Analysis of Testing Under Tie Pads using a Geometric Ballast Plate

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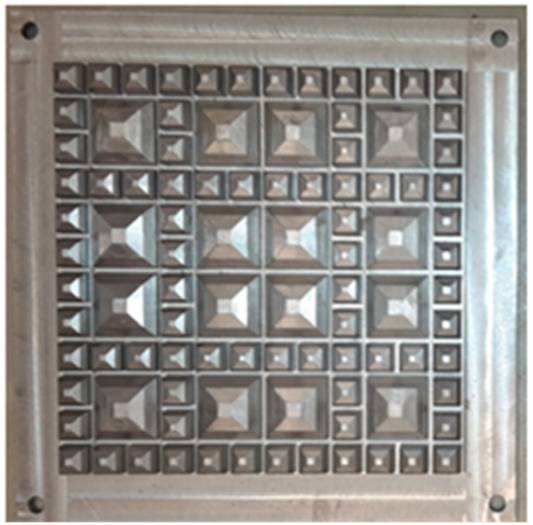
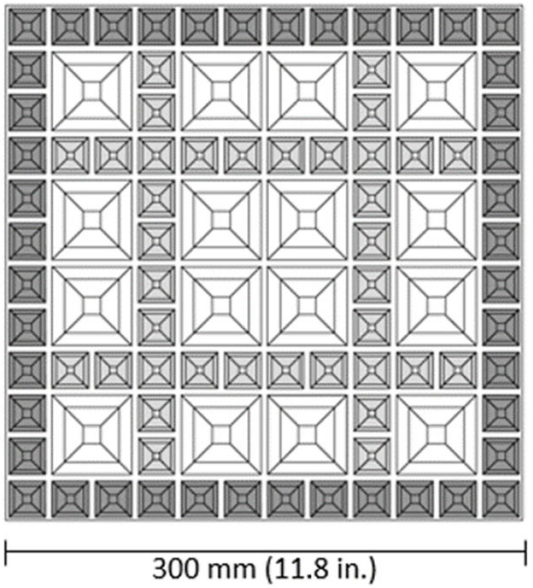
Under Tie Pads (UTPs)

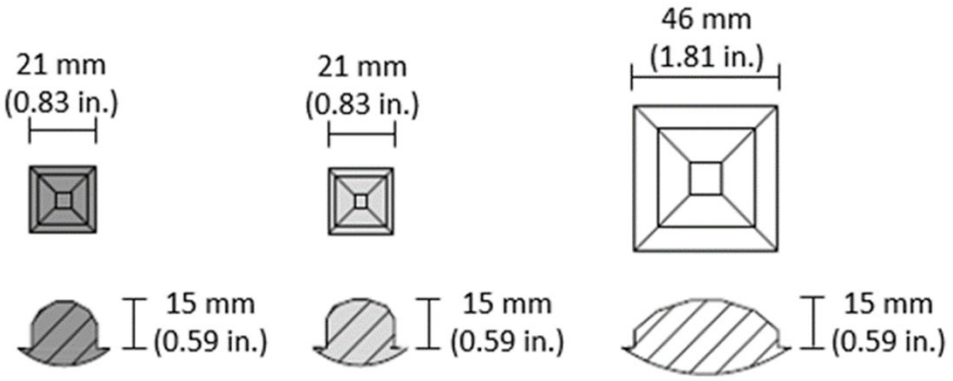
- UTPs are resilient components installed on the crosstie bottom
  - Typically polyurethane, rubber, or EVA
- UTPs serve two primary purposes:
  - Control ground-borne noise
  - Increase contact surface area and reduce pressures at ballast/concrete tie interface
    - Mitigate challenges at stiffness transition zones (bridges, etc.)
    - Reduce ballast particle degradation and tie bottom abrasion
    - Reduce maintenance of track components

Geometric Ballast Plate (GBP)

- Engineered “ballast” plates used to simulate ballast support conditions in international testing standards
  - EN 16730 (European Standard) - UTPs
- Simplified testing process
  - Ease of handling
  - Repeatable support condition
- Consists of 96 total “nodes” to replicate ballast particle contact
  - 3 node types with varying top geometry arranged in geometric grid





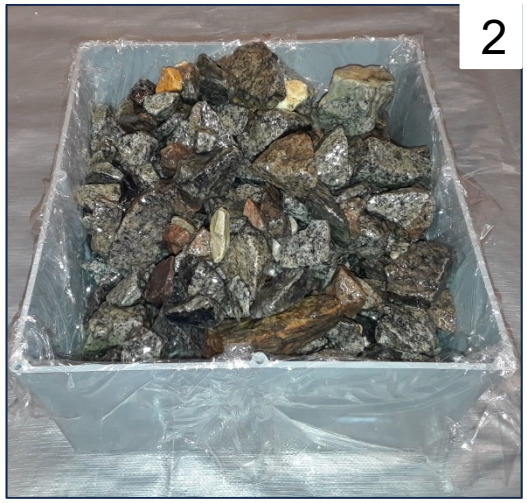


Current Research Objectives

- Compare GBP to ballast particles via:
  - Top surface contact areas
  - Pressure distribution
  - 3D scans
- Comment on how testing procedures with GBP represent testing on ballast
- Recommend changes to established testing procedures
  - Assist in the development of recommended practices for AREMA C-30

