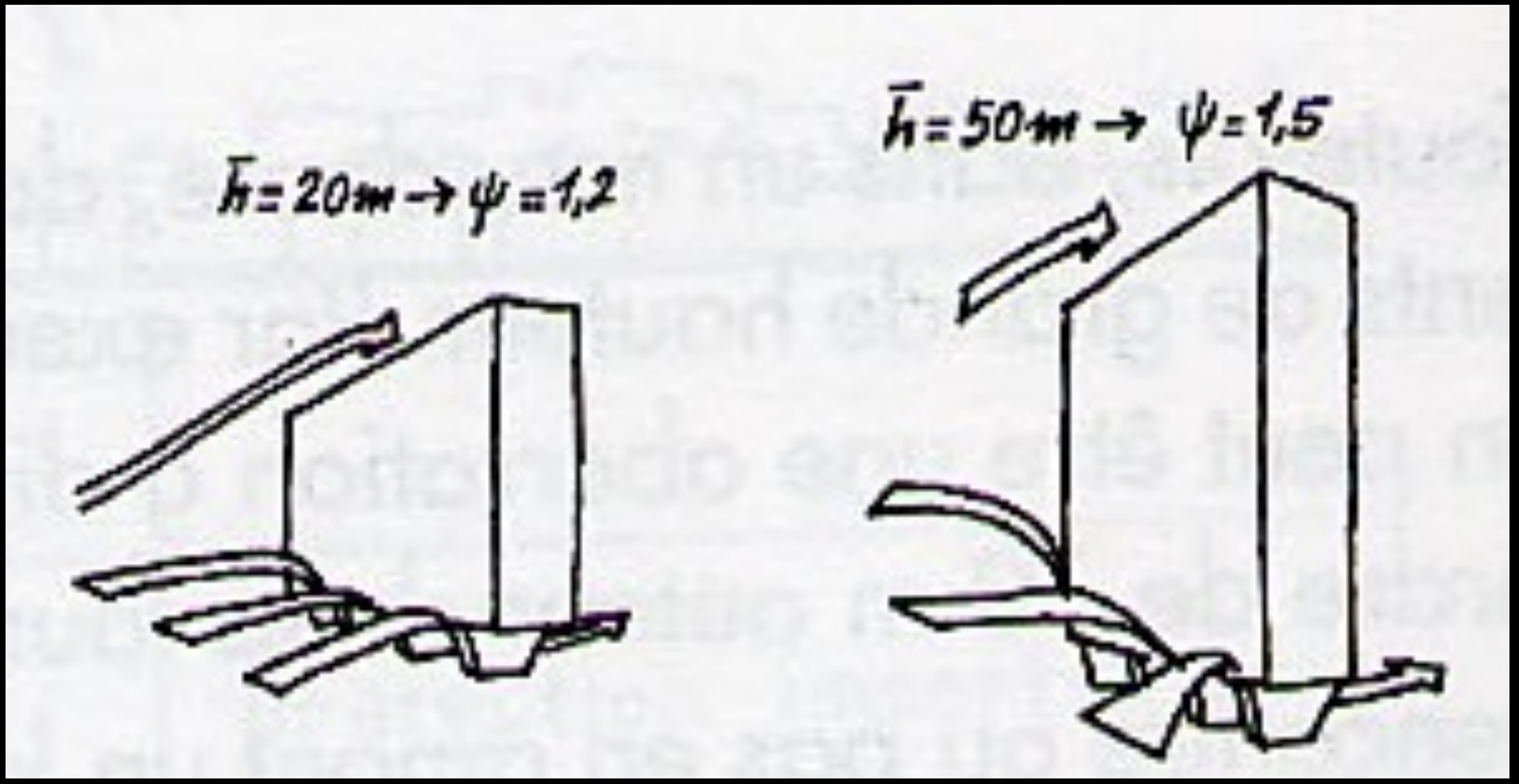
. The maximum allowable speed of comfort for the pedestrian is v = 5m/S

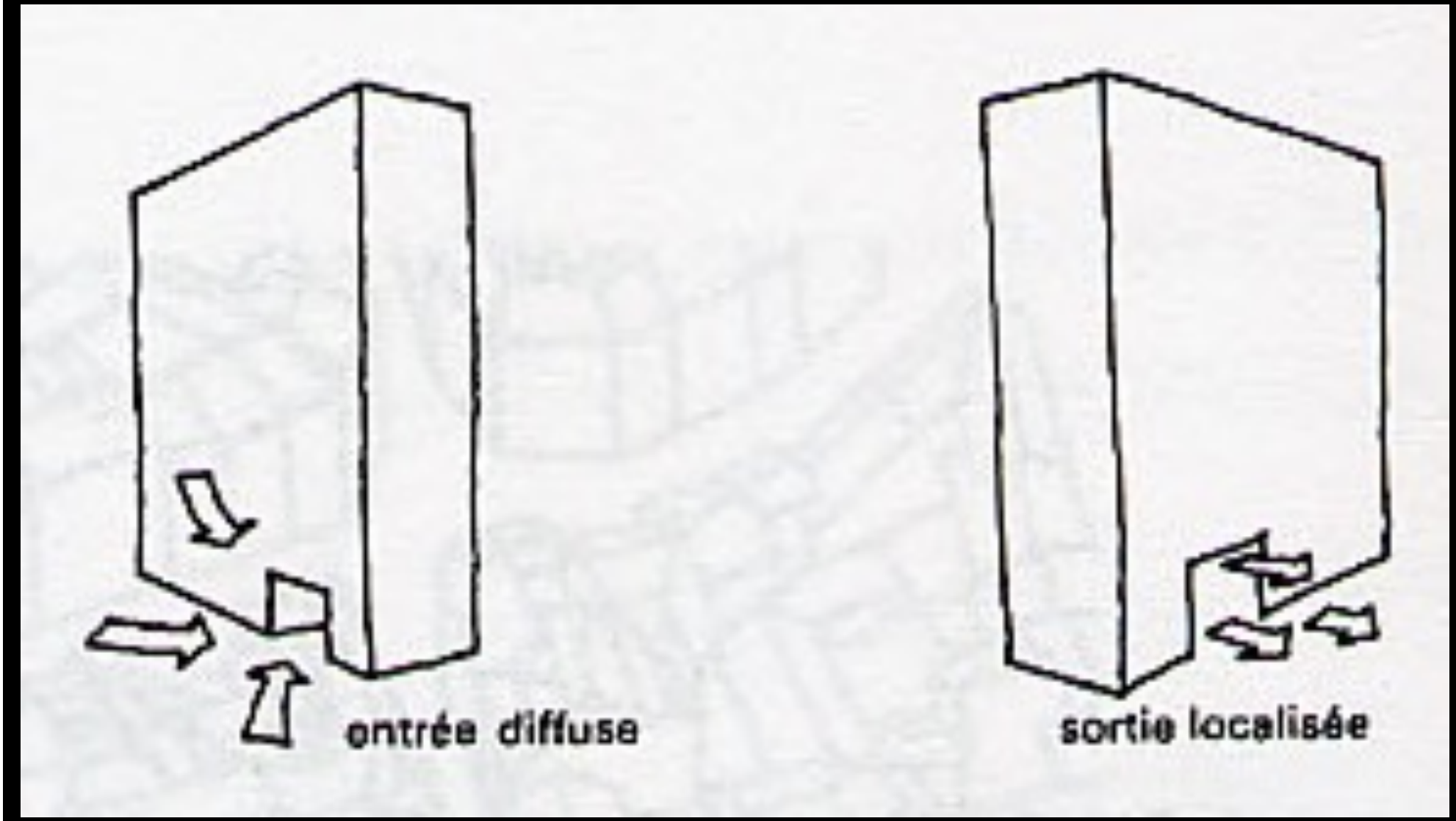
Typical wind effects on buildings with high >15m
phenomenon of flow in holes or passage under buildings



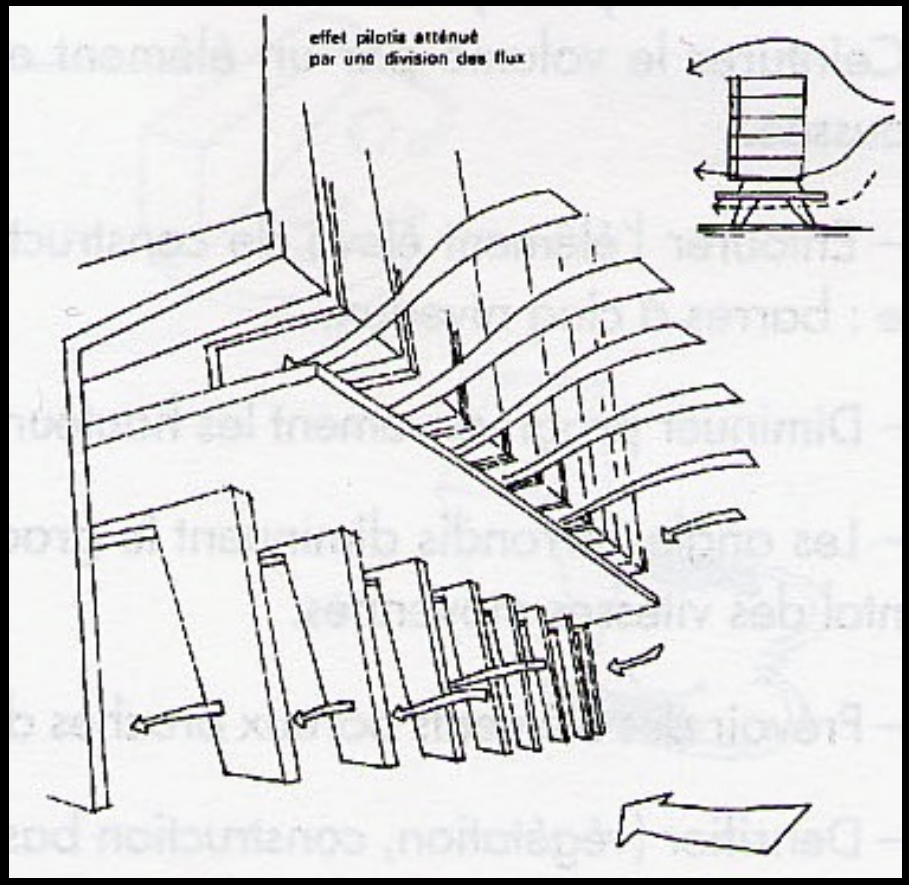



fort débit
important débit
faible débit
90°
45°
0°


$\bar{h}$ = 20 m → ψ = 1,2
$\bar{h}$ = 50 m → ψ = 1,5

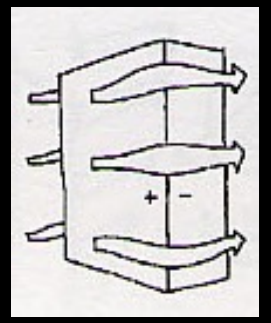

ontrée diffuse
sortie localisée

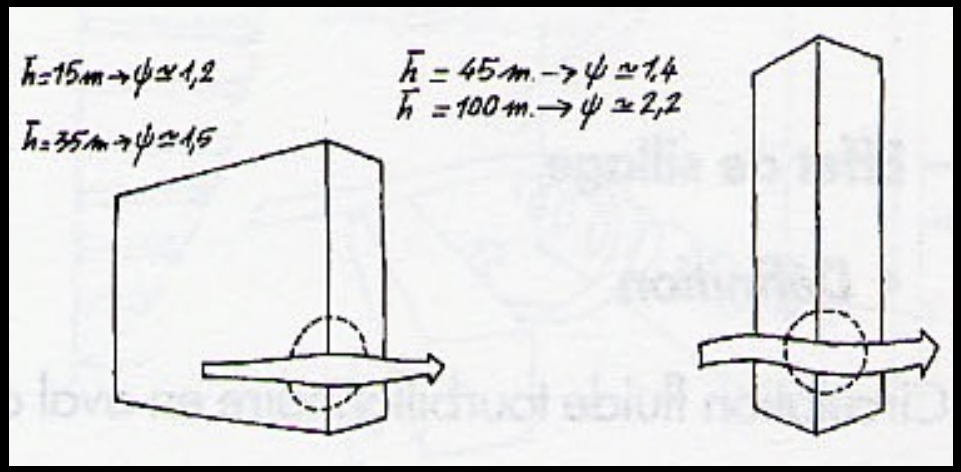
-Orient buildings on stilts or with holes under an incidence parallel to the wind
- Provide the foot of vegetation buildings and buildings
- Introduce elements that introduce pressure drops in the link volumes
- Avoid solid-form stilted buildings
- Divide the flows at the foot of the buildings by increasing the porosity of the building

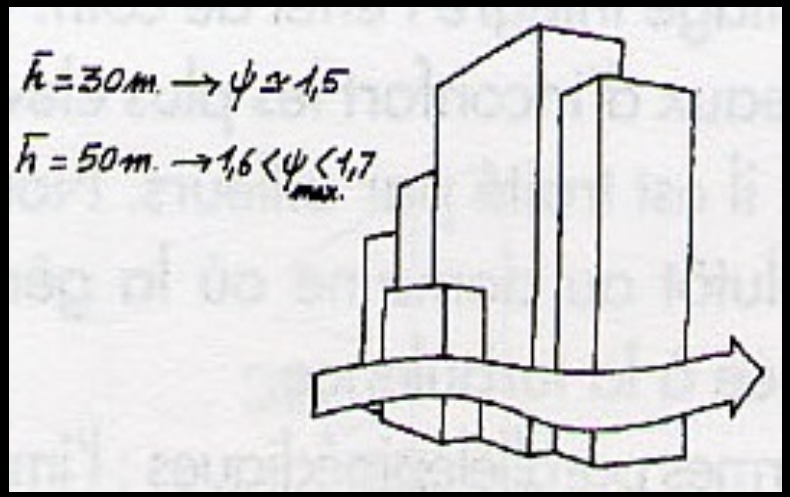


Corner Effect

phenomenon of flow at the corners of buildings that connect the upstream overpressure zone and the lateral depression zone of the building.







