Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute of Structural Engineering

Experimental Study on Mechanical Behavior and Failure Mechanism of Transmission Tower Structures

---Review and Reflect from the perspective of Resilience

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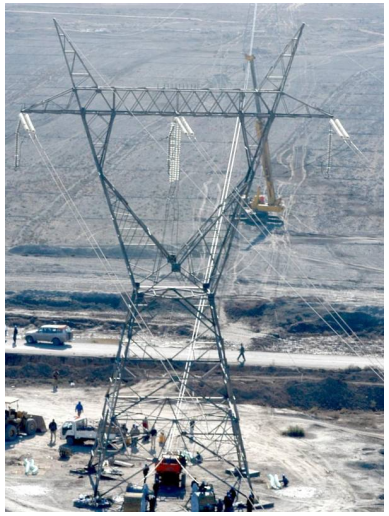
Institute of Structural Engineering

Chair of Structural Dynamics and Earthquake Engineering

Prof. Dr. Božidar Stojadinović

Electric Power Supply System: an Infrastructure Network

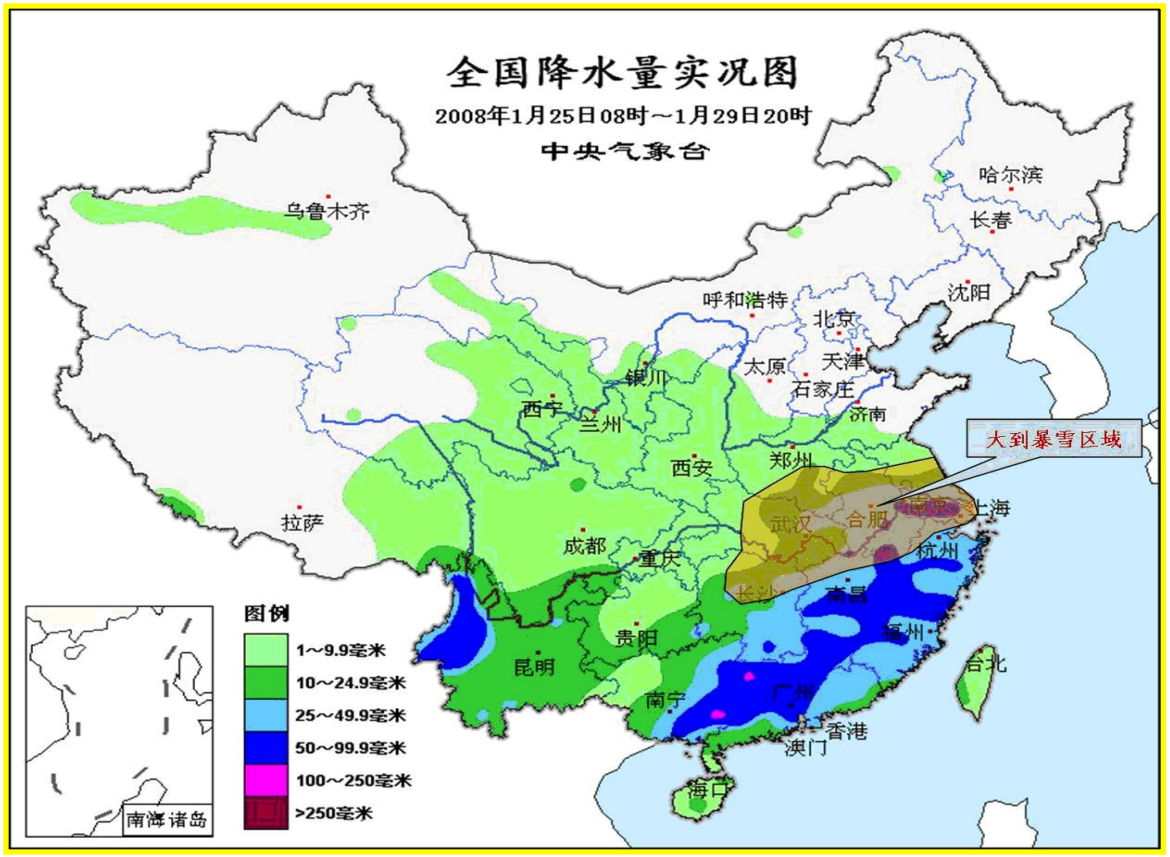
Generation → Transmission and Distribution → Users