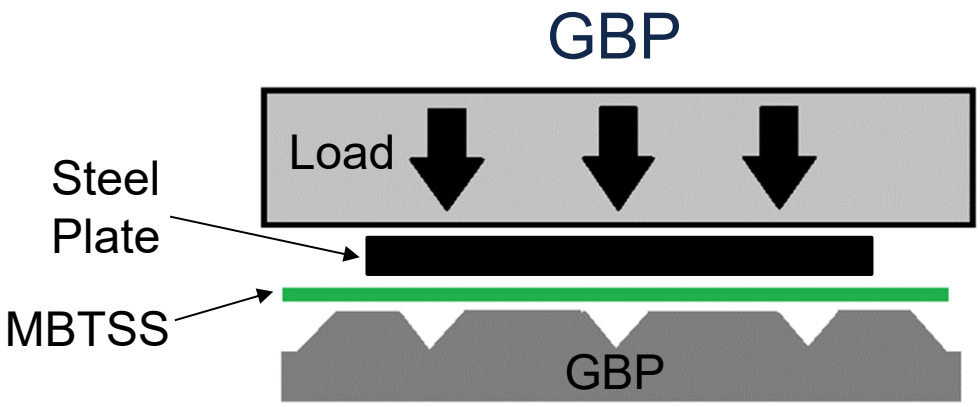
Ballast Block Preparation

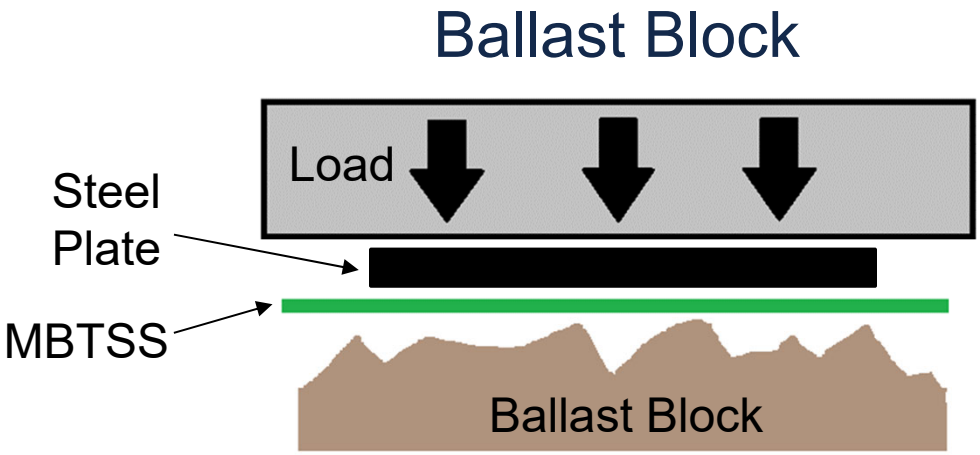
- 12”x12”x4” “ballast blocks” constructed out of AREMA Grade 4A ballast
  - Ballast stones bonded using BASF Elastotrack™ epoxy (1)
  - Block cast in PVC form and compacted with vibratory compactor (2,3)
  - Gypsum cement base formed to provide level footing (4)
- 3 “standard” blocks with uniform support condition
- 1 block “modified” for poor support condition



