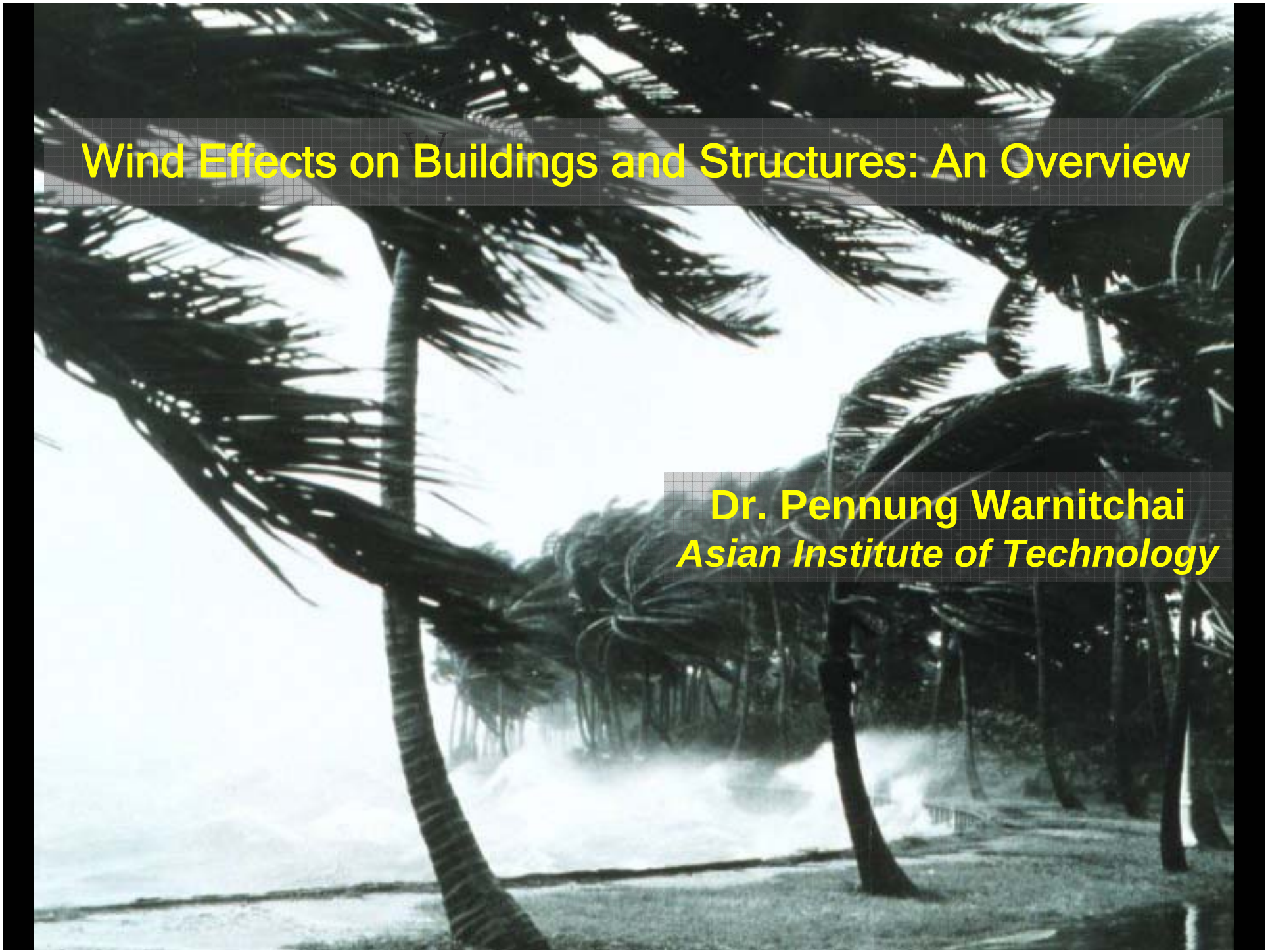


Wind Effects on Buildings and Structures: An Overview

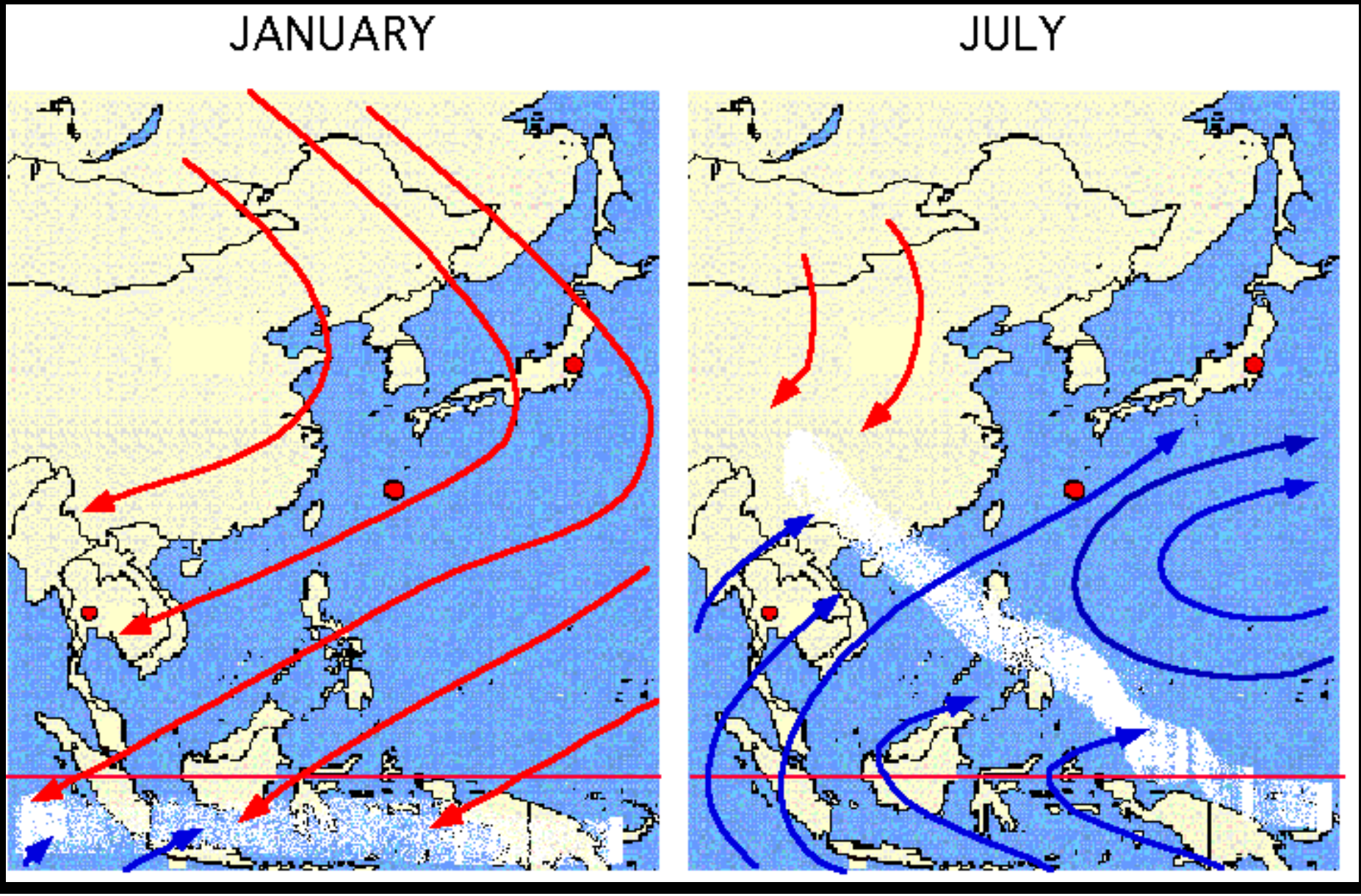
Dr. Pennung Warnitchai
Asian Institute of Technology

Types of Wind

Monsoons, Typhoons, Thunderstorms

Monsoons

Large-scale seasonal winds: SW and NE monsoons

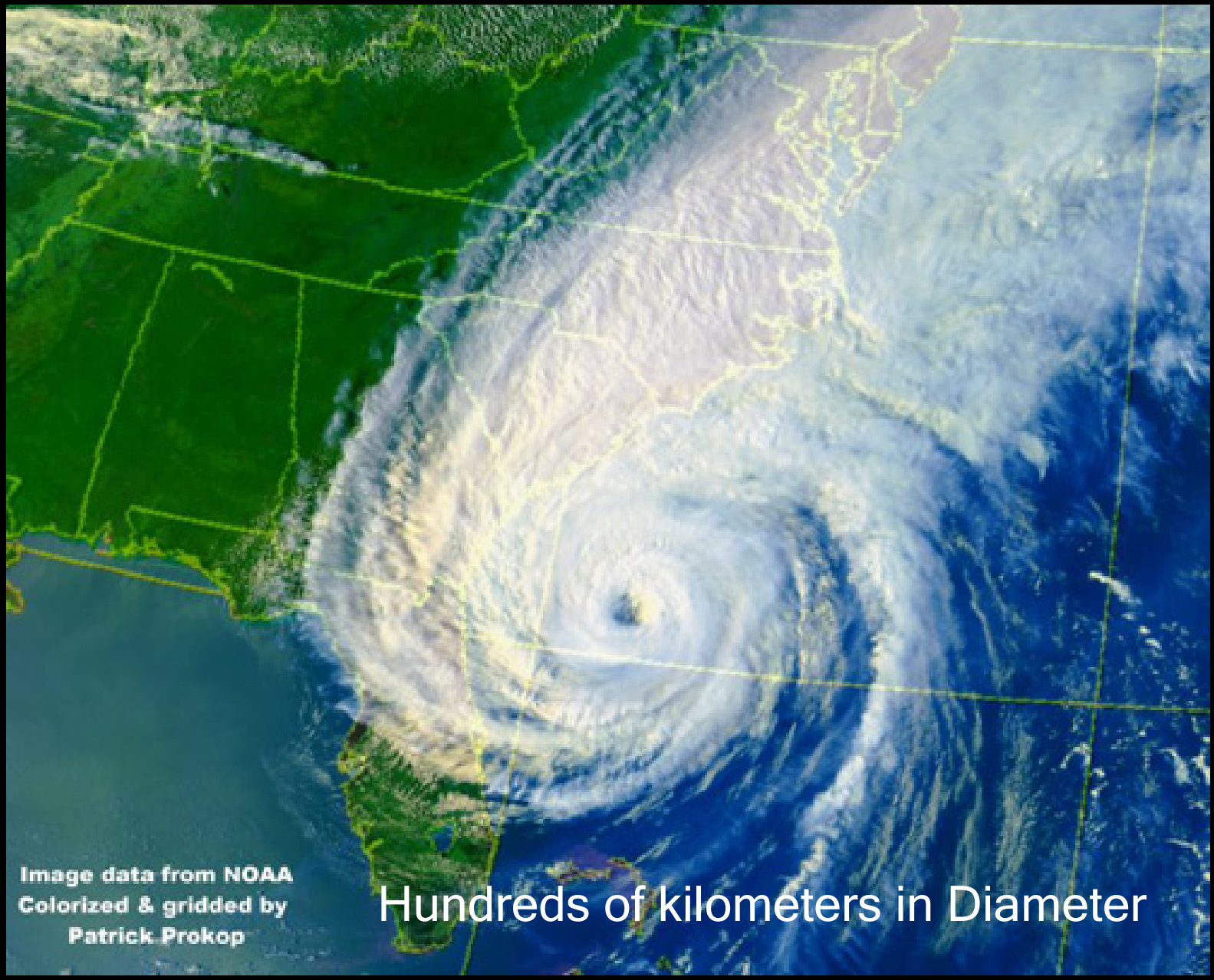


Satellite Image of a Typhoon

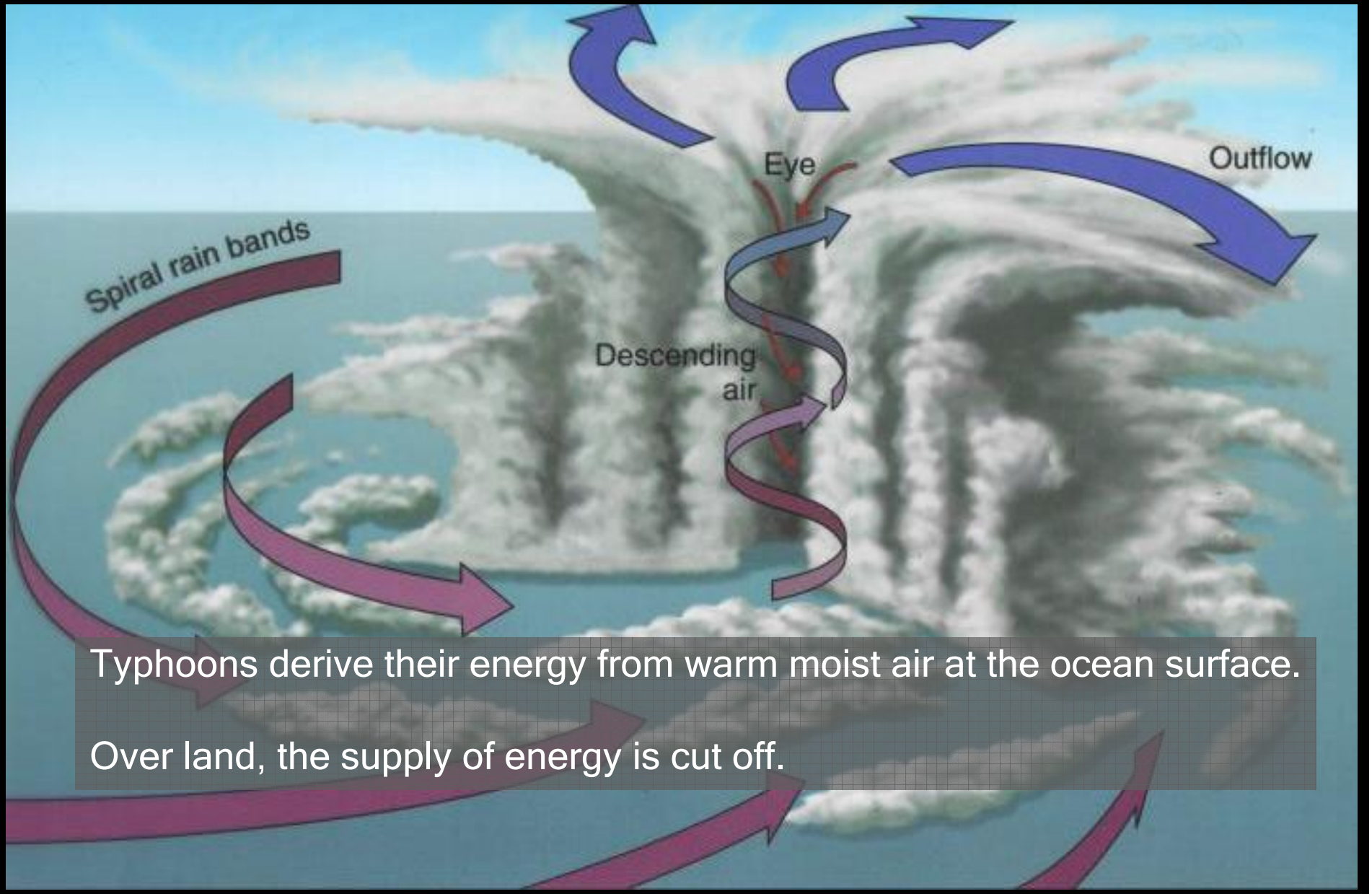
Typhoon = Hurricane = Tropical Cyclone with surface wind speeds higher than 120 km/hr.

