Vehicle Recovery Points

And some technical aspects

by Mike Lauterbach

Many of us, probably most, don't give our vehicle recovery points much thought, and go out and buy our recovery gear, and might even have a winch fitted. Now we have a selection of shackles, all rated bow shackles, because we have heard and learnt that these are the ones to buy for 4x4 vehicles. We also possess a pull strap, a snatch strap, and even a tree protector. But do we know where to attach them and do we know how to safely use them? Unfortunately the answer in many cases is NO.

Many say that our vehicles are fitted with recovery points, and yes, we know that the tow ball is not made for recovery, but we still use it in an "emergency". Many vehicle have 12mm round bar hooks, or those handy towing eyes held in place by a 5mm s-clips. The Land Rover also has those handy lashing eyes. Now, before we use these, let's have a look at some theory about the strength of materials:

I will start with **safety factors**. Safety factors are employed because the quality of steel and workmanship cannot be guaranteed, especially for mass produced steel. The chemical composition does vary within an "acceptable" range. There can be hidden flaws in the material. Also, without accurate computer finite element analysis, it is very difficult to calculate present stresses and strains, especially on complex fittings, where the load path is not obvious or linear. The safety factors are "supposed" to cover these factors.

The strength of steel is measured by two parameters, the Yield Point, and the Tensile Strength. The yield point is the stress point at which permanent strain (deformation) occurs. Before this point, the material will deform or stretch under load, but will spring back to its original size or form when the force is removed. The tensile strength of the material is the point at which it will break.

The lifting industry uses a safety factor of 5. This is calculated on the tensile strength figure. As an example, lets take structural mild steel used in the construction of, for example, angles and square tubing. This is usually BS4360 43A (300WA), which has the following specs:
Yield point = 300 MPa
Tensile strength = 450 to 600 MPa (ave 525 MPa)

A safety factor of 5 means that in our designs, the stress of the material may not exceed 525/5 = 105 MPa. This leaves us with a permanent deformation safety factor of 300/105 = 2.85.

Many other non-critical applications use a safety factor of 3, ie allowable stress = 525/3 = 175MPa.

There are 3 basic stresses which need to be evaluated in the material, and they are tensile, shear and bearing stresses. If you take a bolt as an example, the tensile stress would be the stress resulting from longitudinal tension in the bolt, the shear stress would be the stress caused by eg two plates, held together by the bolt, trying to shear the bolt. Bearing stress is basically the contact force on the surface trying to deform the surface.

The table below gives the allowable bearing forces in tons of mild steel pins and holes for different hole/pin diameters and plate thicknesses. A safety factor of 3 is used, allowable stress = 505 MPa/3 = 168 MPa

Allowable bearing force (tons) (Tensile breaking point)						
Plate thickness	**Shear pin diameter Ø**					
	8 mm	**10 mm**	**12 mm**	**16 mm**	**20 mm**	**25 mm**
0.5 mm	0.07	0.09	0.10	0.14	0.17	0.21
1.0 mm	0.14	0.17	0.21	0.27	0.34	0.43
1.5 mm	0.21	0.26	0.31	0.41	0.51	0.64
2.0 mm	0.27	0.34	0.41	0.55	0.69	0.86
2.5 mm	0.34	0.43	0.51	0.69	0.86	1.07
3.0 mm	0.41	0.51	0.62	0.82	1.03	1.29
3.5 mm	0.48	0.60	0.72	0.96	1.20	1.50
4.0 mm	0.55	0.69	0.82	1.10	1.37	1.72
4.5 mm	0.62	0.77	0.93	1.24	1.54	1.93
5.0 mm	0.69	0.86	1.03	1.37	1.72	2.14
5.5 mm	0.76	0.94	1.13	1.51	1.89	2.36
6.0 mm	0.82	1.03	1.24	1.65	2.06	2.57
6.5 mm	0.89	1.12	1.34	1.78	2.23	2.79
7.0 mm	0.96	1.20	1.44	1.92	2.40	3.00
8.0 mm	1.10	1.37	1.65	2.20	2.75	3.43
9.0 mm	1.24	1.54	1.85	2.47	3.09	3.86
10.0 mm	1.37	1.72	2.06	2.75	3.43	4.29
12.0 mm	1.65	2.06	2.47	3.29	4.12	5.15
15.0 mm	2.06	2.57	3.09	4.12	5.15	6.43
19.0 mm	2.61	3.26	3.91	5.22	6.52	8.15
20.0 mm	2.75	3.43	4.12	5.49	6.86	8.58
22.0 mm	3.02	3.78	4.53	6.04	7.55	9.44
25.0 mm	3.43	4.29	5.15	6.86	8.58	10.72