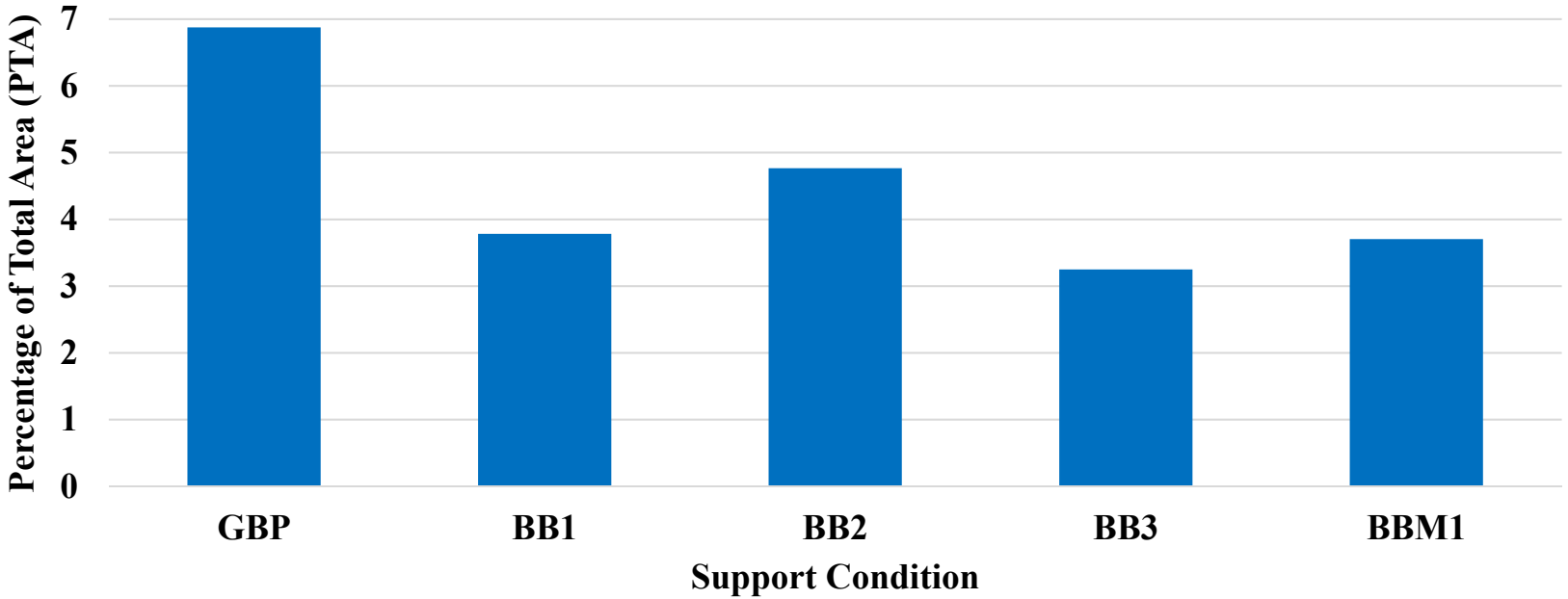
Surface Contact Experiment Setup

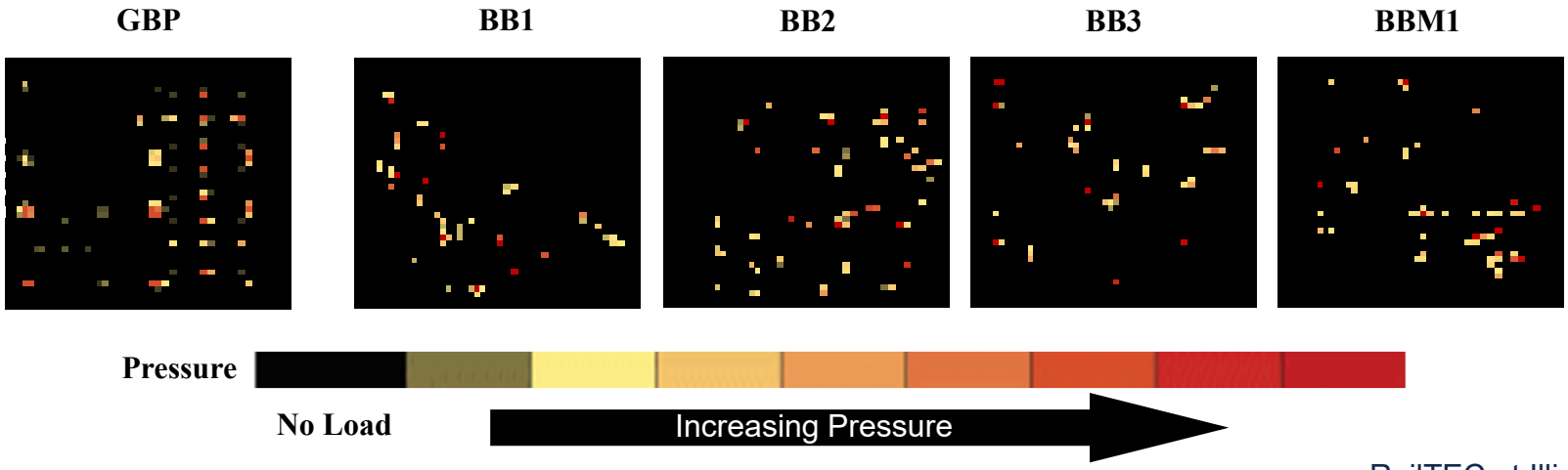
- Modified from standard EN procedures for UTP testing
  - North American loading
- 8”x8”steel plate used to ensure flat surface
- 3 replicates for each support condition
- Matrix based tactile surface sensor (MBTSS) measured contact area





