Recent research on Timber Engineering at Tongji University

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Outline

1 History of timber structures in china

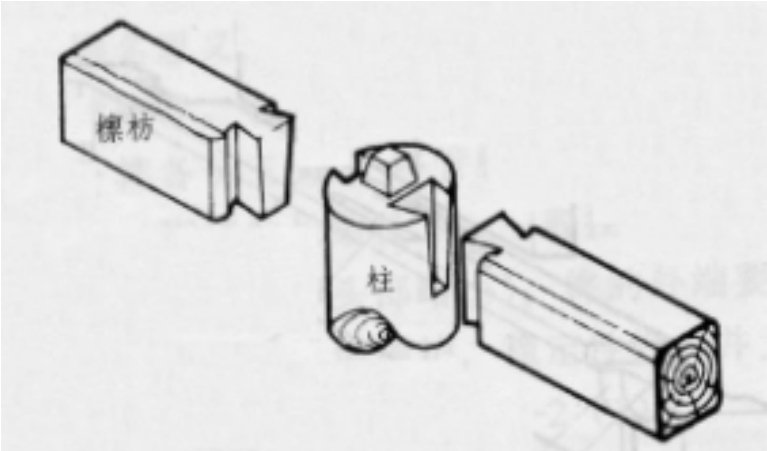
2 Important issues on the development of timber structures in China

3 Recent research on timber engineering at Tongji University

4 Prospect

1 History of timber structures in china

Timber sturctures has a very long history in China. About 3500 years ago, Chinese started to build post and beam timber constructions connected by mortise and tenon.

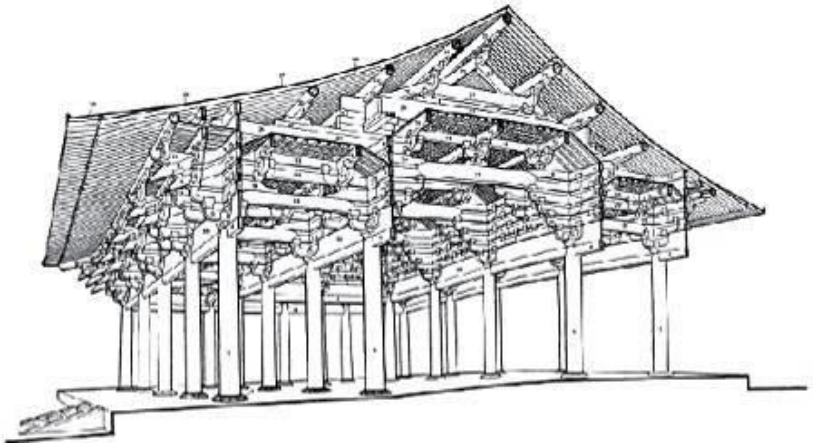


Tenon

Dougong

1 History of timber structures in china

Now a lot of timber palace, temples and pagodas are still in existence.



Foguang Temple

Built in 857 A.D. It is 34m in length and 17.77m in width.

1 History of timber structures in china

Yingxian Wooden Pagoda

(built in 1056 A.D.)

It is 67 m in height.

The pagoda is a 9-story octagonal building and was constructed without using any metal connectors. It is also one of the tallest ancient wooden buildings in the world.

1 History of timber structures in china

Hundreds of year ago, a lot of large scale timber constructions were built.

1 History of timber structures in china

From 50s to 70s last century, brick or concrete - timber hybrid structures were built in lot of areas.

2 Issues on the development of timber structures in China

In the 1980s, concerning the large population and shortage of wood resource, our government restricted people to use timber as construction material.

2 Issues on the development of timber structures in China

Recent ten years, with the increasing of imported wood resource and local fast planted forest, our government encourage to use timber as a kind of building material.

2 Issues on the development of timber structures in China

Wood frame constructions in resident houses

Vancouver Garden in Beijing

Villa in Shanghai

2 Issues on the development of timber structures in China

Wood frame constructions in public buildings

Xiang'e school in Dujiangyan

Tourism Buildings in Sichuan

Conference center in Caofeidian, Hebei Province

2 Issues on the development of timber structures in China

Glulam Structures in public buildings

A Toll gate in Yunnan province

Shanghai Roller coaster

Entrance of Chengdu Happy Valley

2 Issues on the development of timber structures in China

Glulam Structures in public buildings

Bridge in a golf club Shanghai

A club in residential area Beijing

2 Issues on the development of timber structures in China

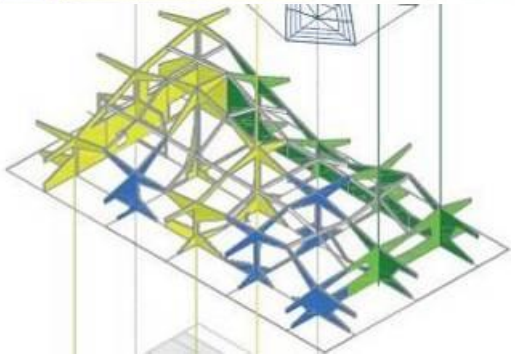
Glulam Structures in public buildings

Building-selling center in Wanke Jilin
2610 m²

Tourism center in Qindao
1800 m²

2 Issues on the development of timber structures in China

Glulam Structures in public buildings



Norway Pavilion, consists of fifteen assembled "trees". Each "tree" structure is constructed of laminated timber. After the Expo each tree can be easily moved and become part of a new landscape elsewhere.

2010 Shanghai Expo Building- Norway Pavilion

2 Issues on the development of timber structures in China

Glulam Structures in public buildings

2010 Shanghai Expo Building- Swedish Pavilion

The cube as the entrance is post and beam construction made of Glulam.

2 Issues on the development of timber structures in China

Glulam Structures in reconstruction of temples

Xiangji Temple in Hangzhou

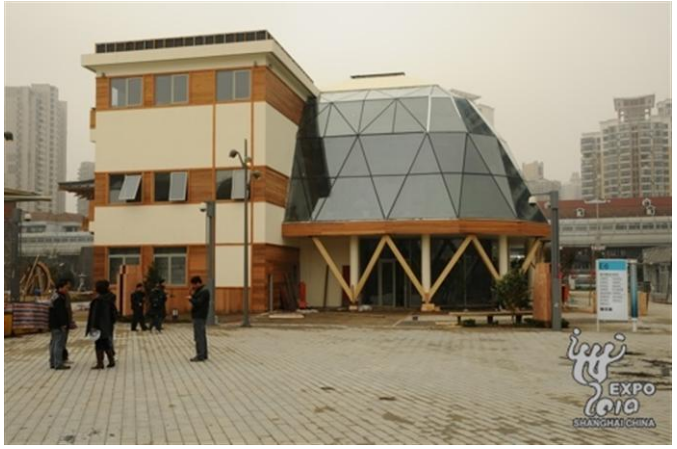
2 Issues on the development of timber structures in China

Glulam Structures in reconstruction of temples

Laojunge in Sichuan

2 Issues on the development of timber structures in China

Hybrid Structures



2010 Shanghai Expo Building - Vancouver Pavilion

It is a three-story wooden-concrete hybrid building. The first floor is reinforced concrete frame-shear wall structure and the second to third floor is timber structure.

