Superstructure Guidelines

Selecting the superstructure type depends on several factors: cost, span lengths, depth of structure (relates to road profile, vertical clearance, low member elevation), bridge curvature, and speed of construction.

While there are many structure types used for local bridges, these guidelines will only cover the most common used types: Pre-Stressed Concrete Beams, Concrete Slab Spans, Inverted T-Beams, Timber, and Steel Beams.

These additional guidelines may help determine the appropriate superstructure type:

Pre-Stressed Concrete Beams (PCB's)

Pre-stressed concrete beams (PCB's) are precast by a beam fabricator and are one of the most common bridge type used on the local bridge program. These beams don't require much maintenance and are ideal for single and multi-span arrangements on straight or slightly curved alignments.

Currently there are seven I-Beam shapes available (from 27" to 96" depths) and 3 rectangular shapes (from 14" to 22"). These beams represent maximum span lengths ranging from 42' to 206'. The span chart from the MnDOT LRFD Bridge Design Manual (BDM) can be found here (PDF).

For depth of structure scoping, it would be common to add 12-13" (9" for bridge deck and 3-4" for stool build-up) to the beam depth for total superstructure depth. Consider allowance for steeper cross slopes when adding for stool build-up.

Bridge No. 04528 – 36M PCB's

Bridge No. 50587 – 27M PCB's

Bridge No. 70551 – 18RB PCB's

Bridge No. 25619 – MN45 PCB's

Advantages of Pre-Stressed Concrete Beams

- PCB bridges are a perennial low-cost structure type. Check out the prices here.
- PCB's are low maintenance and do not require painting.
- PCB's have a good track record of long term performance.
- PCB's can achieve large span arrangements which account for most bridge sites.
- PCB's can be used on highly skewed (>45°) span arrangements.
- Bridge deck formwork does not affect the low member, so PCB's are ideal for construction over traffic.
- Façade panels can be incorporated to achieve a desired architectural affect for the bridge.

Disadvantages of Pre-Stressed Concrete Beams

- Highly curved bridge decks do not work well with the straight PCB's.
- For smaller span arrangements (50' or less) PCB's may not give you the lowest depth of structure result. It may be advised to consider the Concrete Slab Span (C-SLAB) or the Inverted T-Beam (INV-T) as a structure type.
- Since PCB's cannot be spliced (like steel girders), the really long (200') MN96 beams may not be able to be shipped to some job sites. It is advisable to verify shipping for any beam over the length of 140'.

See the Hydraulic Guidelines (PDF) document for low member requirements for PCB bridges.

The MnDOT LRFD Bridge Design Manual (BDM) offers in-depth guidance on Pre-stressed Concrete Beam design. Section 5 (Concrete Structures) (PDF) discusses the design and span limitations for PCB's and Section 9 (Deck and Deck Systems) (PDF) discusses the deck design as it interacts with the beams. The MnDOT Bridge Office website Bridge Details Manual Part II has the standard plan sheets for all of the beam sizes.

Concrete Slab Spans (C-SLAB's)

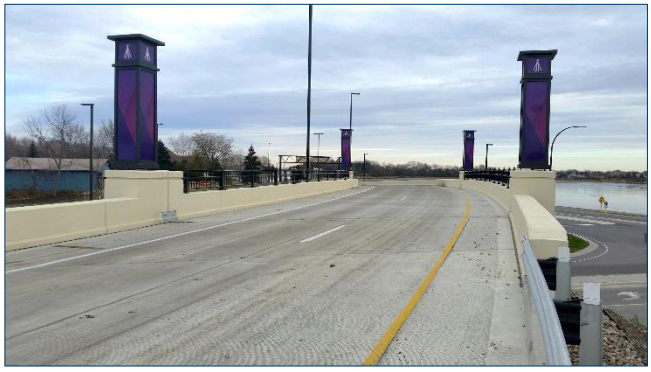
Concrete Slab Spans (C-SLAB's) are falsework-formed reinforced concrete deck slabs and are another common structure type used for local bridges. Since there are no girders to contend with, the C-SLAB bridges have a lower structure depth and can also be used for curved applications.

C-SLABS can be used for single spans up to 40' and up to 50' for 3 or more spans, with a depth of structure ranging from 15" to 24" (without haunches). If the slab depth has a variable haunch, then these spans increase to 40' for single spans and 60' for 3 or more spans. These maximum span lengths are a general guide and may be increased during the design phase.

Please note that the MnDOT Bridge Office is developing standard plan sheets for the Inverted T-Beam structure type, which has similar structure depths to C-SLAB's but do not require falsework for construction. See below for details on this new structure type.