Corner effect

. Conseils pratiques

Ceinturer le volume par un élément en rez-de-chaussée

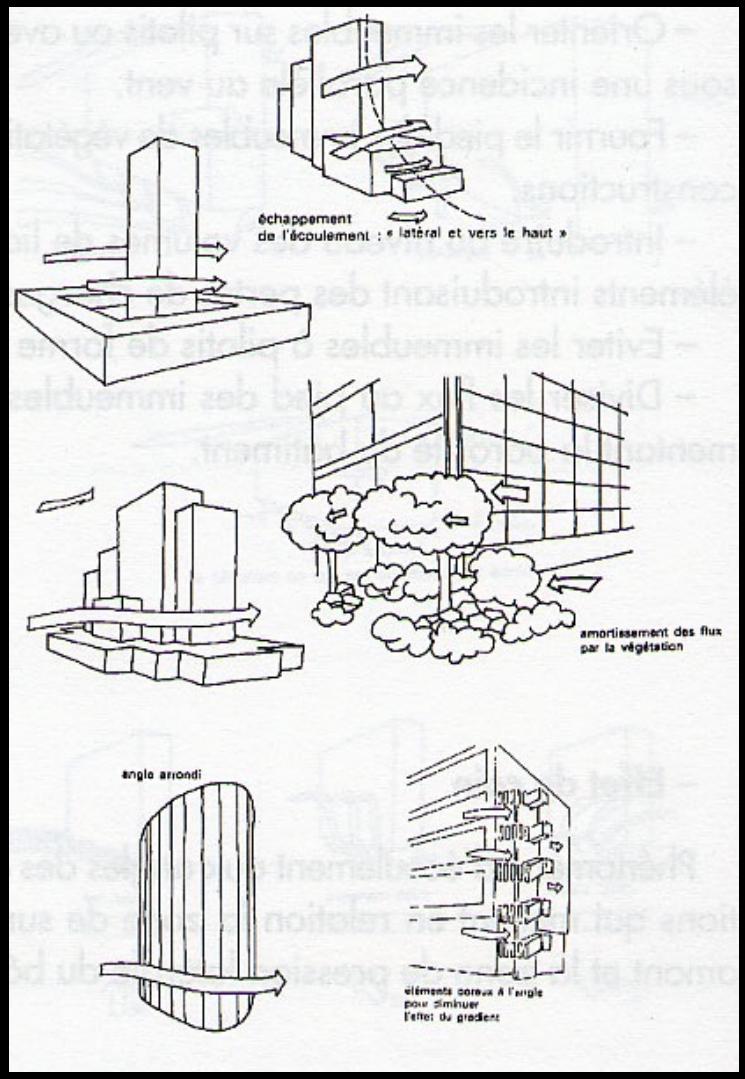
Entourer l'élément élevé de constructions telles que :

. Diminuer progressivement les hauteurs

. Les angles arrondis diminuent la variation de vitesse aux angles

. Prévoir des éléments poreux aux angles

. Densifier (végétation, construction basse) le voisinage immédiat des coins



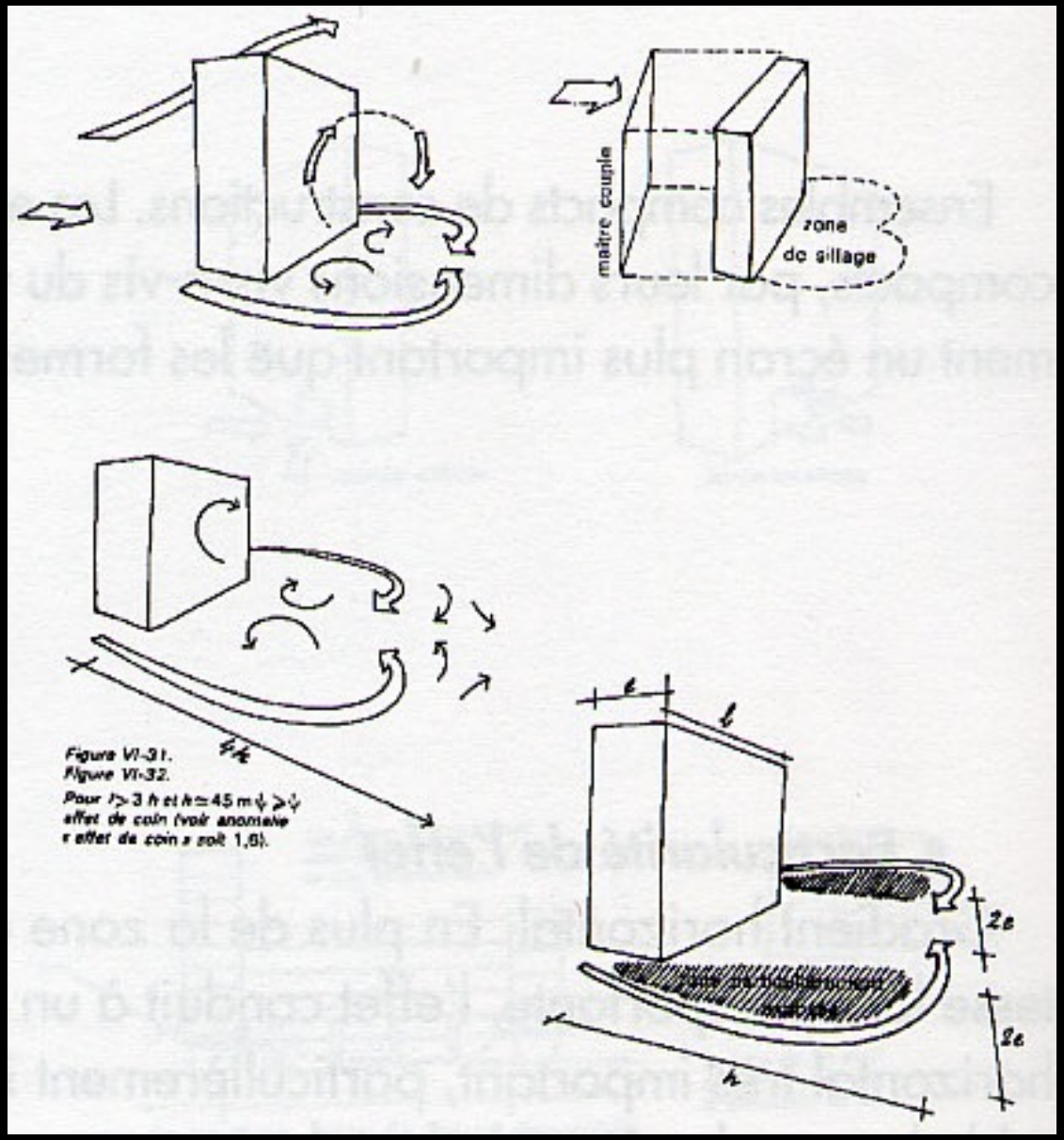
Cf. Chatelet et alii

Wake effect
swirling fluid circulation downstream of the shapes

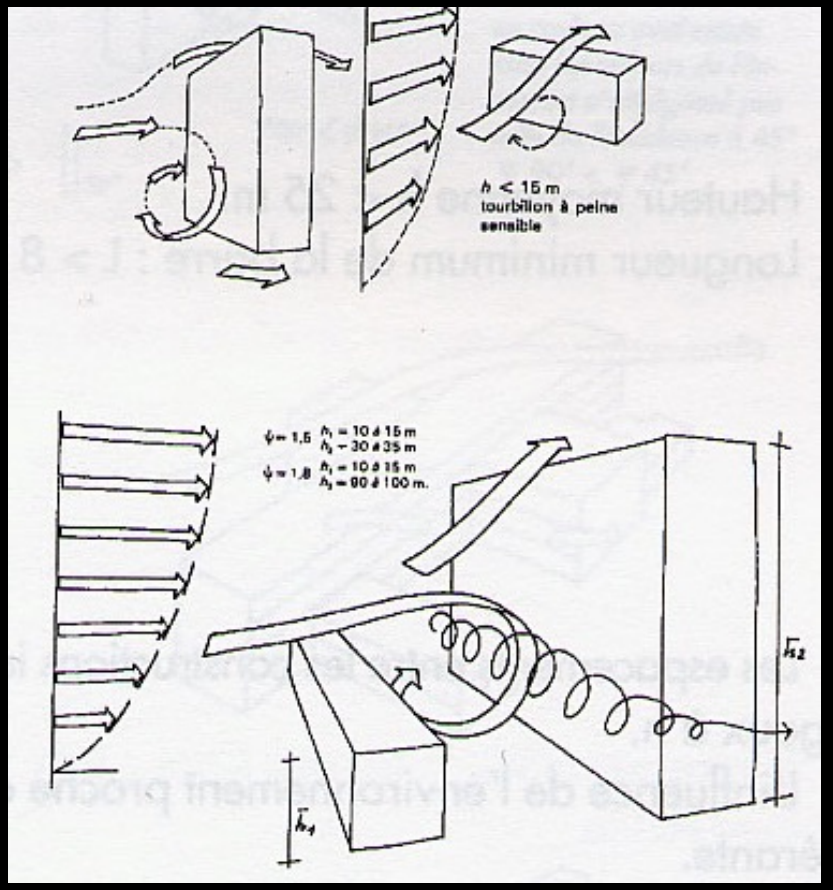
Parallelepiped buildings

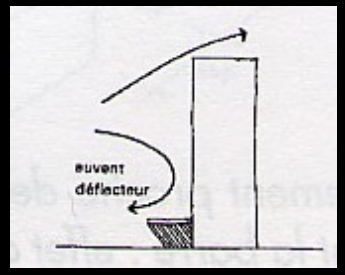
45m < h < 100m
Persistence of the effect over 4 x h
Exposure area = h x 2e

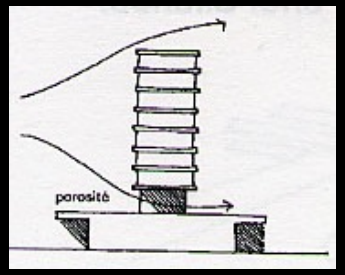
- planting breaks the wake effect
- the denser the built environment
the more the wake effect is attenuated

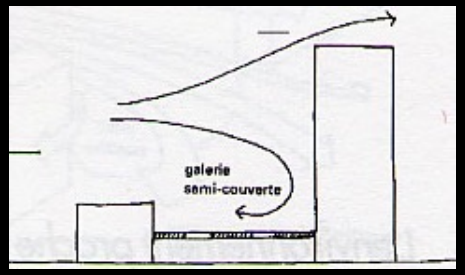


whirlwind roller
whirlwind roller at the foot of the windward face
Tips
Densifying the surrounding environment
Introducing deflector awnings
introduce porosity above the level
pedestrian



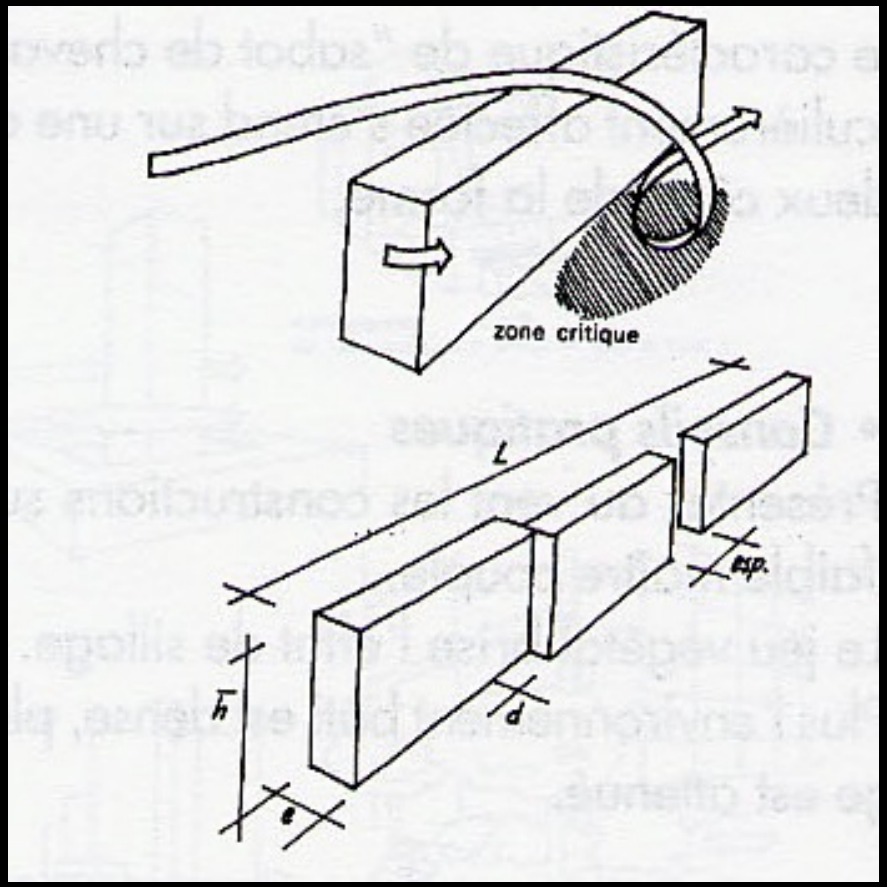


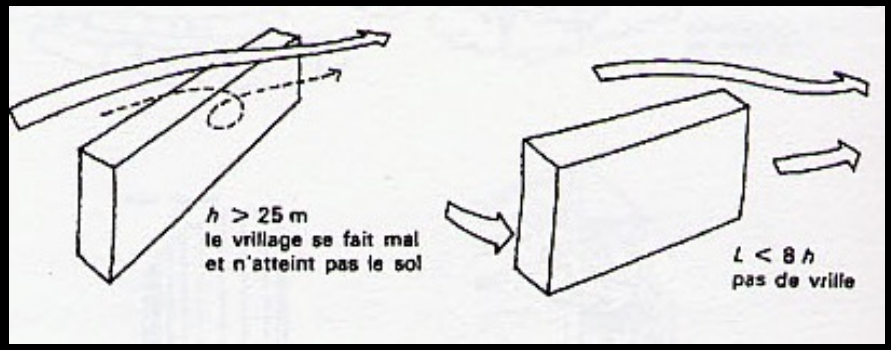


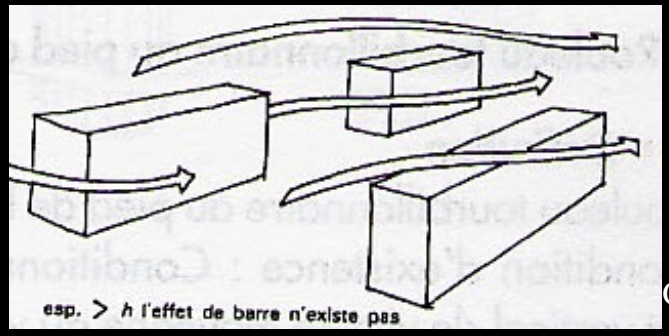


Helm wind effect
. Definition: twisted deflection of the flow when passing a bar for an incidence of around 45°

