

50.23 Culvert and Culvert Bridge Design

The following is an outline of minimum design requirements for culverts and culvert bridges built within Saint Louis County right-of-way. Cast-in-place reinforced concrete box culvert and box culvert bridge design shall generally be in accordance with the Missouri Department of Transportation (MoDOT) Bridge Design Manual. However, MoDOT standard drawings for these structures may only be used where specifically permitted herein. Precast concrete box culverts and culvert bridges shall be designed as directed herein. Circular and elliptical reinforced concrete pipe culverts and culvert bridges shall be designed and specified as directed herein. The use of corrugated metal and corrugated aluminum culverts and culvert bridges is not permitted except by the direct written authority of the Director or his designee. For culvert and culvert bridge design items not specifically covered in the MoDOT Bridge Design Manual, the "Standard Specifications for Highway Bridges" adopted by the American Association of State Highway and Transportation Officials shall be used as design specifications.

The design information in the above mentioned references shall be supplemented and superseded by the following requirements:

GEOTECHNICAL INVESTIGATION AND REPORT REQUIREMENTS

Detailed Geotechnical investigations and reports are required for the design of all bridges to be constructed within Saint Louis County right-of-way. This report shall be submitted for review by the Department prior to the commencement of design.

1) Investigation Requirements

At a minimum, one boring shall be taken per 75 feet of proposed culvert length taken along the centerline of the culvert. The borings shall be taken within 5 feet either side of the centerline of the proposed culvert measured perpendicular to the centerline of the proposed culvert. These borings shall also be taken within the length of the proposed culvert or no more than 5 feet beyond either end of the proposed culvert. All borings shall be taken to auger refusal or a depth of twice the distance between the proposed centerline profile grade and the proposed flow line of the channel, whichever is higher. When auger refusal is obtained, rock cores are to be extracted for a minimum depth of 5 feet.

The above requirements are to be waived for single barrel culverts of less than 8 feet clear span/diameter or with the prior written permission of the Director or his designee.

Drilling and sampling are to be performed in accordance with standard practice and applicable ASTM procedures. A minimum of one (1) undisturbed Shelby tube sample is required per every fifteen feet (15') of boring depth, provided that auger refusal is not reached in the first ten feet (10') of boring. A minimum of one Split-spoon sample is required for every five feet (5') of boring.

2) **Laboratory Testing Requirements**

- a) Visual classification shall be made for all samples and at changes in strata.
- b) Moisture contents are to be determined for all cohesive samples.
- c) Atterberg limits shall be determined for at least one sample per boring.
- d) Shear strength shall be determined in unconfined compression test for all Shelby tube samples.

3) **Report Requirements**

The report submitted for review by the Department shall contain the following information:

a) **Project and Site Description**

- i) Projection Description
- ii) Discussion of known geological characteristics of the area

b) **Field exploration**

- i) Location of borings
- ii) Method used for determining elevations
- iii) Equipment used
- iv) Drilling methods and sampling frequencies
- v) Problems encountered during the investigation
- vi) Personnel present

c) **Laboratory Testing**

- i) Frequency and type of tests performed
- ii) Location of results

d) **Discussion of Subsurface Conditions**

- i) Description of soil stratigraphy
- ii) Location and competency of rock
- iii) Extent of groundwater encountered

e) Design Considerations and Recommendations

- i)** Allowable bearing pressure
- ii)** Surface preparation
- iii)** Buoyancy protection
- iv)** Frost protection

Note: Saint Louis County Department of Highways and Traffic generally considers culverts and culvert bridges to be non-susceptible to frost effects. However, should the consultant find an unusual field condition which indicates that frost damage is possible, mitigating measures must be included in the report.

- v)** Anticipated settlement
- vi)** Lateral pressure

(1) Recommended design lateral pressure shall be presented. Lateral pressure shall meet MoDOT requirements for Seismic Performance Category B (45 p.c.f. minimum unless a smaller value can be justified by Monabe-Okabe analysis).

f) Field Data

- i)** Plan of Site and Borings
- ii)** Boring Logs
- iii)** Summary of Laboratory Tests
- iv)** Description of Terms and Symbols
- v)** Photographs of Rock Cores
- vi)** Any required design charts
- vii)** Mononabe-Okabe calculations, if required.

