



DESIGNING AND BUILDING CATTLE GUARDS

Handbook for Exhibitors

This handbook is designed to help those designing and building cattle guards to enter as an agricultural mechanics project in shows all over Texas. It is suggested that students should do some research on the internet regarding cattle guards. It is advised to include technical information gained in this research in the Documentation required of all ag mechanics projects that are entered in the San Antonio Junior Agricultural Mechanics JAM Project Show.

Designing and Building Cattle Guards

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1. Size – Cattle Guard Width and Length

Note: Length of guard determines Length of Beams supporting runners. Could also be considered as distance Across guard.

Width of guard identifies the length of runners

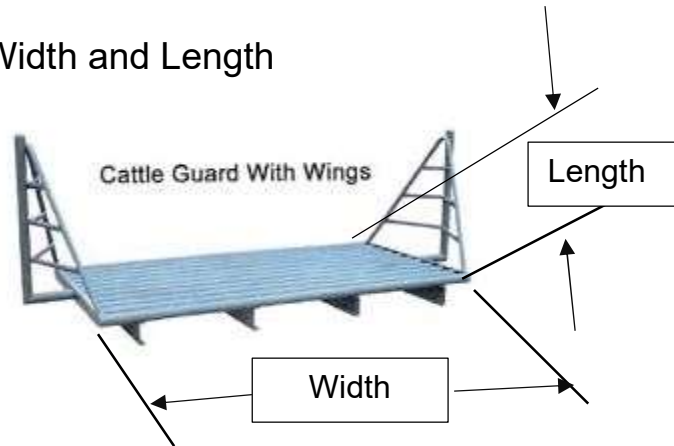


Figure 1 Cattle Guard with Wings

Width should be large enough to accommodate the vehicles that will use guard. Normally on farms, trucks and tractors will pull trailers over the guard. These vehicles are wider than the normal Pickup Truck. The minimum width of should be 9 to 10 feet. Some guards also have gates to keep vehicles from entering. Those guards that have double gates could be 18 to 20 feet Wide. Extra wide guards will need more than the 4 beams shown in Figure 1. Gates may be over the cattle guard, usually at midpoint of the length but some may be before or after crossing the guard.

To accommodate large wide equipment such as grain drill, cultivators, combines most farmers provide a gate off to the side of the guard to provide entrance and exit. These opening may also be provided to allow large heavy loads such as grain trucks, dozers fuel trucks, fire trucks and 18 wheelers to keep from having to design and build such a massive guard to accommodate these heavy loads. Gates are provided sometimes near the guard to move animals through.

Length (Across) Guard must be long enough (distance across) to prevent Livestock from jumping over or from thinking they can jump it. The minimum length is 7 to 8 feet. Deer can easily jump 16 feet,

2. Foundation Support

The size and weight of loaded vehicles using the guard dictate load carrying capacity. Loads will also influence the support used for the guard. Guards designed to sit on the ground do not require large beams to supports the loads going over them. See Figure 2

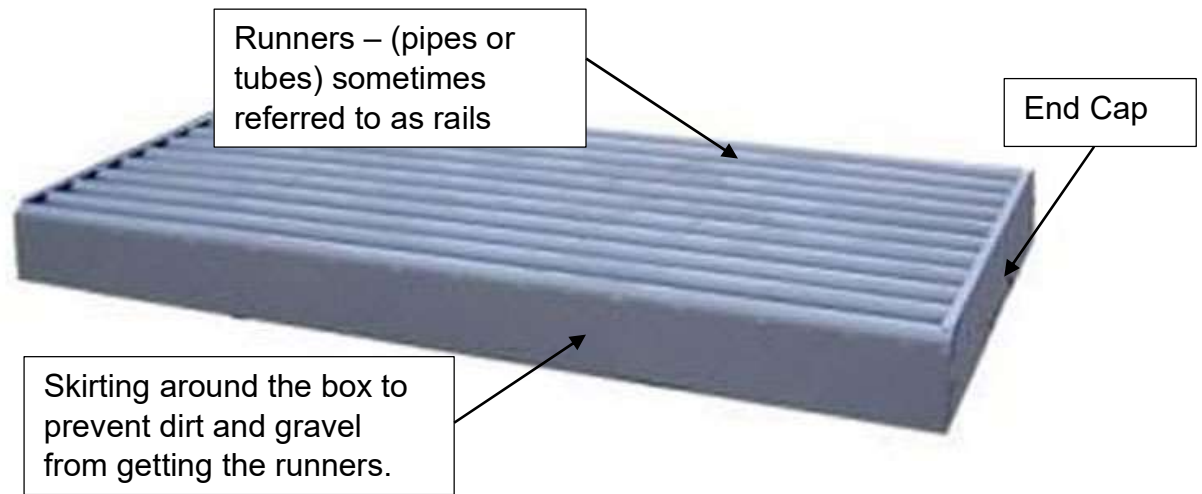


Figure 2 - Box style Guard

Supports for Small to Medium loads

This box design allows for the guard to be placed on the ground with skirts around it to keep dirt and gravel filling in under the pipe runners. The box design shown here also closes off the ends of the rails with end caps, preventing rusting on inside. Caps also keeps out snakes, small rodents and insects

Because they rest on the ground the site should be well drained and prepared to make it level for any slope will allow guard to walk down slope when driving over it. . Guards should be higher in elevation than the sites around them so water will drain from them. Most farmers, ranchers will install a crushed bed of gravel to help support guard in wet weather. This will also help drain the water away to preserve the installation. Also the a rock road bed will retard the growth of weeds that will grow up in the guard

Heavy Loads

Guards designed for heavy loads should be supported by concreted footing – foundation. See calculating weight carrying capacity in Design section below.