Research Background

◆Damage due to extreme ice load

Rare ice disaster in South China in 2008



by courtesy of CMA

Research Background

Jiangxi Province

by courtesy of Prof. Qiang Xie

Failure due to cable disconnect

Failure due to unbalanced tension in cables

Research Background

Zhejiang Province

by courtesy of Prof. Qiang Xie

Failure due to unbalanced cable tension

Research Background

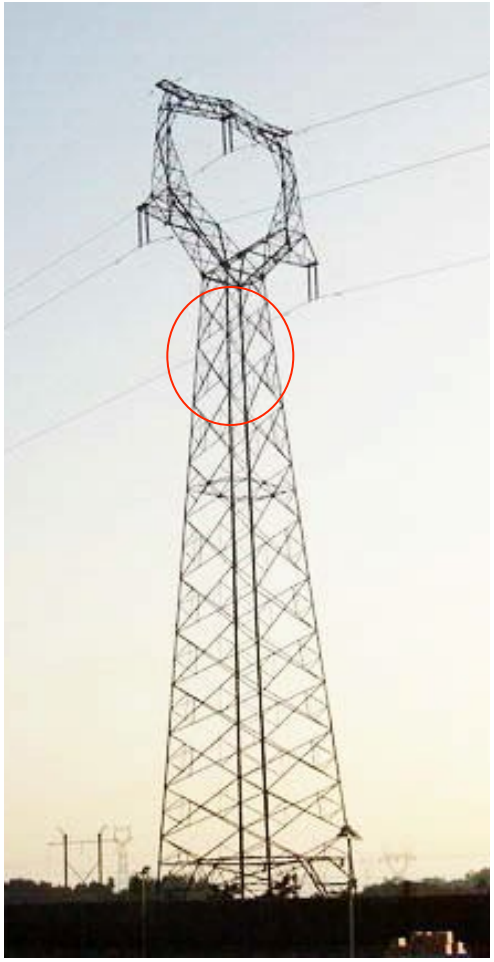
- **Damage due to extreme wind load**

Xuyu, JiangSu Province, 2005

by courtesy of Prof. Qiang Xie

Outline

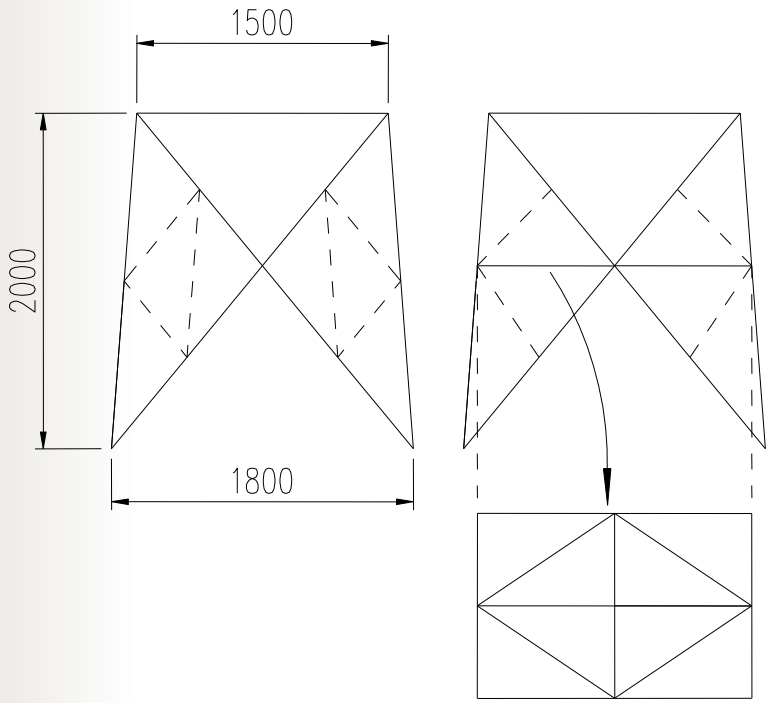
- *Test Program*
- *Discussion on some issues*
- *Reflection on test results*
- *Conclusions and future works*



