Classification of Bridges at Fort Wingate, New Mexico
Letter Report

NEWTEC

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Mr. Moon performed a visual inspection of Bridges 143, 144, 145, 146, and 427. The following discrepancies were revealed:

2.1 Bridge 143
- Watch erosion on pile bents.
- It may be necessary to line the channel with concrete to minimize erosion (for both structural and security reasons).
- The headwalls continue to deteriorate.

2.2 Bridge 144
- Erosion continues on both east and west abutments.

2.3 Bridge 145
- Soil is eroding from north pile on west abutment.
- Water is causing erosion behind both abutments.
- Rip-Rap or shot-crete west abutment to stop erosion from pile.

2.4 Bridge 146
- Excavate and backfill both abutments to stop erosion.

2.5 Bridge 427
- Remove trees growing under bridge.

Additionally Mr. Moon performed a drive-by visual inspection of several culverts on the west side of Fort Wingate noted in the April 2008 report. These culverts are still clogged with debris which has reduced the capacity of the culverts and will result in a complete washout if not cleaned, removed, and headwalls repaired and or replaced. The main arroyo where this damage was noticed is east of Gate 209. It is understood the west side of Fort Wingate is contaminated from past ammunition demilitarization operations; it is a BRAC responsibility which the Corps of Engineers is responsible for. Another culvert that needs headwall repairs is on the north-south road just north of Bridge 144. These areas are shown on Figures 48-52 of this document.

The bridge load limit signs on Bridges 141, 243, 144, 145, 146, and 427 are deteriorated and the load limits are unreadable. New signs for each bridge should be made and installed. There is no load limit sign on Bridge 1. NewTec is fabricating and installing bridge signs shown on the next page.

Bridge No. 144 Capacity Wheel 50 Tons Track 40 Tons

Bridge No. 145 Capacity Wheel 5 Tons Track 5 Tons

Bridge No. 1 Capacity Wheel 54 Tons Track 50 Tons

The arroyos under all of the bridges are filled with undergrowth and debris which can cause the flow path to meander and cause unpredictable erosion. They should be cleaned and the debris removed.

It was noticed that all of the major paved roads (double bituminous surface treatment (DBST)) are in poor condition apparently from a lack of maintenance. It would be reasonable to consider applying a two-inch Chip Seal to prevent further deterioration of these roads. These roads could be a safety concern especially in the snow and icing conditions that occur in the winter months.

Safety of the permanent workforce is another concern. It is not prudent to have a workforce of one in this isolated location. A great deal of heavy equipment is used and if an accident or illness occurred there would be no one to render first aide or notify emergency officials. Additionally, there appears to be more work than one person can accomplish on this large site (650 acres). Also considering the wildlife present (bears, mountain lions, bobcats, and poisonous snakes), it is highly recommended that an additional person should be hired to support the current caretaker.

An analysis of the moment and shear caused by the TRACS Van and the HERA missile trailer on Bridge 141 was performed and can be found in Appendix B. These values were compared to the moment and shear capacity of Bridge 141. A similar analysis should be performed when axle loads are available for the new TRACS Van. Because Bridge 1 has a larger moment and shear capacity than Bridge 141, it can support all the current expected launch equipment being used at Fort Wingate. If larger equipment is planned a new analysis should be performed.

4.1.2 Bridge 141 east abutment north pile requires the following repairs:

- Excavate around the bottom pile past the dry rot
- Cut off the dry rotted portion of the pile
- Weld 6" nelson studs to the two steel plates
- Compact the soil around the pile
- Place a 4' x 4' reinforced concrete slab from the compacted base to the bottom of the top pile.

4.1.3 Excavate/replace deteriorated headwall timbers, fill and compact potholes behind the abutments on Bridges 141, 143, 144, 145, and 146.

4.1.4 Clean and remove debris on channels under all of the bridges and repair the erosion on the west abutment of Bridge 145 with compacted soil. Fill and shot-Crete the area to protect the soil.

4.1.5 Inspect and maintain as necessary the streambeds and arroyos annually.

4.1.6 Lease or procure a "Bobcat" tractor to provide the workforce the equipment to efficiently perform stream bed maintenance throughout the year.

4.1.7 Remove the debris and repair the headwalls on the culverts along the arroyos that flow next to Gate 209 (approximately four or five culverts).

4.1.8 Repair the damaged headwall on the culvert near Bridge 144.

4.1.9 When axel loads are available for the new TRACS Van, perform an analysis of the moment and shear caused by the new TRACS Van and compare the results to the moment and shear capacity of Bridge 141.