Allowable Pin Shear Forces
again, using the allowable stress of 168 MPa for MS, and 880/3 = 293MPa for the high tensile steel

Pin Diameter	Mild Steel	High tensile
8 mm	863 kg	1503 kg
10 mm	1348 kg	2348 kg
12 mm	1941 kg	3382 kg
16 mm	3450 kg	6012 kg
20 mm	5391 kg	9394 kg
25 mm	8423 kg	14678 kg
30 mm	12129 kg	21136 kg

The following forces are calculated in the thread area, and not at the shank side.

Factored Allowable Bolt Forces		
	Max Tensile Forces kg	**Max Shear Forces kg**

Bolt Course thread	MS	4.6MPa	8.8MPa	MS	4.6MPa	8.8MPa
5 mm	174 kg	282 kg	651 kg	200 kg	320 kg	751 kg
6 mm	246 kg	400 kg	922 kg	288 kg	461 kg	1081 kg
8 mm	448 kg	728 kg	1679 kg	512 kg	820 kg	1921 kg
10 mm	709 kg	1153 kg	2661 kg	801 kg	1281 kg	3002 kg
12 mm	1031 kg	1676 kg	3867 kg	1153 kg	1845 kg	4323 kg
16 mm	1920 kg	3121 kg	7202 kg	2050 kg	3279 kg	7686 kg
20 mm	2997 kg	4870 kg	11239 kg	3202 kg	5124 kg	12009 kg
24 mm	4318 kg	7017 kg	16193 kg	4612 kg	7378 kg	17293 kg
30 mm	6862 kg	11151 kg	25734 kg	7205 kg	11529 kg	27021 kg
36 mm	9994 kg	16240 kg	37477 kg	10376 kg	16601 kg	38910 kg
42 mm	13700 kg	22263 kg	51376 kg	14123 kg	22596 kg	52960 kg
48 mm	17982 kg	29220 kg	67431 kg	18446 kg	29514 kg	69173 kg

Bolt Fine thread	Max Tensile Forces kg			Max Shear Forces kg		
	MS	**4.6MPa**	**8.8MPa**	**MS**	**4.6MPa**	**8.8MPa**
6 mm	269 kg	437 kg	1009 kg	288 kg	461 kg	1081 kg
8 mm	480 kg	779 kg	1798 kg	512 kg	820 kg	1921 kg
10 mm	749 kg	1217 kg	2807 kg	801 kg	1281 kg	3002 kg
12 mm	1127 kg	1831 kg	4225 kg	1153 kg	1845 kg	4323 kg
16 mm	2043 kg	3320 kg	7661 kg	2050 kg	3279 kg	7686 kg
20 mm	3327 kg	5407 kg	12477 kg	3202 kg	5124 kg	12009 kg
24 mm	4697 kg	7633 kg	17615 kg	4612 kg	7378 kg	17293 kg
30 mm	7596 kg	12344 kg	28486 kg	7205 kg	11529 kg	27021 kg
36 mm	10581 kg	17194 kg	39679 kg	10376 kg	16601 kg	38910 kg

With these tables we can now assess the strength of various items.

Let's use the 110 Defender as an example.

1. Lashing eyes (also incorrectly called towing bracket or towing eyes)
These are made from 7mm thick steel, and attached to the vehicle with one **ø**10mm bolt. Lets assume that the bolt is a high tensile (8.8) bolt.