Ground with good drainage is critical. The American Association of State Highways and Transportation Office (ASSHTO) publishes Specifications that identify Load Class including ground support specifications.

Concrete runners are commercially available or can be poured using cattle guard forms

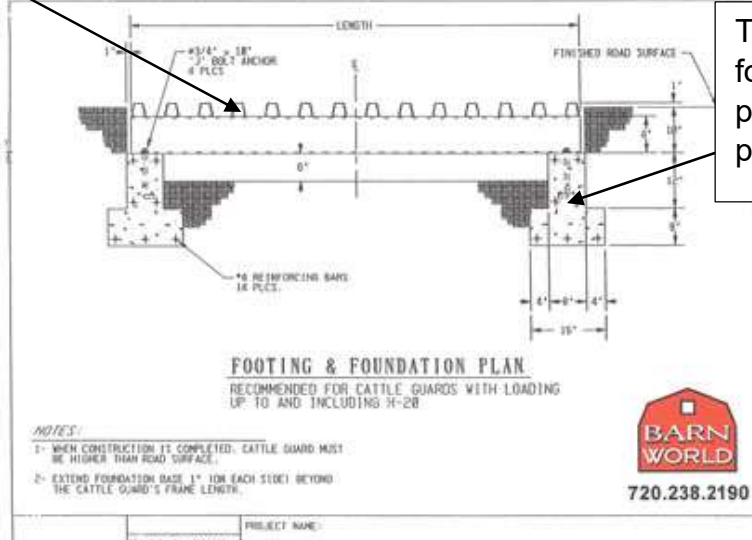


Figure 2- Concrete Footing



Shelf to support 12 inch steel Beams

Figure 3 – Concrete Foundation including Footing

Because guard illustrated in Figure 3 is on clay soils it requires additional support, especially for wet conditions. Diesel Fuel truck with 20,000 lb. per axle loads will use it. The footings have 4 ft. piers underneath them for extra support. Guards with foundations like this usually have a drain in one corner of the floor to prevent filling with water and rusting the beams and guard. Cattle guard set in this foundation is approximately 16 inches deep.

3. Design

Animal Safety. Cattle Guard design must consider the safety of animals it is being used to control. Some designs have enough space between the runners to allow cattle that might try to cross the guard and gets their hoof between the runners can extract it without getting stuck and perhaps breaking a leg. If using a runner spacing wide enough for hoof to be pulled out, the depth of the pit under the guard should not be so deep that animals cannot reach the bottom to prevent danger of breaking her leg. Remember animals other than cattle may be using the guard – horses, goat, sheep and deer for example. Each of these different species have different size requirements. Wide spacing of runners should not be used over deep pit type Cattle Guards.

Wings and Gates - The wings shown in Figure 1 allows for extra width of trailer and truck beds to use the guard, in essence increasing the usable width of the guard. Wings also helps to prevent animals from trying to jump or get around end post.

Gates shown in Figure 3 are placed at the mid-section of the guard. The gates on the right pins into hole in foundation and is located at end of guard to allow for extra wide vehicles and extra heavy 18 wheeled vehicles to open gate and bypass the guard. This gate (opening) also allows for bypassing guard to allow moving animals through it. Gates located across or in front or back of the guard do not allow for bypassing the guard but are for preventing vehicles from crossing the guard and entering the farm or pasture.

Cattle Guards directly on the ground.

If guard is infrequently used and if soil types are well drained, guard can lay directly on the ground. Sometimes these are considered movable guards. These types of guards do not need the same size beam supporting the runners as those that will be supported by footings and foundations. Many of the beams for cattle guards that will lay directly on the ground are constructed from pipe – in most cases 4 inch diameter pipe. The Box style guard shown in Figure 2 is considered a ground laying type that is movable.

Guards that lay on the ground will not have much space beneath them and they become filled with dirt and road materials making it easier for animals to walk them. Weeds also grow up in guards laying directly on the ground. Weeds hide the runners and animals will assume they can walk them and may get stuck in them.

Having runners at greater distances apart will be rough when driving over it. They also should be larger in diameter than 2 inch schedule 40 pipe due to bending.

In most cases the steel runners are welded close enough to prevent the normal sized animal from getting their leg – hoof caught between them.

Runners are usually made from steel pipe or tubing. Size may vary from 2 inch to 2 7/8 inch diameter. The larger diameter of pipe or tube including wall thickness used for runners is important for heavy loads and wider guards in that they help transmit the load to the beams under them. Other materials used to make runners are; angle iron, channel iron, small I beam, square tubing, concrete and sucker rod (not recommended). Commercial forms are available to pour concrete runners. Making runners from Angle Iron and Channel or C frames are not recommended in that the hoofs of cattle caught between them cannot be removed and in most cases the cattle will break their legs in trying to get out.

Cattle Guards supported on concrete footings.

