CHAPTER 5

NONSTANDARD SUSPENSION BRIDGES

SECTION I

BRIDGE DESIGN

94 GENERAL.—The design of a suspension bridge requires an analysis of the following items:

- **A** Loads to be carried.
- **B** Panel length and stringers.
- **C** Floor beams.
- **D** Stiffening truss and sway bracing.
- **E** Dead load.
- **F** Suspenders.

G Sag ratio.
H Main cables.
I Towers.
J Tower bracing and back guys.
K Anchorages.

95 LOADS.—One or a combination of the following loads may be carried.

A Foot troops with full field packs.
B Loaded pack animals.
C One-quarter-ton truck with normal load.
D Trail tractor.
E Three-quarter ton weapon carrier with normal load.

96 PANEL LENGTH AND STRINGER DESIGN.—To maintain the general parabolic shape of main cables the panel lengths should be between 10 and 15 feet. As a general rule 10 feet is practical. Stringers for 10-, 12-, 14-, and 15-foot panel lengths may be designed by using Table VIII.

97 EXAMPLE OF STRINGER DESIGN.—
Load to be carried — ¼-ton truck
Panel length = 10 feet
Stringers available are 2- by 6-inch plank
Gross weight of ¼-ton truck = 3,250 pounds
From Table VIII, safe gross load of stringer 1 inch wide by 6 inches deep by 10 feet long is 0.19 tons.
Each 2- by 6-inch by 10-foot stringer will support 0.38 tons.

TABLE VIII. *Safe gross load in tons per inch of stringer width.*

Span in Feet	Depth of Beam in Inches					
	6	8	10	12	14	16
10	.19	.34	.55	.80	1.05	1.40
12	.15	.28	.44	.65	.90	1.15
14	.13	.24	.37	.55	.75	.95
15	.12	.22	.35	.50	.70	.90

NOTE: For round timber, use diameter of timber as depth and 0.4 of diameter as width.

0.38 tons = 760 pounds, gross load.

$$\text{Number of stringers} = \frac{\text{Gross weight of truck}}{\text{Loads each stringer supports}}$$

$$= \frac{3{,}250}{760} = 4.3 \text{ or } 5 \text{ stringers}$$

Hence five 2- by 6-inch 10-foot stringers are used.

98 FLOOR BEAMS.—Floor beams to hold the specified loads are given in Table IX.

99 STIFFENING TRUSS AND SWAY BRACING.—The action of the stiffening truss is to furnish vertical stability by spreading the load to two or more suspenders. The siderail and its cross braces may be designed to furnish this stiffening action. *V*-shaped bracings as shown are recommended.

Sway bracing or wind bracing furnishes lateral stability to the bridge. Wire or wood sway bracing is recommended for bracing a bridge.

100 DEAD LOAD.—Dead load is calculated in pounds per panel. It includes the weight of parts listed below.

2 suspenders
1 floor beam
2 stringers and (floor planks)
2 toeboards
2 side posts
2 kneebraces
4 braces
2 to 4 siderails
2 curbs (if used)
Cable clips and bands

TABLE IX. *Floor-beam size for given load.*

Load	Floor-beam Cross Section
Foot troops with full pack Loaded pack animals with handlers	4 by 4 inches
¼-ton truck with normal load	6 by 6 inches
¾-ton weapons carrier with normal load	8 by 8 inches

101 SUSPENDERS.—Suspenders are designed to carry the dead and live load plus an allowance for impact. The effect of wind is neglected.

The dead load is calculated as described in paragraph 100. The live load used is the gross weight of troops, animals, or vehicle. See Table X.

Impact is assumed to be equal to the total live load.

To find the total weight on both suspenders at a panel point take the sum of the following:

1 - Dead load (one panel)
2 - Live load
3 - Impact

The weight carried by one suspender is half the sum of these three factors. To find the size of suspender cable required for a given load see Appendix II.

