Design Calculations for Motorcycle Rack for Kenny Watkins (2015 IBC)

Chad Porter, PE

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Having analyzed the existing motorcycle rack it has been determined that it is sufficiently strong to support the motorcycle and snowmobile loads along with the snow load in Eden Utah. However, given the height and slenderness of the rack, it is my recommendation that the owner remove the top section and use the middle section as just a covering (keep unloaded). Doing this drastically reduces any risk of overturning due to wind or earthquake and will allow for multiple single level racks that are easier and safer to load and unload. It will also reduce any adverse visual appearance. It is also my recommendation that the owner laterally support the rack by welding either expanded metal or diagonal bracing to the back side. Currently the sections of rack are only connected in a few locations. The owner has also been advised to properly connect all sections at all available locations using properly sized timber blocking and bolts of the same size and type as existing in the few already connected locations. The owner has been advised of all of these recommendations and is willing to comply.

Design Calculation for Motorcycle Rack for Kenny Watkins (IBC 2015)
Main **Support**
10/23/2017

Input Variables

$span := 9ft$ $\phi := 0.9$ $E_{Steel} := 29000ksi$ $F_y := 36000psi$

$W_T := 2ft$ Tributary Width

$H_{Beam} := 4in$ $W_{Beam} := 1.75in$ $T_{Beam} := .125in$

Live Loads:

$L_R := 38.4psf$ Live Load of 2 snowmobiles @ 700 lbs each

$L_{Snow} := 70psf$ Snow Load

Dead Loads:

$DL := 5psf$

Main Beam Design

Factored loads:

$w_{LL} := 1.6 \cdot (L_R \cdot W_T + L_{Snow} \cdot W_T) = 346.88 \cdot plf$

$w_{DL} := 1.2(DL \cdot W_T) = 12 \cdot plf$

$w := w_{LL} + w_{DL} = 358.88 \cdot plf$

Reaction

$$R_1 := \frac{(w \cdot span)}{2} = 1.615 \cdot kip$$

$R_2 := R_1 = 1.615 \cdot kip$

Bending

$$M_U := \frac{\left(w \cdot span^2\right)}{8} = 3.634 \cdot kip \cdot ft$$

$$Z_{Required} := \frac{M_U}{\phi \cdot F_y} = 1.346 \cdot in^3$$

$$Z_{Main\_Support} := \frac{\left[W_{Beam} \cdot H_{Beam}^{\ 3} - \left(W_{Beam} - 2.T_{Beam}\right) \cdot \left(H_{Beam} - 2 \cdot T_{Beam}\right)^3\right]}{6 \cdot H_{Beam}} = 1.371\ in^3$$

$$Z_{Main\_Support} \geq Z_{Required}$$

Bending is Ok

Shear

$$V_U := R_1 = 1.615 \cdot kip$$

$$A_w := 2 \cdot H_{Beam} \cdot T_{Beam} = 1\ in^2$$ Area of the Web

$$V_n := 0.6 \cdot \phi \cdot F_y \cdot A_w = 19.44 \cdot kip$$

$$V_n \geq V_U$$

Shear is Ok

Deflection

$$\delta_{Allow} := \frac{span}{120} = 0.9 \cdot in$$

$$I_{Required} := \frac{\left(5 \cdot w \cdot span^4\right)}{\left(384 \cdot E_{Steel} \cdot \delta_{Allow}\right)} = 2.03 \cdot in^4$$

$$I_{Main\_Beam} := \frac{\left[W_{Beam} \cdot H_{Beam}^{3} - \left(W_{Beam} - 2.T_{Beam}\right) \cdot \left(H_{Beam} - 2 \cdot T_{Beam}\right)^{3}\right]}{12} = 2.742\ in^{4}$$

$I_{Main\_Beam} \geq I_{Required}$

Deflection is Ok

Design Calculation for Motorcycle Rack for Kenny Watkins (IBC 2015)
Lipped C-Channel Support
10/23/2017

Input Variables

$span := 4ft$ $\phi := 0.9$ $E_{Steel} := 29000ksi$ $F_y := 36000psi$

$W_T := 2.17ft$ Tributary Width

Live Loads:

$L_R := 38.4psf$ Live Load of 2 snowmobiles @ 700 lbs each

$L_{Snow} := 70psf$ Snow Load

$Z_{Lipped\_C\_Channel} := 0.29in^3$ Section modulus. See attached sheet of properties for Lipped C-Channel.