Diaphragm

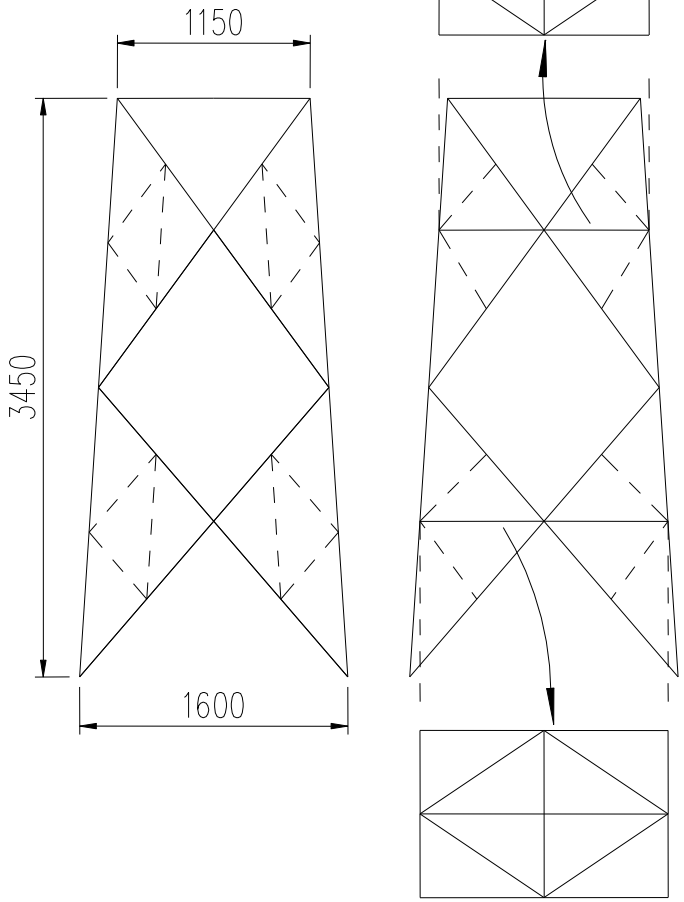
1. *Test Program*

- ***Test prototypes***



Diaphragm

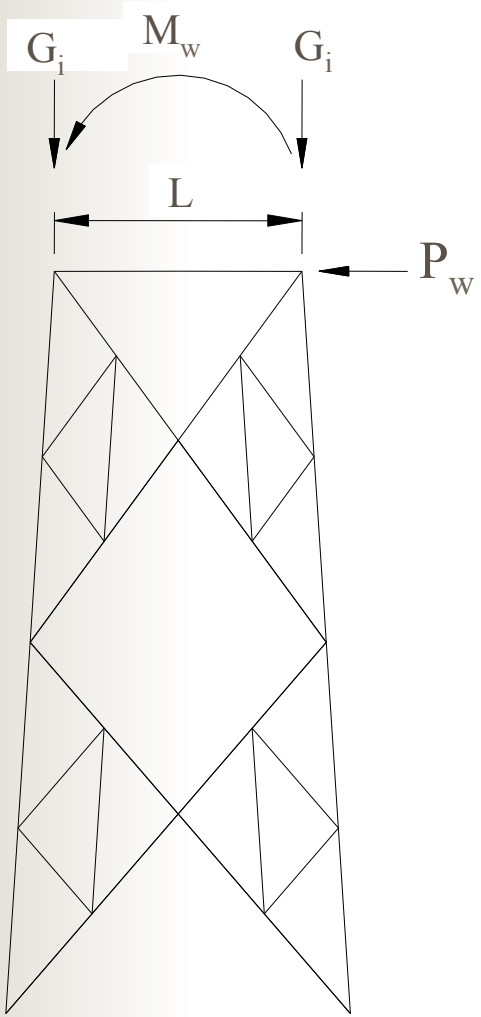
2:3



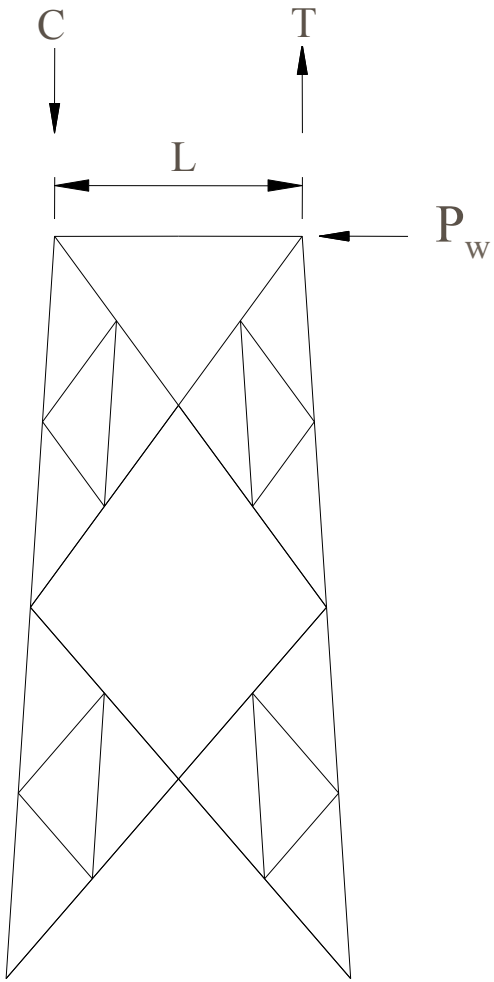
Diaphragm

1:2

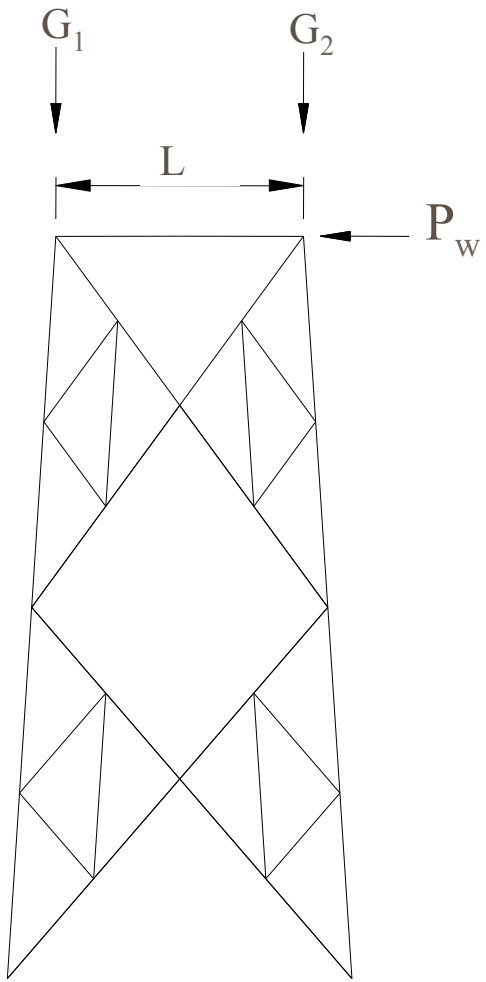
◆ *Loading types*



general load

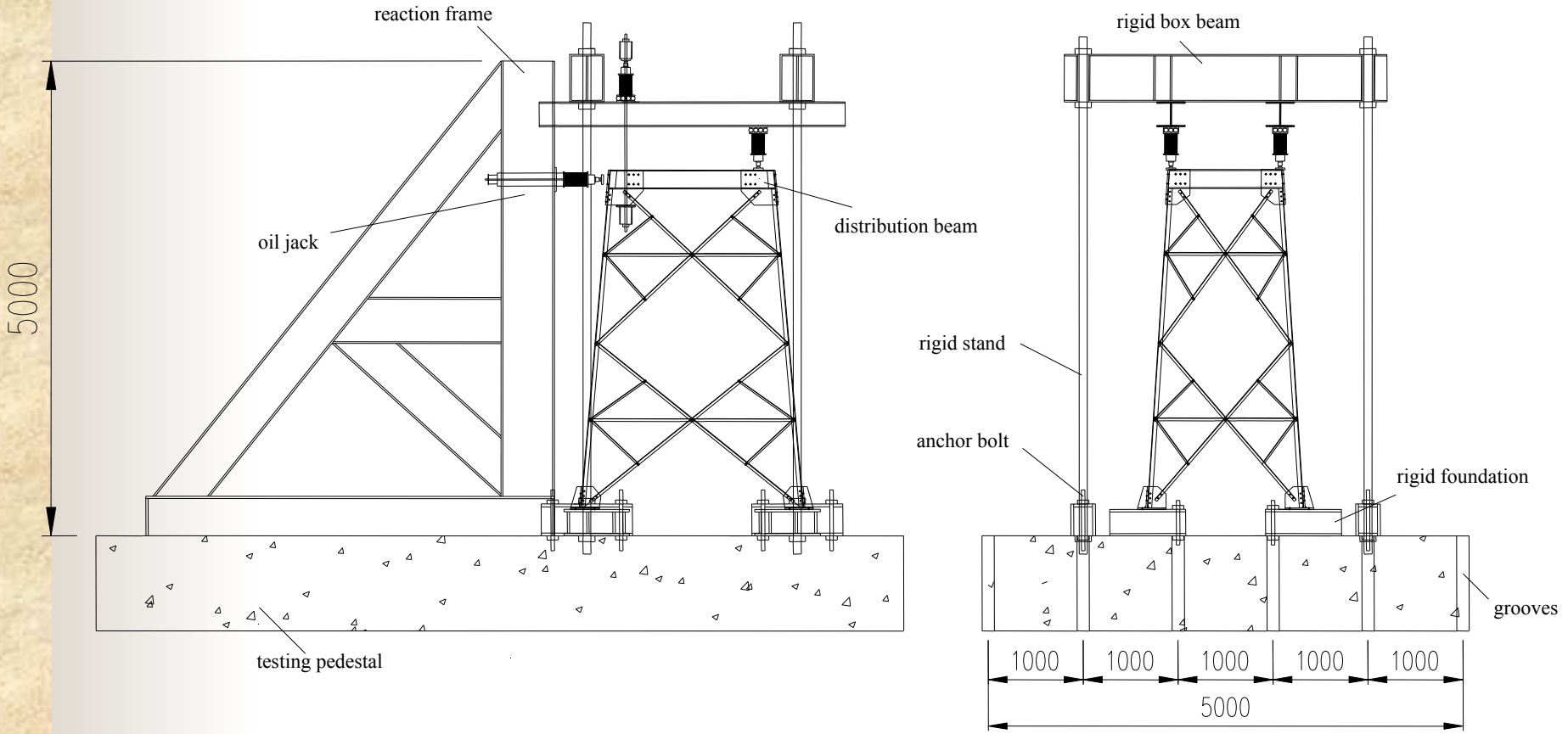


wind load



ice load

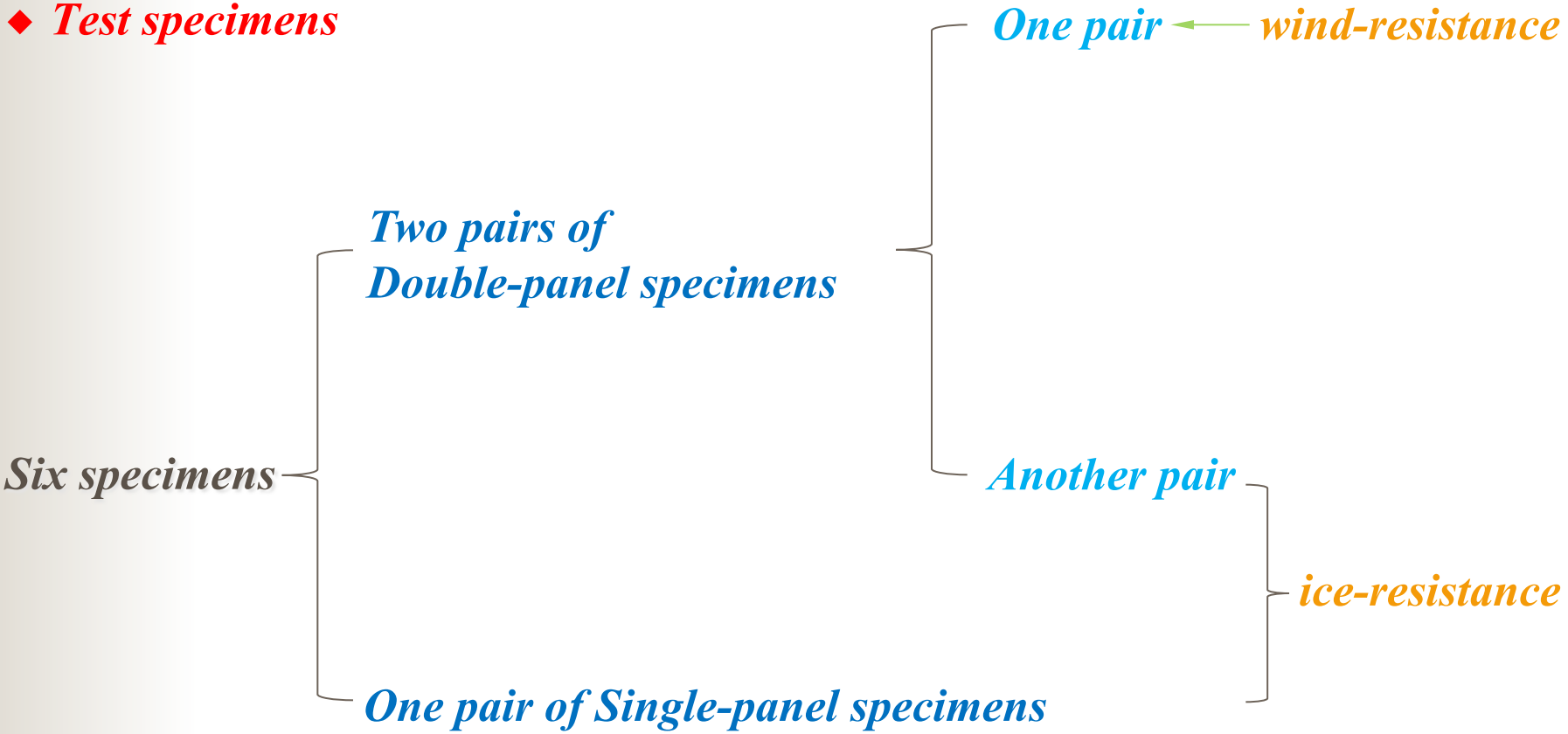
◆ *Laboratory loading setup*



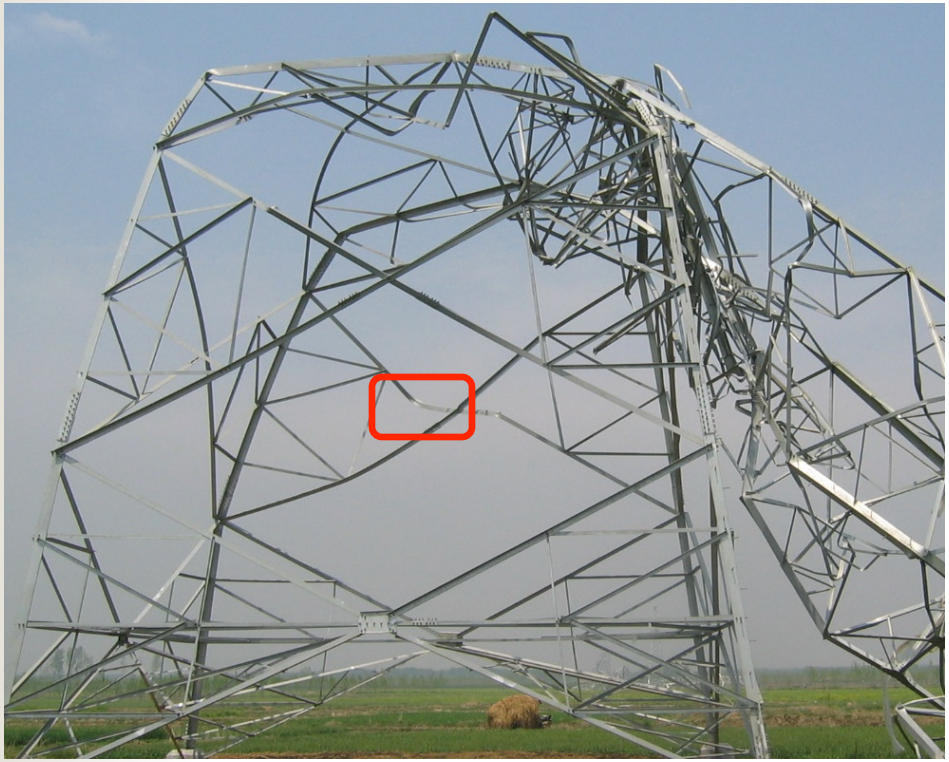
wind-resistance