102 LENGTH OF SUSPENDERS (fig. 47).—Suspender lengths are obtained from the formula:

$$h = L + \left(\frac{n}{N}\right)^2 (C + d)$$

in which h = effective suspender length
L = effective length of center suspender
n = panel point of suspender
N = panel point of tower
C = camber of bridge
d = dip of main cable

Example:

L = 5 feet 0 inches
n = 2
N = 4
C = 2 feet
d = 8 feet

$$h = 5 + \left(\frac{2}{4}\right)^2 (2 + 8) = 7\frac{1}{2} \text{ feet}$$

103 SAG RATIO.—The sag ratio of nonstandard bridges varies from 5 to 15 percent.

The nonstandard foot bridge described in paragraph 108 uses a 5 percent sag ratio. Heavier nonstandard bridges use a 10 percent sag ratio.

TABLE X. *Live loads for suspender design.*

Load	Gross Weight
Foot troops	200 pounds
Pack animal and handler	1,000 pounds
¼-ton truck	3,250 pounds
¾-ton weapons carrier	5,240 pounds

104 MAIN CABLE.—Main-cable design is governed by the load on the suspenders and the sag ratio.

In main-cable design the total load on the bridge—dead load, live load, and impact—is calculated. Table XI gives the relation between sag ratio and tension in main cables.

Example:

Using Table XI find maximum tension on both main cables:

Assume span 200 feet, sag ratio 10%	
Suspended weight of bridge	20,000 pounds
Live load on bridge	8,000 pounds
Impact on bridge	8,000 pounds
Total	36,000 pounds

Maximum tension in all cables for 10-percent sag ratio is 36,000 x 1.35 = 48,600 pounds (see column 2, Table XI).

If two main cables are used each must have a tensile strength of 24,300 pounds. See Appendix II.

The length of the cable required to span the gap is the sum of the cable length between towers, the two back-stay lengths, and the turns and ties at the deadmen.

Using the length factor in column (3) of Table XI, the cable required to span the gap between towers =

200 x 1.026 = 205.2 feet.

105 TOWERS.—Towers take the downward thrust of the main cables. Twelve- by twelve-inch timbers as posts and cap pieces will take military loads including the 2½-ton truck.

TABLE XI. *Main-cable design data.*

(1) Sag Ratio	(2) Maximum Tension in Both Main Cables, in Parts of Total Suspended Weight of Bridge and Load	(3) Length of Cable Between Towers, in Parts of Span Length
7%	1.94	1.012
8%	1.57	1.018
9%	1.46	1.022
10%	1.35	1.026
11%	1.23	1.033
12½%	1.12	1.041
16 2/3 %	.90	1.070

106 BRACING AND GUY LINES.—All towers have back, side, and fore braces of 6- to 8-inch timbers.

Side and back guys of ½-inch wire rope are used to brace the towers. Side guys have a 1 to 1 slope, while back guys are fastened to the main-cable deadman and have a 2½ horizontal to 1 vertical slope.

107 ANCHORAGES.—Design and placing of a deadman is described in paragraph 15. The total pull exerted on the deadman by the cables is the same as the maximum tension in all cables described in paragraph 104.

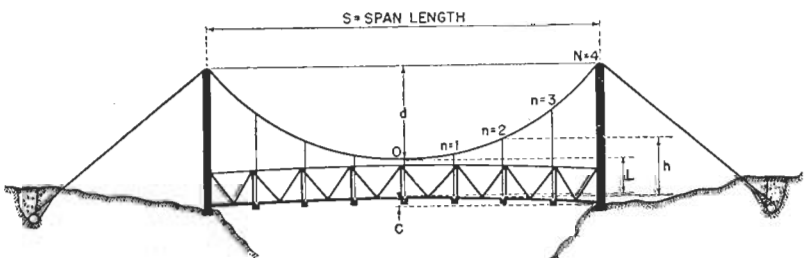


FIGURE 47. *Length of suspenders. Formula used to find EFFECTIVE suspender length.*

