Investigation of wind damage processes by Typhoon Yolanda, identification of effective damage reduction measures, and its facilitation to recovery work

Kazuyoshi Nishijima, DPRI, Kyoto University

Mary Ann Espina, College of Architecture, University of the Philippines, Diliman

Japan–Philippine Urgent Collaborative Projects regarding "Typhoon Yolanda" within the J-RAPID Program

JST Japan Science and Technology Agency

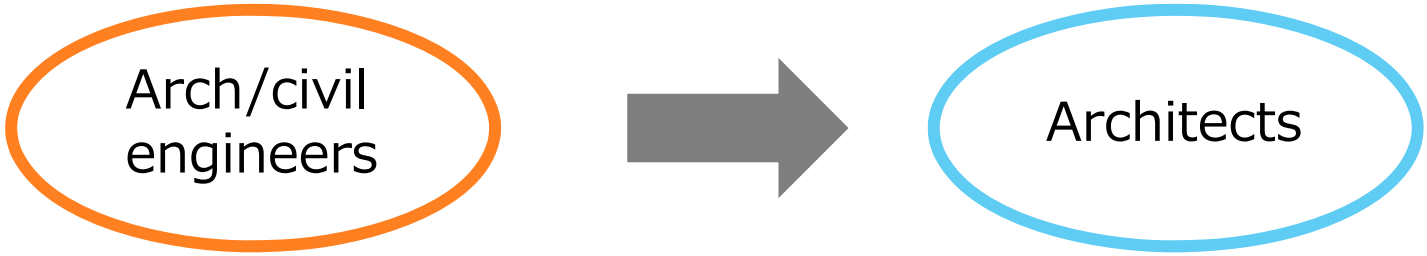
DOST PCIEERD

Aim of the project

- To propose an improved wind design method,
- for the purpose of effective wind damage reductions in future typhoon events
- by identifying physical processes of wind damages to residential and school buildings during the Typhoon Yolanda.

What our team achieved are:

- To propose an improved wind design method,
- for the purpose of effective wind damage reductions in future typhoon events
- by identifying physical processes of wind damages to residential and school buildings during the Typhoon Yolanda.



Our team

University of the Philippines, Diliman

- Mary Ann Espina (Philippine leader)
- Jaime Hernandez
- Liezl Raissa Tan
- Howell Tungol



Disaster Prevention Research Institute, Kyoto University

- Kazuyoshi Nishijima (Japan leader)
- Hiroaki Nishimura
- Takashi Maruyama



Tokyo Polytechnic University

- Masahiro Matsui
- Akihito Yoshida
- Yukio Tamura

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- Alexis Acacio
- Mario delos Reyes



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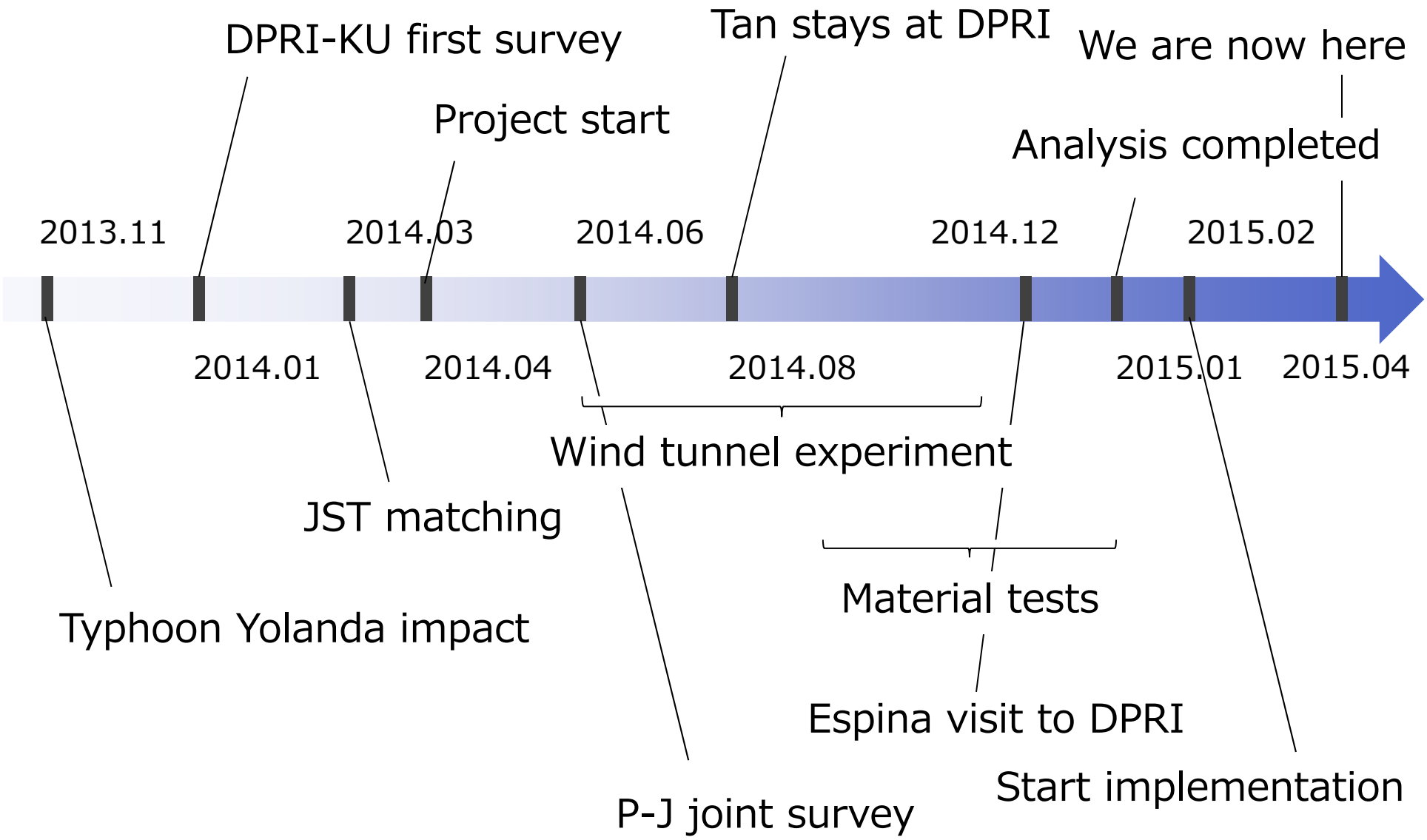
- Yukio Tamura



