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Structural insulated panels (SIPs) – durability, seismic and fire performance

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Assessing SIPs in New Zealand

Agenda:

- Introduction
- Seismic performance
- Durability
- Fire performance
- Q&A

What are SIPs?

- Prefabricated panels used as walls, roofs and floors
- Made of two face layers and an insulating inner core
- Different face layer materials

Background to the research

- SIPs have been used overseas for many decades but have a relatively short history of use in New Zealand
- SIPs aren't currently considered in the NZBC
- Offer one potential solution to New Zealand's need for fast, affordable construction

What does the research involve?

- Three workstreams each looking at SIPs from a different angle
- Mixture of experimental work and review of research that's already been done overseas and in New Zealand
- Open to engage with industry and understand what is/isn't an issue from those working with SIPs

Project schedule and funding

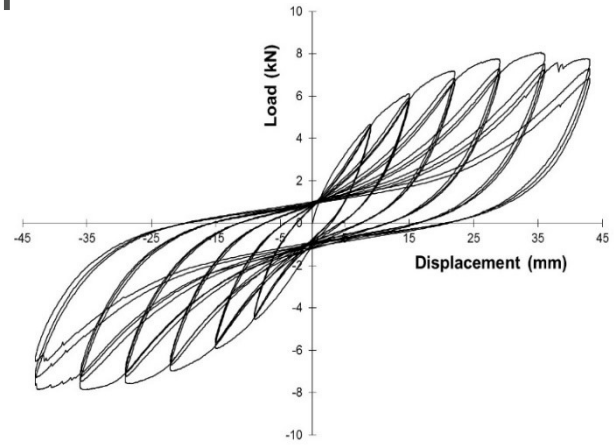
- March 2021: results from seismic performance work available
- December 2021: end of project
- Funded by the Building Research Levy and EQC

Seismic performance of SIPs

Seismic performance of SIPs

Topics covered:

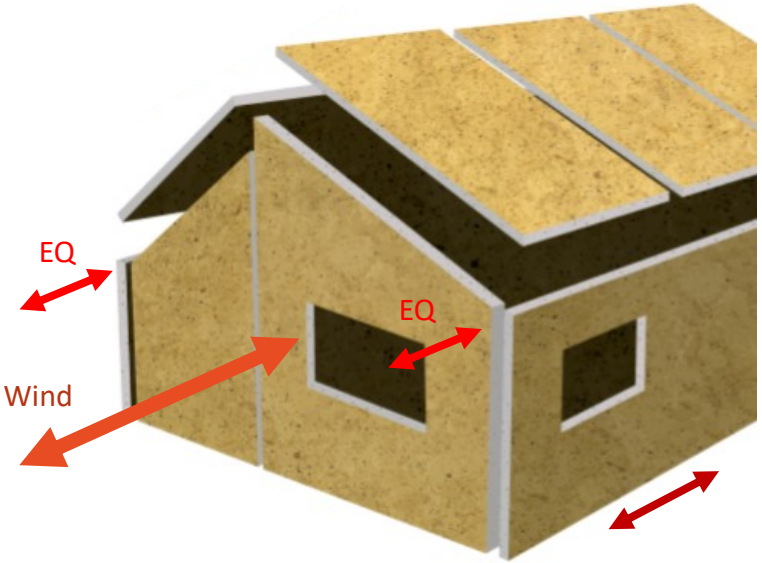
- Wall bracing in buildings
- P21 testing
  - Specimens
  - Test method
- SIPs bracing
- Other bracing systems
- Results so far
- What next?



Seismic performance of SIPs

Wall bracing in buildings

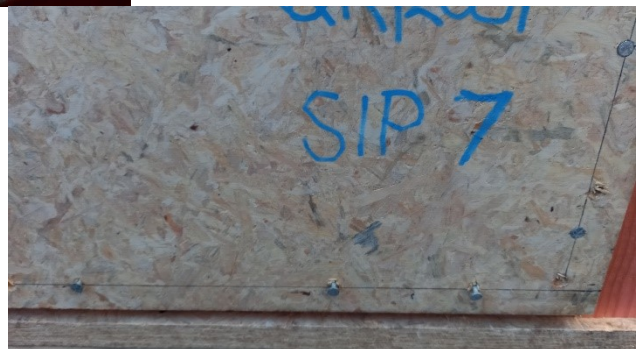
- Resists lateral loads from wind and earthquakes
- Roofs, walls and floors drive loads
- Bracing walls
  - Resist loads in the plane of wall
  - Carry load to foundations
- Bracing units (NZS 3604:2011)
  - Indicative measure of capacity
  - P21 test



