

# A Review on Design and Analysis of Shear Clips

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## ABSTRACT

Shear clips are principally used as support structure for the purpose of joining together one structural member to another. It is the most utilized type of joining two parts together.

If their design is overlooked, they can become the cause of inadequate or faulty main structural designs.

## Keywords

Shear clips, fixed supported beam, simply supported beam, Single angle clip (type-A), Back to back angle clips (type-B), A tee clip (type-C)

## 1. INTRODUCTION

Shear clips are used to attach stringers to ribs. The shear clip resists shear only but the tension clip principally transfers axial tension loads. Shear clips are principally used as support structure for the purpose of joining together one structural member to another

Shear clips are used for mounting brackets to support electrical wiring harnesses, electrical and mechanical equipment hardware, gauge, indicator, instruments etc. A shear clip is designed to rotate under load an amount without inducing or causing failure.

### 1.1 About shear clips

A shear clip connection must be simply supported; otherwise it causes the joint to become overstressed. To have a stiffer support structure, upper and lower splice plates can be added and is called fixed support. Fixed supported beam (FSB) is more efficient than simply supported beam (SSB) because internal shears and bending moments generated in FSB are better distributed along entire span of beam.

## 2. DESIGN PARAMETERS FOR SHEAR CLIPS

- No welding is used.
- Provide sufficient edge distance for metallic structures:  $e/d = 2D + .30$  to allow next larger size fastener.
- Design shear and tension clips made of extruded sections with normal fillet radii and formed section with minimum bend radii.
- Do not mix bolts and rivets in the same fastener pattern.
- Avoid discontinuities or joggles to prevent cracking where possible.

The FAA requires a fitting factor of 1.15 to comply with shear clip support design, their fasteners, and bearing upon the joined members when no structural test data has been proved.

Shear clips are often considered as secondary structure whose weakening directly affect the primary structure. Shear clips are designed in various shapes and sizes.

### 2.1 The three main support types are:

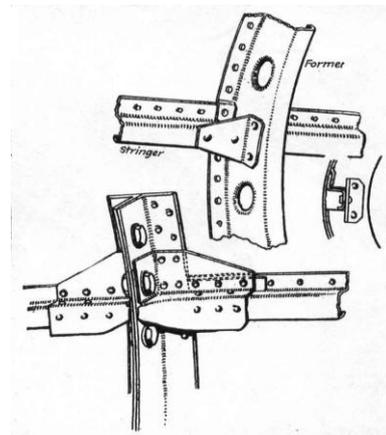
- Single angle clip (type-A)
- Back to back angle clips (type-B)
- A tee clip (type-C)

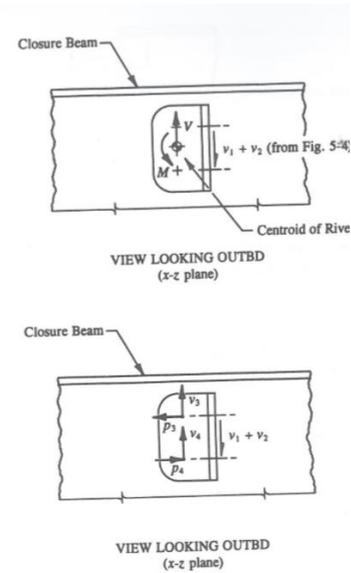
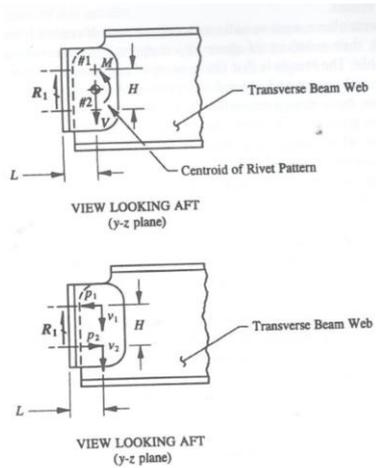
The tee clip is the most efficient one.