$I_{Lipped\_C\_Channel} := 11.8in^4$ Modulus of Elasticity. See attached sheet of properties for Lipped C-Channel.

Dead Loads:

$DL := 5psf$

Lipped C-Channel Design

Factored loads:

$w_{LL} := 1.6 \cdot (L_R \cdot W_T + L_{Snow} \cdot W_T) = 376.365 plf$

$w_{DL} := 1.2(DL \cdot W_T) = 13.02 \cdot plf$

$w := w_{LL} + w_{DL} = 389.385 plf$

Reaction

$$R_1 := \frac{(w \cdot span)}{2} = 0.779 \cdot kip$$

$R_2 := R_1 = 0.779 \cdot kip$

Bending

$$M_U := \frac{\left(w \cdot span^2\right)}{8} = 0.779 \cdot kip \cdot ft$$

$$Z_{Required} := \frac{M_U}{\phi \cdot F_y} = 0.288 \cdot in^3$$

$$Z_{Lipped\_C\_Channel} \geq Z_{Required}$$

Bending is Ok

Shear

$$V_U := R_1 = 0.779 \cdot kip$$

$A_w := 0.64 in^2$ Area of the Web

$$V_n := 0.6 \cdot \phi \cdot F_y \cdot A_w = 12.442 \cdot kip$$

$$V_n \geq V_U$$

Shear is Ok

Deflection

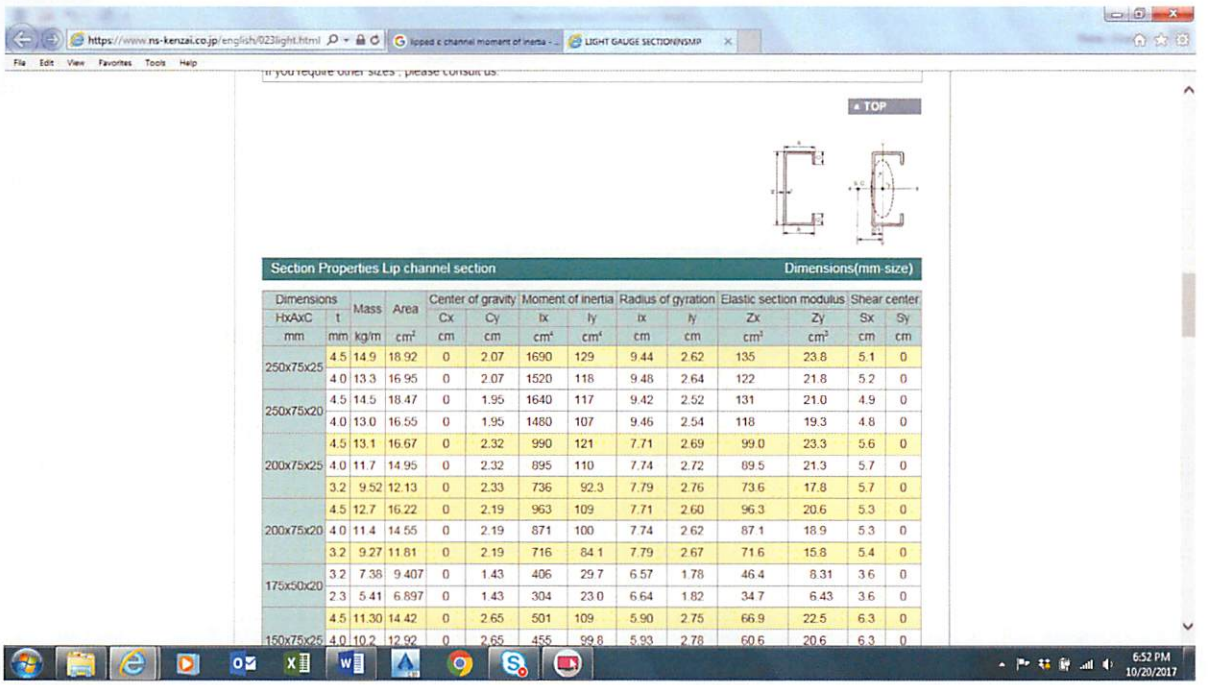
$$\delta_{Allow} := \frac{span}{120} = 0.4 \cdot in$$