Minimal conditions of the phenomen to be observed
. Average height h < 25m .
. Minimum bar length L > 8h
. Spacing too large, no effect







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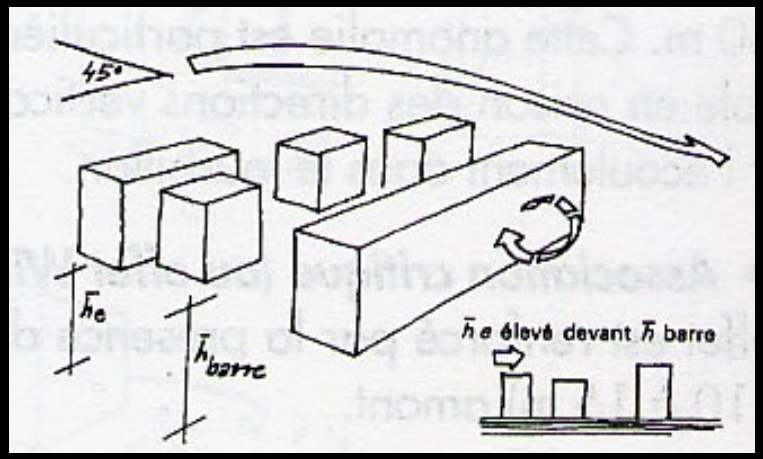
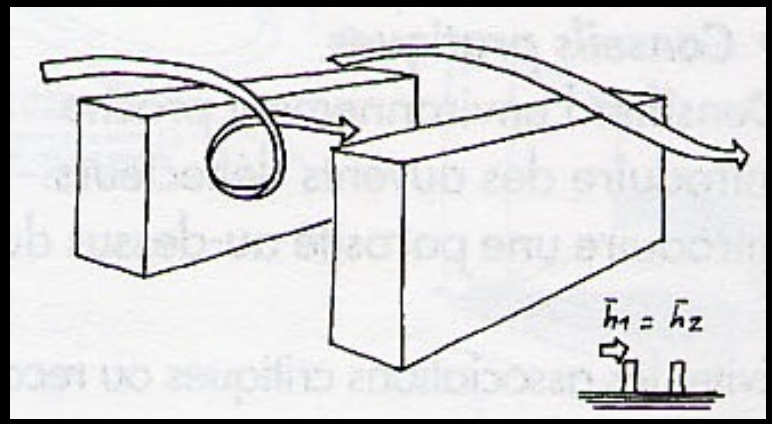
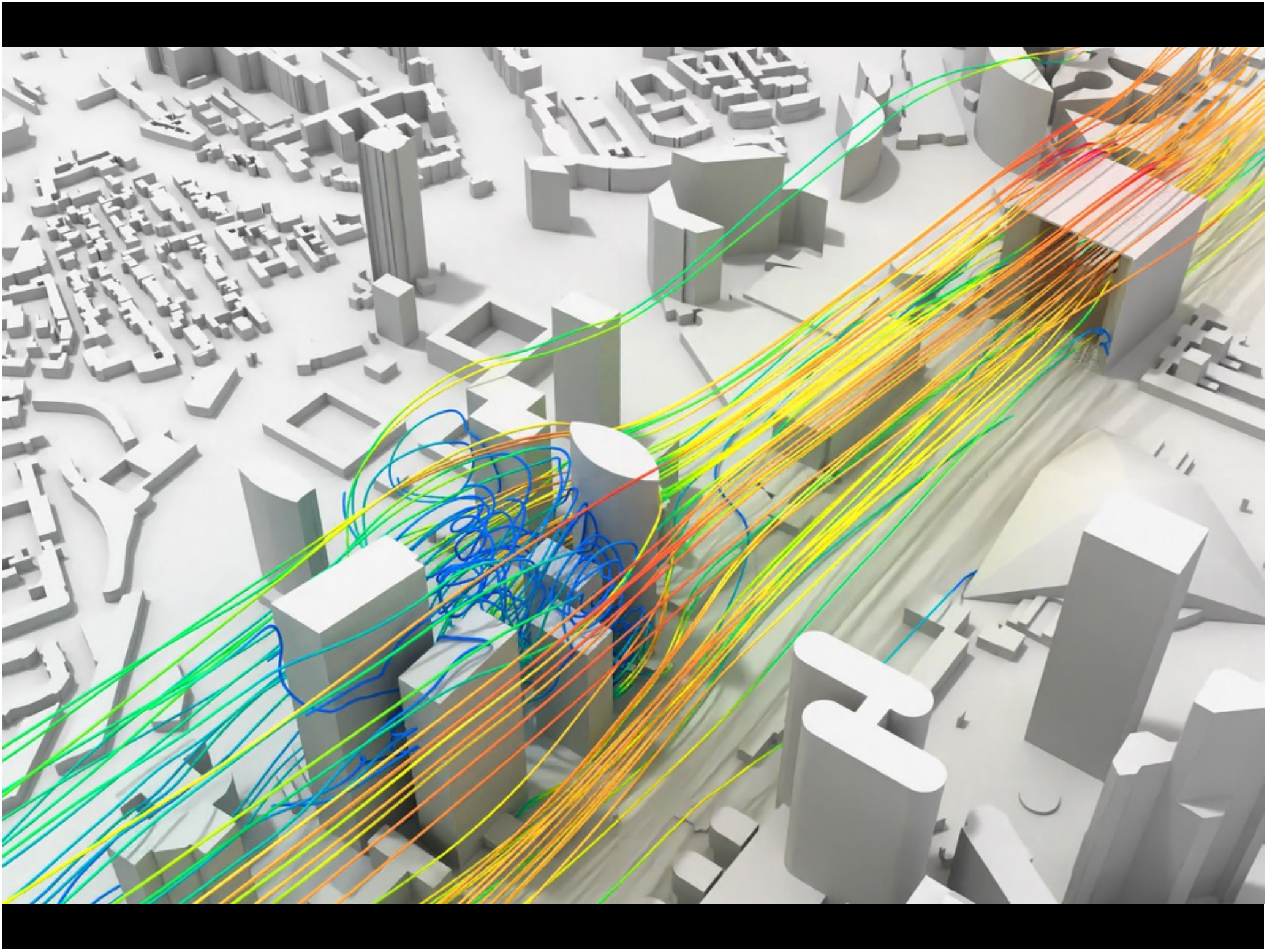
Helm wind effect

If the Near Environment of Medium Height ->Reduced Effect



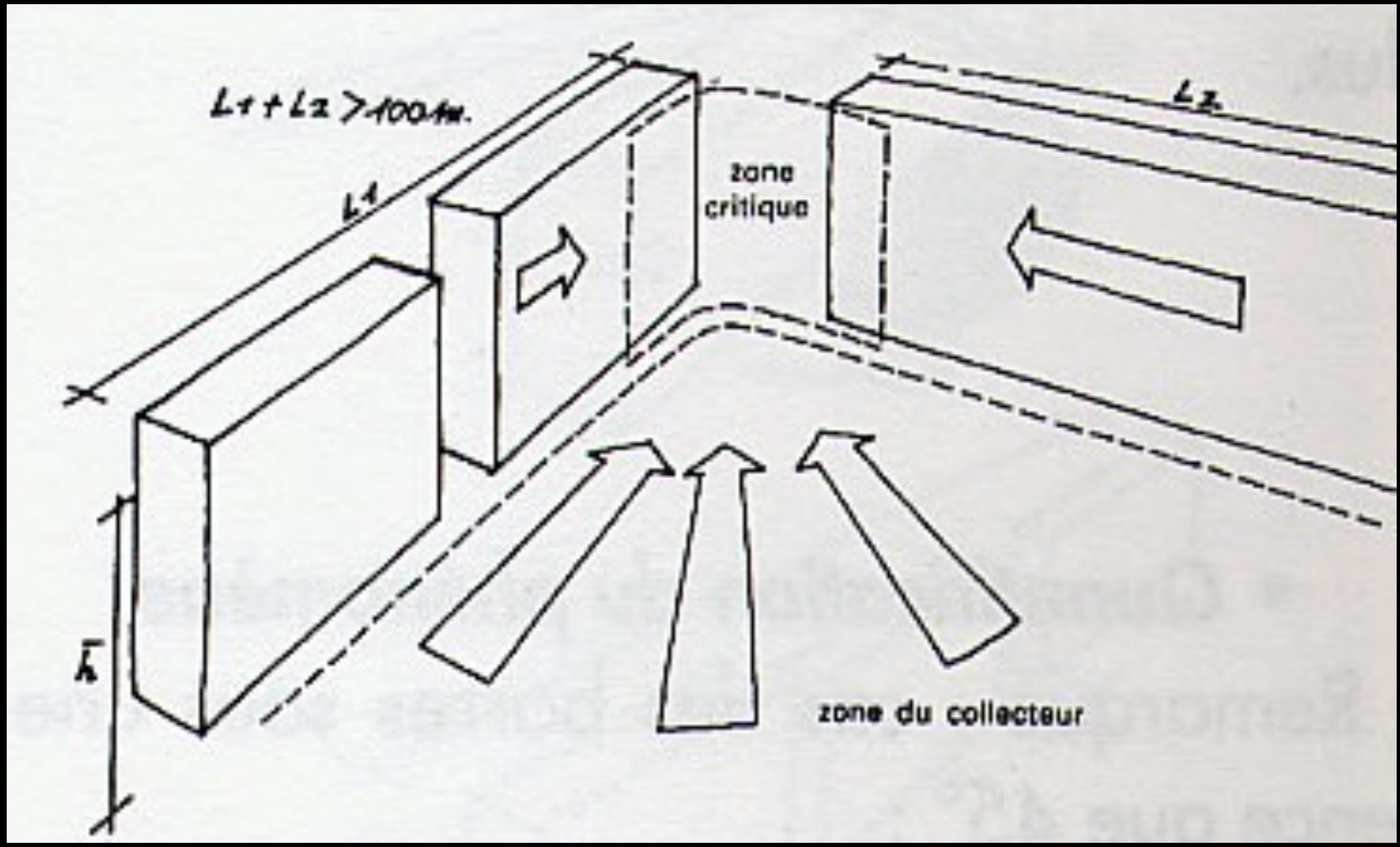
Near environment is a parallel the helm wind effect is maintained on the first building



