10 FOOT WIDE DOUBLE TEE
DESIGN CRITERIA & SPAN-LOAD CHARTS

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USE OF DOUBLE TEE SPAN-LOAD CHARTS

ATTENTION: The Span-Load Charts included herein are intended as aids to preliminary sizing, and must be interpreted using sound engineering judgement.

INTRODUCTION - The standard double tee with composite topping is used for moderately loaded applications, such as floors for warehouses, office buildings, schools, shopping malls and parking garages. The cast-in-place concrete topping provides a smooth, level floor surface that serves as the horizontal diaphragm. Deviations from the standard double tee section, such as thickened flanges or alternate top surface finishes, are available at an economical cost. Contact Concrete Technology Corporation for cost and span capability information.

DESIGN CRITERIA FOR DEVELOPMENT OF THE SPAN-LOAD CHARTS

The Span-Load Charts were developed in accordance with the provisions of the “Building Code Requirements for Structural Concrete”, ACI 318-19, as described below:

COMPRESSION - The extreme fiber stress in both the double tee flange and topping slab is limited to 0.45$f'c$ under prestress plus sustained service load and 0.60$f'c$ under prestress plus total service load [ACI 318-19, Table 24.5.4.1].

TENSION - The extreme fiber stress in the precompressed tensile zone under the application of full service live load is limited to $7.5\sqrt{f'c}$ (Class U) [ACI 318-19, Table 24.5.2.1]. When service live loads are applied in combination with snow loads, the allowable extreme fiber tensile stress is increased to $12\sqrt{f'c}$ (Class T). If service is to be in a corrosive environment (salt water, certain industrial chemicals, etc.), or if full design loads are likely to be sustained for extended periods (such as in warehouses), designers should consider using an allowable tensile stress of $6\sqrt{f'c}$.

ULTIMATE STRENGTH - The nominal flexural strength, $\Phi M_n$, exceeds the required ultimate strength $M_u = 1.2 M_i + 1.6 M_l$ [ACI 318-19, Table 5.3.1]. The stress in the prestressed reinforcement at nominal strength ($f_{ps}$) was calculated as set forth in ACI 318-19, Section 20.3.2.3.1, and all superimposed loads were considered as live loads. When ultimate strength governs the design, a more rigorous analysis based on strain compatibility may increase the span-load capacity, as will superimposed loads comprised of dead and live load combinations.

SHEAR - The nominal shear strength, $\Phi V_n$, exceeds the required ultimate shear $V_u = 1.2 V_i + 1.6 V_l$ [ACI 318-19, Table 5.3.1]. Web and flexure shear strengths were calculated as set forth in ACI 318-19, Sections 22.5.6.3 and 22.5.7.

Full scale load tests have been performed by Concrete Technology Associates (CTA, 1973) and others (Aswad, 2004) to verify the shear capacity of double tees without web reinforcement. Test results also confirm that, with a rough screeded top flange, full composite action is achieved without the use of mechanical ties to develop the horizontal shear requirements of ACI 318-19, Section 16.4.

Contact CTC’s Marketing Department for further information concerning test results or special design considerations.

CONCRETE RELEASE STRENGTH and TOP FLANGE TENSION REINFORCEMENT requirements have been checked for conformance to ACI 318-19, Section 24.5. In the case of compressive stresses at release and shipping, an allowable temporary compressive stress of $0.70f'c$ has been used for the entire
length of the member based on relevant testing performed at the University of Texas at Austin (Bayrak, 2010).

**CONCRETE STRENGTH** varies depending on the total amount of prestress and the length of the double tees. The span-load charts assume that double tees will have a 28-day compressive strength of 8,000 psi, with a release strength that varies based on the required amount of prestressing. The strength of the topping at 28-days is a minimum of 4,000 psi. Designs using higher values of $f'_c$ for both the double tees and topping slab are also possible. Where higher design values are desired, contact CTC’s Marketing Department for capabilities.

**PRESTRESSING STEEL** is ½” diameter, 270 ksi, 7-wire, low-relaxation strand. Initial jacking stress is $0.75f_{pu} = 202.5$ ksi. Long term losses will vary based on level of prestressing.