2 Issues on the development of timber structures in China

Wood frame resident houses:

(1) How to solve the problem of limited land resource?

(2) Glulam structures are more favored. Wood frame works as wall panel.

Glulam constructions:

How to increase lateral resistant strength and rigidity for post-beam construction?

Timber constructions:

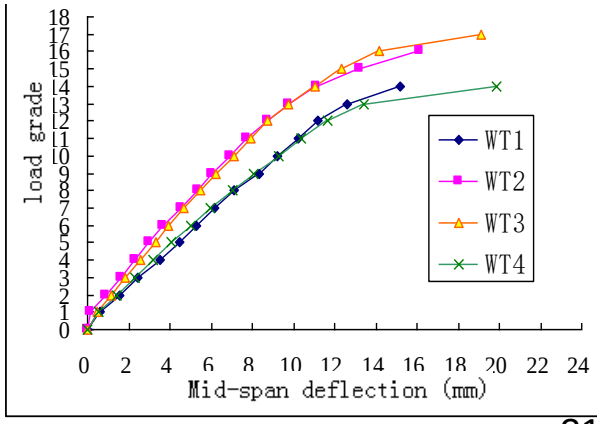
How to increase the ratio of land utilization?

Wood frame constructions

(1) Tests and analysis for wood trusses

Load bearing capacity test

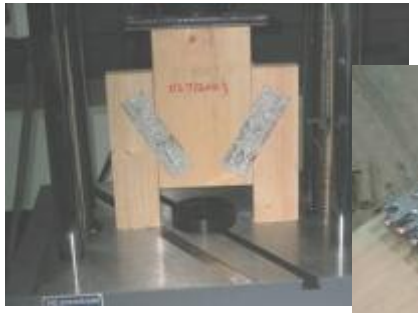
Failure mode

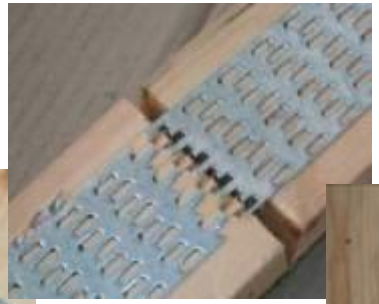


Load-displacement curve

