SHEARING BEHAVIOR OF SIP WALL SHELLED WITH BAMBOO SCRIMBER PANEL

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Introduction

About SIP: utilized as building members such as

- **Structural:** a sandwich-structural panel
- **Where to use:** wall, roof, and floor for concrete, steel and wood frame structures in Europe, America, and Japan.
- **Core board:** a thicker layer, usually non-structural and ridged, commonly made of plastic foam such as expanded polystyrene (EPS) as well as polyurethanes (PUR) foam
- **Face board:** two layers of rigid materials. metal, cement, gypsum, oriented strand board and so on, are suggested and applied as SIP shell.

Studies about using bamboo-based panels as SIP shell has not been reported

Introduction

- About bamboo scrimber:
- How product:

bamboo tube

bamboo scrimber

- Scrimber property: highly direction, higher compression and tension strength than wood
- Where to use: non-structural component, floor, veneer and son on.

Introduction

What done in this study:

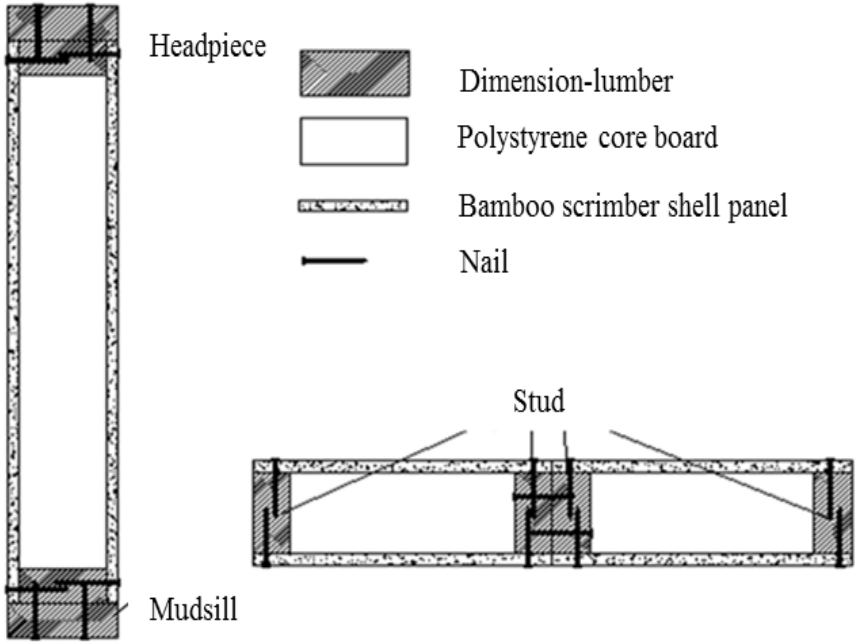
- To investigate performance of bamboo scrimber used in SIP system:

1 Bamboo scrimber was used as face board of SIP wall

2 SIP wall was tested under monotonic and cyclic loads

3 Failure phenomenon was observed and shearing parameters were calculated

Material and method



Section of SIP panel

- consitution: two piece of SIP panels:

two face panels, one core board, dimension-lumber

- connected by: adhesive, nails

Parametre of wall members

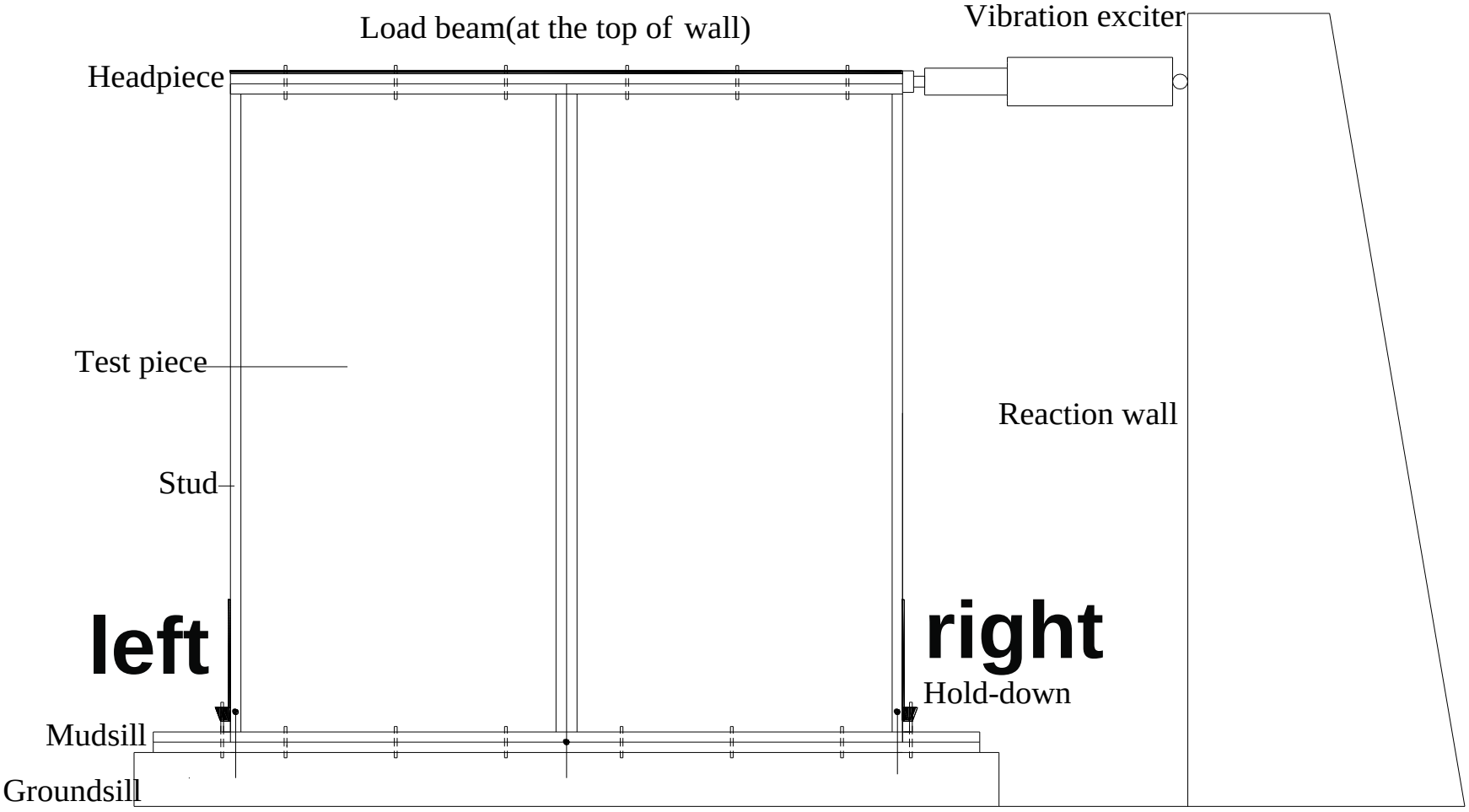
Part	Material	Size		Property parameter
Frame	Dimension-lumber (SPF)	Headpiece (upper)	2440*113*38	MOE: 9650 MPa
		Headpiece (lower)	2440*89*38	
		Stud	2364*89*38	
		Mudsill (upper)	3000*89*38	
		Mudsill (lower)	3000*113*38	
Core board	Polystyrene board	2364*1144*89		Density: 20kg/m^3, tensile strength: 140 KPa
Shell panel	Bamboo scrimber	2440*1220*6		MOE (longitudinal/transverse): 4545/1965MPa