FIGURE 48. *Nonstandard footbridge.*

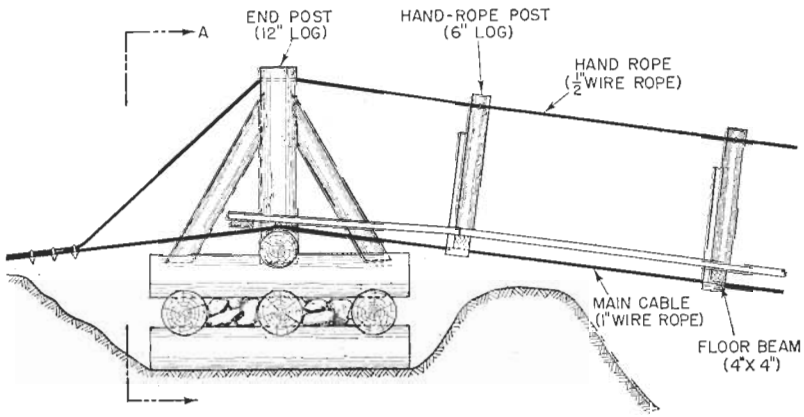
SECTION II

TYPICAL NONSTANDARD BRIDGES

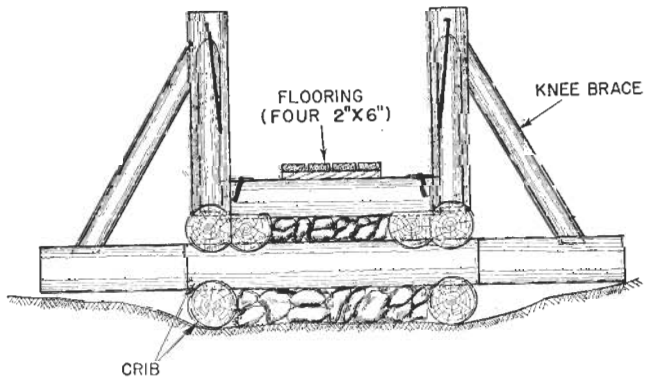
108 NONSTANDARD FOOTBRIDGE (fig. 48).—In this bridge the main cables support the flooring and extra capacity is added by the carrying power of the ½-inch handrail cables. No cable suspenders are used. The sag ratio is 5 percent. The bridge may be built in spans up to 150 feet in length.

The bridge will cross foot troops at 3-pace intervals. Pack animals cannot be crossed.

Design features are covered in figures 49 and 50.



ELEVATION



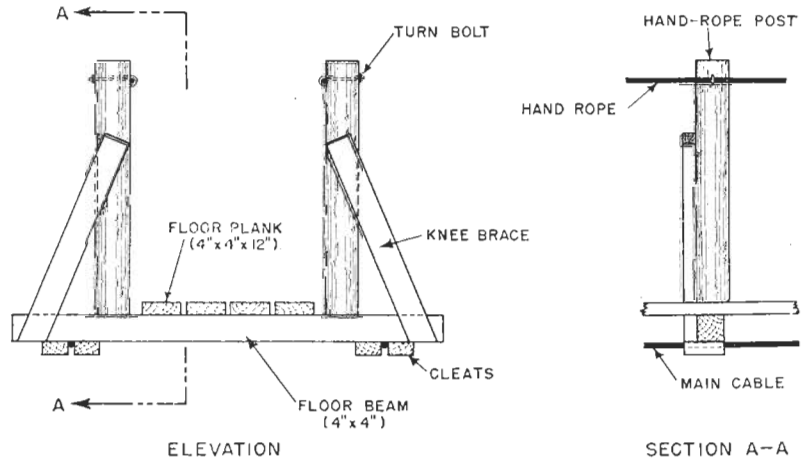
SECTION A-A

FIGURE 49. *Nonstandard footbridge design. Posts are used as suspenders.*

109 PACK-TRAIN SUSPENSION BRIDGE (fig. 51).—This is a more permanent bridge of 4,000-pound capacity. It may be built to span gaps up to 300 feet.

Its main design features are shown in figures 52 and 53. Its capacity may be doubled by adding an extra set of 1-inch main cables.

With one set of main cables, as shown, it will carry 40 foot troops or 8 pack mules and handlers.