Tongji University, Shanghai

- ***Test specimens***



- ***The principal failure mode --- Out-of-plane deformation….***



by courtesy of Prof. Qiang Xie

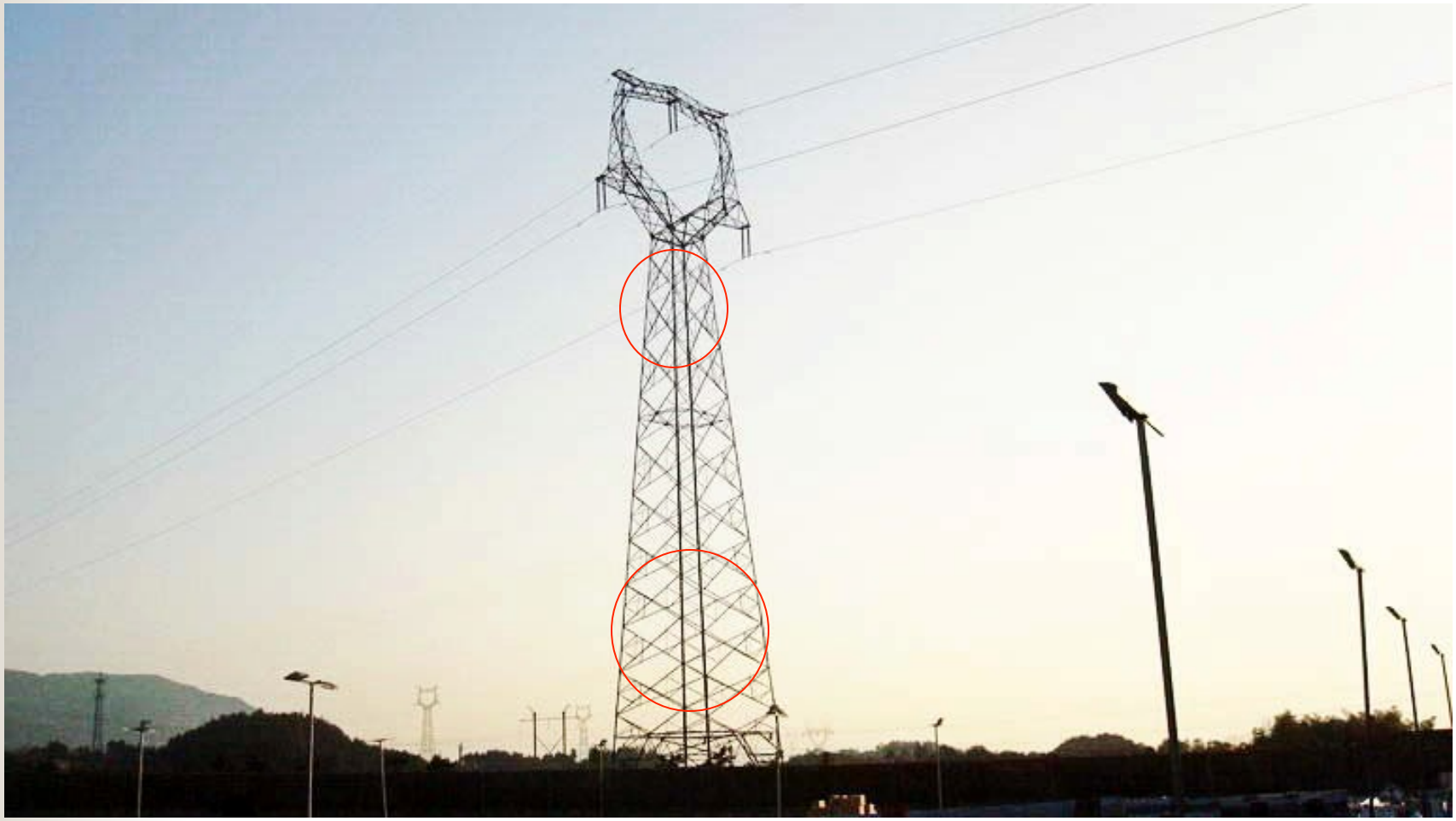
How long is the buckling length?!

2. *Discussion on some issues*

- Are the tests of individual sub-assemblages are indicative of the overall behavior of the system?

- Are the cumulative second order effects have a significant impact on the buckling load distribution to individual members?