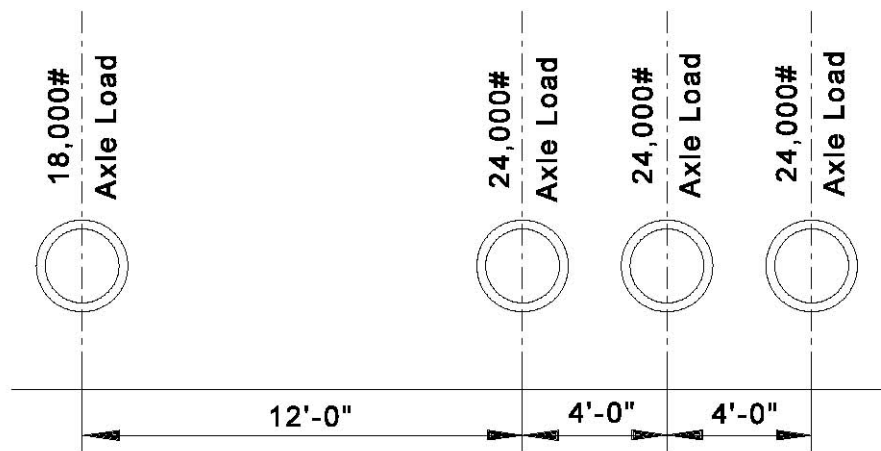
LOAD DESIGN CRITERIA

The following criteria apply to the design of ALL culverts and culvert bridges to be constructed within Saint Louis County right-of-way (may be waived by the Director for single barrel and precast culverts with clear spans of less than eight (8) feet in favor of HS-20 loading, MoDOT standard drawings or ASTM/AASHTO precast culvert specifications):

1) Highway Live Load:

The design loading for each structural component shall be the more severe of:

a) Saint Louis County T45 Loading

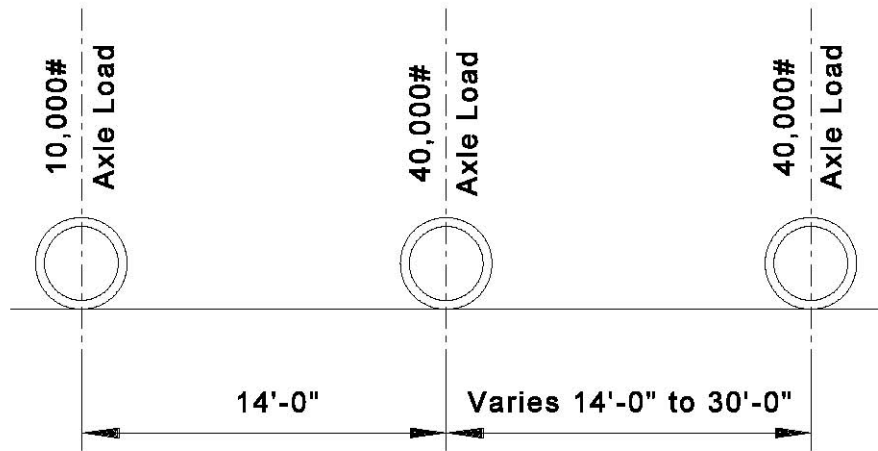


Transverse wheel spacing is to be 6 feet.

This loading is to be applied as a truck loading **ONLY**. (There is no equivalent lane load for long spans)

b) **HS25 Loading**

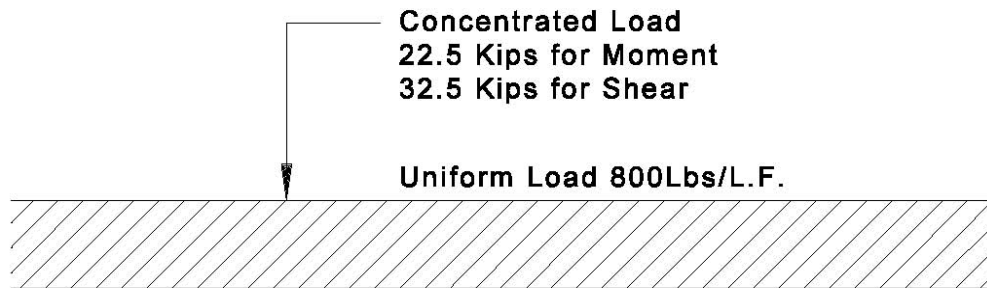
TRUCK LOADING



Transverse wheel spacing shall be 6 feet.

Rear axle spacing to be used shall be that which produces the maximum stress.

LANE LOADING



HS25 loadings shall be positioned as per Article 3.11 of the AASHTO Standard Specifications for Highway Bridges.

2) **Future Wearing Surface**

Designs shall include a provision for a future wearing surface equivalent to three (3) inches of asphaltic concrete pavement.

3) Load Distribution Through Fill (Cast-in-place reinforced concrete box culverts)

Distribution shall conform to Article 6.4 of the AASHTO Standard Specifications for culverts with design fill heights of greater than two (2) feet. The design fill height shall be considered to be the fill height at the high quarter point between the roadway curbs (or edge of shoulders for roadways without curbs.) Distribution may not carry across transverse expansion joints.

4) Provisions for Precast Reinforced Concrete Box Culverts

As previously stated, ALL culverts and culvert bridges constructed within Saint Louis County right-of-way shall be designed to carry the greater of the Modified Military or HS25 loadings. As a result, ASTM C-1433 tables may NO LONGER BE USED to design precast concrete box culverts (except for precast culverts with clear spans of less than 8 feet where specifically approved by the Director). These culverts shall be individually designed using the FHWA's BOXCAR program or other approved method. Precast concrete box culverts may not be used where the fill height at any location within the right-of-way is less than one (1) foot.

