Trees and Winds

In Storms

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Trees and Winds

Introduction

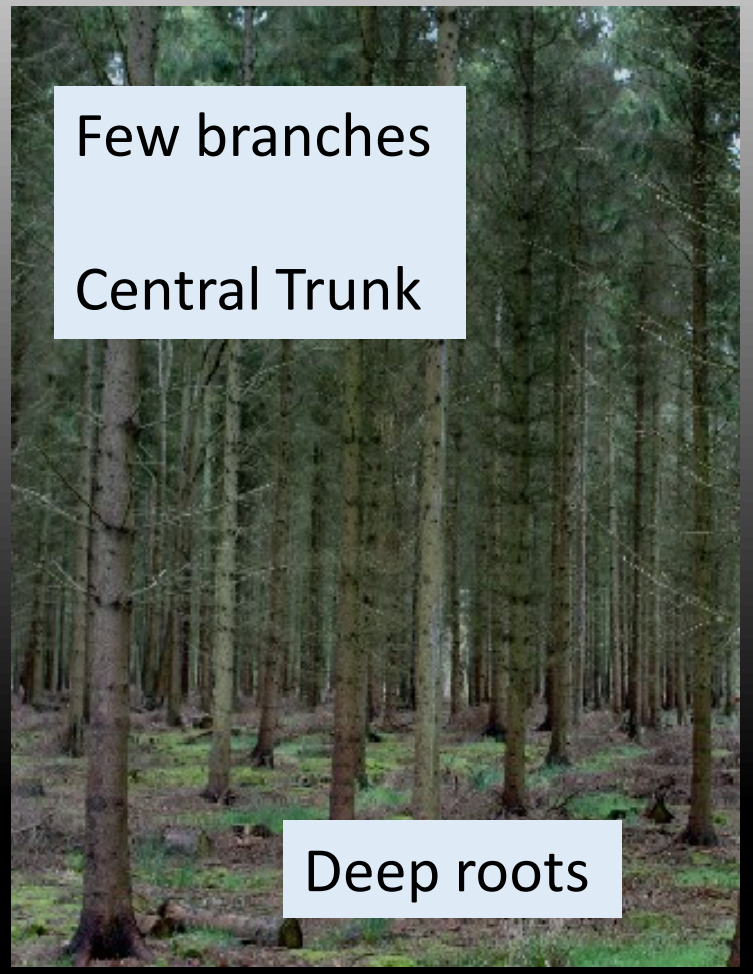
1. FORCES on Trees in winds
2. *STRUCTURE* of Urban Trees
3. Failure of Trees in winds
4. Wind Environment in Cities
5. Manage trees in storms
6. STABILTY of Trees

STRUCTURAL Differences

Urban Trees

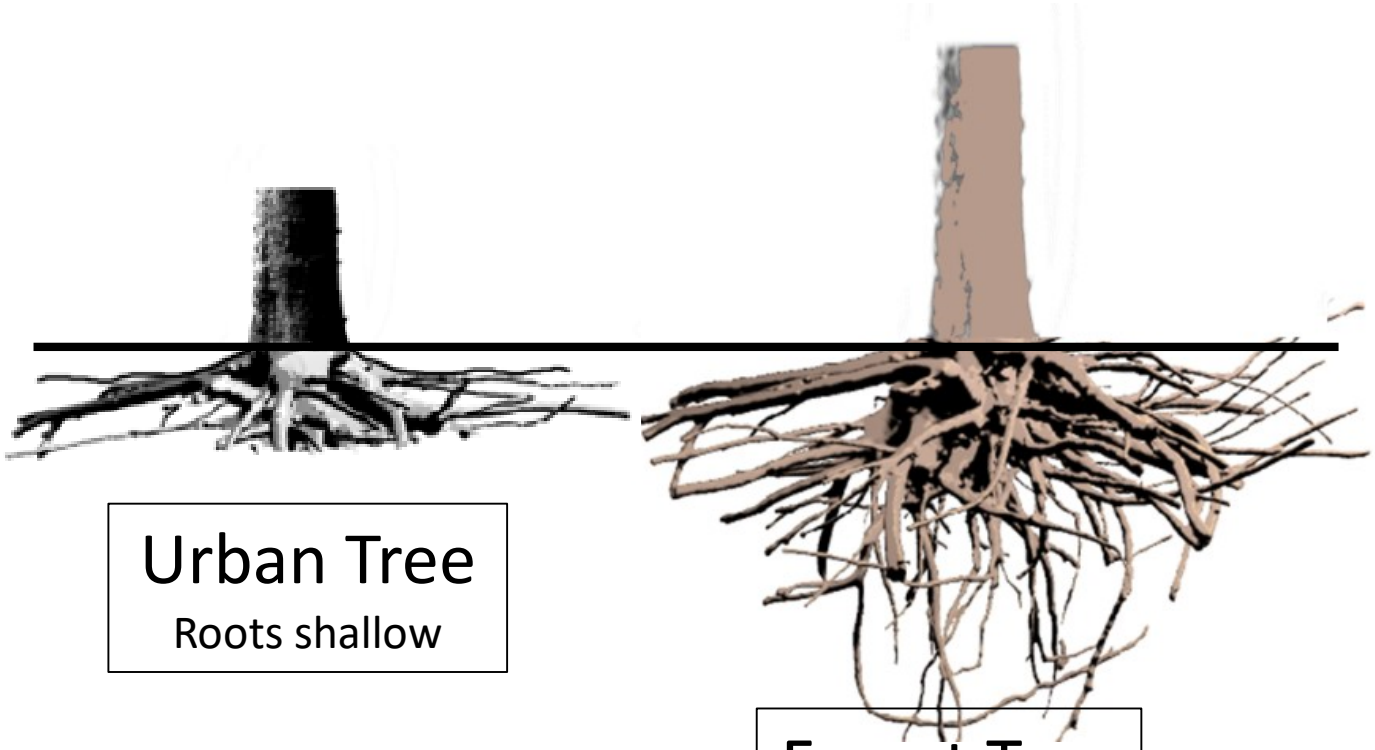
Hyde Park, Sydney, Australia

Forest Trees



Urban Tree Failure - Shallow Root Plates

Melbourne, Australia



Urban Tree
Roots shallow

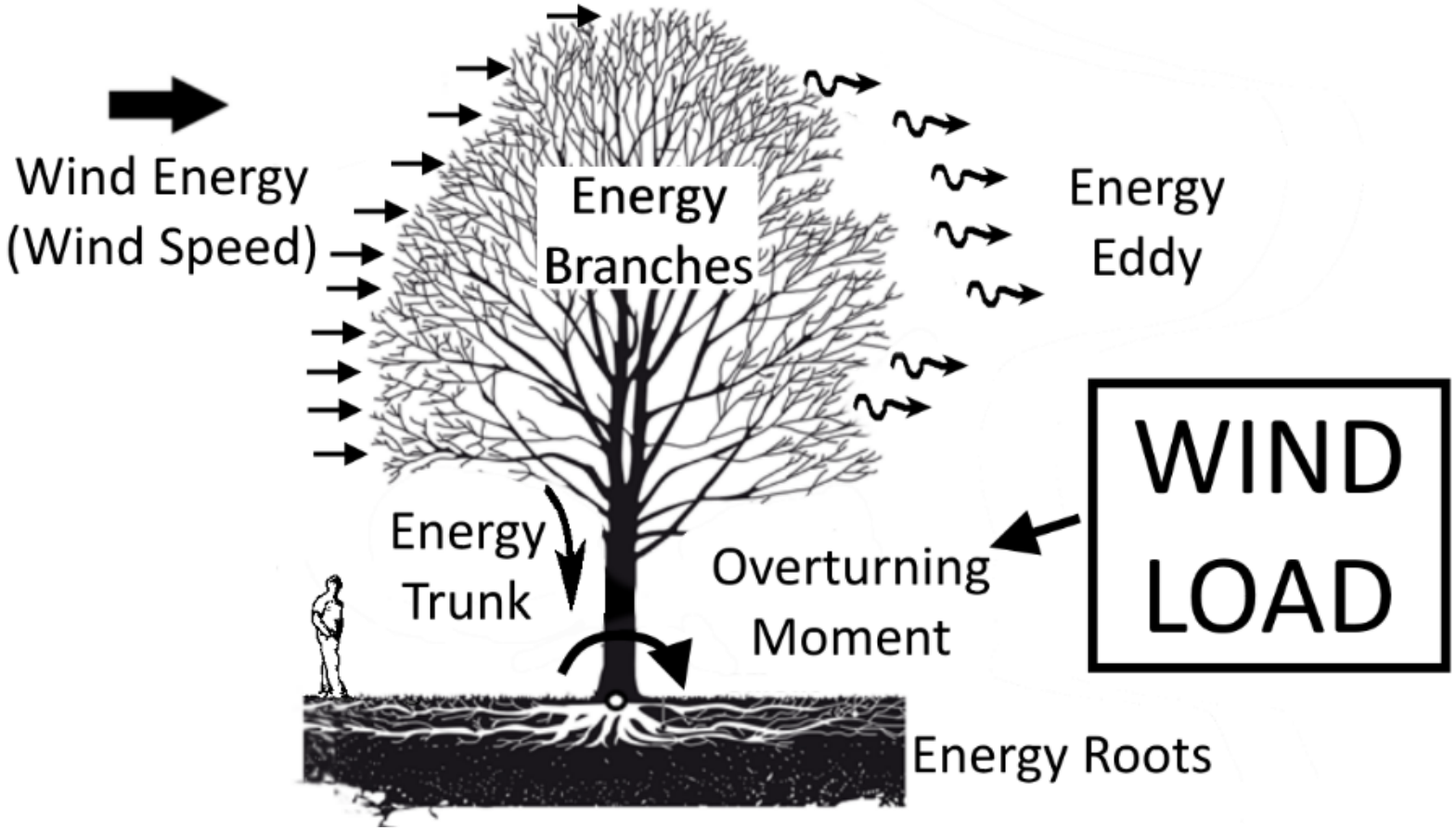
Soil disturbed

Forest Tree
Roots Deep

Soil DEEP
Not disturbed

What are the Wind Loads on Trees?