4.1.10 Perform a similar comparison for any new missiles to be used at Fort Wingate.

5.0 REFERENCES

5.1 Letter Report, NEWTEC-LTRRPR-1DB1-NNS-001, 21 June 2001.

5.2 Letter Report, NEWTEC-LTRRPR-SDG400-NDA-001, 23 December 2003.

5.3 Letter Report, NEWTEC-LTRRPT-S2JC00-7A.03-001, 16 April 2008.

5.4 TM 5-312, Military Fixed Bridges, December 1968.

5.5 FM 5-34, Engineer Field Data, December 1965.

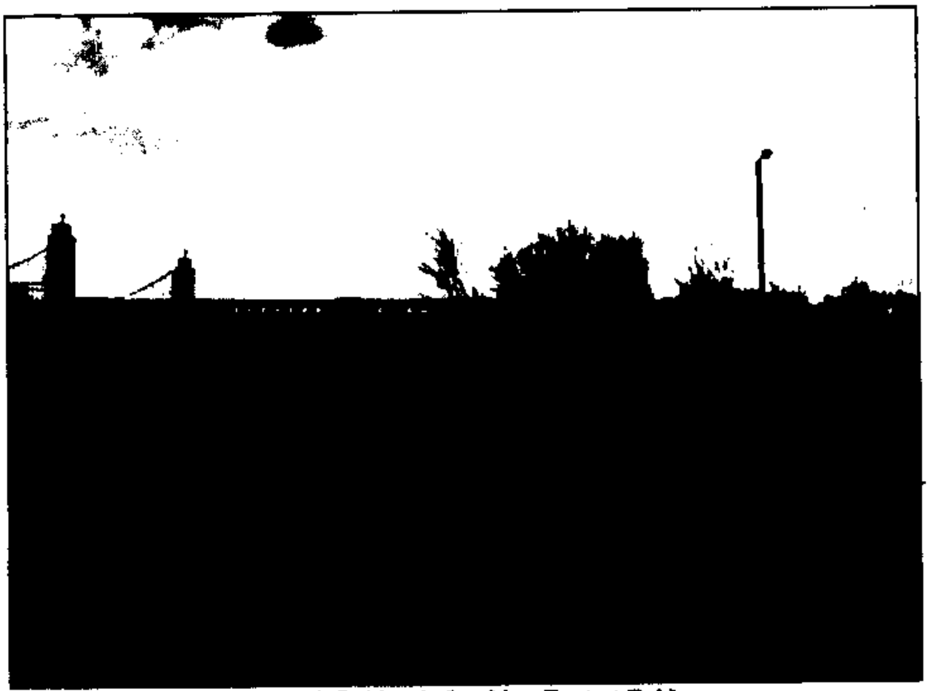


Figure 6, Bridge 1: Looking East at Bridge

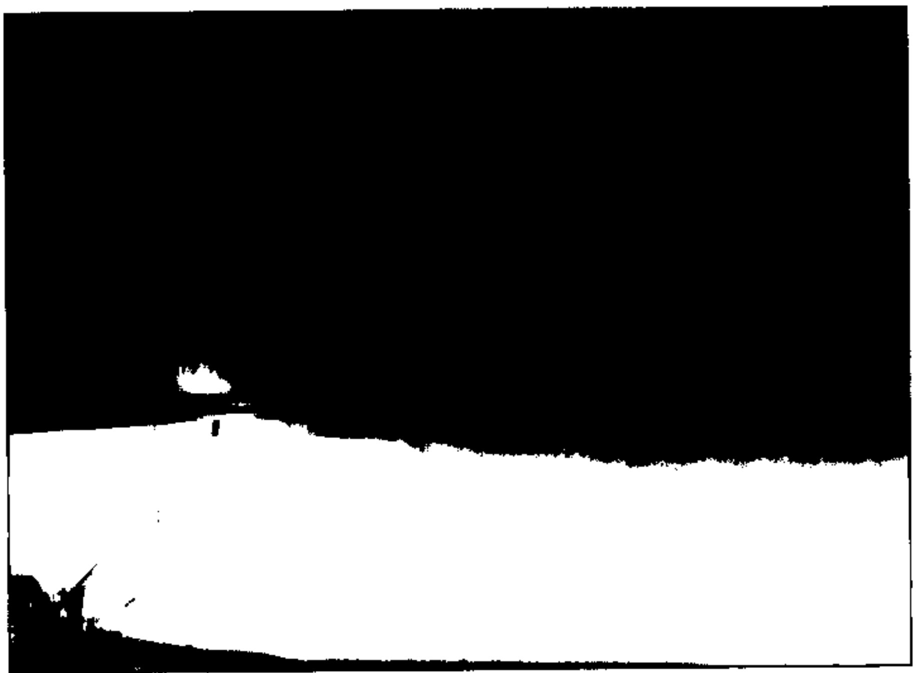


Figure 7, Bridge 1: Looking at North Abutment

Figure 10, Bridge 1: Looking North Showing Lateral Bracing

Figure 11, Bridge 1: Looking South

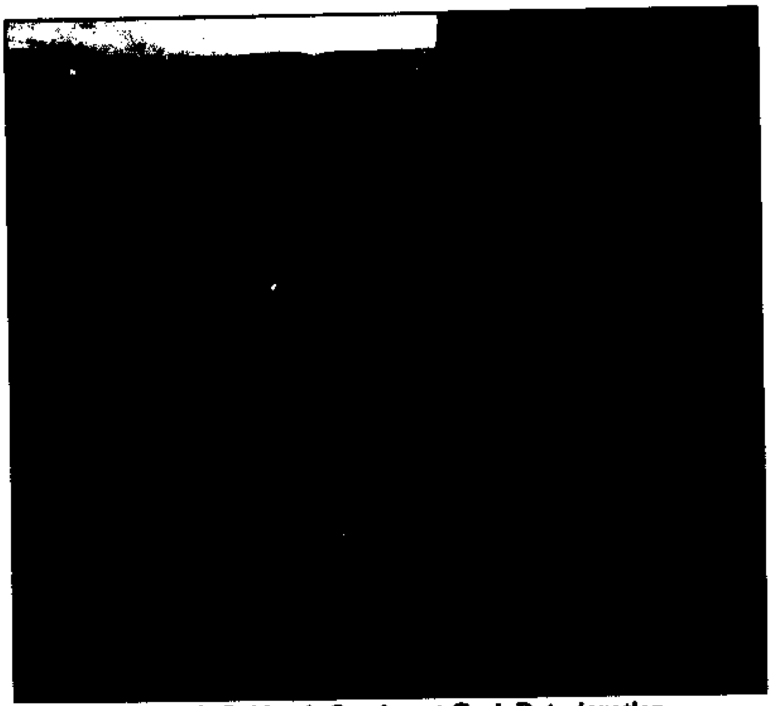


Figure 2, Bridge 1: Southwest Curb Deterioration

Figure 3, Bridge 1: Southeast Curb Deterioration

Figure 14, Bridge 141: Pothole at Northeast Abutment

Figure 15, Bridge 141: Pothole at Southeast Abutment

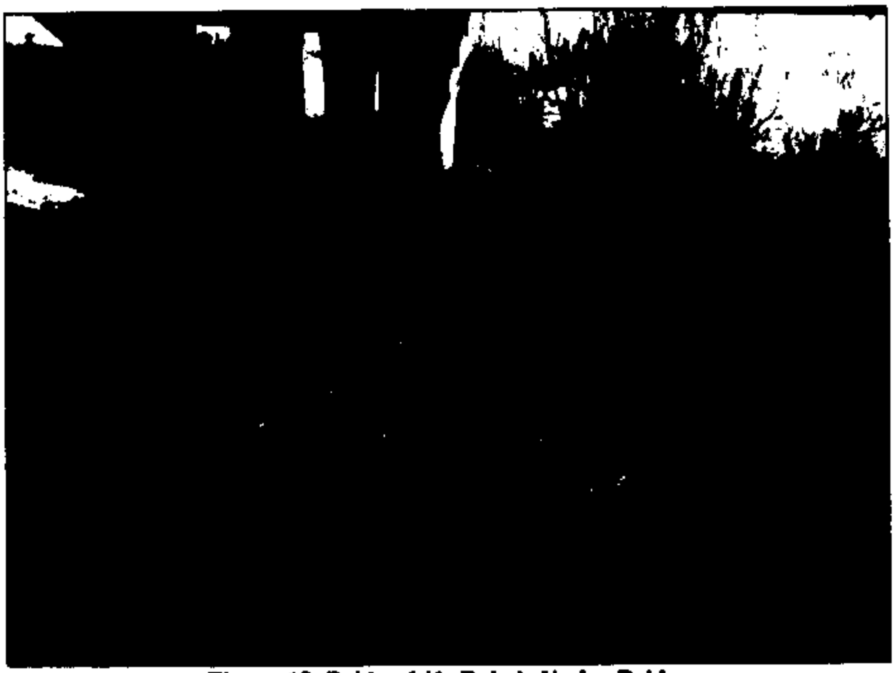