JST J-RAPID project timeline

18 months



DPRI-KU first survey

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DPRI-KU first survey

DPRI-KU first survey

- Significant damages to school buildings and non-engineered houses

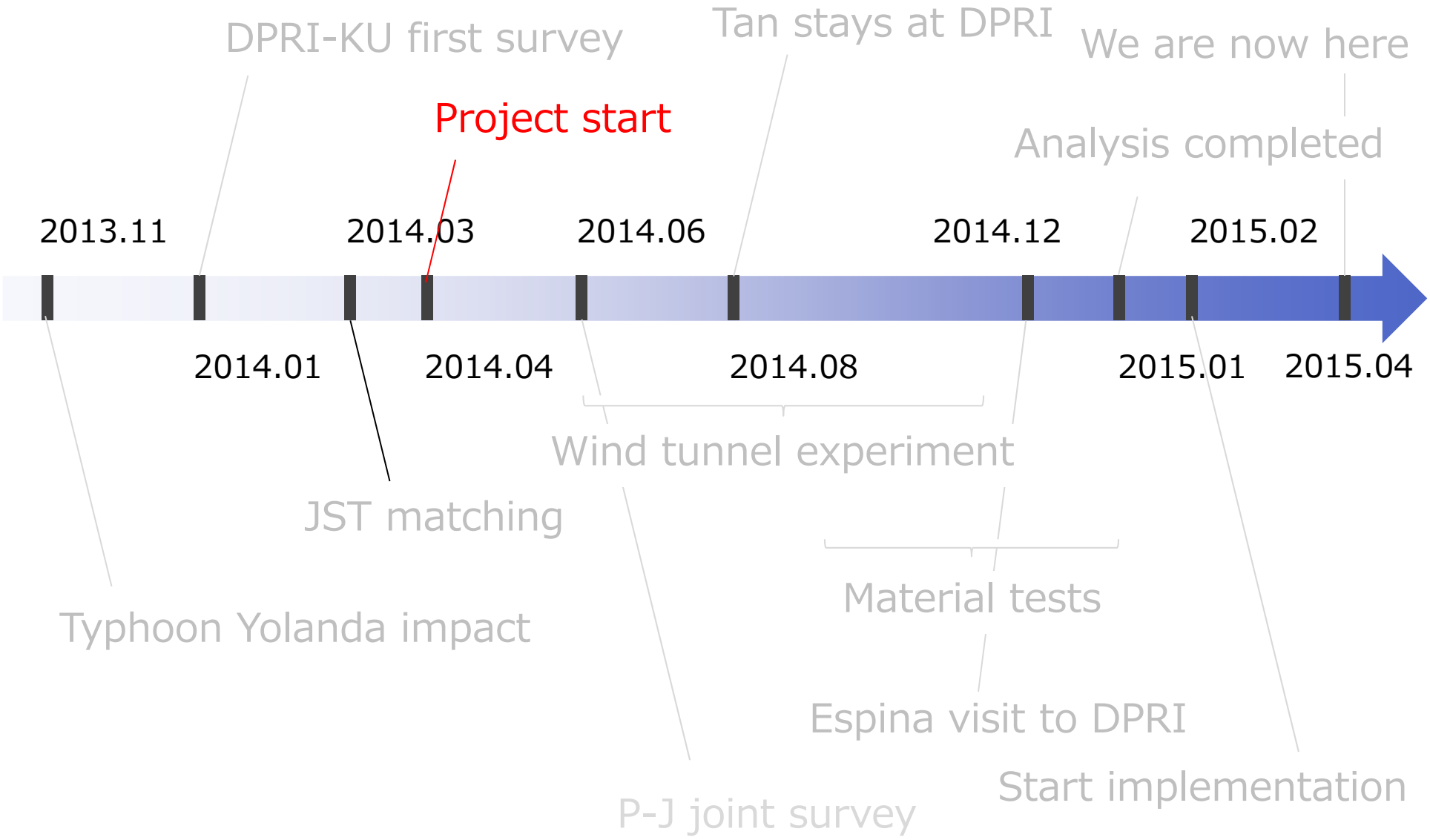
Important infrastructure

Risk left behind

Ignored by engineering research communities

This is the motivation of our JST J-RAPID project!

