INVERTED TEES

Jon Boleware, P.E.
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Inverted Tees

Conventional  Inverted Tee
When to Use Inverted Tees

Vertical Clearance
When to Use Inverted Tees

Vertical Clearance
When to Use Inverted Tees

Aesthetics
Cost Comparison

Research Report
1410-2F
Sept. 1998

- [Link](https://fsel.engr.utexas.edu/pdfs/1410-2f.pdf)

![Diagram showing cost comparison between two bridge designs](https://fsel.engr.utexas.edu/pdfs/1410-2f.pdf)

<table>
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<tr>
<th>Description</th>
<th>Cast-in-place Circular Columns</th>
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<tr>
<td>Bent Length</td>
<td>20m (66')</td>
<td>20m (66')</td>
</tr>
<tr>
<td>Volume of Concrete</td>
<td>37 m³ (48 yd³)</td>
<td>76 m³ (99 yd³)</td>
</tr>
<tr>
<td>Unit Cost*</td>
<td>$420/m³ ($320/yd³)</td>
<td>$485/m³ ($370/yd³)</td>
</tr>
<tr>
<td>Total Cost per Bent</td>
<td>$15,300</td>
<td>$36,600</td>
</tr>
<tr>
<td>Estimated Construction Time</td>
<td>~ 4 weeks</td>
<td>~ 4 weeks</td>
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Construction Issues

- Ben White

IH 35 Interchange
Construction Issues
Construction Issues
Construction Issues
Construction Issues
Joints

SHOWING EXPANSION JOINTS

SHOWING CONST JTS OR CONTROLLED JTS

REINFORCEMENT OVER INV-T BENTS
Joints

Concrete I-Girder Span to Concrete I-Girder Span
Design Provisions

Load Path
Design Provisions

- Punching Shear
  - Resistance at exterior girder must equal or exceed the factored load at adjacent interior girder
  - Not doing so limits our ability to widen bridges
  - No proven way to add punching shear strength to existing ledges
Design Provisions

- **Cap Extension**
  - **Guideline:** Extend caps at least 2 ft past the centerline of the exterior beam
  - Prevents excessive hanger and ledge reinforcing requirements
  - Note: A 2 ft cap extension may not be adequate for punching shear
Design Provisions

- Early practice, no longer recommended
  - Example of no cap extension past end of beam

- Typical Practice
  - Example of cap extension of 2 ft past $\bar{c}$ of exterior beam
Design Provisions

- In-service cracked inverted tee straddle bent caps
  - TxDOT Project 0-6416
  - Size Inverted-Tee Cap by limiting Service I Shear to $V_{cr}$
  - Possibly post-tension inverted tee straddle bent caps
Design Provisions

- Recent research recommendation (TxDOT Project 0-5253)
- Size Inverted-Tee Cap by limiting Service I Shear to $V_{cr}$

\[ V_{cr} = \left[ 6.5 - 3 \left( \frac{a}{d} \right) \right] \sqrt{f'_c b_w d} \]

but not greater than $5 \sqrt{f'_c b_w d}$ nor less than $2 \sqrt{f'_c b_w d}$

where:

- $a =$ shear span (in.)
- $d =$ effective depth of the member (in.)
- $f'_c =$ specified compressive strength of concrete (psi)
- $b_w =$ width of member’s web (in.)
Design Provisions

- Add hanger loads to shear and torsion
  - Hanger + Shear + Torsion

- Stirrups for torsional restraint must be anchored with 135 degree standard hooks (AASHTO LRFD Article 5.11.2.6.4)

135 Degree Hook

90 Degree Hook
Design Provisions

- Geometry of Inverted tee caps
  - Skewed vs. flat
  - Extending beyond slab for heavy loads
Questions?

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