Figure 18, Bridge 141: Debris Under Bridge

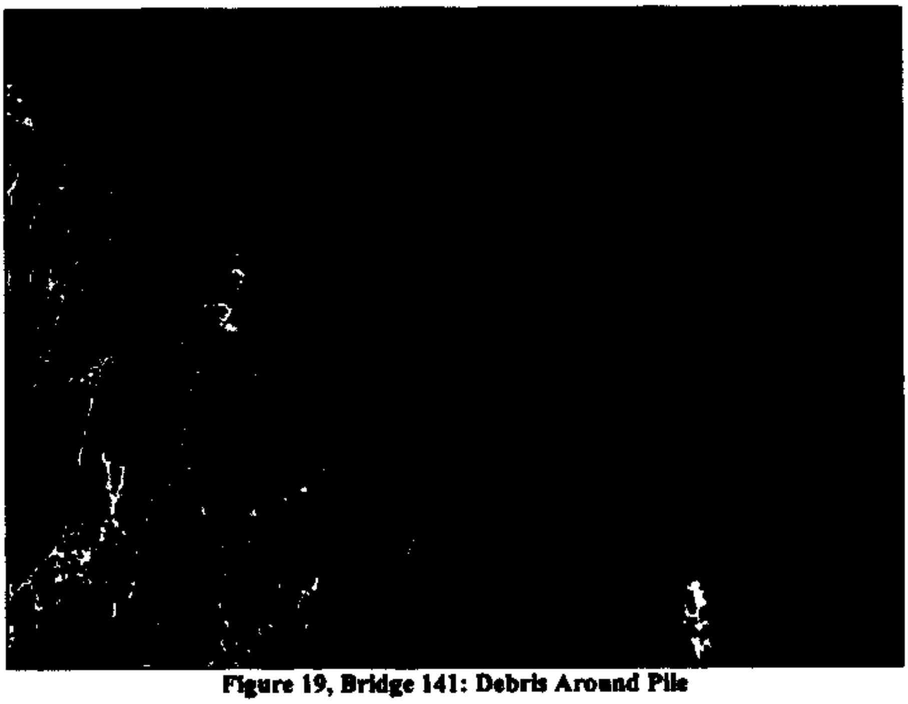


Figure 19, Bridge 141: Debris Around Pile

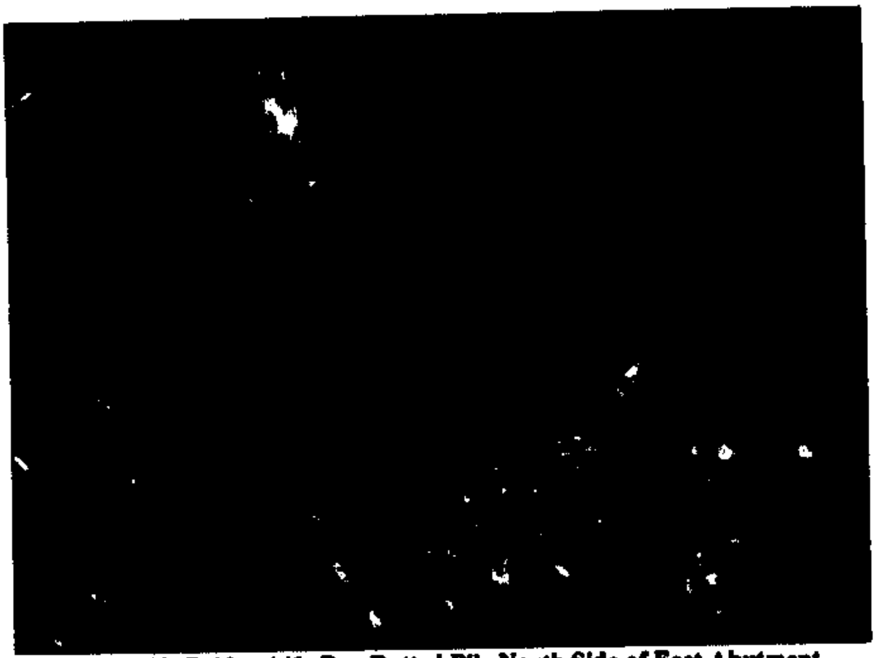


Figure 22, Bridge 141: Dry Rotted Pile North Side of East Abutment

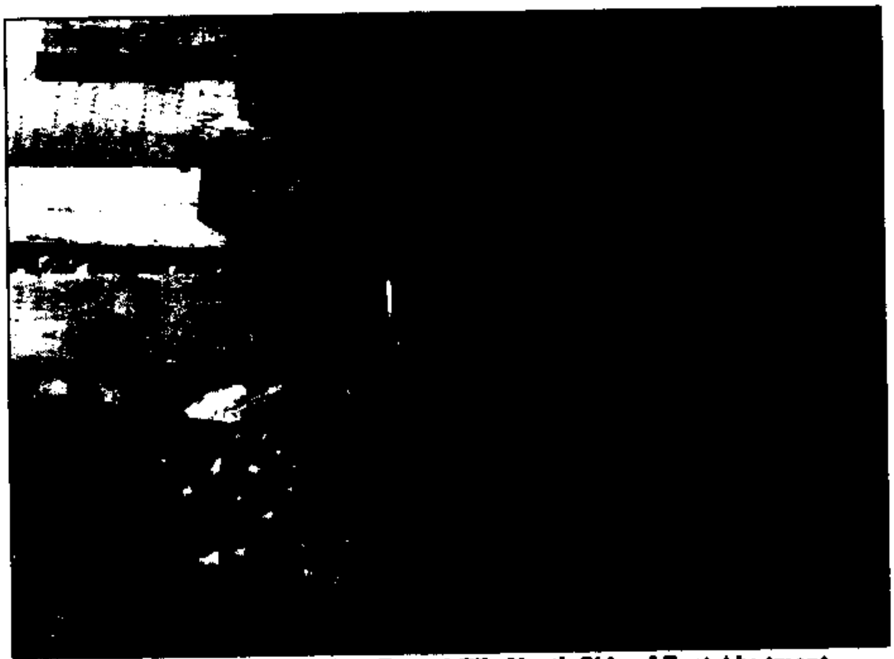


Figure 23, Bridge 141: Dry Rotted Pile North Side of East Abutment

Figure 26, Bridge 144: East Abutment Head Wall

Figure 27, Bridge 144: Loose Nut on Pile Bent X Brace

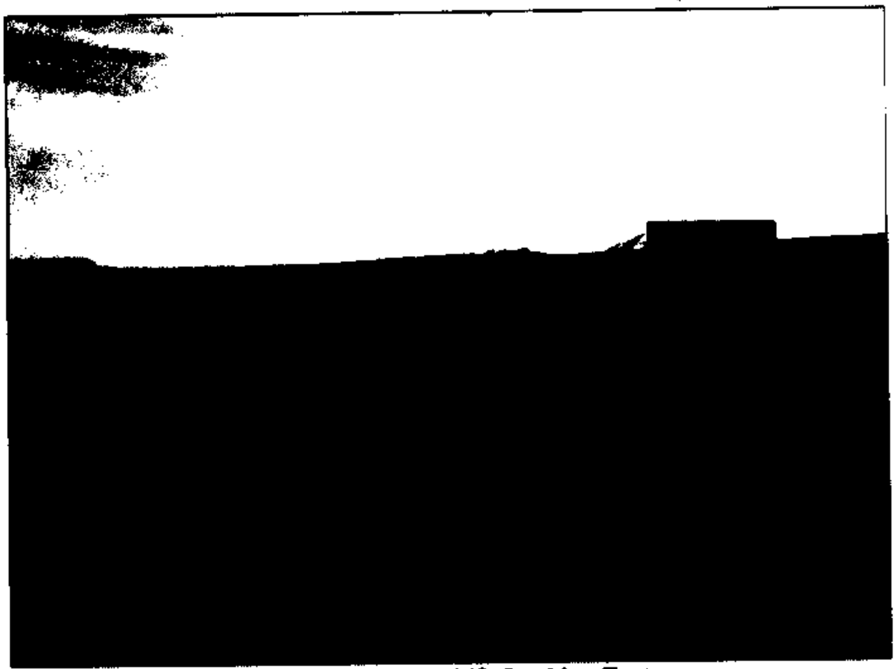


Figure 30, Bridge 143: Looking East

Figure 31, Bridge 143: Pothole East Abutment and Dry Rotted Headwall Timber

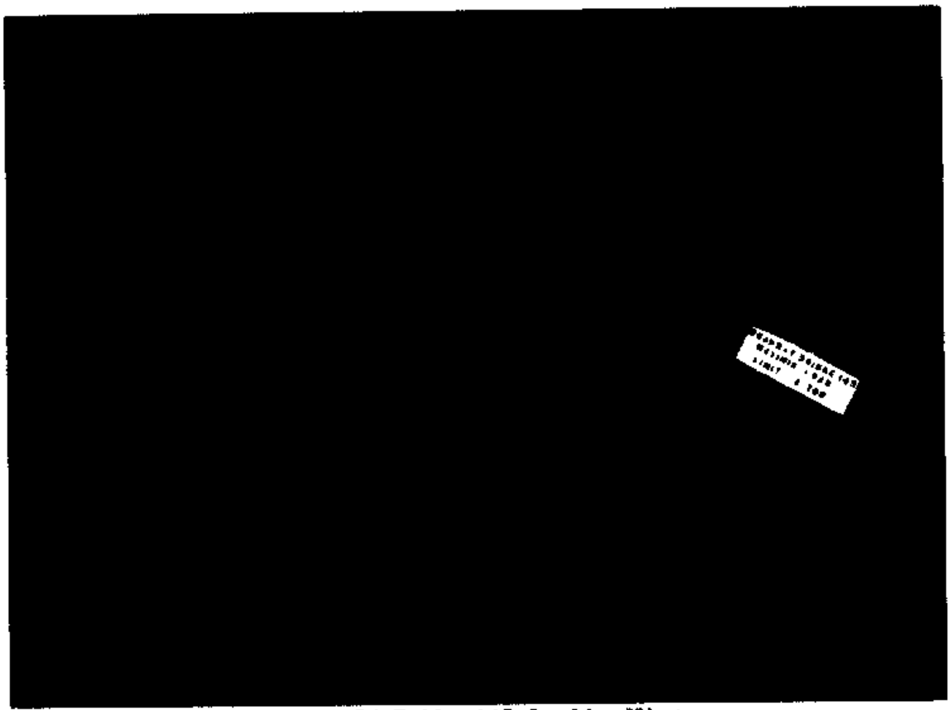


Figure 34, Bridge 145: Looking West

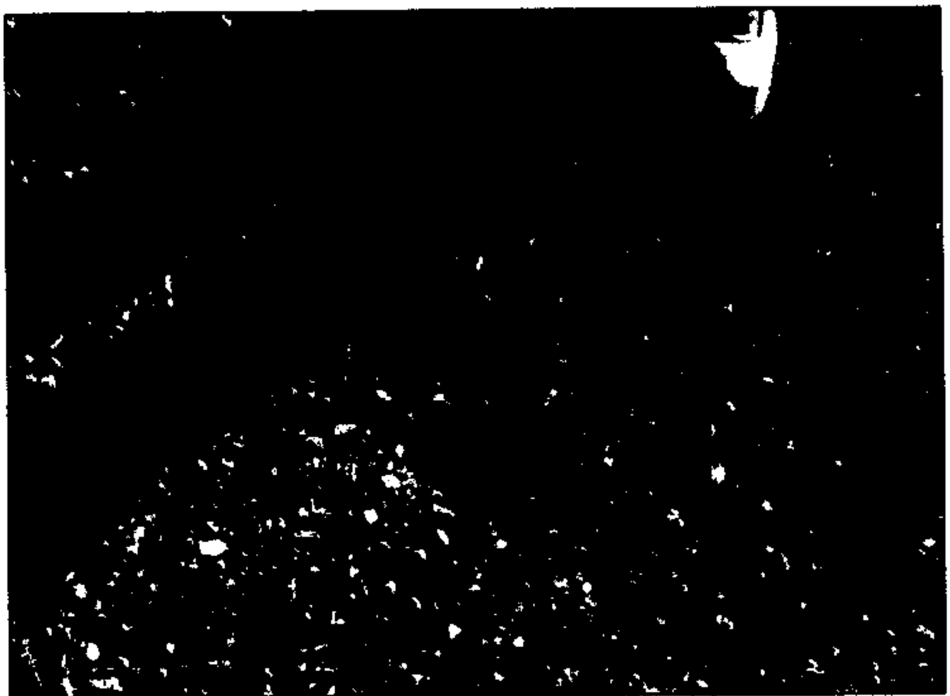


Figure 35, Bridge 145: West Abutment Broken Tread Way Timbers

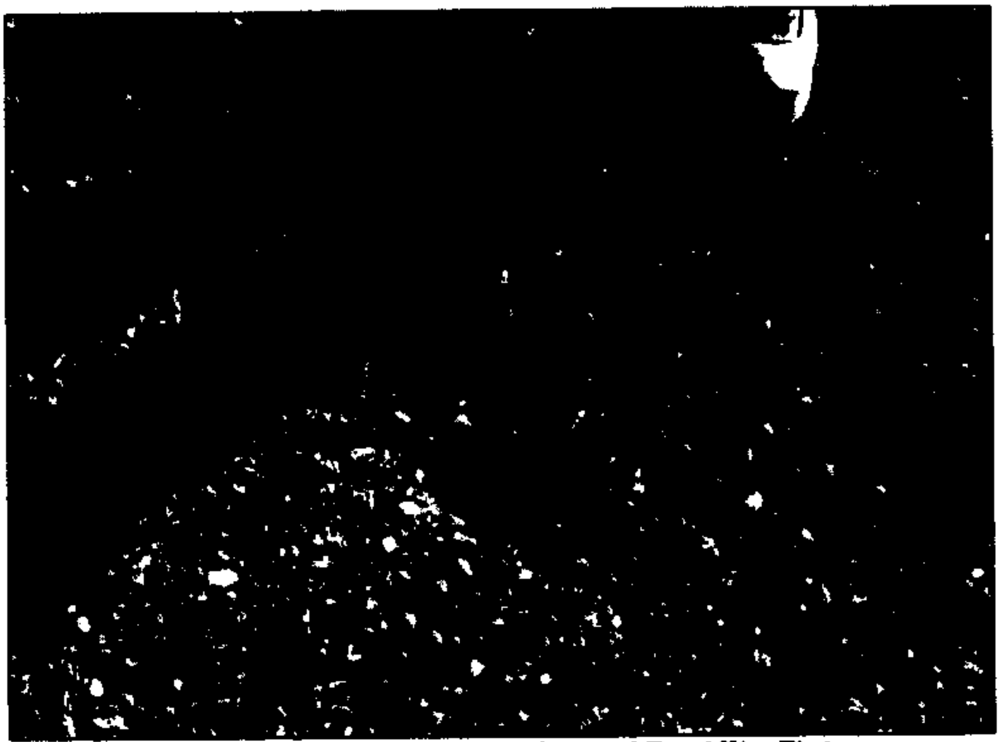


Figure 38, Bridge 145: Pothole and Damaged Tread Way Timber

Figure 39, Bridge 145: Looking South

Figure 42, Bridge 146: Looking South