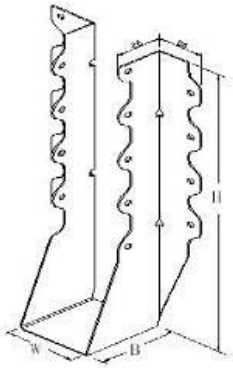
Wood frame constructions

(2) Connections





Tooth plate connections

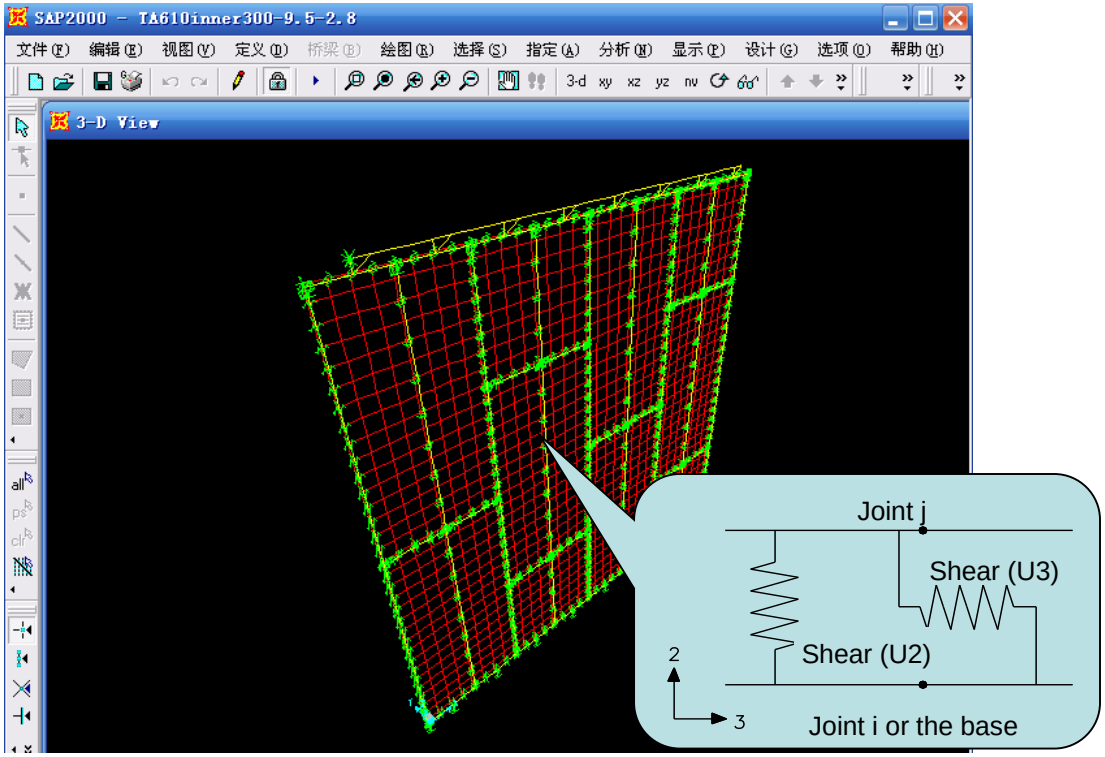


Joist hanger

Wood frame constructions

(3) Shear walls

Shear wall tests



Shear wall modeling

Compare between different wood-based panels

The lateral resistant ability of gypsum in share wall

Numerical modeling of shear wall

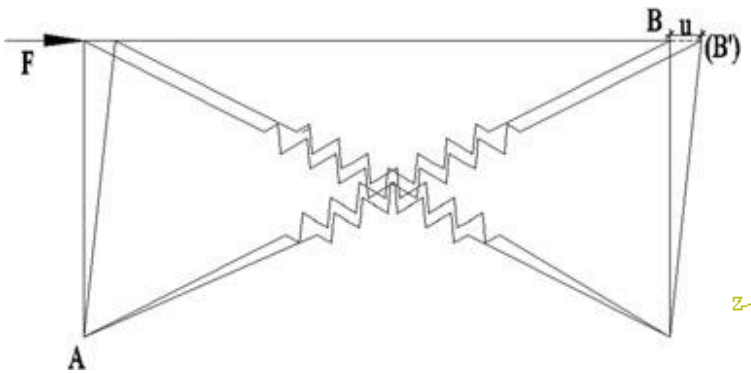
Wood frame constructions

(4) Seismic performance - shaking table tests

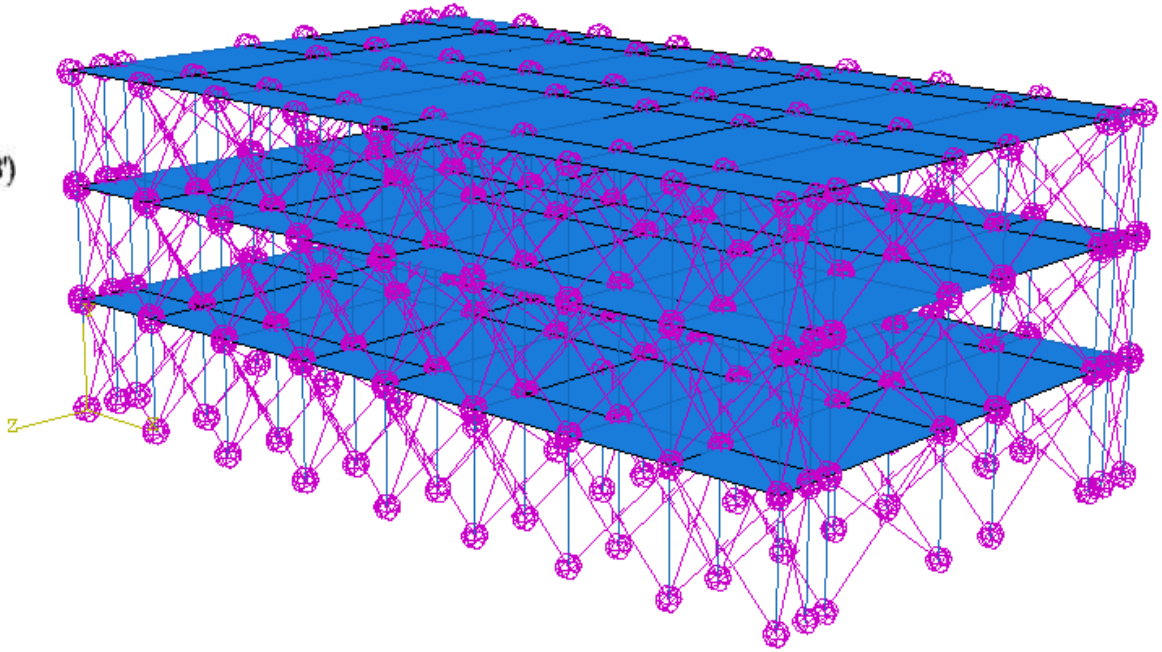
Light wood frame building

Wood frame constructions

(5) 3D Numerical modeling



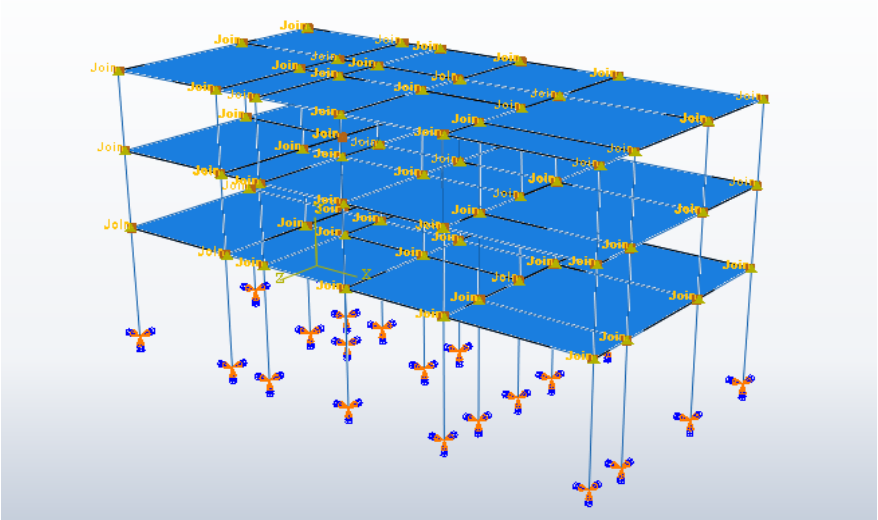