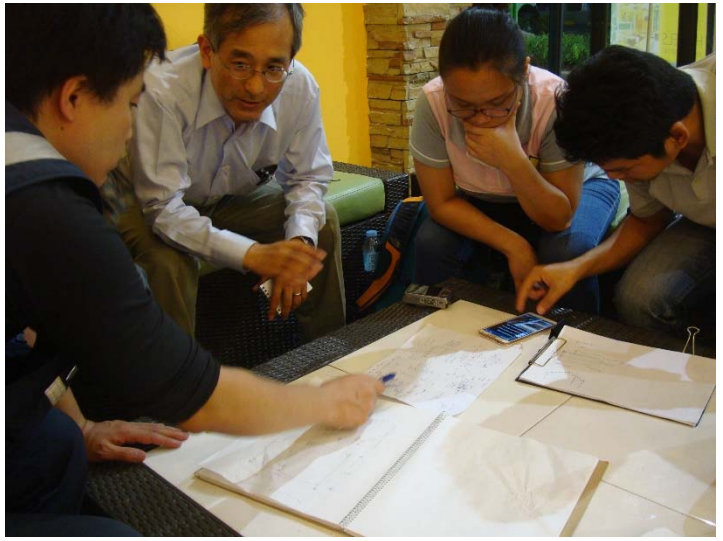
JST J-RAPID project timeline



P-J joint survey

Sketching

Sampling



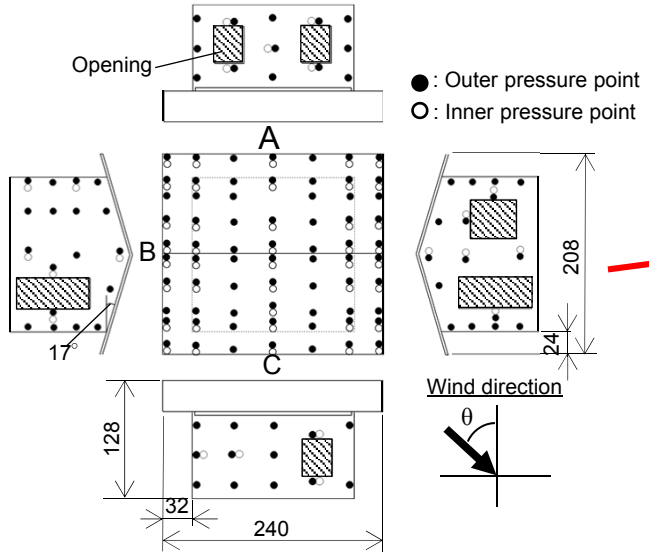
Briefing

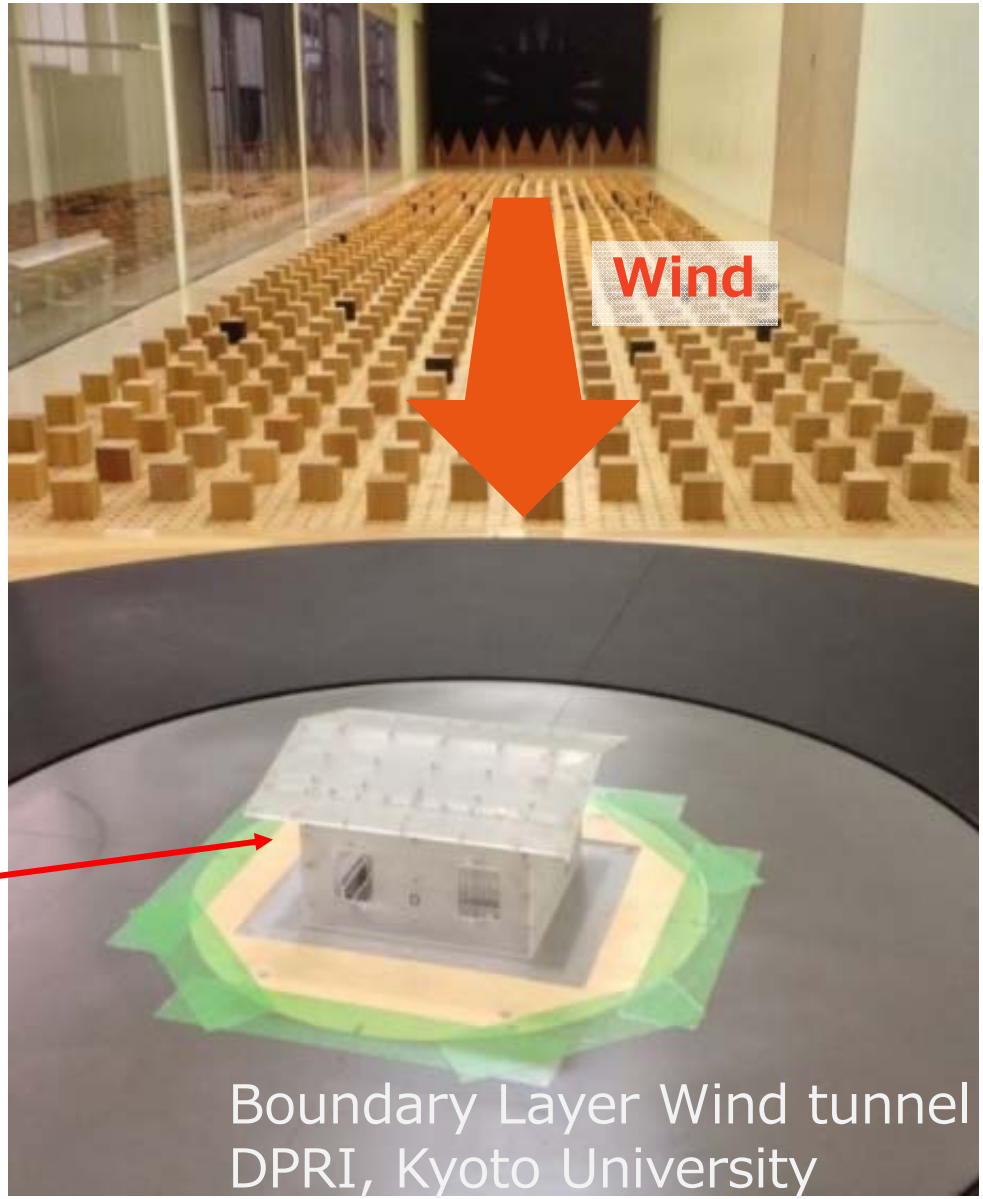
Weak point identification

(This photo was taken in the first survey.)

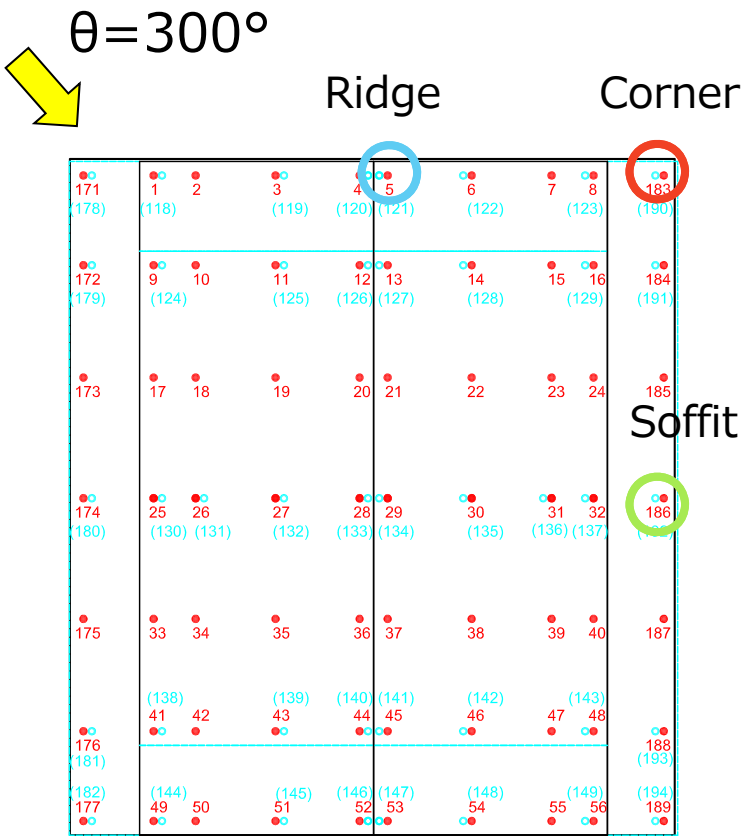
- Roof covering
- Roof-column connection
- Column-foundation connection