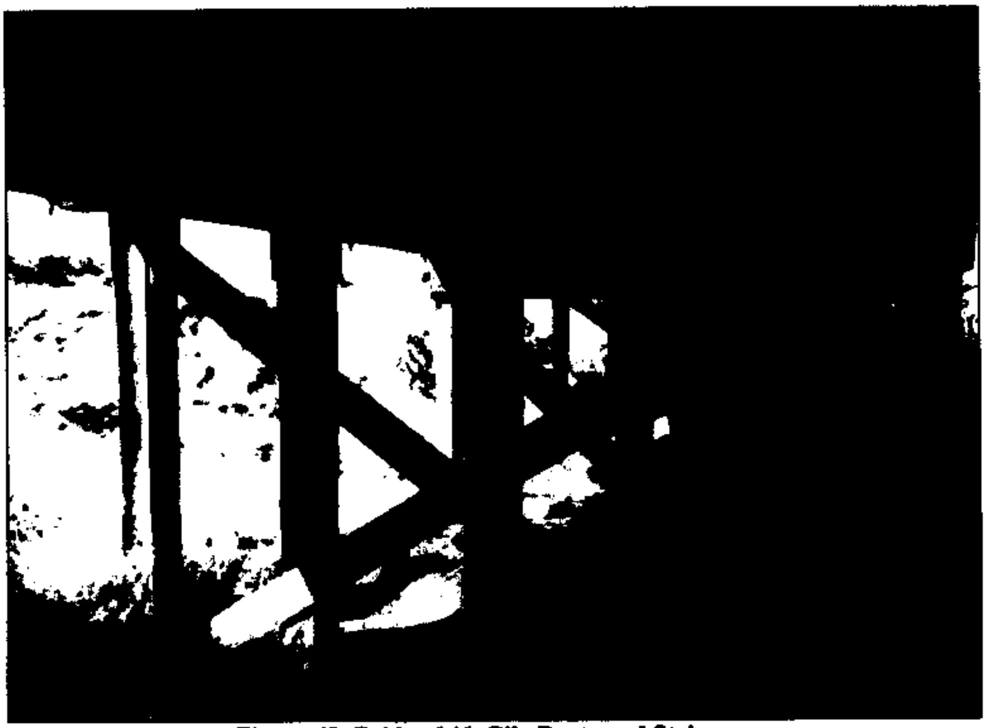


Figure 43, Bridge 146: Pile Bents and Stringers

Figure 46, Bridge 427: Looking North

Figure 47, Bridge 427: Undergrowth that should be Removed

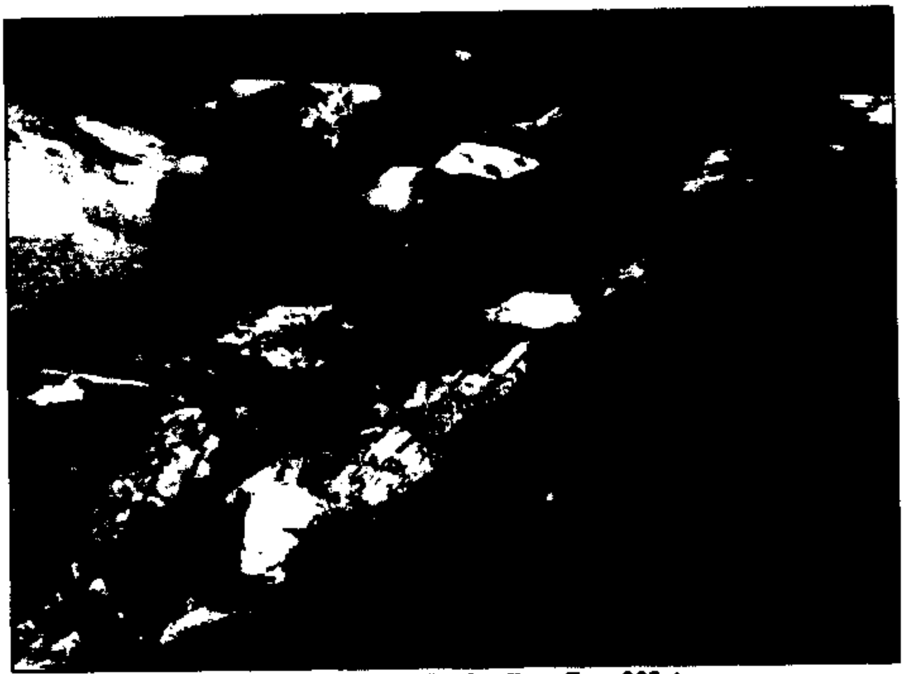


Figure 50, Demolished Headwall on Gate 209 Arroyo

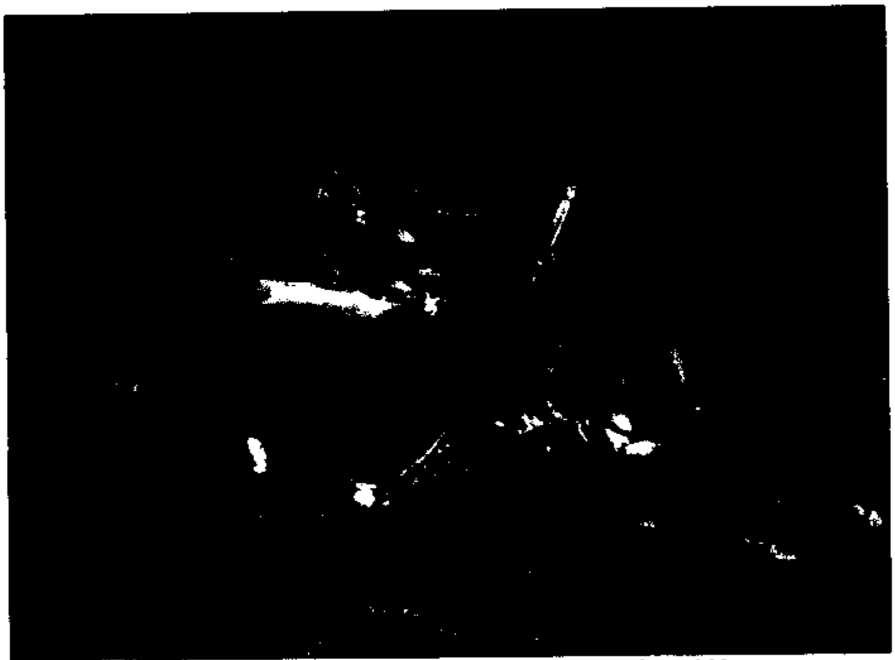


Figure 51, Clogged Culvert on Arroyo by Gate 209

6.0 APPENDIX A: LOAD CARRYING CAPACITY OF BRIDGES AT FORT WINGATE, NEW MEXICO

Bridge 1

Fort Wingate Bridge 1
Classification of Steel Stringer Bridge Ref. FM 3-34.343 (FM5-446)
The following analysis follows the procedure referenced in FM 3-34.343 for classifying a steel girder bridge by the analytical classification method.
a. Moment Capacity, m.

The stringers were determined to be W36x194
From Table D-2

$S_x := 663.6\,in^3$

From Table 3.5

$F_y := 33000\,\frac{lbf}{in^2}$

From Table 3.6

$F_b := 0.75\,F_y$

$F_b = 24750\,\frac{lbf}{in^2}$

Moment Classification for simple spans
