

BASIS OF DESIGN

DESIGNED IN ACCORDANCE WITH 2014 AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SEVENTH EDITION AND MNDOT BRIDGE DESIGN MANUAL.

MATERIAL PROPERTIES:

WELDED WIRE REINFORCEMENT, MINIMUM SPECIFIED YIELD STRESS	65 KSI
REBAR REINFORCEMENT, MINIMUM SPECIFIED YIELD STRESS	60 KSI
CONCRETE, MINIMUM SPECIFIED COMPRESSIVE STRENGTH	5 OR 6 KSI (SEE TABLES)

SOIL DATA:

UNIT WEIGHT	120 lb/ft ³
RATIO OF LATERAL TO VERTICAL PRESSURE FROM WEIGHT OF EARTH	0.50 MAX TO 0.25 MIN
INTERNAL FRICTION ANGLE OF BACKFILL	30 DEGREES
SOIL STRUCTURE INTERACTION FACTOR, F _o	F _o = 1 + 0.20(H/B) ^c
	B _c = OUTSIDE WIDTH OF CULVERT
	H = FILL HEIGHT, DEFINED AS THE DISTANCE FROM THE TOP OF THE CULVERT TO THE TOP OF THE PAVEMENT OR TO TOP OF FILL IF THERE IS NO PAVEMENT.

RESISTANCE FACTORS

(FROM AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS):

FLEXURE	1.0
SHEAR	0.90

LOADING DATA:

LOAD MODIFIERS:

DUCTILE STRUCTURES	η = 1.0
FOR EARTH FILL: NON-REDUNDANT MEMBER	η = 1.05
FOR LIVE LOAD: REDUNDANT MEMBER	η = 1.0

LOAD FACTORS: (STRENGTH)

DEAD LOAD	MAX DC = 1.25, MIN DC = 0.90
EARTH LOAD (VERTICAL)	MAX EV = 1.30, MIN EV = 0.90
EARTH LOAD (HORIZONTAL)	MAX EH = 1.35, MIN EH = 0.90
LIVE LOAD	LL = 1.75
APPROACHING VEHICLE LOAD	LS = 1.75
WATER	WA = 1.0

LOAD COMBINATIONS

STRENGTH LIMIT STATE	
MAX V/MAX H	1.25DC + 1.30EV + 1.75(LL+IM) + 1.35EH + 1.75LS
MAX V/MIN H	1.25DC + 1.30EV + 1.75(LL+IM) + 1.00WA + 0.9EH
MIN V/MAX H	0.9DC + 0.9EV + 1.35EH + 1.75LS

SERVICE LIMIT STATE	
MAX V/MAX H	1.0DC + 1.0EV + 1.0(LL+IM) + 1.0EH + 1.0LS
MAX V/MIN H	1.0DC + 1.0EV + 1.0(LL+IM) + 1.0WA + 1.0EH
MIN V/MAX H	1.0DC + 1.0EV + 1.0EH + 1.0LS

LIVE LOAD

GREATER OF:

TRUCK AXLE LOAD	32 kips
TANDEM AXLE LOAD	2 AT 25 kips EACH

LIVE LOAD DISTRIBUTION

IF DEPTH OF FILL, H < 2 FT.	
DIRECTION PERPENDICULAR TO SPAN	E = 96 (In.) + 1.44SPAN (ft.)
DIRECTION PARALLEL TO SPAN	Espan = 10 (In.) + 1.15H (In.)

IF DEPTH OF FILL, H ≥ 2 FT.	
DIRECTION PERPENDICULAR TO SPAN	W = 20 (In.) + 1.15H (In.)
DIRECTION PARALLEL TO SPAN	L = 10 (In.) + 1.15H (In.)