$$I_{Required} := \frac{\left(5 \cdot w \cdot span^4\right)}{\left(384 \cdot E_{Steel} \cdot \delta_{Allow}\right)} = 0.193 \cdot in^4$$

$$I_{Lipped\_C\_Channel} \geq I_{Required}$$

Deflection is Ok

https://www.ns-kenzai.co.jp/english/023light.html

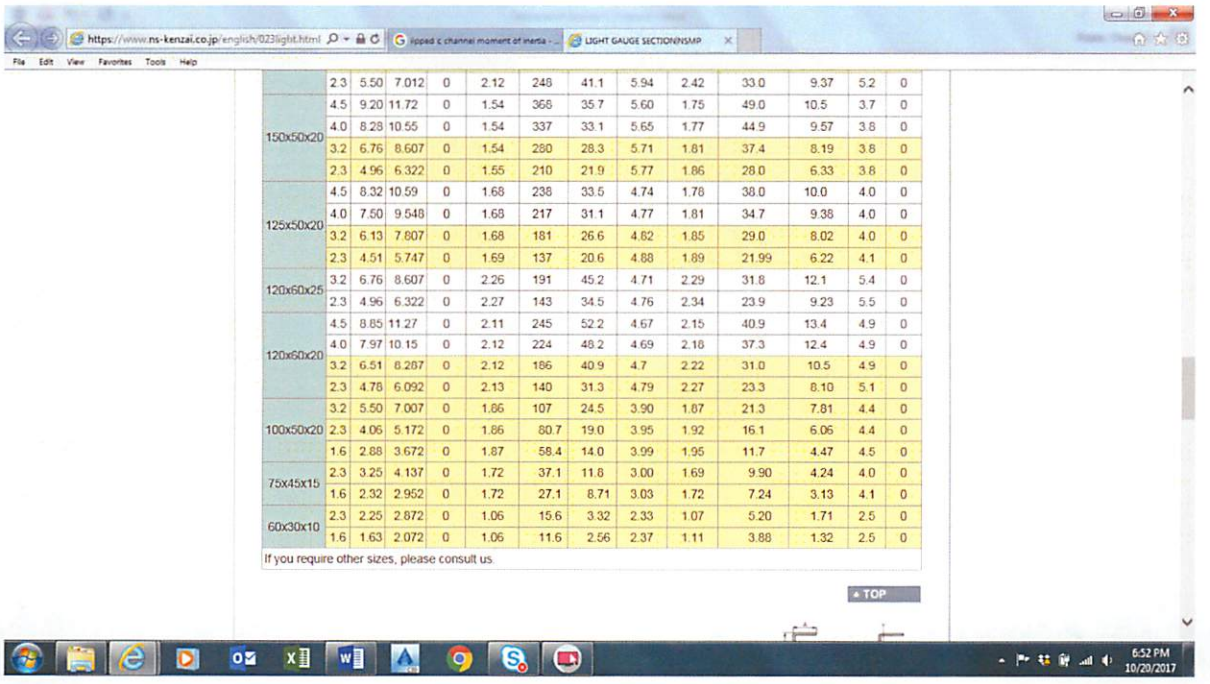


▲ TOP

Section Properties Lip channel section — Dimensions(mm·size)