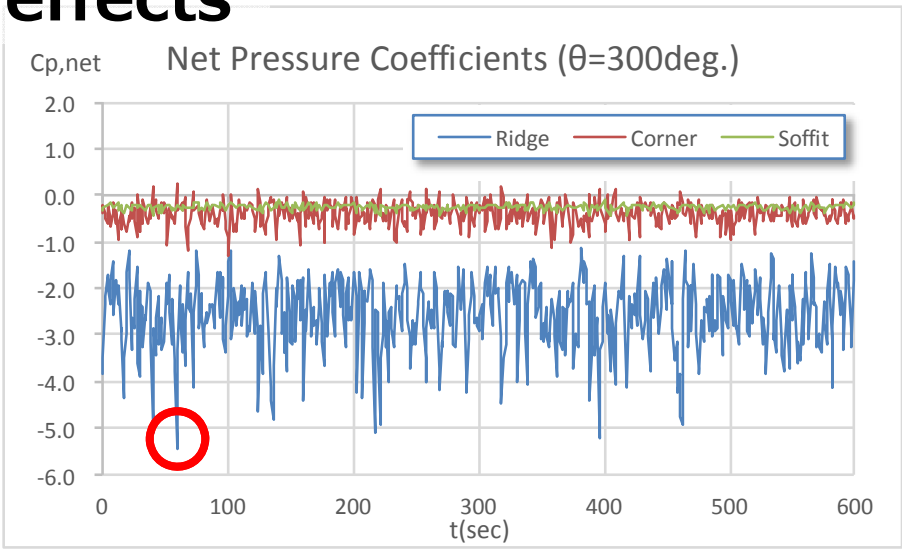
Wind tunnel experiment

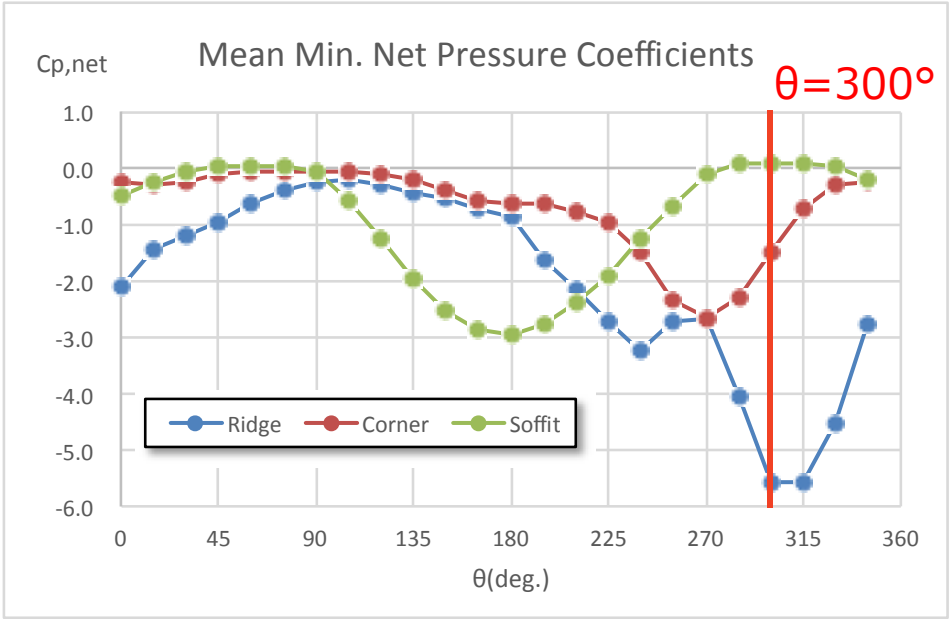




Assessment of wind load effects



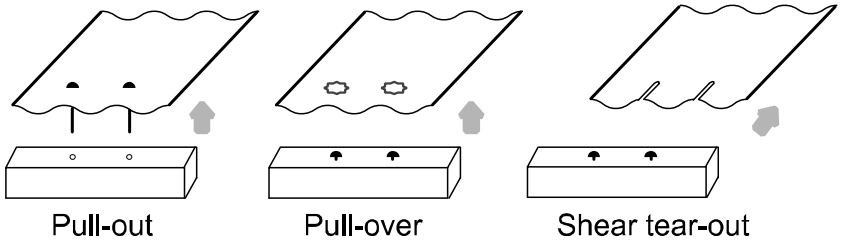




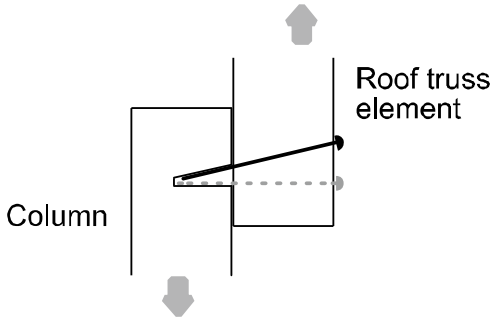
Unique characteristics of wind loading was observed, which arises due to its large openings