When Guards are supported on concreted footings – see Figure 2 and 3- the Structural Steel beams used in constructing them must sustain the load - weight of the vehicle that will cross them.

Structural Steel for Beams

- A. **Beam Structural Types** – The most common structural steel type beams used to support the runners for these kinds of cattle guard are, I Beam (most common), Channel, Pipe and T Beams. Which Structural Steel to use is primarily determined by load requirements on the beam – (weight of the vehicle using the Cattle Guard) Soil types and drainage also contribute to determining support necessary. Knowing load requirement one can determine the most economical and available material for selecting the beams. Channel or C Beams are shown in Figure 1

B. **I Beams or W Style** - usually identified as shown in Figure 4. Another criterion used in describing a beam is its weight/ft length. See table below.

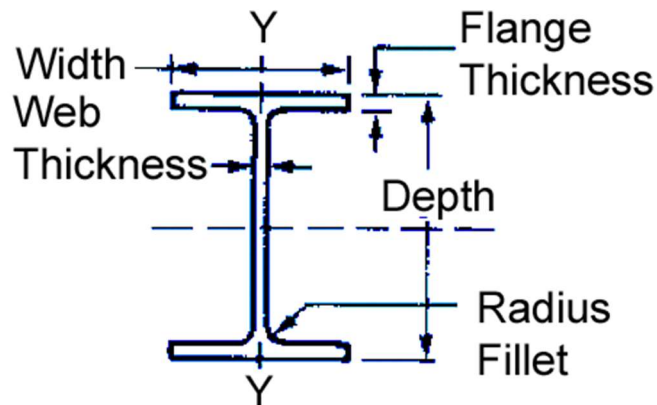


Figure 4 – Beam Cross Section

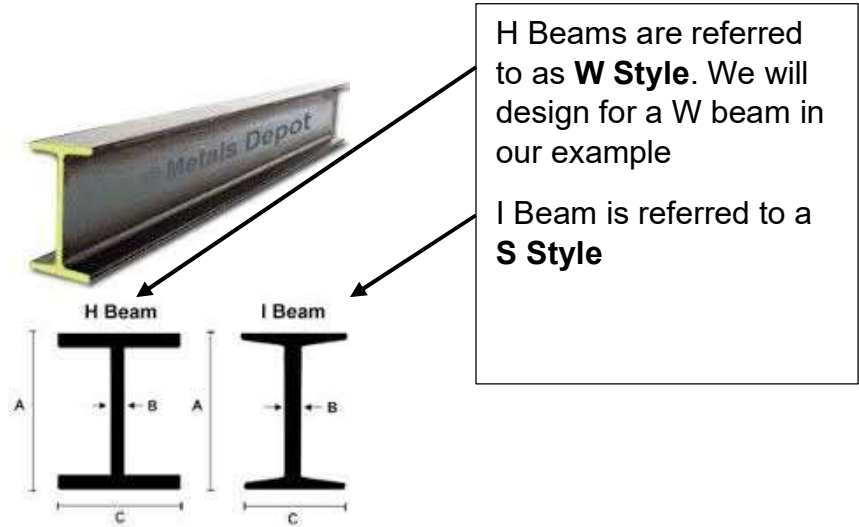


Figure 5 - Beam Style

C. **Load Design** – As identified above the size of beams and other materials for building a cattle guard will be influenced mostly by the loads of the vehicles crossing the guard. The American Association of State Highways and Transportation Office publishes specifications that identify ASSHTO Load Classes. Please get on their [WEB](#) page and download their Cattle Guard Design Requirements Worksheet.

A Pickup is considered to have an approximate weight per axle of 4,000 lbs. and requires a H 10 ASSHTO Load Class. Most farms use large vehicles, trucks, tractors, machinery that far exceed this class. The HS 20 Load Class is common for these types of vehicles. HS 20 will accommodate up to 32,000 lbs. per axle. The Federal and State axle weight limits for vehicles used on the highways: 20,000 lbs. for single axle and 34,000 lbs. for tandem axle.

ASSHTO also publishes data for Soil Bearing Capacity for support of the cattle guard.

Cattle Guard Manufacturers should provide specifications that show design meets the load requirements.

4. Example Design

As an example, design the main beams of a cattle guard to meet the HS 20 Load Class 32,000 lb. per axle given the following:

Assumptions or Givens for Design Example

- Main Beam – (W Beam)– 4 Beams with 2 main Beams set on approximately 6 ft tread width.
- Assume 35,000 psi tensile strength steel.
- Simple, point loaded beams (not uniform load)
- Runners - 2 7/8 inch pipe (0.25 wall thickness)
- Runner spacing - 2 7/8 inches apart
- Width of guard (across) 8 feet
- Length of Runners, 12 feet
- Concreate Footing/Foundation – Depth - bottom of Pit to top of Guard 16 inches.
- Drain in one corner of Pit
- Will not design for wings since there is a gate over guard and another gate on other end of guard.

Step 1 Determine Size of Beam, (W Beam)

Size necessary to carry the weight of vehicles and their cargo that will be going over the Cattle Guard

Structural Steel Tables are available that provide load capacity of different kinds and sizes of Structural Steel members. In most cases the loads provided in the tables are for uniform loads not point loads.

Because tables do not provide a point load capacity it is necessary to determine the size of the beam by Section Modulus - S.