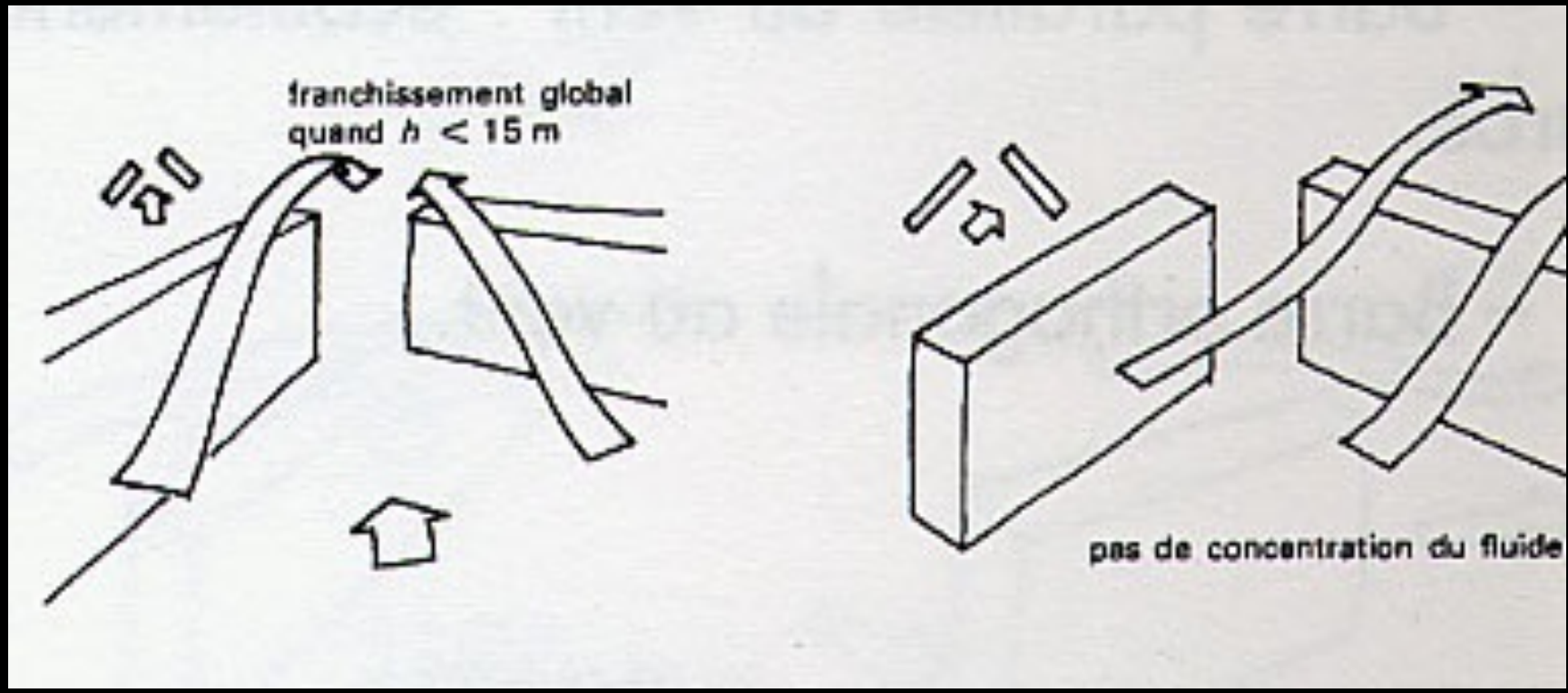


Venturi effect

Collector phenomenon formed by constructions drawing an angle open to the wind. The critical zone for comfort is at the choke



No Venturi effect in these case studies



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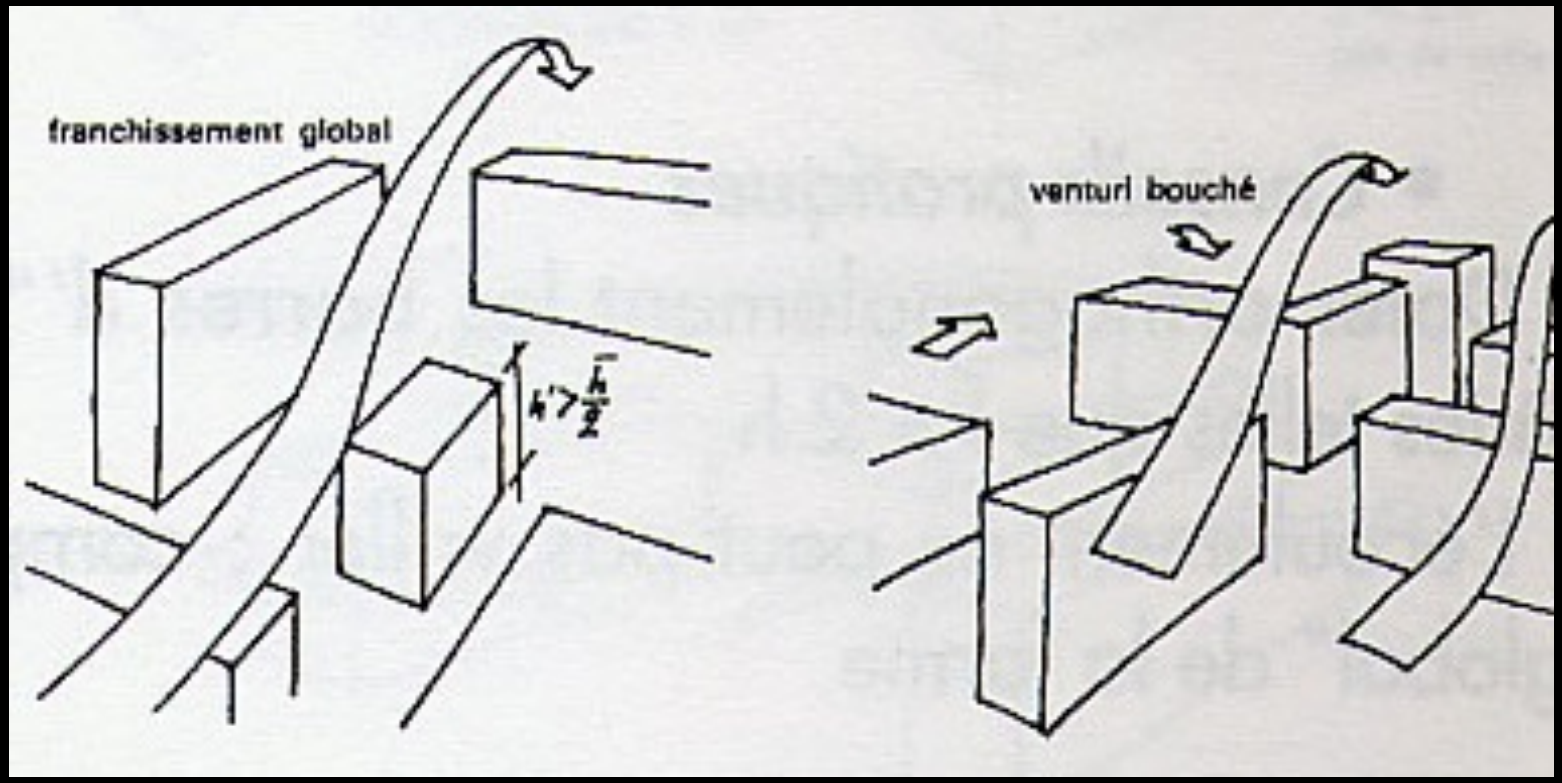

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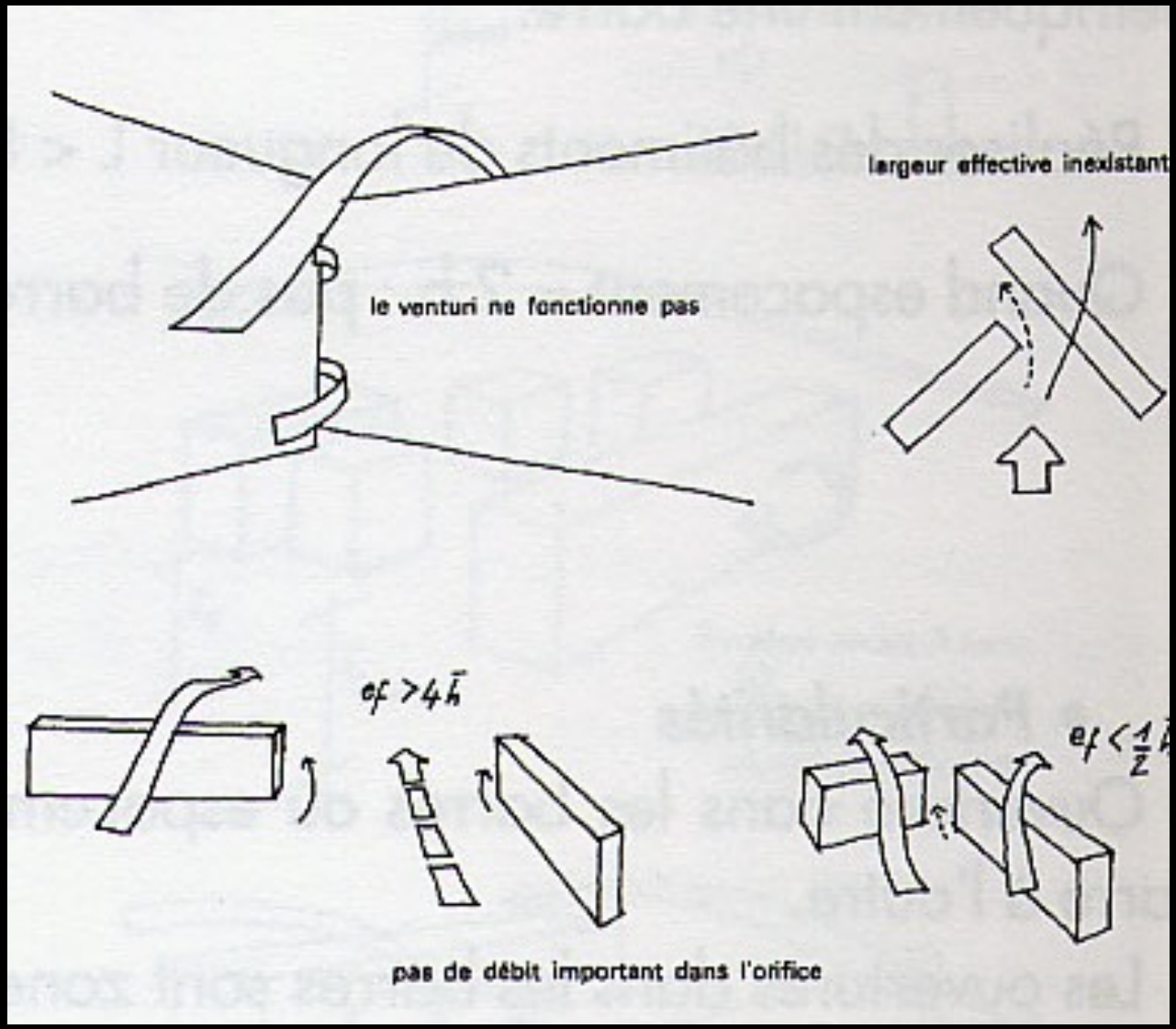
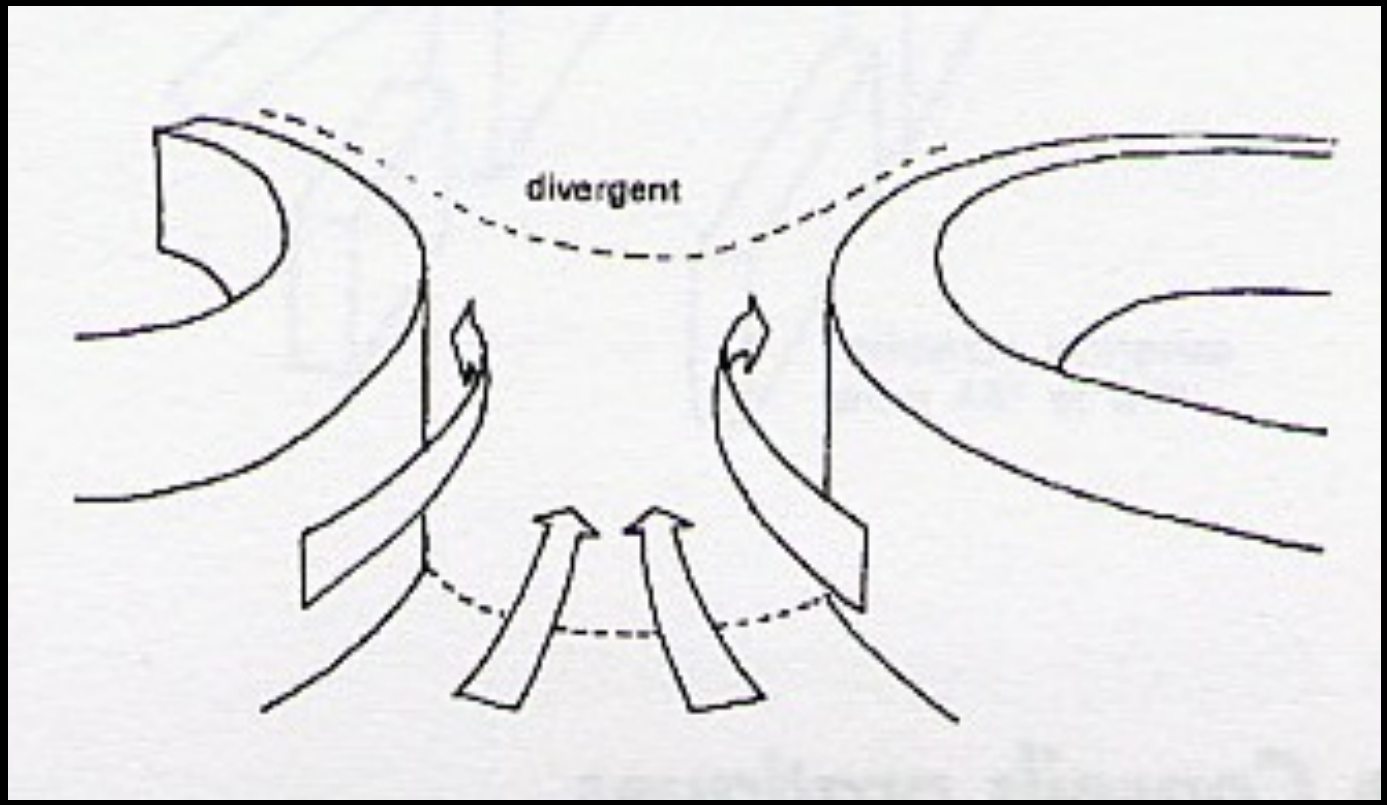


Effect Venturi

Particular venturi: curved shapes create aerodynamic nozzles. The overspeed effect is violently amplified



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To avoid Venturi effect .