Considered failure modes

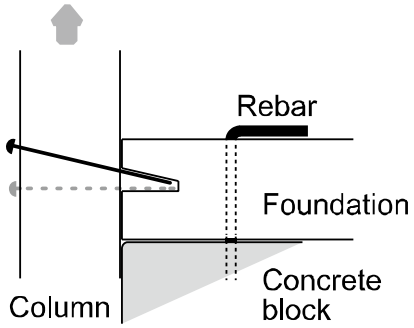
(a) Roof covering failure



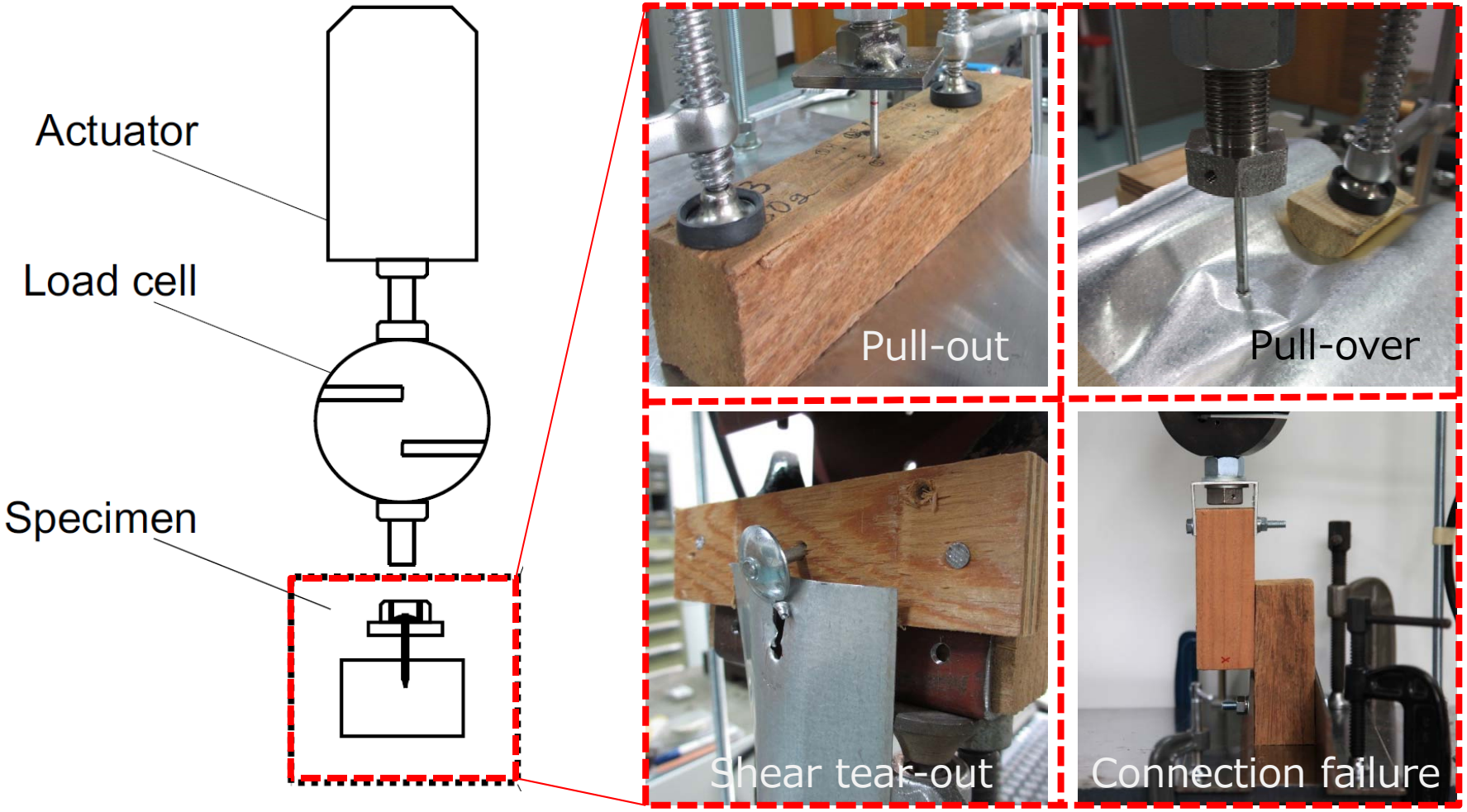
(b) Roof-column connection failure



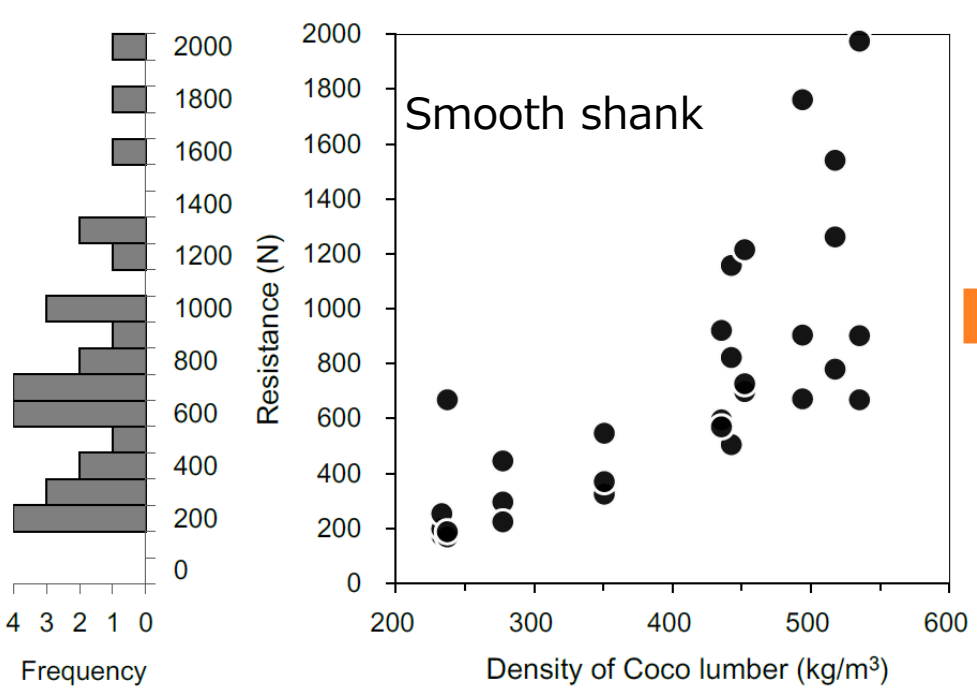
(c) Column-foundation connection failure

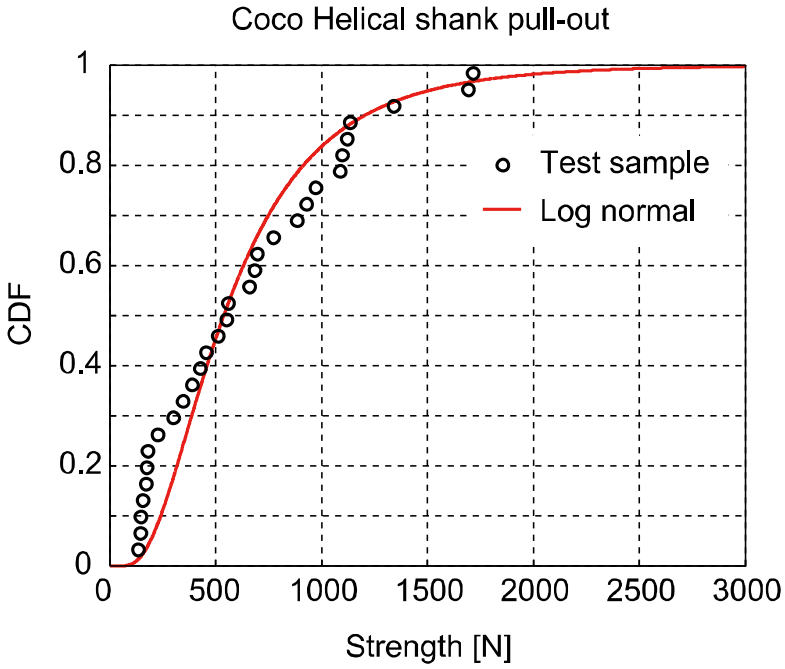


Test devices



Resistance modeling (for pull-over failure)