ELEVATION SECTION A-A

FIGURE 50. *Hanger assembly of nonstandard footbridge.*

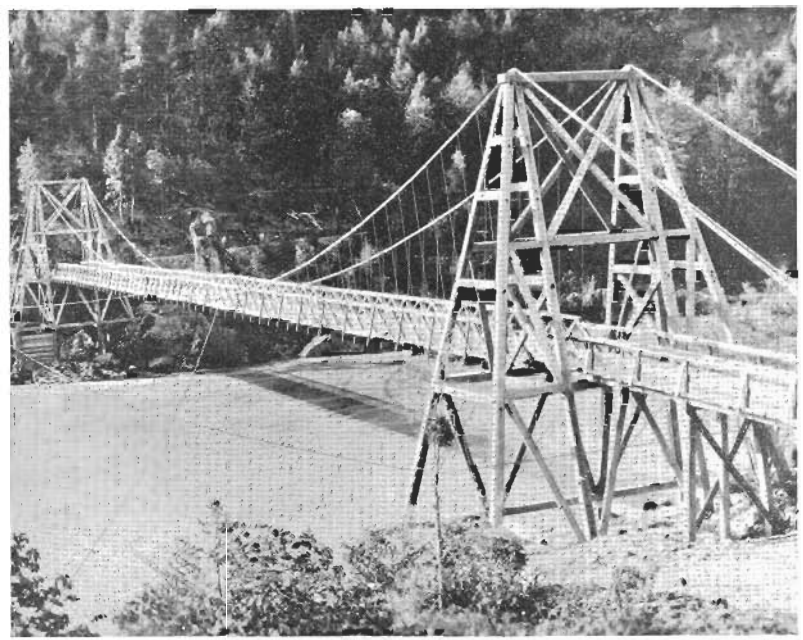


FIGURE 51. *Pack-train suspension bridge. Used when a heavy type of bridge is required for mule traffic. Note tower design.*