Dimensions HxAxC	t	Mass	Area	Center of gravity Cx	Cy	Moment of inertia Ix	Iy	Radius of gyration ix	iy	Elastic section modulus Zx	Zy	Shear center Sx	Sy
mm	mm	kg/m	cm²	cm	cm	cm⁴	cm⁴	cm	cm	cm³	cm³	cm	cm
250x75x25	4.5	14.9	18.92	0	2.07	1690	129	9.44	2.62	135	23.8	5.1	0
	4.0	13.3	16.95	0	2.07	1520	118	9.48	2.64	122	21.8	5.2	0
250x75x20	4.5	14.5	18.47	0	1.95	1640	117	9.42	2.52	131	21.0	4.9	0
	4.0	13.0	16.55	0	1.95	1480	107	9.46	2.54	118	19.3	4.8	0
200x75x25	4.5	13.1	16.67	0	2.32	990	121	7.71	2.69	99.0	23.3	5.6	0
	4.0	11.7	14.95	0	2.32	895	110	7.74	2.72	89.5	21.3	5.7	0
	3.2	9.52	12.13	0	2.33	736	92.3	7.79	2.76	73.6	17.8	5.7	0
200x75x20	4.5	12.7	16.22	0	2.19	963	109	7.71	2.60	96.3	20.6	5.3	0
	4.0	11.4	14.55	0	2.19	871	100	7.74	2.62	87.1	18.9	5.3	0
	3.2	9.27	11.81	0	2.19	716	84.1	7.79	2.67	71.6	15.8	5.4	0
175x50x20	3.2	7.38	9.407	0	1.43	406	29.7	6.57	1.78	46.4	8.31	3.6	0
	2.3	5.41	6.897	0	1.43	304	23.0	6.64	1.82	34.7	6.43	3.6	0
150x75x25	4.5	11.30	14.42	0	2.65	501	109	5.90	2.75	66.9	22.5	6.3	0
	4.0	10.2	12.92	0	2.65	455	99.8	5.93	2.78	60.6	20.6	6.3	0

https://www.ns-kenzai.co.jp/english/023light.html



150x50x20	2.3	5.50	7.012	0	2.12	248	41.1	5.94	2.42	33.0	9.37	5.2	0
	4.5	9.20	11.72	0	1.54	368	35.7	5.60	1.75	49.0	10.5	3.7	0
	4.0	8.28	10.55	0	1.54	337	33.1	5.65	1.77	44.9	9.57	3.8	0
	3.2	6.76	8.607	0	1.54	280	28.3	5.71	1.81	37.4	8.19	3.8	0
	2.3	4.96	6.322	0	1.55	210	21.9	5.77	1.86	28.0	6.33	3.8	0
125x50x20	4.5	8.32	10.59	0	1.68	238	33.5	4.74	1.78	38.0	10.0	4.0	0
	4.0	7.50	9.548	0	1.68	217	31.1	4.77	1.81	34.7	9.38	4.0	0
	3.2	6.13	7.807	0	1.68	181	26.6	4.82	1.85	29.0	8.02	4.0	0
	2.3	4.51	5.747	0	1.69	137	20.6	4.88	1.89	21.99	6.22	4.1	0
120x60x25	3.2	6.76	8.607	0	2.26	191	45.2	4.71	2.29	31.8	12.1	5.4	0
	2.3	4.96	6.322	0	2.27	143	34.5	4.76	2.34	23.9	9.23	5.5	0
120x60x20	4.5	8.85	11.27	0	2.11	245	52.2	4.67	2.15	40.9	13.4	4.9	0
	4.0	7.97	10.15	0	2.12	224	48.2	4.69	2.18	37.3	12.4	4.9	0
	3.2	6.51	8.287	0	2.12	186	40.9	4.7	2.22	31.0	10.5	4.9	0
	2.3	4.78	6.092	0	2.13	140	31.3	4.79	2.27	23.3	8.10	5.1	0
100x50x20	3.2	5.50	7.007	0	1.66	107	24.5	3.90	1.87	21.3	7.81	4.4	0
	2.3	4.06	5.172	0	1.66	80.7	19.0	3.95	1.92	16.1	6.06	4.4	0
	1.6	2.88	3.672	0	1.67	58.4	14.0	3.99	1.95	11.7	4.47	4.5	0
75x45x15	2.3	3.25	4.137	0	1.72	37.1	11.8	3.00	1.69	9.90	4.24	4.0	0
	1.6	2.32	2.952	0	1.72	27.1	8.71	3.03	1.72	7.24	3.13	4.1	0
60x30x10	2.3	2.25	2.872	0	1.06	15.6	3.32	2.33	1.07	5.20	1.71	2.5	0
	1.6	1.63	2.072	0	1.06	11.6	2.56	2.37	1.11	3.88	1.32	2.5	0

If you require other sizes, please consult us

▲ TOP