Seismic performance of SIPs

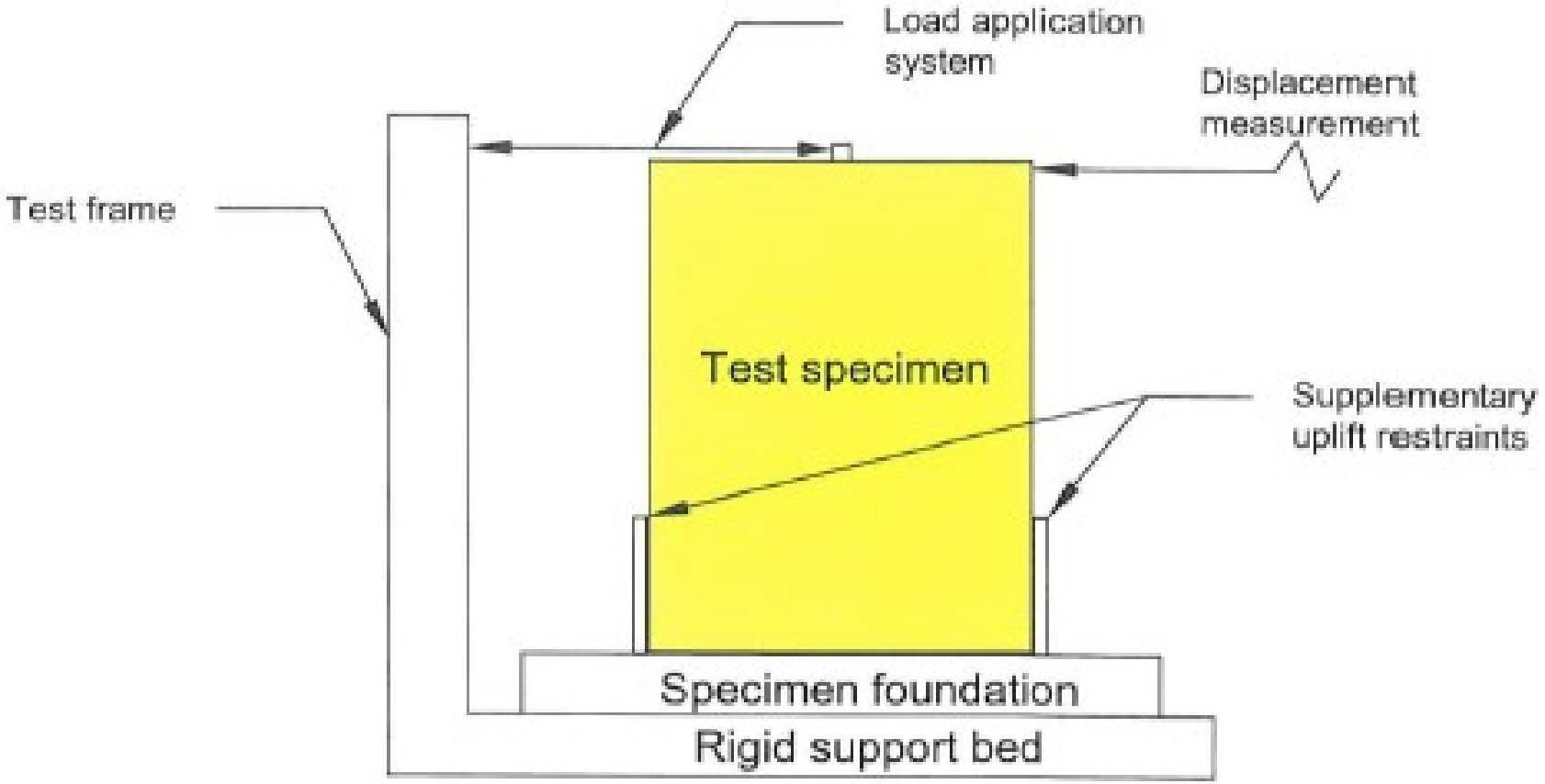
P21 testing – specimens

- 1.2 m x 2.4 m
- 90 mm x 45 mm in panel rebates
- 2.8 mm x 50 mm nails, 150 mm o.c.
- P21 end restraints
  - No other vertical load
- 3604 bottom plate fixings
- Hold-downs
  - Next round of testing
- Provide information on generic or non-proprietary system