**HARPEP Strand Designs** are calculated for a midpoint harp and a single row of stacked strands (see page 5). For heavily stranded Double Tees, significant improvement in eccentricity may be achieved by using a double row harp design. However, little capacity improvement is achieved by two-point harping at 0.4L, so the single point harp is recommended for economy. Contact CTC’s Marketing Department for economical alternate strand configurations.

**Composite Double Tee Designs** have already considered the weight of the cast-in-place topping. This should not be deducted from the allowable superimposed load. Double tees which are designed with composite topping will have a raked top surface to ensure good bond to the topping.

**Structural Lightweight Concrete**, with reinforced unit weights as low as 130 pcf and 28-day strengths of 8,000 psi, can be used where reduced dead load can be of advantage. In considering its use, the designer should be aware of the reduced elastic modulus resulting in larger cambers than the magnitude of those estimated for normal weight concrete. Larger differential cambers can result from large absolute cambers. Contact CTC’s Marketing Department for job-specific information.

**Special Widths** are available, although it is desirable to maintain the 10’ nominal width to minimize cost. If a layout suggests a non-standard width be used, it is most economical to use as many 10’ units as possible, and fill the remainder with non-standard widths. The minimum width of a double tee is 6’-2”.

The Span-Load Charts are calculated for the standard 10’ nominal width. Narrower widths will allow heavier loading conditions than are reflected in the charts for a given span. Contact CTC’s Marketing Department for span-load capacities of special width double tees.

**The Fire Resistance Rating** of double tees varies depending on many factors, including but not limited to cover over the prestressing, type and thickness of the topping slab and/or roofing, materials, normal or lightweight concrete, etc. In many cases, additional prestressed or mild reinforcement can be added to improve the fire resistance rating. Two excellent design guides are the PCI Design Handbook, and PCI MNL-124-18, “Specification for Fire Resistance of Precast/Prestressed Concrete.”

**Camber** (net upward deflection) due to the eccentricity of the prestressing force should be recognized and accounted for in the design process. Many variables affect camber, including the concrete strength at release, member length, number and placement of strands, placement of supports for storage, differential temperature, age of member prior to erection and placement of superimposed loads, relative humidity, etc. Associated building elements which may be affected by camber should be placed with adequate tolerances. It is not practical to deflect the formwork to produce desired cambers.

Suggested methods for calculating cambers and deflections are described in the PCI Design Handbook. Contact CTC’s Marketing Department with any questions about camber.
REFERENCES


STRAND LOCATION FOR PRESTRESSING

TABLE OF ECCENTRICITIES

<table>
<thead>
<tr>
<th>Total Number of ½” Diameter Strands</th>
<th>$Y_b - e$ at ends (inches)</th>
<th>$Y_b - e$ at harp (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3.25</td>
<td>2.50</td>
</tr>
<tr>
<td>6</td>
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<td>5.50</td>
</tr>
<tr>
<td>30</td>
<td>16.25</td>
<td>5.75</td>
</tr>
<tr>
<td>32</td>
<td>17.25</td>
<td>6.00</td>
</tr>
<tr>
<td>34</td>
<td>18.25</td>
<td>6.25</td>
</tr>
</tbody>
</table>

NOTE:
The configurations for single row harp, as shown above, were used in developing the Double Tee Span-Load Tables. Span-Load values using double row harp configurations are available by contacting CTC’s Marketing Department.
CONCRETE TECHNOLOGY CORPORATION