Surface Contact Test Results

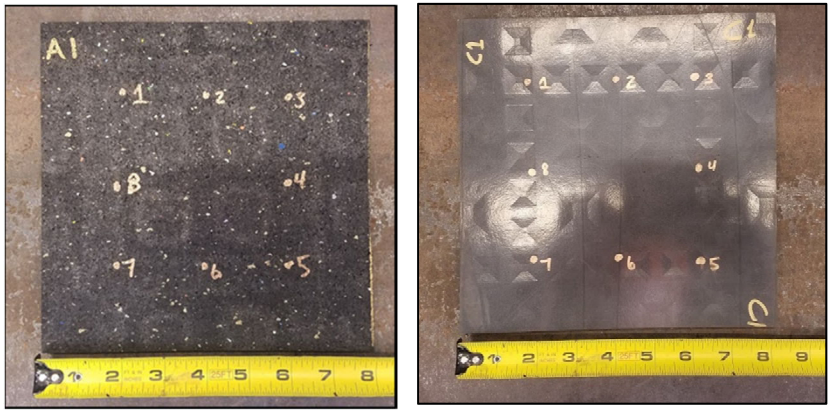


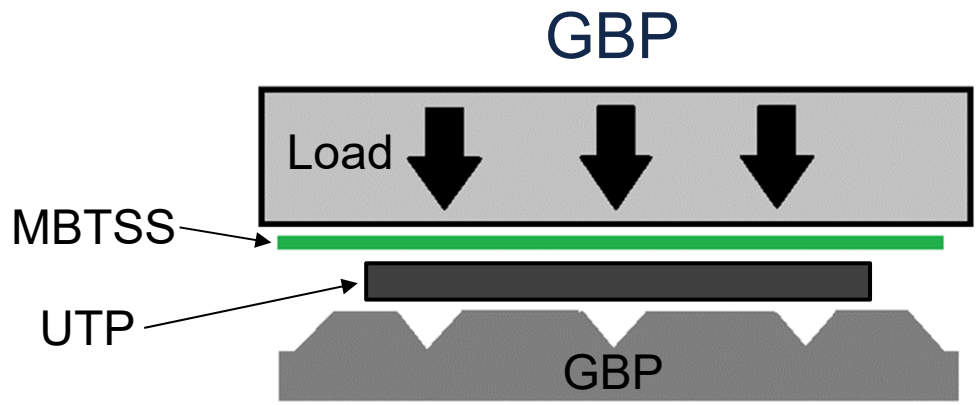


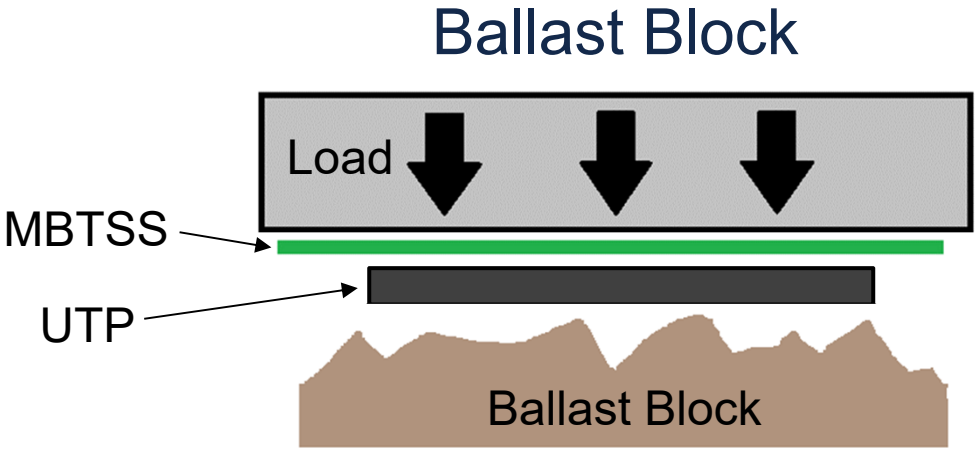
*No UTP

UTP Pressure Experiment Setup

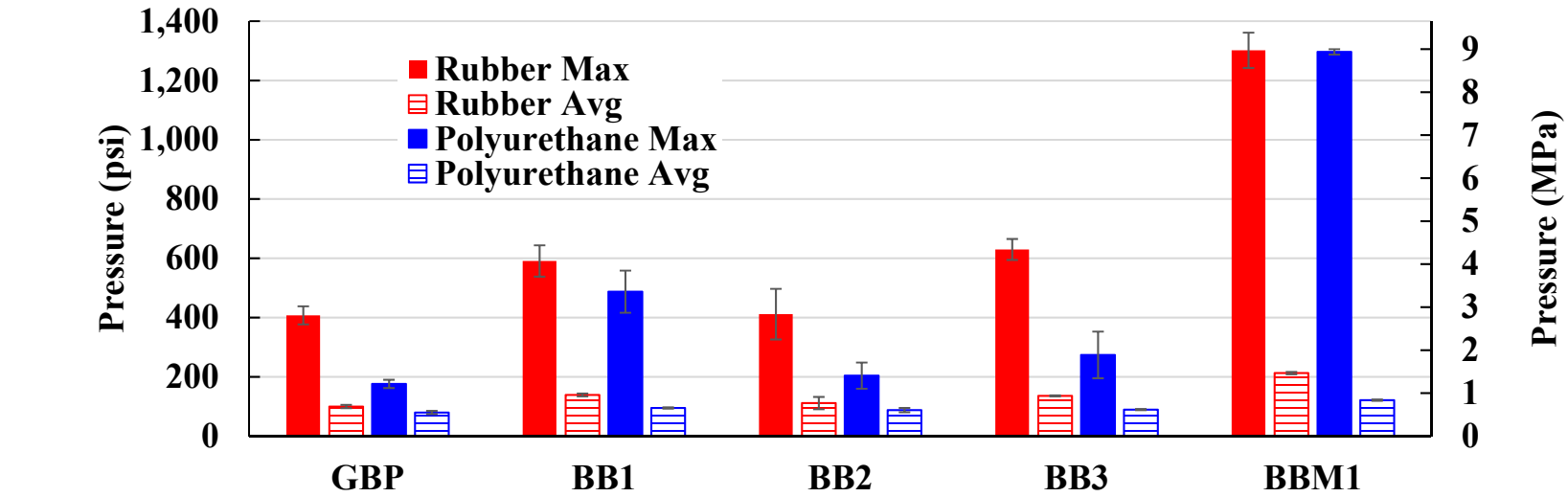
- Modified from standard EN procedures for UTP testing
  - North American loading
- Two generic UTP types:
  - Rubber
  - Polyurethane
- 3 replicates for each support condition and UTP material type