Bridge No. 12553 – C-SLAB

Bridge No. 70555 – C-SLAB (Haunched/Curved)



Bridge No. 70555 – C-SLAB (Haunched/Curved)

Advantages of Concrete Slab Spans

- C-SLAB's are traditionally the lowest cost structure type on the local system. Check out the prices here.
- C-SLABS's offer a low structure depth, which is ideal for water crossings with tight profile grade tolerances.
- C-SLAB bridges are robust structures, since the deck slab is firmly connected to the substructures. This means that the low member can be situated 1' below the Design Tailwater elevation for velocities less than 5fps (and no debris problems). For velocities greater than 5fps (or debris problems) the low member should be situated at the Design Tailwater elevation. These low member guidelines are 1' lower than the PCB structure and 2' lower than a timber bridge.
- C-SLAB bridges can easily built on curves and super-elevated lane slopes.
- Since there are no beams to order, project timelines can be reduced.

Disadvantages of Concrete Slab Spans

- C-SLABS's that have high skews require an in-depth analysis and may be susceptible to deck cracking in the sharp corner areas.
- C-SLABS's require falsework forms. Where temporary vertical clearance is an issue, the falsework could infringe on the vertical clearance envelope. If the bridge is being built over vehicular or railroad traffic this may require a temporary clearance approval.
- Be aware that the falsework forms may be held up with timbers and the removal of these support timbers may have an adverse effect on waterways. Make sure the SWPPP (Storm Water Protection Plan) is in order and will account for the safe removal of the forms and supports.
- C-SLAB span ranges are somewhat limited so they might not fit every project site.

See the Hydraulic Guidelines (PDF) document for low member requirements for C-SLAB bridges.

The MnDOT LRFD Bridge Design Manual (BDM) offers in-depth guidance on Concrete Slab Span design. Section 5 (Concrete Structures) (PDF) discusses the design of Concrete Slab Spans.

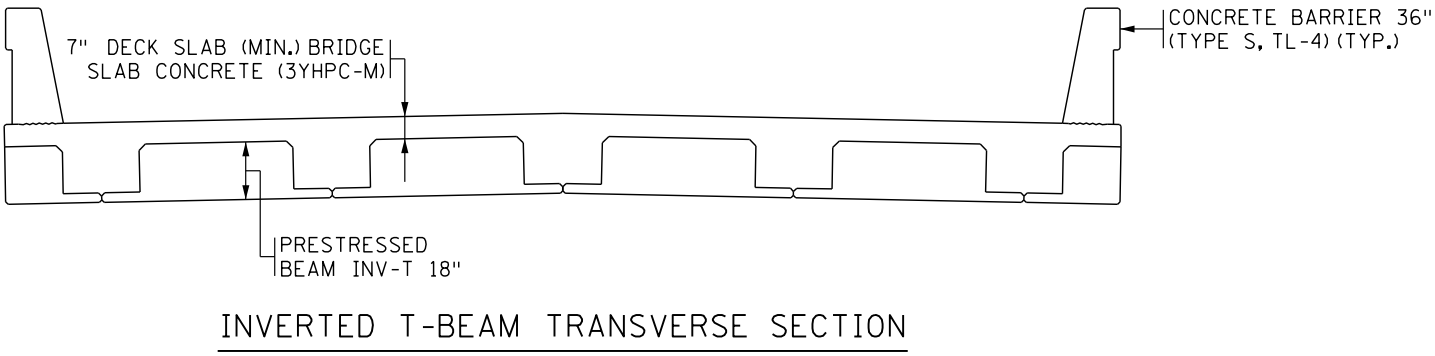
Inverted T-Beams (INV-T)

Inverted T-Beam (INV-T) bridges are a relatively new structure type developed by the MnDOT Bridge Office. The inverted T-beam is a series of pre-stressed beam/deck panels (shaped like an upside-down capital letter T) that interfaces with a concrete topping pour to create a deck system that is a similar depth to Concrete Slab Spans.

The INV-T structure type can make for a fast construction time frame, given the lack of deck forming needed. In the past MnDOT has used pre-cast substructure units to make construction even faster.

It is worth noting that currently (July, 2018) the MnDOT Bridge Office is developing standard plan sheets for the INV-T superstructure. These sheets will be similar to the MnDOT Box Culvert sheets in terms of the various span arrangements and bridge widths will be charted for geometry and reinforcement. This means that a local design consultant will only need to design/detail the substructure units for a bridge plan and would not need to design the superstructure (but would insert standard sheets into the design plans).

The standard sheets being developed will be for single span/no skew bridges with spans ranging from 20'-60' (in 2' increments). The bridge roadway widths will accommodate a 26', 28', and 32' gutter-to-gutter width. These standards will all use the new Type S barrier.



