American Concrete Pipe Association

PIPE SCHOOL 2024
STRENGTH. RESILIENCE. SUSTAINABILITY.
JAN 29-FEB 1, 2024 | FRISCO, TX

Bridge Replacement with Box Culverts: Iowa DOT's use of pipe and precast to replace ageing structures

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IOWA | DOT

Why concrete pipe/precast?

- **Strength, Resilience, Sustainability, of course**
- **Quality, consistency, uniformity**
- **Compress construction schedule**
  - Acceleration ($) vs. built-in compression w/ precast
- **Mitigate weather risks and impacts**
  - Precast advantage over CIP
- **Minimize traffic impacts and user costs**
  - Reduce number and severity of crashes
  - Fatality reduction (TX CY22: 4,481 or 1 every 2.25 hrs)
    - Secondary crash- semis
  - Operational considerations are key- TSMO concepts

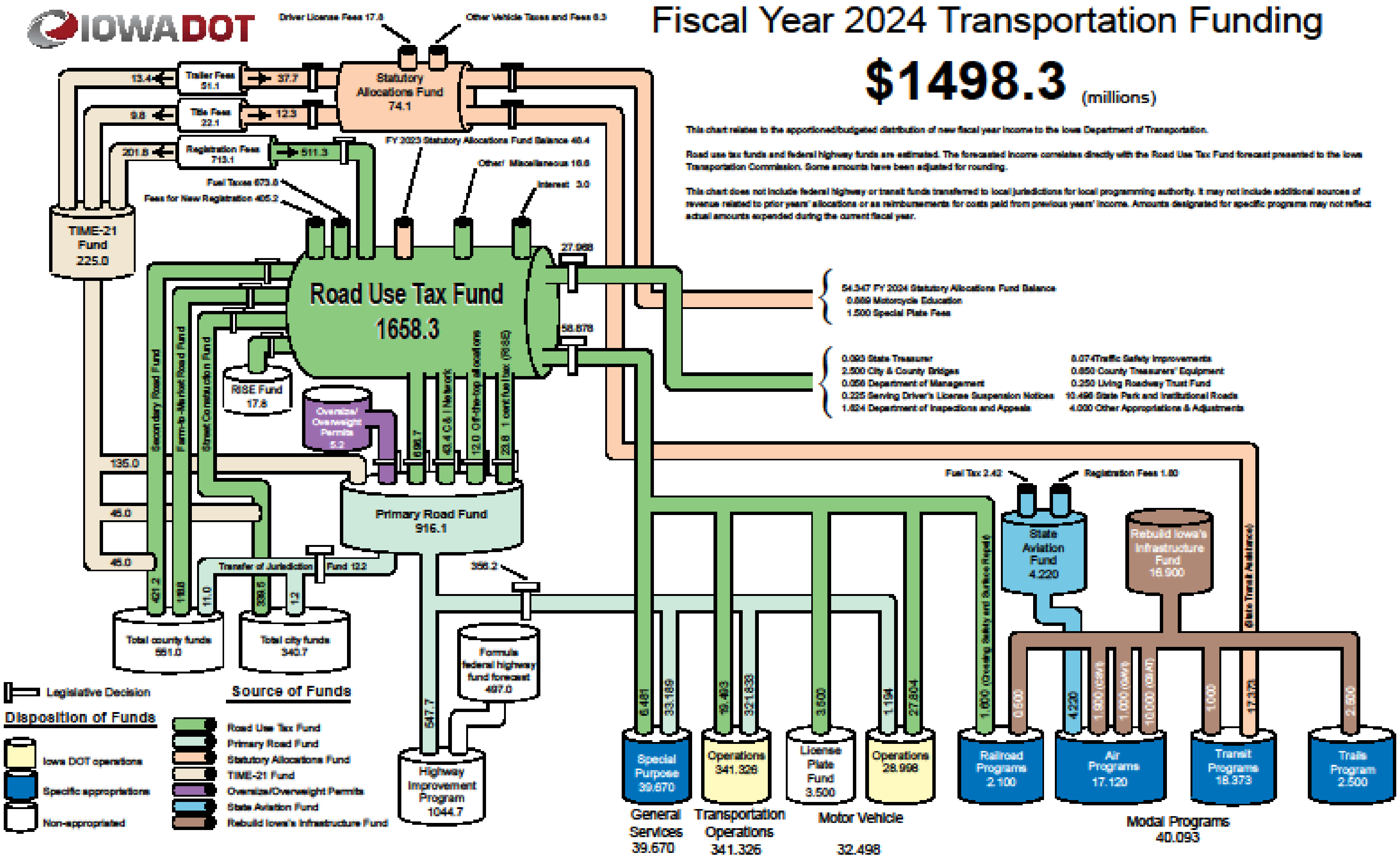
Fiscal Year 2024 Transportation Funding

$1498.3 (millions)

This chart relates to the apportioned/budgeted distribution of new fiscal year income to the Iowa Department of Transportation.

Road use tax funds and federal highway funds are estimated. The forecasted income correlates directly with the Road Use Tax Fund forecast presented to the Iowa Transportation Commission. Some amounts have been adjusted for rounding.

This chart does not include federal highway or transit funds transferred to local jurisdictions for local programming authority. It may not include additional sources of revenue related to prior years' allocations or as reimbursements for costs paid from previous years' income. Amounts designated for specific programs may not reflect actual amounts expended during the current fiscal year.



What

- Replace old bridge with new buried precast pipe or box culvert
- Install new precast culvert (typically concrete box) under existing bridge while bridge remains open to traffic
- Abandon existing bridge in place (old bridge = new road) after backfilling process completed

Where

- Good option for small, short span bridges in need of replacement
- Bridges where we can size the culvert for similar hydraulic capacity compared to original bridge
- Locations with adequate height/width clearance for construction
  - Effective in surprisingly tight clearance areas (precast advantage over CIP).
  - Need approx. 18-in horizontal clearance from face of bridge component, and about 6-in vertical from top of culvert to bottom of beam
  - Need 2-3 FT vertical clearance for slab bridges- no “bonus clearance” between beams