## 3. DESCRIPTION

In the final analysis, however the capacity of the shear clip is governed either by bearing failure of its joined members or by shearing failure of its fasteners. A shear clip provides the ability to restrain the end of a beam from physically moving in the plane of the attached web.

Shear clips are always given some degree of resistance or restraint axially and are not considered normally. While designing shear clip it is important to understand how they work and how they react to their intended applied shear loads.





Let us investigate these supports by first considering type-A.,

From statics,

A vertical shear reaction  $r_1$  is denoted at the support end. The over loading effect of the areas (which would include the support at B) could ultimately cause some premature failure of the structure, although the shear clip (or joined members at support A) was the real cause of failure in the first place, but did not fail.

Let us determine the equilibrium forces to balance the shear clip in the y-z plane.

The shear  $V$  and bending moment  $M$  divide equally between equal size and strength fasteners.

$$v_1 = v_2 = V/2$$

$$p_1 = p_2 = M/H$$

Where  $V = R_1$

$$M = R_1L$$

$H$  = distance measured between fastener centres

$L$  = distance measured from the rivet line to the shear plane of the attached leg.

Resultant shearing force for fastener #1:

$$P_1 = (v_1 + p_1)/2$$

Resultant shearing force for fastener #2:

$$P_2 = (v_2 + p_2)/2$$

Shearing failure:

$$\text{Margin of safety} = P_{su}/P_{sk} - 1$$

Where:  $P_{su}$  = ultimate shear allowable for the fastener

$P_{sk}$  = resultant shearing force of the fastener

$K = 1.15$  (fitting factor used in joint and connection designs).

Bearing failure:

$$\text{Margin of safety} = M.S. = P_{bru}/P_{sk} - 1$$

Where:  $P_{bru}$  ultimate bearing allowable of the material

$P_{sk}$  = resultant shearing force of the fasteners

$k = 1.15$  (fitting factor used in joint and connection designs)

now let us rotate the shear plane in x-z plane, our solution in this plane begins by distributing the reaction shear  $v_1 + v_2$  (which equals  $r_1$ ) from the y-z plane to the centroid of the rivet pattern.

$$v_3 = v_4 = v/2$$

$$p_3 = p_4 = M/H$$

Where  $V = R_1$

$$M = R_1L$$

$H$  = distance measured between fastener centres

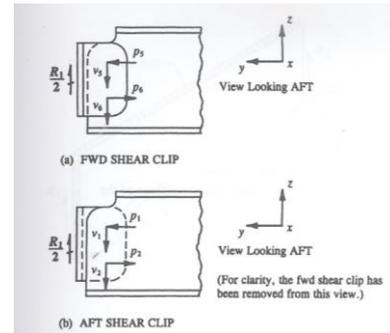
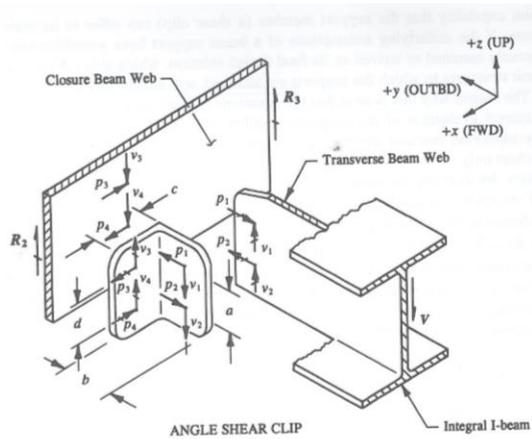
$L$  = distance measured from the rivet line to the shear plane of the attached leg.

Resultant shearing force for fastener #1:

$$P_3 = (v_3 + p_3)/2$$

Resultant shearing force for fastener #2:

$$P_4 = (v_4 + p_4)/2$$



And thus, from their description on the isolated shear clip, the following are extracted:

1.  $v_1 = v_2 = v_3 = v_4 = V/2$
2.  $p_1 = p_2 = Vb/a$  (based on the couple force relationship of moments  $M/H$ )
3.  $p_3 = p_4 = Vc/d$  (also based on the force relationship of moments  $M/H$ )

Each rivet used in a structural design is limited by a minimum sheet thickness requirement. The limitation (minimum design sheet thickness for rivets) and the effect of eccentricity on shearing and bearing failures, in effect control the basic design of shear clip.

