Large-Scale Experimental Investigation of Modular Structural Concrete Insulated Panels

By: Usha Pant

Mentor: Dr Mustafa Mashal

Idaho State University

Date: 3/17/2022

Problem statement

Even though the use of precast structural concrete insulated panels in construction can offer structurally sound buildings, structural engineers rarely consider it as an alternative to wood or masonry methods due to a lack of understanding of the material and construction technique

Introduction

Structural Concrete Insulated Panels (SCIPs)

- It is a version of Structural insulated panels (SIPs)
- It uses Reinforced concrete instead of plywood to provide the two load-bearing faces.

MetRock SCIP

- It is a modular form of SCIP.

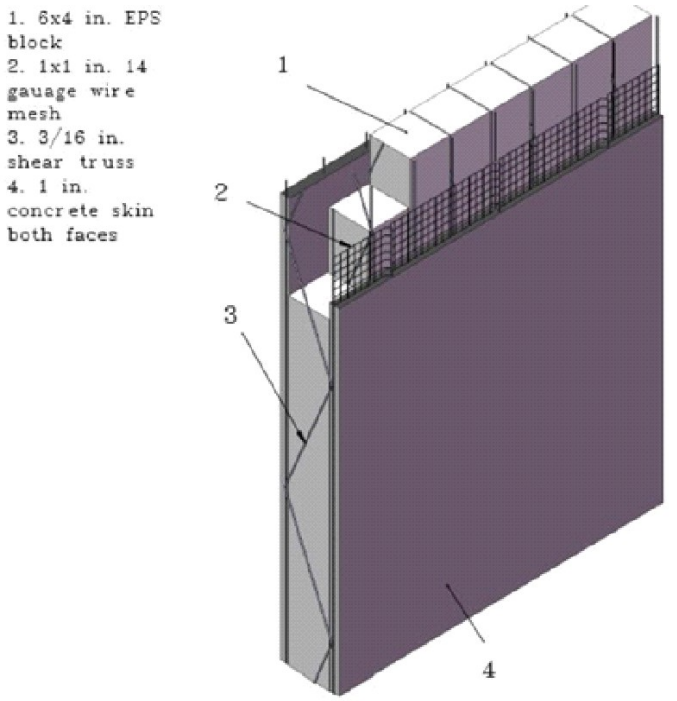

Figure 1. Details for a typical MetRock SCIP

(MetRockSCIP, 2019)

Introduction

Advantages of SCIPs

- **Thermal Insulation** :Increase in thermal resistance of built structures
- **Time efficient:** Increase in efficiency of construction by reducing the construction time
- **Energy Efficient:** Significant reduction in energy consumption for heating and cooling
- **Environment friendly:** Reduction in the environmental effect of a construction project on the construction site

Introduction

Modular SCIPs

- They are built away from the construction site and then transported for installation.
- They are fabricated and assembled using a portable hydraulic jig press and pneumatic hog rig tie
- Appropriate connection details for the wall-foundation and wall-slab are identified for the onsite assembly.

Large scale experimental program on MetRock SCIPs

Material characterization : SCC

- Self Consolidating Concrete was designed using an ACI absolute volumetric method

Table 2. Mix design used for precast SCIP panel

Material	Volume (ft^3)	Weight (lb)
Cement	0.165	32.4
Fly Ash	0.056	8.14
Fine aggregates (FA)	0.452	76.6
Coarse aggregates (CA)	0.248	36
Water	0.259	15.8
Total	1.18	168.94

Large experimental program on MetRock SCIPs

- The experimental investigation was conducted in Idaho state university structural lab.
- The two SCIP were developed, manufactured and evaluated according to ASTM E72 standards

Figure 2. Pouring the bottom layer

Large experimental program on MetRock SCIPs

Figure 3. Pouring the top layer

Figure 4. Final smooth layer

Large experimental program on MetRock SCIPs

Figure 5. Finishing the top layer

Figure 6. Covering the panel with wet burlap

Figure 7. Six cylinders for compression test

Large experimental program on MetRock SCIPs

Test setup

Each panels were simply supported in between two rollers and was loaded using one-point load at 12.5” and 13” distance on each panel respectively.