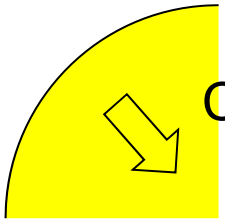
Test result

Resistance changes significantly as a function of coco lumber density

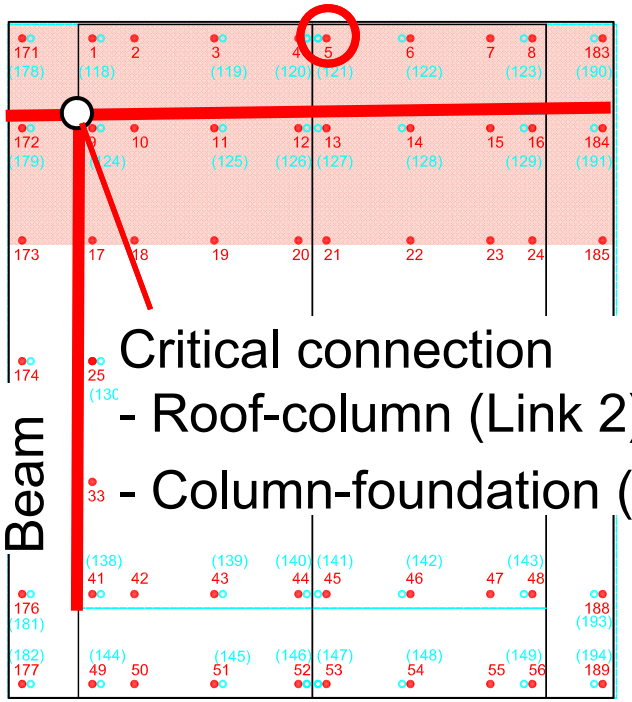
Probabilistic Modeling*

***Not differentiated according to coco lumber density**

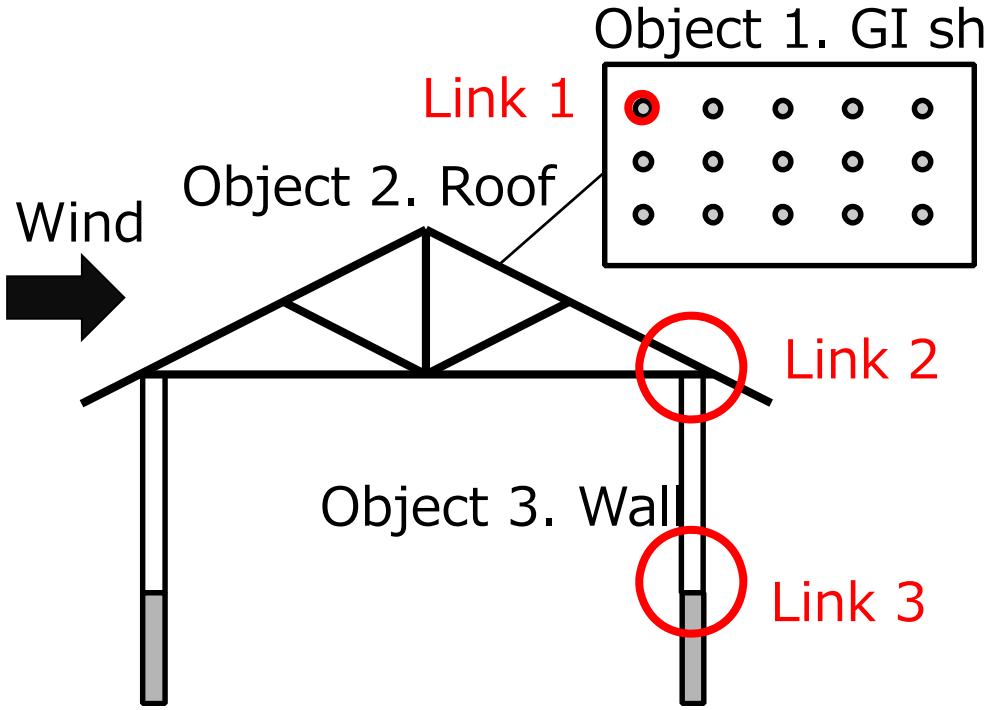
Structural system analysis



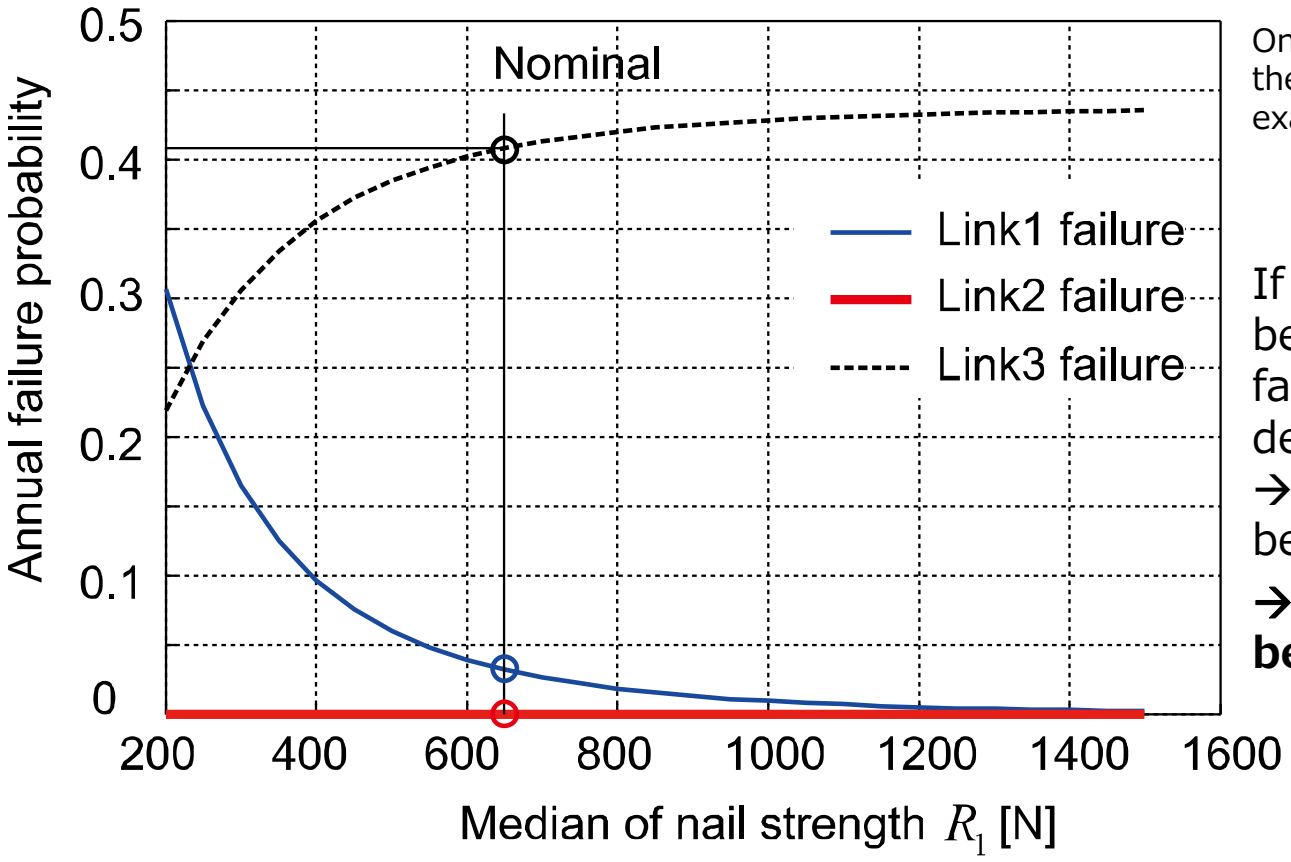
Critical fastener (Link 1)



Critical connection
- Roof-column (Link 2)
- Column-foundation (Link 3)



Assumed scenario
(wind direction, failure mechanism)



Only valid under assumed condition and the assumptions should be further examined.

If wind direction is assumed to be uniform and random, the failure probability may decrease by a few factors.
→ Annual failure probability becomes 10%~20%.

→ Expected failure time becomes 5 to 10 years.

Link 3 failure probability increases when Link 1 resistance increases.
This is because: if GI sheet does not fail, the house carries more wind load, which can lead to failure of connections.

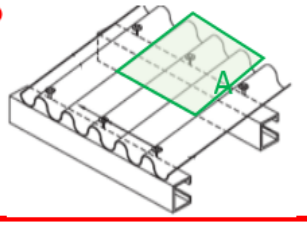
→Lesson: Care must be taken to reinforce one part, without considering its effect to the whole.

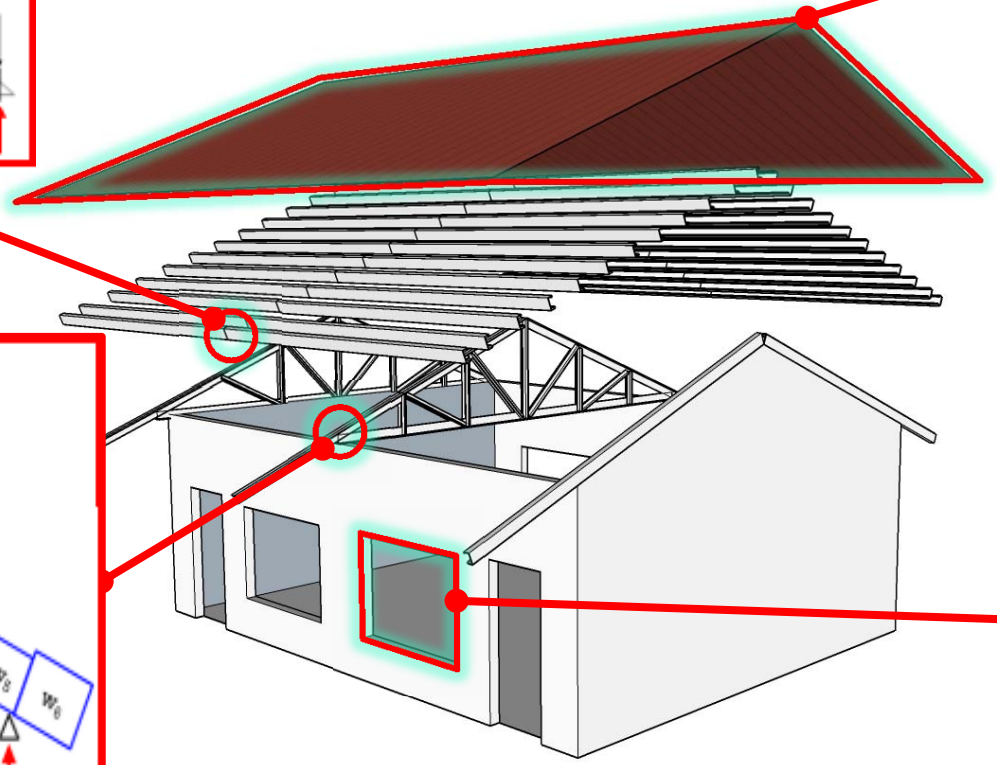
Observed Damages and Evaluation of Component Failures