WIND Load - Biggest FORCE on Trees (DYNAMIC)

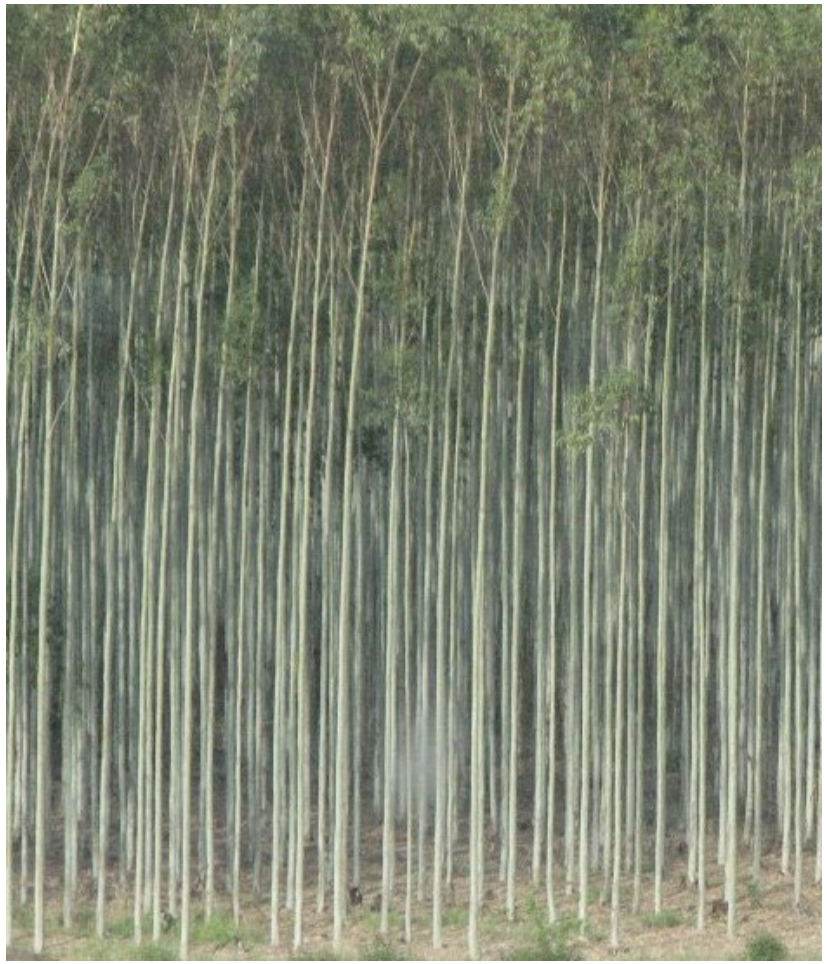


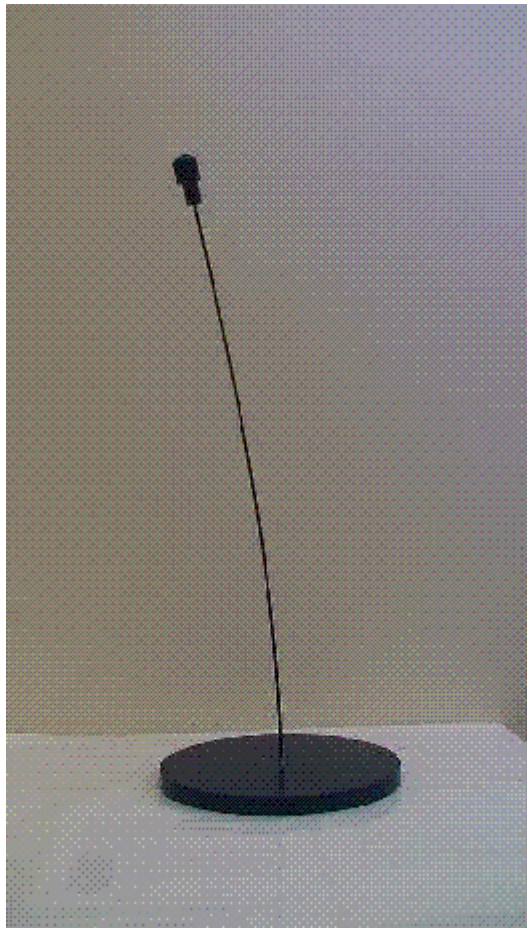
Wind Loads –DYNAMIC not Static

Wind Loads – toilet blown upwards?

Dynamics of Forest Trees

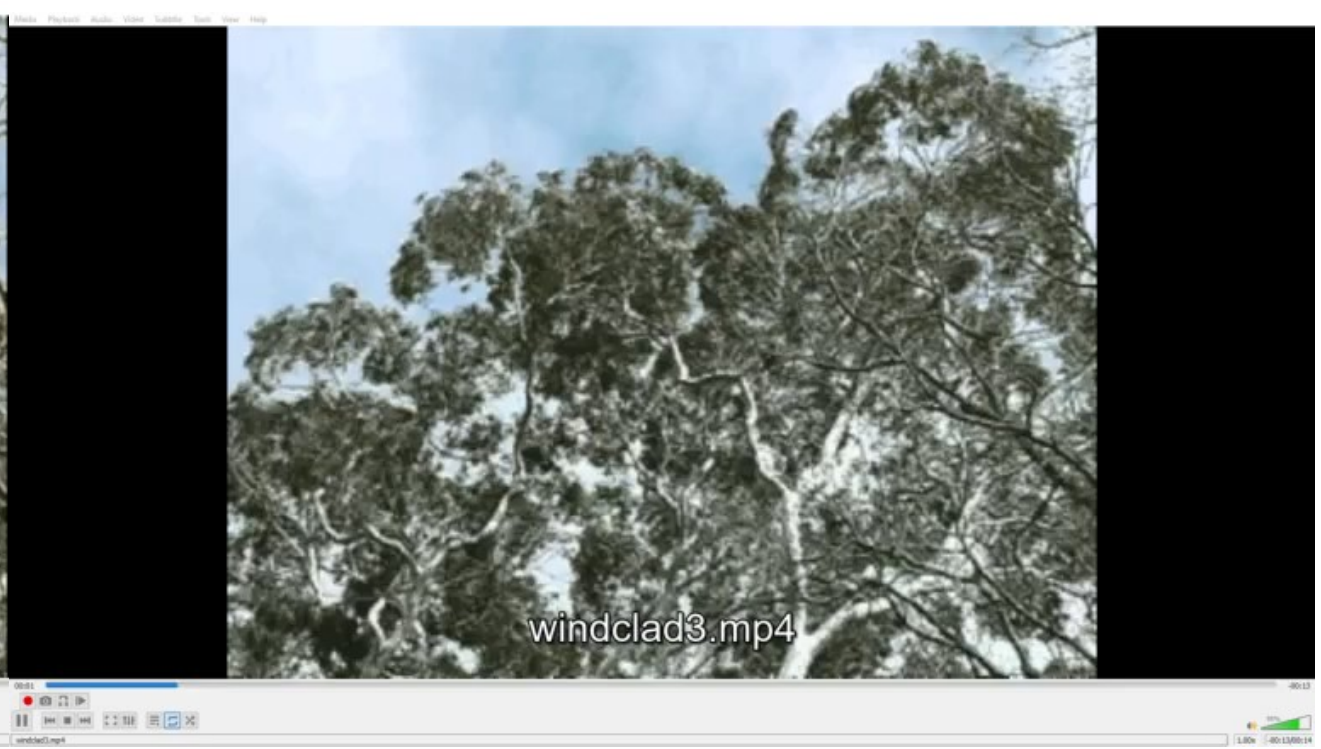
Few branches - Large Sway – LOW DAMPING





Dynamics of Urban Trees

Many branches - Complex sway – Mass Damping



Replay – normal speed

Replay – x3 normal speed

VIDEO: 1. windclad1.mp4

2. windclad3.mp4

Structural Loads on Trees

Ficus, Botanic Gardens, Sydney, Australia

Static Forces - Weight

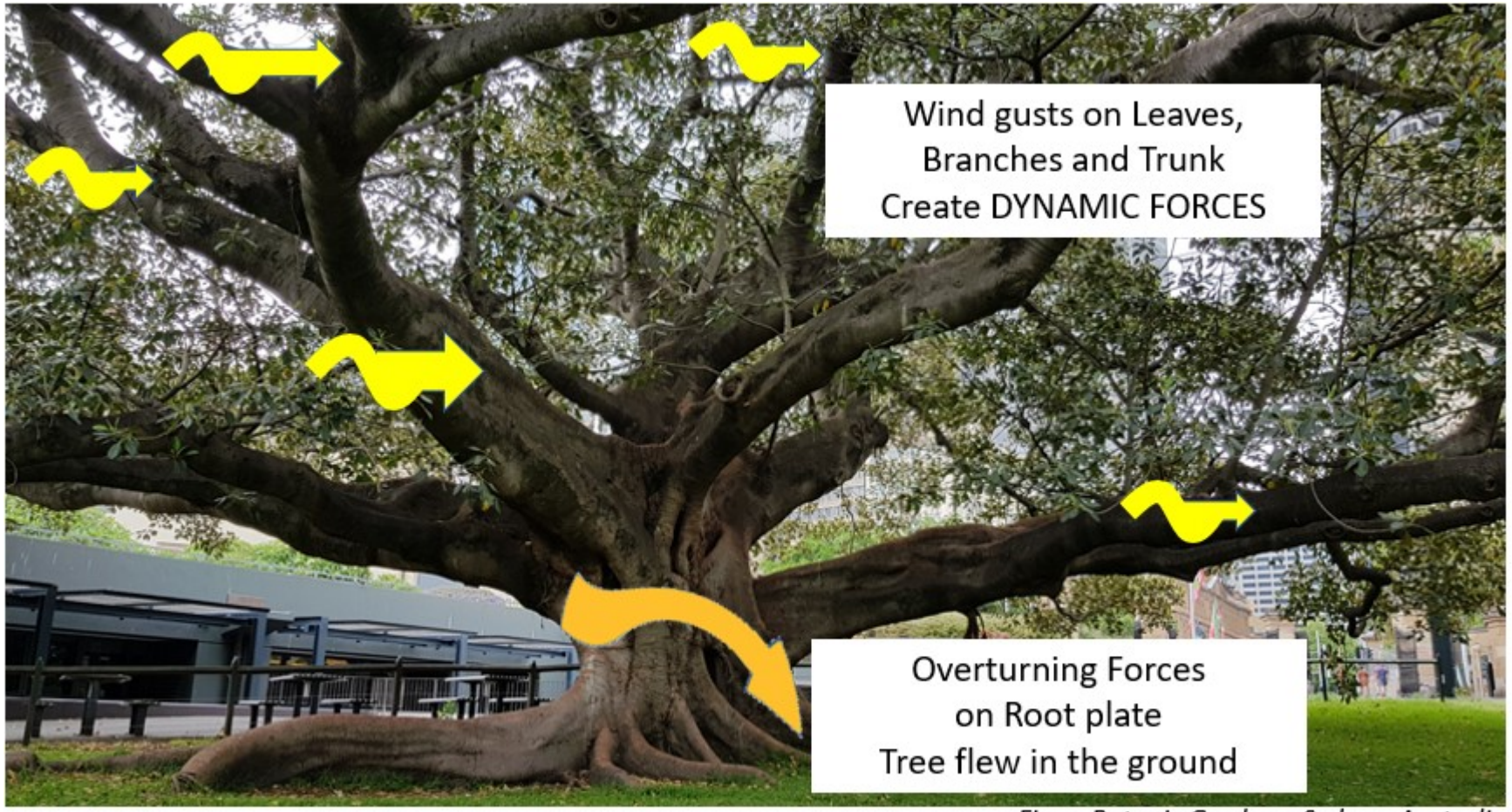
Ficus, Botanic Gardens, Sydney, Australia