Max. Typhoon winds may reach 320 km/hr.

Satellite Image of a Typhoon



Cross-section of a Typhoon

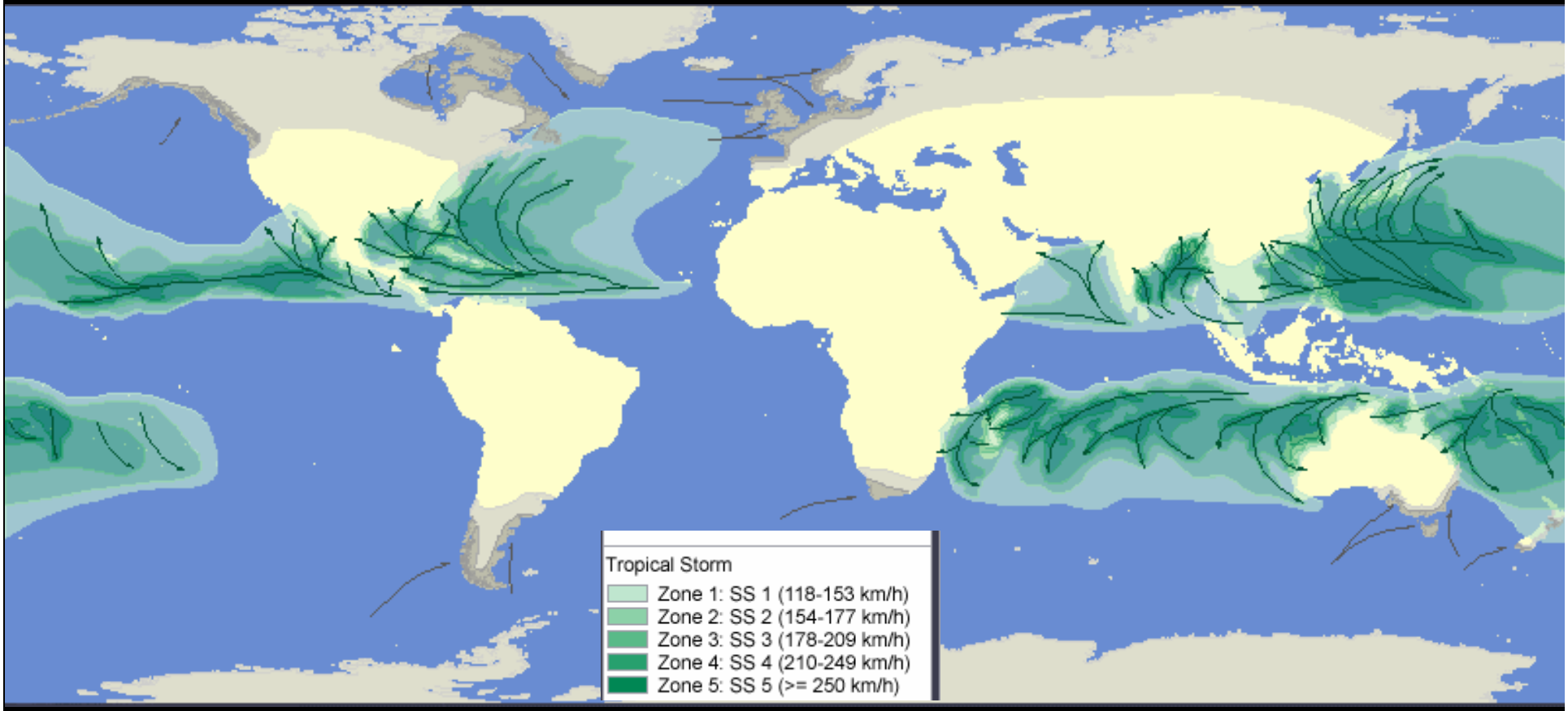


Typhoons derive their energy from warm moist air at the ocean surface.

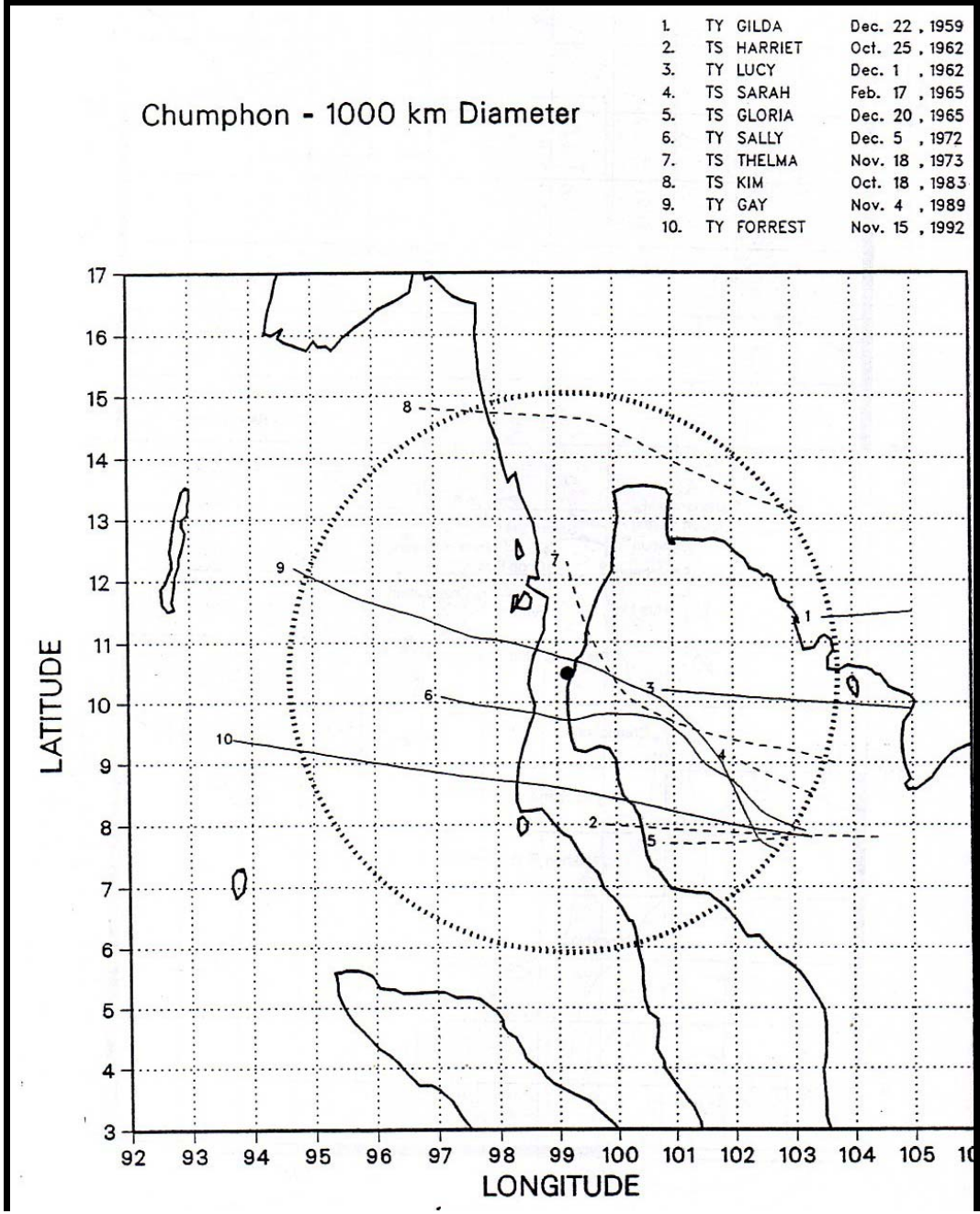
Over land, the supply of energy is cut off.

World Map of Tropical Storm Hazard

(Tropical Cyclones, Hurricanes, Typhoons)

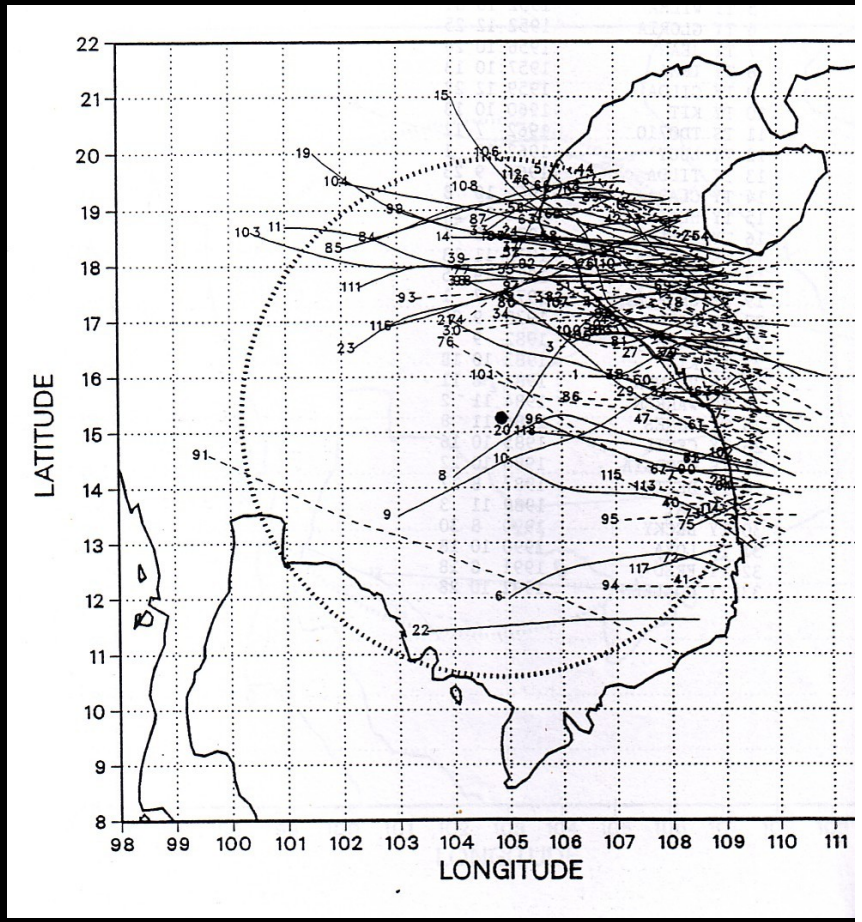


Tropical Cyclone Paths in Thailand and Neighbouring Countries



Some are strong enough to be called 'Typhoons'.

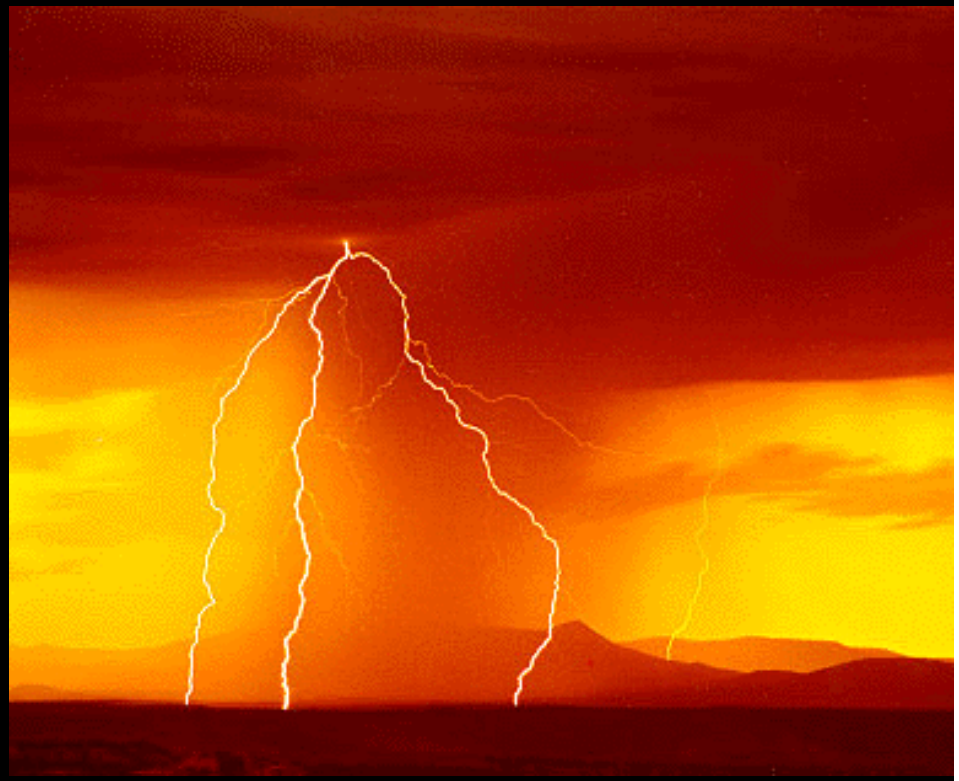
'Direct hit' in the southern Thailand.