Simplified model



Nonlinear FE model for time-history analysis

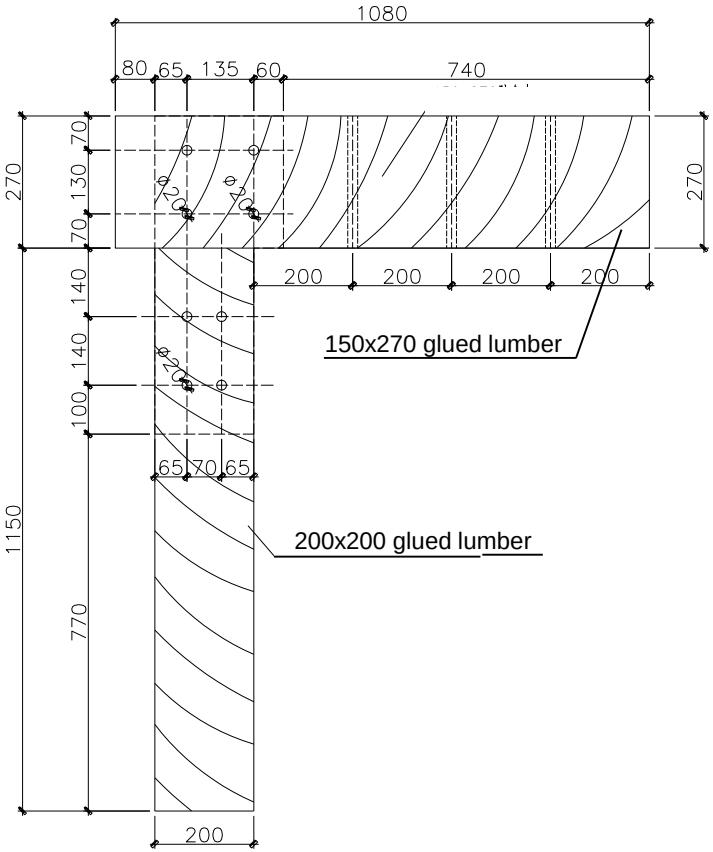
Wood frame constructions

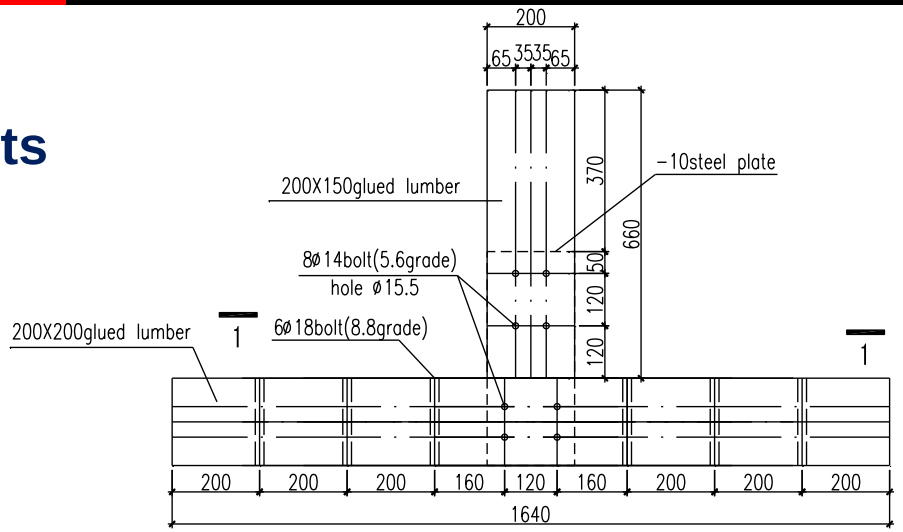
(6) Numerical modeling based on field measurement

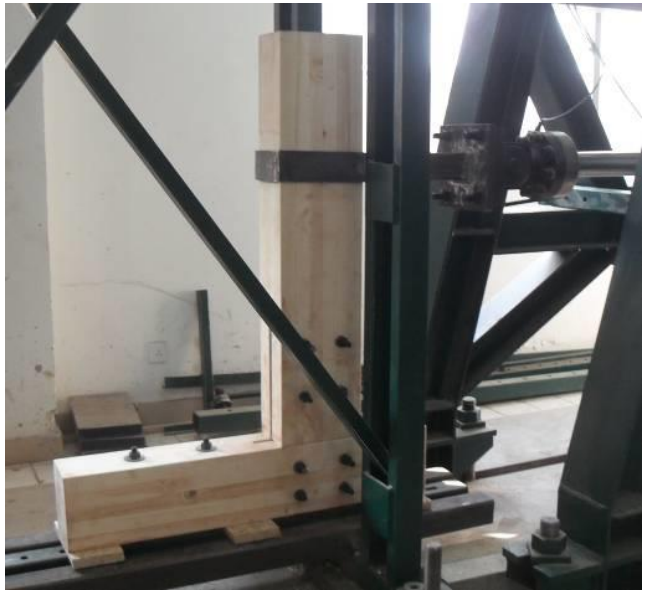


Glulam constructions

(1) Performance of post-beam joists

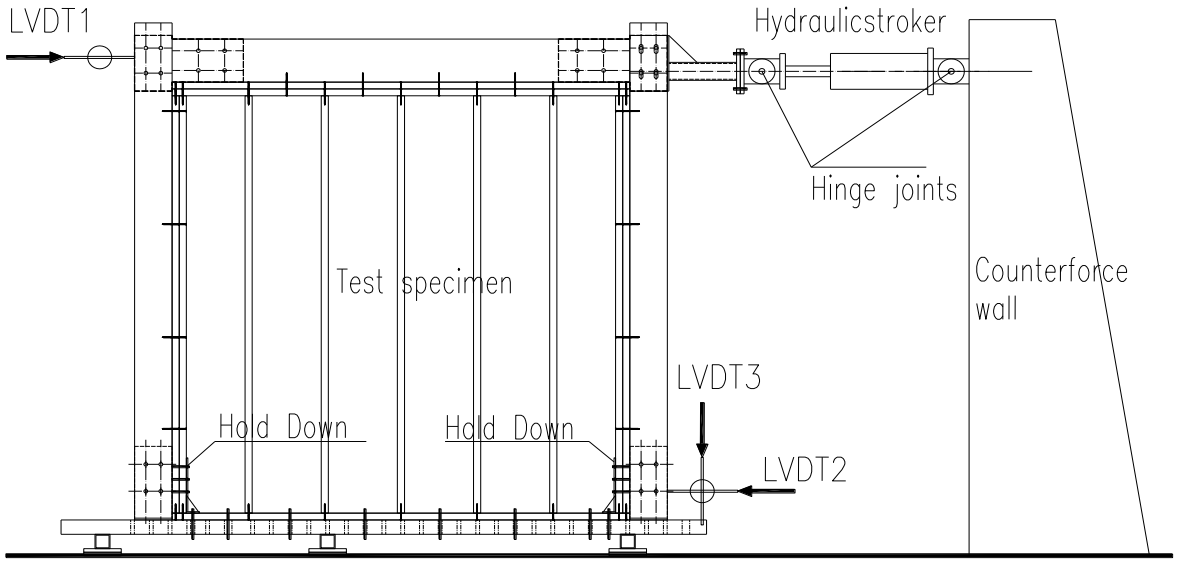






Glulam constructions

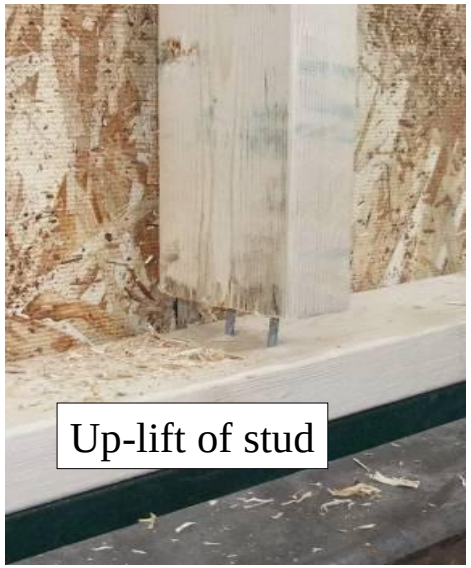
(2) Lateral performance combining of wood frame and post-beam



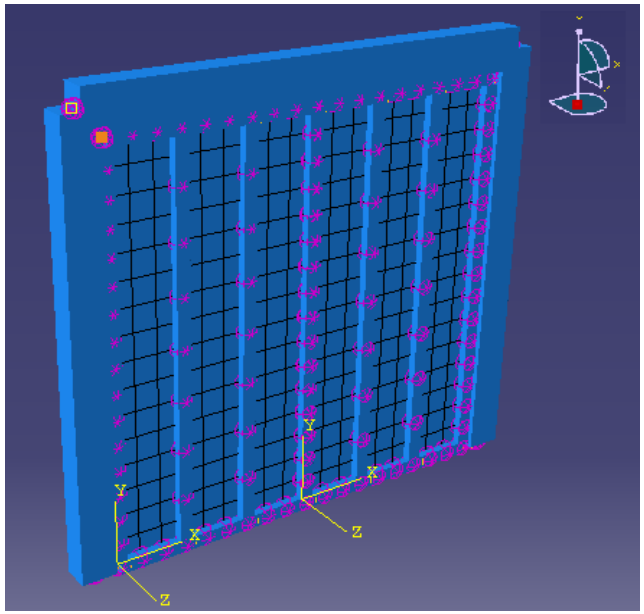
The wood frame shear walls are used to increase the lateral resistance for this kind of composite structural system.