Static Pull Test

Note: Top of tree removed for Static Test

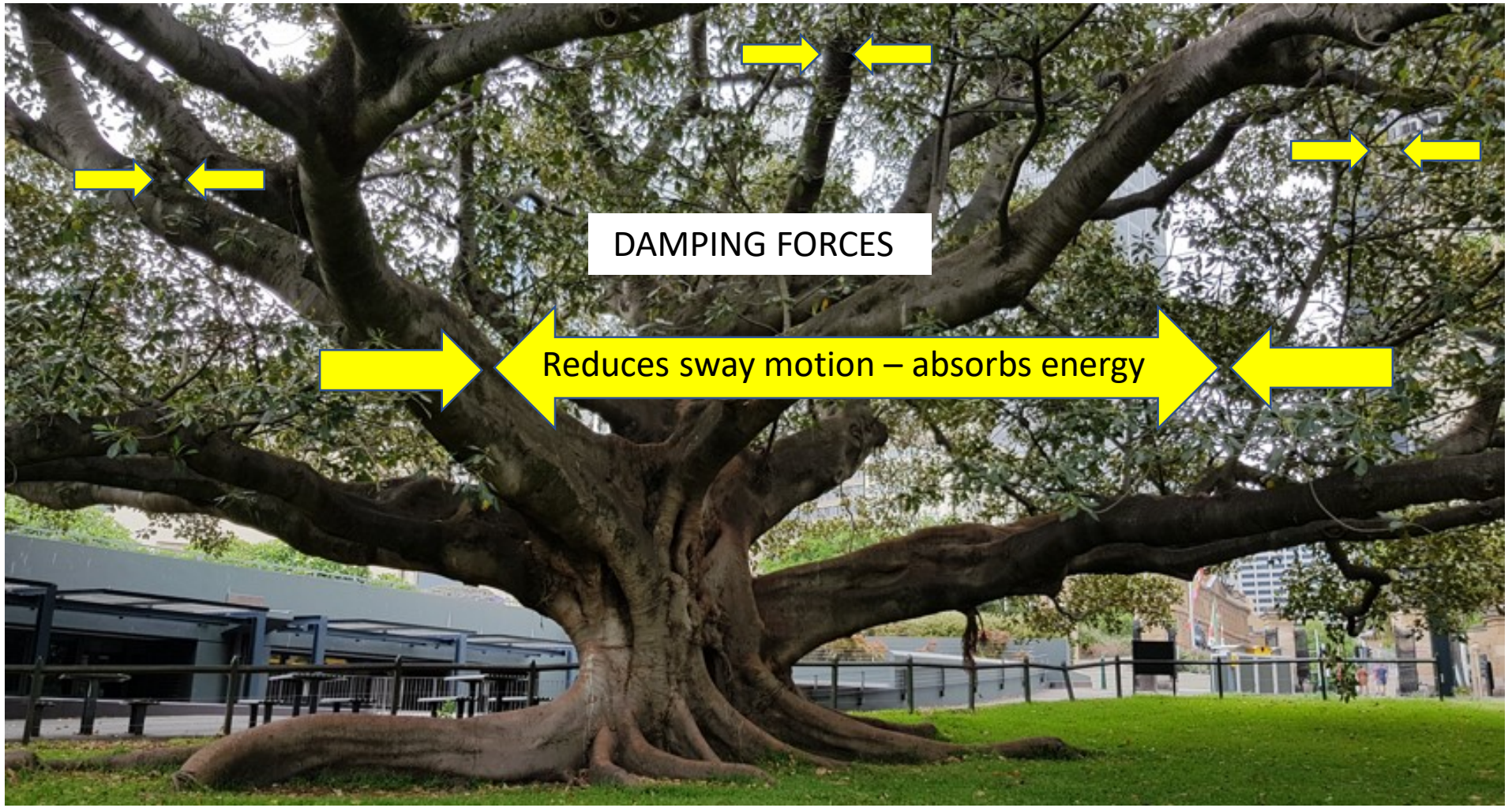
Research at Biomechanics Week, USA, 2013

1. Dynamic Forces – Wind Gusts



Ficus, Botanic Gardens, Sydney, Australia

2. Dynamic Wind Forces - Damping



Ficus, Botanic Gardens, Sydney, Australia

3. Dynamic Wind Forces - Inertia

Ficus, Botanic Gardens, Sydney, Australia

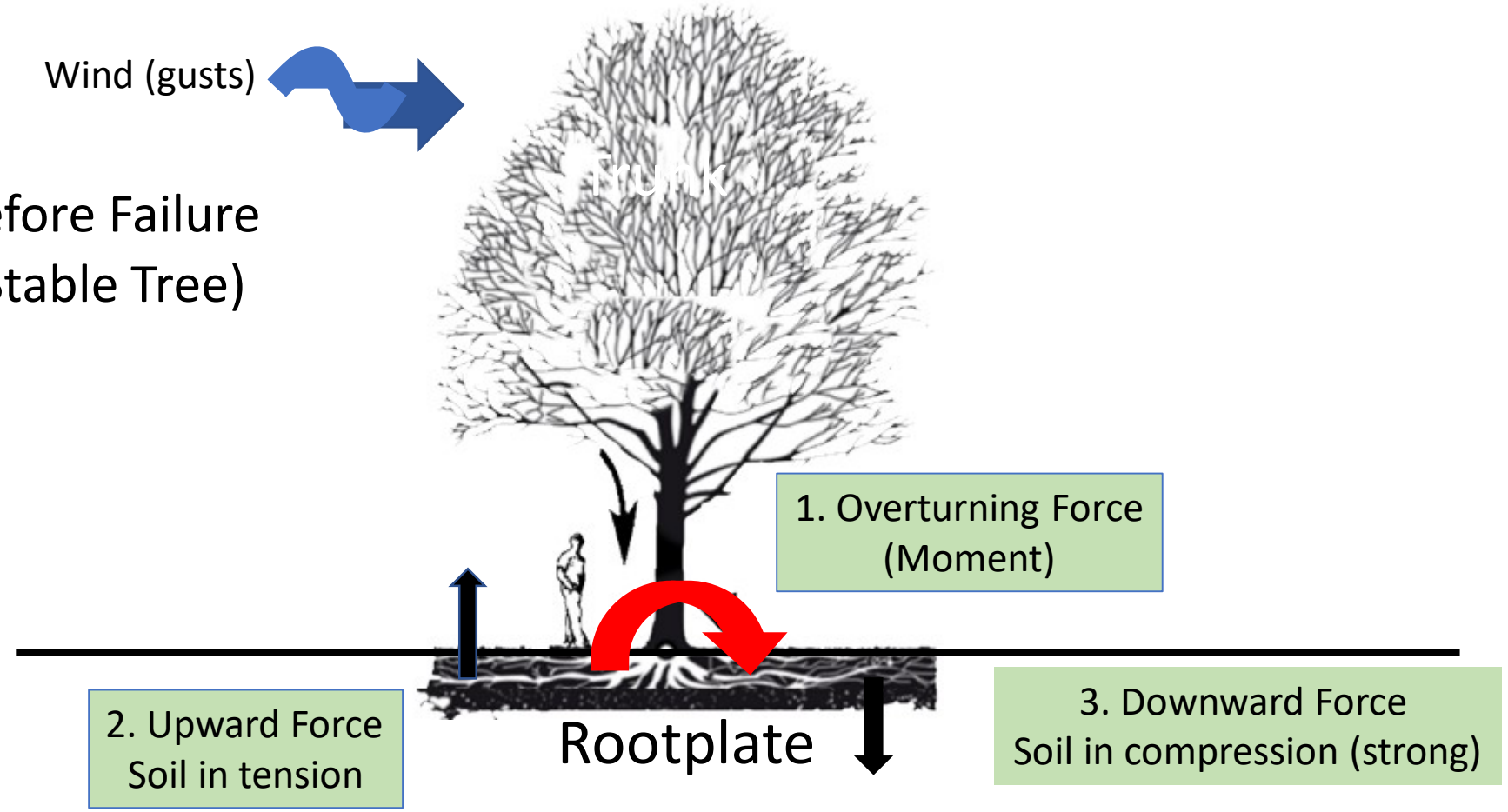
Example of Dynamics – Inertial Forces

Moving masses, Big Forces

Big Mass moving, INERTIAL FORCES keep it moving

How do Trees fail in wind?

Wind creates Overturning Forces at base



Root Plate Failure - “not all at once”

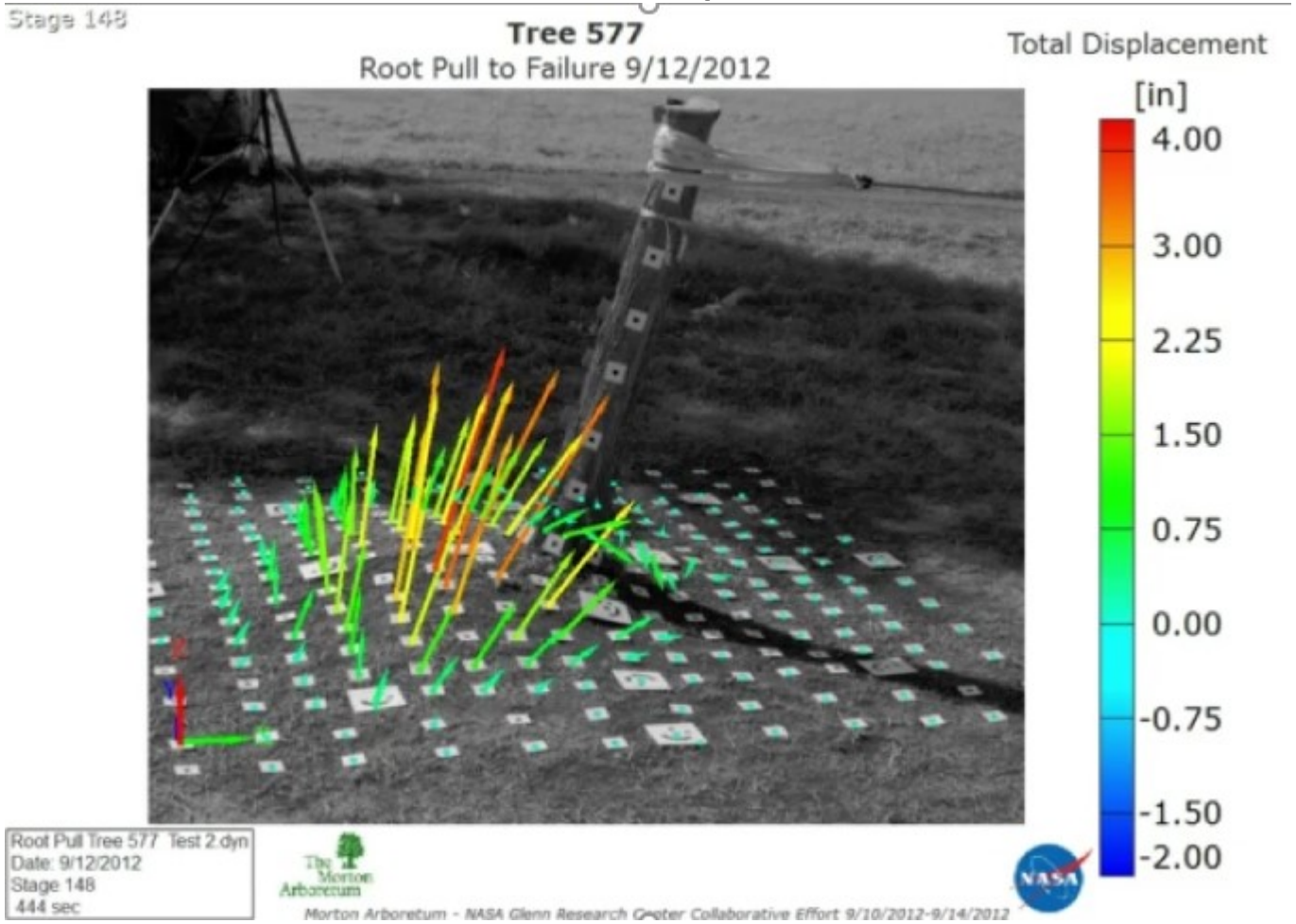
Nelson, New Zealand

- Root fatigue may be important
- Failure is not “All at once”
- Some roots may fail in a storm, causing tree to move slightly
- Rocking occurs in next storm
- Progressive root damage occurs
- Finally tree falls.