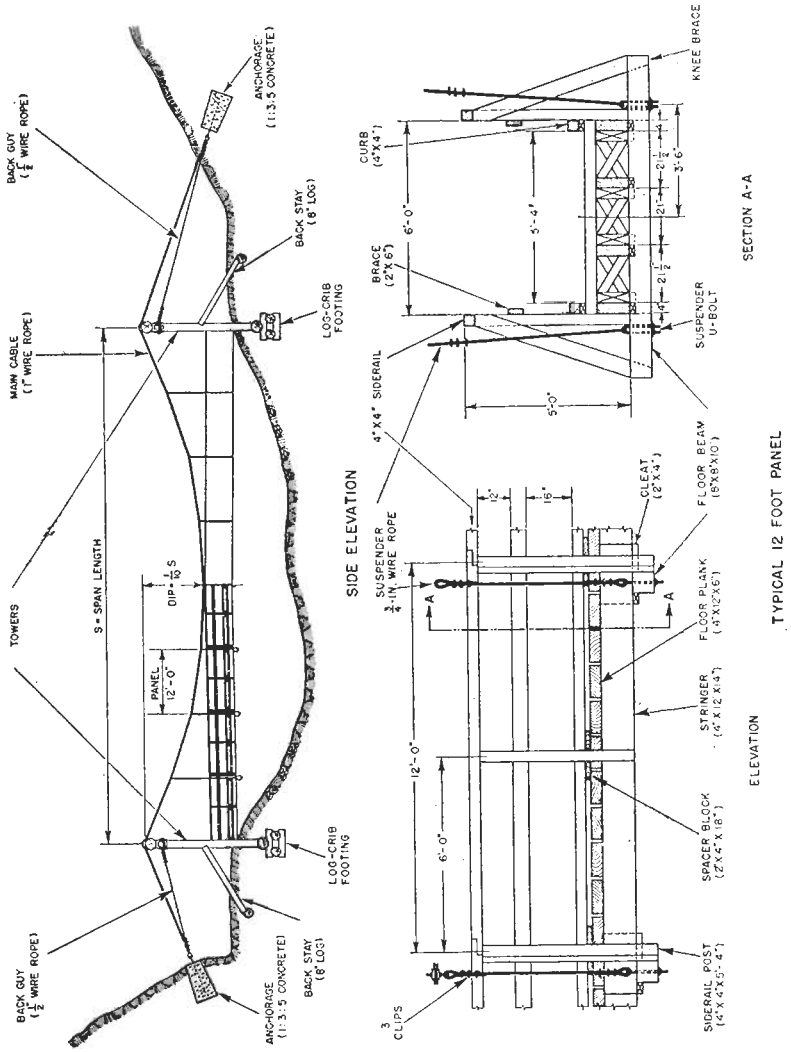


FIGURE 52. *Pack-train suspension bridge. General view and hanger assembly.*

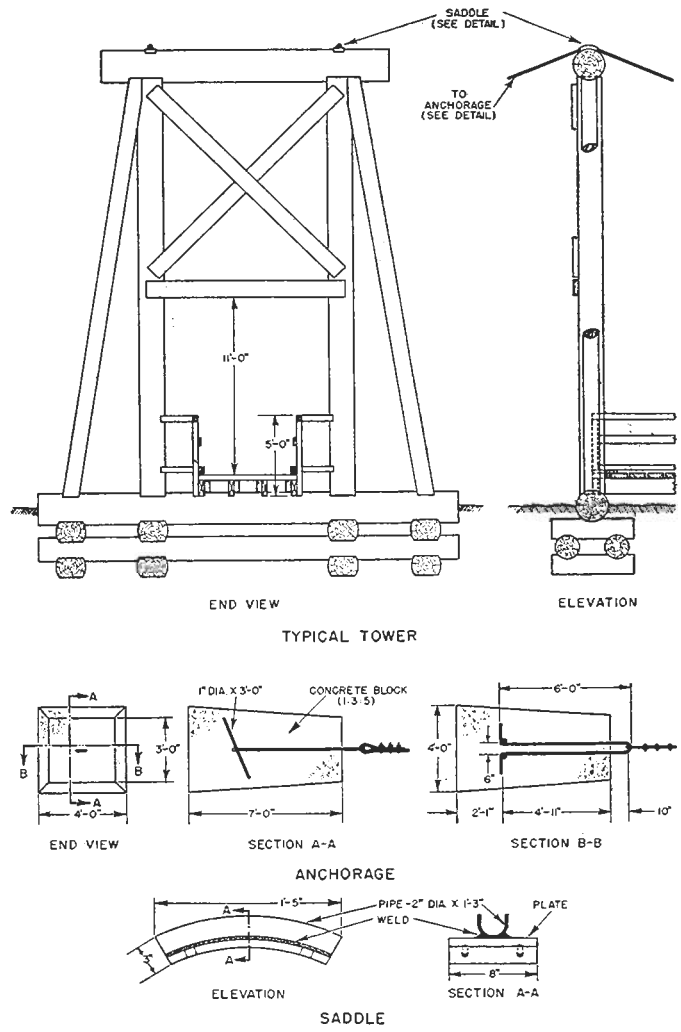


FIGURE 53. *Pack-train suspension bridge. Tower and anchorage.*

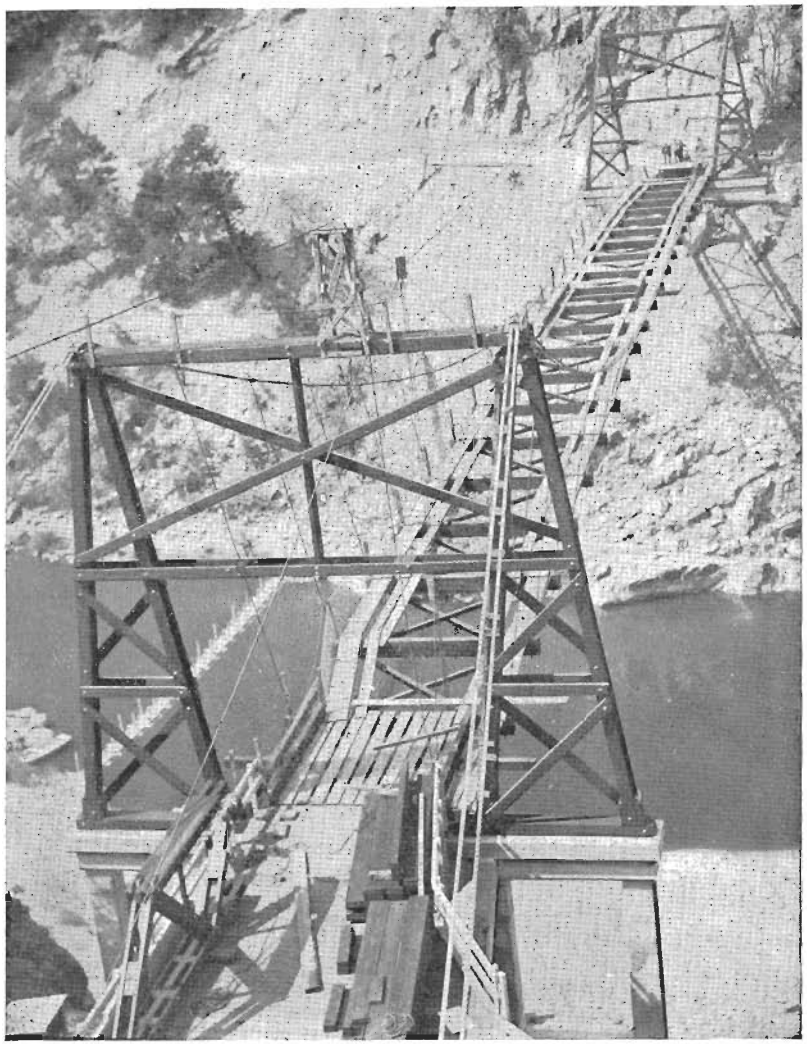


FIGURE 54. *Vehicular suspension bridge. Bridge under construction before placing stringers.*

110 VEHICULAR SUSPENSION BRIDGE.—Figures 54 and 55 show a vehicular suspension bridge. Sets of four to six 1-inch cables are used as main cables.