Glulam constructions

(3) Numerical Modeling based on test result



Failure Mode



Numerical Model

Glulam constructions

(4) Full size connection tests of real project

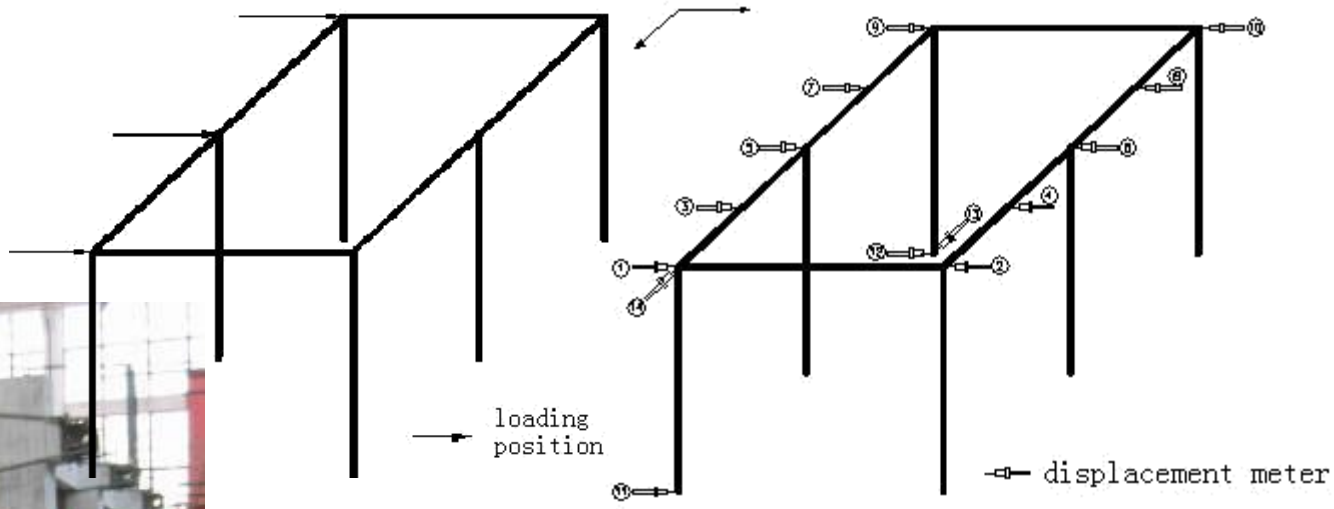
Hybrid constructions

(1) Comparison between timber floor and steel-concrete composite floor

For timber floor:
Decrease total structure weight: 23%
Decrease seismic action: 32%
Decrease vertical load on foundation: 48%