Seismic performance of SIPs

P21 testing method



Seismic performance of SIPs

P21 testing method

- Displacement controlled
- Fully reversed cyclic loading
  - Positive and negative
- 9, 15, 22, 29, 36, 43 mm (3x each)
  - Top plate movement
- Applied load (kN) and top plate displacement (mm) measured
  - Hysteresis loops
  - Data used for analysis

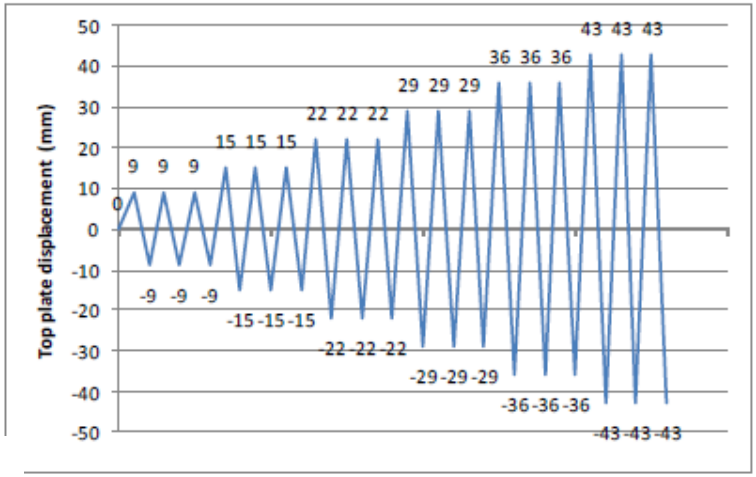
Top plate displacement

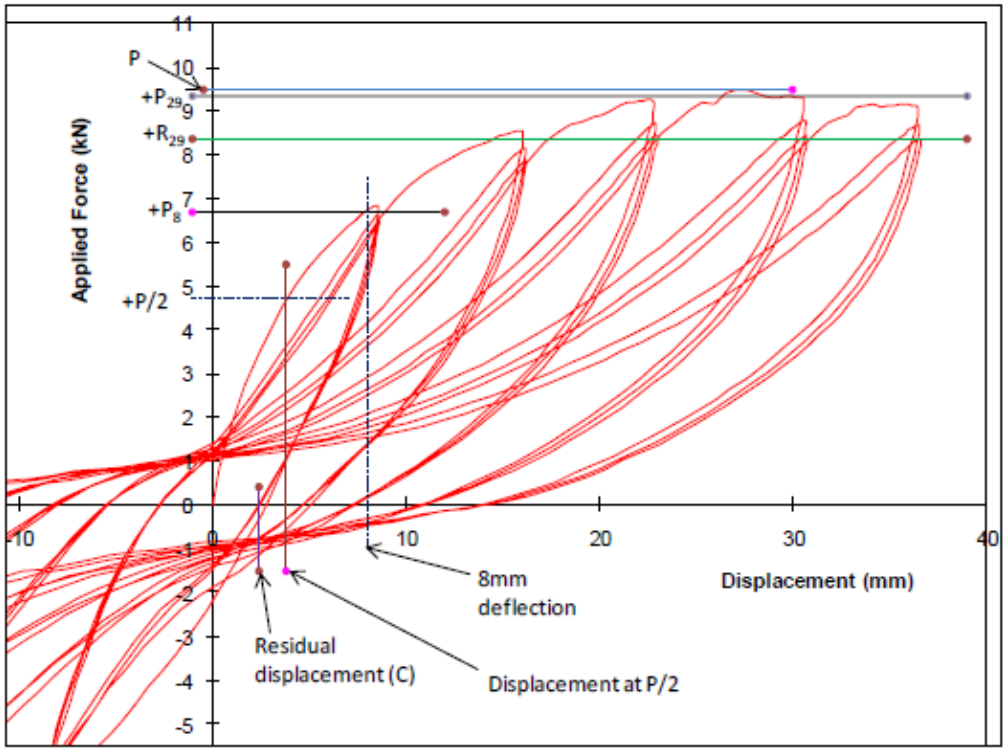
Fixed bottom plate

Seismic performance of SIPs

P21 testing method

- Load-displacement data for analysis
- Result: bracing ratings!