Clips, anchorage *U*-bolts, suspender *U*-bolts, and tower fittings are made in a blacksmith shop. Tower members are bolted and doweled. Concrete anchorages are used instead of deadmen.

Erection procedure generally is the same as that of standard bridges. Five days to 2 weeks is required to build 150- to 400-foot spans.

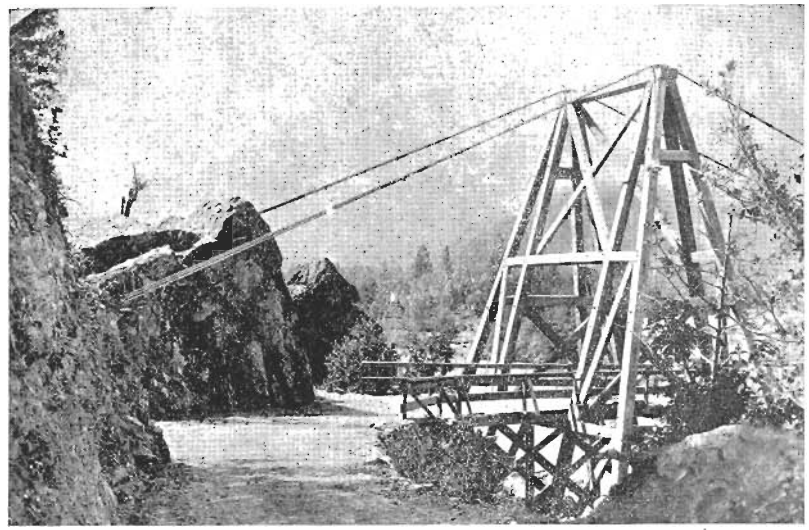


FIGURE 55. *Vehicular suspension bridge-tower.*