. Making porous « arms »

. Do not align the bisector of the collector opening according to the prevailing winds

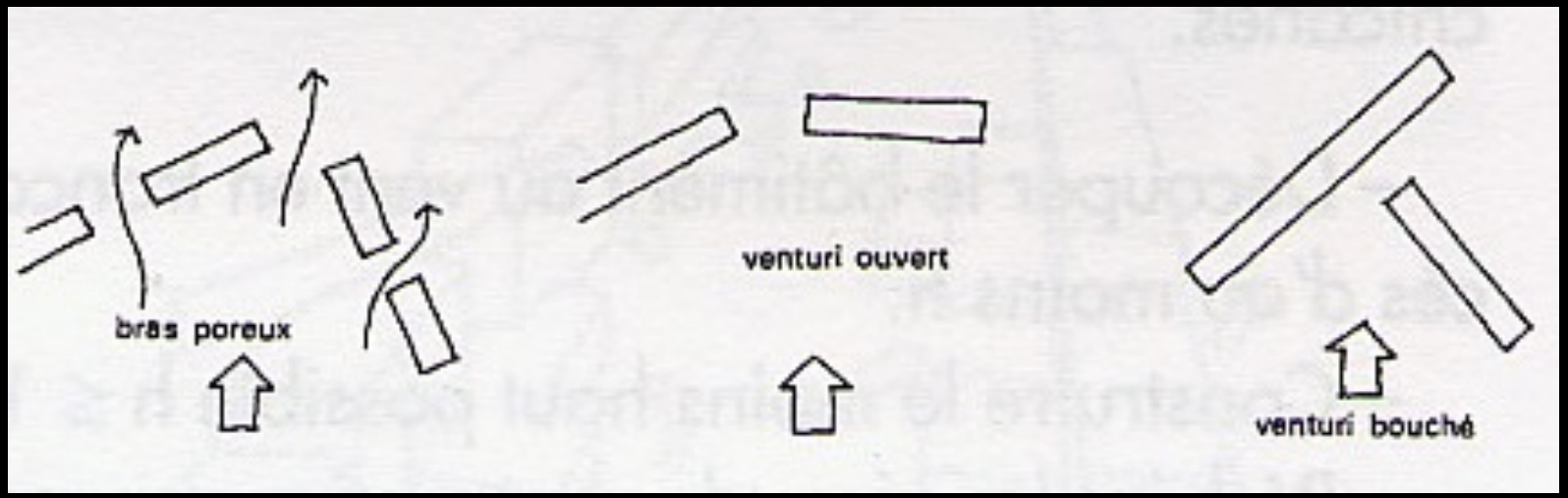
. Building as low as possible

. Reduce arm length

. Densifying the immediate environment

. Open or close the Venturi corner

. Extend as much as possible beyond the strangulation of one of the arms



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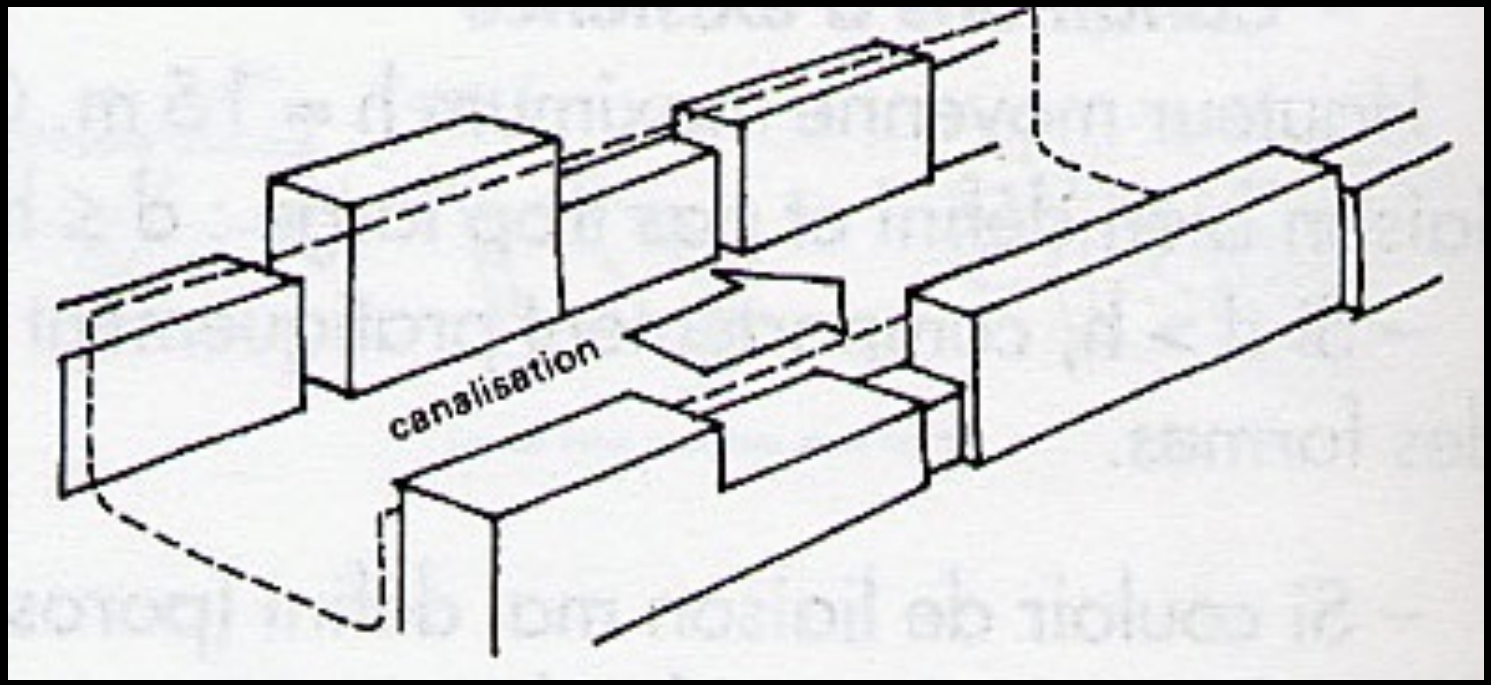
Channeling effect

Built complex forming an open-air corridor
A pipe does not constitute a particular hindrance except that it can transmit an anomaly along its entire length (Venturi)



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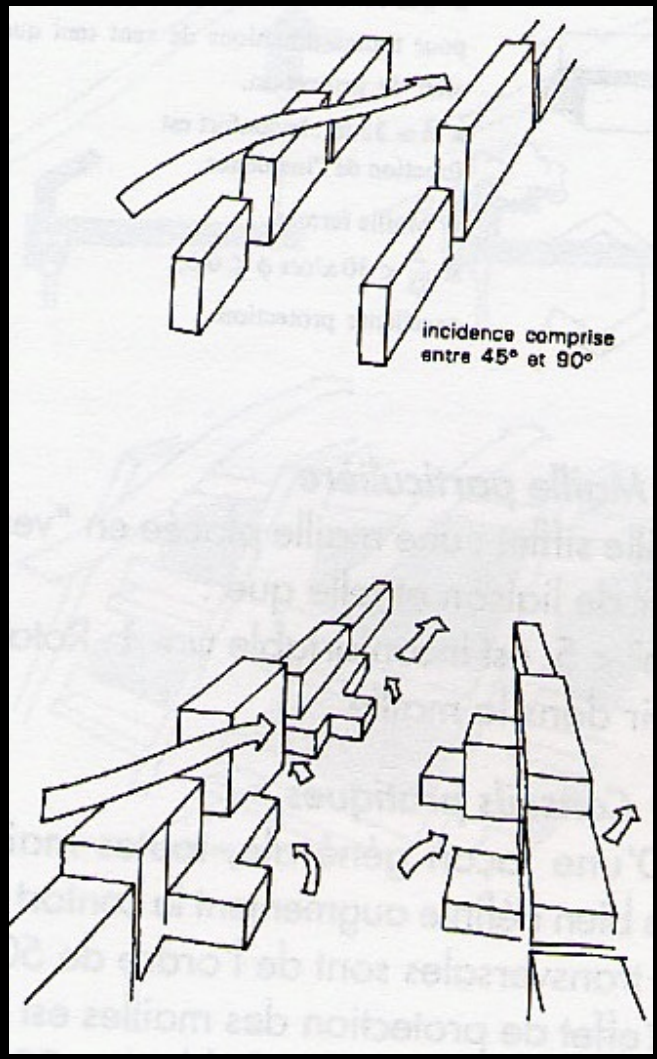
Effet de canalisation

Miniaml condition to be observed
. Low-porous walls
Width of the corridor< 2 h (if width > 3 h, the effect fades)
tips to avoid such wind effect
- adjust a direction of streets under incidence between 90° and 45° (beware of the helm effect)
- increade spacing (porosity)
- foster building dropouts to introduce pressure drops
- Introduce a width > 2h



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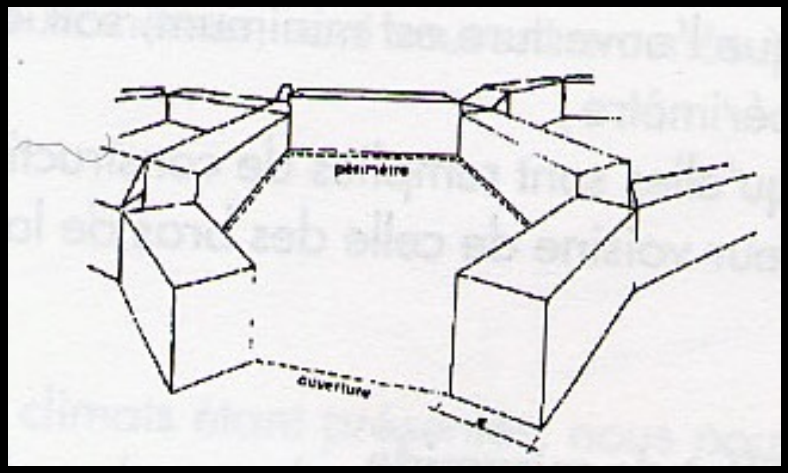
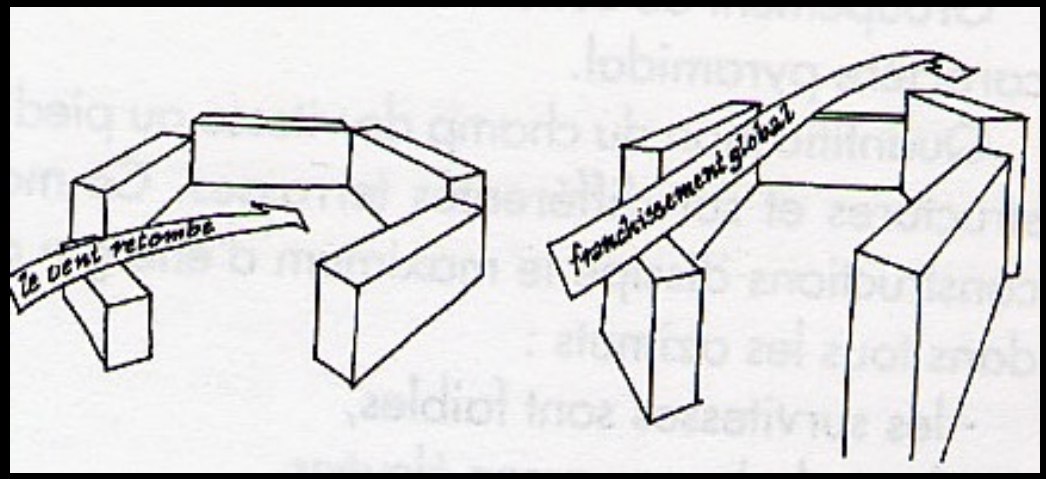
Mesh effect

. Juxtaposition of buildings that form a cell or pocket

… depends on height h and wind direction





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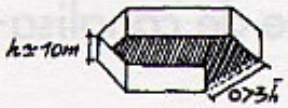
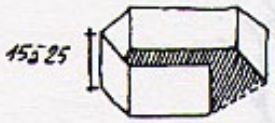


- $\bar{h} \simeq 10$ m, ouverture $\geqslant 3\,\bar{h}$ } $\psi > 1$,

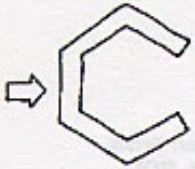
Maille exposée pour toutes les orientations de vent.



- $\bar{h} \simeq 15$ à 25 m : $0{,}4 < \psi < 0{,}8$,

pour toutes directions de vent tant que $\frac{S}{\bar{h}^2} < 10$, effet de protection.

- $\bar{h} \simeq 35$ m : le confort est fonction de l'incidence.



- Maille fermée,

si $\frac{S}{\bar{h}^2} < 30$ alors $\psi \leqslant 0{,}5$,

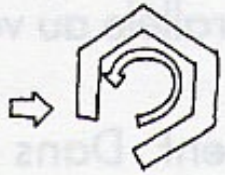
excellente protection.

- Maille ouverte,

si $\frac{S}{\bar{h}^2} < 20$ alors $\psi \leqslant 0{,}8$,

protection dans 0,75 % de la surface

(« l'embouchure » n'est pas protégée).