m = total moment capacity of the individual structural component, in kip-feet.
F.b = allowable bending stress of the member, in kips per square inch (ksi)
S.x = section modulus, in cubic inches (Appendix C for timber and Appendix D for steel)

$m := F_b \cdot S_x$

$m = 16424100\,lbf \cdot in$

$m = 1368675\,lbf \cdot ft$

Dead Load and Dead-Load Moment of a Component
From section 3-35
mDL = dead-load moment per component, in lb-ft

wDL = total dead load per stringer, in lbpf (equiation 3-1)

L = span length, in feet (equivalent span length for continuous spans)
Compute for an average 1 ft length of bridge span. For W36x194, the unit weight stringers = 194 lb/ft. Unit weight of concrete = 150 lb/ft^3. Unit weight of channel braces = 33.9 lb/ft.

$w_s := 194\,\frac{lbf}{ft} \cdot \frac{1 \cdot ft}{12 \cdot in}$

$w_s = 194\,\frac{lbf}{ft}$

Live-Load Moment of a Component

m.LL = live-load moment per component, in lb-ft

m = total moment capacity, in lb feet (equation 3-2)

m.DL = dead-load moment per component, in lb-ft (equation 3-3)

x = impact factor (0 for timber; 0.15 for steel or concrete)

$x := 0.15$

$m_{LL} := \frac{m - m_{DL}}{1 + x}$

$m_{LL} = 803955 lbf \cdot ft$

$m_{LL} = 9647463 lbf \cdot in$

$S_s := 6$

$N_1 := \frac{14}{S_s}$

$N_1 = 2.333$

$N_2 := \frac{11}{S_s}$

$N_2 = 1.833$

Total Live-Load Moment Per Lane

$M_{LL1} := N_1 \cdot m_{LL}$

$M_{LL1} = 1875896 lbf \cdot ft$

$M_{LL2} := N_2 \cdot m_{LL}$

$M_{LL2} = 1473918 lbf \cdot ft$

M.LL = total live-load moment per lane, in lbf-feet

N.1,2 = number of effective components supporting the live load, for either one or two lane traffic. (Table 3.3, page 3-14)

m.LL = live-load moment per component, in lbf-ft. (equation 3-4)

Moment Classification

One Lane = W74, T64 based on a 63 ft span
Two Lane = W54, T50 based on a 63 ft span

Deck Classification

Seldom critical in bridge rating. Will be considered insignificant for these calculations.

