1.2 HSS Section Properties (Rotated)

Per 13th Ed., Manual of Steel Construction, p. 17-42: (For Beams and Channels)

\[ I_x = I_y \text{ for sq. HSS} \]

\[ I_{Rx} = I_{Ry} = I_x \sin^2 \theta + I_y \cos^2 \theta \]

\[ \sin \theta = \cos \theta, \text{ when } \theta = 45^\circ \]

\[ \sin \theta = \cos \theta = 0.707106781 \]

\[ \sin^2 \theta = \cos^2 \theta = 0.5 \]

\[ I_{Rx} = I_{Ry} = 0.5I_x + 0.5I_y = 1.0I_x = 1.0I_y \]

\( I \text{(Rotated 45°) is THE SAME AS } I_x \text{ (NOT Rotated)} \)

\( I \text{ (Rotated)} = \sqrt{\frac{I}{A}} = \text{SAME AS NOT ROTATED} \)

\[ S_R = \frac{I}{Cr} \text{ (in}^3) \]
For HSS $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$

- $Wt./Ft. = 3.04 \text{ lb.}$
- $Thickness = 0.114''$
- $t/\bar{t} = \frac{h}{\bar{h}} = 5.6$ (Compact Section)
- $A = 0.84''^2$
- $I = 0.235 \text{ in.}^4$; $S = 0.314 \text{ in.}^3 = \frac{I}{c}$
- $r = 0.528 \text{ in.}$

Rotated Properties ($45^\circ$)

- $W = 3.04 \text{ plf}$
- $t = 0.114 \text{ in.}$
- $A = 0.84''^2$
- $I = 0.235 \text{ in.}^4$
- $r = 0.528 \text{ in.}$
- $S = \frac{0.235}{1,060} = 0.222 \text{ in.}^3$. 

[Diagram showing rotated properties]
For HSS 3 x 3 x \( \frac{1}{4} \) 

\[ \text{Wt./Ft.} = 8.81 \text{ lb.} \]

\[ \text{THICKNESS} = 0.233 \text{ "} \]

\[ \frac{b}{2} = \frac{h}{2} = 9.9 \text{ } (\text{COMPACT SECTION}) \]

\[ A = 2.44 \text{ sq. "} \]

\[ I = 3.02 \text{ in}^4 \]

\[ S = 2.01 \text{ in}^3 \]

\[ r = 1.11 \text{ in.} \]

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Rotated Properties (45°) 

\[ W = 8.81 \text{ plfs} \]

\[ t = 0.233 \text{ "} \]

\[ A = 2.44 \text{ sq. "} \]

\[ I = 3.02 \text{ in}^4 \]

\[ r = 1.11 \text{ in.} \]

\[ S = \frac{3.02}{2.1213} = 1.42 \text{ in}^3 \]
For HSS 4 x 4 x 1/4

WT. / FT. = 12.21 LB.
Thickness = 0.233"

b/2 = l/2 = 1.52" (Compact Section)
A = 3.37 sq"

I = 7.80 in.⁴ ; S = 3.90 in.³ = \( I \over C \)

R = 1.52 in.

Rotated Properties (45°)

W = 12.21 Plf
L = 0.233"

A = 3.37 sq"

I = 7.80 in.⁴
diag. Dim = \( \frac{4}{0.707106781} \)

\( CR = \frac{PD}{2} = 2.83" \)

R = 1.52 in

\( S' = \frac{7.80}{2.83} = 2.75 \) in.³
A1a: The calculations that were submitted result in the Elastic Section Modulus (S), which should only be used to investigate the flexural capacity of a beam based on the elastic stress distribution (not the plastic stress distribution which the AISC 13th. edition utilizes). For an elastic stress distribution, it is shown that square HSS members rotated 45° from standard orientation will have approximately 70% of the elastic flexural capacity of the same member that has not been rotated.

\[
\begin{align*}
M_n &= f_b \times S_{\text{unrotated}} \\
M_{n,\text{rotated}} &= f_b \times S_{\text{rotated}} = f_b \times 0.707 \times S_{\text{rotated}}
\end{align*}
\]

It should be noted that the calculations do not investigate the effect of the rotation of the member on its shear capacity. This could greatly affect the member capacity since the walls of the HSS in the rotated position are no longer aligned with the transverse shear force, and localized wall bending may govern the shear strength calculations (i.e. the cross-section will be more prone to squishing, in the rotated orientation).

Thus, \( V_{n,\text{rotated}} < V_n \)
For HSS 1½ x 1½ x 3/16

- Wt./Ft. = 3.04 lb,
- Thickness = 0.174 in
- \( \frac{h}{t} = \frac{L}{t} = 5.6 \) (Compact Section)
- \( A = 0.84 \text{ in}^2 \)
- \( I = 0.235 \text{ in}^4 \); \( S = 0.314 \text{ in}^3 = \frac{I}{t} \)
- \( r = 0.528 \text{ in} \)

Rotated Properties (45°)

- \( W = 3.04 \text{ plf} \)
- \( \ell = 0.174 \text{ in} \)
- \( A = 0.84 \text{ in}^2 \)
- \( I = 0.235 \text{ in}^4 \)
- \( r = 0.528 \text{ in} \)
- \( S_r = \frac{0.235}{1.060} = 0.222 \text{ in}^3 \)

1. Another way to look at it is
   \( C_r = 1.414 \times C \), therefore \( S_r = 0.707 \times S \)
2. This makes sense because there is less material in the extreme fiber stress regions, so \( M_y > M_{r,y} \)