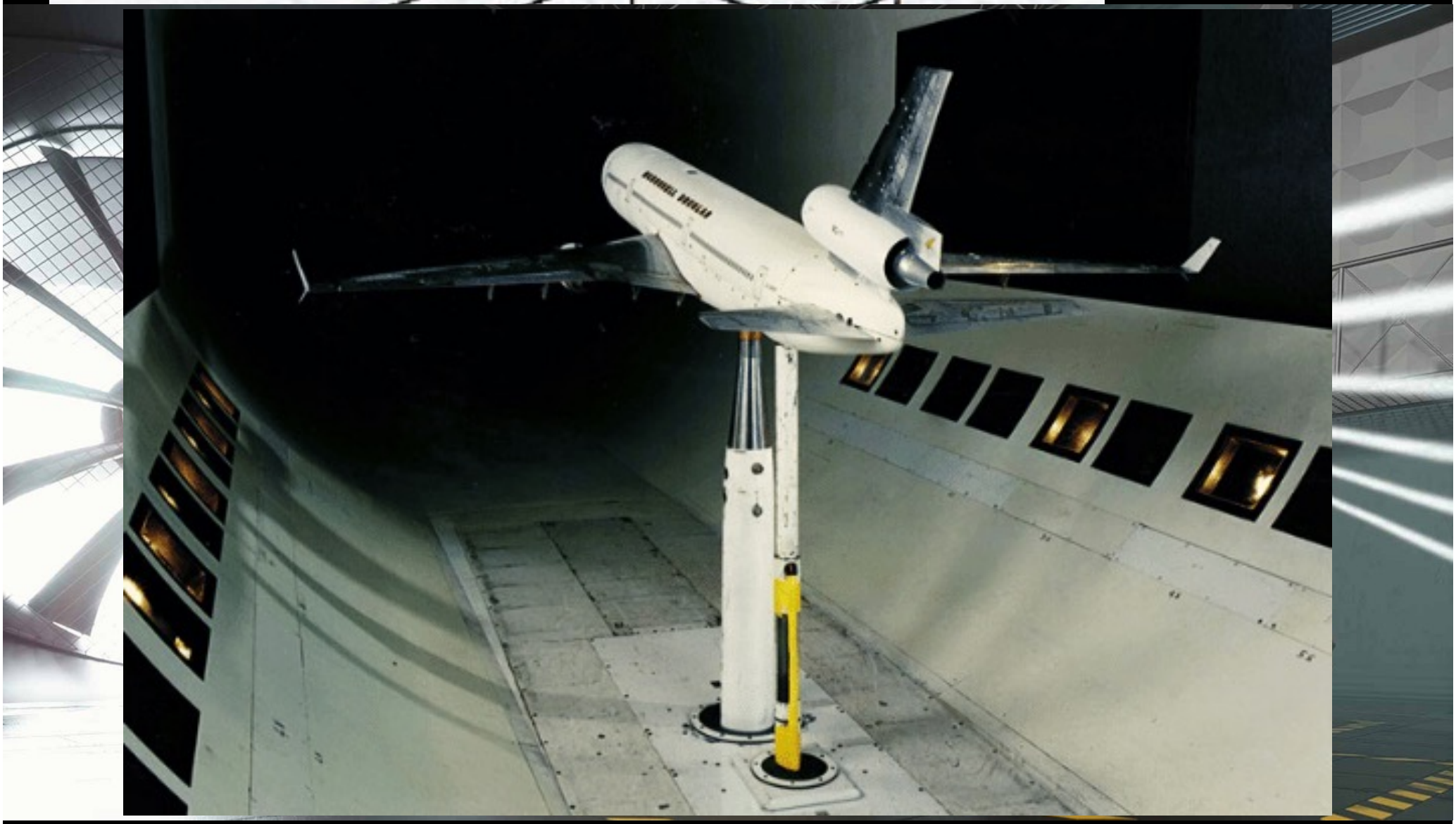
- Maille à 45°, pour $\frac{S}{\bar{h}^2} < 20$,

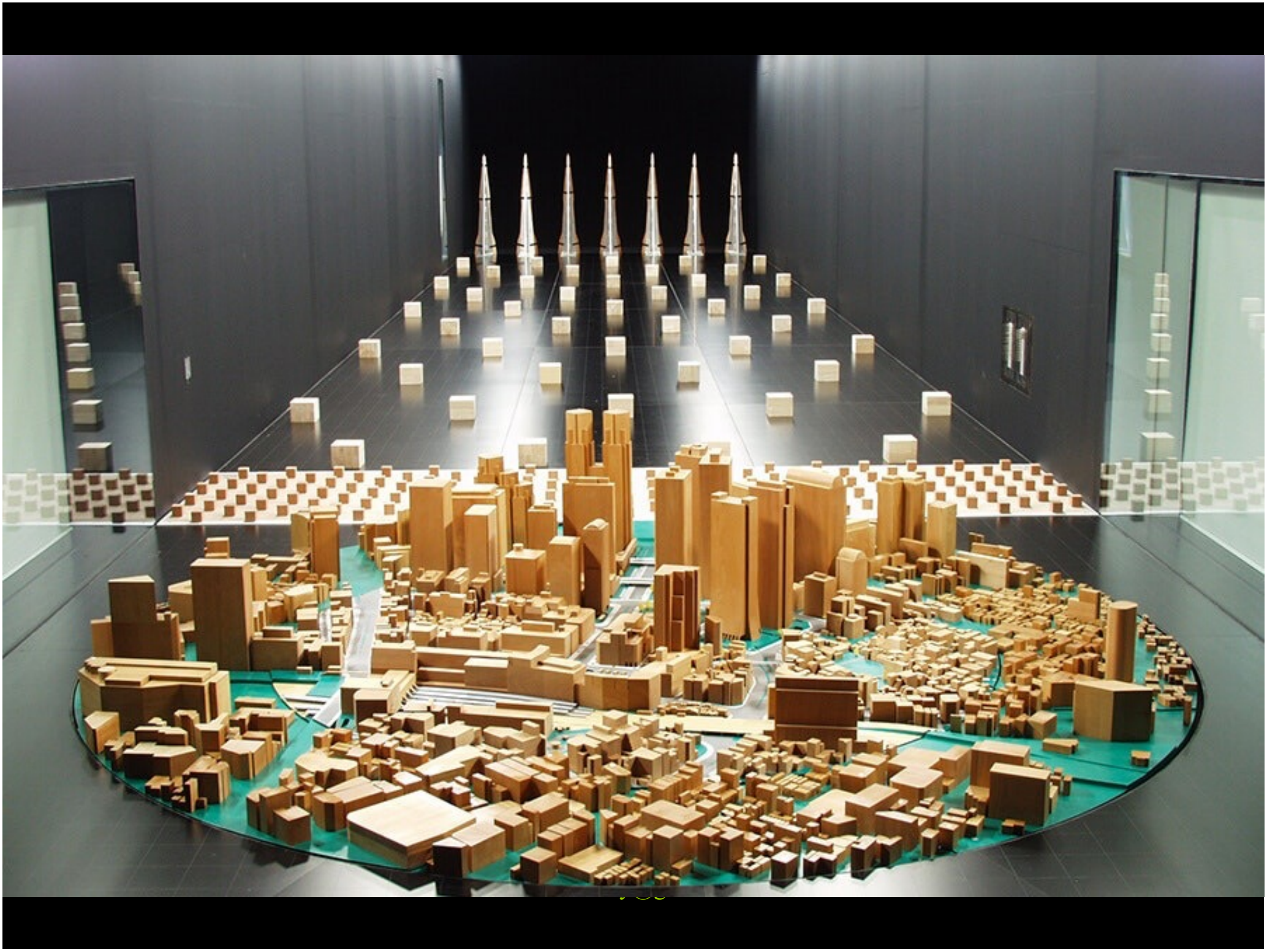
confort variable suivant les zones : $0{,}7 < \psi \leqslant 1{,}1$, il y a rotation intérieure de l'air.

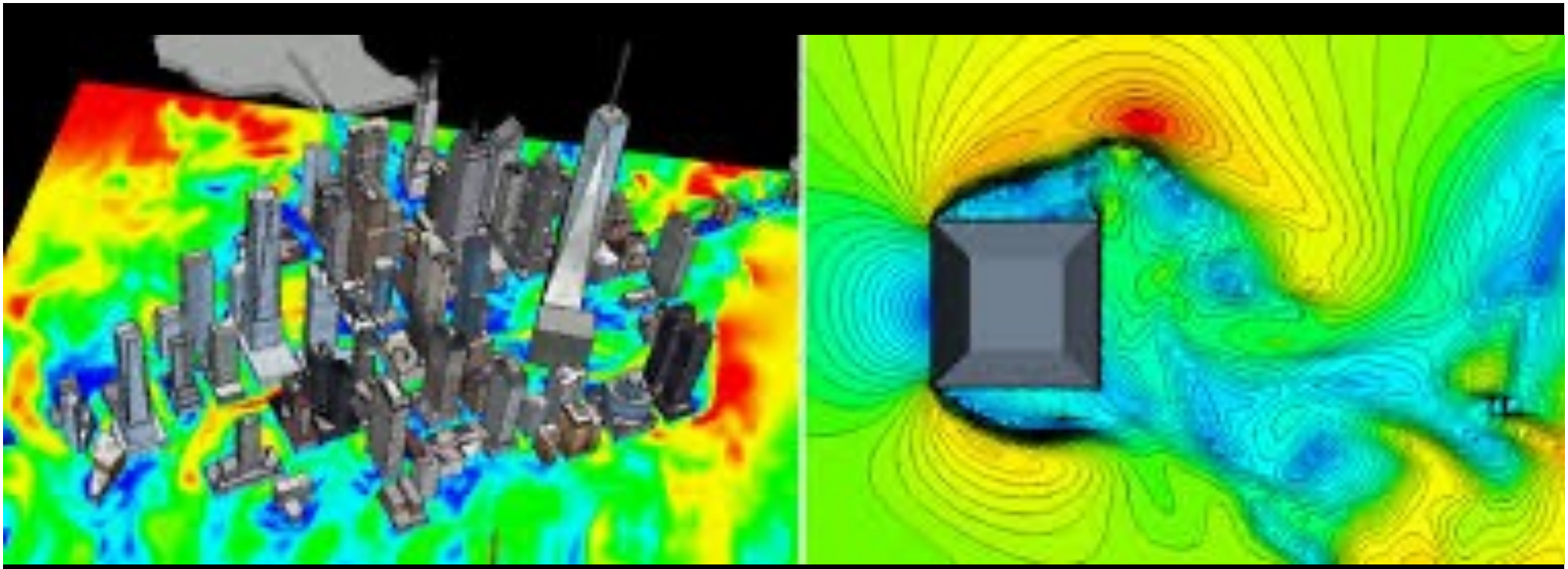
- Maille « parallèle »,

phénomène identique au précédent (maille à 45°) mais tant que : $\frac{S}{\bar{h}^2} < 20$ alors $\psi \leqslant 1$.

Cf. Chatelet et alii







CFD Modelisation – Food For Rhino or dedicated software

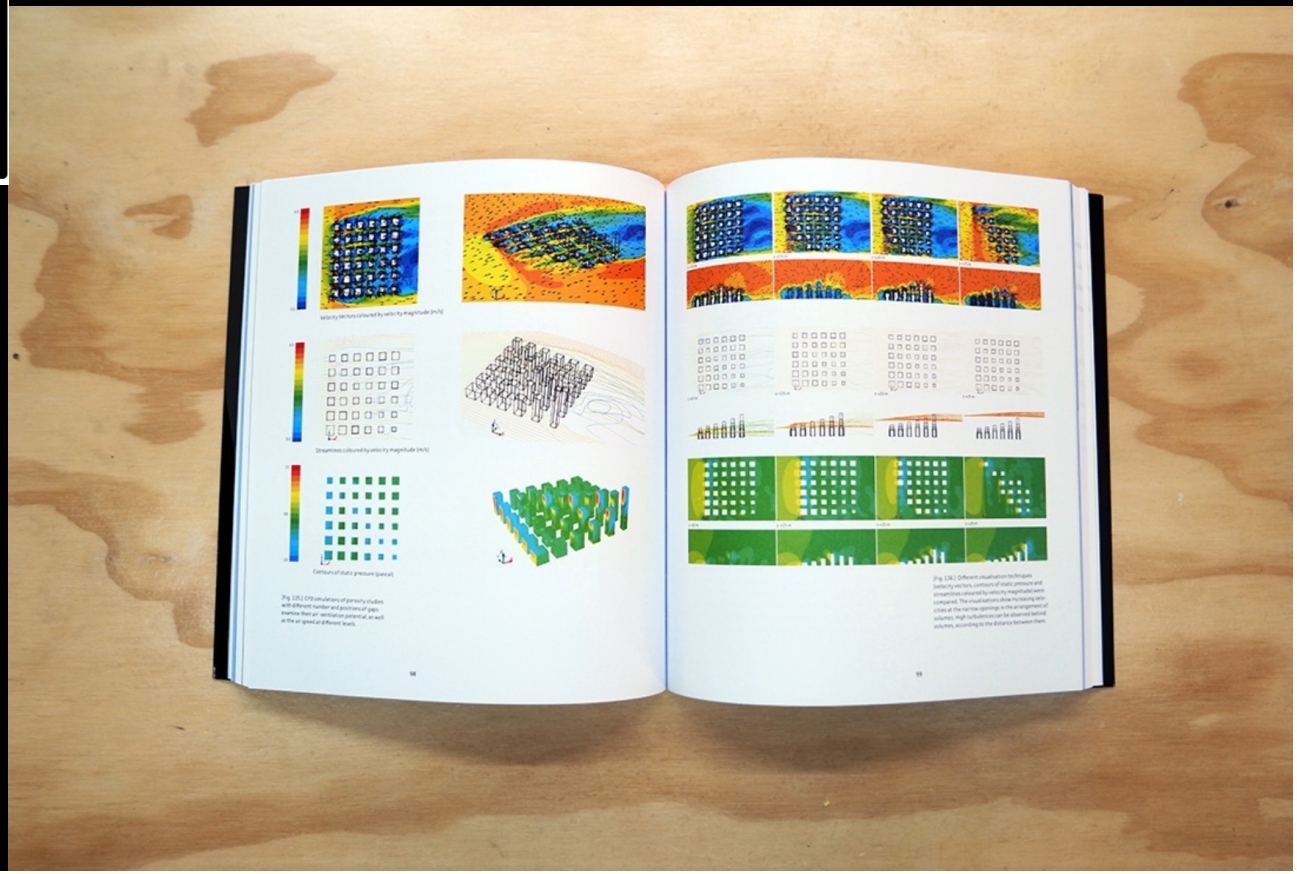
Comutational Fluid Dynamics .. Air, wind, smoke, water, etc ..

