Appendix H
Methods of Attacking Bridges with Demolitions

The methods of attack in this appendix are for the most common types of bridges; however, they are not all inclusive. When faced with unusual construction methods or materials (for example, Hayricks which are linear-shaped charges used by host NATO countries), the responsible engineer shouId adapt one the of the recommended methods or recategorize the bridge as a miscellaneous bridge and design the demolition using the principles in Chapter 4.

Table H-1. Minimum E_R values for bottom attack (percent)

$\frac{H}{L}$	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
$\frac{E_R}{L}$	0.0002	0.0008	0.0020	0.0030	0.0050	0.0070	0.0100	0.0130	0.0160	0.0200
$\frac{H}{L}$	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20
$\frac{E_R}{L}$	0.0240	0.0290	0.0340	0.0390	0.0440	0.0500	0.0570	0.0630	0.0700	0.0770

NOTES:

1. The values in this table are based on the following formula:

$$\frac{E_R}{L} = [4(\frac{H}{L})^2 + 1]^{1/2} - 1$$

where—

E_R = required end clearance.
L = span length.
H = beam, truss, or bow depth (including deck).

2. If the result of $\frac{H}{L}$ is not on the chart exactly as calculated, round UP to the next higher value. For example, $\frac{H}{L} = 0.076$, use the column headed 0.08. Read down that column to determine $\frac{E_R}{L}$. In this case, $\frac{E_R}{L} = 0.013$.

3. Multiply the $\frac{E_R}{L}$ value determined from the chart by L to get E_R.

Table H-2. Minimum L_C values for top attack (midspan)

$\frac{H}{L}$ \ $\frac{L_s}{L}$	Ratio of Section Removed to Span Length ($\frac{L_c}{L}$)														
	0.004	**0.006**	**0.008**	**0.010**	**0.012**	**0.014**	**0.016**	**0.018**	**0.020**	**0.030**	**0.040**	**0.050**	**0.060**	**0.080**	**0.100**
0.01	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.009	0.010	0.011	0.013	0.015
0.02	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.011	0.012	0.015	0.017	0.019	0.022	0.026	0.030
0.03	0.008	0.009	0.011	0.012	0.014	0.015	0.016	0.017	0.018	0.022	0.026	0.029	0.033	0.039	0.045
0.04	0.011	0.013	0.015	0.016	0.018	0.019	0.021	0.022	0.023	0.029	0.034	0.039	0.043	0.052	0.060
0.05	0.013	0.016	0.018	0.020	0.022	0.024	0.026	0.028	0.029	0.036	0.043	0.049	0.054	0.065	0.075
0.06	0.015	0.019	0.022	0.025	0.027	0.029	0.031	0.033	0.035	0.044	0.051	0.058	0.065	0.078	0.090
0.07	0.018	0.022	0.026	0.029	0.031	0.034	0.036	0.039	0.041	0.051	0.060	0.068	0.076	0.091	0.105
0.08	0.021	0.025	0.029	0.033	0.036	0.039	0.042	0.044	0.047	0.058	0.068	0.078	0.087	0.104	0.120
0.09	0.023	0.028	0.033	0.037	0.040	0.044	0.047	0.050	0.053	0.065	0.077	0.087	0.097	0.116	0.135
0.10	0.026	0.032	0.036	0.041	0.045	0.049	0.052	0.055	0.058	0.073	0.085	0.097	0.108	0.129	0.150
0.11	0.028	0.035	0.040	0.045	0.049	0.053	0.057	0.061	0.064	0.080	0.094	0.107	0.119	0.142	0.165
0.12	0.031	0.038	0.044	0.049	0.054	0.058	0.062	0.066	0.070	0.087	0.102	0.116	0.130	0.155	0.180
0.13	0.033	0.041	0.047	0.053	0.058	0.063	0.067	0.072	0.076	0.095	0.111	0.126	0.140	0.168	0.195
0.14	0.036	0.044	0.051	0.057	0.063	0.068	0.073	0.077	0.082	0.102	0.119	0.136	0.151	0.181	0.210
0.15	0.038	0.047	0.054	0.061	0.067	0.073	0.078	0.083	0.088	0.109	0.128	0.145	0.162	0.194	0.225
0.16	0.041	0.050	0.058	0.065	0.072	0.078	0.083	0.088	0.093	0.116	0.136	0.155	0.173	0.207	0.240
0.17	0.043	0.053	0.062	0.069	0.076	0.082	0.088	0.094	0.099	0.124	0.145	0.165	0.184	0.220	0.255
0.18	0.046	0.056	0.065	0.073	0.080	0.087	0.093	0.099	0.105	0.131	0.154	0.175	0.194	0.233	0.270
0.19	0.049	0.060	0.069	0.077	0.085	0.092	0.099	0.105	0.111	0.138	0.162	0.184	0.205	0.246	0.285
0.20	0.051	0.063	0.073	0.081	0.089	0.097	0.104	0.110	0.117	0.145	0.171	0.194	0.216	0.259	0.300