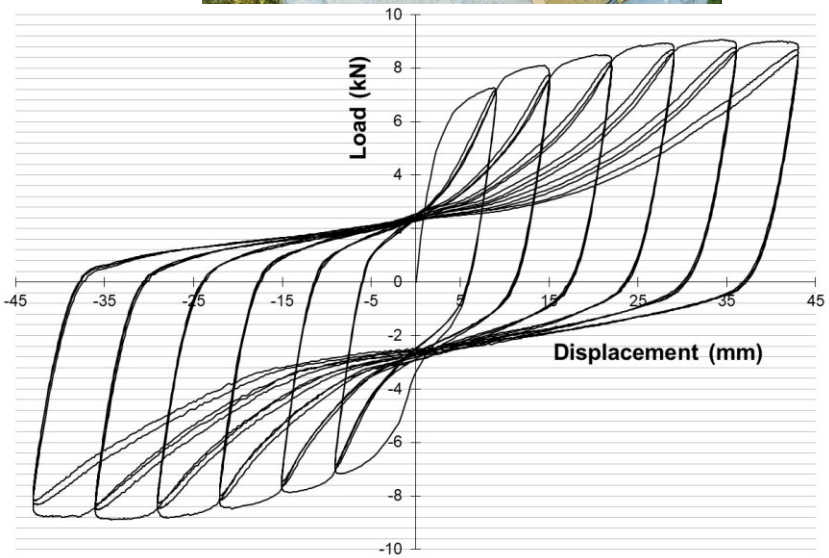


- Wind
- Earthquake
- For use with NZS 3604
- Can be converted from BU to kN for SED
  - With caution!

Seismic performance of SIPs

SIPs bracing

- What are we looking at?
- Strength
- Stiffness
- Shape of loops
- Energy dissipation/ductility
- Failure and damage
- Bracing units/ratings