Tree Failures in Wind

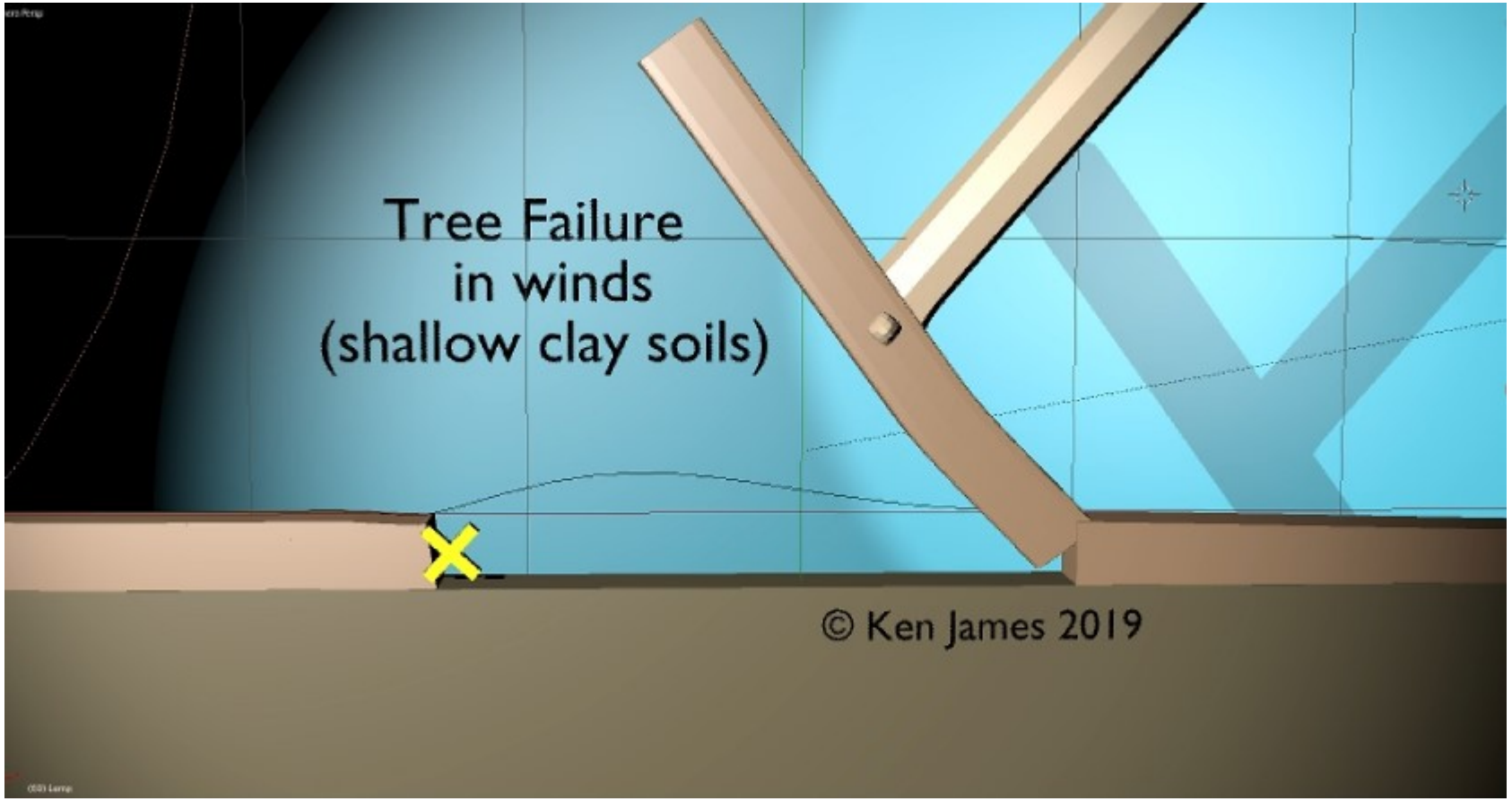
1:52

Forces - Rootplate Failure



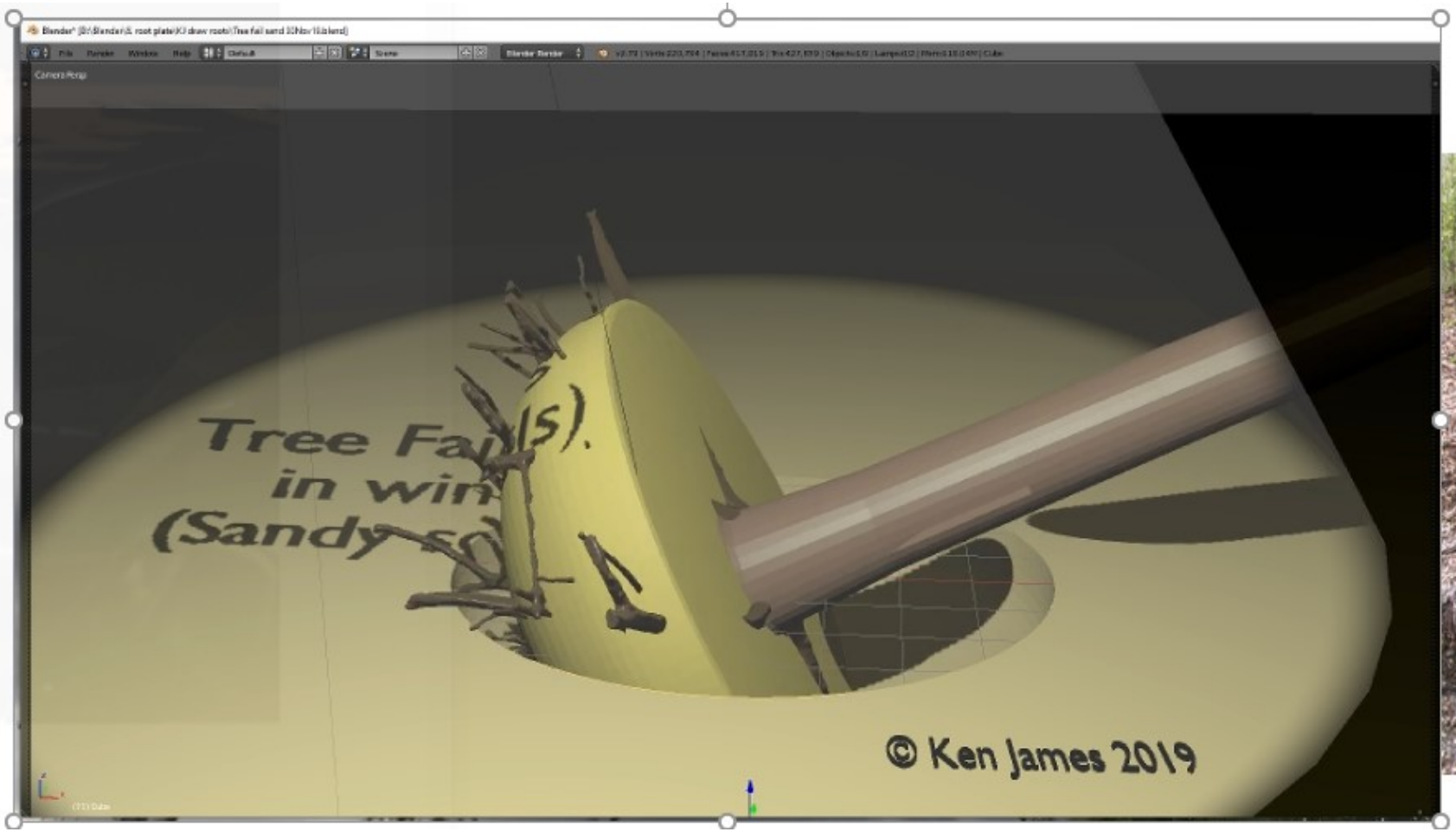
Research Tests using NASA technology, The Moreton Arboretum, USA

Root Plate Failure – cohesive (clay) soils



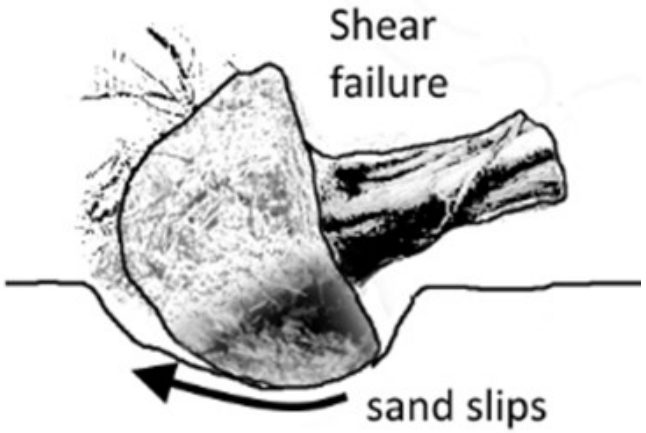
Root Plate Failure – cohesive (clay) soils