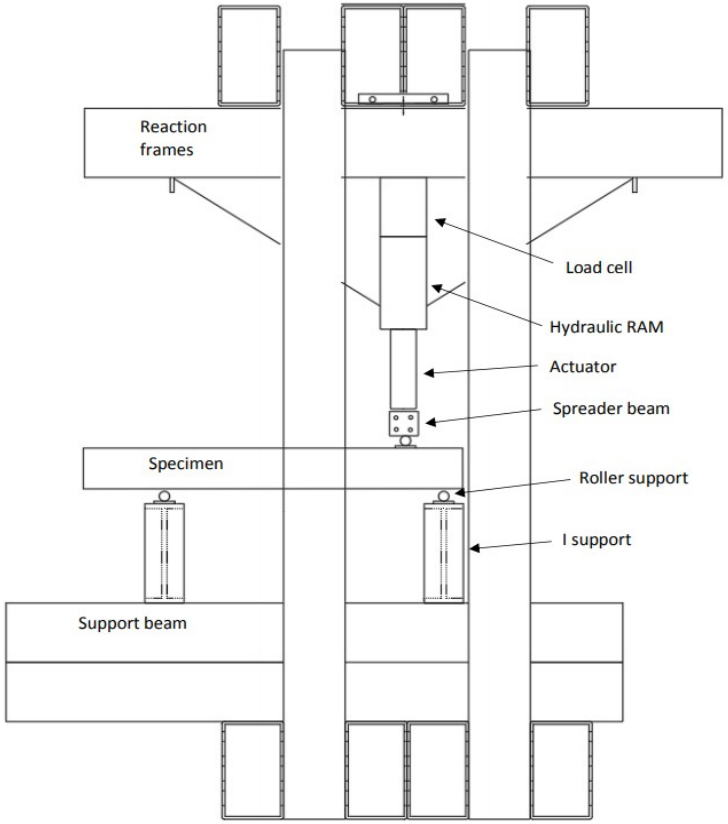

Figure 8. Schematic of shear failure test

Large experimental program on MetRock SCIPs

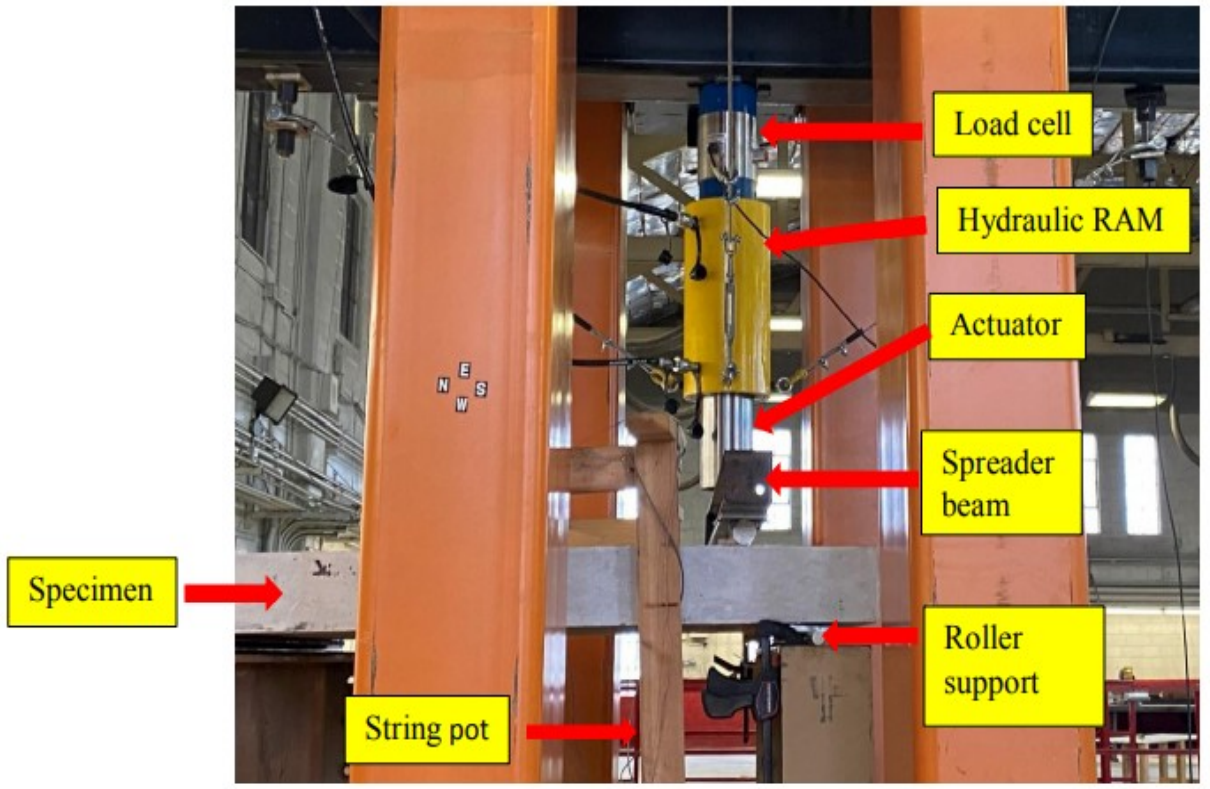

Figure 9. Test setup used to conduct the shear test of slab specimen (East side)