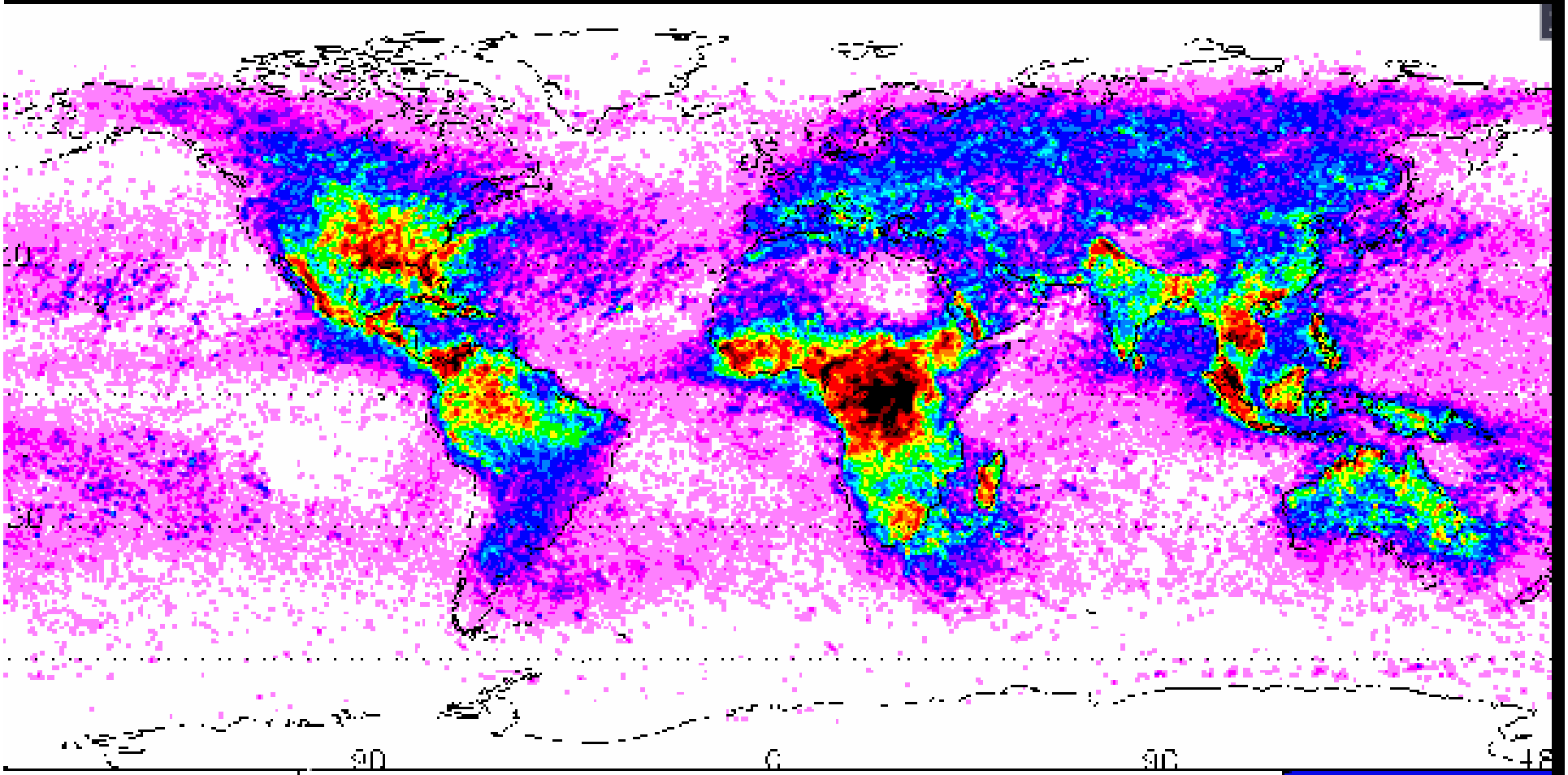
Thunderstorm

- Small-scale wind: Kilometers in diameter
- Produce lightning flashes

Thunderstorm



World Map of Lightning Hazard



Orbits	11290
Areas	519244
Flashes	2704444
Groups	12863929
Events	26006503

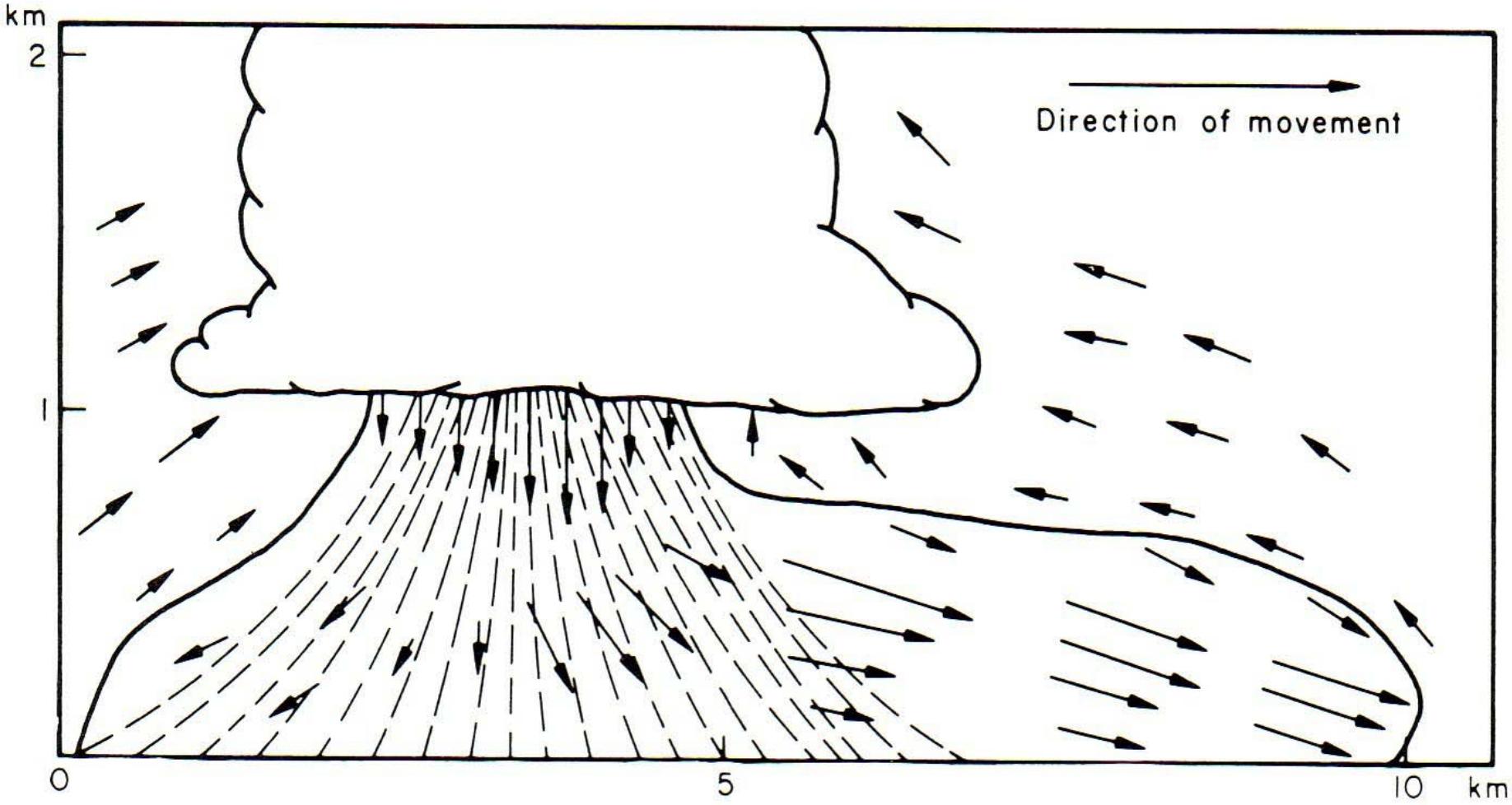
April 12, 1995 — December 31, 1997

OTD OPTICAL TRANSIENT DETECTOR

NASA / MSF

Thunderstorm

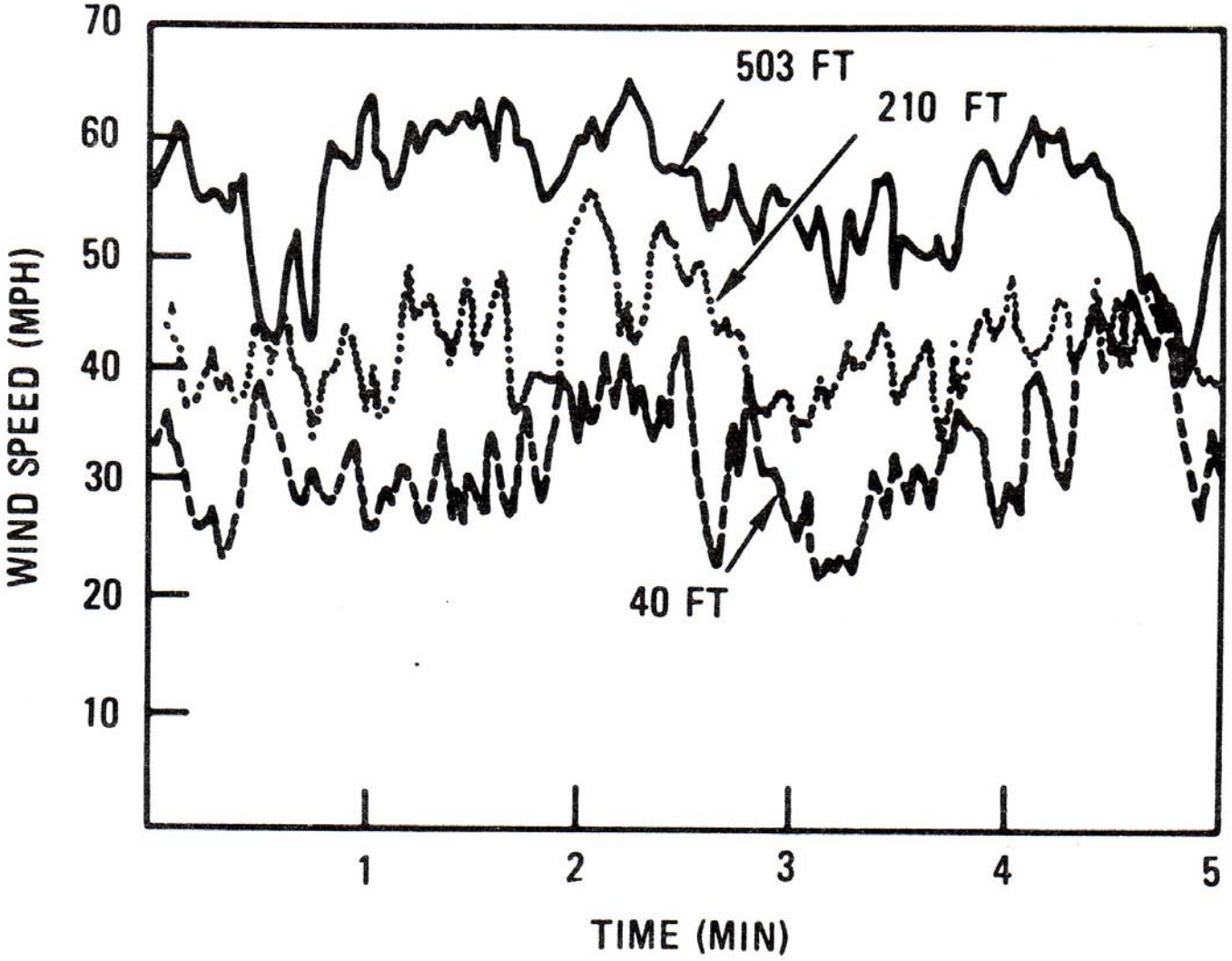
Thunderstorm



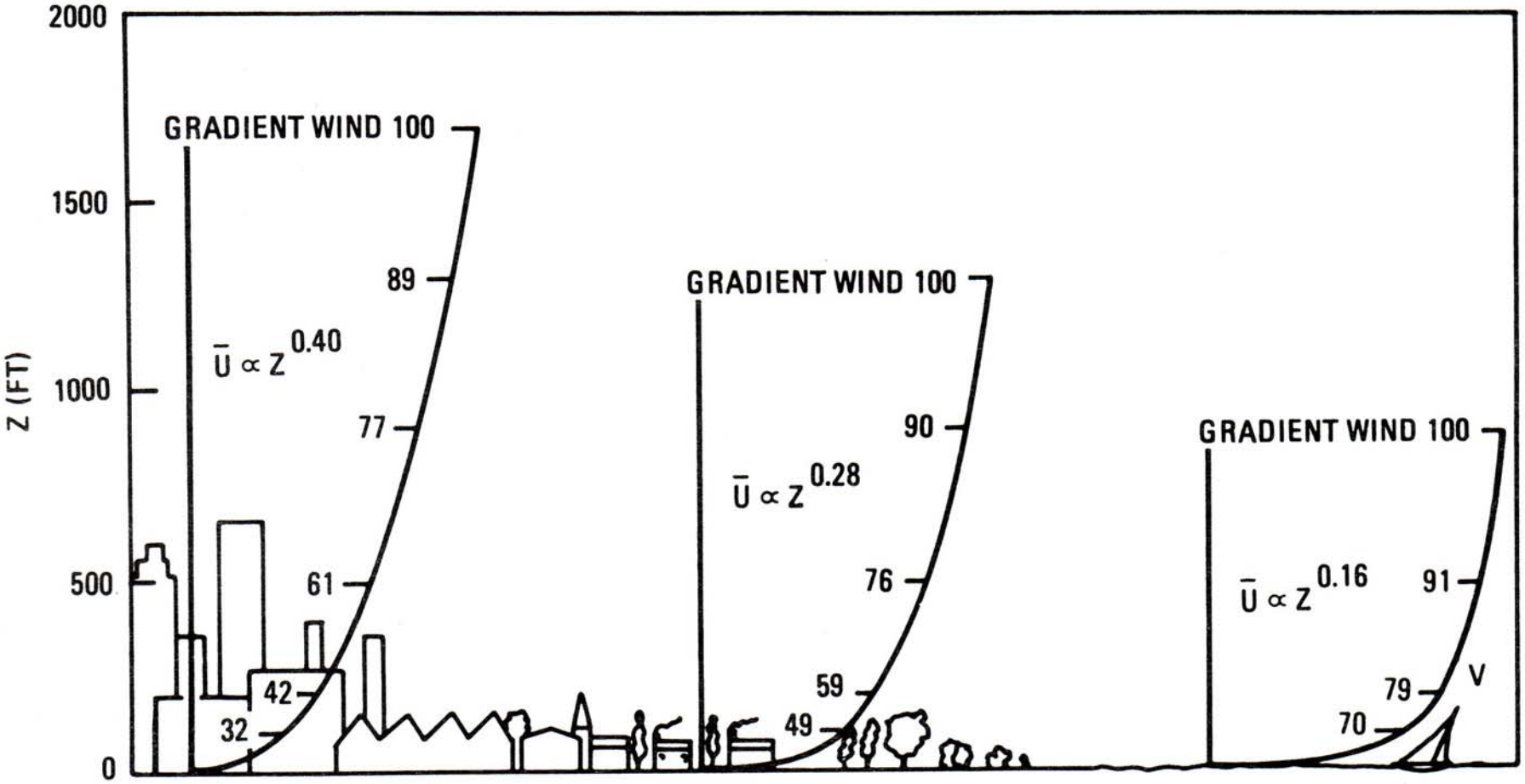
Some Important Characteristics of Wind

from Engineering Viewpoint

Record of wind speed at three different heights



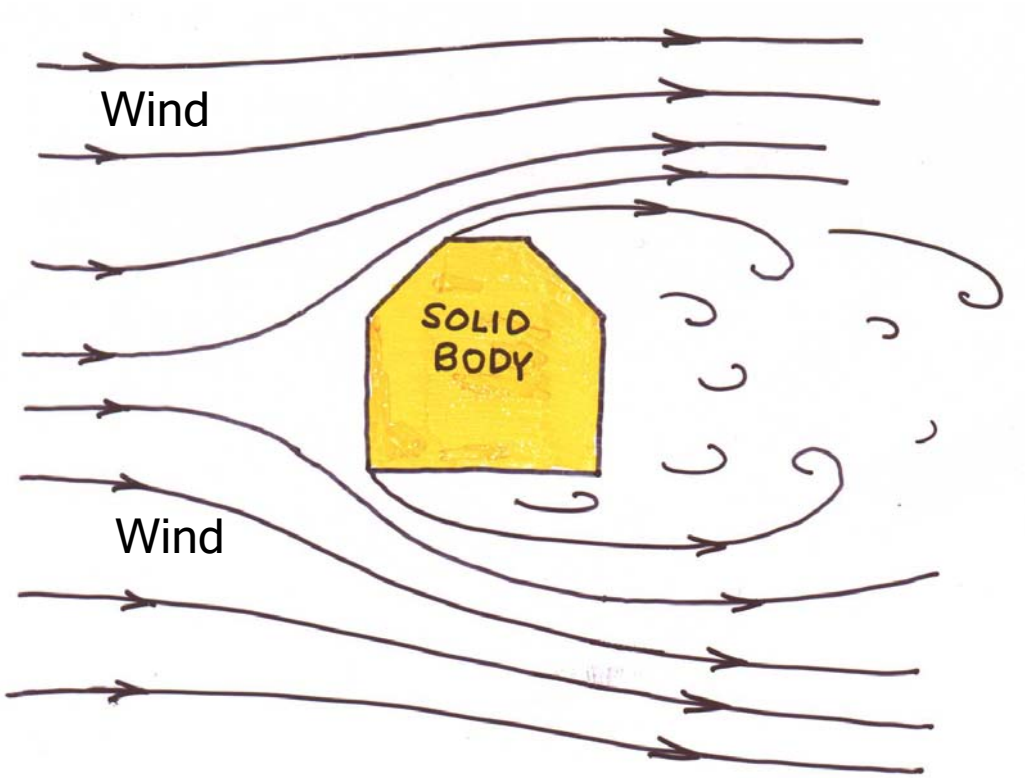
Profiles of mean wind velocity over flat terrains of different roughness



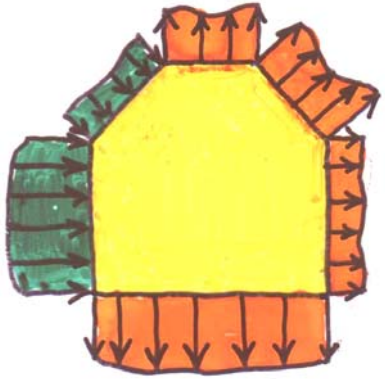
AERODYNAMICS

Wind-induced Pressures and Forces on Solid Objects

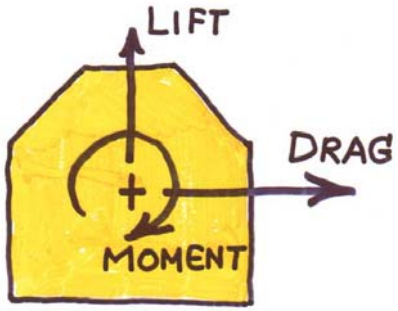
Aerodynamics



Wind-induced pressures

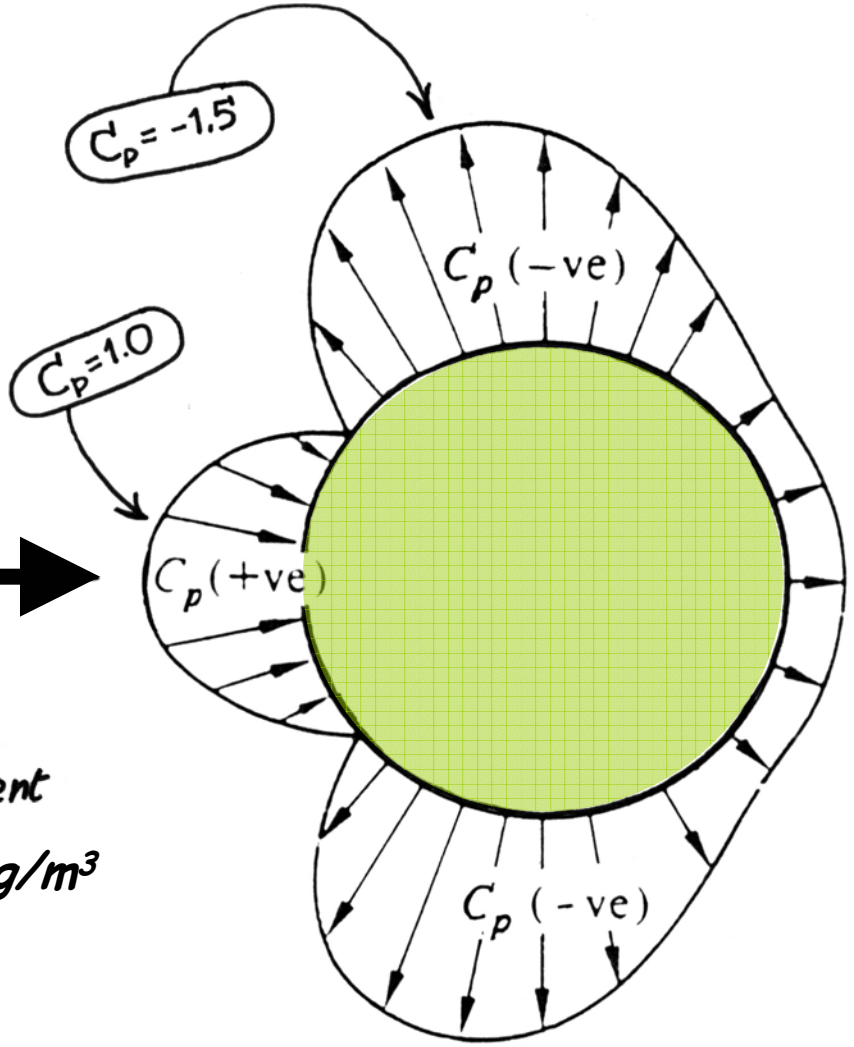


Wind-induced forces



Pressure distribution around a circular cylinder

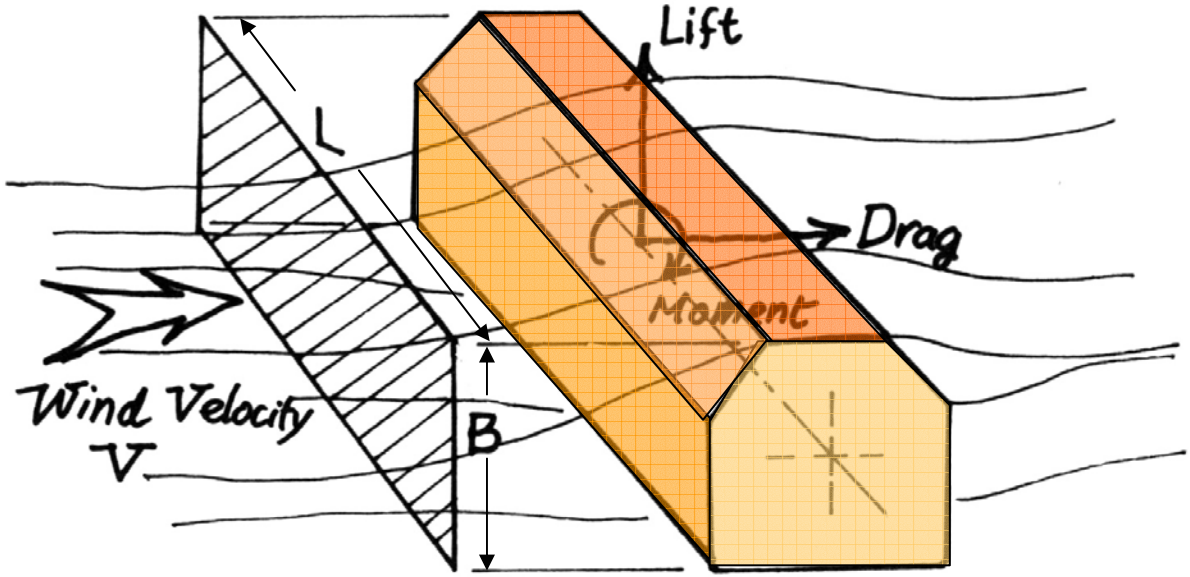
$$\text{Pressure} = \tfrac{1}{2}\rho V^2 C_p$$