MANUFACTURING TOLERANCES

a = Length...........................................± 1 in.
b = Width (overall).................................± 1/4 in.
b₁ = Stem Width....................................± 1/8” in.
b₂ = Distance Between Stems......................± 1/4 in.
b₃ = Stem to Edge of Top Flange.................± 1/4 in.
c = Depth (overall)................................± 1/4 in.
c₁ = Flange Thickness............................+ 1/4 in., - 1/8 in.
d = Variation From Specified Plan End
   Squareness or Skew.............................± 1/8 in. per 12 in. width, 1/2 in. maximum.
e = Variation From Specified Elevation End
   Squareness or Skew
   Greater than 24 in. in depth....................± 1 1/8 in. per 12 in., ±1/2 in. max.
   24 in. or less depth............................± 1/4 in.
f = Sweep, for Member Length:
   Up to 40 ft. member length.................± 1/4 in.
   40 ft. to 60 ft. member length..............± 3/8 in.
   Greater than 60 ft. member length..........± 1/2 in.
g = Camber Variation from Design Camber.....± 1/4 in. per 10 ft., ± 3/4 in. max.
g₁ = Differential Camber between Adjacent
   Untopped Members of the Same Design to
   Receive Topping......................................1/4 in. per 10 ft., 3/4 in. maximum
h = Local Smoothness of Any Surface..............1/4 in. in 10 ft.
k = Location of Strand
   individual........................................± 1/4 in.
   bundled..........................................± 1/2 in.
k₁ = Location of Harp Points for Harped Strands
   from Design Location.........................± 20 in.
l₁ = Location of Embedment........................± 1 in.
l₂ = Tipping and Flushness of Embedment......
   ± 1/8 in. per 12 in., ±1/2 in. max.
m₁ = Location of Bearing Assembly..............± 1/4 in.
m₂ = Tipping and Flushness of Bearing
   Assembly........................................± 1/8 in.
n₁ = Location of Blockout........................± 1 in.
n₂ = Size of Blockouts............................± 1/2 in.
o = Location of Sleeves Cast in Stems, in Both
   Horizontal and Vertical Plane..............± 1 in.
p = Location of Inserts for Structural
   Connections......................................± 1/2 in.
q₁ = Location of Handling Device Parallel to
   Length of Member..............................± 6 in.
q₂ = Location of Handling Device Transverse to
   Length of Member.............................± 1 in.

Notes:
1. Double tee concrete properties: f'_c = 8,000 psi & w_{conc} = 155 pcf
2. Topping concrete properties: f'_c = 4,000 psi & w_{conc} = 150 pcf
3. A concrete unit weight of 160 pcf is assumed for dead load calculations
SECTION PROPERTIES

\[ l_c = 7,415 \text{ in}^4 \quad S_{lc} = 2,593 \text{ in}^3 \quad S_{bc} = 723 \text{ in}^3 \quad S_{if} = 4,241 \text{ in}^3 \quad A = 398 \text{ in}^2 \]
\[ w = 77 \text{ psf} \quad y_{lc} = 4.25 \text{ in} \quad y_{bc} = 10.25 \text{ in} \quad y_{if} = 1.75 \text{ in} \]

NOTES:
1. The values in the chart are in compliance with ACI 318-19.
2. The values in the chart assume that additional shear reinforcement is added as necessary.
3. Extrapolation beyond the bounds of the chart is not permitted.
4. The standard top flange reinforcement is WWF 8x4-W2.9/W2.9, and the maximum safe uniform load on the flange with this reinforcement is 80 psf. The maximum safe concentrated load is 500 lbs.
5. This Span-Load chart is intended as an aid to preliminary sizing. Sound engineering judgement is required for the application of this information to specific design cases.
6. Design cases presented above were limited to a maximum span-to-depth ratio of 30.
7. Contact CTC’s Marketing Department for concrete release strength requirements.
SECTION PROPERTIES

\[ I_c = 15,094 \text{ in}^4 \quad S_{tc} = 4,243 \text{ in}^3 \quad S_{bc} = 1,142 \text{ in}^3 \quad S_{tf} = 5,420 \text{ in}^3 \quad A = 454 \text{ in}^2 \]

\[ w = 83 \text{ psf} \quad y_{tc} = 5.29 \text{ in} \quad y_{bc} = 13.21 \text{ in} \quad y_{tf} = 2.79 \text{ in} \]

NOTES:
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CONCRETE TECHNOLOGY CORPORATION