Large experimental program on MetRock SCIPs

Figure 10. String pots attached on the specimen

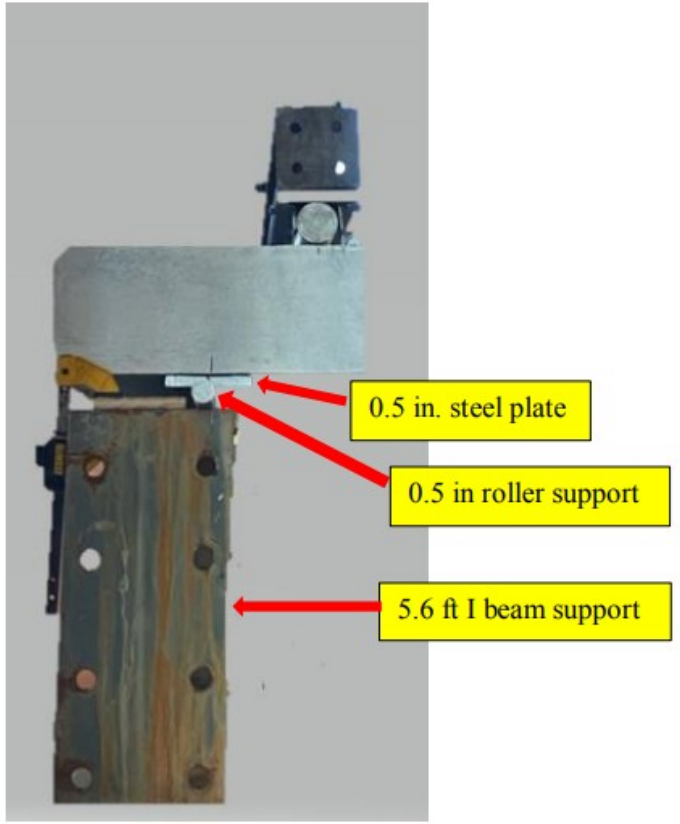

Figure 11. End support details for shear test

Large experimental program on MetRock SCIPs

