New Punching Shear Reinforcement for Flat Slabs

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ERICO
• Problem/Solutions
• Lenton® Shear Fortress
• Experiments
• Results
• Conclusions
Conventional Reinforcement

• Difficult to anchor
• Difficult to install
• Does not facilitate prefabrication
Stud-rail Systems

- Priority over flexural re-bar installation
- Conceptual issues
  - System
  - Anchorage
  - Shear design
Lenton® Steel Fortress

The LSF on top of the upper flexural reinforcement

Leg depth

Leg spacing along the strip

Top rebar layer (T1)

Strip length

Tail anchor

1"

depth
Advantages

- Maximum effective depth
- Easy placement/ Adaptability
- Shear design based on Codes (e.g. ACI 318)
- Excellent anchorage
• 1\textsuperscript{st} Series (PSSA-D)
• 2\textsuperscript{nd} Series (PSSF-H)
• Beam Tests (B1-B10)
• Slabs with holes (PSSH1-5)
• Slabs with FRP reinforcement
• Tests for ICC Certification (California)
• Cyclic tests (California)
Testing Arrangement

6’ 7”

top #5 @ 8”

Column 4#5

8”

bottom #4 @ 8”

links 3#2 @ 20”
FLAT SLAB TESTING

Loading Frame

Reaction Frame

Slab

Loading Ring Frame

Jacks

Column Stub

Reaction Ring Frame

Load Application
Strain gauge location

Displacement Measurements
## Control Slab PSSA

<table>
<thead>
<tr>
<th>Slab</th>
<th>Maximum Load</th>
<th>Maximum Displacement</th>
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<tbody>
<tr>
<td></td>
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PSSB versus PSSC

The diagram shows the load in kN (kips) on the y-axis and microstrains on shear reinforcement on the x-axis. The graph compares the load behavior of PSSB and PSSC, with PSSB represented by black lines and PSSC by gray lines. The load range is from 0 to 600 kN (kips) and the microstrain range is from 0 to 3000.
PSSF and PSSG
**Load - Deflection**

### Graph

- **Load (kN) vs. Displacement (mm) at D850**

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Load - Strain

Microstrain in the Shear Reinforcement

Load (kN)

Microstrain in the Shear Reinforcement

PSSE

SS3

SS9

The University Of Sheffield.
Strain normally measured at cross-section without hole to avoid recording stress concentration due to hole.
PSSH Load-Deflection

- PSSH capacity increased by more than 100%
Conclusions

The LSF:

- Prevents brittle punching shear failure and leads to ductile behavior
- Fast and easy fixing; placed on top of main reinforcement for max anchorage
- Can be designed as conventional shear reinforcement
- Evidence of LSF yielding