3. *Reflection on test results*



Principal failure mode: out-of-plane deflection and buckling

- **Why did the observed damage occur?**

The location of tower stiffening diaphragms was not adequate

The design principles for distributing stiffening diaphragms in the tower body should be revisited

- **How the out-of-plane deflection of diagonal bracings negatively affect the stability performance of the tower structure?**

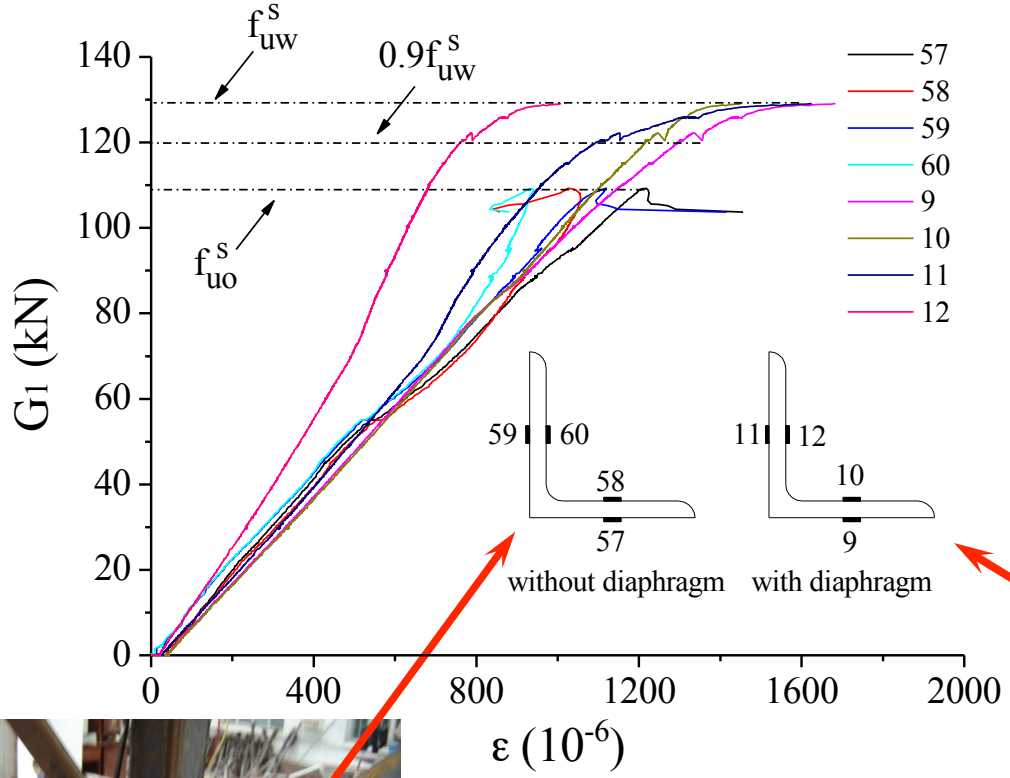
¬ From **three** perspectives:

I. *Considering the **main leg**…*

II. *Considering the **diagonal bracings**…*

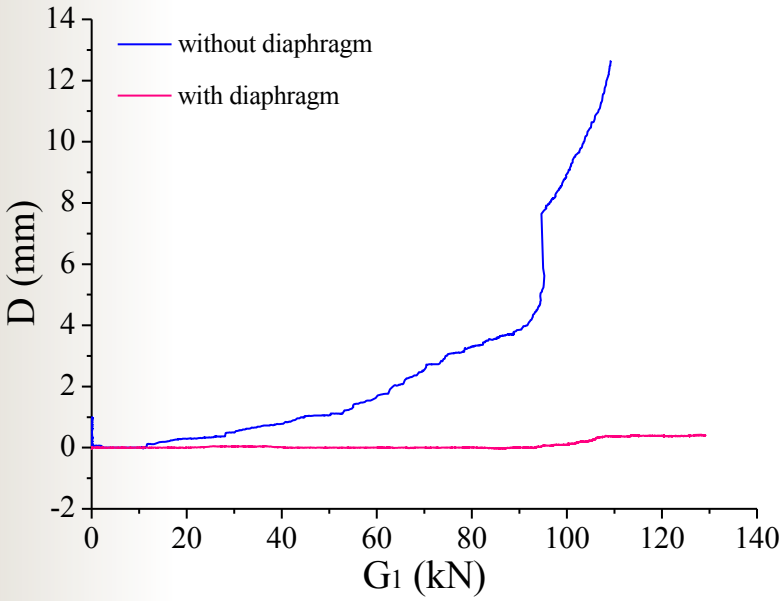
III. *Considering the **INTERACTION** between the main leg and the diagonal bracings…*