First, consider the lashing eye material at the bolt hole:
The allowable bearing force here (t=7mm, **ø** = 10mm) is *1720 kg.*

The allowable bolt shear force (high tensile, **ø** = 10mm) is *2348 kg.*

Now check the chassis at the back. The chassis thickness is 2mm, and there is no stiffener welded on as there is on the front. The older Range Rovers, and Discos series 1 and 2 do have such stiffeners on the back as well. Only a spacer is used inside the chassis to prevent the chassis section from pulling together when tightening these bolts, and it does not add to the strength. Therefore the critical factor will be bearing stress on this area. From the top table we get

Allowable bearing force = *340kg*. Multiply by 3 (if you are feeling brave) and you get hole deformation (tearing) at 1020kg, assuming the material composition is perfect.

This tells us that one should not attach more than 340kg force to the back eye lashings. This does not even make it suitable for towing. As bearing failure, or tearing of the chassis is not as critical as a sheared bolt, we could assume that in the worst case scenario that we can attach up to 1020kg to each eye at the back. This is definitely not advisable though.

The eye lashings at the front are connected to a reinforced section, where the material is 4.5mm thick, and reinforced. Each of these should be able to withstand about 4 tons force. Therefore, the critical factor for the front would be allowable bearing force on the eye lashing, ie ***1720kg**.* This is still not suitable as a recovery point, but if both sides are used simultaneously, gentle winching could be attempted. This also goes for towing.

2. The Front Bumper

The bumper is attached to the chassis with 2 10mm bolts per side. the bumper thickness at this joint is 3.5mm.

The allowable bearing force per side on the bumper is thus
4 x 600kg = **2400kg per side**.

The allowable bearing force per side on the 2mm chassis is
4 x 340kg = 1360kg per side. But the section is reinforced. So let's assume that the allowable stress is the equivalent as the tensile strength, without a safety factor, for the 2mm section. ie Allowable force = 1360 x 3 = **4080kg per side**.

The allowable shear force per side (with HT bolts) is
4 x 2348kg = 9392 kg per side.

The lower section has a reinforced bolt hole through 4.5mm material. Again, removing the safety factor to compensate for the reinforcement, we get
Allowable bearing force = 2 x 770 x 3 = 4620kg per side, and
Allowable bolt shear force = 2 x 2348 = 4696kg per side.

Therefore, the front bumper can be reinforced so that the attachment material at the bolt section is 6mm thick, top and bottom. Then an eight ton force can be applied to the bumper, 4 ton each side, IF the bumper has decent attachments welded to it.

A jate ring, or similar attachment can be attached to the horizontal bolt in the lower section. Again, the applied force should be limited to 4 tons per side.

3. The back of the vehicle.

As determined in 1 above, the defender can not use jate rings at the back section, as the existing bolt holes are un-reinforced, and can only take **340kg per hole**. Therefore, a plan needs to be made where the tow hitch is beefed up, and supported with a backing plate, one needs to have recovery points, like those found on the Discos and Rangies, welded onto the chassis. If the chassis is galvanised, forget this avenue, as the weld, even with cleaning up, will not be strong enough.

The attachments on the Discos and Range Rovers are good enough for loads up to 4 tons per side. With suitable jate rings, this is where you will then attach your snatch strap, with the help of a strong strap.

On the Defender, using a specially designed recovery tow hitch plate, with a backing plate, is thus the only realistic solution for recovery. It is difficult to calculate the exact safe forces here without proper computer modeling due to the complex shape of the back chassis member. I would hesitate applying more than 6 ton force through here though.

These examples above should be able to give you an idea of how to use the above tables. Please note that the tables assume ideal materials and conditions, with straightforward loads. Loads tend to be more complex though, eg a towing, or recovery force at a 20 degree angle to the vehicle. Suddenly bending forces also come into play. So use the above data with care, and as an indication only, as the forces you will realise will probably be higher.