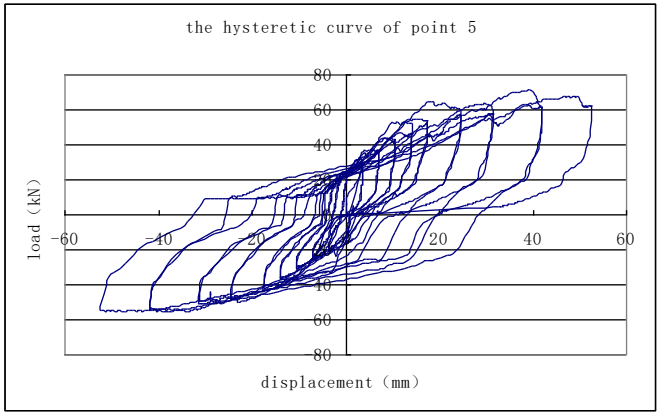
Hybrid constructions

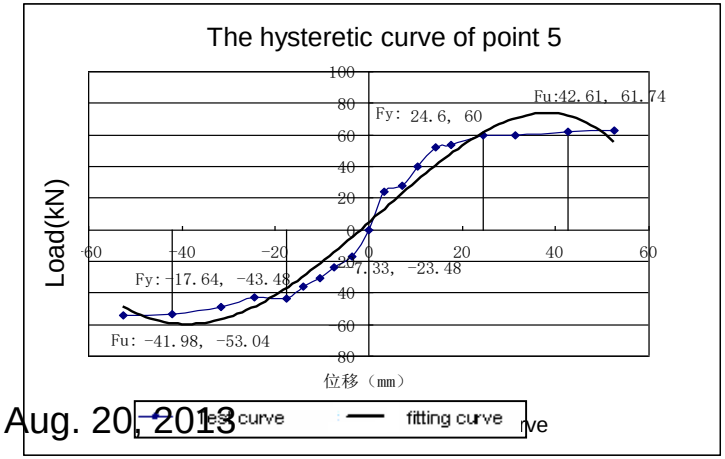
(2) Timber and concrete structure test

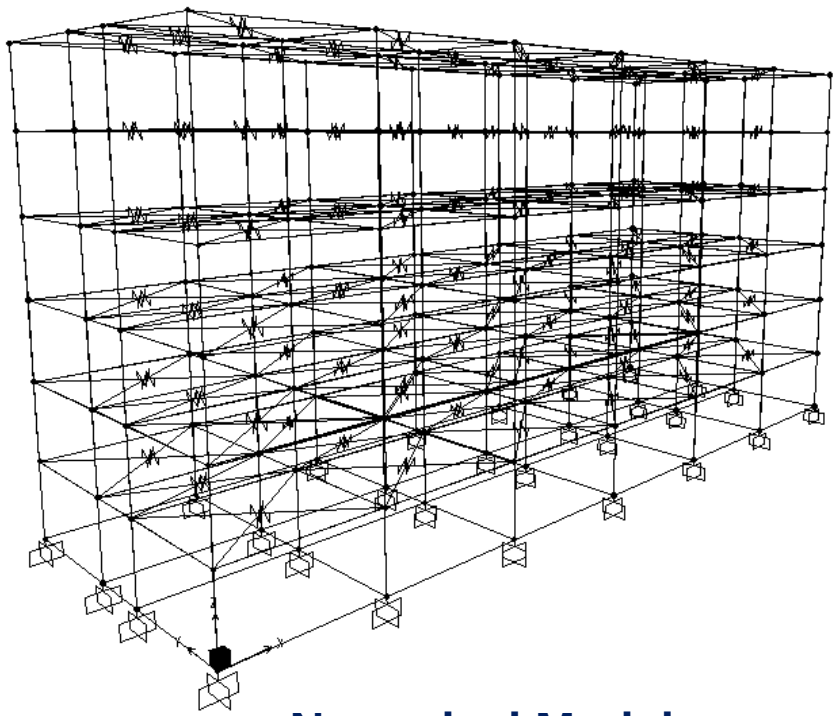


Hybrid constructions

(3) Timber and concrete structure modeling







Numerical Model

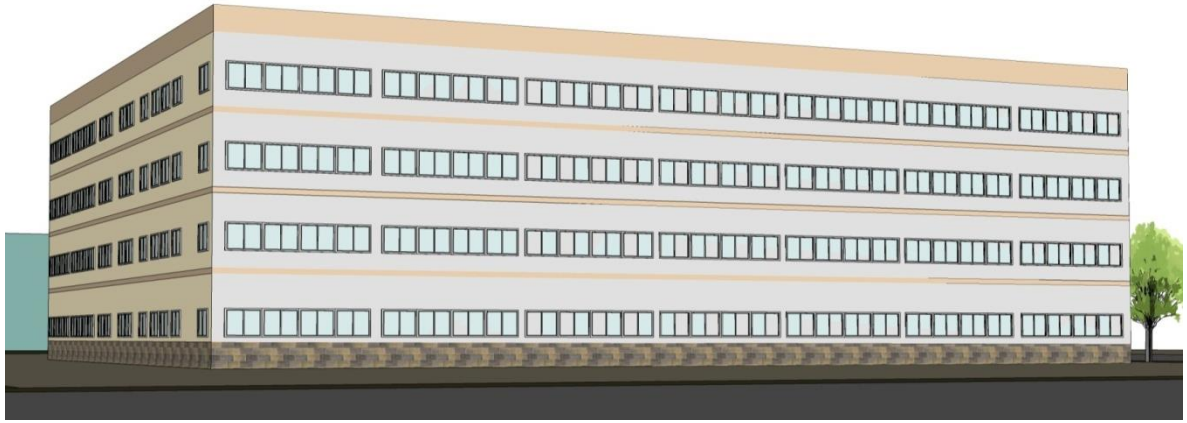
Hybrid constructions

(4) Shaking table tests of timber – concrete hybrid structure

3-storey hybrid building

Hybrid constructions

(5) Steel - timber hybrid structure -1



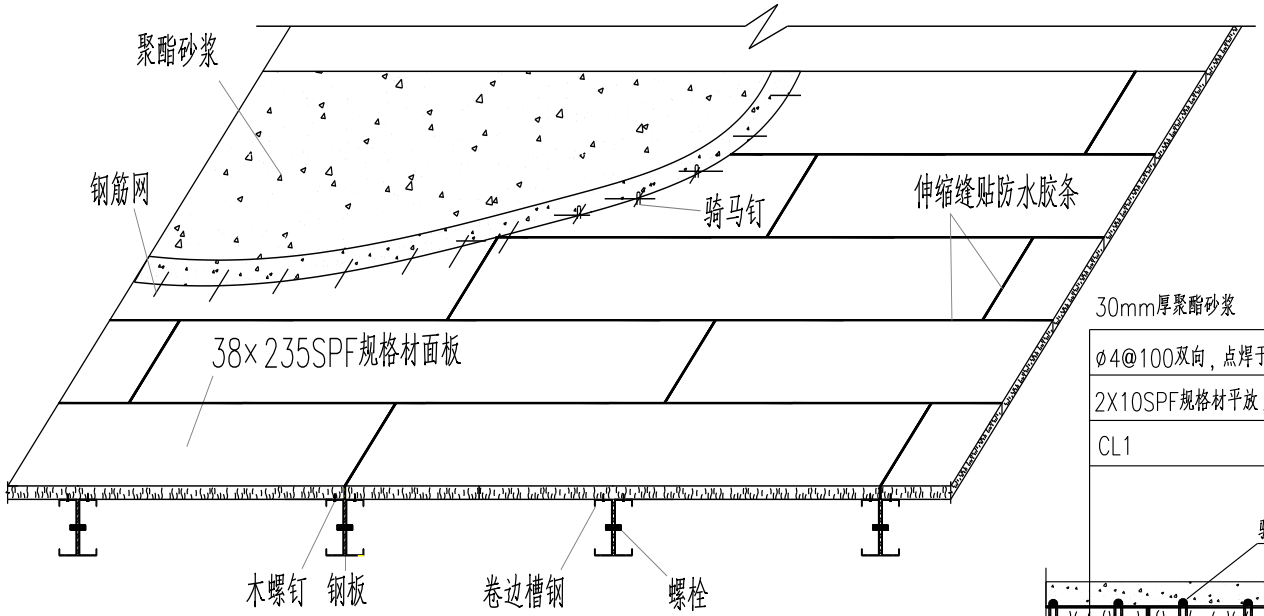
Timber-steel hybrid structure

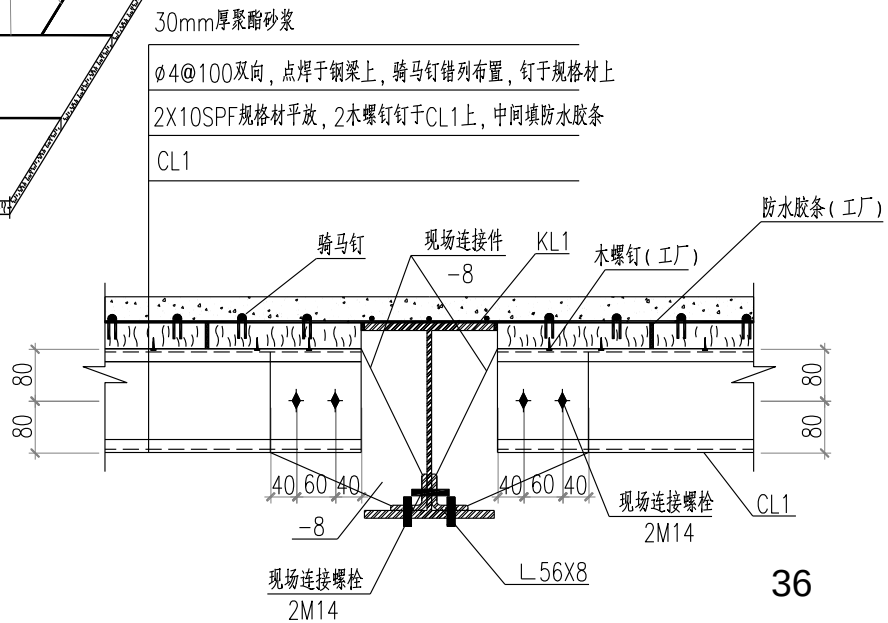
- Timber diaphragm
- Steel moment resisting frame
- Light wood-framed shear wall