I. *Considering the main leg…*

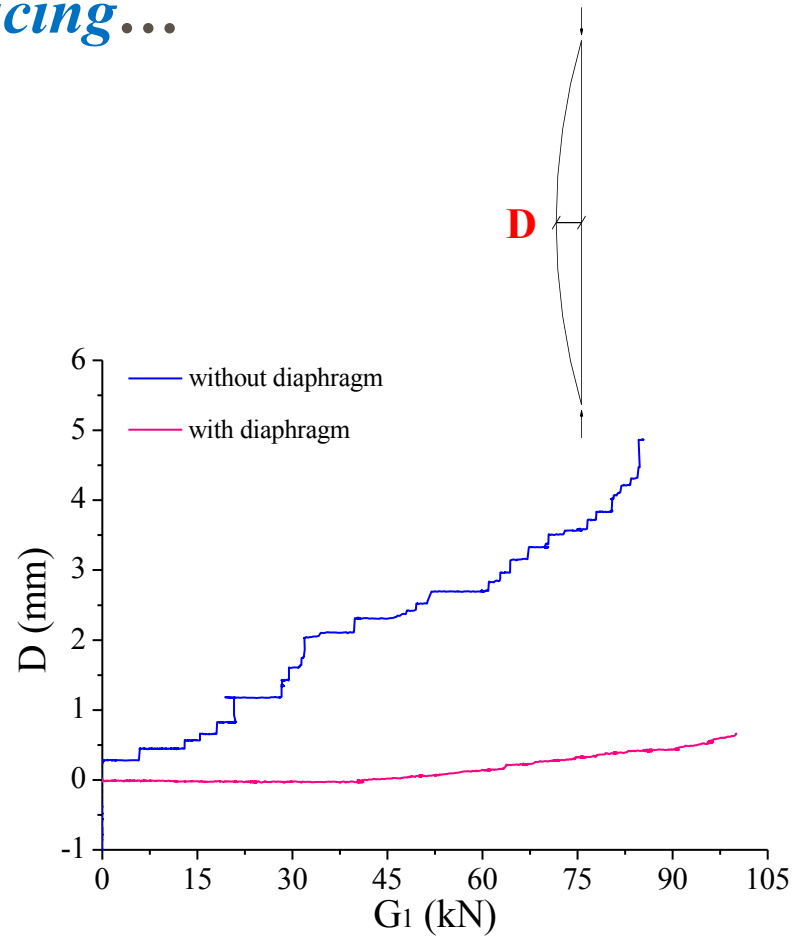


II. *Considering the diagonal bracing…*

Axially loaded member…

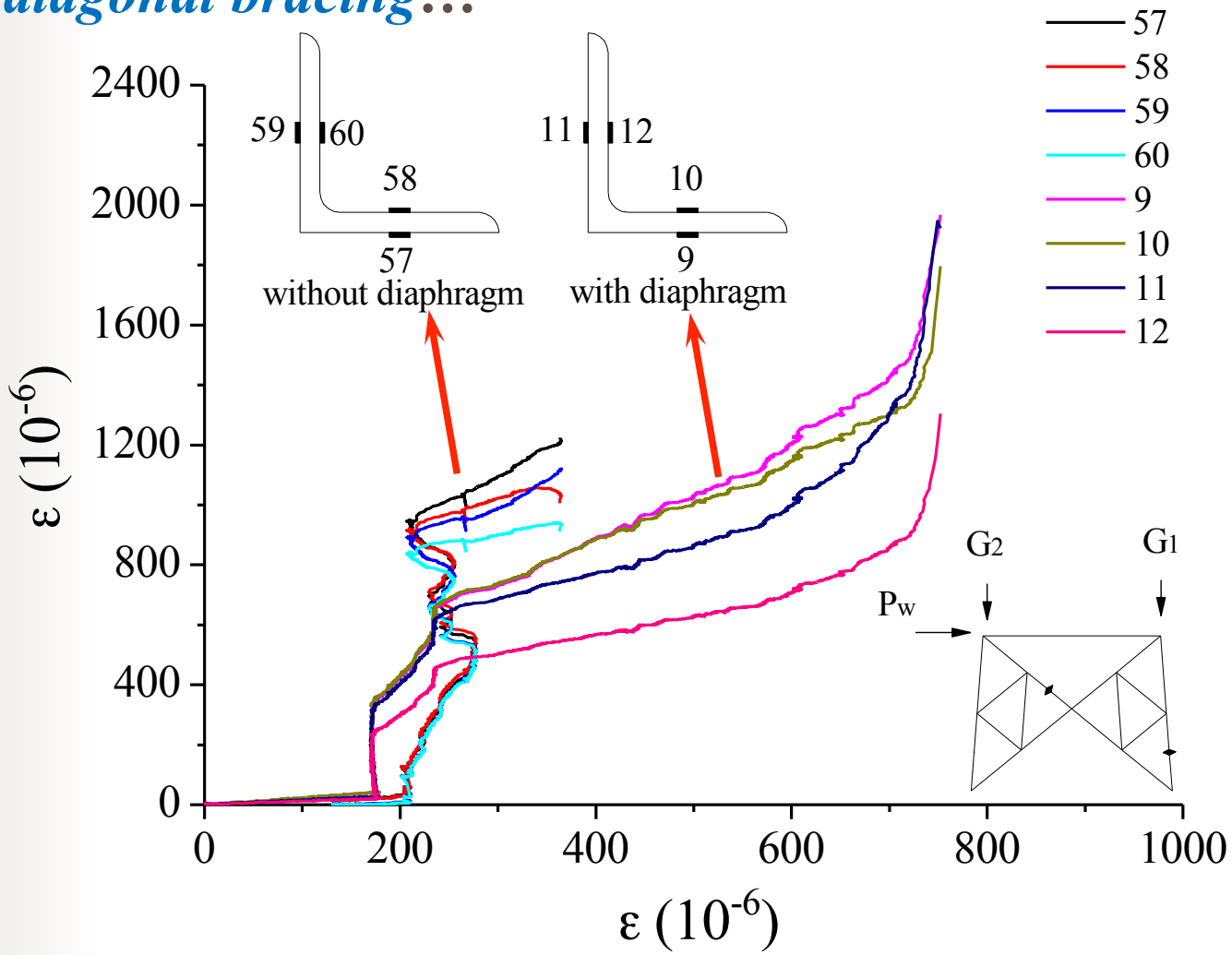


single-panel



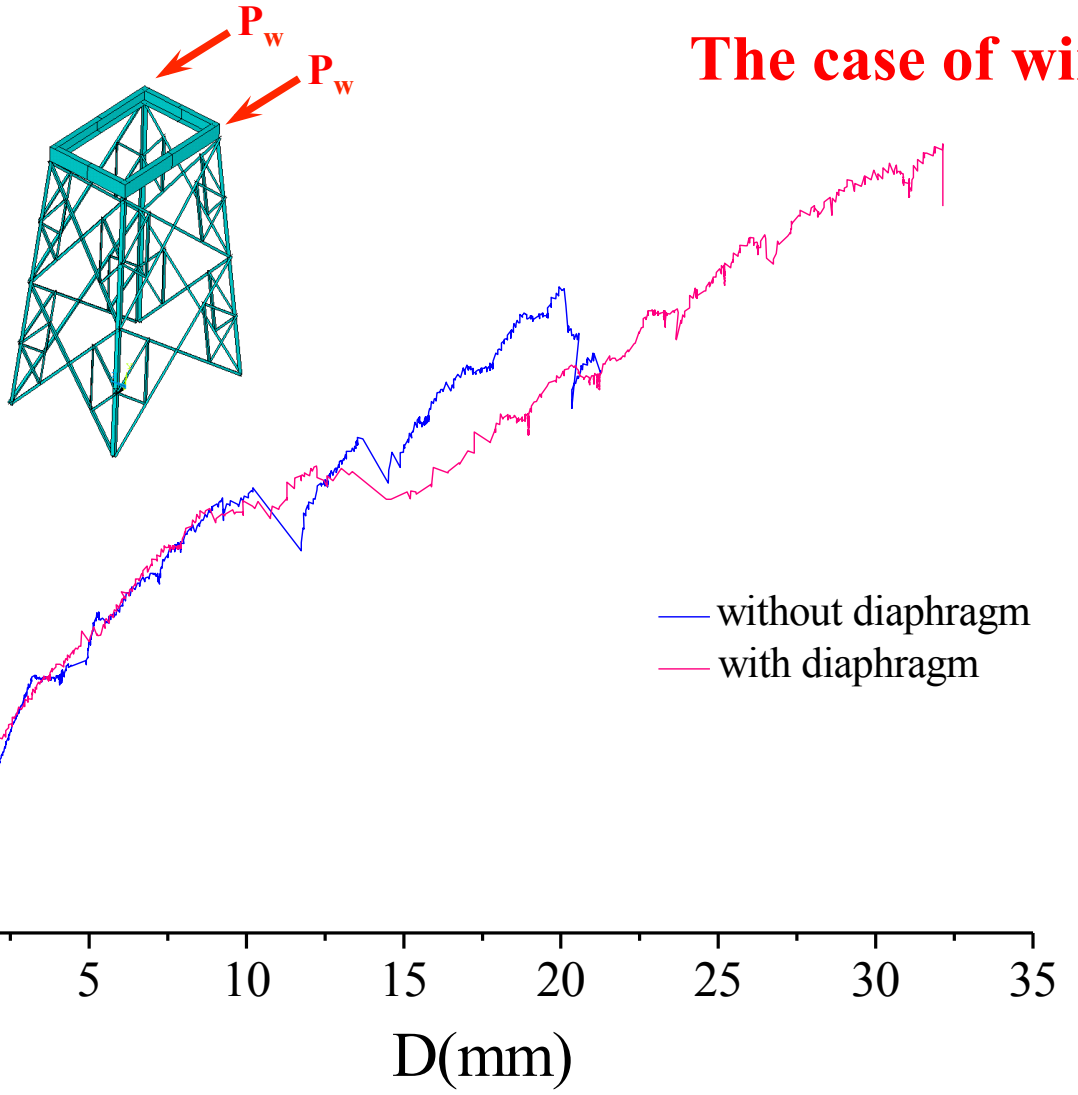
double-panel

III . *Considering the INTERACTION between the main leg and the diagonal bracing…*



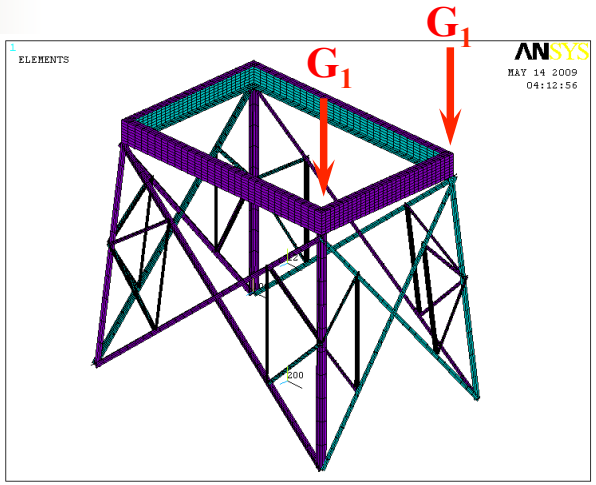
- ***What is the difference of load-carrying capacity?***