Root Plate Failure – Non cohesive (sand) soils



SHEAR Failure – Sand slips under load

Sandy Soil
- shear failure
- failure as sand slips
- circular pattern

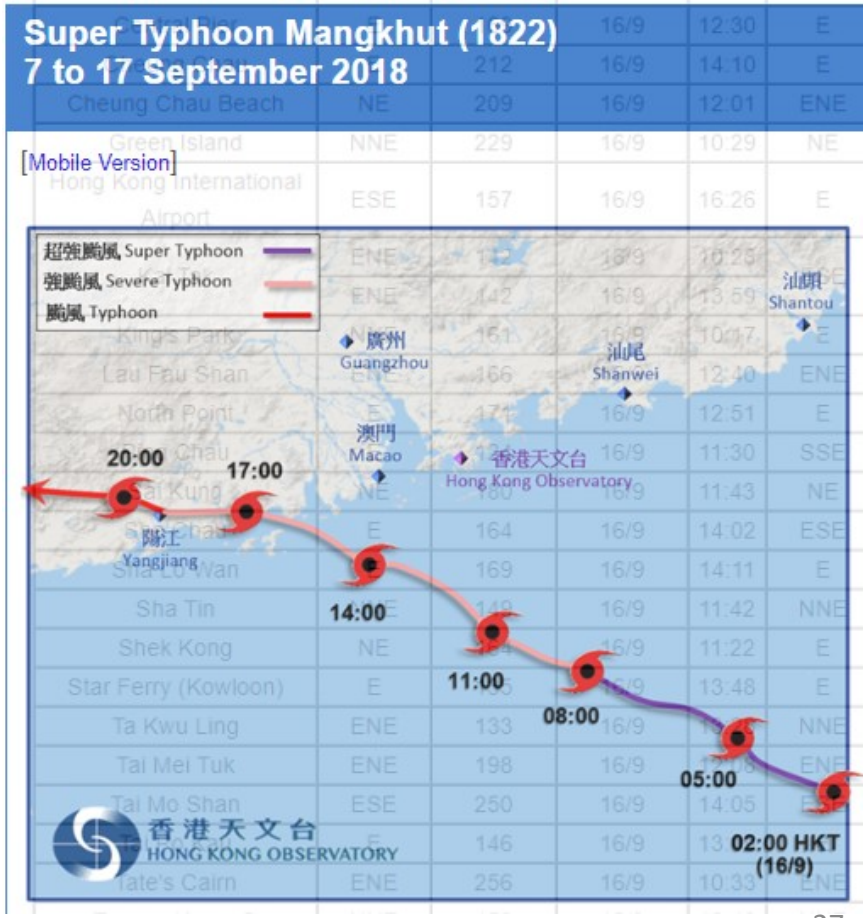


The Wind Environment in Cities

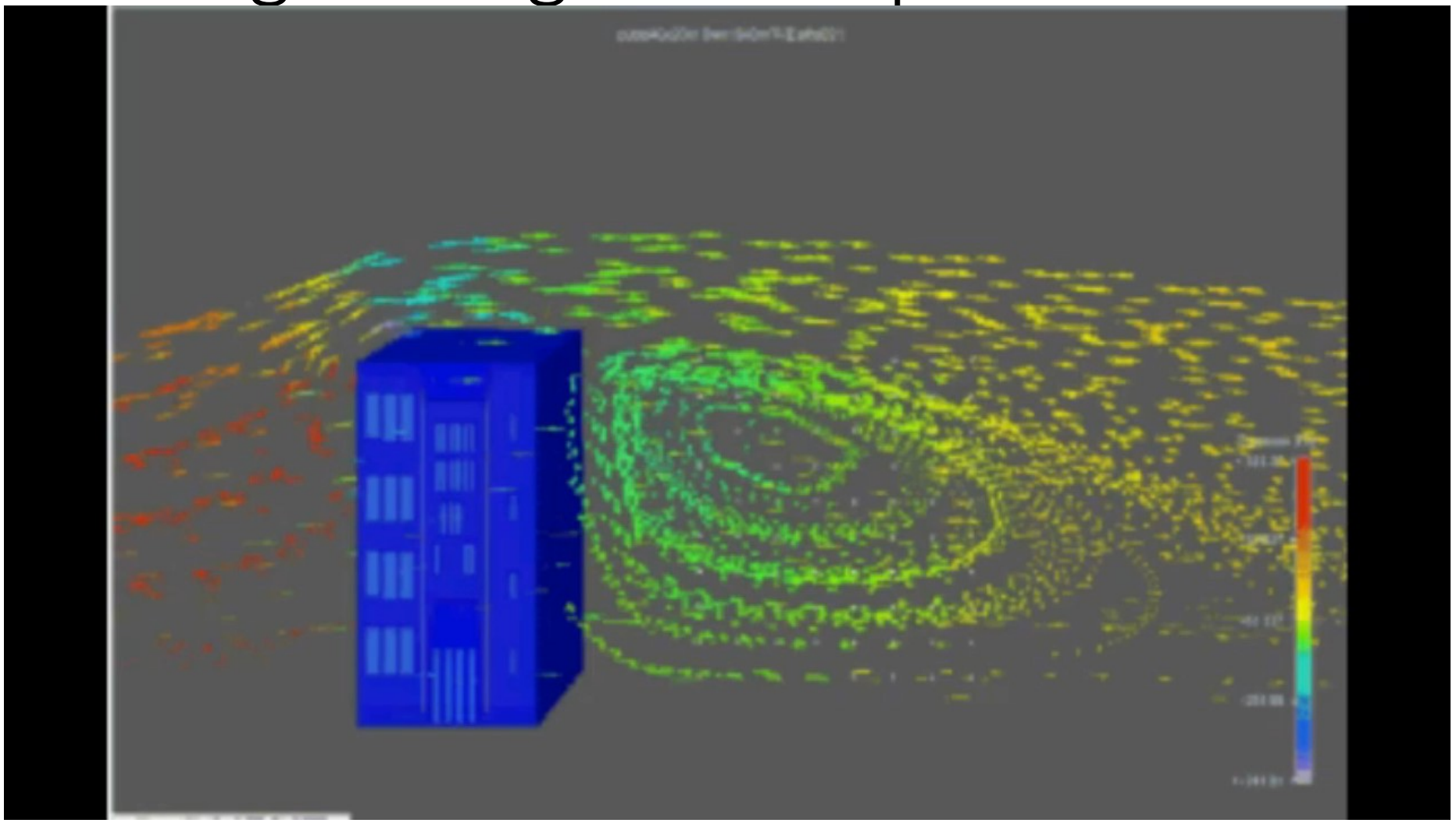
Typhoon Mangkhut officially Hong Kong's most intense storm since records began

Hong Kong Observatory said sustained winds reached 250km/h

Max 60-minute mean wind speeds
161 km/h - Waglan Island
157 km/h - Cheung Chau

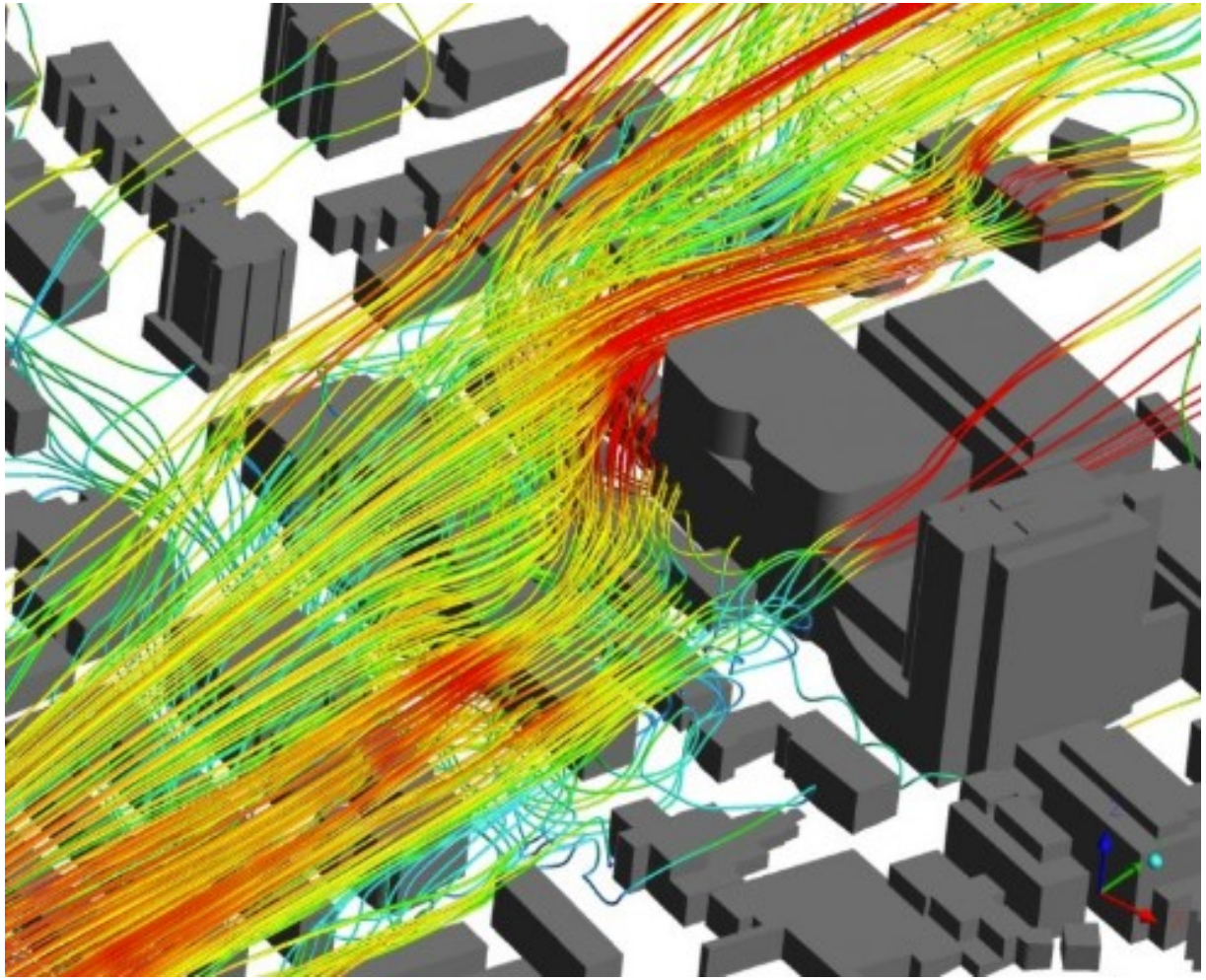


Buildings changes Wind profile in Cities



Wind speed increases around buildings

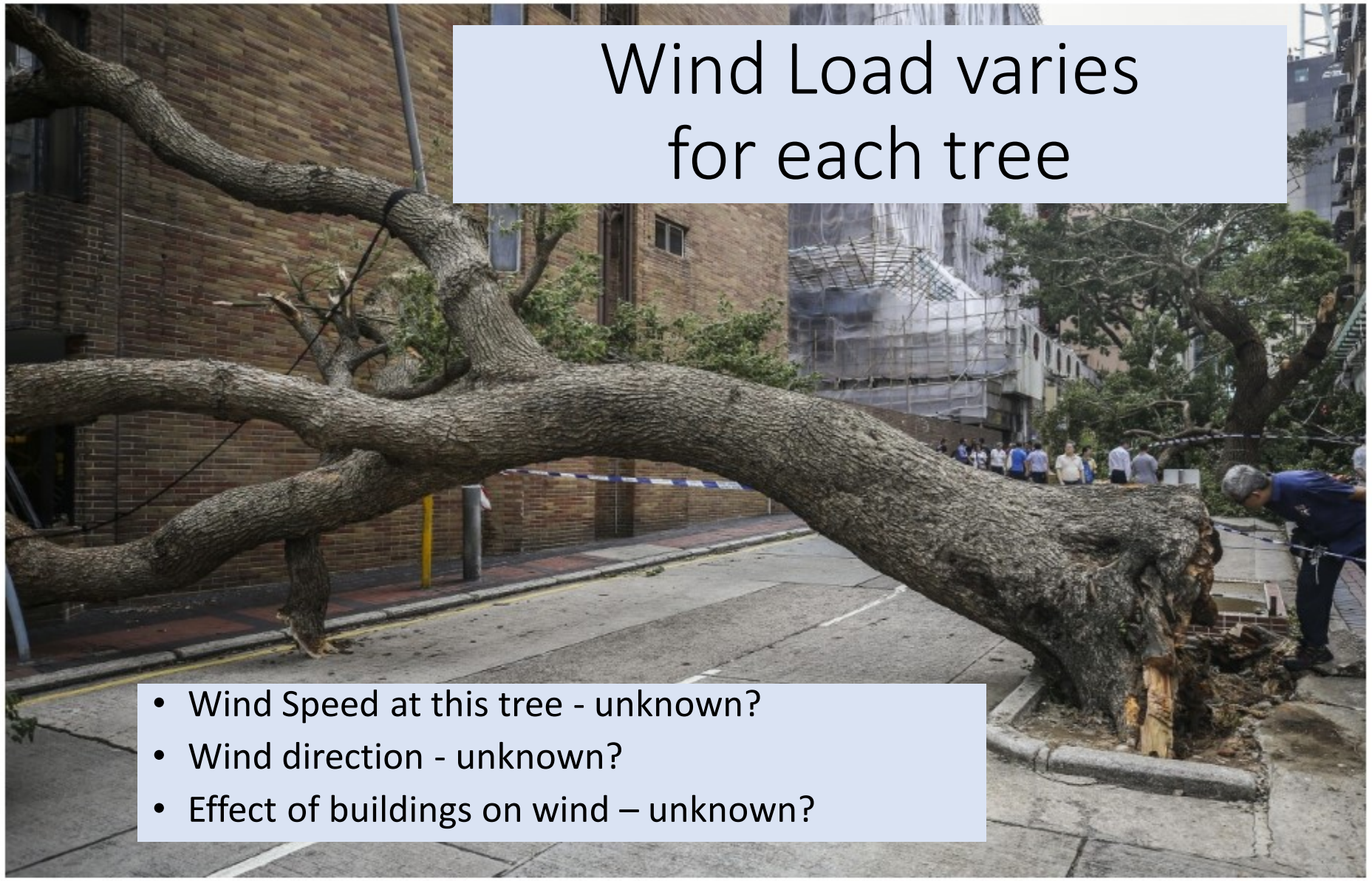
Funnel effect of streets



Typhoon Mangkhut 2018

An uprooted tree blocks Tak Shing Street in Jordan after Typhoon Mangkhut. Photo: Sam Tsang

