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

Anna Walsh & David Carradine
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
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
Seismic performance of SIPs

- Video of SIP testing
  - Overall view and some bottom (42 sec)
  - 20201019_152452 - bottom plate action (34 sec)
  - 152715 - hyst and panels
Seismic performance of SIPs
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
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