Width Classification

One Lane = For a class W74, or T64 a minimum curb-to-curb width of 14.75 ft is required. Bridge 1 has a one lane curb-to-curb width of 25 ft. Therefore its One Lane classification shall be increased to W150 and T150.

$$\gamma := 40 \cdot \frac{lbf}{ft^3}$$

$$DL1 := Ns1 \cdot b1 \cdot d1 \cdot \gamma$$

$$DL1 = 311.667 \frac{lbf}{ft}$$

$$Ns2 := 10$$

$$DL2 := Ns2 \cdot b2 \cdot d2 \cdot \gamma$$

$$DL2 = 229.167 \frac{lbf}{ft}$$

Deck: width

$$Wd := 22 \cdot ft$$

$$td := \frac{1}{3} \cdot ft$$

$$DLd := Wd \cdot td \cdot \gamma$$

$$DLd = 293.333 \frac{lbf}{ft}$$

Asphalt: width

$$Wa := 21 \cdot ft$$

$$ta := \frac{1}{6} \cdot ft$$

$$\gamma a := 150 \cdot \frac{lbf}{ft^3}$$

$$DLa := Wa \cdot ta \cdot \gamma a$$

$$DLa = 525 \frac{lbf}{ft}$$

Accessories:

$$DLac := 100 \cdot \frac{lbf}{ft}$$

$$DLtot := DL1 + DL2 + DLd + DLa + DLac$$

$$DLtot = 1.459 \times 10^3 \frac{lbf}{ft}$$

Dead Load Moment Per Stringer:

$$wdl := \frac{DLtot}{Ns1 + Ns2}$$

Span Length:

$$L := 20 \cdot ft$$

$v2 = 1.32 \times 10^4 \, lbf$

Dead Load Shear:

$$vdl := \frac{wdl \cdot L}{2}$$

$vdl = 694.841 \, lbf$

Use v2:

$vll := v2 - vdl$

$vll = 1.251 \times 10^4 \, lbf$ Allowable Total Shear:

$$V := \frac{16}{3} \cdot vll \left(\frac{N1}{N1 + 1} \right)$$

$V = 5.648 \times 10^4 \, lbf$

Use Table D-4 of Reference 4a: Class 50 Wheel
Table D-5 of Reference 4a: Class 40 Track

Check Deflection

$E := 1.2 \cdot 10^6 \cdot psi$

$$dmin := \frac{35L \cdot fb}{E}$$

$dmin = 23.1 \, in$

Since the minimum depth of the stringer, dmin, is > 17 inches, the deflection check is OK.

Lateral Bracing

Since d/b > 2 for both stringer types, lateral bracing is required.
Maximum unsupported length:

$$Lu := \frac{8.1 \cdot 5.5}{2.4}$$

$Lu = 18.563$

Lateral bracing is used at the third points, or 6.67 ft; OK.

Timber End Bearing

Allowable bearing stress

$fb := 500 \cdot psi$

Actual bearing stress:

$Cb := 11 \cdot in$

$$fba1 := \frac{v1}{b1 \cdot Cb}$$

$fba1 = 247.273 \, psi$

$$fba2 := \frac{v2}{b2 \cdot Cb}$$

$M := fb \cdot \frac{b \cdot d^2}{6}$

$M = 7.627 \times 10^4\, lbf \cdot ft$

Dead Load:

Stringers

Number of Stringer:

$Ns := 5$

Specific weight:

$\gamma := 40 \cdot \frac{lbf}{ft^3}$

$DL := Ns \cdot b \cdot d \cdot \gamma$

$DL = 144.444 \frac{lbf}{ft}$

Deck: width

$Wd := 12 \cdot ft$

$td := \frac{1}{4} \cdot ft$

$DLd := Wd \cdot td \cdot \gamma$

Accessories:

$DLac := 100 \cdot \frac{lbf}{ft}$

$DLtot := DL + DLd + DLac$

$DLtot = 364.444 \frac{lbf}{ft}$

Dead Load Moment Per Stringer:

$wdl := \frac{DLtot}{Ns}$

Span Length:

$L := 26.50 \cdot ft$

$mdl := \frac{wdl \cdot L^2}{8}$

$mdl = 6.398 \times 10^3\, ft^2 \frac{lbf}{ft}$

Allowable Live Load Moment per Stringer:

$mll := M - mdl$

$mll = 6.987 \times 10^4\, lbf \cdot ft$

Live Load Moment Capacity for Bridge:

$$dmin := \frac{35L \cdot fb}{E}$$

$dmin = 30.608 in$

Since the minimum depth of the stringer, dmin, is > 17 inches, the deflection check is OK.

Lateral Bracing

Since d/b > 2 for both stringer types, lateral bracing is required.

Maximum unsupported length:

$$Lu := \frac{8.1 \cdot 6.5}{3.3}$$

$Lu = 15.955$

Lateral bracing is used at the third points, or 8.83 ft; OK.

Timber End Bearing

Allowable bearing stress

$fb := 500 \cdot psi$

Actual bearing stress:

$Cb := 11 \cdot in$

$$fba := \frac{v}{b \cdot Cb}$$

$fba = 232.727 psi$

Since actual timber bearing stress is less than the allowable; OK.

Adequacy of Deck Thickness

Use figure 6-7 of the Reference 4a. The deck thickness is 3 inches. The stringer spacing is 36 inches. Therefore the bridge class based on deck thickness is less than Class 8; about Class 5.

Capacity of Trestle Bents

Reference 4b, page 163,

Load capacity per pile, 12-inch diameter, is 28 tons. There are 3 piles per bent. Therefore the bent load capacity is 3 * 28 = 84 tons.