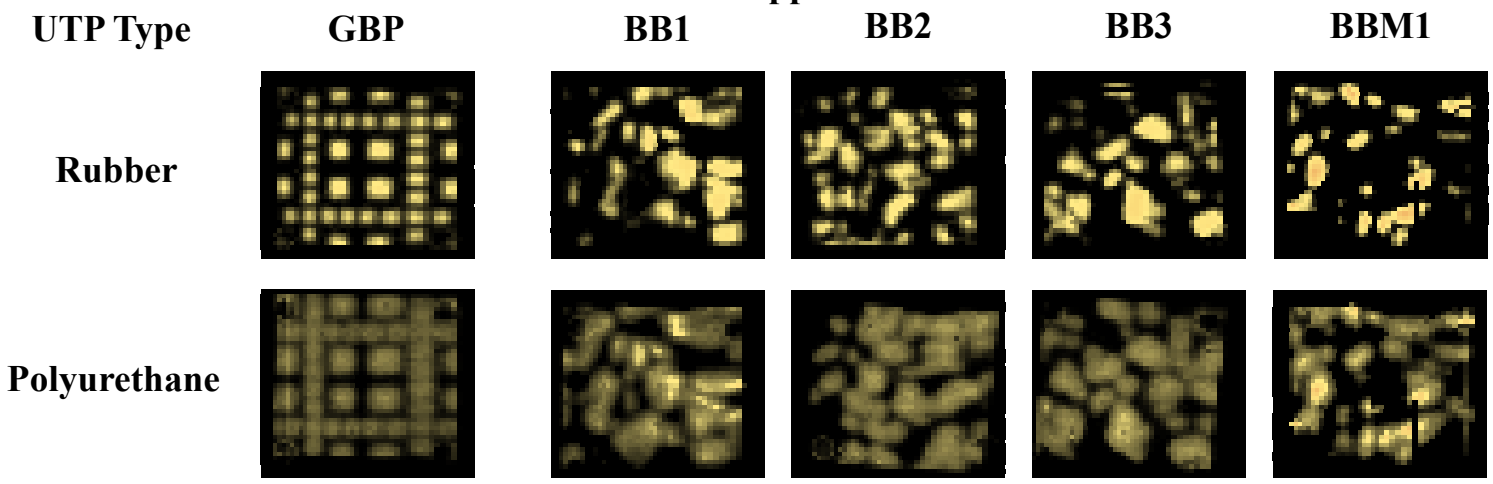


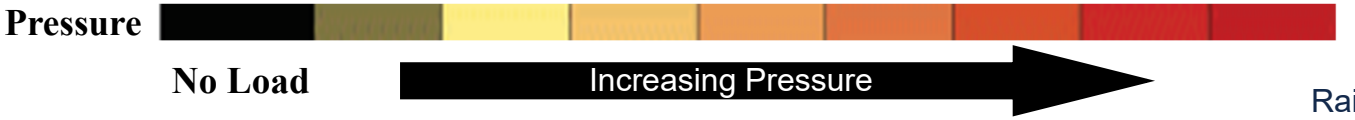




UTP Pressure Experiment Results

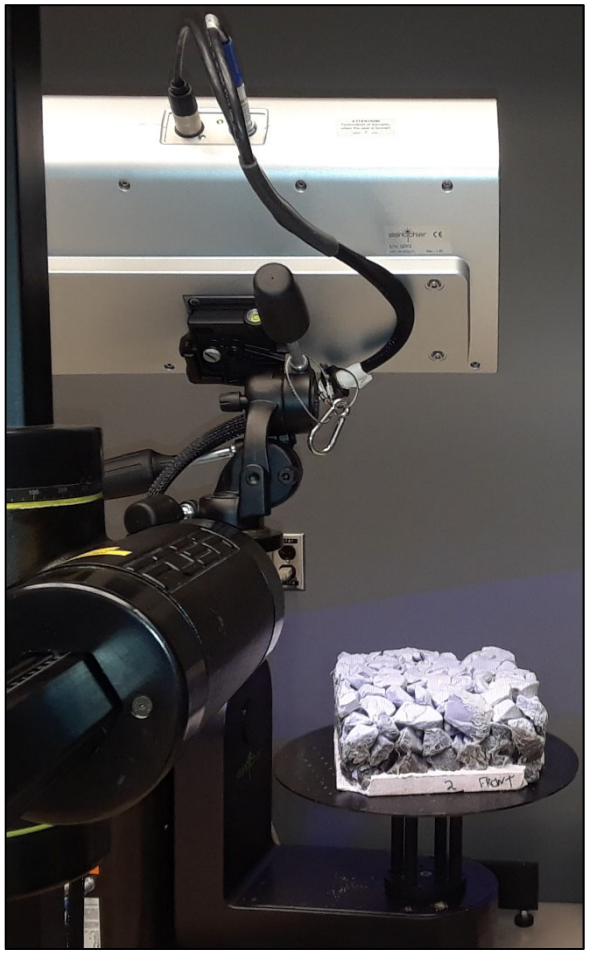




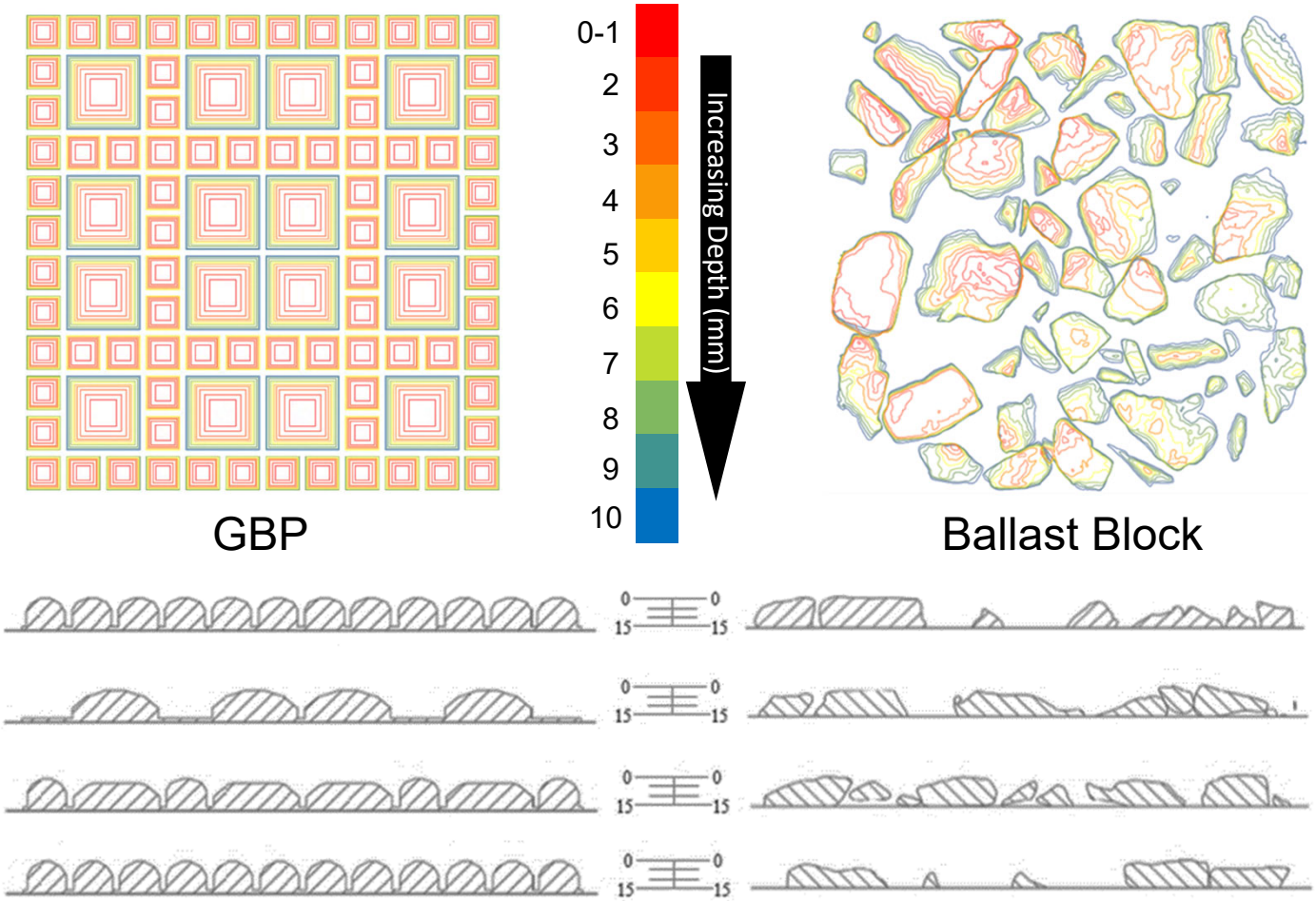


3D Scanning

- 3D scanning performed to compare surface geometry of GBP and ballast
- Allows for qualitative analysis
  - Contour maps
  - Cross sectional comparison
- 3 main quantitative metrics:
  - Total area at various depths
  - Average area at various depths
  - Average particle spacing