- Solution more prevalent in rural areas with bridges crossing streams and drainage ditches, but can be used anywhere a precast solution is hydraulically acceptable
- Method has also occasionally been used for pedestrian tunnel construction.

When

- We like replacing small bridges with culverts whenever we can, hydrology permitting, because culverts are much more cost effective and easier to maintain.
- We like this option whenever it is important to minimize traffic or detour route impacts… impacts associated are much less significant than a conventional remove/replace of existing structure.
- This option has also been used for staged projects where multiple work phases and temporary widenings/traffic shifts have been required. The box can be installed in advance of the other construction and the embankment above and adjacent to the box can be built/reconfigured/removed as needed to accommodate shifting traffic staging above.
- Under an aggressive construction schedule, it only requires a few days to get a precast box installed beneath a bridge, and a few more days for the backfill process. Total contract duration can be six weeks or less.

Why

- Significantly mitigate traffic impacts compared to conventional bridge removal/replacement. Total road user impacts and costs can be reduced to days or weeks instead of months as with a bridge replacement.
- Mitigate exposure and repair costs associated with undesirable detour routes on state or local roads where pavement condition is a concern. and there are risks of significant repair costs… explain typical detour agreements and approach with repairs, structural damage vs. surface.
- Clear cost savings advantage- while there are many project and site variables, typically less than 1/3 cost of new bridge, even with staging and backfill process.
- Longer term maintenance advantages- buried precast as opposed to structure that must be regularly inspected and maintained, eliminates frost formation with around 3-FT of backfill cover and need for maintenance “frost runs”.
- Reduce risks associated with stopped or queuing traffic, secondary crashes… Iowa DOT initiatives to reduce annual fatalities below 300.
- Compressed construction duration with precast segments produced in plant setting helps mitigate weather and flooding risks and contractor down-time. Many variables in construction vs. precast plant. Faster construction during low-flow periods where drainage can beeasier managed. Use of Late Start or Completion Date contracts provide optimum window for work.