STRUCTURAL FORM

1) Culvert Barrels

- a) Culverts and culvert-bridges beneath Saint Louis County rights-of-way shall be limited to a maximum of three (3) adjacent barrels in order to prevent excessive debris build-up.
- b) Skewed precast concrete box culvert sections will not be permitted unless specifically approved by the Director or their designee. Skewed precast concrete box culverts may be accomplished by constructing skewed cast-in-place end sections at the culvert ends.
- c) Precast headwalls, toewalls, wingwalls, wingwall footings and aprons will not be permitted. These items are to be constructed cast-in-place and connected to the culvert by the following means:
 - i) Extending the box culvert mesh 15 inches beyond the end of the end culvert section into the cast-in-place work.
 - ii) Using dowel bar splicing anchors to splice #5 bars at 12 inch centers into the cast-in-place work a minimum distance of 15 inches.
 - iii) Schemes involving drilling and grouting of reinforcing bars after casting of the culvert section will **not** be approved.
- d) Elbows in precast concrete box culvert sections will not be permitted. These areas shall be cast-in-place for a minimum distance of five (5) feet either side of the interior elbow angle. The cast-in-place wingwall shall be attached to the remainder of the culvert in a method similar to that used to connect the wingwalls.

- e) Culverts and culvert-bridges beneath Saint Louis County rights-of-way shall provide for headwalls and wingwalls sufficient to maintain 3H:IV slopes at all locations.
- f) Cast-in-place reinforced concrete box culverts shall be constructed with:
 - i) Full upstream and downstream aprons extending between the exterior wingwalls.
 - ii) Upstream and downstream toewalls of a minimum one (1) foot thickness extending a minimum of two (2) feet beneath the bottom of the apron.
 - iii) Intermediate wingwalls extending from and having the same thickness as the interior culvert walls. The intermediate wingwall shall be of the same length as the exterior wingwalls.
- g) Precast reinforced concrete box culverts shall be constructed with:
 - i) Full upstream and downstream aprons extending between the exterior wingwalls.
 - ii) Upstream and downstream toewalls of a minimum one (1) foot thickness extending a minimum of two (2) feet beneath the bottom of the apron.
 - iii) Intermediate wingwalls extending from and having the same thickness as the interior culvert walls. The intermediate wingwall shall be of a minimum length equal to one-half the exterior wingwall length.
- h) Precast and cast-in-place reinforced concrete box culverts shall be constructed with traffic safety features (either reinforced concrete safety barrier or three-beam bridge rail) which are integrally connected to the structure, as required.
- i) Culverts or culvert bridges with design fills one (1) foot or less shall incorporate full depth bridge approach slabs conforming to Standard Drawing C503.00 or C503.01.
- j) Chain link fence conforming to Standard Drawing C607.12 shall be installed on all headwalls and exterior wingwalls for all culverts greater than 3.5 feet in clear height. If fence is required, it shall be extended for the entire length of the wingwall.

MATERIAL AND MISCELLANEOUS DETAILING REQUIREMENTS

1) Reinforcing Steel

- a) All reinforcing steel incorporated into culverts or culvert bridges on Saint Louis County right-of-way shall be Grade 60 bars conforming to ASTM A615, Yield Stress = 60,000 p.s.i.

- b) Welded wire fabric used in the construction of precast concrete box culverts shall be as specified in the Saint Louis County Standard Specifications for Highway Construction.
- c) Epoxy coated reinforcing steel shall be used within two (2) feet of the roadway surface. This includes bars which protrude into this area from lower elevations. Bar supports for epoxy coated reinforcement must also be epoxy coated.
- d) Clearances - Minimum concrete cover for reinforcing steel in cast-in-place culverts shall be as follows (except where the use of MoDOT standard drawings have been specifically approved by the Director):

Cast Against Earth.....	3 inches
Clearance to Top Roadway Surface.....	3 inches minimum
Barriers	1½ inches
All Other Reinforcement	2 inches

For precast concrete culverts, the reinforcement clearances shall be as specified in the Section 1049 of the Saint Louis County Standard Specifications for Highway Construction.

2) Concrete

- a) Cast-in-place culvert and culvert bridge concrete shall be Class B, design 28-day strength, $f_c = 3,500$ p.s.i. Should design strengths greater than 3,500 p.s.i. be required for economical design, Class B2 concrete shall be specified.
- b) Precast concrete culvert concrete shall be as specified in Section 1049 of the Saint Louis County Standard Specifications for Highway Construction. The minimum design strength shall be 5,000 p.s.i.
- c) Safety barrier concrete shall be Class B1, design 28-day strength, $f_c = 4,000$ p.s.i.

DESIGN CALCULATIONS

After the culvert and bridge design is complete, the design calculations must be bound, legible, signed and sealed by a Registered Professional Engineer in the State of Missouri, and submitted to the Project Manager.