Seismic performance of SIPs

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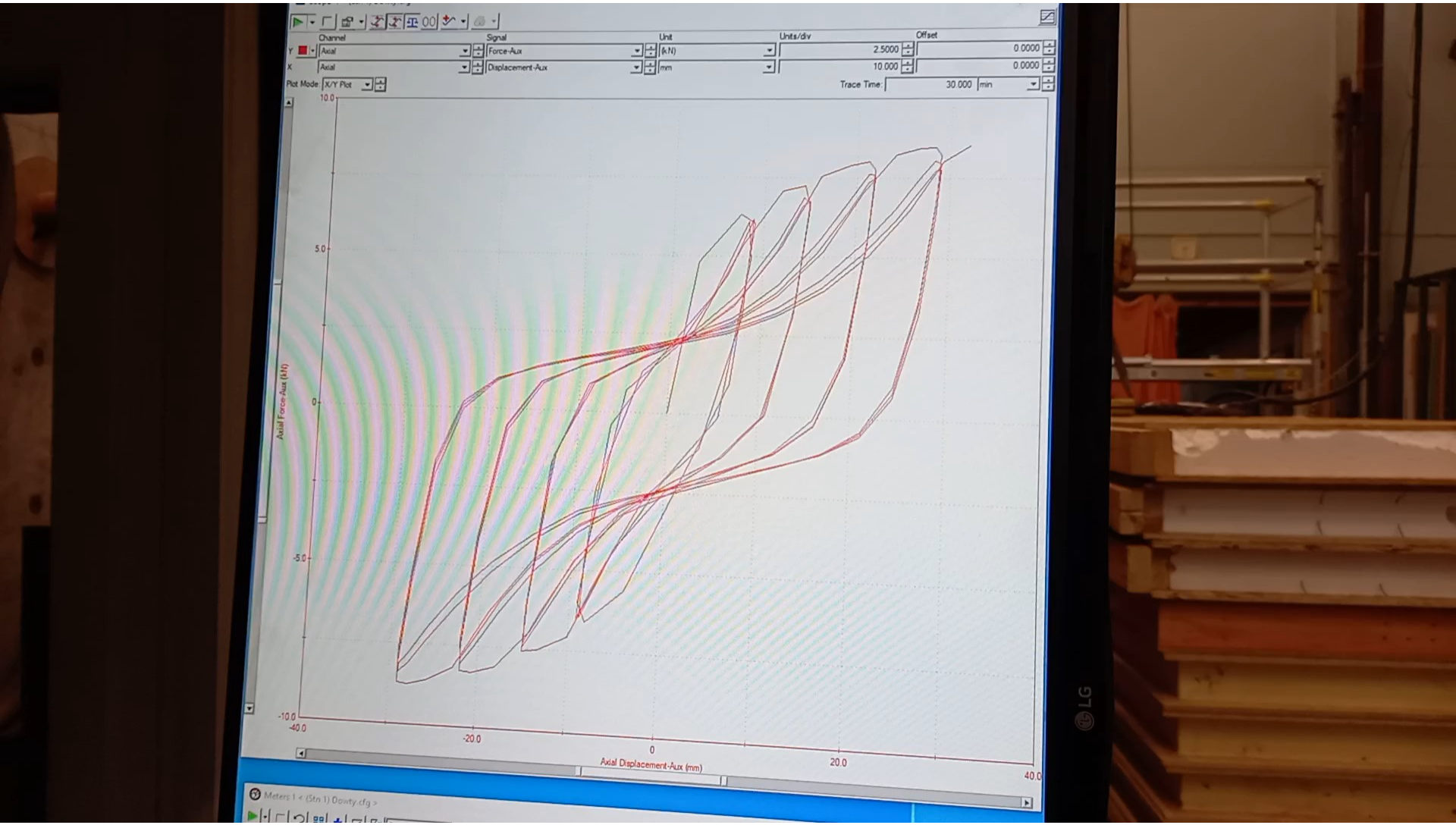
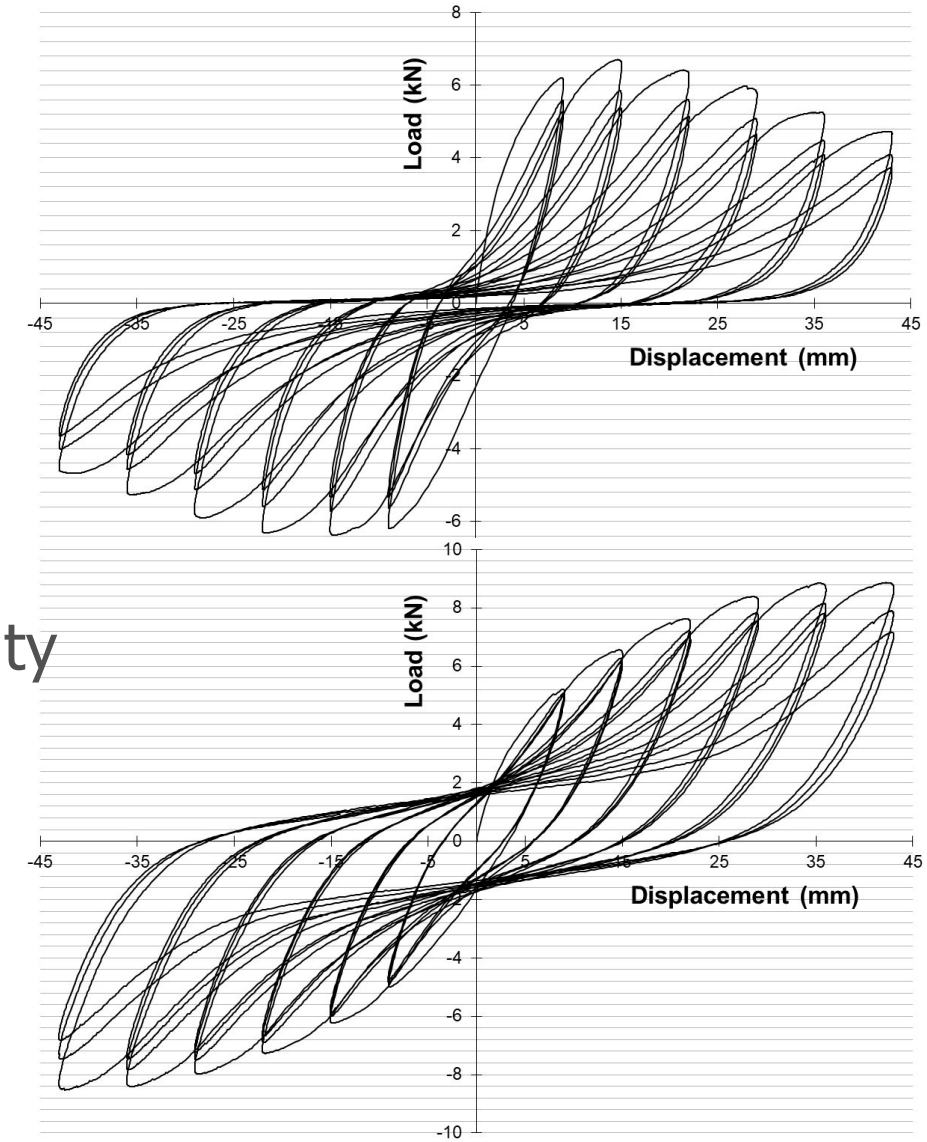