C_p = Aerodynamic pressure coefficient

ρ = Air mass density = 1.25 kg/m^3

V = Wind Velocity



$$\text{Lift} = \frac{1}{2}\rho V^2 . A . C_L$$

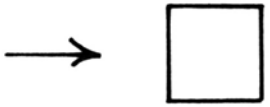
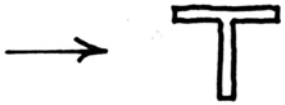
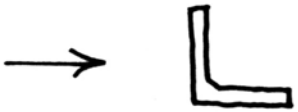
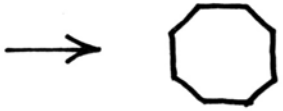
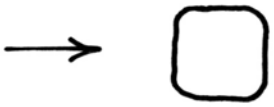
$$\text{Drag} = \frac{1}{2}\rho V^2 . A . C_D$$

$$\text{Moment} = \frac{1}{2}\rho V^2 . A . B . C_M$$

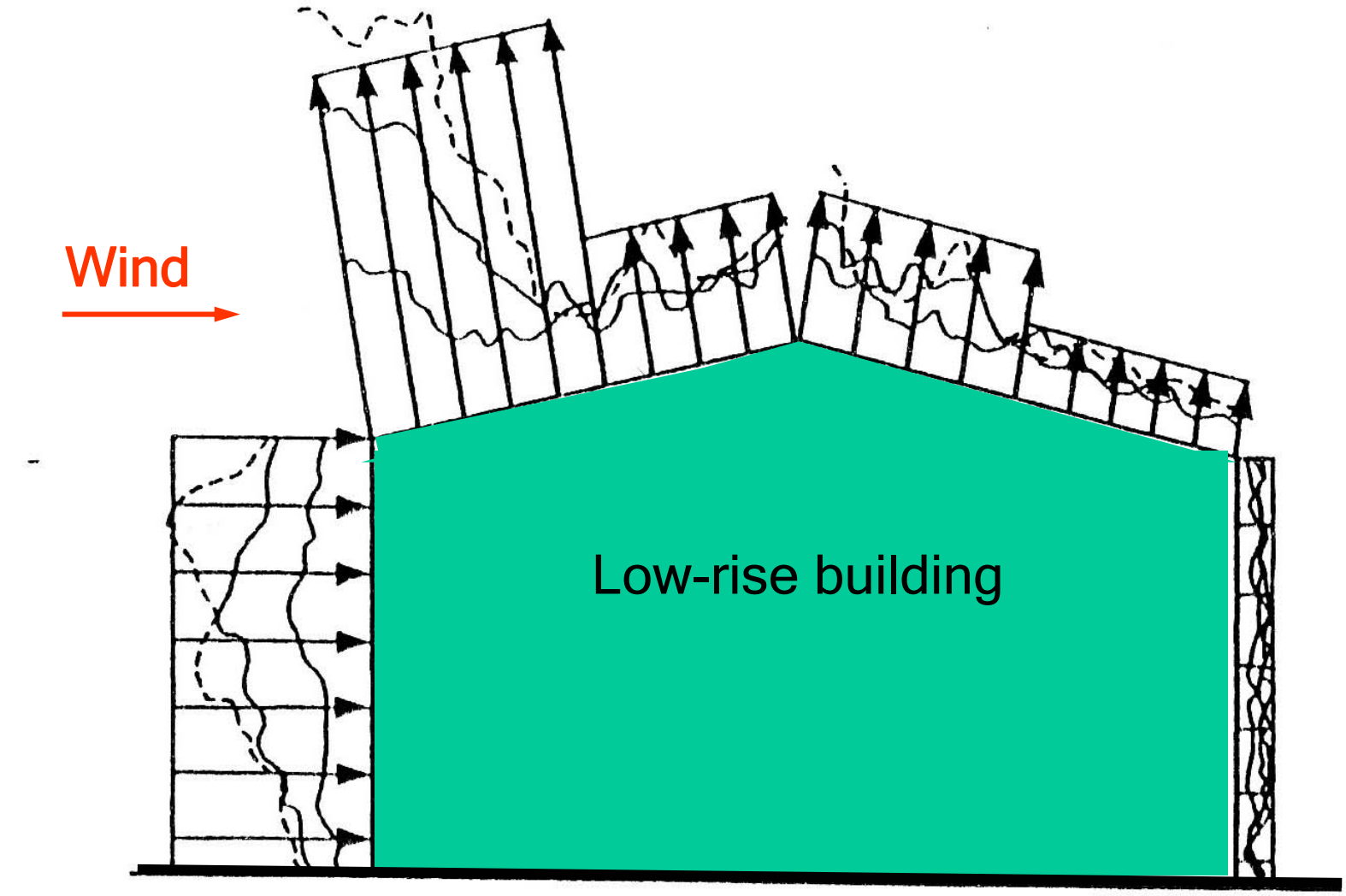
where A = Projected area of the body on a plane normal to the wind direction

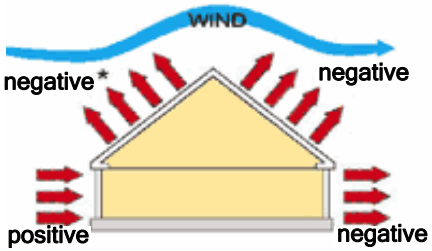
$A = B.L$

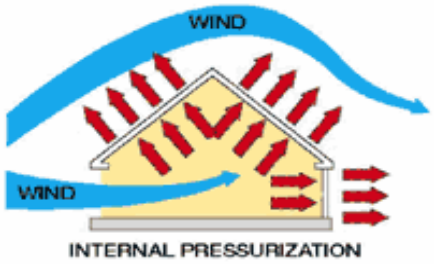
C_D, C_L, C_M = Aerodynamic drag, Lift, and moment coefficients

Cross Section and Wind direction	C_D	C_L
	2.0	0
	1.2	0
	1.8	1.0
	2.0	0.3
	1.4	0
	1.2	0

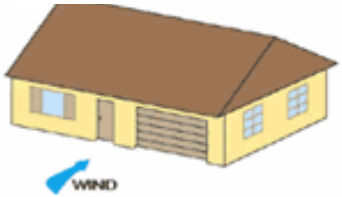
Instantaneous external pressure distributions and Simplified code distributions



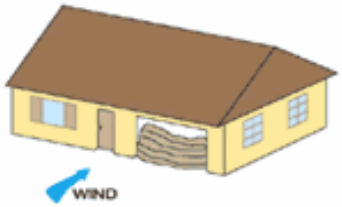




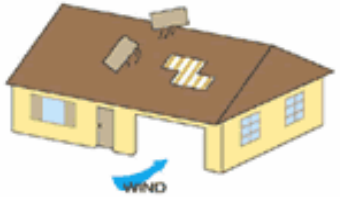
wind



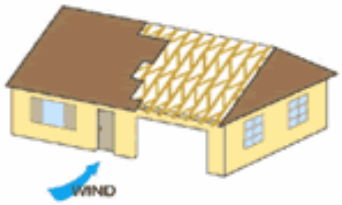
1. Hurricane force winds hit a house.