NOTES:

1. Tabulated values are for $\frac{L_c}{L}$, from which you can calculate L_c: $L_c = \frac{L_c}{L}(L)$.
2. This table is based on the formula:

$$\frac{L_c}{L} = \frac{2H[\frac{L_s}{L} - (\frac{L_s}{L})^2]^{1/2}}{L(1/2 - \frac{L_s}{L})}$$

3. If the results of $\frac{L_s}{L}$ or $\frac{H}{L}$ are not on the chart exactly as calculated, round UP to the next higher value on the chart. For example, if $\frac{H}{L} = 0.021$, use 0.03; if $\frac{L_s}{L} = 0.0142$, use 0.016. Intersect the $\frac{L_s}{L}$ and $\frac{H}{L}$ values on the chart to get the value of $\frac{L_c}{L}$. Multiply the $\frac{L_c}{L}$ value by L to get L_c.

Table H-3. Attacks on simply supported bridges

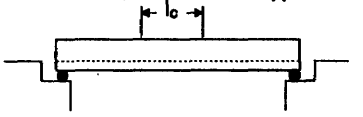
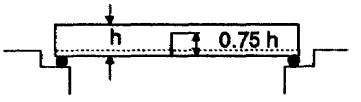
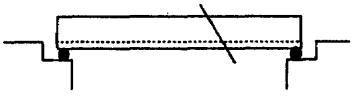
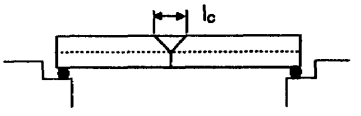
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
1	Steel Beam	Through Bridge, Method I	Top Attack: E is less than E_R  1. Cut at midspan. 2. Cut beams, including bottom flange in "V." 3. Do not consider cutting deck.	None
2		Through Bridge, Method II	Bottom Attack: E is greater than E_R  1. Cut at midspan to 0.75h, as shown. 2. Cut deck across full bridge width.	None
3		Through Bridge, Method III	Angled Attack:  1. Cut between 1/3-span and midspan. 2. Cut deck across full bridge width.	End clearance is not a consideration.
4		Through Bridge, Method IV	Bottom Attack: E is less than E_R 1. Cut at midspan to 0.75h. 2. Cut deck across full bridge width. 3. Attack one abutment or pier to create sufficient end clearance.	None
5		Through Bridge, Method V	Top Attack: E is less than E_R  1. Cut at midspan. 2. Where deck is located well above beam bottom, cut bridge as shown. 3. Do not consider cutting deck.	None

Table H-3. Attacks on simply supported bridges (continued)