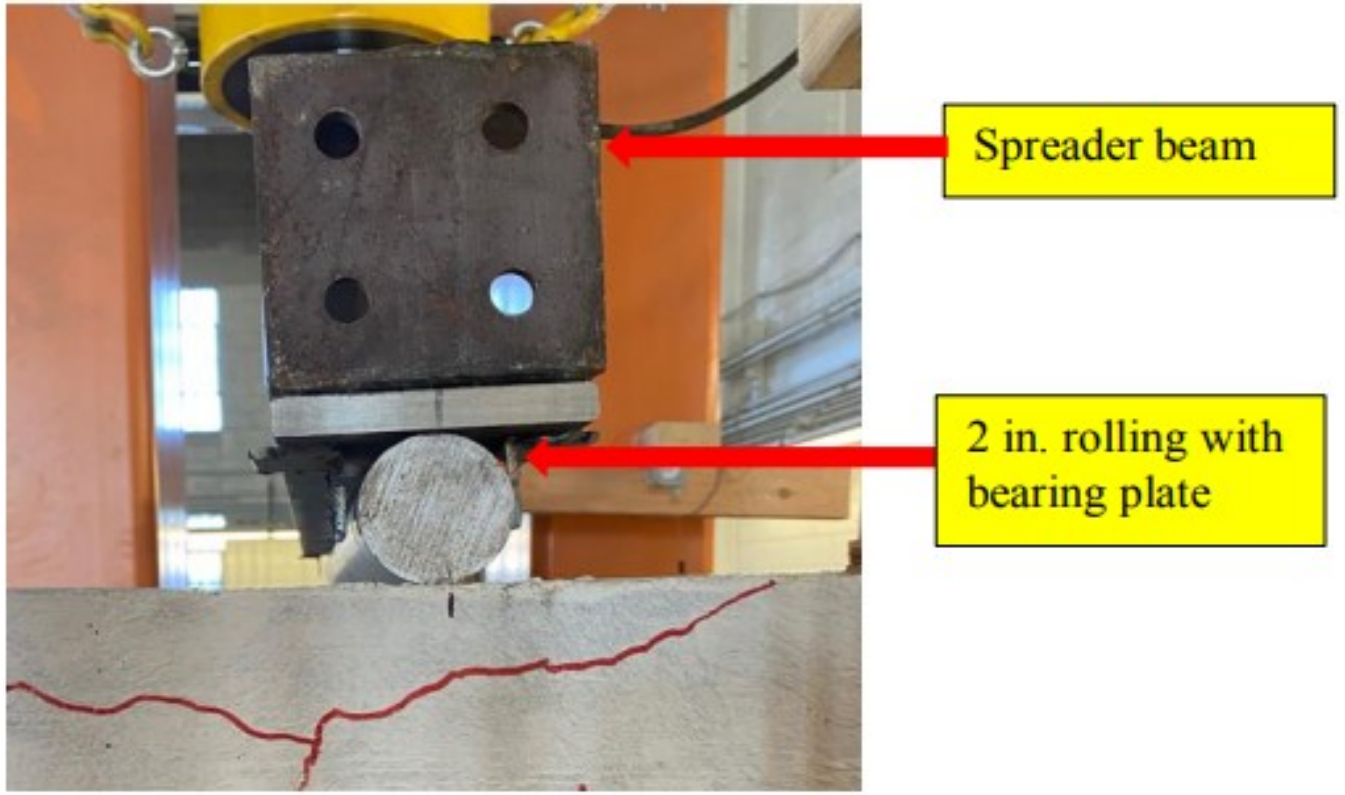

Figure 12. Point loading detail for shear test of slab specimen

Experimental observations

Figure 13. Shear cracks on before and after test on east edge panel 1