2. Impacts by windborne debris and high wind pressures cause the garage door to buckle and blow in.

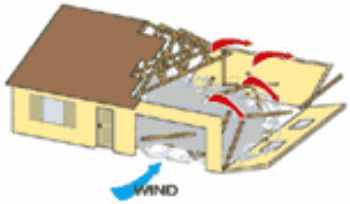


3. With the garage door gone, wind blows into the garage pressurizing the attic space above. The roof sheathing-to-roof truss connection starts to fail and roof sheathing starts to blow off.



4. A large section of the roof sheathing has pealed away. Because the roof sheathing acted as lateral bracing for the roof trusses by keeping them upright, they are now vulnerable to collapse.

5. A section of roof trusses collapses into the house. The roof trusses, before they collapsed, were bracing the tops of the exterior walls, keeping them upright.



6. With the roof trusses gone, the wind topples the exterior walls.

Damage caused by Hurricane Georges in Puerto Rico (1998)

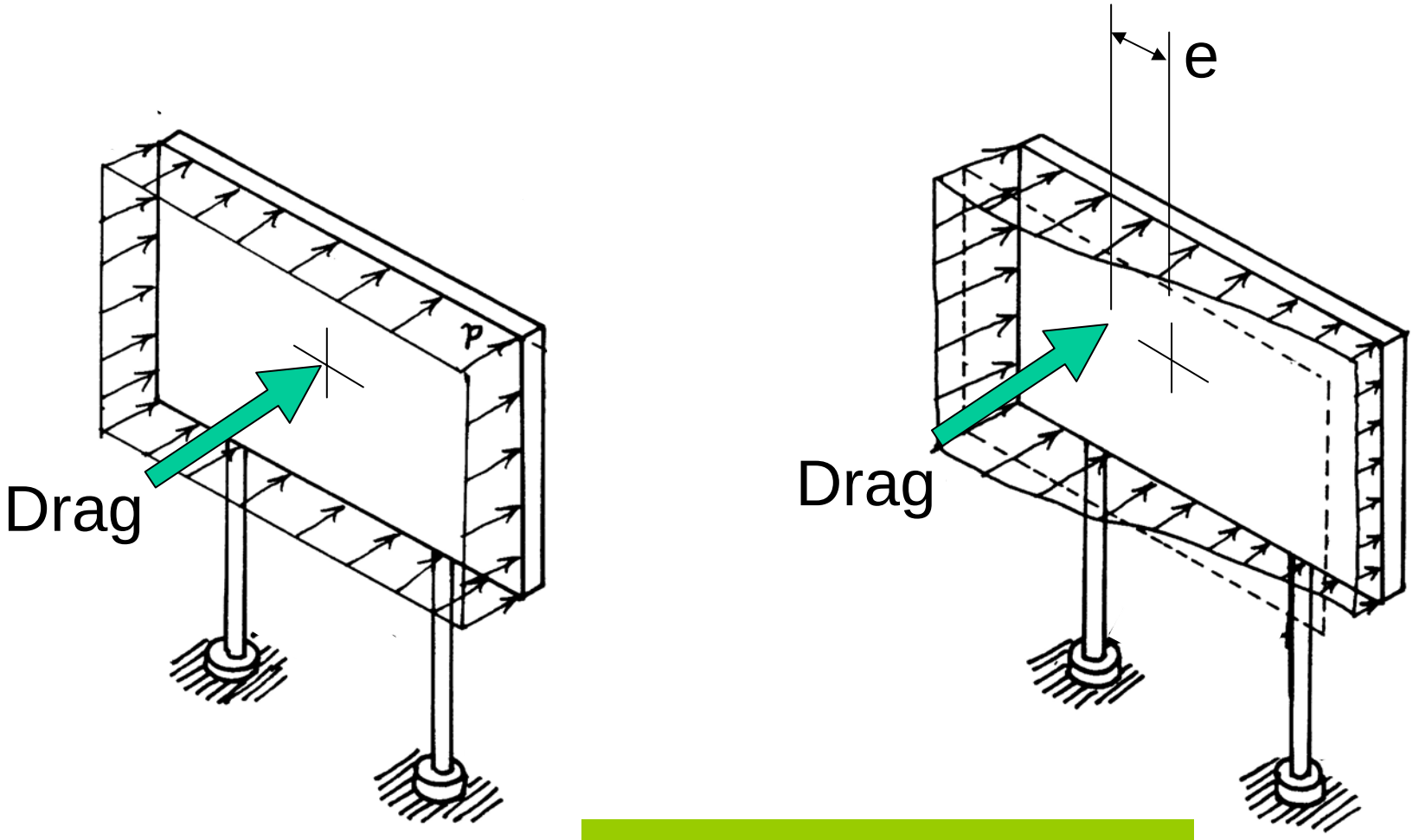
Damage in a coastal village in Chumporn by Typhoon Gay (1989)

กฎกระทรวงฉบับที่ 6 (พ.ศ. 2527) ออกตามความใน พระราชบัญญัติควบคุมอาคาร พ.ศ. 2522 รวมทั้งข้อบัญญัติกรุงเทพมหานคร เรื่องควบคุมการก่อสร้างอาคาร พ.ศ. 2522 ได้อนุญาตให้วิศวกรใช้หน่วยแรงลมดังต่อไปนี้ในการคำนวณหา “แรงลมสูงสุด”:

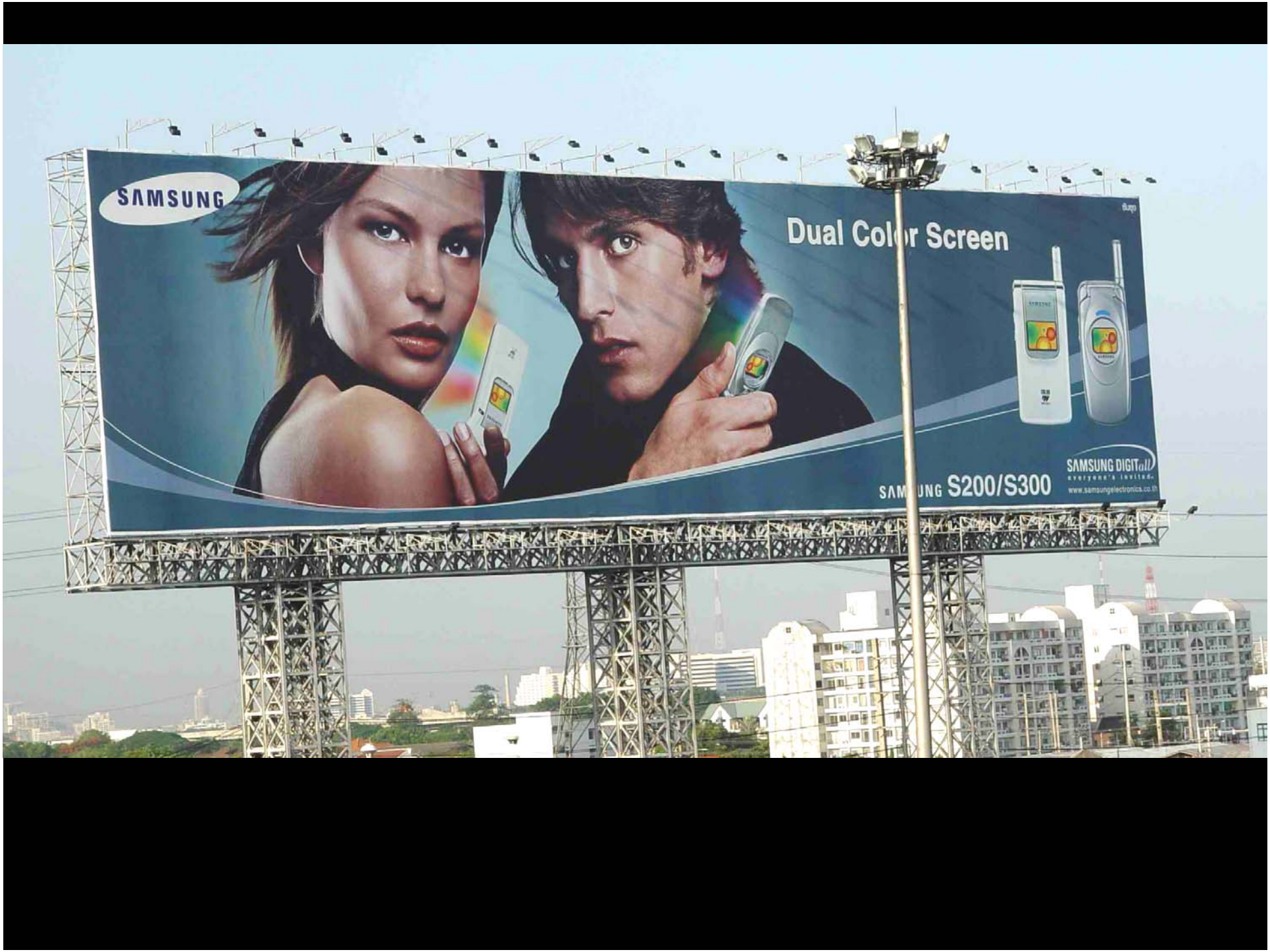
พื้นที่รับแรงปะทะลมที่สูงจากพื้นดินไม่เกิน 10 เมตร	*มีหน่วยแรงลม 50 กิโลกรัมต่อตารางเมตร*
พื้นที่รับแรงปะทะลมที่สูงกว่า 10 เมตร แต่ไม่เกิน 20 เมตร	*มีหน่วยแรงลม 80 กิโลกรัมต่อตารางเมตร*
พื้นที่รับแรงปะทะลมที่สูงกว่า 20 เมตร แต่ไม่เกิน 40 เมตร	*มีหน่วยแรงลม 120 กิโลกรัมต่อตารางเมตร*
พื้นที่รับแรงปะทะลมที่สูงกว่า 40 เมตร	*มีหน่วยแรงลม 160 กิโลกรัมต่อตารางเมตร*

หน่วยแรงลมเหล่านี้ คือค่าแรงลมสูงสุดต่อพื้นที่ 1 ตารางเมตรของแผ่นป้าย

Effect of Non-uniform Pressure Distribution



Drag x e = Torsion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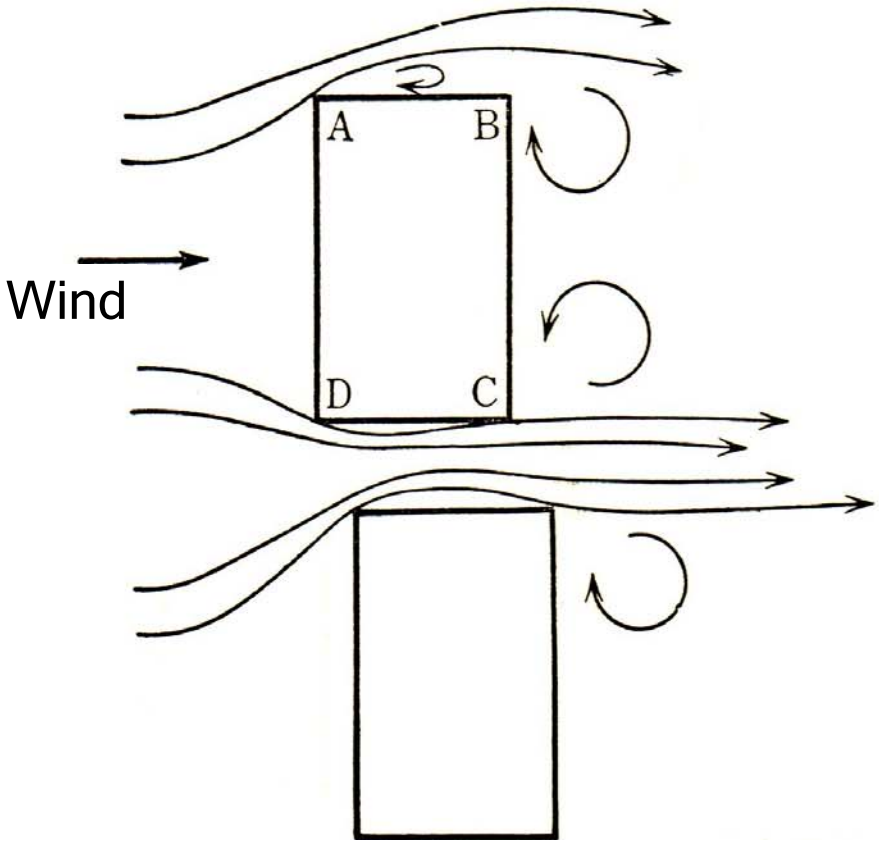
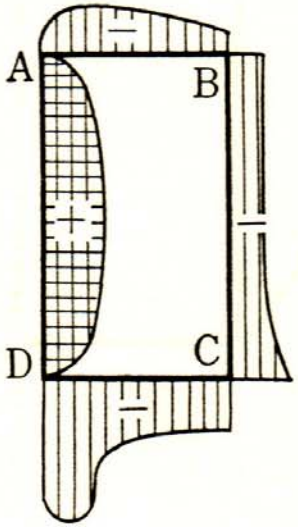
Collapse of a large billboard (50 m high) in Bangkok during a severe thunderstorm on June 2002