- Horizontal system
- Vertical system

Hybrid constructions

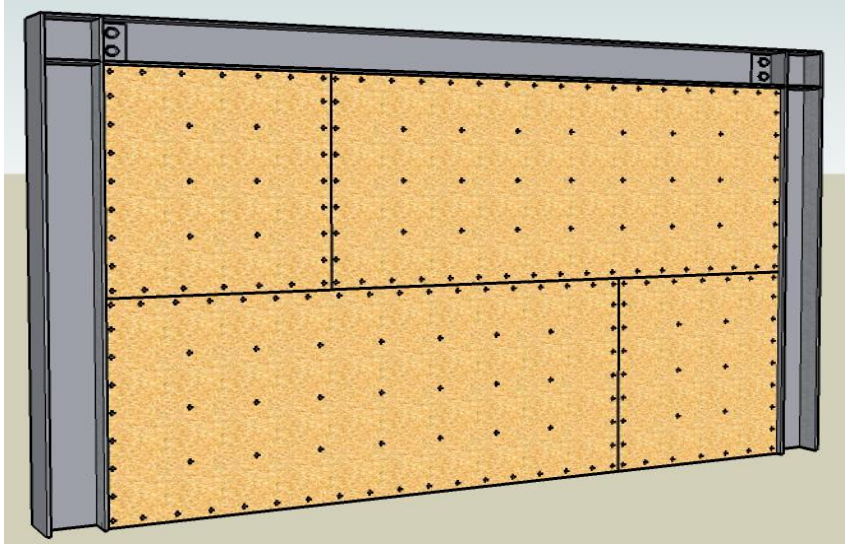
(5) Steel - timber hybrid structure -2

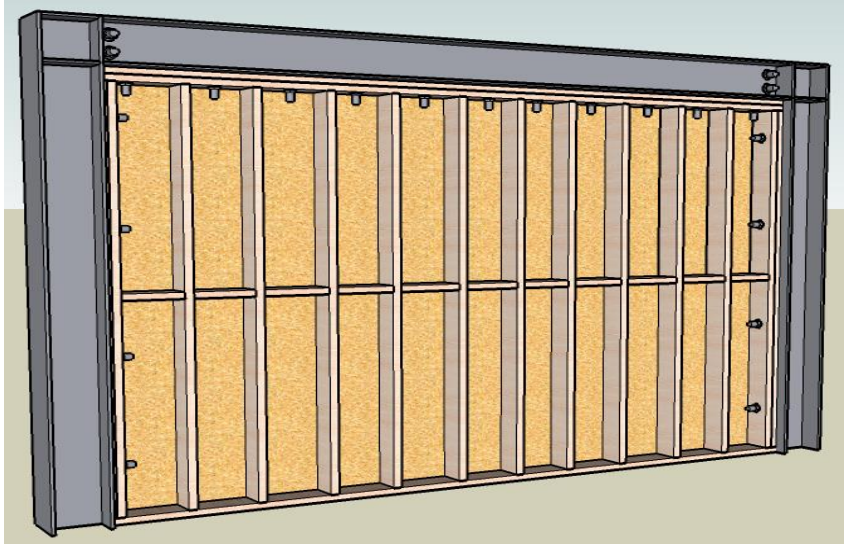




Hybrid constructions

(5) Steel - timber hybrid structure -3

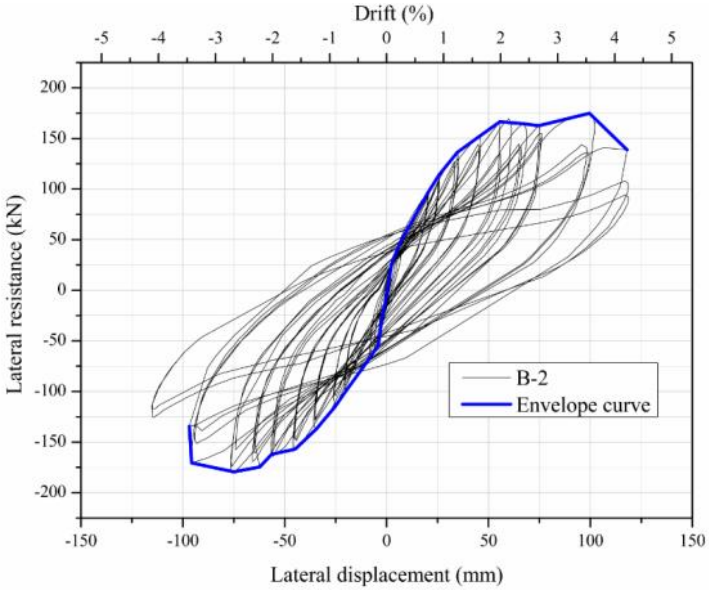


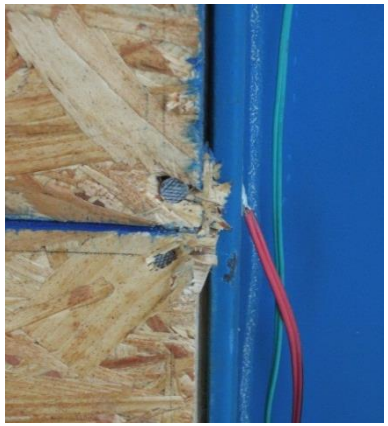


Hybrid constructions

(5) Steel - timber hybrid structure -4

Reversed cyclic loading test

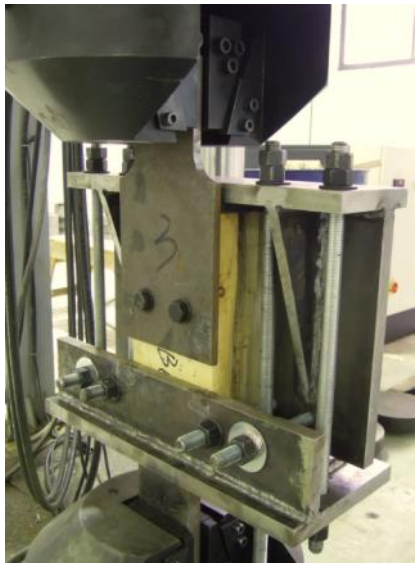


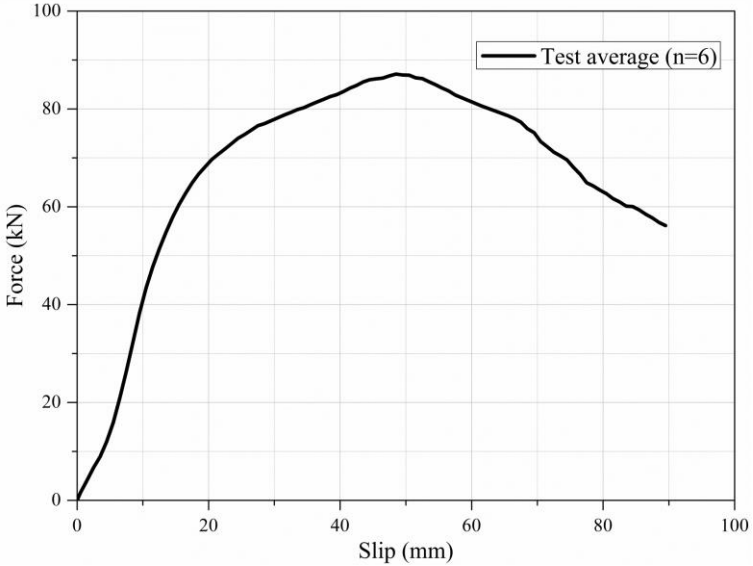


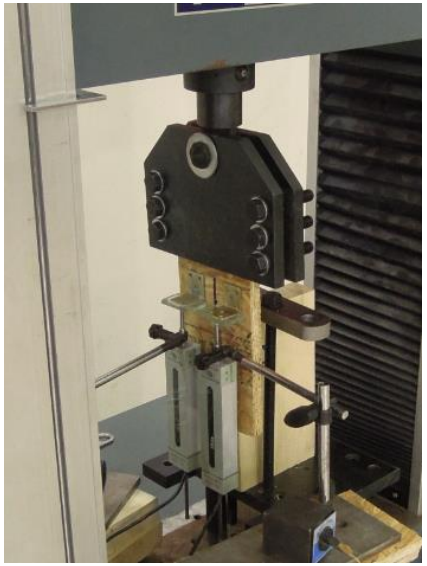
Failure modes

Hybrid constructions

(5) Steel - timber hybrid structure -5







Timber-steel connection test

Wood nail connection test

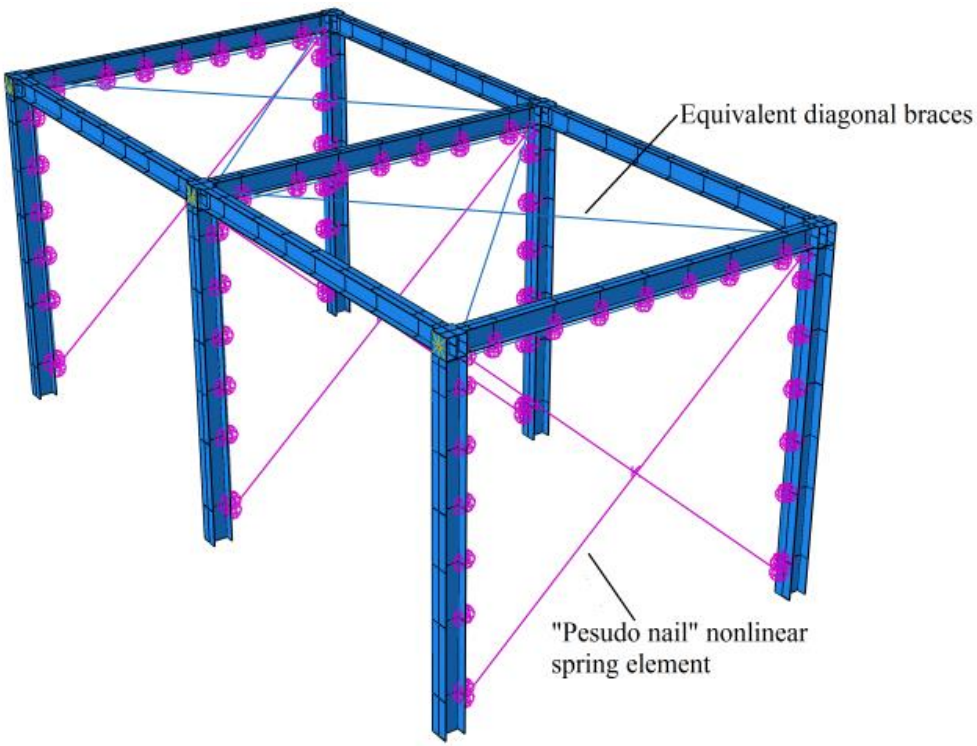