City and Wind
Climate as an Architectural Instrument

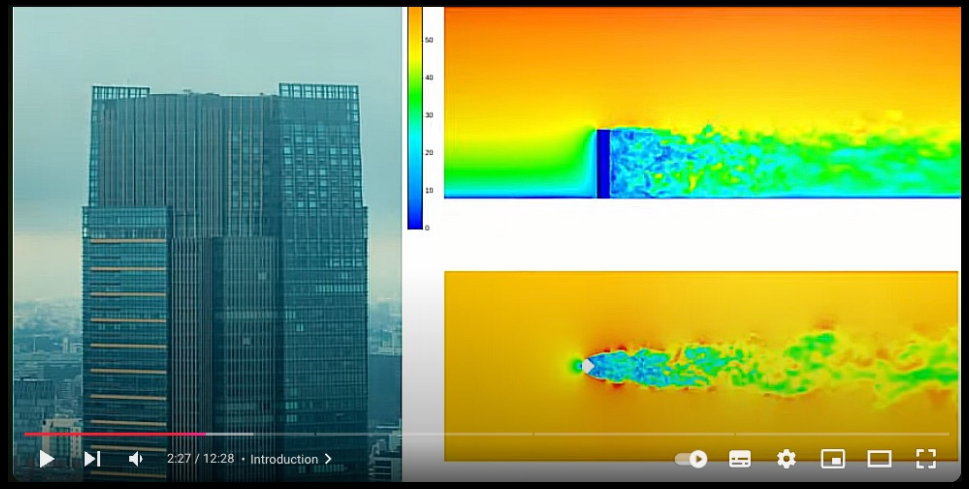
Mareike Krautheim / Ralf Pasel /
Sven Pfeiffer / Joachim Schultz-Granberg

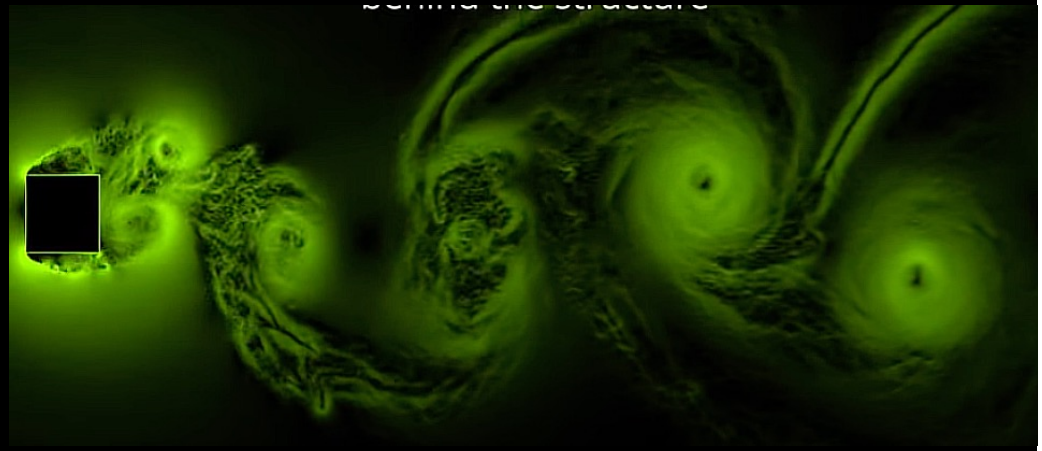
Basics

DOM
publishers



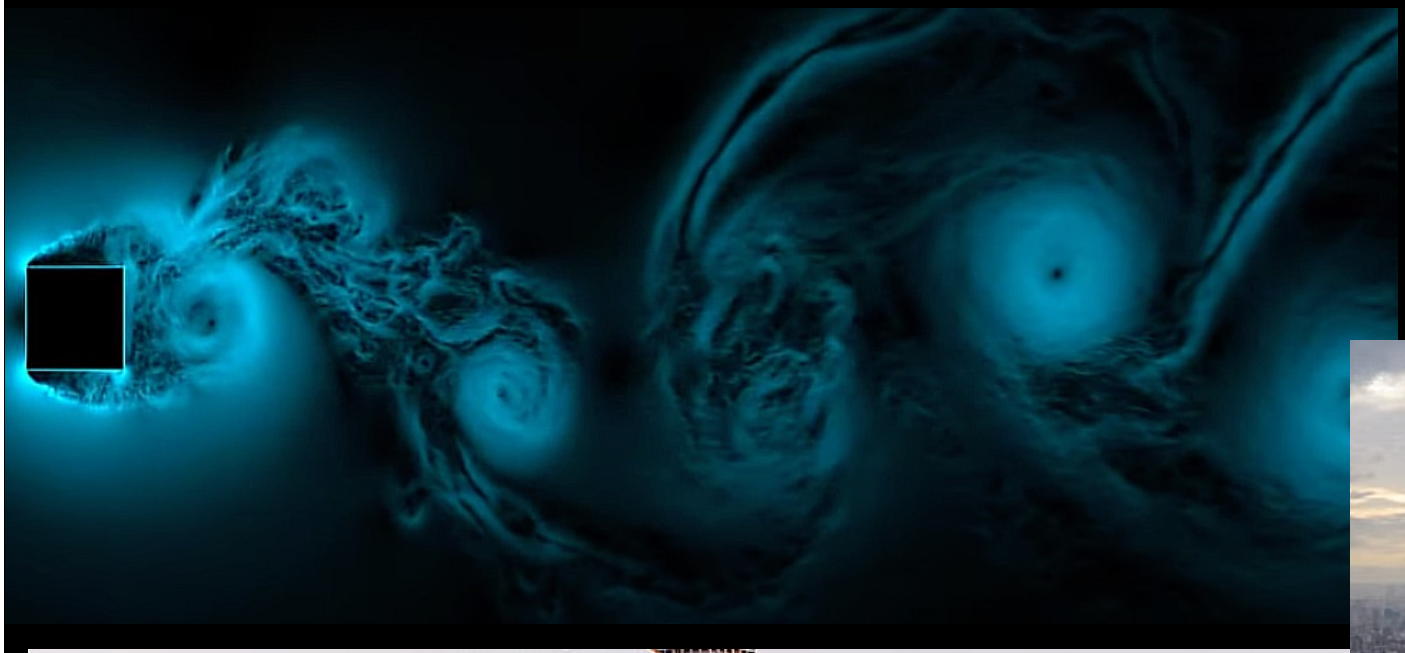
Shaping buildings to reduce wind loads | Designing tall buildings for wind

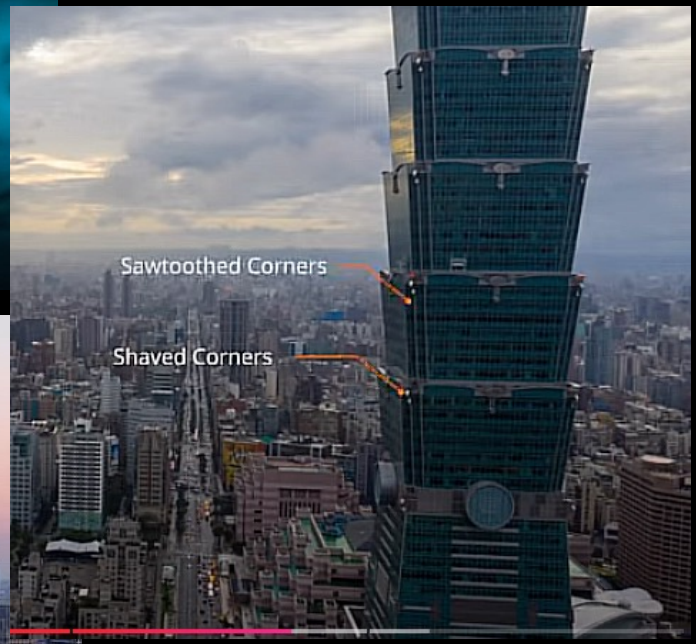




https://youtu.be/lgnFvl9rlsc?si=nvyf5I5Wv5Wdd9hz

Ecole d'architecture de Grenoble > M1CV2> nicolas.remy@grenoble.archi.fr





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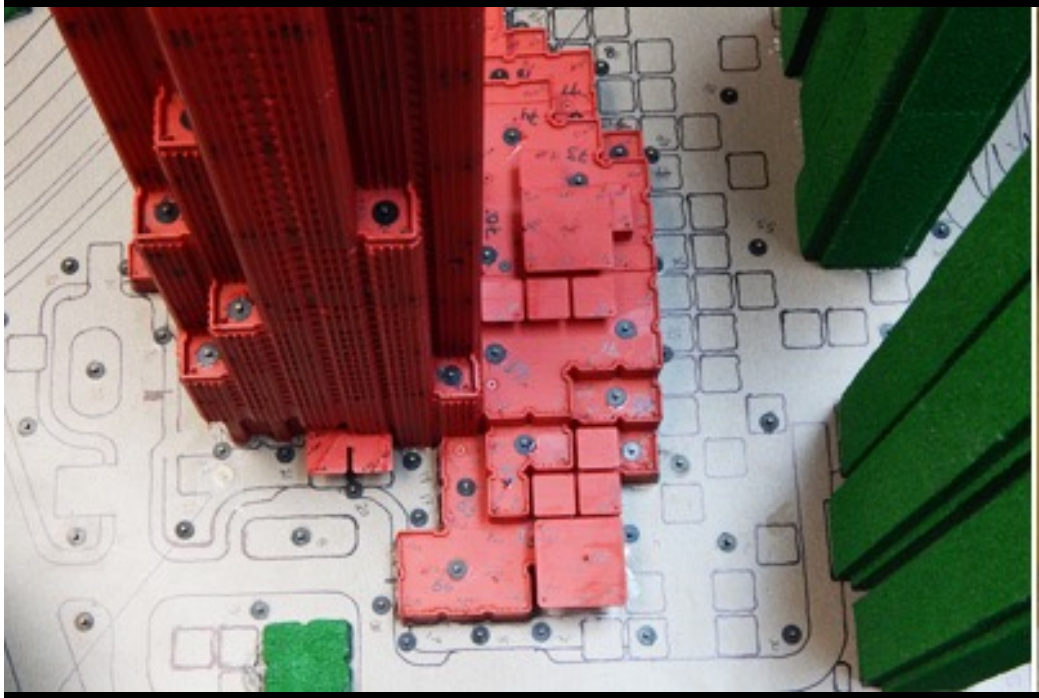

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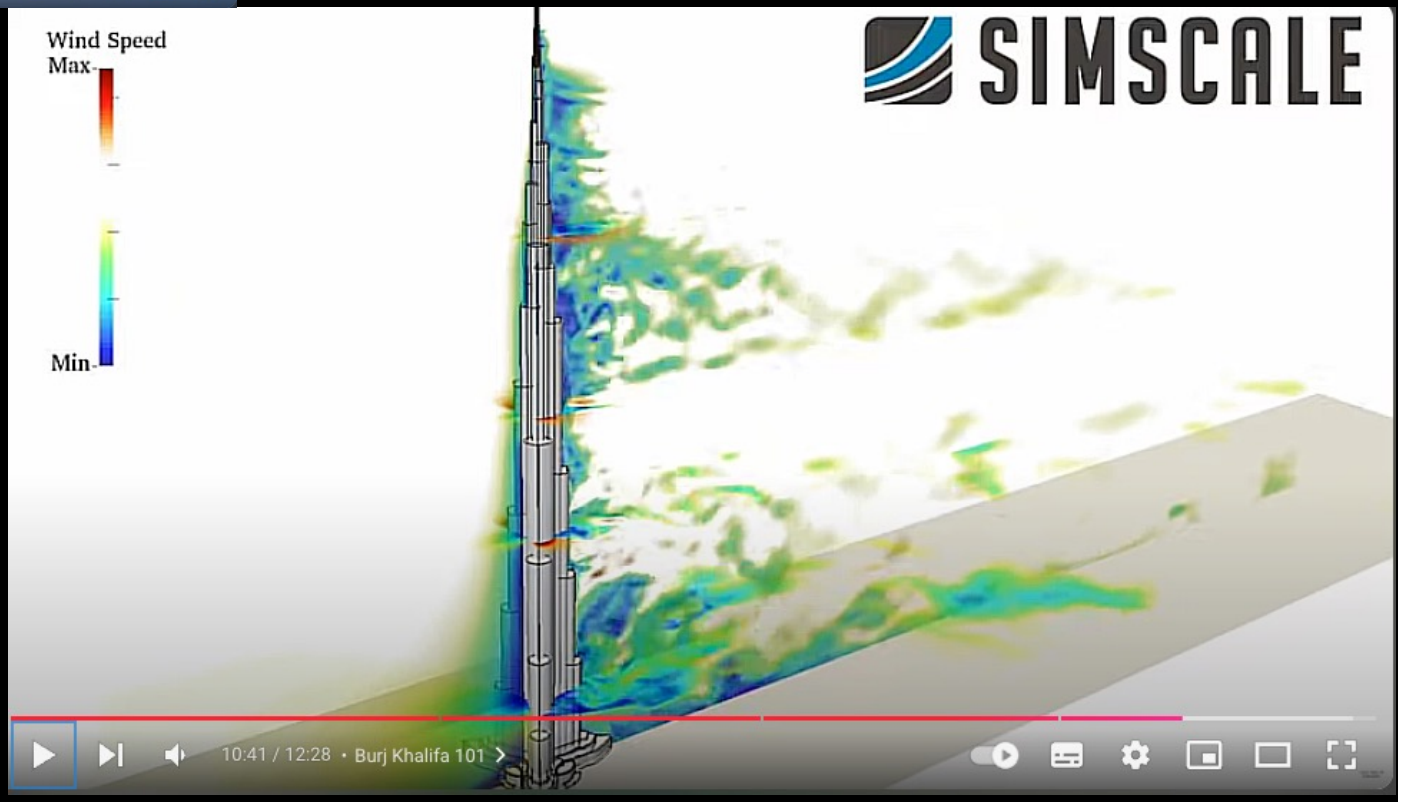