The S (Section Modulus) from Structural Steel Tables and the weight per ft of beam will identify beam dimensions, specifically Depth needed to carry design load, in this example 32000 lbs. per axle. As noted above the heaviness of the beam in lbs/ft is also an important criterion, in that it is a measure of the cross sectional dimensions. For example, Web depth, Web and Flange thickness along with Flange size all contribute to the weight per foot of the beam which Section Modulus is a measure of. The thicker and wider flanges and thicker webs make heavier beams, along with larger Depths, (See Figure 4)

Note: It is suggested that you get on the internet and review the terminology used. For example, Section Modulus – may be identified as K. It considers major dimensions and how beam is oriented in use. For example, a common 2 x 4 wood stud has a 3.06 in³ when used on its edge but laying flat has only 1.31 Inch³. The same applies to the W beam we are using here. Laying on its side will not provide near the strength or S_x as if it is upright on its flanges.

Step 2 Determine S

Formula to determine the Section Modulus S_x (in³) (Elastic S using X axis)

$$S_x = BM/TS$$

BM (Bending Moment) = $\frac{1}{4}$ WL (**For simple beam with point Load**)

W= Weight (lbs.) Use 32000 per axle weight of vehicle crossing cattle guard.

Note: There are two wheels, one on each end of axle, each wheel is on one of the beams, making 16000 lbs/wheel on each beam. Most trucks of this size will have tandem axles and both axles wheels will be on guard at the same time, therefore we will use 32,000 lbs (2 wheels per beam) for our point load per beam in this problem.

We will assume all the weight is on the two beams that are located at approximately tread widths and will not consider the load the two beams on the ends are carrying. Using a Uniform Load Partially Distributed Formula would be more accurate and in that situation we would consider all 4 beams. With Cattle Guards the Point Load Formula will be close enough. We will use the end beams as our safety factor.

L= Length (inches) of Beam -Use length of Guard 8 ft x 12 inches/ft = 96 inches (Must be in inches)

$$BM = W \times L/4 = 32000 \text{ lbs} \times 96 \text{ inches} / 4 = 768,000 \text{ in-lbs}$$

TS (Tensile Strength of Steel) Given = 35,000 lbs/in²

$$S_x = BM/TS = 768,000 \text{ in-lbs} / 3500 \text{ lbs/in}^2 = \mathbf{21.9 \text{ in}^3}$$

Step 3 Find I Beams in table with at least a $S_x = 20 \text{ in}^3$

American Wide Flange Beams - W Beam

Designation Imperial (in x lb/ft)	Depth h (in)	Width w (in)	Web Thickness t_w (in)	Flange Thickness t_f (in)	Sectional Area (in^2)	Weight (lb/ft)	Static Parameters			
							Moment of Inertia I_x (in^4)	I_y (in^4)	Elastic Section Modulus S_x (in^3)	S_y (in^3)
W 12 x 87	12.53	12.125	0.515	0.810	25.6	87	740	241	118	39.7
W 12 x 79	12.38	12.08	0.47	0.735	23.2	79	662	216	107	35.8
W 12 x 72	12.25	12.04	0.43	0.670	21.1	72	597	195	97.4	32.4
W 12 x 65	12.12	12	0.39	0.605	19.1	65	533	174	87.9	29.1
W 12 x 58	12.19	10.01	0.36	0.640	17.0	58	475	107	78	21.4
W 12 x 53	12.06	9.995	0.345	0.575	15.6	53	425	95.8	70.6	19.2
W 12 x 50	12.19	8.08	0.37	0.640	14.7	50	394	56.3	64.7	13.9
W 12 x 45	12.06	8.045	0.335	0.575	13.2	45	350	50.0	58.1	12.4
W 12 x 40	11.94	8.005	0.295	0.515	11.8	40	310	44.1	51.9	11.0
W 12 x 35	12.50	6.56	0.3	0.520	10.3	35	285	24.5	45.6	7.5
W 12 x 30	12.34	6.52	0.26	0.440	8.8	30	238	20.3	38.6	6.2
W 12 x 26	12.22	6.490	0.23	0.380	7.7	26	204	17.3	33.4	5.3
W 12 x 22	12.31	4.03	0.26	0.425	6.5	22	156	4.7	25.4	2.3
W 12 x 19	12.16	4.005	0.235	0.350	5.6	19	130	3.8	21.3	1.9
W 12 x 16	11.99	3.990	0.22	0.265	4.7	16	103	2.8	17.1	1.4
W 12 x 14	11.91	3.970	0.2	0.225	4.2	14	88.6	2.4	14.9	1.2
W 10 x 112	11.36	10.415	0.755	1.250	32.9	112	716	236	126	45.3
W 10 x 100	11.1	10.340	0.680	1.1120	29.4	100	623	207	112	40.0
W 10 x 88	10.84	10.265	0.605	0.990	25.9	88	534	179	98.5	34.8
W 10 x 77	10.60	10.190	0.530	0.870	22.6	77	455	154	85.9	30.1
W 10 x 68	10.40	10.130	0.470	0.770	20.0	68	394	134	75.7	26.4
W 10 x 60	10.22	10.080	0.420	0.680	17.6	60	341	116	66.7	23.0
W 10 x 54	10.09	10.030	0.370	0.615	15.8	54	303	103	60.0	20.6
W 10 x 49	9.98	10	0.340	0.560	14.4	49	272	93.4	54.6	18.7
W 10 x 45	10.10	8.020	0.350	0.620	13.3	45	248	53.4	49.1	13.3
W 10 x 39	9.92	7.985	0.315	0.530	11.5	39	209	45.0	42.1	11.3
W 10 x 33	9.73	7.960	0.290	0.435	9.71	33	170	36.6	35.0	9.2
W 10 x 30	10.47	5.81	0.3	0.510	8.84	30	170	16.7	32.4	5.8
W 10 x 26	10.33	5.770	0.26	0.440	7.6	26	144	14.1	27.9	4.9
W 10 x 22	10.17	5.750	0.240	0.360	6.5	22	118	11.4	23.2	4
W 10 x 19	10.24	4.020	0.250	0.395	5.6	19	96.3	4.3	18.8	2.1
W 10 x 17	10.11	4.010	0.240	0.330	5	17	81.9	3.6	16.2	1.8
W 10 x 15	9.99	4	0.230	0.270	4.4	15	68.9	2.9	13.8	1.5
W 10 x 12	9.87	3.960	0.190	0.210	3.5	12	53.8	2.2	10.9	1.1
W 8 x 67	9.00	8.280	0.570	0.935	19.7	67	272	88.6	60.4	21.4
W 8 x 58	8.75	8.220	0.510	0.810	17.1	58	228	75.1	52.0	18.3
W 8 x 48	8.5	8.110	0.400	0.685	14.1	48	184	60.9	43.3	15.0