How

- Core-out, subbase prep, place bedding below bridge. Methodology can also work with CIP, but much more risk of weather exposure and downtime. Small CIP culvert contractors may be able to meet an aggressive schedule, but still places owner/DOT/public at increased risk of delays.
- Need sliding method below bridge to allow precast segments to be slid into place- can't be dropped in place from top because bridge in the way.
- Various options for sliding method, but wide, centrally positioned concrete runways have preferable advanatages. Dishsoap has been used for lubrication in a number of cases.
- Wherever access permits use of small construction/compaction equipment, place granular floodable fill as backfill below bridge footprint
- Where construction equipment cannot access, place flowable mortar as fill.
- Install ring of compacted earthwork fill outside the footprint of the original bridge to contain the floodable/flowable material. Accommodate proper drainage of material. Use at least two separate lifts of flowable mortar, allowing settlement/ set time between.
- Block off / "square off" the shape of the structural beams below the bridge deck. Intent is for the abandoned bridge to have full bearing contact above the fill.
- Final lift to be placed through holes drilled in existing deck to ensure complete filling.

Culverts Under Bridges

Becoming a common retrofit for small, old bridges that need to be replaced.

Culverts and embankments are typically cheaper, easier to maintain than small bridges.

Allows traffic to remain active on bridge while culvert is being constructed below.

Install new culvert below bridge, then completely fill the void space between culvert and bridge.

Existing bridge deck is supported by new fill, converts “old bridge” into “new road”.

Floodable fill and flowable mortar used in areas not accessible to conventional earth compaction methods.

Method can be used with cast-in-place or precast culverts.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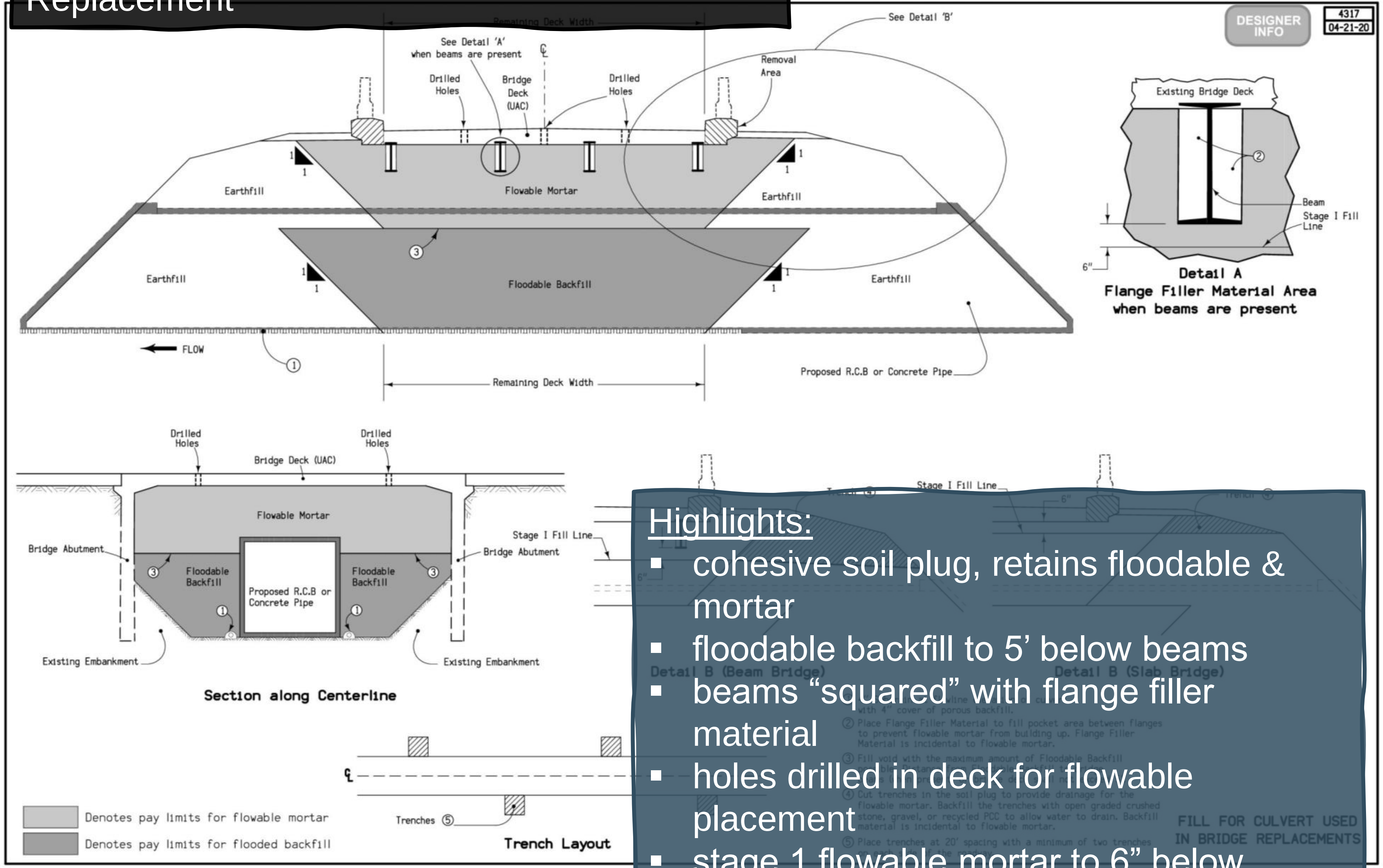
Roadway Standard Details:
4317: Fill for Culverts Used for Bridge Replacement