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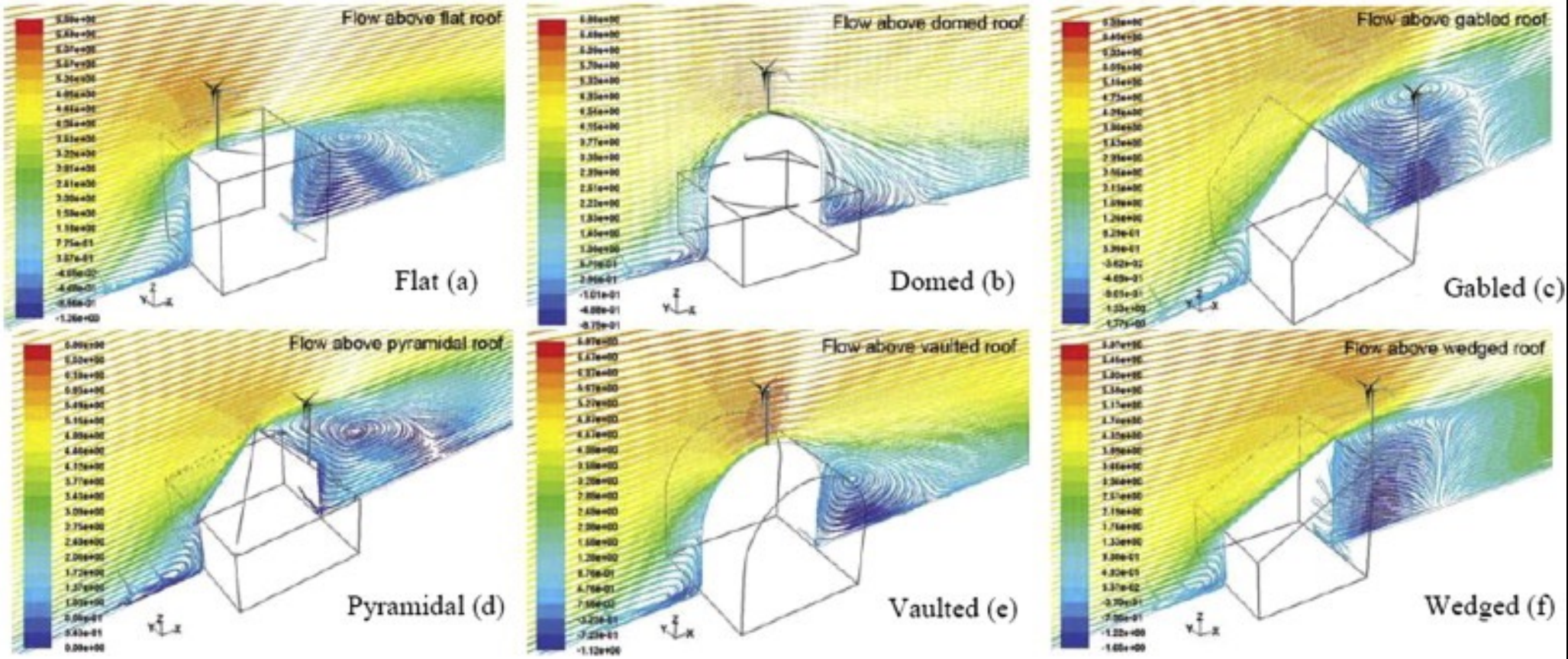
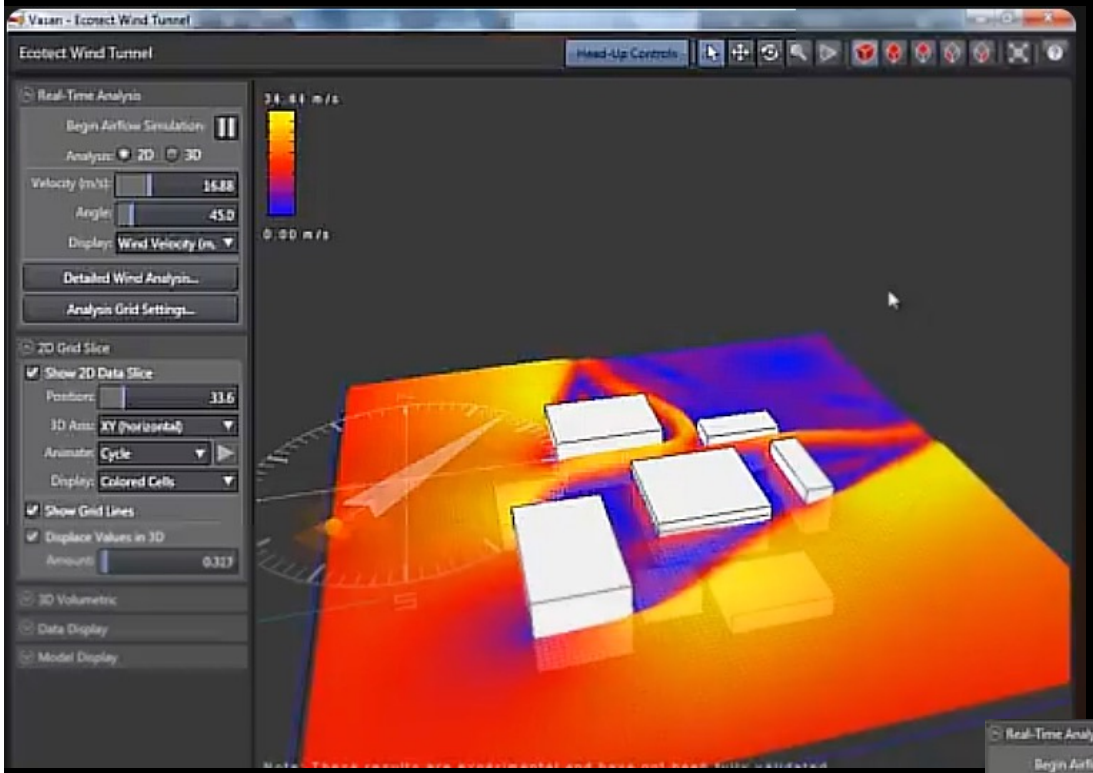
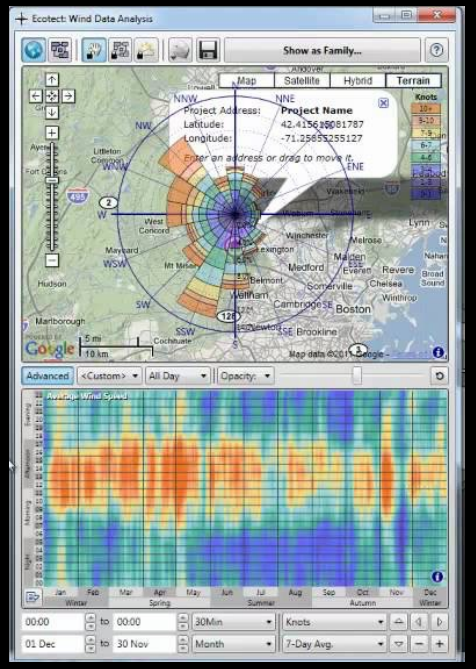
Renewable Energy
Volume 50, February 2013, Pages 1106-1118

Effect of roof shape, wind direction, building height and urban configuration on the energy yield and positioning of roof mounted wind turbines

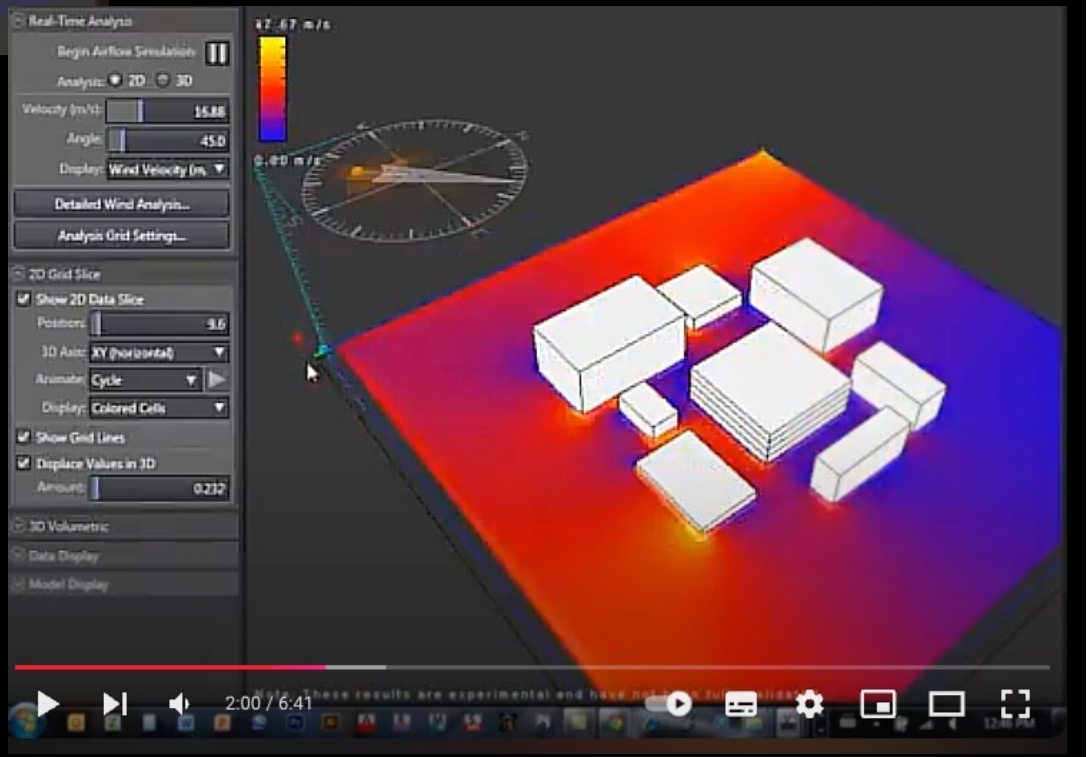
Islam Abohela, Neveen Hamza, Steven Dudek

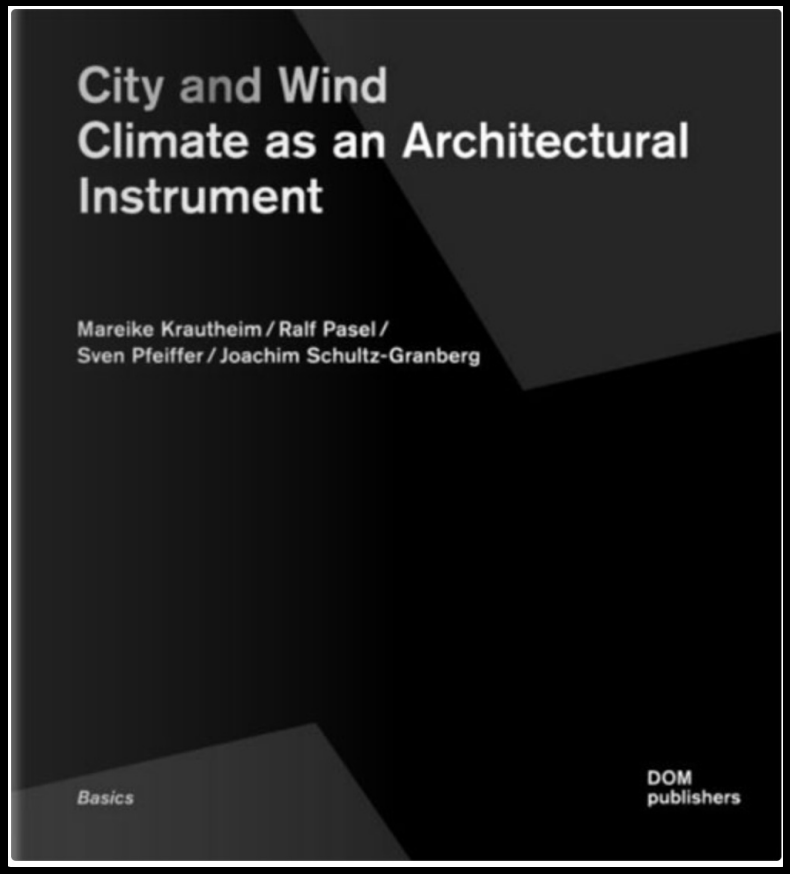






Autodesk Vasari Wind Tunnel
Vasari 2.1 Ecotect Wind Tunnel
(free until 2015)





Anemoi: The Greek Winds