Hybrid constructions

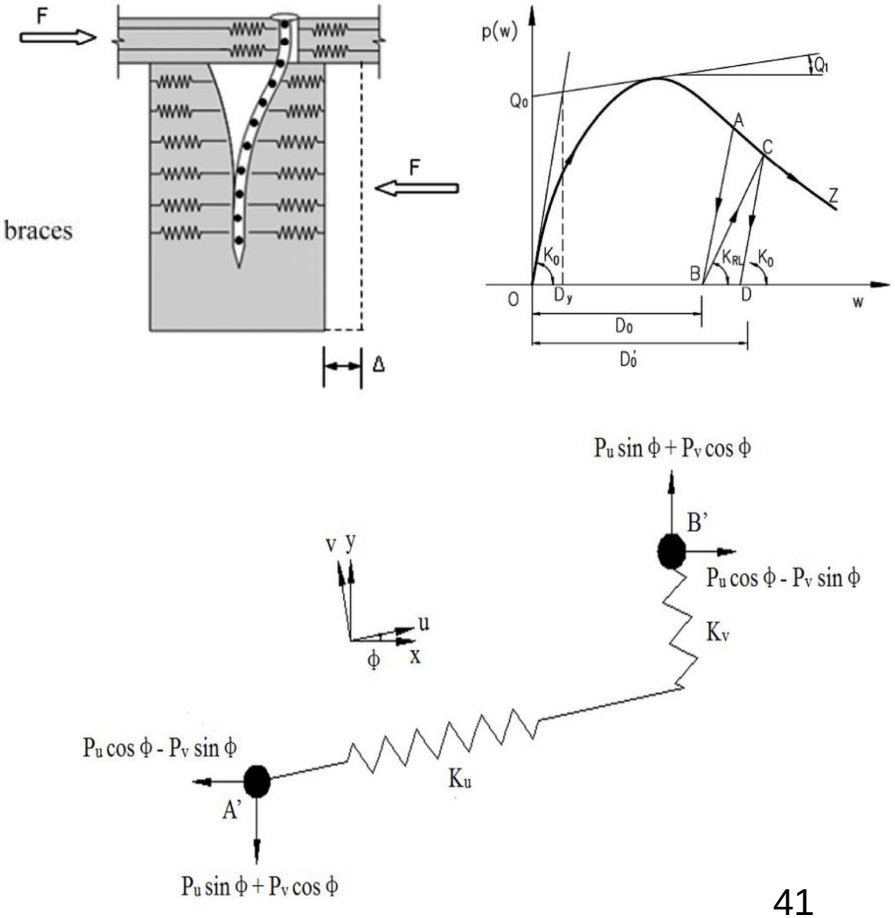
(5) Steel - timber hybrid structure -6

In-plane test for timber-steel hybrid diaphragm

Hybrid constructions

(5) Steel - timber hybrid structure -7





Numerical modeling

4 Prospect

- Issues on **natural resource saving, energy-efficient technique and low carbon emissions etc.** can not be ignored in the development of construction industry. There will be more opportunities for timber constructions in China.
- Because of large population and lack of land resource in China, **multi-storey timber and timber hybrid buildings** may be a reasonable alternative.

Thanks for your attention!

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