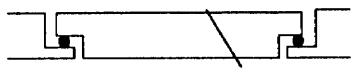
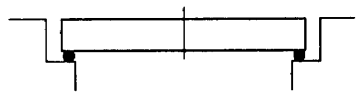
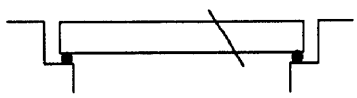
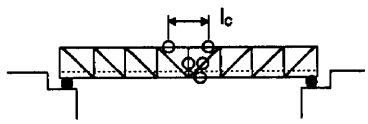
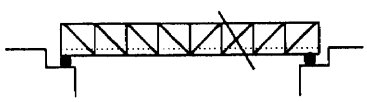
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
6	Steel Beam	Deck Bridge, Top Support	Angled Attack:  1. Cut between 1/3-span and midspan. 2. Cut deck across full bridge width.	1. Configuration found in cantilever and suspended-span bridges 2. End clearance is not a consideration.
7		Deck Bridge, Bottom Support, Method I	Bottom Attack: E is greater than E_R  1. Cut at midspan. 2. Do not consider cutting deck.	None
8		Deck Bridge, Bottom Support, Method II	Bottom Attack: E is less than E_R 1. Cut at midspan. 2. Do not consider cutting deck. 3. Attack one abutment or pier to create sufficient end clearance.	None
9		Deck Bridge, Bottom Support, Method III	Angled Attack:  1. Cut between 1/3-span and midspan. 2. Cut deck across full bridge width.	End clearance is not a consideration
10	Steel Truss	Through Bridge, Method I	Top Attack: E is less than E_R  1. Cut at midspan. 2. Cut top chord twice, vertically (if necessary), and diagonals and bottom chord. 3. Remove wind bracing over midspan. 4. Do not consider cutting deck.	None
11		Through Bridge, Method II	Angled Attack:  1. Cut between 1/3-span and midspan. 2. Cut top chord, diagonals, and bottom chord in one bay only. 3. Cut deck across full bridge width.	None

Table H-3. Attacks on simply supported bridges (continued)

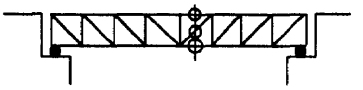
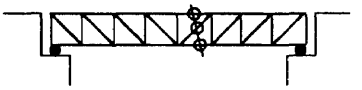
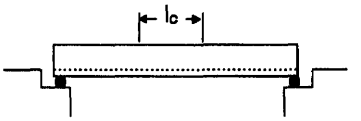
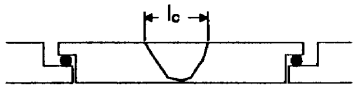
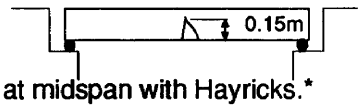
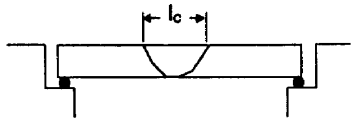
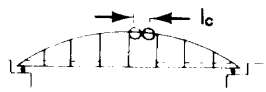
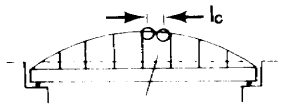
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
12	Steel Truss	Deck Bridge, Top Support	Bottom Attack:  1. Cut between 1/3-span and midspan. 2. Cut top chord, diagonals, and bottom chord in one bay only. 3. Do not consider cutting deck.	1. Configuration found in cantilever and suspended-span bridges 2. End clearance is not a consideration.
13		Deck Bridge, Bottom Support, Method I	Bottom Attack: E is greater than E_R  1. Cut at midspan. 2. Cut top chord, diagonals, and bottom chord in one bay only. 3. Do not consider cutting deck.	None
14		Deck Bridge, Bottom Support, Method II	Bottom Attack: E is less than E_R 1. Cut at midspan. 2. Cut top chord, diagonals, and bottom chord in one bay only. 3. Do not consider cutting deck. 4. Attack one abutment or pier to create sufficient end clearance.	None
15		Deck Bridge, Bottom Support, Method III	Angled Attack:  1. Cut between 1/3-span and midspan. 2. Cut deck across full bridge width.	End clearance is not a consideration
16	Concrete	Through Bridge	Bottom Attack:  1. Cut between midspan. 2. Cut deck across full bridge width.	This method applies to slab bridges only.

Table H-3. Attacks on simply supported bridges (continued)

Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
17	Concrete	Deck Bridge, Top Support	Top Attack:  Cut at midspan with a concrete-stripping charge.	1. Configuration found in cantilever and suspended-span bridges 2. Remove concrete for L_c distance to full width and depth of beams.
18		Deck Bridge, Bottom Support, Method I	Bottom Attack: E is greater than E_R  Cut at midspan with Hayricks.*	1. This method applies to slab bridges only. 2. Sufficient reinforcing bars are cut to cause bridge collapse.
19		Deck Bridge, Bottom Support, Method II	Bottom Attack: E is less than E_R 1. Cut at midspan with Hayricks.* 2. Attack one abutment or pier to create sufficient end clearance.	This method applies to slab bridges only.
20		Deck Bridge, Bottom Support, Method III	Top Attack: E is less than E_R  Cut at midspan with a concrete-stripping charge.	Remove concrete for L_c distance to full width and depth of beams.
21	Bowstring	Normal	Top Attack:  1. Cut at midspan. 2. Cut bow in two places. 3. Cut all hangers between bow cuts. 4. Do not consider cutting deck..	None
22		Reinforced Beam or Truss	Top Attack plus Girders:  1. Cut truss or beam with the appropriate method (Serials 1 through 15). 2. Cut bow in two places, including hangers.	None