Seismic performance of SIPs

Other bracing systems

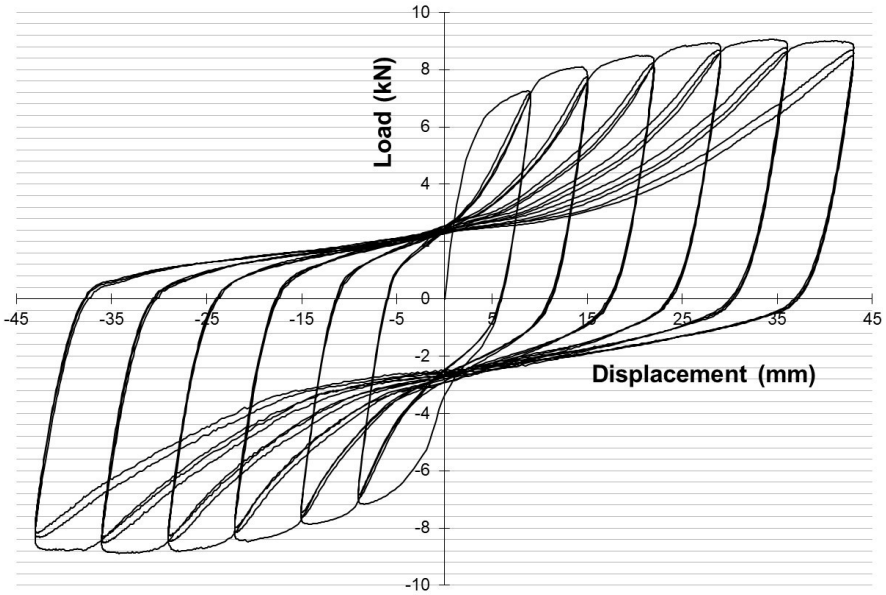
- Plasterboard
- Plywood
- Fibre-cement
- Combinations
- Comparisons with SIPs
  - Deformation compatibility
  - Causes of damage
  - Overall performance



Seismic performance of SIPs

Results and comparisons

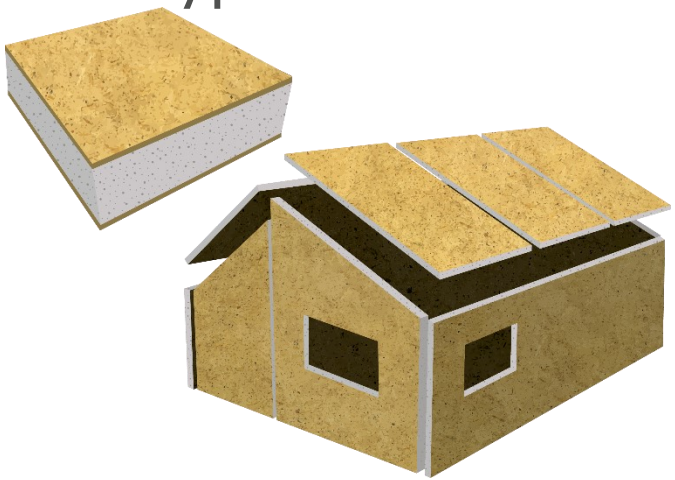
- Strength
- Stiffness
- Energy dissipation/ductility
  - SIPs – bending/yielding of nails
- Damage
  - SIPs – fasteners only, no significant damage to skin materials
  - Very little crushing around nails



Seismic performance of SIPs

Where to from here?