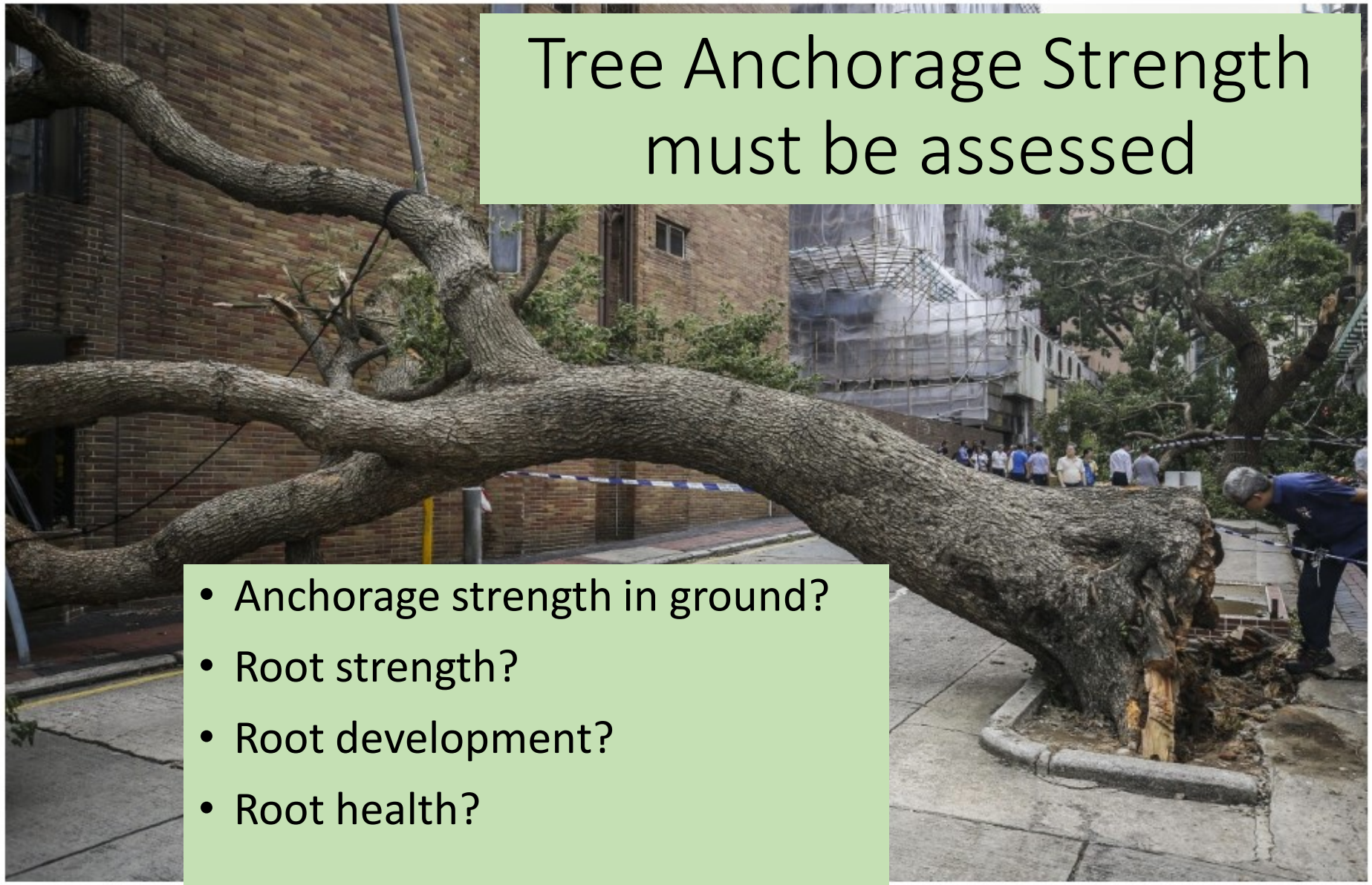
Wind Load varies for each tree



- Wind Speed at this tree - unknown?
- Wind direction - unknown?
- Effect of buildings on wind – unknown?

An uprooted tree blocks Tak Shing Street in Jordan after Typhoon Mangkhut. Photo: Sam Tsang

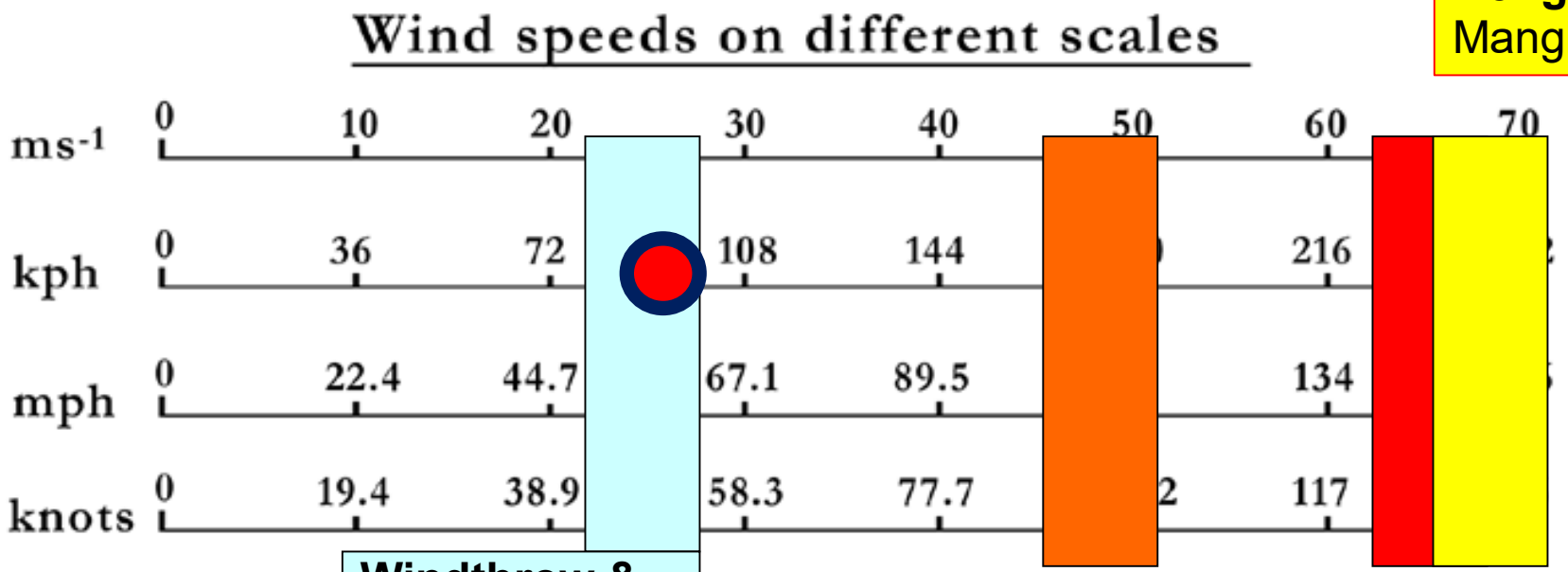
Tree Anchorage Strength must be assessed



- Anchorage strength in ground?
- Root strength?
- Root development?
- Root health?

An uprooted tree blocks Tak Shing Street in Jordan after Typhoon Mangkhut. Photo: Sam Tsang

Wind Speeds – Tree Failures



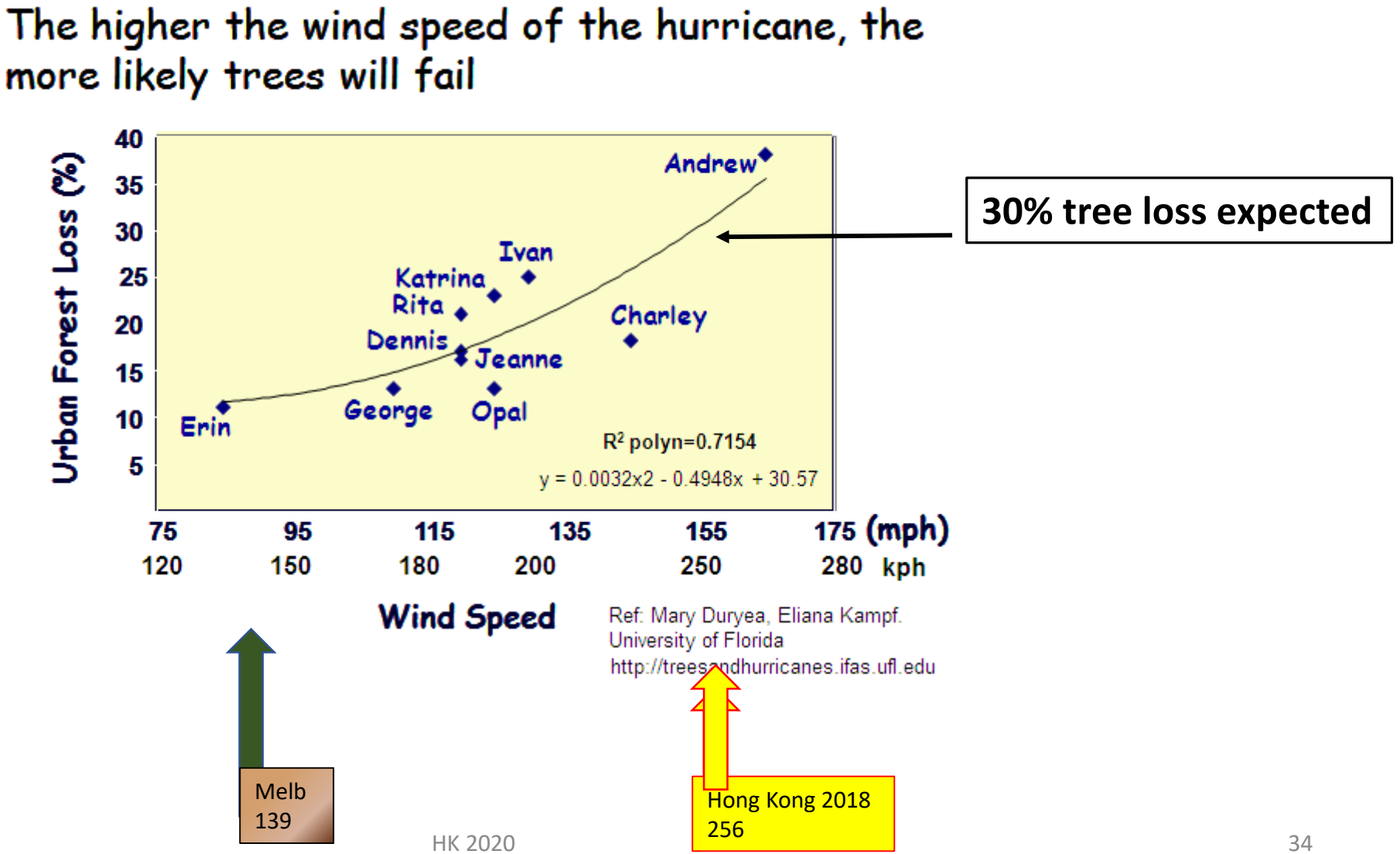
Hong Kong
Mangkhut (2018)