Material and method

Parameters of connectors

Connector	Parameters	
Polyurethane adhesive	Spreading rate: 180g/m^2	
Nail	Length: 60mm, diameter: 4mm	Distance between neighbor nails: 150mm
Hold-down	450*41mm (length*width)	Ten holes at diameter 6.5 mm were drilled on side of hold-down. Tapping screws of diameter 6 mm were used to connect hold-down and out-side stud; 1 hole of diameter 21 mm was drilled on bottom of hold-down. Screw bolt was used to connect hold-down and mudsill
Screw bolt in headpiece	Diameter: 14mm	Distance between neighbor screw bolts: 400mm
Screw bolt in mudsill	Diameter: 20mm	Distance between neighbor screw bolts: 400mm

Material and method



- SIP wall installation and loading position

Material and method

Loading method

- **Only horizontal load**, no vertical load was applied during testing
- Monotonic and cyclic load testing were loaded
- Monotonic load testing was loaded according to standard **ISO 22452**. Loading program was controlled by force. Loading speed was set at 6 kN/min.
- Cyclic load testing was loaded according to standard **ISO 21581**. Loading program for cyclic load testing was controlled by displacement. The ultimate displacement obtained in monotonic load testing was used as control displacement. 1.25%, 2.50%, 5.00%, 7.5%, and 10.00% was repeated for one time. 20%, 40%, 60%, 80%, 100%, 120% was repeated for three times. Loading speed was set at 100 mm/min.

Material and method

Shearing behavior parameters

- Ultimate load
- Limiting displacement (Δu): displacement when load reached 80% ultimate load after failure, or the displacement when wall was seriously damaged.
- Elastic stiffness (K): slope of the secant line between base point and 40% ultimate load on rising step of displacement-load curve was defined as elastic stiffness
- Energy dissipation per unit length (E): absolute area enclosed by hysteresis loop in unit length

Rusult

Phenomenon of SIP wall damage

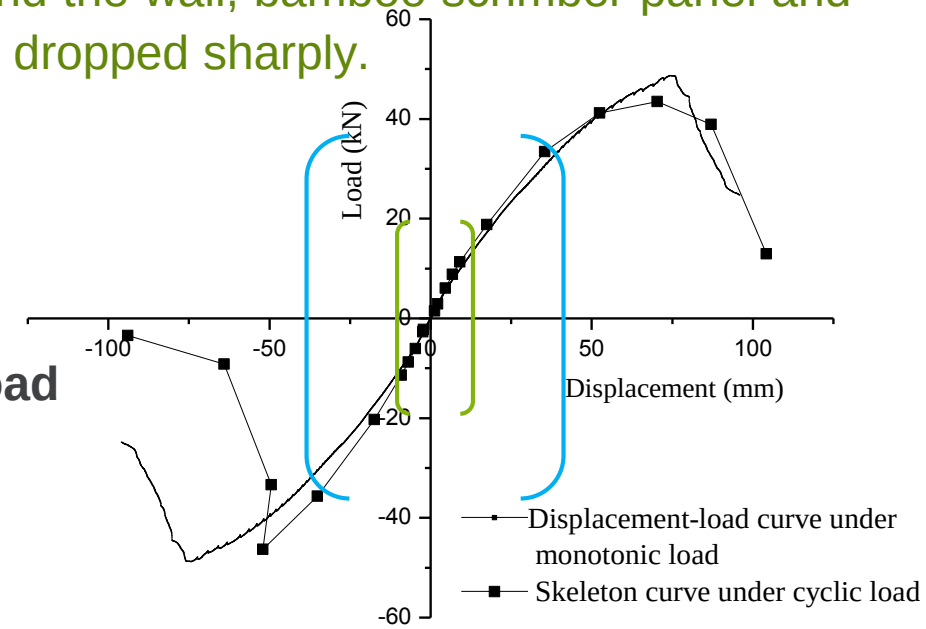
There were both three stages under both monotonic and cyclic loads:

Elastic stage: load-displacement curve shaped nearly linear.

Plastic stage: wall displacement increased with slight sound.

Failure stage: as increasing to maximum load, displacement increased rapidly, cracks turned up between hold-down and the wall, bamboo scrimber panel and the mudsill, bearing capacity of the wall dropped sharply.