Interference Effects

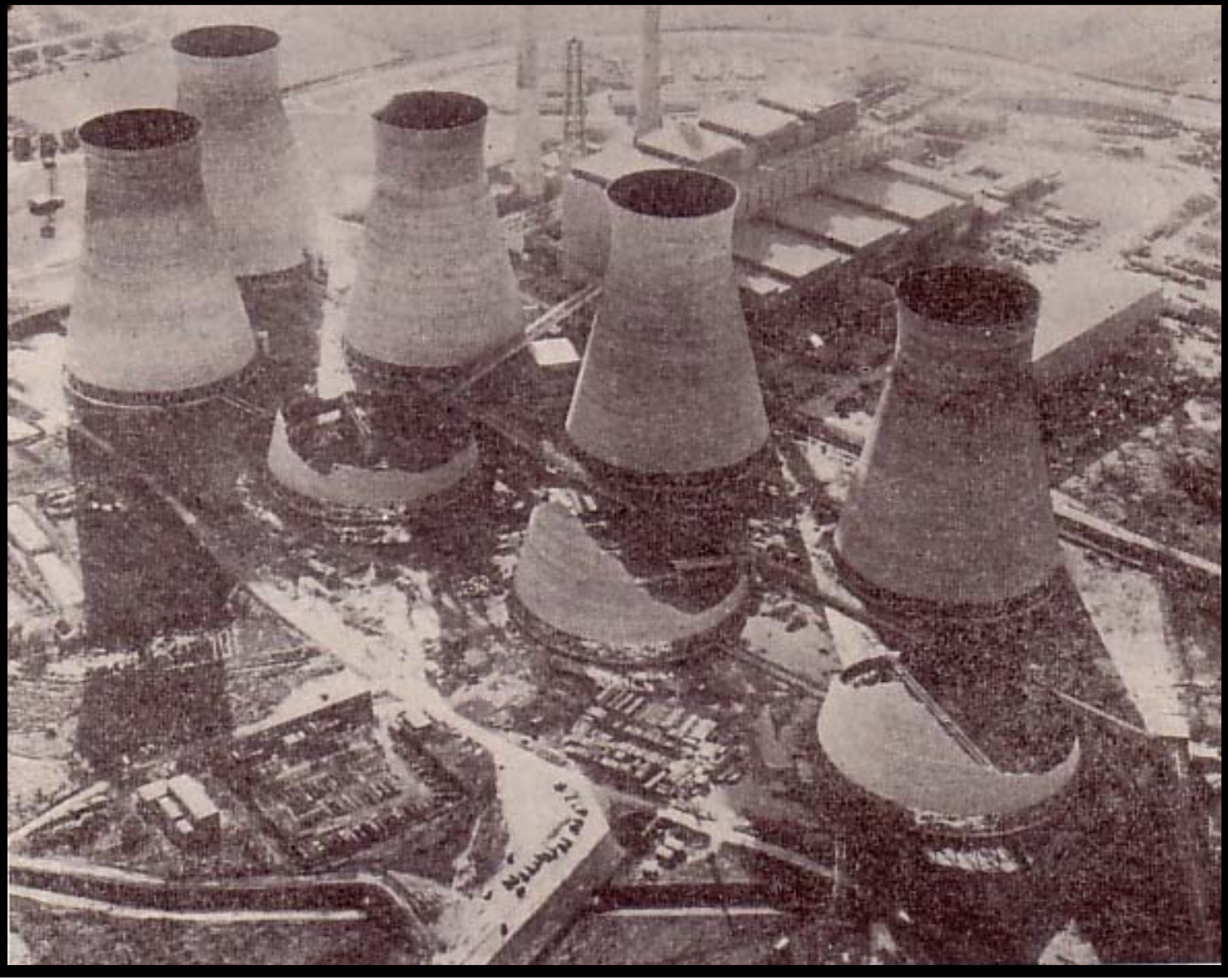




Pressure Distribution

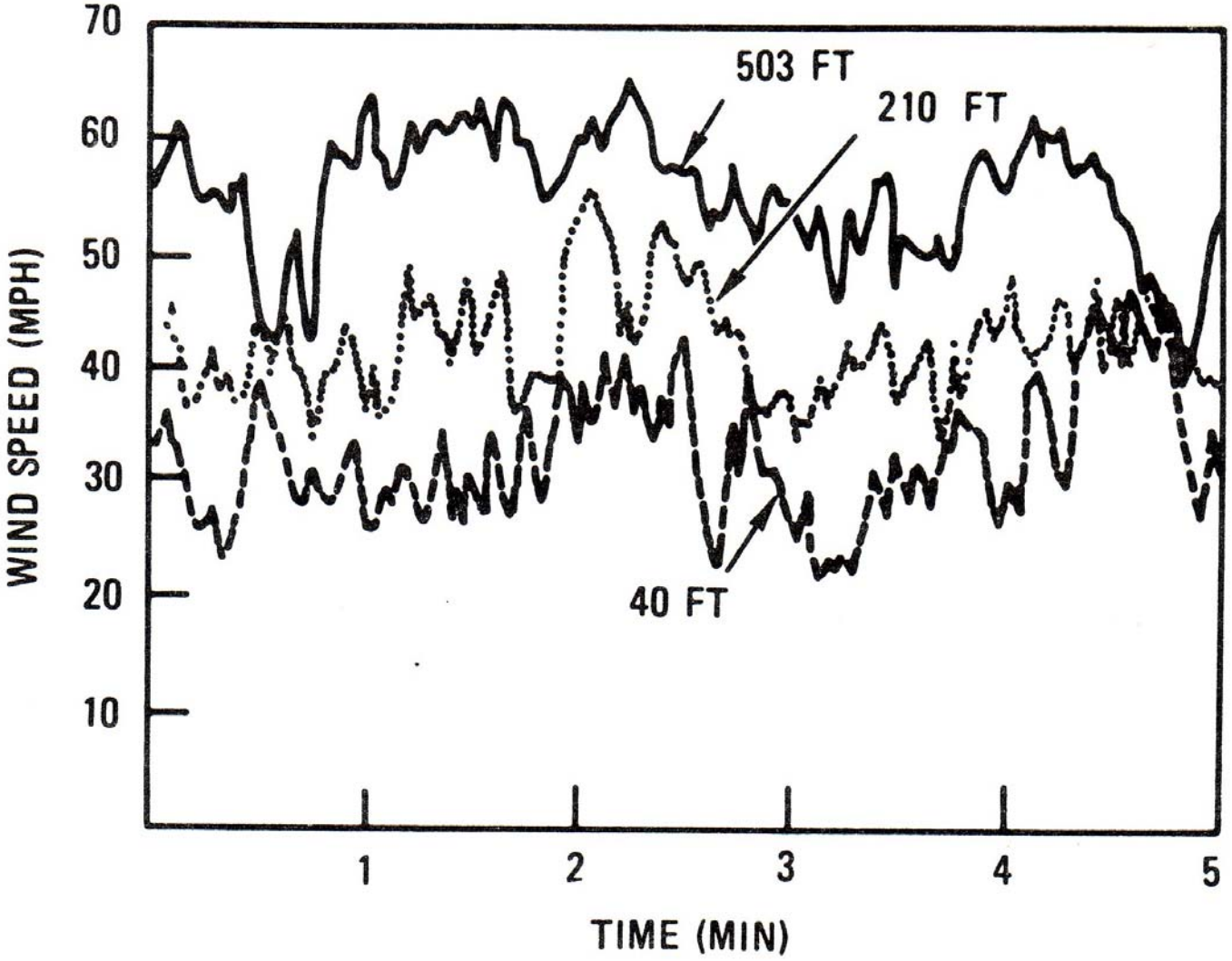
Failure of Hyperbolic Cooling Towers

The Ferrybridge Power Station, England, 1965



Tall Buildings–*Dynamic Wind Effects need to be considered !*

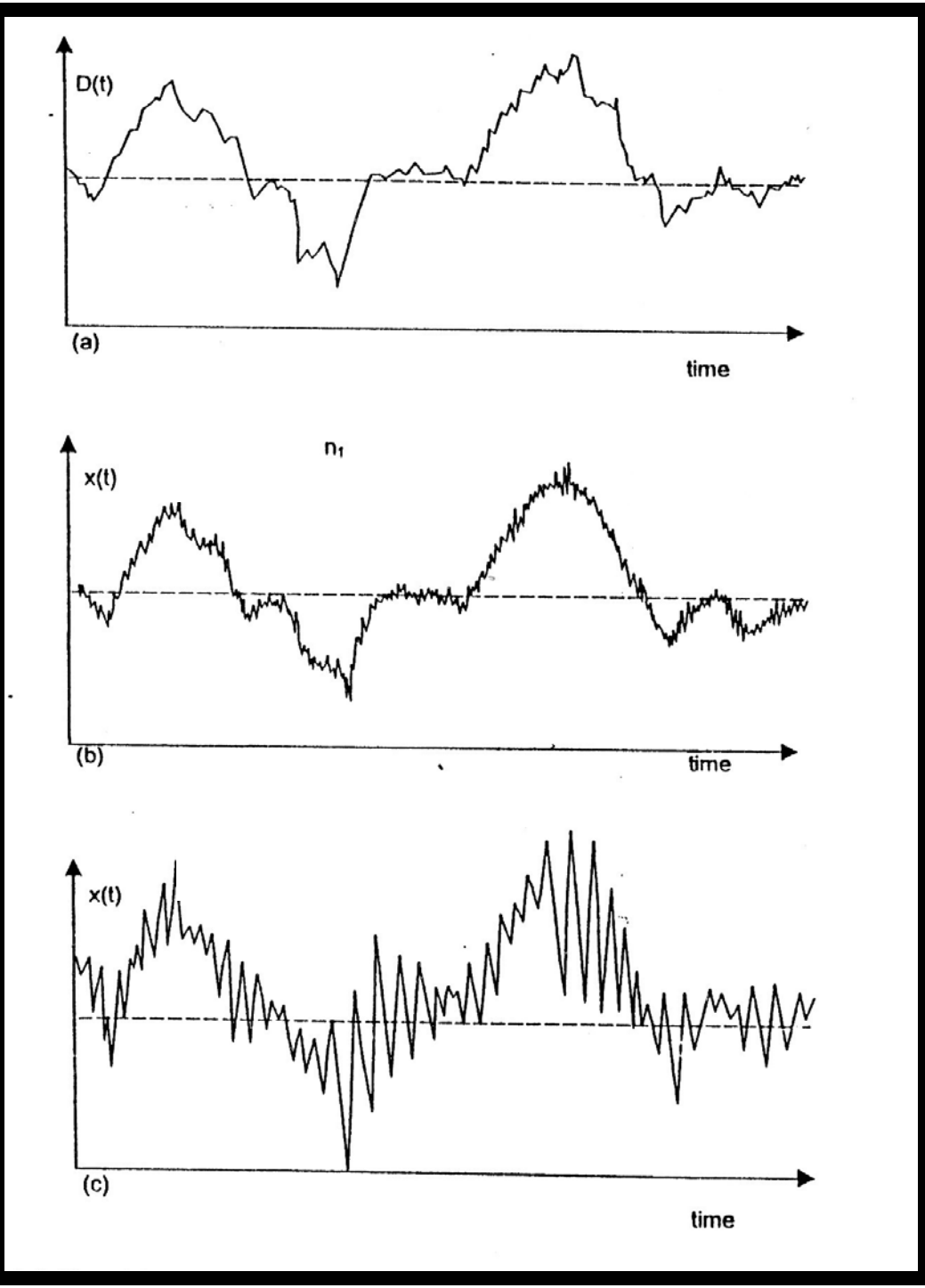
Record of wind speed at three different heights



Wind force (Drag)

Response of a mid-rise building with a high natural frequency

Response of a high-rise building with a low natural frequency



ASCE 7-98

ASCE STANDARD

American Society of Civil Engineers

Minimum Design Loads for Buildings and Other Structures

Revision of ANSI/ASCE 7-95

This document uses both Système International (SI) units and customary units.