- Testing with hold-downs
- Combination testing of SIPs and other commonly used bracing systems
  - Interactions
  - Deformation compatibility
- Different types of SIPs?



Durability

Topics covered:

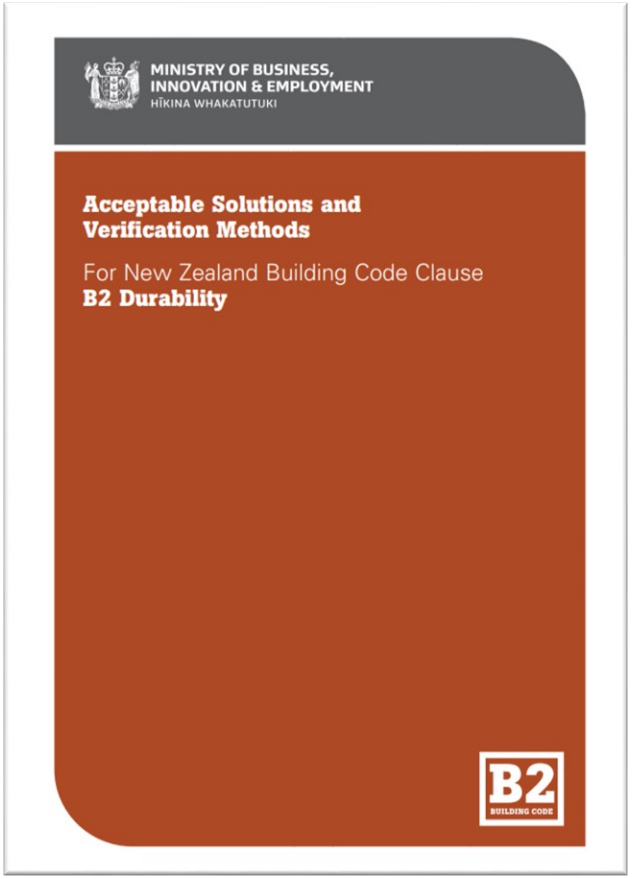
- Durability requirements
- Assessing SIPs
  - Accelerated ageing
  - Natural weathering
  - Mechanical testing
- Results and next steps

New Zealand Building Code requirements

- Durability is defined as ‘resistance to wear and decay’
- Clause B2 *Durability* specifies minimum durability periods for building elements
- Loadbearing SIPs must demonstrate a durability of 50 years

Demonstrating compliance

- SIPs not included in Acceptable Solution or Verification Method
- Compliance must be demonstrated via an alternative solution



Laboratory testing

- Draft method developed
- Based on established tests used overseas
- Research is refining the methodology so that it is applicable to SIPs in New Zealand climate

Accelerated ageing

- Time and equipment size need to be considered
- Subjects samples to cycles of realistic in-service temperature and humidity conditions

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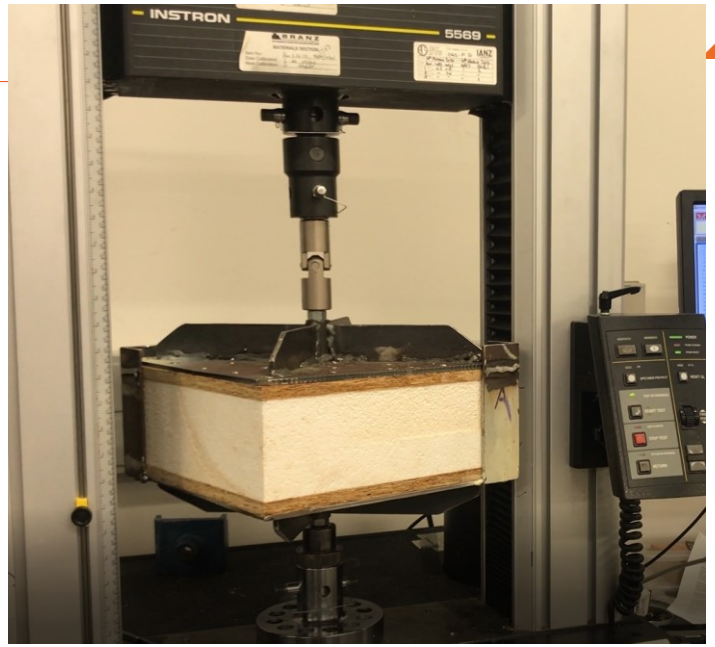
Outdoor exposure