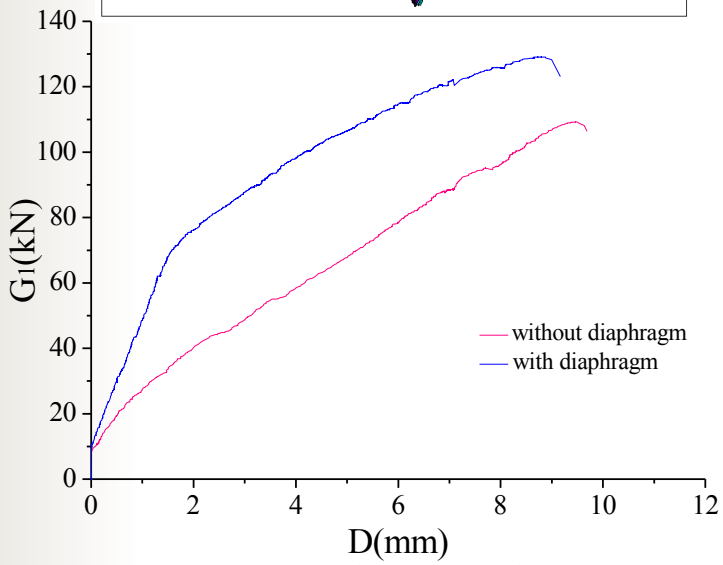
The case of wind resistance



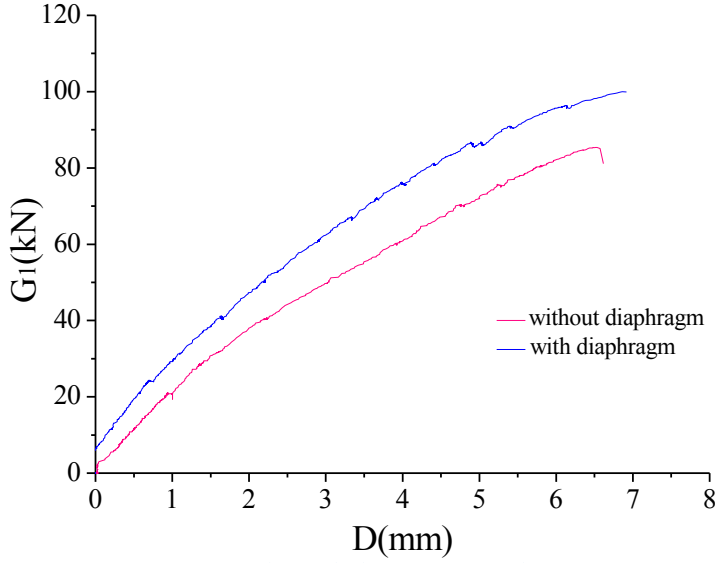
◆ *What is the difference of load-carrying capacity?*

The case of ice resistance





single-panel



double-panel

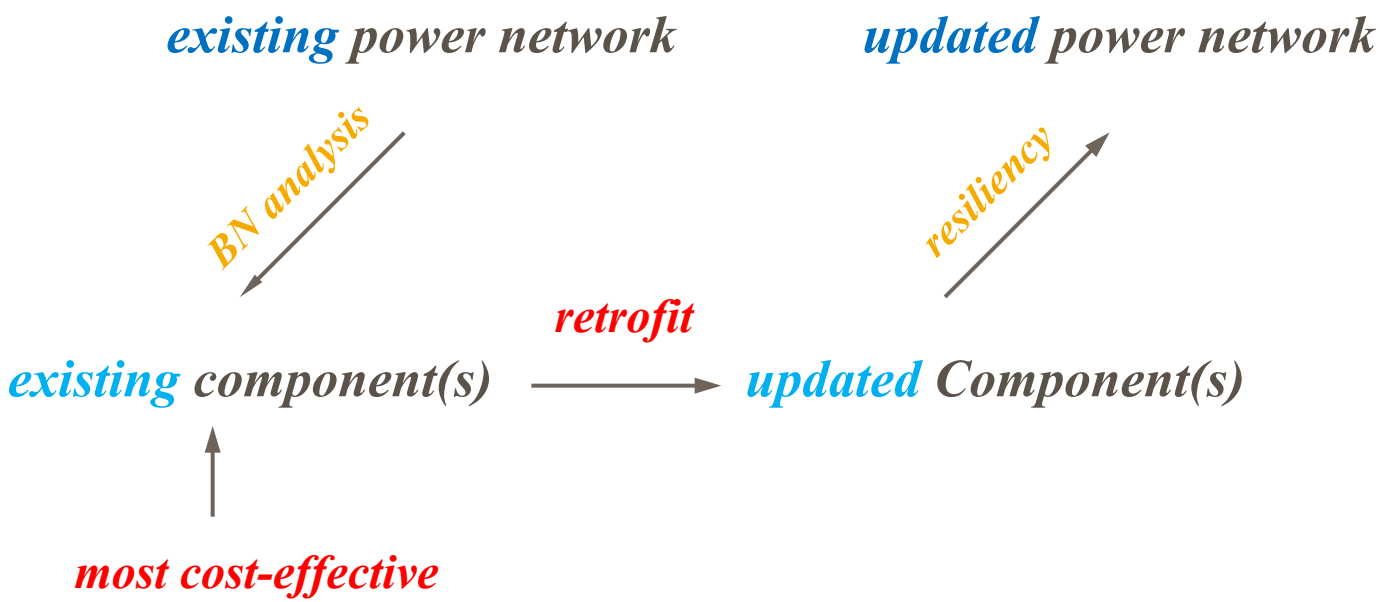
4. Conclusions and Future Work

Conclusions:

- ***The out-of-plane deflection of diagonal bracing is "critical" but difficult to avoid;***
- ***The stability performance of both the individual member and the overall tower structure is remarkably influenced by the out-of-plane deflection of diagonal bracings;***
- ***Adding diaphragms on the vulnerable panels of tower structure would be a practical and effective retrofitting strategy.***

Future work:

1. *Investigation of dynamic response*
2. *Risk-informed performance analysis*



Thank you for your attention!

Looking forward to working with all of you…

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Any question?
Or comments?