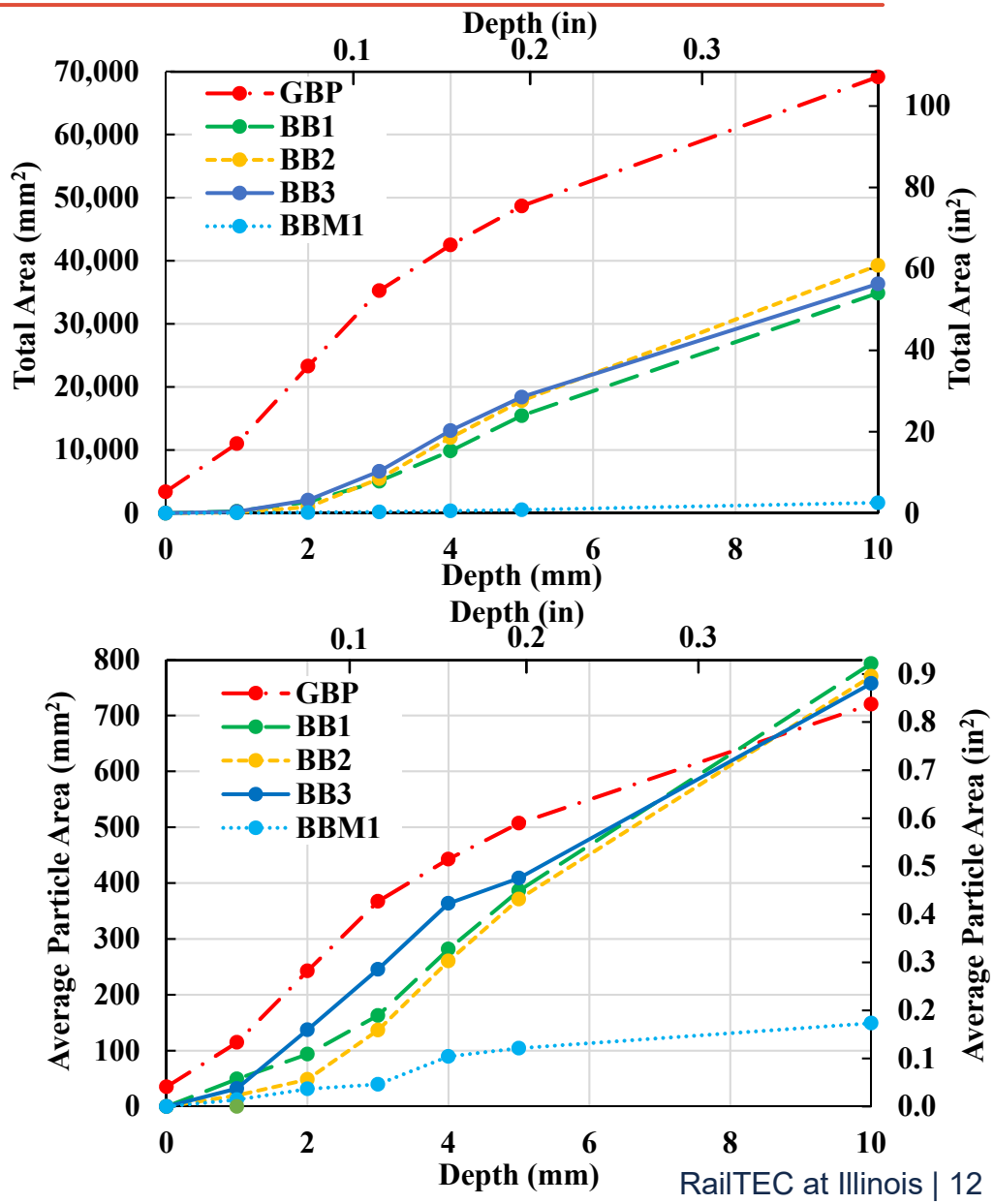
3D Scan Qualitative Comparison



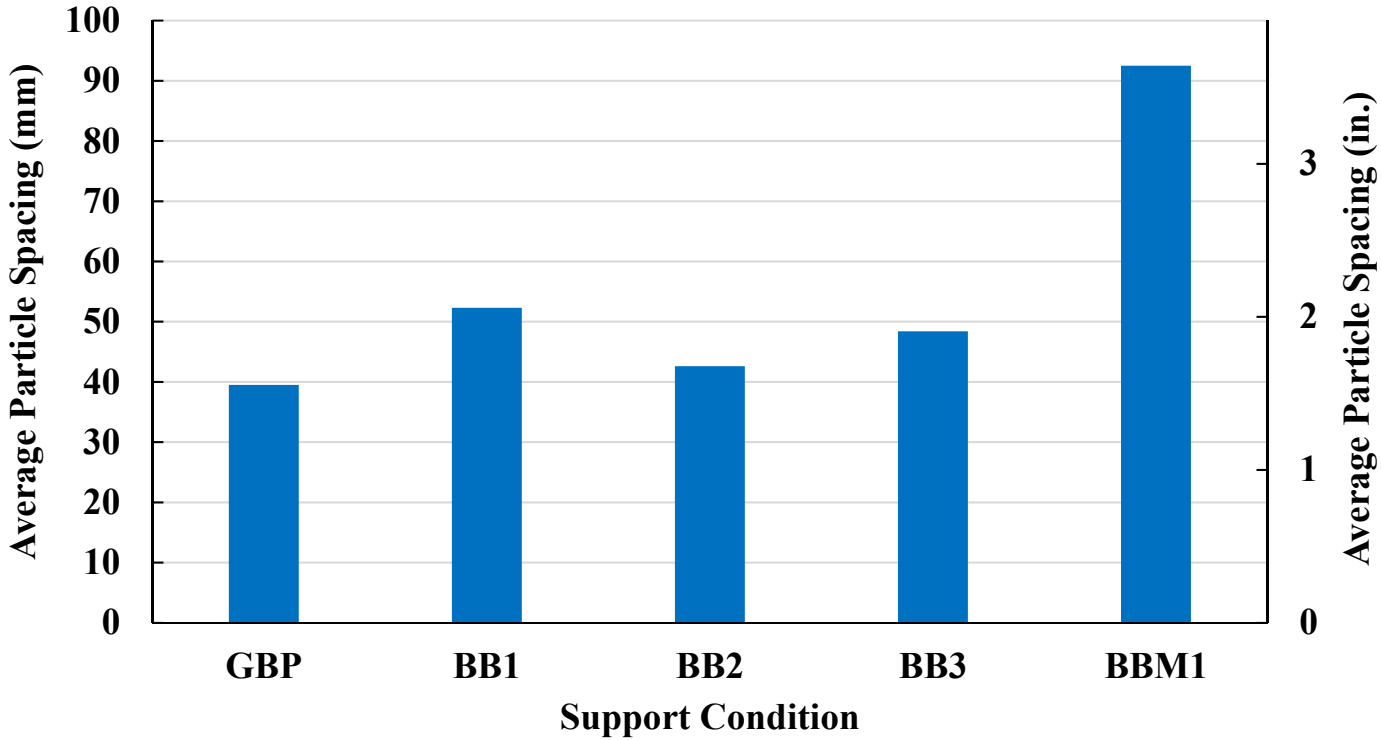
- GBP shows greater area at shallower depths than ballast blocks
- Ballast blocks exhibit areas of higher angularity than GBP
- Random distribution of ballast particles in ballast blocks

Total Area vs. Average Particle Area

- GBP exhibited higher total areas than standard blocks
  - 3x higher at 5mm depth
  - 2x higher at 10 mm depth
- GBP areas substantially higher than modified block areas at all depths
- Mixed results for average particle area
  - GBP average area 1.3 times higher at 5mm depth
  - Block average area 1.1 times higher at 10mm depth
- GBP particle sizes conservative only at deeper elevations



Average Particle Spacing



- Standard block particles spaced 1.1-1.3 times farther than GBP
- Modified block particles spaced over 2 times farther than GBP
- GBP provides more even distribution and less opportunity for component tearing than ballast blocks

Conclusions

- GBP overestimated ballast contact in nearly all metrics
  - GBP results in 1.8 times higher top surface contact than standard ballast
  - GBP exhibited 1.5 and 3.2 times lower contact pressure than standard blocks with rubber and polyurethane UTPs, respectively
  - GBP shows greater total and average areas at most elevations
  - GBP yields 1.1 to 1.3 times closer average particle spacing than standard ballast
- Ballast likely to result in less ideal contact conditions than GBP

Future Work

- Adapt findings to aid development of enhanced testing procedures for UTPs
  - Potential new GBP design
  - Increased loading to reflect higher pressures
- Further refinement of testing procedures for N.A. conditions
- Quantification of crosstie bending moments with and without UTPs

Thank you for your attention!

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NURail Center

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