CONSTRUCTION COMPACTOR LOAD	55 kips DISTRIBUTED OVER 84 In. X 24 In.
MULTIPLE PRESENCE FACTOR	MPF = 1.2 (FOR ONE LANE)

DYNAMIC LOAD ALLOWANCE (VARIABLE WITH DEPTH)	IM = 0.33(1-0.125H), H ≤ 8, IF H > 8 IM = 0
LANE LOAD (APPLIED TO BOXES WITH SPANS OF 15 ft. OR GREATER)	640 p/f DISTRIBUTED PER AASHTO 3.6.1.2.4

APPROACHING VEHICLE LOAD (PARALLEL TO SPAN) (TRAPEZOIDAL PRESSURE) ②	LS = K * Y _s * heq
	K = 0.33 ②
	Y _s = 120 lb/ft ³

EQUIVALENT FILL HEIGHT	
ABUTMENT HEIGHT (ft.) ①	heq (ft.)
< 5.0	4.0
5.0 TO 10.0	5- 0.2*(ABUTMENT HEIGHT)
10.0 TO 20.0	4- 0.1*(ABUTMENT HEIGHT)
> 20.0	2.0

① THE ABUTMENT HEIGHT CORRESPONDING TO THE LATERAL PRESSURE AT THE TOP OF THE CULVERT IS THE DISTANCE FROM THE TOP OF THE TOP SLAB TO THE TOP OF THE PAVEMENT OR FILL.

THE ABUTMENT HEIGHT CORRESPONDING TO THE LATERAL PRESSURE AT THE BOTTOM OF THE CULVERT IS THE DISTANCE FROM THE BOTTOM OF THE BOTTOM SLAB TO THE TOP OF THE PAVEMENT OR FILL.

② TRAPEZOIDAL LATERAL LIVE LOAD PRESSURE METHODOLOGY WAS USED TO APPROXIMATE A BOUSSINESQ DISTRIBUTION.

WATER

DEPTH OF WATER IN BOX SECTION EQUAL TO INSIDE RISE

MINIMUM DISTANCE BETWEEN ADJACENT LINES OF BOX CULVERTS:

THE USE OF "U BOLT TIES" (REFER TO ROADWAY STD PLATE 3145) TO SECURE CULVERT SECTIONS REQUIRES APPROXIMATELY 18" OF ROOM BETWEEN ADJACENT LINES OF BOX CULVERTS TO ALLOW FOR INSTALLATION OF THE TIE. THIS DISTANCE CAN BE REDUCED TO AS LITTLE AS 6" BY USING A "DOUBLE CONNECTION TIE" (REFER TO ROADWAY STD PLATE 3145) AND PLACING THE TIE ON THE INTERIOR SIDE OF THE SECOND (AND THIRD) CULVERT LINE. PROVIDE A NUT AND WASHER AT EACH END OF THE DOUBLE CONNECTION TIE ROD. IN NO CASE SHALL THE DISTANCE BETWEEN ADJACENT BOXES BE LESS THAN 6".

LOAD RATING

ALL STANDARD CONCRETE BOX CULVERTS WERE DESIGNED TO MEET THE 2014 AASHTO LRFR REQUIREMENTS WITH A MINIMUM LRFR BRIDGE OPERATING RATING FACTOR = 1.3 FOR HL-93, MNDOT STANDARD PERMIT TRUCKS G-80, AND MNDOT STANDARD PERMIT TRUCKS G-07. HL-93 WAS THE GOVERNING LOAD.

STRUCTURAL ARRANGEMENT:

REINFORCEMENT AREAS SHOWN ON FIGURES 5-395.100(B)-(E) ARE IN SQUARE INCHES PER LINEAL FOOT OF BARREL. ALL REINFORCEMENT LENGTHS AND AREAS ARE MINIMUM REQUIREMENTS. REINFORCEMENT REQUIREMENTS AND AREAS ARE FOR WELDED WIRE REINFORCEMENT. IF BAR REINFORCEMENT IS SUBSTITUTED FOR WELDED WIRE REINFORCEMENT, INCREASE THE AREA OF REINFORCEMENT BY 8%, AND SUBMIT DESIGN CALCULATIONS VERIFYING COMPLIANCE WITH AASHTO 5.7.3.4 "CONTROL OF CRACKING BY DISTRIBUTION OF REINFORCEMENT".

TRANSVERSE REINFORCEMENT IS PARALLEL TO THE CULVERT SPAN.

LONGITUDINAL REINFORCEMENT IS PERPENDICULAR TO THE CULVERT SPAN.

REINFORCEMENT SPACING 4.0 In. MAX.
SPACE CENTER TO CENTER OF TRANSVERSE WIRES NOT LESS THAN 2" NOR MORE THAN 4". SPACE CENTER TO CENTER OF LONGITUDINAL WIRES NOT MORE THAN 8".