Experimental observations

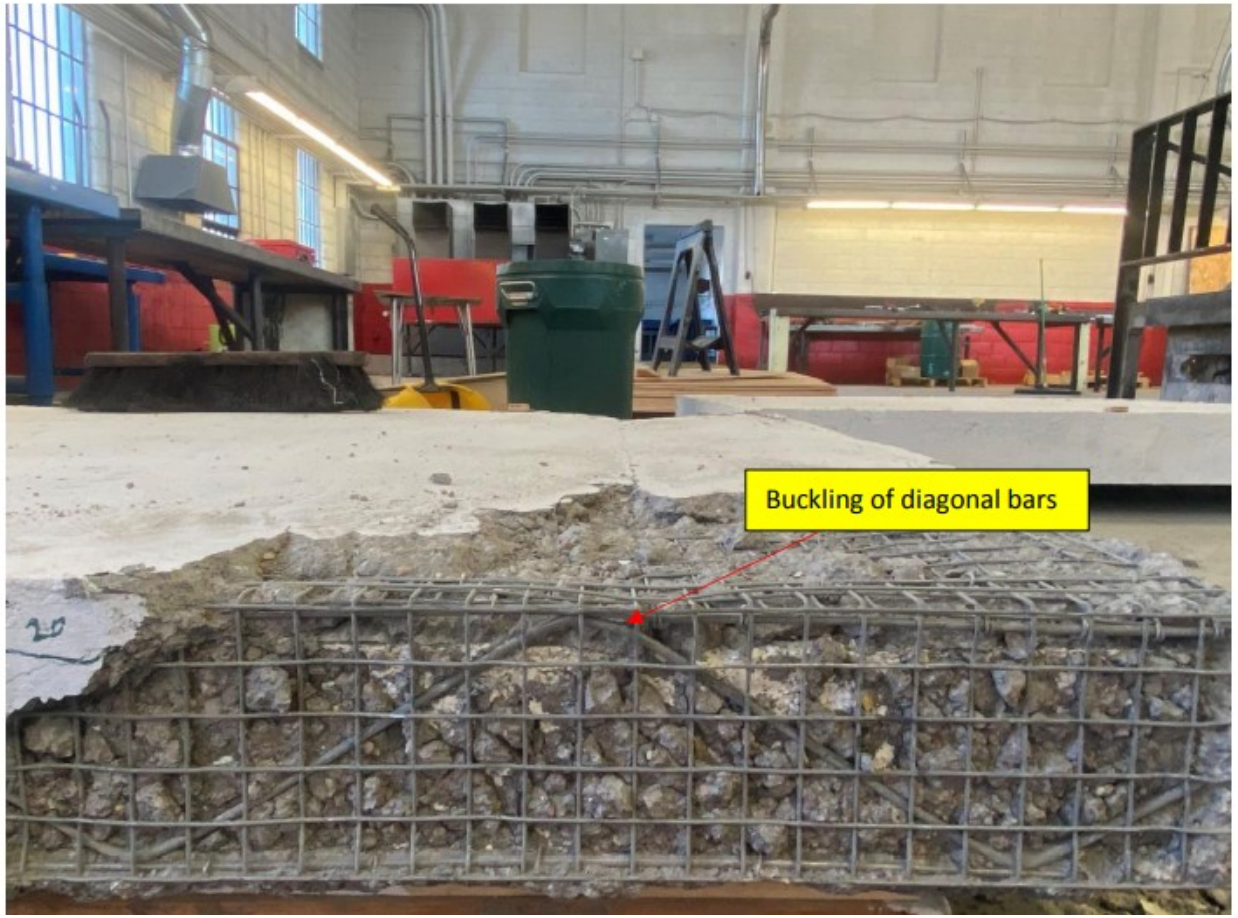

Figure 14. Buckling of panel **1**

Experimental Observations

Figure 15. Shear cracks on before and after test on east edge of panel 2

Experimental observations