$F_{RES_{con}} <?\ F_A$

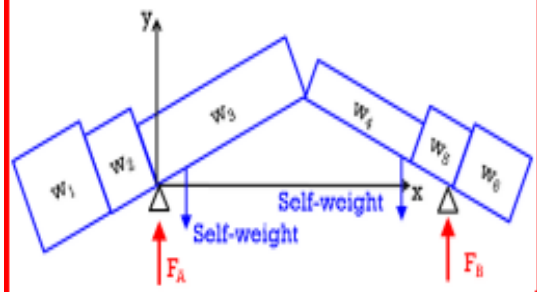
$\min\begin{pmatrix} F_{RES_{pull-out}} \\ F_{RES_{pull-thru}} \end{pmatrix} <?\ F_{LOAD}$

$F_{LOAD} = \frac{1}{2}\rho v^2 C_{p_{net}} A$

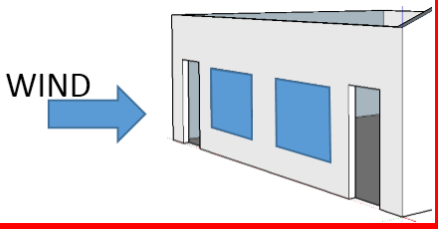


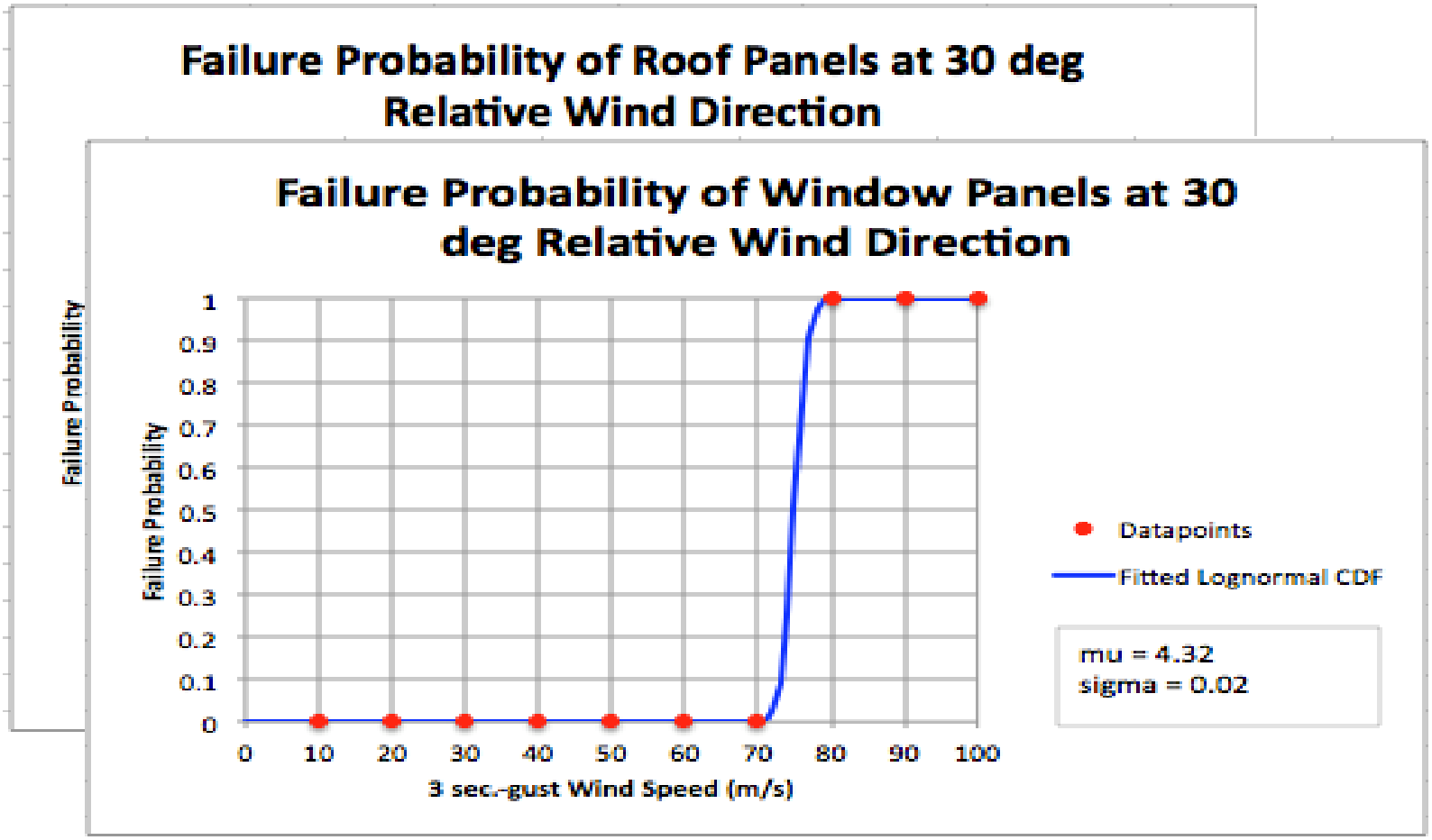


$F_{RES_{con}} <?\ F_A$



$P_{RES_{window}} <? \frac{1}{2}\rho v^2 C_{p_{net}}$




Failure Probability of Roof Panels at 30 deg Relative Wind Direction
Failure Probability of Window Panels at 30 deg Relative Wind Direction
Failure Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
3 sec.-gust Wind Speed (m/s)
Datapoints
Fitted Lognormal CDF
mu = 4.32
sigma = 0.02

Main findings:

- fasteners and connections are weak points
- construction materials locally available are limited
- construction materials are not used in effective manners
- non-engineered houses can fail due to strong wind with the return period of less than 10 years.

***Technical summary is reported at the annual convention 2015**
Nishijima, K. et al., Evaluation of wind resistant performance of a non-engineered buildings in the middle of the Philippines, Part I – III.

We are ready to provide architects with answers for wind-resistant performance improvement.