CONCRETE COVER OVER REINFORCEMENT (ALL FACES) 1/2 In. MIN., 2 In. MAX.
③ HAUNCH DIMENSIONS 12 In. VERTICAL, 12 In. HORIZONTAL (ALL SPANS AND RISES)

CULVERTS CONSTRUCTED WITHOUT HAUNCHES REQUIRE SPECIAL DESIGN NOT INCLUDED IN THESE STANDARDS.

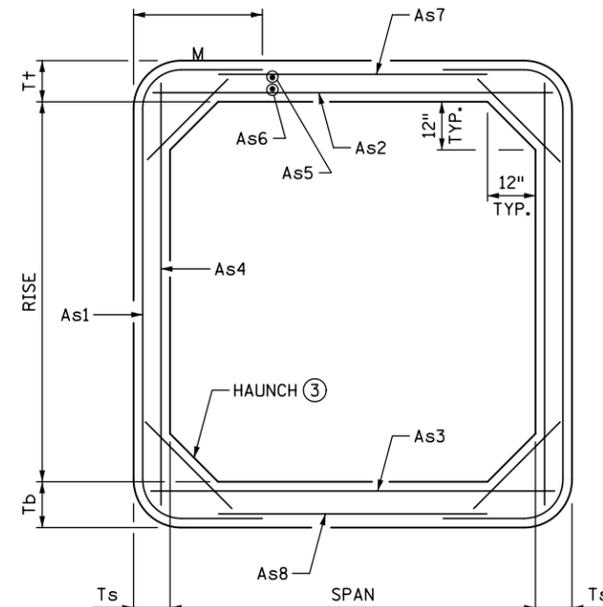
MINIMUM REINFORCING PARALLEL TO SPAN,
INCLUDING As1, As2, As3, As4, As7, As8 0.002 * b * h, (b = THICKNESS OF SLAB, h = 12 In.)
PERPENDICULAR TO SPAN, INCLUDING As5, As6 0.06 In²/ft

SKEW BOX CULVERT SECTIONS WERE DESIGNED ASSUMING TRAFFIC TRAVELING PARALLEL TO THE SPAN AND UP TO A SKEW ANGLE OF 45°. IF CULVERT SECTIONS ARE PLACED IN A DIFFERENT ARRANGEMENT, THEY MAY NEED TO BE REDESIGNED. BOX CULVERT END SECTIONS WERE DESIGNED FOR SKEW EFFECTS AND ARE LOCATED ON FIG. 5-395.102 THROUGH 5-395.110(B).

AXIAL THRUST THE BENEFIT OF AXIAL THRUST WAS NOT INCLUDED IN THE BOX CULVERT DESIGN FOR THE STRENGTH LIMIT STATE, HOWEVER IT WAS INCLUDED IN THE SERVICE LIMIT STATE CRACK CONTROL CHECK.

SHEAR SHEAR CHECKED AT 1.0 d_v FROM TIP OF HAUNCH PER AASHTO 5.13.3.6.1. FOR SLABS OF BOXES WITH LESS THAN 2.0 ft. OF FILL AND FOR WALLS OF BOXES OF ALL FILL HEIGHTS SHEAR RESISTANCE CALCULATED PER AASHTO 5.8, SECTIONAL METHOD GENERAL PROCEDURE. FOR SLABS OF BOXES WITH 2 FT. OF FILL OR GREATER THE SHEAR RESISTANCE WAS CALCULATED PER AASHTO 5.14.5.3. UP TO A MAXIMUM THICKNESS OF 12 INCHES. FOR SUCH SLABS WITH THICKNESSES EXCEEDING 12 IN., CONTACT THE BRIDGE STANDARDS UNIT FOR SHEAR PROVISIONS.

CRACK CONTROL CRACK CONTROL CHECK PER AASHTO 5.7.3.4 ASSUMING CLASS 2 EXPOSURE CONDITIONS. THE STRESS IN THE STEEL REINFORCEMENT CALCULATED PER AASHTO C12.11.3 AND LIMITED TO 0.6*f_y. INCLUDE AXIAL THRUST IN SERVICE LIMIT STATE ANALYSIS.



BOX CULVERT CROSS SECTION

REVISION: 10-09-2015
APPROVED: MARCH 24, 2011
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DO NOT INCLUDE WITH PLAN

FIG. 5-395.100(A)
TITLE:
PRECAST CONCRETE BOX CULVERT-
BASIS OF DESIGN