ASCE

SEI
Structural Engineering Institute

AS/NZS 1170.2:2002

Building Code of Australia
Primary referenced Standard

Australian/New Zealand Standard™

Structural design actions

Part 2: Wind actions

ABCB

Standards Australia

STANDARDS NEW ZEALAND

วิศวกรรมสถานแห่งประเทศไทย ในพระบรมราชูปถัมภ์
THE ENGINEERING INSTITUTE OF THAILAND
UNDER H.M. THE KING'S PATRONAGE

มาตรฐานการคำนวณแรงลมสำหรับการออกแบบอาคาร

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วิศวกรรมสถานแห่งประเทศไทย ในพระบรมราชูปถัมภ์

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มาตรฐาน ว.ส.ท.
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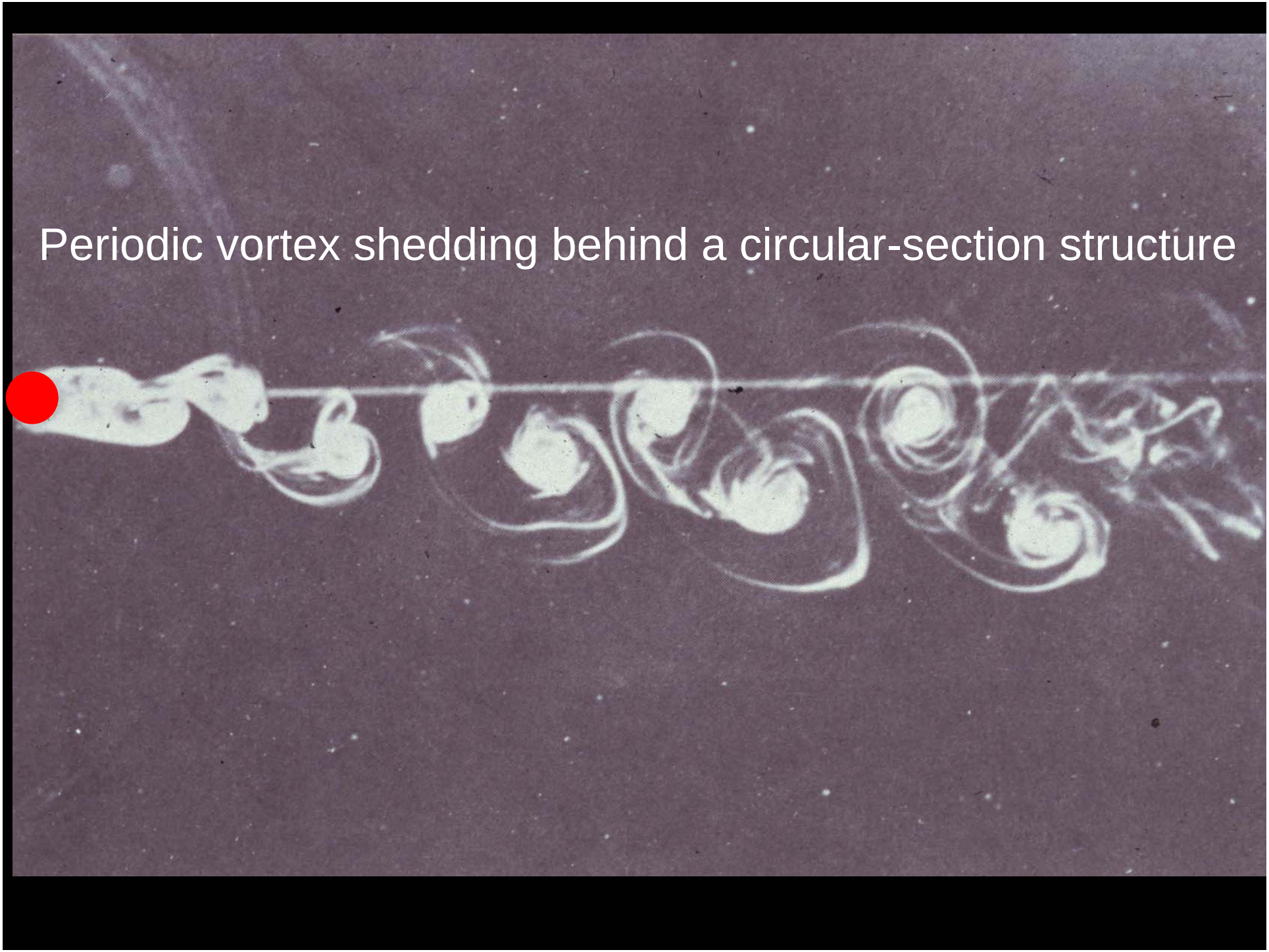
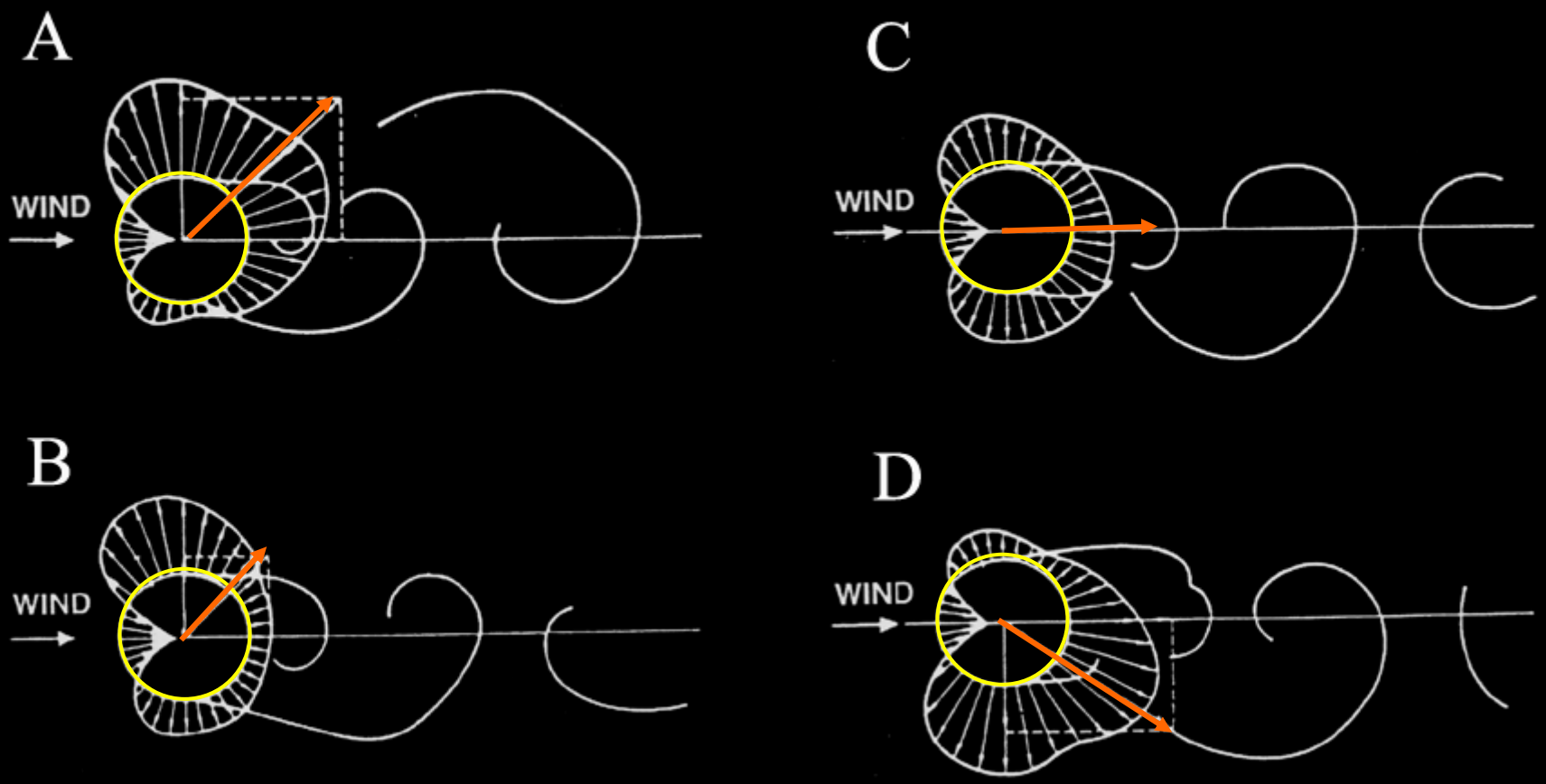
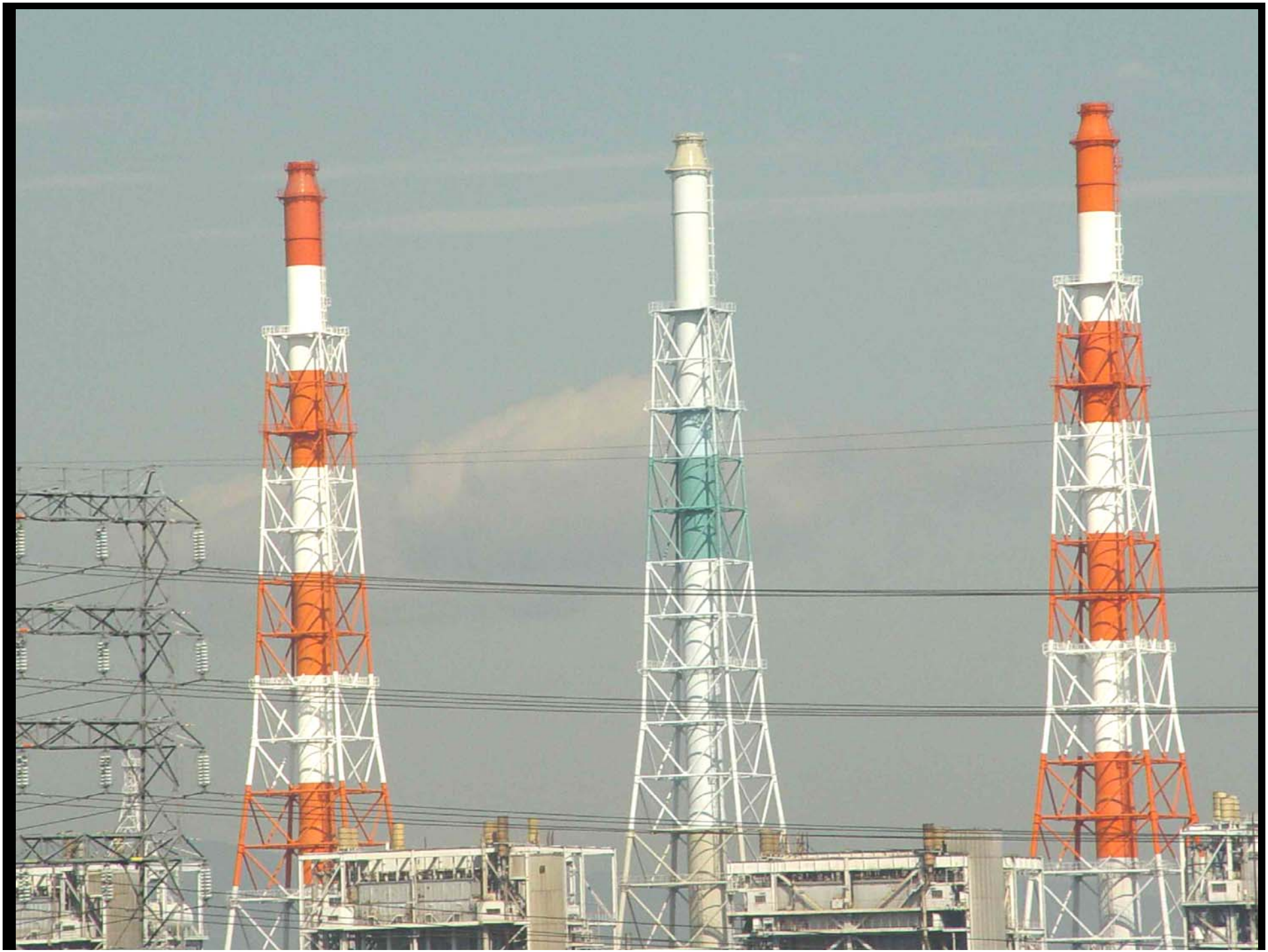
มกราคม 2546
ราคา 120 บาท

