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A Study on Displacement Estimation of Lath-Mortar under Earthquake

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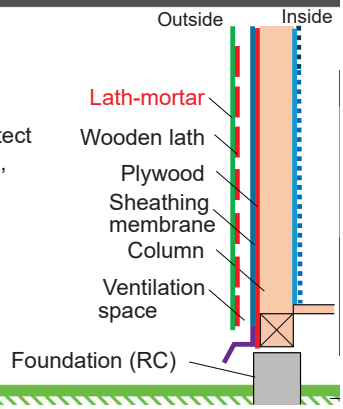
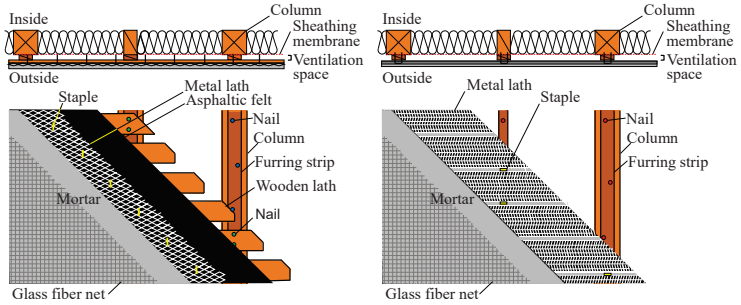
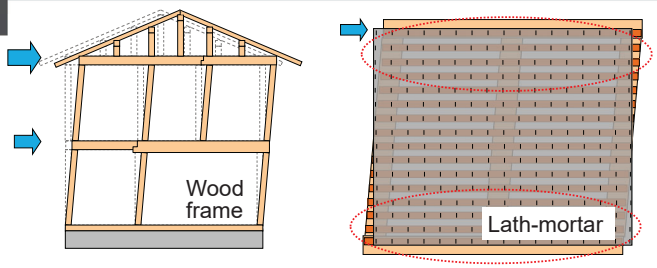
Introduction

Lath-mortar is constructed outside to protect the timber framework from rain, sunshine, wind, fire, etc.

Lath-mortar is also known to contribute seismic performance of relatively small timber buildings.







In case of an earthquake, a large relative displacement between the lath-mortar and the wood frame occurs.
Poor fastening may cause a fall-off of the lath-mortar, might be an expansion of fire after a large earthquake.

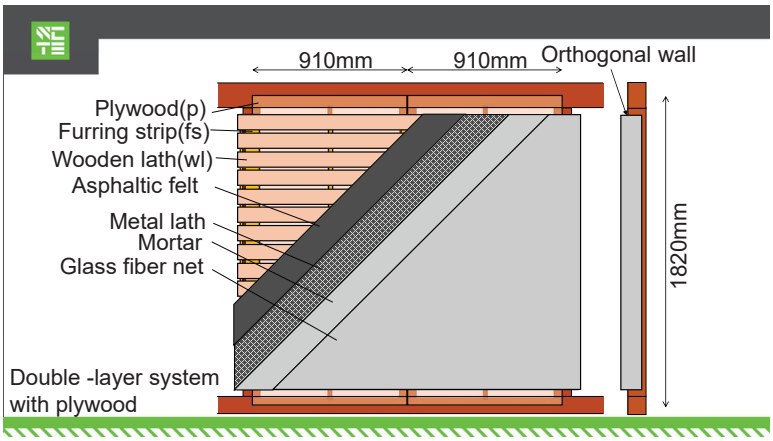
In this study,

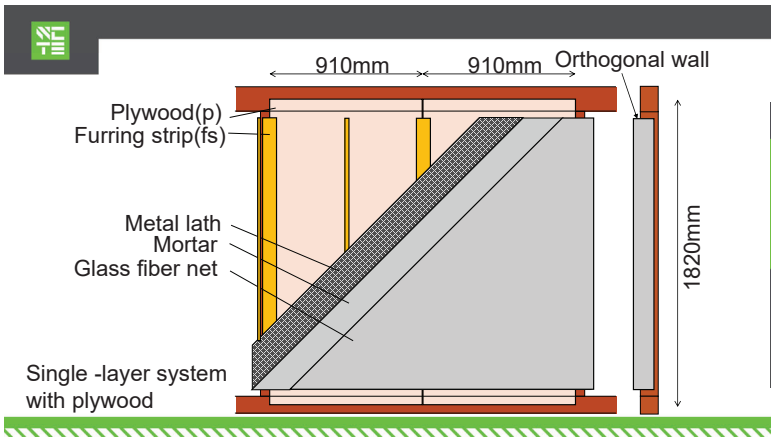
- Static shear loading tests of lath-mortar external wall specimens with plywood and orthogonal wall were conducted first.
- Considering the results of the loading tests, the FEM structural model of the external wall with lath-mortar was tried to build.

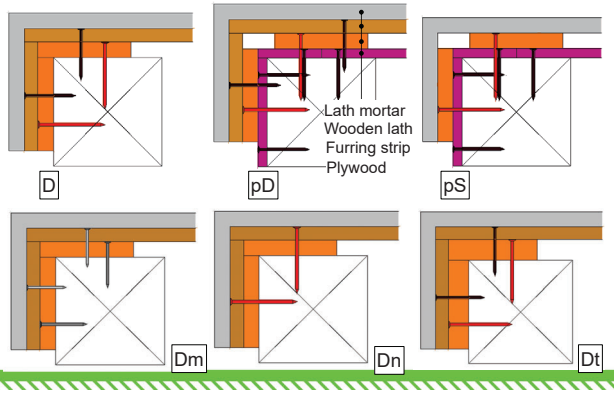
An accurate prediction of lath-mortar's behavior under earthquakes contributes to a resilient city.