Note: Hayricks are not in the US Army supply system.

Table H-4. Attacks on continuous bridges

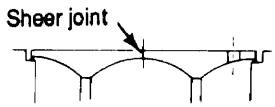
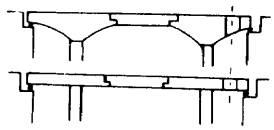
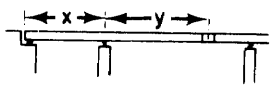
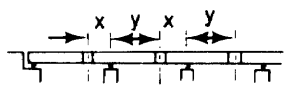
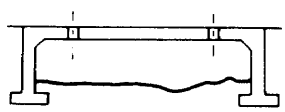
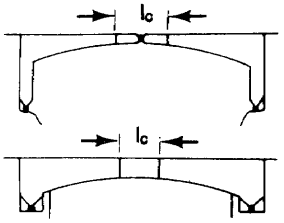
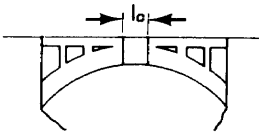
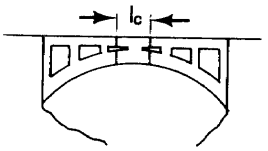
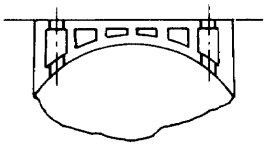
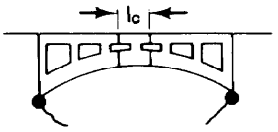
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
1	Concrete	Cantilever	Two Cuts:  1. Cut anchor span as closely to the pier as practical. 2. Cut midspan shear joint.	1. Cutting anchor span may require a two-stage attack. 2. Use a concrete-stripping charge for the first stage.
2		Cantilever and Suspended Span	One Cut:  Cut anchor as closely to the pier as practical.	1. Cutting anchor span may require a two-stage attack. 2. Use a concrete-stripping charge for the first stage. 3. If demolition of the suspended span will create the desired obstacle, regard the span as simply supported and attack accordingly.
3		Beam or Truss with Short Side Span	One Cut:  1. Cut interior span so *y* is greater than 1.25*x*. 2. If necessary, cut other interior spans as in Serial 4.	1. Cutting longer spans may require a two-stage attack. 2. Use a concrete-stripping charge for the first stage.
4		Beam or Truss without Short Span	Two or More Cuts:  Cut interior span so *y* is greater than 1.25*x*.	1. Cutting these spans may require a two-stage attack. 2. Use a concrete-stripping charge for the first stage.
5		Portal, Fixed Footing	Two Cuts:  Cut span twice, close to pier.	1. Cutting these spans may require a two-stage attack . 2. Use a concrete-stripping charge for the first stage.

Table H-4. Attacks on continuous bridges (continued)

Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
6	Concrete	Portal, Pinned Footing	Strip Concrete:  Remove concrete from midspan over length L_c with a concrete-stripping charge.	1. Remove all concrete for L_c. 2. A one-stage attack should be adequate. 3. When footing conditions are unknown, use Serial 5.
7		Arch, Open Spandrel, Fixed Footing, Method I	Strip Concrete:  Remove concrete from midspan over length L_c with a concrete-stripping charge.	1. Applies to arches greater than 35 meters 2. A one-stage attack should be adequate.
8		Arch, Open Spandrel, Fixed Footing, Method II	Strip Concrete:  1. Remove concrete from midspan over length L_c with a concrete-stripping charge. 2. Attack springing with Hayricks* at the top face of the arch ring.	1. Applies to arches greater than 35 meters 2. A one-stage attack should be adequate.
9		Arch, Open Spandrel, Fixed Footing, Method III	Four Cuts: 	1. Alternative to Method II, applies to arches greater than 35 meters 2. Two-stage attack may be required. 3. Use concrete-stripping charge for first stage.
10		Arch, Open Spandrel, Pinned Footing	Strip Concrete:  Remove concrete from midspan over length L_c with a concrete-stripping charge.	A one-stage attack should be adequate.