Highlights:

- cohesive soil plug, retains floodable & mortar
- floodable backfill to 5’ below beams
- beams “squared” with flange filler material
- holes drilled in deck for flowable placement
- stage 1 flowable mortar to 6” below

[Detail 4317]

“construct earthfill soil plug beyond limits of deck width… fill void with the maximum amount of floodable backfill possible… distance from floodable backfill to bridge beams shall not exceed 5’… place Stage 1 flowable mortar to within 6” of bottom of beams… ”

[Detail 4317]

“place flange filler material to fill pocket area between flanges to prevent flowable mortar from building up…”

[2526.02.F.2]

“in locations where fluidity is critical, such as inside existing culverts and between the beams under existing bridges, the Engineer will measure fluidity prior to placement and at least once every 4 working hours until work is complete…”

[2526.02.F.1 & 2526.02.F.2]
“measure the fluidity of the flowable mortar… prior to filling the flow cone with flowable mortar, pass the mixture through a ¼” screen… in locations where fluidity is critical, use an efflux time of 10 seconds to 16 seconds…”

[Detail 4317]
“drill holes in deck to allow Stage 2 flowable mortar placement through deck…”

[Detail 4317]

“Stage 2 flowable mortar placement to completely fill all remaining voids below deck…”


Genie


Genie
Genie S-45 XC


BEBO Arch Systems
Genie

Advantages

- Minimal road use impacts
- Eliminate need for detour route and associated repair costs
- Relatively simple and straightforward construction methods.
- For cost, durability, maintenance, and inspection reasons, culverts are preferred over bridges… it's better to replace an old bridge with a new culvert instead of a new bridge whenever possible.
- The final roadway profile is consistent with standard, embankment supported construction. Eliminates hazards, drop-offs, potential shoulder restrictions, and ice/hydroplaning vulnerabilities associated with bridges.

Disadvantages

- This method is comparatively more expensive than road closure, bridge removal, and open-trench precast RCB construction, but reduced user impacts and long-term maintenance cost savings can more than offset the minor cost differential.
- Buried/abandoned bridge can eventually become a nuisance or obstruction when the road gets reconstructed in the future. However the method of abandoning the structure also serves as a preservation method to some extent, so full removal may not be required for some time.
- For precast boxes, sliding segments over extended distances is generally less preferrable than lifting them into place. There are some unique risks associated with sliding segments over longer distances that requires thoughtful consideration.
- There have been a few cases where the original bridge foundations were already at or near capacity due to the bridges being subjected to heavier traffic load than originally designed for. In these cases, there has been concern that the existing bridge foundation might not be able to handle all the load associated with the new fill weight being installed beneath the bridge. It is conceivable that the existing bridge foundations could be subject to settlement as construction progresses and the new fill weight is added. The extent to which this is a concern may merit further investigation, although not a safety concern as the new fill supports everything from collapse/failure. This method of construction has not been used (without mitigation) where the existing foundation capacity is questionable.

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