ngtoolbox.com/american-wide-flange-steel-beams-d_1319.html

Structural Steel Table 1

American Wide Flange Beams - W Beam

Designation Imperial (in x lb/ft)	Depth h (in)	Width w (in)	Web Thickness t_w (in)	Flange Thickness t_f (in)	Sectional Area (in ²)	Weight (lb/ft)	Static Parameters			
							Moment of Inertia I_x (in ⁴)	I_y (in ⁴)	Elastic Section Modulus S_x (in ³)	S_y (in ³)
W 8 x 40	8.25	8.070	0.360	0.560	11.7	40	146	49.1	35.5	12.2
W 8 x 35	8.12	8.020	0.310	0.495	10.3	35	127	42.6	31.2	10.6
W 8 x 31	8.00	7.995	0.285	0.435	9.1	31	110	37.1	27.5	9.3
W 8 x 28	8.06	6.535	0.285	0.465	8.3	28	98.0	21.7	24.3	6.6
W 8 x 24	7.93	6.495	0.245	0.400	7.1	24	82.8	18.3	20.9	5.6
W 8 x 21	8.28	5.270	0.250	0.400	6.2	21	75.3	9.8	18.2	3.7
W 8 x 18	8.14	5.250	0.230	0.330	5.3	18	61.9	8	15.2	3
W 8 x 15	8.11	4.015	0.245	0.315	4.4	15	48.0	3.4	11.8	1.7
W 8 x 13	7.99	4	0.230	0.255	3.8	13	39.6	2.7	9.9	1.4
W 8 x 10	7.89	3.940	0.170	0.205	2.9	10	30.3	2.1	7.8	1.1
W 6 x 25	6.38	6.080	0.320	0.455	7.3	25	53.4	17.1	16.7	5.6
W 6 x 20	6.20	6.020	0.260	0.365	5.9	20	41.4	13.3	13.4	4.4
W 6 x 16	6.28	4.030	0.260	0.405	4.7	16	32.1	4.4	10.2	2.2
W 6 x 15	5.99	5.990	0.230	0.260	4.4	15	29.1	9.3	9.7	3.1
W 6 x 12	6.03	4	0.230	0.280	3.6	12	22.1	3	7.3	1.5
W 6 x 9	5.90	3.940	0.170	0.215	2.7	9	16.4	2.2	5.6	1.1
W 5 x 19	5.15	5.030	0.270	0.430	5.5	19	26.2	9.1	10.2	3.6
W 5 x 16	5.01	5	0.240	0.360	4.7	16	21.3	7.5	8.5	3
W 4 x 13	4.16	4.060	0.280	0.345	3.8	13	11.3	3.9	5.5	1.9

Structural Steel Table 2

The left hand column (Designation) identifies the Beams (In this case a W Style) depth in inches and the weight in lb./ft.

For example- W 8x40 – 8 inch depth and 40 lbs. per ft. shown on the top row of Table 2 has $S_x = 35 \text{ in}^3$

We need a section modulus S_x for our example problem of 21.9^3 . Looking at the tables 1 & 2 we have a number of options. Different sizes and weights shown above meet our needs. (Since we are not considering the end beams which provides some support we could select those S_x that are a little less than 21.)

- W 12 x 19 = 21.3 (Table 1)
- W 10 x 22 = 23.2 (Table 1)
- W 8 x 24 = 20.9 (Table 2)

We will use a W 8 x 24 in this example problem. (8 inch depth and 24 lbs/ft)

With newer steels today the TS(Tensile Strength) may be approx. 60,000 lb/in². If you are using a higher tensile strength steel you can use smaller and lighter beams than those identified. Use the S_x Formula above but insert the higher TS and you will arrive at a smaller S_x required to support design load.

5. Building Cattle Guard

Steps for Construction after designing. Many of the decisions below must be done before building the foundation or supports for the guard – See discussion below.