Note: Hayricks are not in the U.S. Army supply system.

Table H-4. Attacks on continuous bridges (continued)

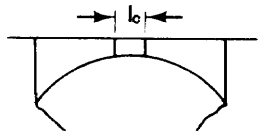
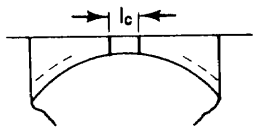
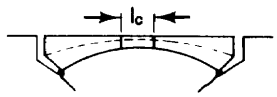
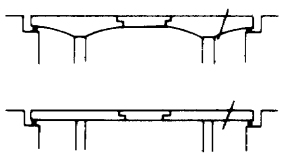
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
11	Concrete	Arch, Solid Spandrel, Fixed Footing, Method I	Strip Concrete:  Remove concrete from midspan over length L_c with a concrete-stripping charge.	A one-stage attack should be adequate.
12	Concrete	Arch, Solid Spandrel, Fixed Footing, Method II	Strip Concrete:  1. Remove concrete from midspan over length L_c with a concrete-stripping charge. 2. Attack both springing points with concrete-stripping charges: a. Against bottom face of arch ring. b. Or against top face (must remove fill beneath roadway to access arch ring)	1. Applies to arches greater than 35 meters 2. A one-stage attack should be adequate.
13	Concrete	Arch, Open Spandrel, Fixed Footing, Method II	Strip Concrete:  Remove concrete from midspan over length L_c with a concrete-stripping charge.	A one-stage attack should be adequate.
14	Steel	Cantilever	Two Cuts:  1. Cut anchor span as closely to the pier as practical. 2. Cut midspan shear joints.	None
15	Steel	Cantilever and Suspended Span	One Cut:  Cut anchor span as closely to the pier as practical.	If demolition of the suspended span will create the desired obstacle, regard the span as simply supported and attack accordingly.

Table H-4. Attacks on continuous bridges (continued)

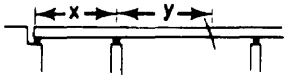
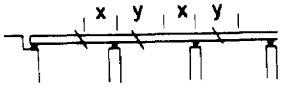
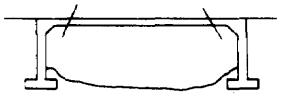
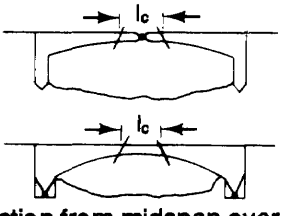
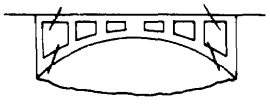
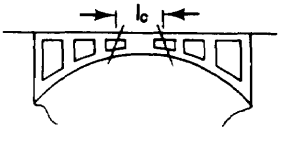
Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
16	Steel	Beam or Truss with Short Side Span	One Cut:  1. Cut interior span so *y* is greater than 1.25*x*. 2. If necessary, cut other interior spans as in Serial 17.	None
17		Beam or Truss without Short Side Span	Two or More Cuts:  Cut spans so *y* is greater than 1.25*x*.	None
18		Portal, Fixed Footing	Two Cuts:  Cut span twice, close to piers.	None
19		Portal, Pinned Footing	Two Cuts:  Remove section from midspan over length L_c.	None
20		Arch, Open Spandrel, Fixed Footing	Four Cuts: 	Angle cuts about 70 degrees
21		Arch, Open Spandrel, Pinned Footing	Two Cuts:  Remove section from midspan over length L_c.	None

Table H-4. Attacks on continuous bridges (continued)

Serial	Subcategory	Type	Attack Method	Remarks
a	b	c	d	e
22	Masonry	Arch, Method I	Two Cuts:  1. Cut at haunches. 2. Attack arch ring, spandrel walls, and parapet.	None
23		Arch, Method II	One Cut:  Breach arch ring at crown.	None