Specimens of lath-mortar wall specimens

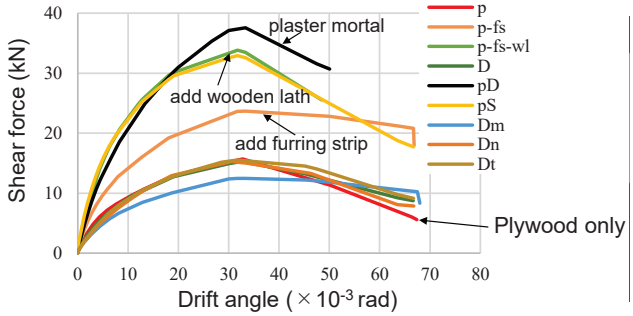
Specimen	Plywood	Furring strip		Wooden lath		Lath-mortar
		Thickness	Nail	Thickness	Nail	
p	○	15mm	N65	—	—	—
p-fs						
p-fs-wl				13mm	N50	
D	—					○
pD	○			—	—	
pS						
Dm	—		N45	13mm	N38	
Dn			—		N65	
Dt		21mm	N65		N50	







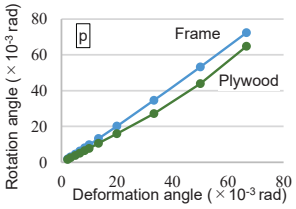
Test result of lath-mortar wall specimens



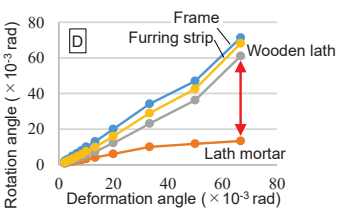
To understand the motion of each member of the specimen, a motion capture system was used.

Markers were attached to each member, and the X, Y, Z coordinates of the markers were recorded, and the rotation angle of each member was calculated.

Rotation angles of each member



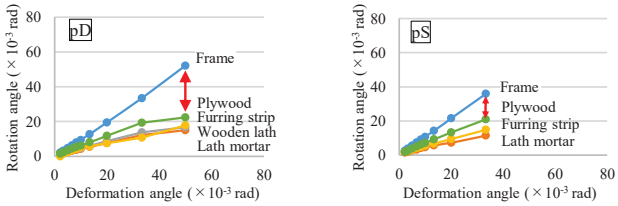
Plywood only



Double -layer system

In the Double-layer system specimen,
the lath-mortar's rotation angle was relatively small due to the orthogonal wall.
The staples fastening the lath-mortar to the wooden lath withdrew or broke.

Rotation angles of each member (cont.)



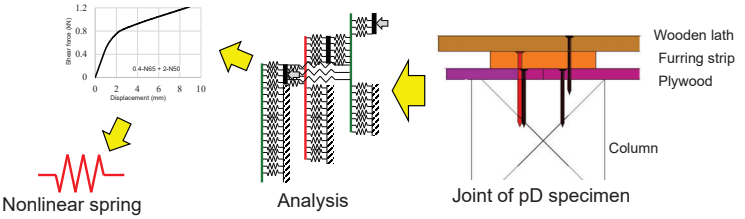
Double -layer system with plywood

Single -layer system with plywood

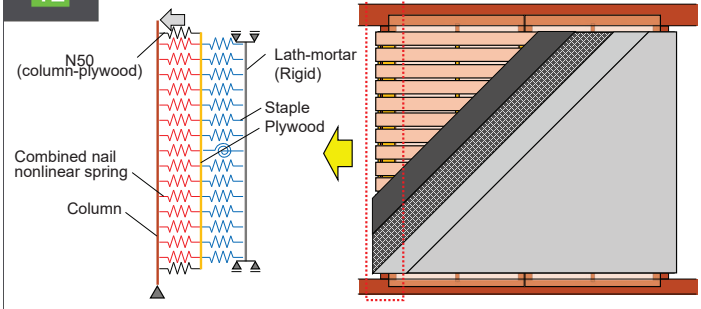
In the specimen with plywood, the lath-mortar's orthogonal wall constrained the rotation of plywood.
The nails fastening the plywood to the wood frame withdrew or broke.

FEM Modeling

To predict a shear force-drift angle relationship and failure mode of the lath-mortar, FEM is one of the helpful tools. However,
How can I model the complicated layered nail-fastened members ?
I conducted a detailed analysis of a joint. And the shear force-displacement relationship was set to a nonlinear spring.

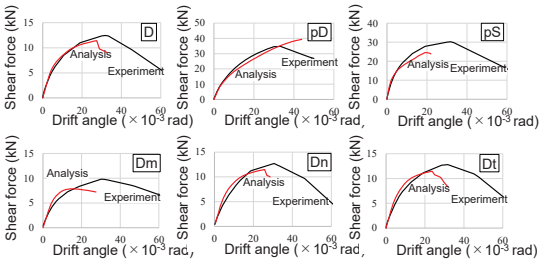


Nonlinear spring — Analysis — Joint of pD specimen



Assuming the lath-mortar as rigid and no rotation, one column of the lath-mortar specimen was modeled simply using the combined nail nonlinear spring and staple spring.

Analysis result



Initial shear stiffness : good
Maximum shear force : lower than the experimental value

Conclusions

In static shear loading tests, it was found that plywood between a timber framework and a lath-mortar increases the maximum shear force remarkably. And it was confirmed that the orthogonal wall constrained the rotation of the lath-mortar.

Using the shear force-displacement relationship derived from the analysis of a layered joint, a simple analysis model of the lath-mortar wall was able to be built.

The analysis showed close initial shear stiffness to the experimental value in most specimens, however, lower maximum shear forces were shown than the experimental values.

Acknowledgement

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科研費 KAKENHI

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