Step 1 – Selection and purchasing Materials – after sizes of all materials have been determined – new versus used steel is considered. In most cases the beams will be made from used steel found in a salvage yard but new steel tubing or pipe for the runners should be considered over used pipe. Much of the used pipe from oil fields is rusty and may have concrete or crude oil inside making cutting very laborious and expensive. Used rusty pipe will pop and flash using torch leaving a very jagged end. New pipe may only be 10 % more in costs when compared to used. Savings in time and consumables when working with new pipe can offset the additional purchase price.

Many times in purchasing new pipe or tubing from a steel yard you have a good selection of lengths. Consider the lengths available before making a hard decision on the width (length of Pipe/runners) of guard.) It is much easier to lengthen or shorten the guard a few inches to fit the cut lengths you can purchase. In other words, cutting off 4 inches of length from runners so guard will fit in the concrete foundation you have poured is wasteful. Check availability of material length and adjust runner length to fit the dimensions. Having to extend lengths by welding joints of pipe together to get the length of runner required is also expensive.

Step 2 – Safety in handling– a completed cattle guard is very heavy and difficult to handle and move. The total weight of a completed guard may exceed the lifting capacity of some tractor loaders or skid steers. Be sure to have a safe and secure plan to handle the completed guard. Some schools may have a lift or crane in their building capable of safely lifting guard to load on truck or trailer. It is imperative that any rack or sawhorses used to raise guard for construction are substantial and will not tip or break.

Step 3– Set Up - Because of the large number of weld beads required to weld the runners to the beams, it is advised that the guard be constructed on stands and/or saw horses at approximately 30 inch height.

It is important that the rack or stands guard is being constructed on is level. Completed welded guard cannot be warped when installed on concrete supports or even on the ground for obvious reasons.

Step 4 – Squareness and Dimensions – Measure diagonals and make sure they are equal so guard is square. Be sure of length and width to make sure guard will drop down on its supports/ foundation. Use straight edge or string to set all runners prior to welding on beams. Equal length of runners is important to make sure completed guard will fit in its foundation and if angle iron or strap used to close off ends can be welded to the cap runners. It is recommended to use cutoff saw instead of oxy/acetylene torch to cut materials especially the rusty pipe for runners.

Note: Any preparation to get metal ready to paint – sandblasting or brushing should be done prior to assembly because of the un welding size and weight of the cattle guard after assembly.

Step 5 – Placement of Beams to weld runners to. If using four beams normally place two middle beams on approximately tread widths of 6 feet. End Beams can come in from ends of runners 6 to 10 inches. Layout runners on beams to determine the spacing of the runners and to make sure they are on squarely.

If using 2 7/8 inch OD tubing/pipe for runners, space approximately 2 7/8 inches. You will need to adjust this distance slightly so it is consistent across the entire cattle guard. In our example our beams are 8 ft long, runners 12 ft. Thumb rule is to make the guard 2 inches smaller in width and length than foundation supporting it.

Step 6 – Calculating number of runners and dimension of space between them.

- 8 ft Beam length x 12 = **96 inches**

Note: Make dimensions of foundation for cattle guards (concrete support) at least 2 inches wider and longer than the Guard – in this example 98 inches to leave room, 1 inch gap around all 4 sides of Cattle Guard) to allow room to drop it in. If foundation is already poured then beam must be approximately 2 inches shorter.)

- Using 2 7/8 OD tubing (2.875 inches)
- Determine number of spaces and runners (2.875) that make up the 96 inches

$96/2.875 = 33.39$ (Approximately $\frac{1}{2}$ of this 33.39 is runners and $\frac{1}{2}$ is spaces. You will need one more runner than spaces therefor 17 runners and 16 spaces and adjust the spaces to make total distance 96 inches.

- 1) 17 runners x 2.875 = 48.875 inches of beam for runners
- 2) 96 – 48.875 = 47.125 inches of beam is space between each runner
- 3) 47.125/16 spaces = 2.94 inch space between each runner.

Step 7 Making space blocks - Make at least four spacer blocks (2 or 3 inch Square tubing cut to length – 2.92 inches - make good spacers – see diagram below) Good thumb rule is to make the spacer slightly shorter (.02) and adjust space between last two runners. Work from both ends of beam toward the middle when placing and welding runners to beams. Any slight adjustments in spaces can be made in the middle two or three runners.