Advantages of Inverted T-Beams

- Since the design of the superstructure has been completed, the bridge design costs should be reduced.
- INV-T bridges can be constructed quickly (if the beam delivery has been sorted out properly), which is useful for sites with short construction windows.
- INV-T bridges don't need falsework so they can be ideal for sensitive waterways.
- INV-T's should offer a good alternate to a C-SLAB bridge, as the structure depth is pretty similar.

Disadvantages of Inverted T-Beams

- In the past the INV-T bridges have been fairly expensive, but the price should moderate as more of them get built. The use of standard sheets/designs will also help lower the total project cost.
- While small skews could be accommodated, they will not feature in the first round of the standard sheets.
- Multiple spans can be built as well, but they will also not feature in the first round of standard sheets.

See the Hydraulic Guidelines (PDF) document for low member requirements for INV-T bridges (which would be considered PCB bridges).

Timber Bridges

Timber bridges can fall into two types: Treated Timber Slab (TTS) and Timber Deck Panels. The TTS structure type has been the most common and consists of treated timber spike (or glue) laminated deck panels that support the roadway/barrier loads. The timber deck panels are beam-supported glue laminated transverse panels that use clips to hold them onto the beams.

Each type of timber deck system gets a bituminous overlay and a timber barrier system that can achieve an NCHRP 350 TL-2 or TL-4 test level.

Timber bridges have seen a resurgence lately and offer a fairly low cost alternative to the concrete bridge. They have a nice rustic look and offer a long service life. Steel piles are now used instead of the timber piles that would rot and be the downfall of the older timber bridges on the local system.

Bridge No. 11532 – TTS

Advantages of Timber Bridges

- Timber bridges can be easily constructed in the winter months.
- Timber bridges can be built using county/city forces.
- Timber bridges offer a rustic alternative to the all-concrete bridge.
- Timber bridges are much less susceptible to the corrosive effects of a chloride environment, compared to reinforced concrete.
- Timber bridge superstructures may be easier to repair when damaged.

Disadvantages of Timber Bridges

- Timber bridges can cost more than a concrete alternative. Check out the prices here.
- When the new MASH roadside safety standards go into effect, the current timber barriers may need approval or a design exception.
- Timber TTS bridges have a limited span range, with a 35’ maximum span. Please be advised that timber design is evolving and it is likely that span lengths will increase and/or slab thicknesses will decrease.
- Timber bridges need a greater low member clearance for waterway crossings, when compared to C-SLABS (which can be 2’ lower) and PCB’s (which can be 1’ lower).

See the Hydraulic Guidelines (PDF) document for low member requirements for Timber bridges.

The MnDOT LRFD Bridge Design Manual (BDM) offers in-depth guidance on Timber Bridge design. Section 9 (Wood Structures) (PDF) discusses the design of Timber Bridges.

Steel Beams

Steel beam bridges are not that common on the local system. They are mainly used for bridges that carry railroad tracks, bridges over the Red River, and some Metro District bridges. There also has been a few simple span steel beam bridges that feature a timber deck, mainly used in District 1.

Most steel beam bridges are multi-span continuous steel beams, which can offer a lower beam depth when compared to PCB’s. Steel beams are ideal for curved bridges and long span bridges.

Steel beams come in 2 different options: Rolled Beams and Welded Plate Girders. Rolled beams are typically used for bridge spans up to 120' long. Rolled beams may be difficult to obtain in lengths over 90'. Welded plate girders are typically used for spans up to 350' (in a constant depth) and haunches would be used for spans over 350'.

Steel beams generally need shop fabrication in order to install bearing stiffener, diaphragm connection plates, splice plates, etc.

Steel beams can be made of weathering steel (which doesn't need painting), but these beams may eventually stain the substructures with rust. Painted steel beams will eventually require re-painting.

Advantages of Steel Beams

- Steel beams are ideal for curved bridges and unusual deck shapes.
- Steel beams are ideal for long spans.
- Steel beams are ideal for bridges over fat clays, where the substructures tend to move and the bridges can be 're-set' over an additional set of bearing stiffener plates.
- Steel beams can offer a lower beam depth when compared to PCB's.
- Steel beams that are damaged by traffic hits are usually easier to repair, when compared to PCB's.

Disadvantages of Steel Beams

- Painted steel beams will need to be re-painted.
- Steel beams tend to cost more than PCB's.
- Steel beams need to be ordered and will require shop fabrication, which needs to be considered for project timelines.

See the Hydraulic Guidelines (PDF) document for low member requirements for Steel bridges.

The MnDOT LRFD Bridge Design Manual (BDM) offers in-depth guidance on Steel Beam Bridge design. Section 6 (Steel Structures) (PDF) discusses the design of Steel Beam Bridges.