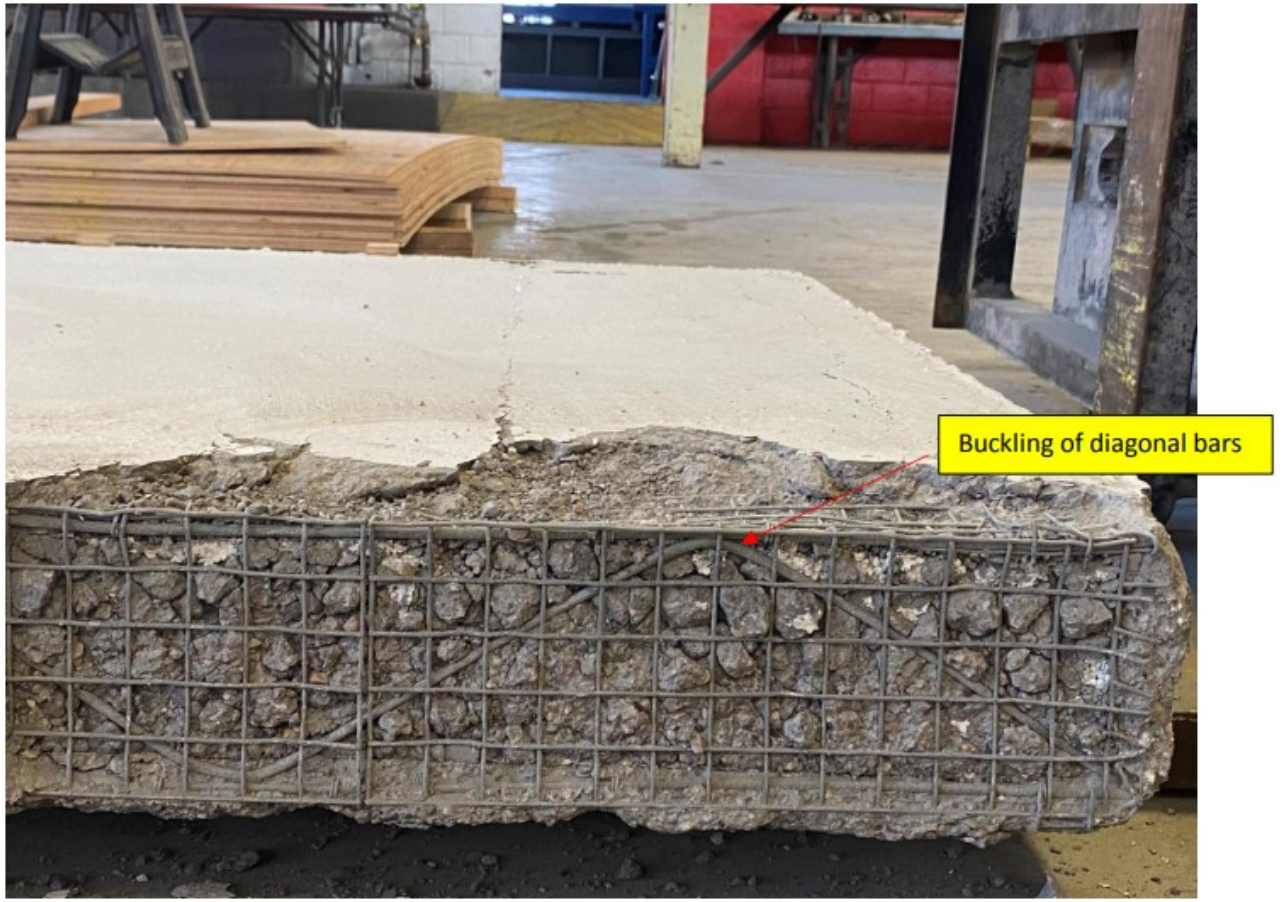

Figure 16. Buckling of panel 2

Experimental observations

Panel 1

The yield capacity and ultimate load capacity are 3395 lb and 20000 lb respectively for panel 1.