Step 8 Welding Runners to Beam

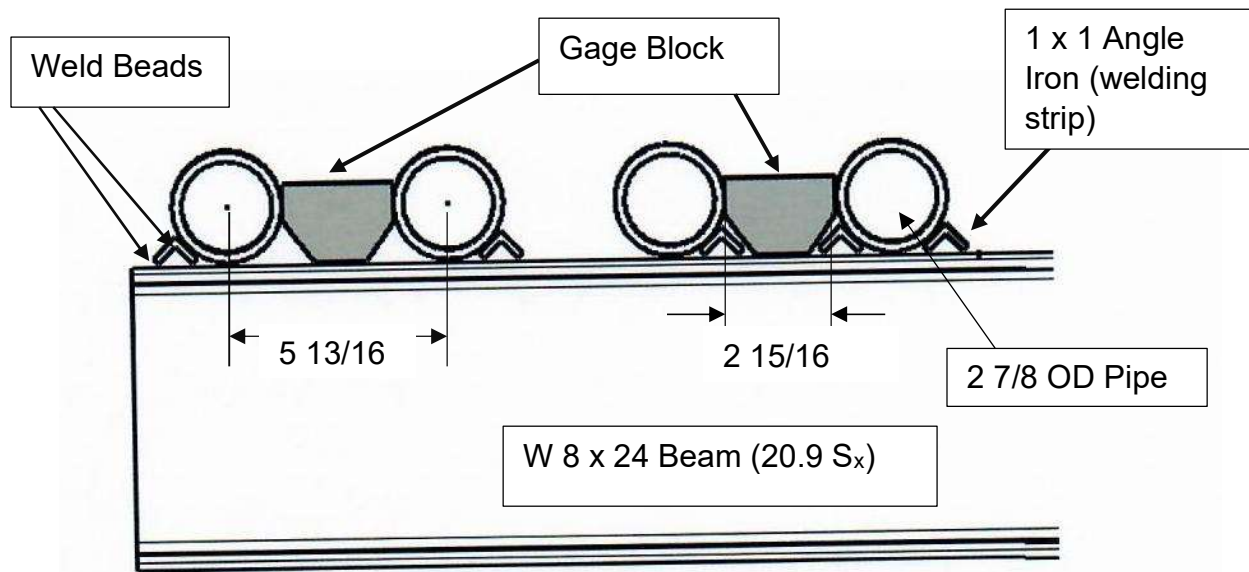


Figure 6 Welding Pipe to Beam

There are different methods to fasten the pipe (runners) to the Beam.

- A. Angle Iron – shown above -to create good welds– Two runners shown on the left end of beam above show starting. Two runners on right show using gage block between spaces when an angle iron has been welded. **All runners should have angle iron on both sides when finished.**

Note: Some builders use rods – even sucker rods or rebar instead of angle iron to increase the weld area. Caution should be used when using sucker rod or rebar in that their steel structure is disturbed when welding them and they may fatigue and pop loose under frequent vibrations caused by loading and unloading when vehicle run over the guard. :

- Using short sections of angle iron to get good weld beads - (1 x 1 x 4 x 3/16) Angle Iron is shown in Figure 6 above to weld the runner to each of the 4 beams. Angle Iron welding strips are approximately 4 inch long. Angle weld strips do not need to be longer than the width of the flange.

- Tables shows W 8 x 24 W Beam to have a 6.495 (6 ½ inches) Flange width.
- A weld bead is run top (apex) of the angle and at the bottom of angle on the beam. This is done on both sides of all runners on each of the four Beams. See Figure 6 above.
- Sequence of placing runners using gage blocks. Blocks can be made from about any material – Sq tubing works well when cut to length as shown above. Notch on two corners may be required to allow for angle iron weld strips. See above. Gauge blocks will not need to be notched if using them on the center beams and placing angle on end beams to weld, then going back and welding the runners to the center beams using angle iron welding strips.
- Weld two outside runners – those on both ends of the beam and work toward the middle.
- Weld angle to runners starting on the left end as shown in Figure 6. Make sure that runner is flat on all 4 beams before welding.
- Place gage blocks (use one on both beams on ends of runners) and place next runner next to block. You may want to use bar clamps to hold runner up against the blocks.
- Place angle iron on outside of second runner and weld. See left end of beam in Figure above.
- Angle can be placed on the inside of both runners after the gage block has been removed and welded. Runners are secure due to the weld beads made on the outsides of each.
- Do the same on opposite end of beam. Work towards the middle. Make any adjustments in space between the runners when approaching middle with at least last 4 runners. Adjustments should be consistent and runner and spacing should be parallel.
- Gage Blocks can be used on the two middle beams (those at about tread width) as explained above and welds made on the beams on ends where there is room for the angle irons to be placed and welded. Then remove the blocks on the middle beams, place angle where block was and weld them.
- Using bar clamps on both ends of the runner to hold the runners up against the blocks and maintain a consistent space between runners.

B. Welding bottom of runners to beam. Some commercial builders build the cattle guard up side down and weld each of the runners to the beams along the both edge of beam where runner crosses it

C. Notching the top of T beam for welding runners. This process eliminates the need for angle or sucker rod to weld runners to beams See figure 7 below.

- Beams may be modified or T Beams. T beams may be constructed from plate when using this method for attaching the runners to the beams.
- Section Modulus should be used when constructing T Beams. If T Beams are made by splitting a W Beam in half the section modular is approximately $\frac{1}{2}$ of W Bea. The tubing makes up for missing Flange on top of Beam.
- Method illustrated in figure below used a 12 inch I (W) Beam and cut in half length wise making it a T Beam, with 6 inch deep web. Since the runners serve as top flange determine S_x of W 6 x 25 = 16.7 inch³ Must use a heavier beam to get 21 S_x or recompute using all 4 beams as load bearing. Because of the integrity of this method, A point load simple beam formula assuming all 4 beams for support because of the runners would transmit one half of load to end beams will work. Runners are of sufficient size – diameter and wall thickness – transmit point loads to 4 beams. Guards wider than 10 feet will need more than 4 beams
- Runner (Pipe or Tube) size – OD, and wall thickness are important with type of design because the runner is part of support in that they help transmit the point loads to all 4 beams. Using 2 inch diameter schedule 40 pipe should only be used for guards designed for light loads,
- This method of attaching the runners to the beam is advantages in that there is a lot less welding (1/4 as many beads) required and still is stout and durable.