Build Back Better - Philippines:

Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

WHAT CAN THE UNIVERSITY OF THE PHILIPPINES DO FOR THE REBUILDING OF --

TYPHOON HAIYAN-STRICKEN AREAS OF TACLOBAN AND SAMAR?

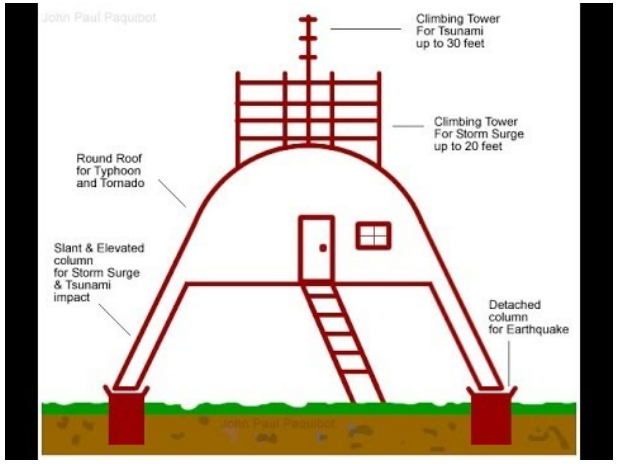
EARTHQUAKE-STRICKEN AREAS OF BOHOL?

Build Back Better - Philippines:

United Architects of the Philippines

yolandatyphoonhouse.blogspot.com

smarthouseidea.com



www.digplanet.com

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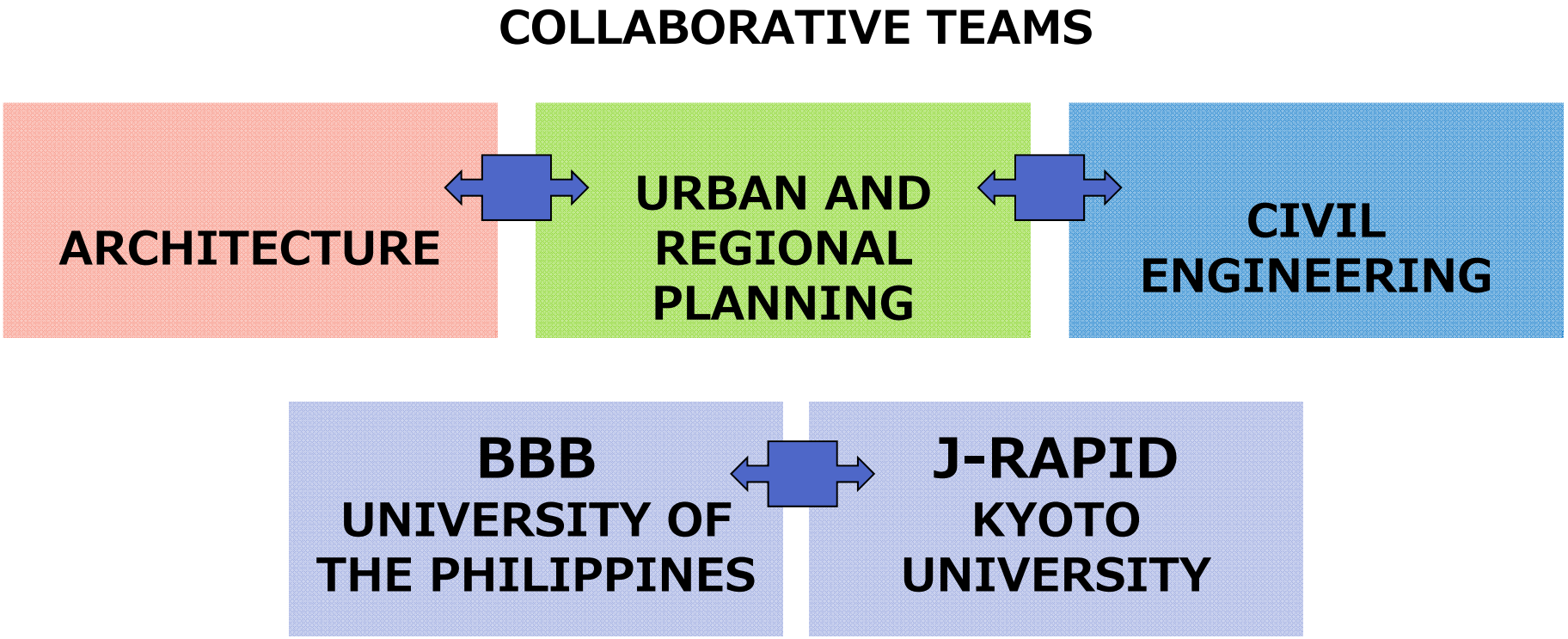

Build Back Better - Philippines:
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Site survey conducted by J-Rapid and BBB in Tacloban City, Leyte
on June 24-28, 2014.

Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

What the survey accomplished for BBB:

- Assessment on the types of damage incurred on the architecture and structure of selected residential and school buildings by Typhoon Yolanda.



Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

What the survey accomplished for BBB:

- Assessment on the role of materials and construction methods of the surveyed buildings in the failure to withstand typhoon stress.



Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

What the survey accomplished for BBB:

- Assessment on the role of the buildings' geographical location, site orientation and building configuration in the failure to withstand typhoon stress.

Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

What the survey accomplished for BBB:

- Assessment on the abilities and limitations of surveyed community to rebuild after typhoon event.

Philippines: The Emergency Architects Foundation continues its action!

Work is progressing in elementary school Tanza Norte (Panay, Capiz, Philippines). Working with laborers, masons and carpenters from the neighborhood of the school, and whose children are mostly students Tanza Norte, the foundation has already been poured most of the posts and beams needed for a real earthquake reconstruction of two buildings destroyed. In January, it will address the roof so that the 287 students at the school can more quickly return to the destroyed buildings. Currently, they are in fact concentrated in some classrooms still healthy and can study in decent conditions. [more]

Build Back Better - Philippines:
The Science and Technology of Designing and Planning Sites and Buildings for Disaster Resilience

What BBB hopes to accomplish in 2016:

To produce a **Practical Guide for Designing and Planning Sites and Buildings for Typhoon- and Earthquake-Disaster Resilience**

To explain the effects of typhoons and earthquakes on sites and building structures.

To provide sample designs for three prototype resilient buildings – houses, schools and evacuation centers.

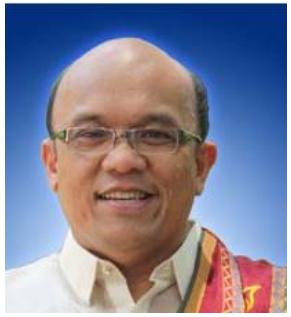
To target homeowners and school builders, and, planners, architects, landscape architects, and engineers.

The most important outcome

At last, but not least, both teams agreed to continue to collaborate for building back better the infrastructure by the Typhoon Yolanda!

Special thanks to

- JST J-RAPID for not only financial support but also support in matching us.






Also thanks to

- Kazuhide Tomisaka, DPRI, Kyoto University
- Ayako Namigishi, DPRI, Kyoto University

for supporting to conduct the wind tunnel experiments and material tests.