- Expose samples outdoors to natural longer-term weathering
- Compare with samples that have been subjected to accelerated ageing

Outdoor exposure – enclosed samples

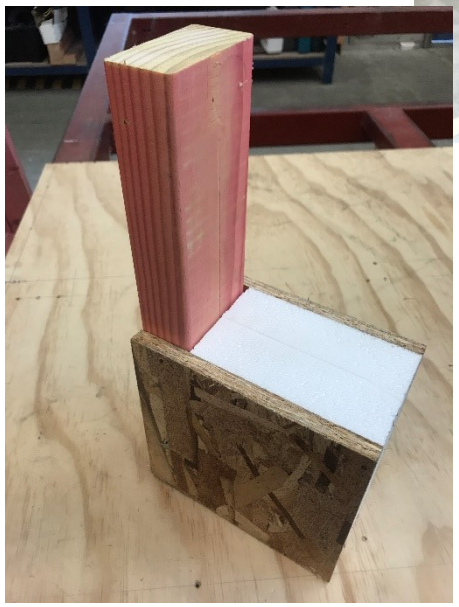
Mechanical testing

- Measure change in strength between control and aged samples
- Realistic in-service loads vs indicative testing
- Tensile
- Shear
- Flexural



Connection tests

- Considering effect of ageing on seismic performance
- Seismic performance determined by connections between plate and skins



Results and next steps

- Method for assessing SIPs in a generic way
- Better understanding of long-term performance of SIPs
- Ageing testing continues
- Refine and finalise test methodology
- Final report due by December 2021

Fire performance

Topics covered:

- Workstream overview
- Main fire safety considerations
  - SIP components
  - SIP system
  - Regulatory requirements
- Next steps

Workstream overview

- SIPs construction can be significantly different to traditional methods
- Reviewing international and New Zealand literature
- Identify any gaps where further work may be needed

Fire performance – SIP components

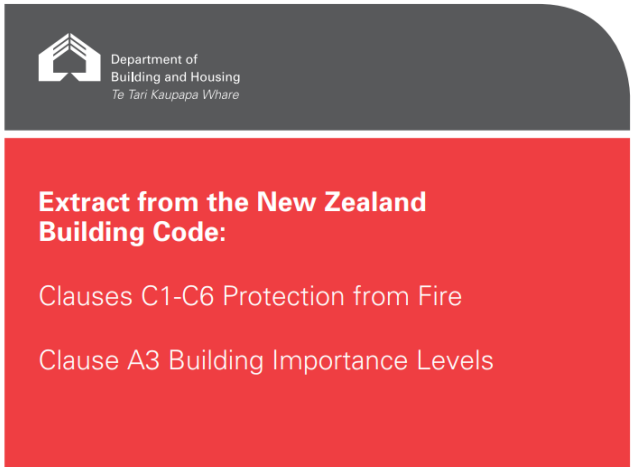
- SIPs can be comprised of many different skin and core materials:
    - Timber
    - Metal
    - Cementitious
    - Polymer foams
    - Bio-based materials

Fire performance – SIP building system

- Need to consider the building as a whole including:
    - Cavities
    - Linings
    - Claddings
    - Penetrations
    - Joints
    - Fixings
- Lessons can be learned from overseas

Regulatory requirements

- Reviewing international and New Zealand regulatory requirements that SIPs need to comply with
- SIPs are considered within US building codes (IBC/IRC)
- NZBC fire performance requirements



Next steps

- Review is under way
- Final report due by December 2021