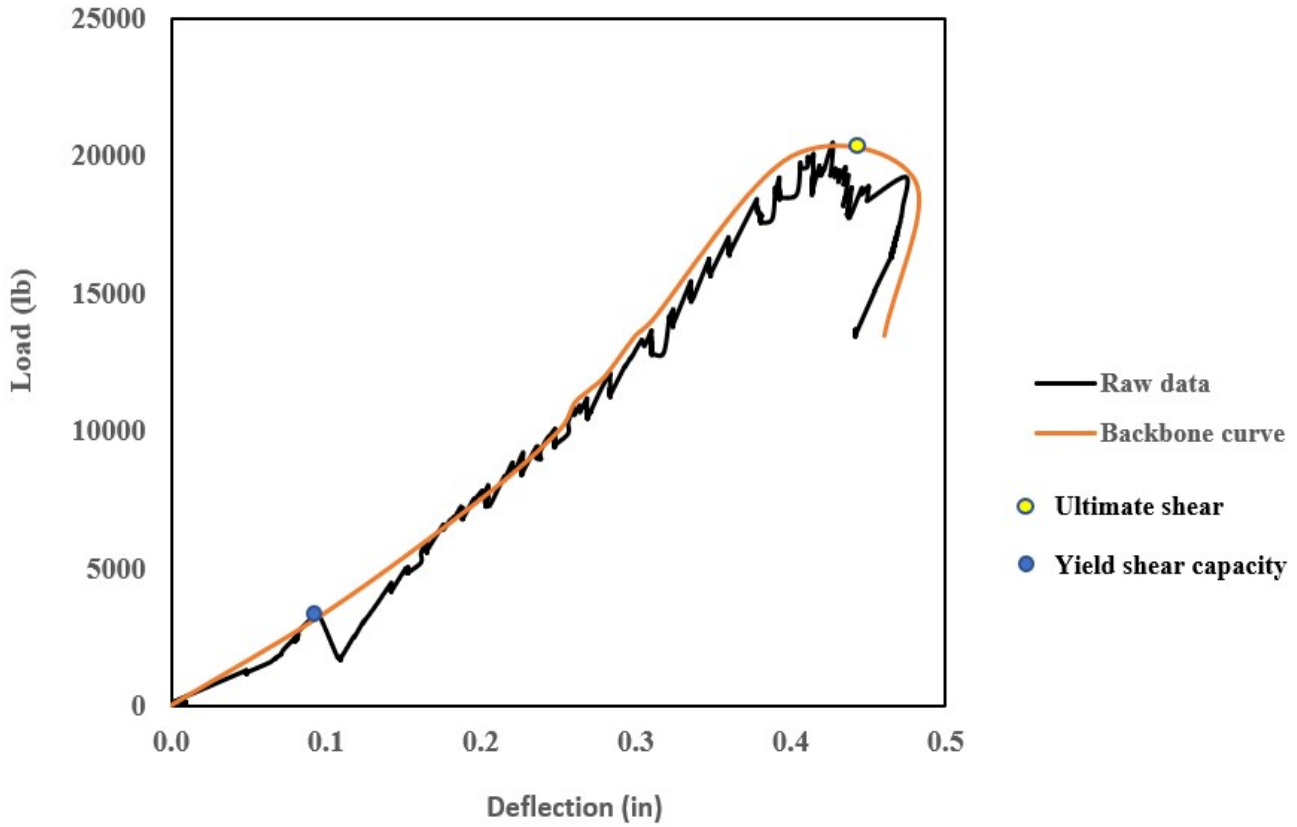

Figure 17. Raw shear test data for panel 1

Experimental observations

Panel 2

The yield capacity and ultimate load capacity are 4758 lb and 16800 lb respectively for panel 2.