Windthrow & Breakage
Cullen (2002)
Spatz (2000)
Sanderson et al (1999)

Hurricane
Hedden(1995)
Dennis(2005)
185 kph

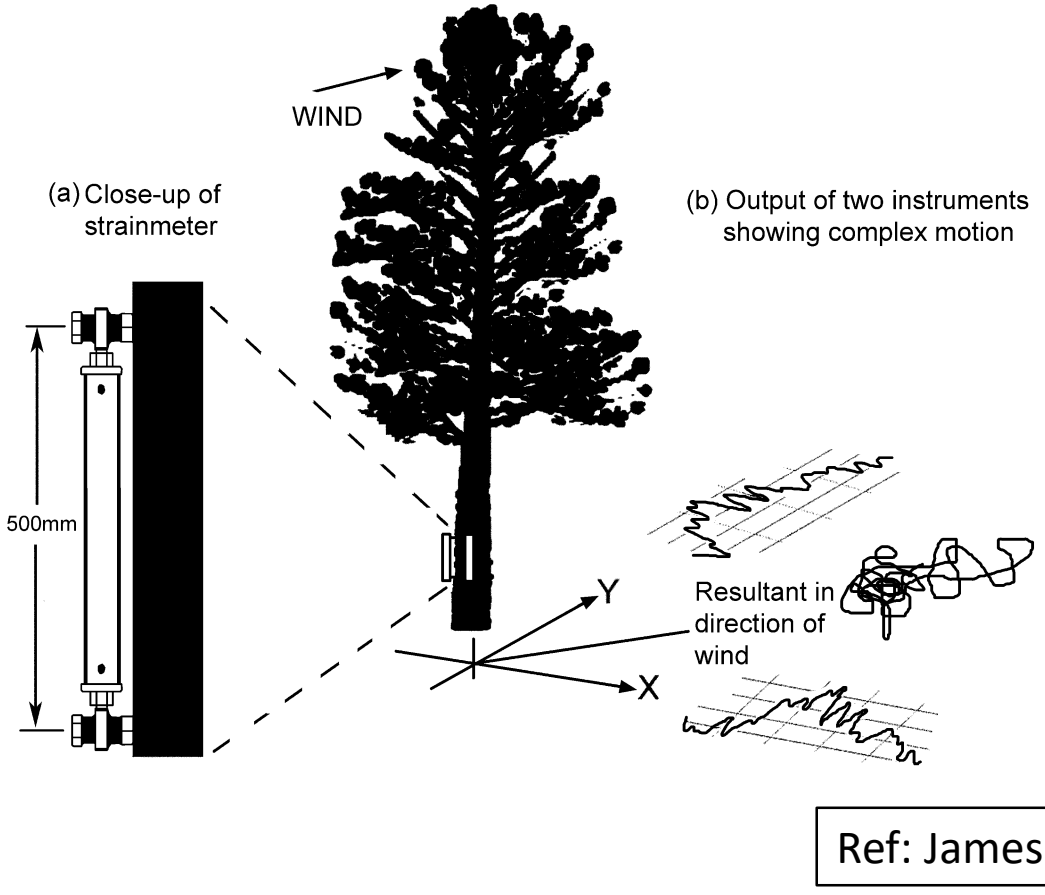
Hurricane max gust
Hedden(1995)

Wind speeds – Hurricanes USA and Hong Kong 2018



How to Measure Wind Loads on Trees

Research Project – James 2010



Ref: James 2010

Strain meters attached to tree trunk.

Wind load - not uniform on all trees

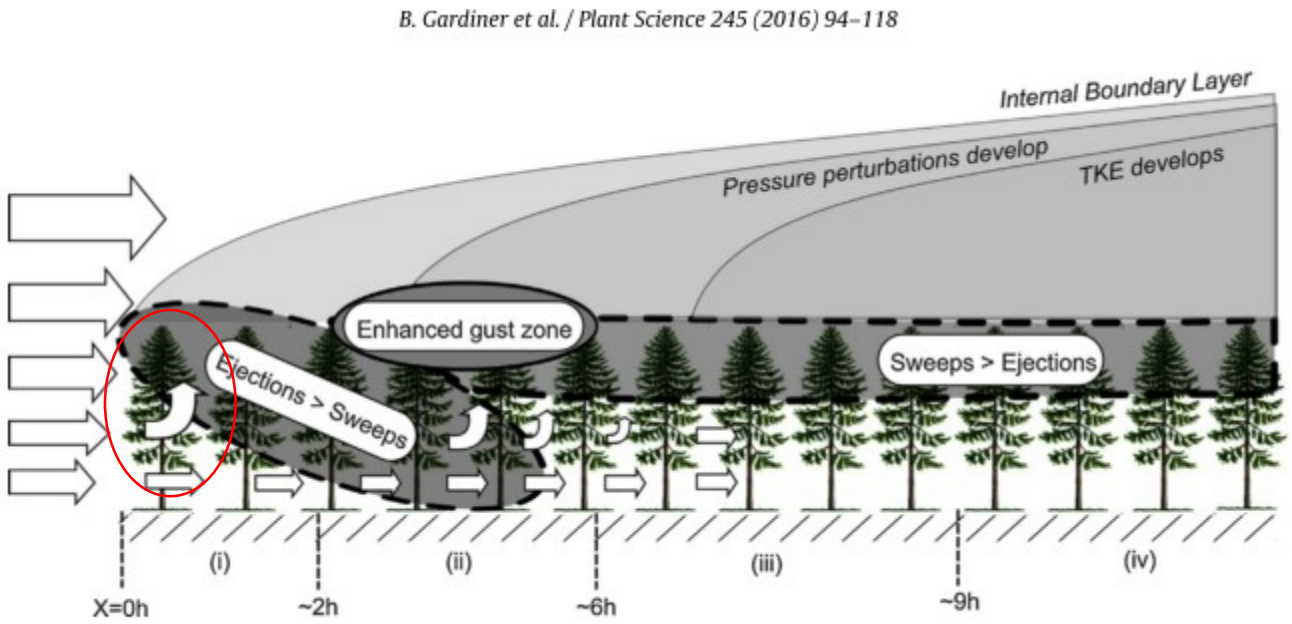
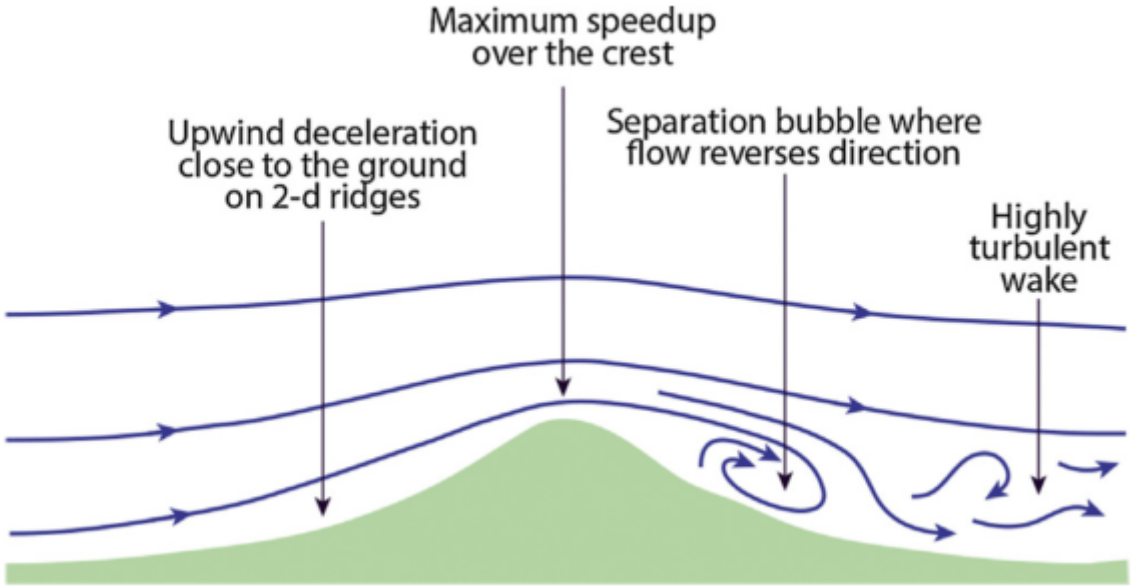


Fig. 4. Flow development over a change in surface conditions such as the edge of a forest.

- Sheltering is very important
- Direction of wind is also very important

Topography influences wind speed



- Topography - local effects very important
- Wind speed varies for trees around hills

What can be done to protect trees in winds?

1. Cable supports
2. Secure root system
3. Design in Cities - Protect/Shelter
4. Monitor Tree Stability in winds

1. Cable supports

Tree saved after overturning in Tornado

Tornado flattens 200 year old Cashmir Cypress

Italy, 2006, Isola Madre

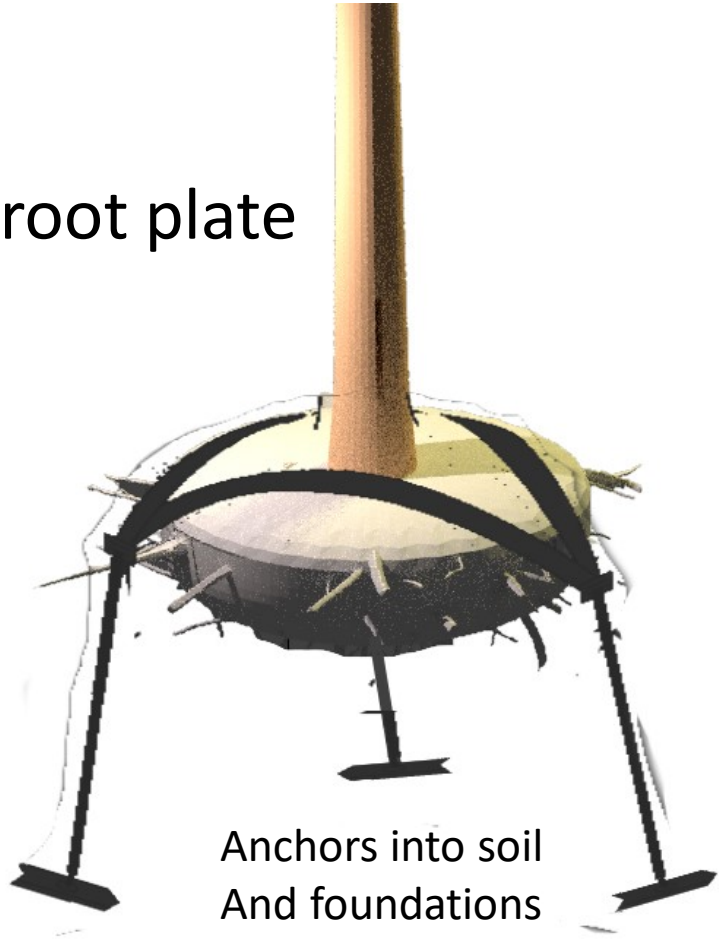
June 29, 2006, Tornado winds from storm

200 year old Cashmir Cypress (*Cupressus cashmeriana*) blown over

Very valuable, symbol of the Borremeo family

2. Secure root system to support tree

Tie down root plate



Anchors into soil
And foundations

This tree may not have failed in the wind storm, if root plate tied down after it was transplanted.