A Steel Stack


Periodic vortex shedding behind a circular-section structure

Vortex-induced surface pressure distributions



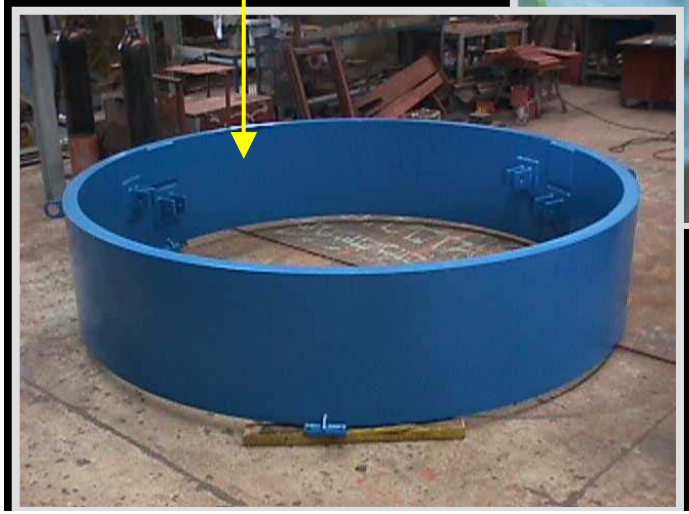


Helical Strake

Pendulum Tuned Mass Damper

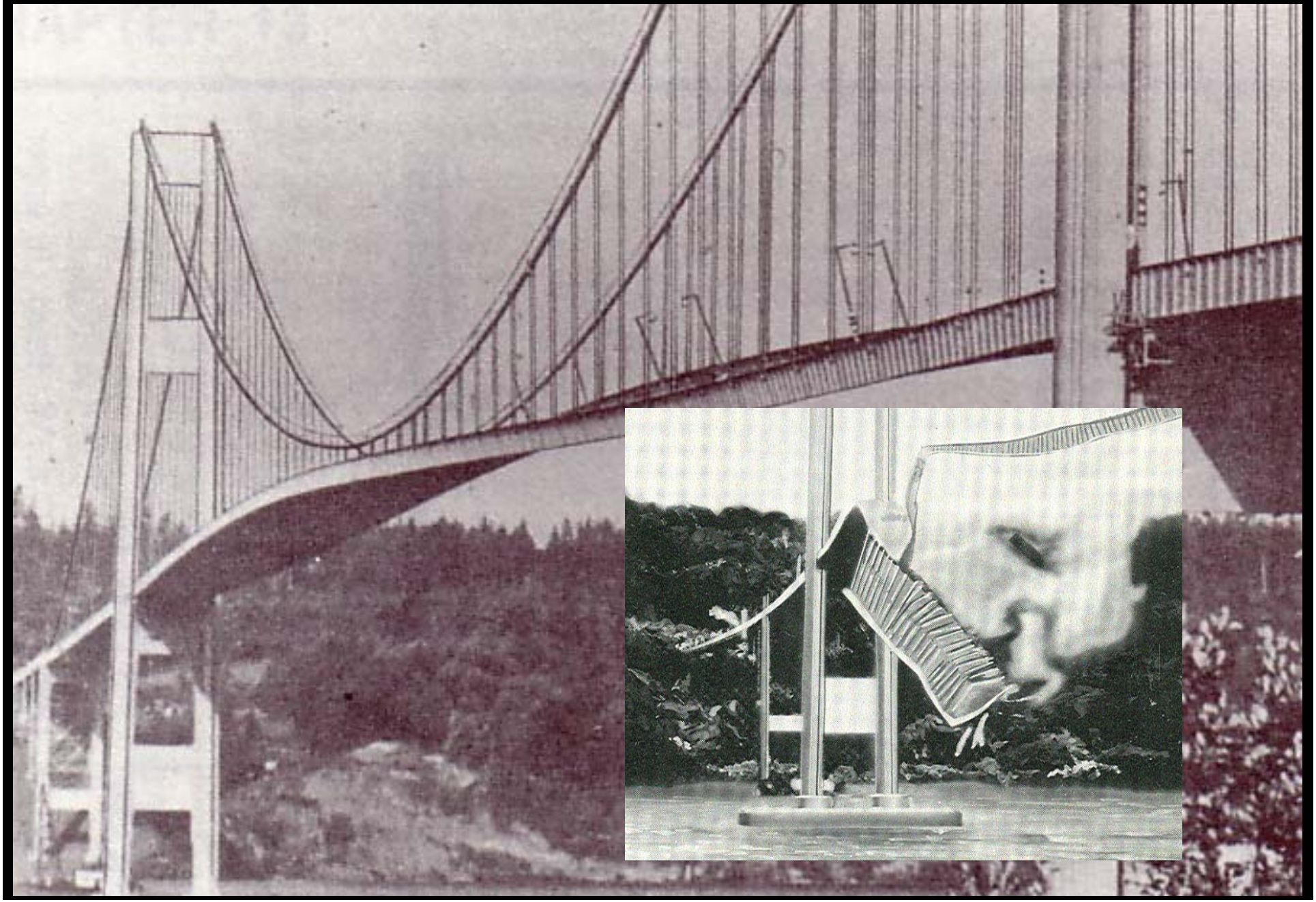
Suspended Wire Rope

Steel Ring



Viscous Damper

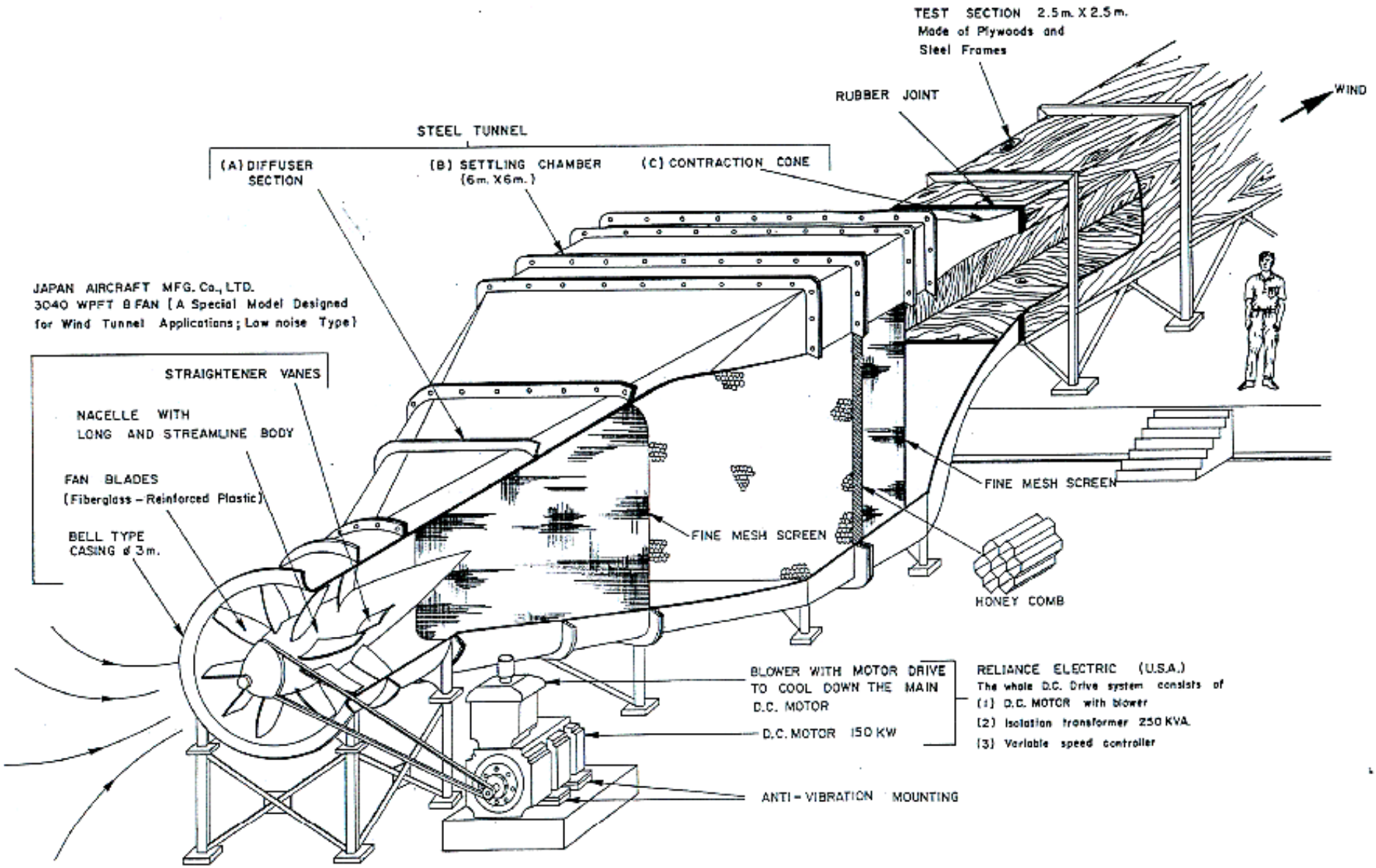
Torsional Flutter of the Tacoma Narrows Bridge in 1940




Wind Tunnel Test on a Bridge Section Model
To check its Aerodynamic Stability

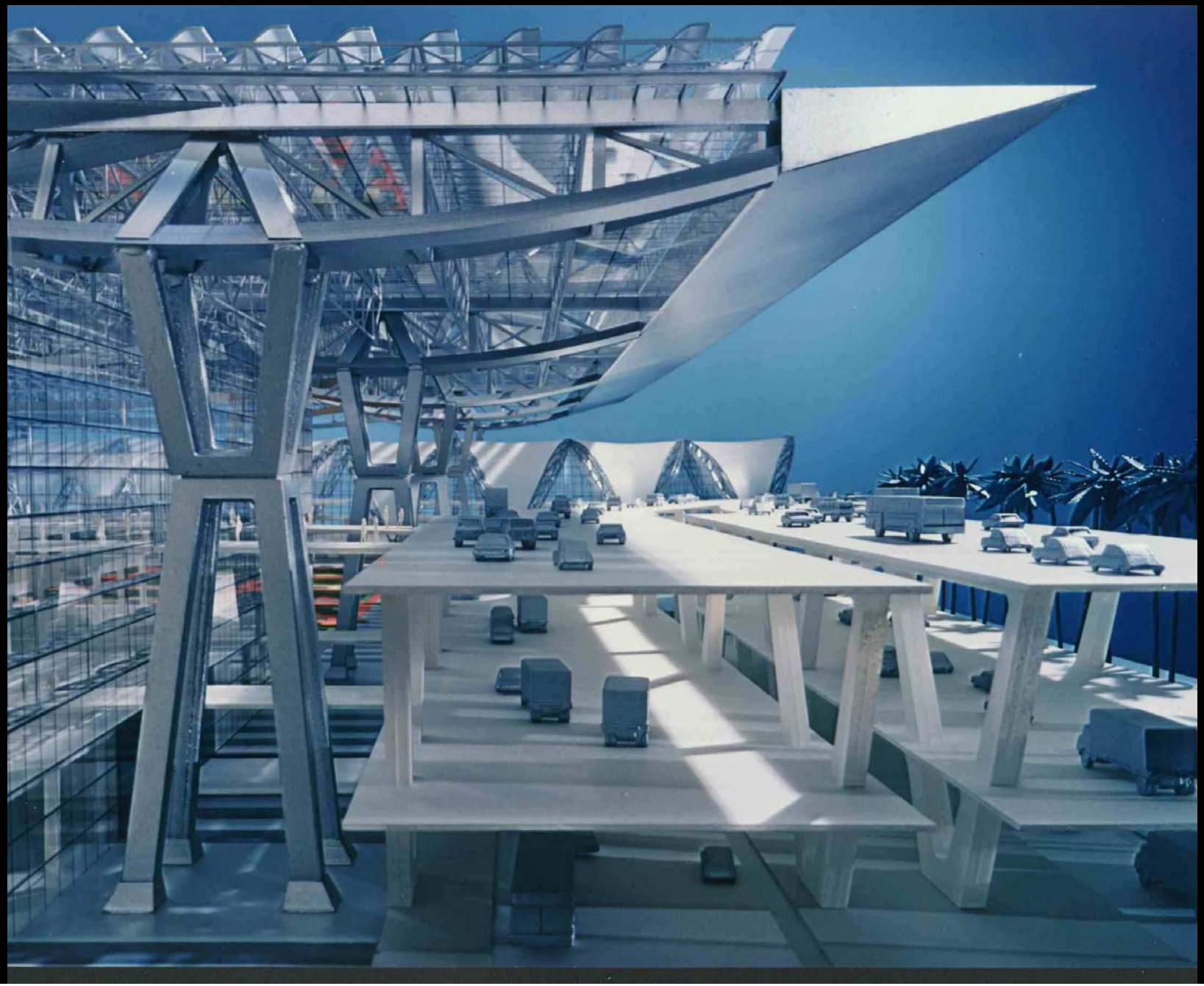
Wind Tunnel Test on a Full Bridge Model

The TU-AIT Boundary Layer Wind Tunnel Laboratory

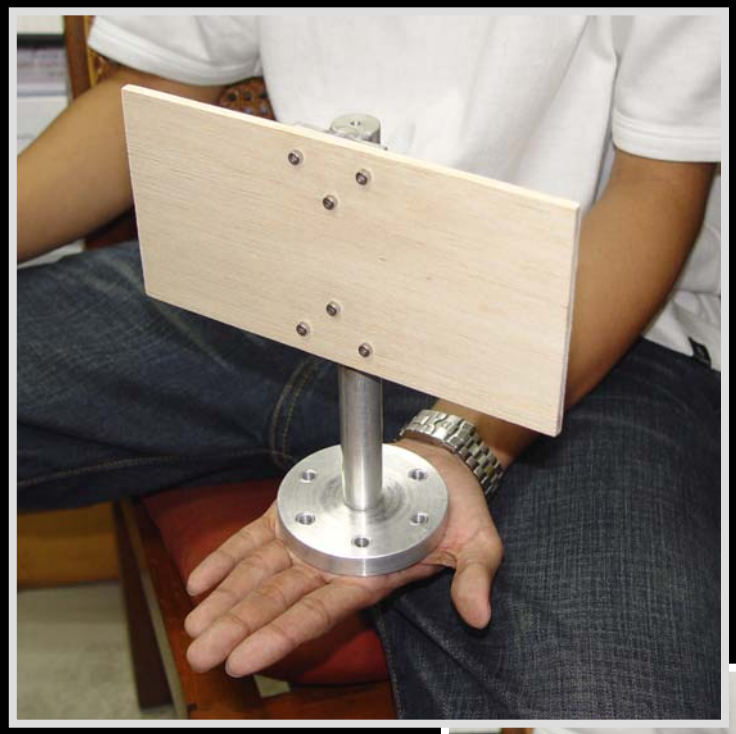

TEST SECTION 2.5m. X 2.5m.
Made of Plywoods and
Steel Frames
RUBBER JOINT
WIND
STEEL TUNNEL
(A) DIFFUSER SECTION
(B) SETTLING CHAMBER (6m. X6m.)
(C) CONTRACTION CONE
JAPAN AIRCRAFT MFG. Co., LTD.
3040 WPFT 8 FAN (A Special Model Designed for Wind Tunnel Applications; Low noise Type)
STRAIGHTENER VANES
NACELLE WITH LONG AND STREAMLINE BODY
FAN BLADES (Fiberglass – Reinforced Plastic)
BELL TYPE CASING ø 3m.
FINE MESH SCREEN
FINE MESH SCREEN
HONEY COMB
BLOWER WITH MOTOR DRIVE TO COOL DOWN THE MAIN D.C. MOTOR
D.C. MOTOR 150 KW
ANTI-VIBRATION MOUNTING
RELIANCE ELECTRIC (U.S.A.)
The whole D.C. Drive system consists of
(1) D.C. MOTOR with blower
(2) Isolation transformer 250 KVA
(3) Variable speed controller

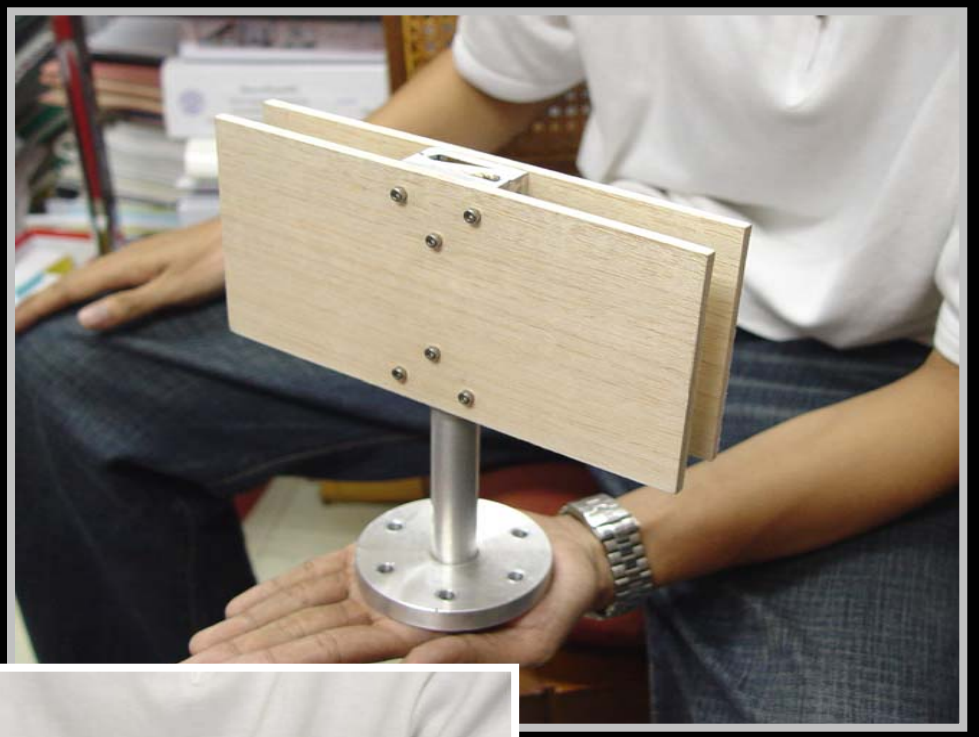
THE NATIONAL ENERGY COMPLEX

Suvarnabhumi Airport




60-degree Wind Direction





Interference Effects from Nearby Structures