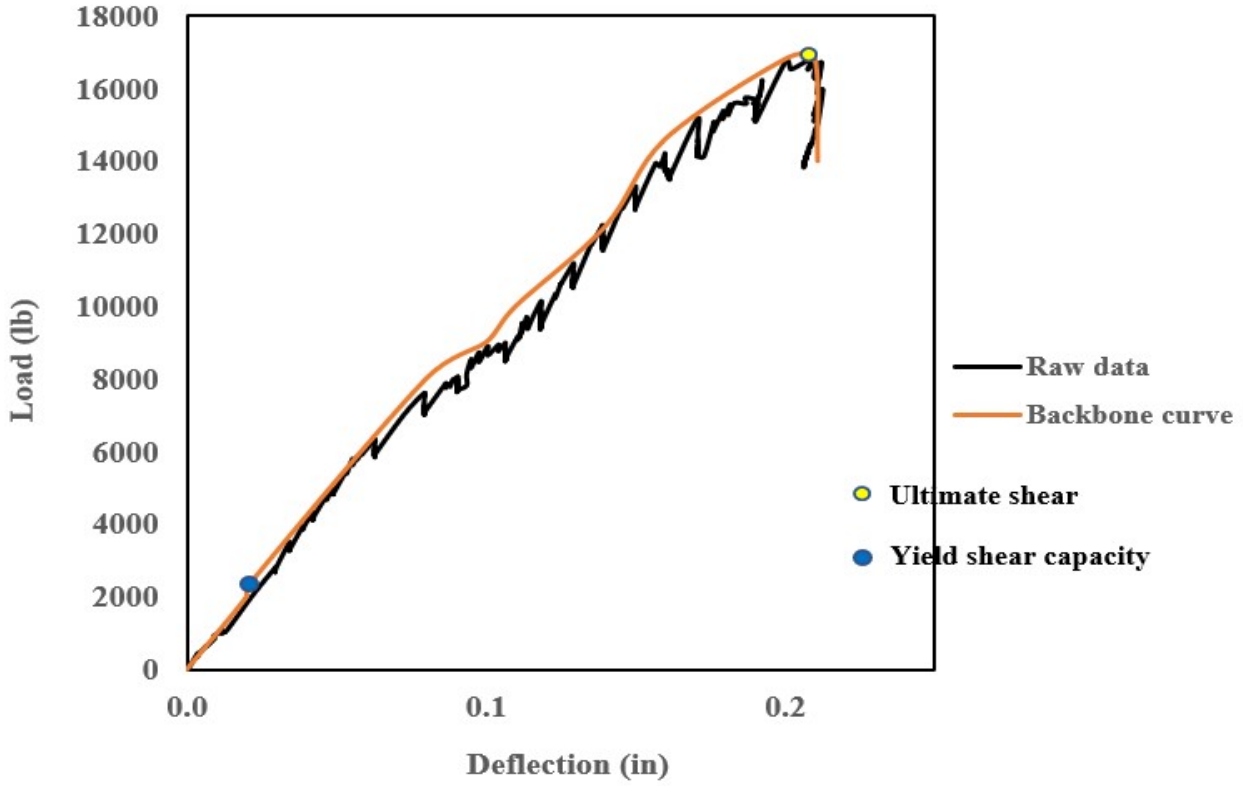

Figure 18. Raw shear test data for panel 2

Experimental Observations

Simplified analysis

The shear capacities are calculated according to ACI 318 (ACI, 2019).

The shear strength at a section of a member (V_i) is the sum of concrete strength "V_c" and reinforcement strength "V_s".

Conclusions

- The average effective moment capacity for the MR panels decreases till until a certain length (in this case 16 ft).
- The maximum deflection is on the point where load was applied for both panels.
- The panel shows buckling of diagonal bars after post failure analysis.
- MR SCIP panels can be used for cost-effective green and environment friendly construction.
- All of the precast specimens were simple to make, handle, and put together.

References

- American Concrete Institute 374.2R-13. (2013). Guide for testing reinforced structural elements under slowly applied simulated seismic loads. Farmington Hills, MI: American Fouad, F. et al. “Behavior of the MR Sandwich Panel in Flexure.” (2009).
- Gurung, K. (2019). “Experimental Investigations of Full-Scale MetRock Structural Concrete Insulated Panels (SCIPs).” Idaho State University.
- MetRockSCIP. (n.d). Retrieved 2019, from https://www.metrockscip.com/