3. Design options for Trees in Cities

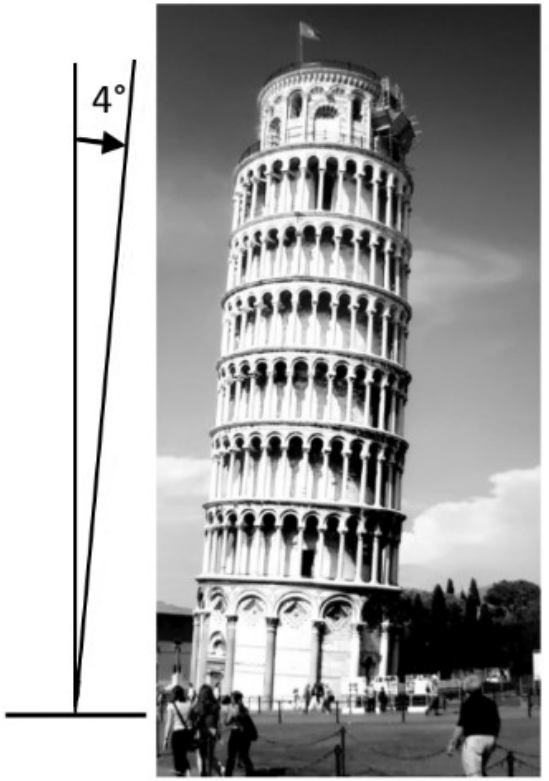
Protect trees from storms

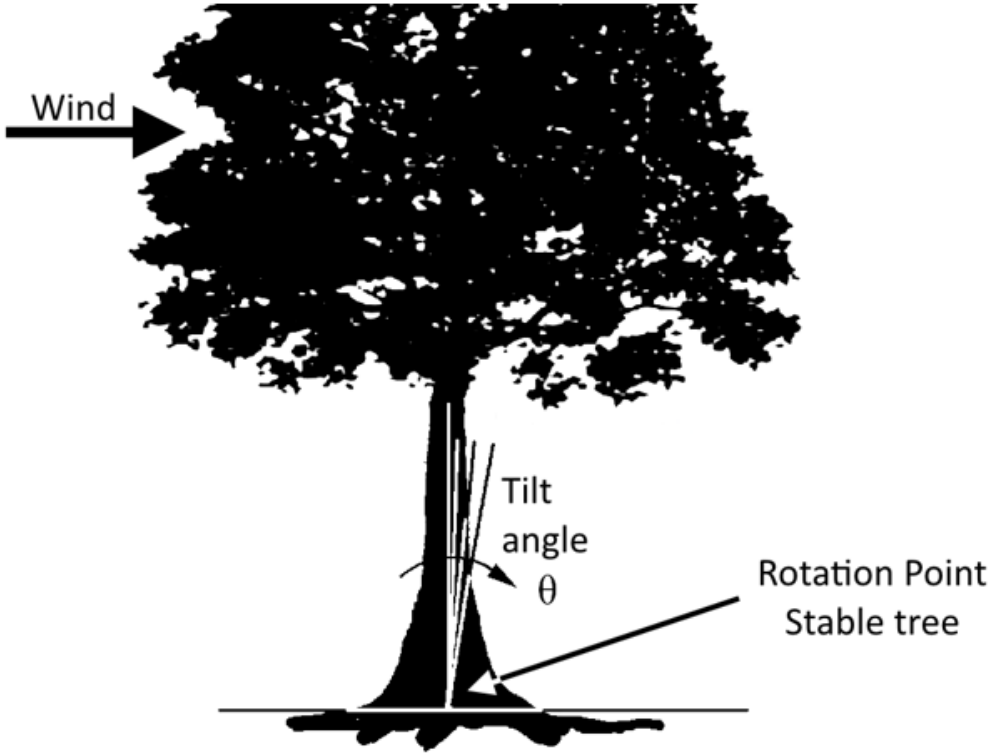
Tree growing above Carpark

Tree in car park

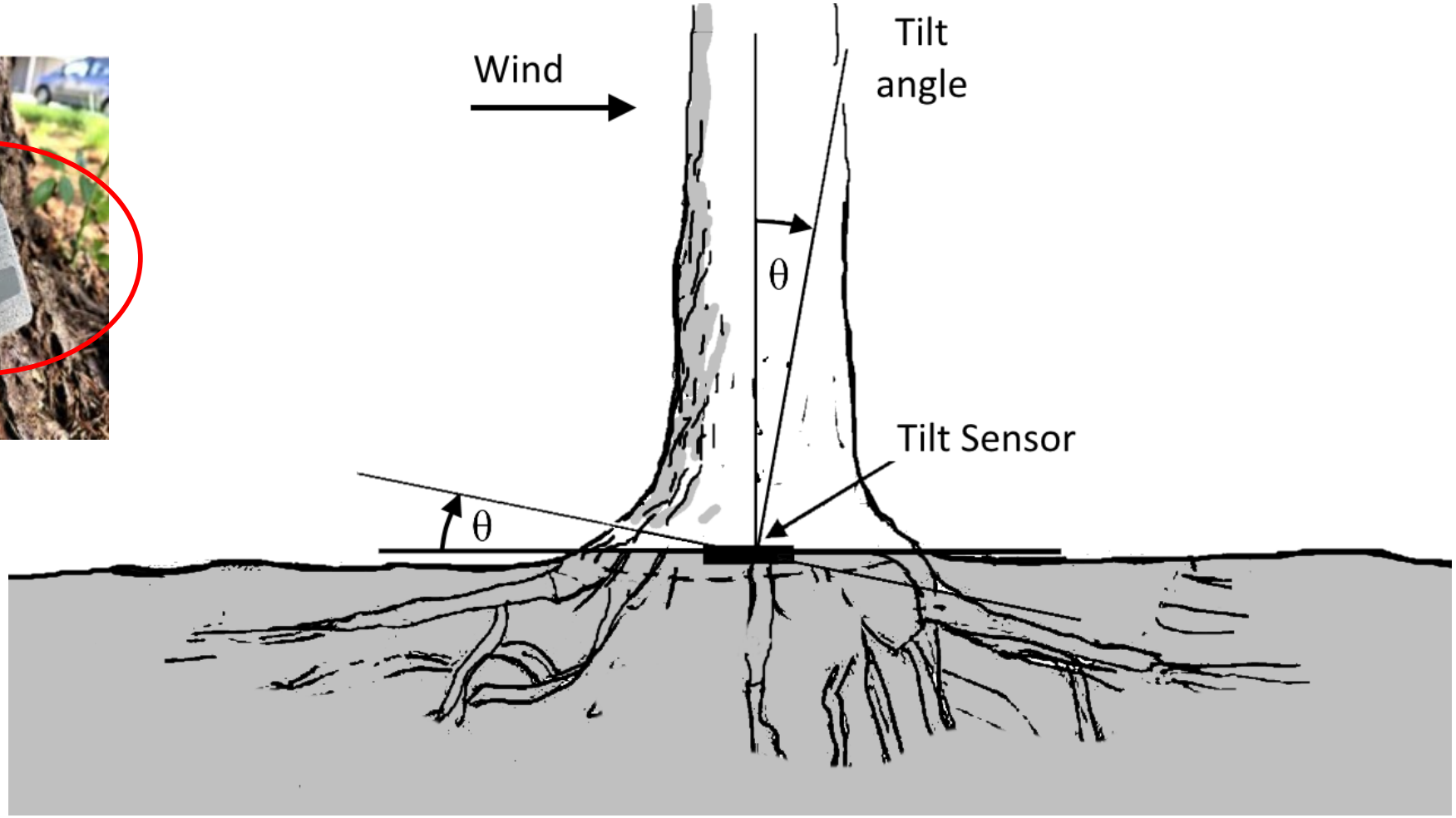
4. Tree Stability can be measured

Instrument records Root plate tilt in winds





Tree Stability - Tilt Instrument



Stability – Tilt Sensors

SPAIN - 2019

Summary

Tree Stability Range	Tilt Recorded in Winds
STABLE Trees	Tilt below 0.60 degrees
Inspect Tree Possible Partial failures	Tilt 0.60 to 1.00 degrees
DANGER Zone for Trees	Tilt above 1.00 degrees

New instruments, Tree Motion Sensor record tree stability in winds

- Used to confirm stability
- Does not predict failure

Tilt Sensors

PiCUS TMS – Tree Motion Sensor

The Wind-Reaction-Measurement with PiCUS TMS is used for in depth tree inspections to obtain information about a tree's stability, defined by its root anchoring force in the ground.

PiCUS TMS 3 – consistently innovative

Bluetooth-communication – control via mobile phone

New inclination measurement – quick and simple installation

Small and stealthy – Even you will have trouble finding it!

Data on tree stability

"Without data
you're just another person
with an opinion."

W. Edwards Deming

Engineer

William Edwards Deming was an American engineer, statistician, professor, author, lecturer, and management consultant. Wikipedia

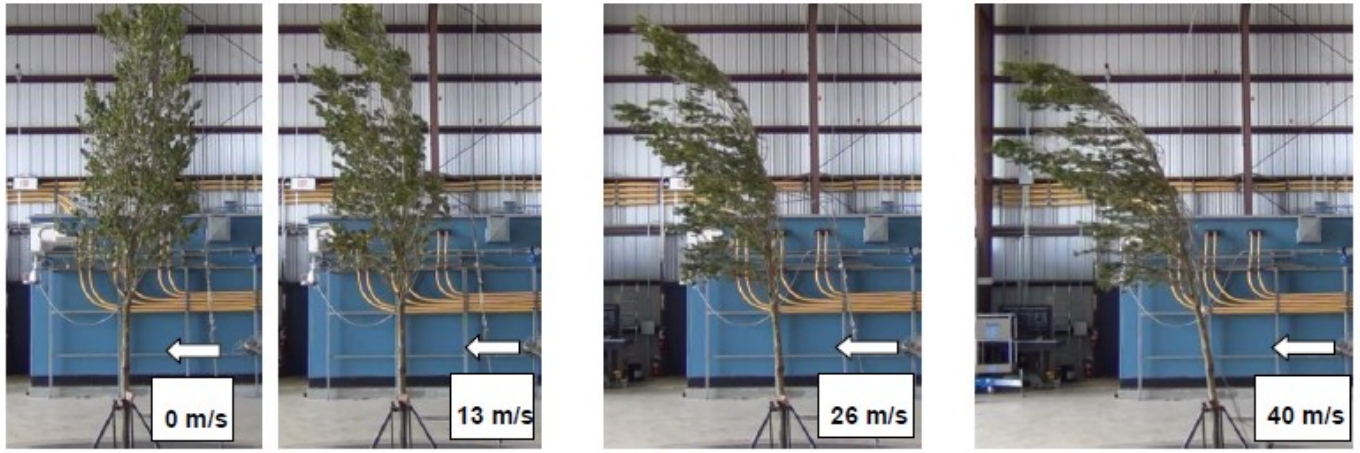
Born: October 14, 1900, Sioux City, Iowa, United States

Died: December 20, 1993, Washington, D.C., United States

Awards: National Medal of Technology and Innovation, Shewhart Medal, Wilks Memorial Award


THE END
Thanks for listening
Dr Ken James

Wind tunnel tests on trees



(a) Phase 1.

(Aly 2013)