20" DOUBLE TEE WITH 2½" TOPPING

SECTION PROPERTIES

\[ I_c = 26,442 \text{ in}^4 \quad S_{tc} = 6,118 \text{ in}^3 \quad S_{bc} = 1,644 \text{ in}^3 \quad S_{if} = 6,744 \text{ in}^3 \quad A = 507 \text{ in}^2 \]

\[ w = 89 \text{ psf} \quad y_{tc} = 6.42 \text{ in} \quad y_{bc} = 16.08 \text{ in} \quad y_{if} = 3.92 \text{ in} \]

NOTES:

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3. Extrapolation beyond the bounds of the chart is not permitted.
4. The standard top flange reinforcement is WWF 8x4-W2.9/W2.9, and the maximum safe uniform load on the flange with this reinforcement is 80 psf. The maximum safe concentrated load is 500 lbs.
5. This Span-Load chart is intended as an aid to preliminary sizing. Sound engineering judgement is required for the application of this information to specific design cases.
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7. Contact CTC's Marketing Department for concrete release strength requirements.
CONCRETE TECHNOLOGY CORPORATION
24" DOUBLE TEE WITH 2½" TOPPING

SECTION PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
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<tr>
<td>$I_c$</td>
<td>41,707 in$^4$</td>
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<tr>
<td>$S_{tc}$</td>
<td>8,146 in$^3$</td>
</tr>
<tr>
<td>$S_{bc}$</td>
<td>2,207 in$^3$</td>
</tr>
<tr>
<td>$S_{fr}$</td>
<td>8,169 in$^3$</td>
</tr>
<tr>
<td>$A$</td>
<td>557 in$^2$</td>
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<tr>
<td>$w$</td>
<td>95 psf</td>
</tr>
<tr>
<td>$y_{tc}$</td>
<td>7.61 in</td>
</tr>
<tr>
<td>$y_{bc}$</td>
<td>18.89 in</td>
</tr>
<tr>
<td>$y_{fr}$</td>
<td>5.11 in</td>
</tr>
</tbody>
</table>

NOTES:

1. The values in the chart are in compliance with ACI 318-19.
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4. The standard top flange reinforcement is WWF 8x4-W2.9/W2.9, and the maximum safe uniform load on the flange with this reinforcement is 80 psf. The maximum safe concentrated load is 500 lbs.
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SECTION PROPERTIES

\[ l_c = 61,084 \text{ in}^4 \quad S_{ic} = 10,280 \text{ in}^3 \quad S_{bc} = 2,818 \text{ in}^3 \quad S_{if} = 9,655 \text{ in}^3 \quad A = 604 \text{ in}^2 \]

\[ w = 100 \text{ psf} \quad y_{ic} = 8.83 \text{ in} \quad y_{bc} = 21.67 \text{ in} \quad y_{if} = 6.33 \text{ in} \]

NOTES:
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**SECTION PROPERTIES**

\[
\begin{align*}
I_c &= 84,597 \text{ in}^4 \\
S_{tc} &= 12,497 \text{ in}^3 \\
S_{bc} &= 3,461 \text{ in}^3 \\
S_{ff} &= 11,169 \text{ in}^3 \\
A &= 648 \text{ in}^2 \\
w &= 105 \text{ psf} \\
y_{tc} &= 10.06 \text{ in} \\
y_{bc} &= 24.44 \text{ in} \\
y_{ff} &= 7.56 \text{ in}
\end{align*}
\]

**NOTES:**

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2. The values in the chart assume that additional shear reinforcement is added as necessary.
3. Extrapolation beyond the bounds of the chart is not permitted.
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SECTION PROPERTIES

\[ I_c = 112,204 \text{ in}^4 \quad S_{ic} = 14,776 \text{ in}^3 \quad S_{bc} = 4,122 \text{ in}^3 \quad S_{if} = 12,779 \text{ in}^3 \quad A = 689 \text{ in}^2 \]

\[ w = 110 \text{ psf} \quad y_{ic} = 11.28 \text{ in} \quad y_{bc} = 11.28 \text{ in} \quad y_{if} = 8.78 \text{ in} \]

NOTES:
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