Skeleton curve under cyclic load and displacement-load curve under monotonic load



Rusult

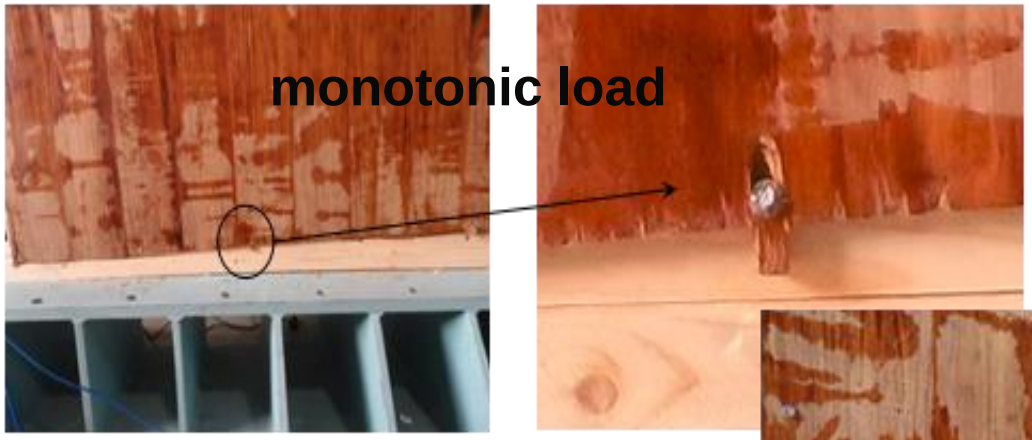
Phenomenon of SIP wall damage

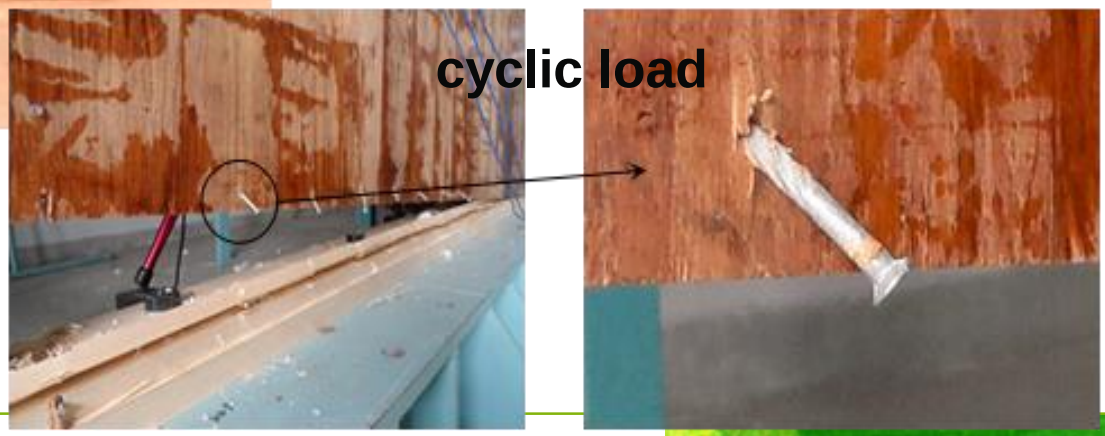
Cracks were mainly distributed at bottom of SIP wall.

Face panel outside mudsil was destroyed under both two loads.

Under monotonic load, nails looked undamaged

Under cyclic load, nails were bended, mudsill was destroyed seriously.





Damage at mudsill

Rusult

Phenomenon of SIP wall damage

Damage of hold-downs at left and right side stud was different.

The left one seemed no damage while the right was pulled out from side stud and bended under monotonic load.

Hold-downs at left and right were both pulled out and bended obviously under cyclic load.