Controlling Load Classification

The deck classification controls: **5 Wheel**
5 Track

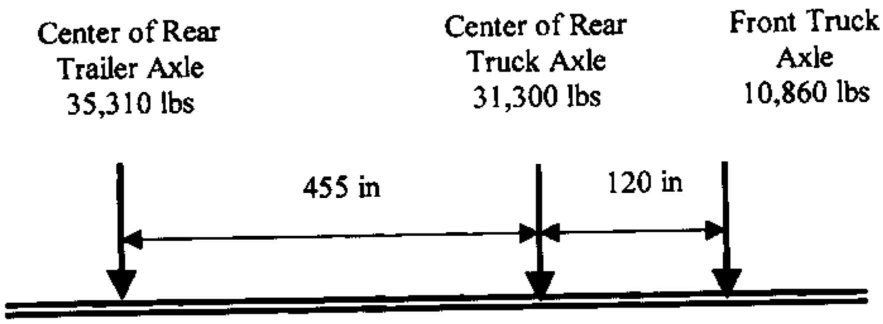
7.0 APPENDIX B: CLASSIFICATION OF TRACS VAN AND MISSILE TRAILER

INTRODUCTION

This document shows the calculations for the shear and moment loads produced by the TRACS Van and the HERA missile trailer on Bridge 141 at Fort Wingate. These two vehicles are required to support missile testing. Bridge 141 is the only bridge at Fort Wingate traversed by these vehicles. The loads produced by these vehicles are compared to the shear and moment capacity of Bridge 141 (see Reference 4a).

TRACS VAN

The data for the TRACS Van model was obtained from References 4b and 4c. The simplified sketch shown below portrays the axle spacing and loads that are used in these calculations.



There are two cases to consider. One is the rear trailer axle on a span. The second is both truck axles on a span.

Case 1: Rear trailer axle on the span.
Case 2: Both truck axles on a span.

$P1 := 31300\,lbf$
$P2 := 10860\,lbf$
$b := 10\cdot ft - a$
$L := 20\cdot ft$

$$M(a) := a\cdot\frac{[P1\cdot(L-a) + P2\cdot(10\cdot ft - a)]}{L}$$

$$\frac{d}{da}M(a) \rightarrow \frac{1}{20}\cdot\frac{[31300\,lbf\cdot(20\cdot ft - a) + 10860\,lbf\cdot(10\cdot ft - a)]}{ft} - 2108\,a\cdot\frac{lbf}{ft}$$

Trial value of a for root function

$a := 5\cdot ft$

$$\mathrm{root}\left[\left[\frac{1}{20}\cdot\frac{[31300\,lbf\cdot(20\cdot ft - a) + 10860\,lbf\cdot(10\cdot ft - a)]}{ft} - 2108\,a\cdot\frac{lbf}{ft}\right], a\right] = 8.712\,ft$$

$a := 8.712\cdot ft$

$b := 10\cdot ft - a$ $M(a) = 1.6\times 10^{5}\,ft\cdot lbf$

The maximum moment occurs at P1 because R1 < P1.

The maximum shear occurs when a = 0.

$$V := \frac{P1\cdot L + P2\cdot 10\cdot ft}{L}$$

$V = 3.673\times 10^{4}\,lbf$

The maximum moment, from Case 1, is $M = 1.765 * 10^5$ ft lbf. The maximum shear, from Case 2, is $V = 3.673 * 10^4$ lbf.

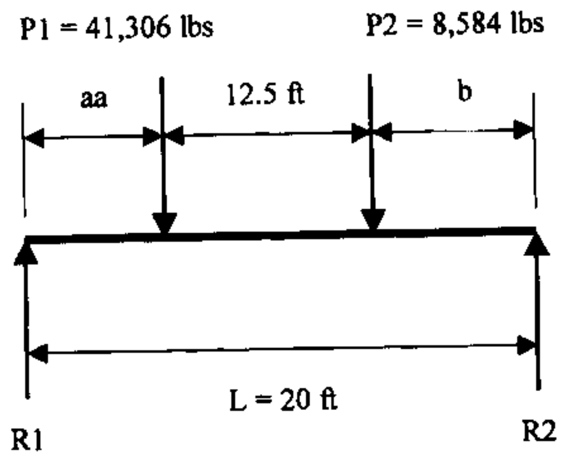
The allowable live load moment capacity for Bridge 141, from Reference 4a, is $Mcap = 2.944 * 10^5$ ft lbf. The allowable shear is $5.648 * 10^4$ lbf. Both values are greater than the corresponding maximum values produced by the TRACS Van.

Therefore, the TRACS Van can safely traverse Bridge 141.

HERA MISSILE TRAILER

The data for the HERA missile trailer model was obtained from Reference 4e. The simplified sketch shown on the next page portrays the axle spacing and loads that are used in these calculations.

Case 2: Both truck axles on a span.



See page 2-299 of Reference 4d.

Calculate the value of "aa" that causes the maximum moment under P1.

$P1 := 41306\,lbf$

$P2 := 8584\,lbf$

$b := 7.5\cdot ft - aa$

$L := 20\cdot ft$

$$M(aa) := aa\cdot\frac{[P1\cdot(L-aa)+P2\cdot(7.5\cdot ft-aa)]}{L}$$

$$\frac{d}{daa}M(aa) \rightarrow \frac{1}{20}\cdot\frac{[41306\,lbf\cdot(20\cdot ft-aa)+8584\,lbf\cdot(7.5\cdot ft-aa)]}{ft}-\frac{4989}{2}\cdot aa\cdot\frac{lbf}{ft}$$

Trial value of a for root function:

$aa := 5\cdot ft$

$$root\left[\left[\frac{1}{20}\cdot\frac{[41306\,lbf\cdot(20\cdot ft-aa)+8584\,lbf\cdot(7.5\cdot ft-aa)]}{ft}-\frac{4989}{2}\cdot aa\cdot\frac{lbf}{ft}\right],aa\right]=8.925ft$$

$aa := 8.925\cdot ft$

$b := 7.5\cdot ft - aa$

$b = -1.425ft$

This is an invalid solution. Calculate the value of bb that causes the maximum moment under P2.

$aa := 7.5\cdot ft - bb$

$$M(bb) := bb\cdot\frac{P1\cdot(7.5\cdot ft-bb)+P2\cdot(L-bb)}{L}$$

$$\frac{d}{dbb}M(bb) \rightarrow \frac{1}{20}\cdot\frac{[41306\,lbf\cdot(7.5\cdot ft-bb)+8584\,lbf\cdot(20\cdot ft-bb)]}{ft}-\frac{4989}{2}\cdot bb\cdot\frac{lbf}{ft}$$

Trial value of a for root function:

$bb := 5\cdot ft$