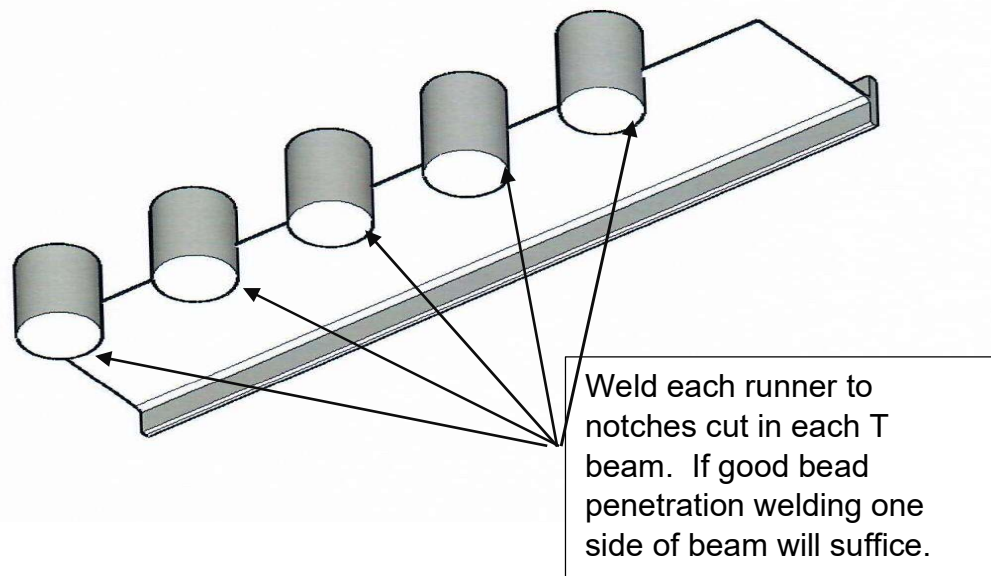
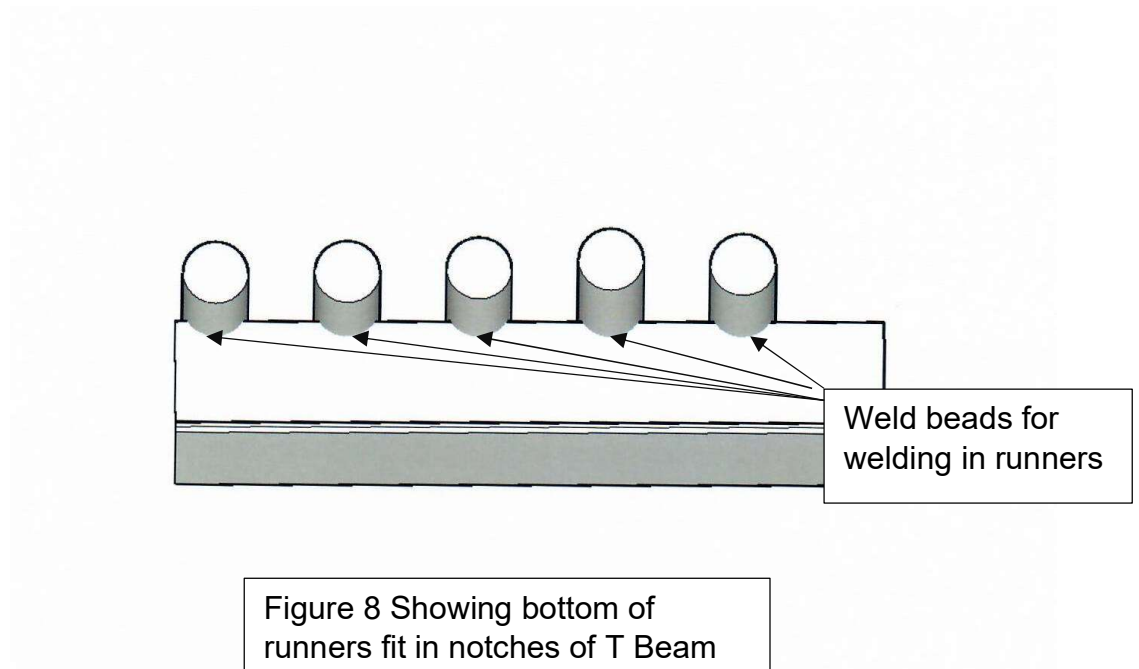


Figure 7 – Splitting 12 inch W Beam making T Beam and notching to weld in runners

- Splitting the W Beam as shown in Figure 6 & 7 makes this a T Beam. T Beams can also be purchased or they can be built from Plate. Thickness and dimension of Plates used must be sufficient to provide the Section Modulus required for the Design Load.



- Notches cut into the Web of beam to weld runners are at least 1 inch deep semicircles or more providing a good long weld bead. The deeper the notch the more weld surface.

7. Conclusion

The objective of this Handbook is to help students design and build Cattle Guards. Part of this objective is to provide information on not only how to build a safe durable cattle guard but to provide technical knowledge that can be applied to many projects. The primary goal is to provide information that the student can use his/her career.