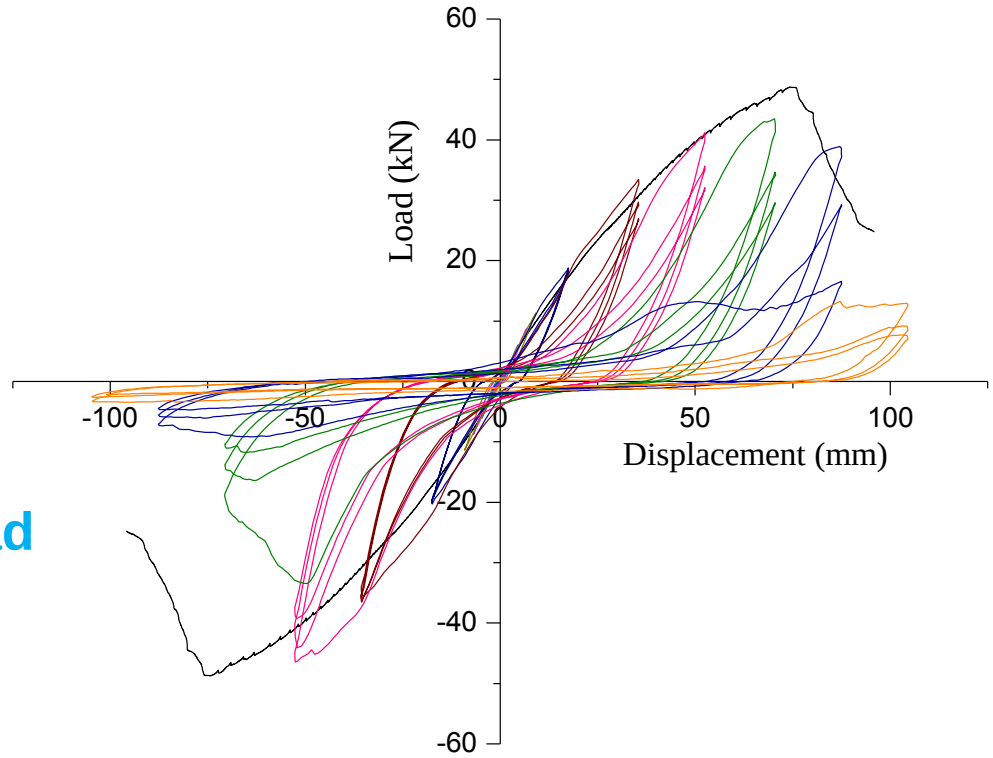







Result

- Among the three cycles, the latter two had a higher contact ratio and lower loads at same displacement compared with the first one. As target displacement increasing, hysteresis loop turned from S-shape to Z-shape at different target-displacement grades, wall slip effect appeared.



Displacement-load curve

Rusult

Shearing behavior

Load mode	Ultimate load F_{max}/kN			Limiting displacement Δu/mm			Elastic stiffness K/kN·m^{-1}			Energy dissipation E/J·m^{-1}
	T	C	AVG	T	C	AVG	T	C	AVG	
Mon	–	48.8	48.8	–	82.5	82.5	–	971.1	971.1	–
Cyc	46.3	43.5	44.9	59.5	67.9	63.7	1194.6	1086.8	1140.7	11556.6

Note: Mon-monotonic load; Cyc-cyclic load; T-tensile; C-compressive; AVG-average

Conclusion

- Failures were mainly occured at bottom of wall. Damage were more seriously under cyclic load than monotonic load.
- Displacement-load curve was almost linear at initial loading stage both under monotonic and cyclic loads. Area enclosed by hysteresis loop was small.
- Ultimate load, limiting displacement and elastic stiffness of the SIP wall shelled with 6 mm bamboo scrimber were 48.8 kN, 82.5 mm, 971.1 kN·m-1 under monotonic load, and 44.9 kN,, 63.7 mm, 1140.7 kN·m-1 under cyclic load. Energy dissipation under cyclic load was 11556.6 44.9 kN.

Thanks for your attention