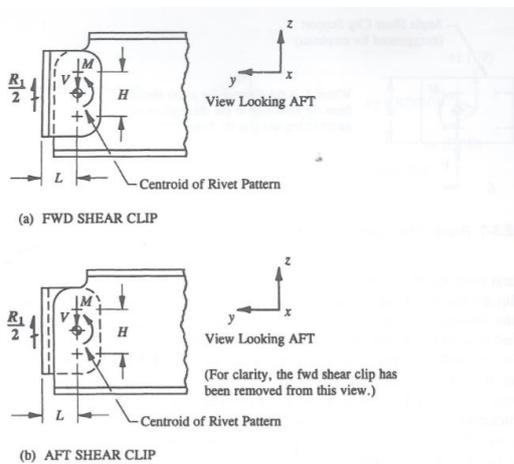


FIGURE 5-8 Equilibrium forces  $V$  and  $M$  indicated for (a) the fwd shear clip and (b) the aft shear clip.

The second type of support structure is type-B (back to back angle shear clips). Like type-A, type-B also assumes a simply supported restraint condition. So all the theories of type-A applies here also except that for the structural arrangement of support members.

$$v_5 = v_6 = V/2$$

$$p_5 = p_6 = M/H$$

$$\text{Where, } V = R1/2 \text{ and } M = [R1/2]L$$

For the aft shear clip:

$$v_1 = v_2 = V/2$$

$$p_1 = p_2 = M/H$$

Resultant shearing force for fastener#1:

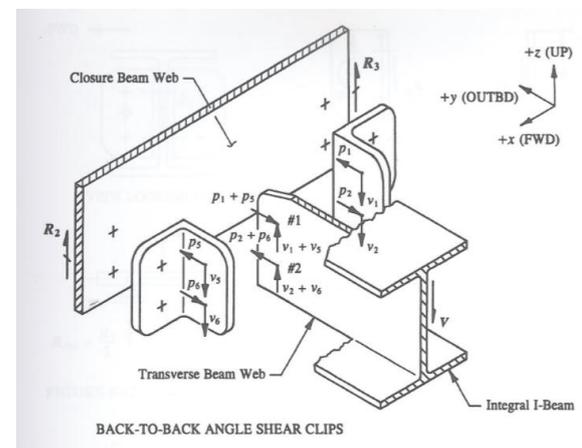
$$P1 = [(p_1 + p_5)^2 + (v_1 + v_5)^2]^{1/2}$$

Resultant shearing force for fastener#2:

$$P2 = [(p_2 + p_6)^2 + (v_2 + v_6)^2]^{1/2}$$

Since the fasteners are of the same size and strength, their resultants are of the same magnitude, that is,

$$P1 = P2$$



Shearing failure:

$$\text{Margin of safety} = P_{su}/p_{sk} - 1$$

Where  $P_{su}$  = ultimate double shear allowable of the fastener

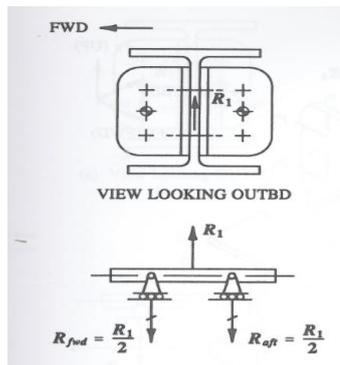
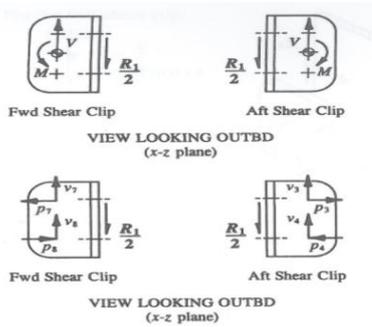
$$P_s = p_1 = p_2$$

$$K = 1.5$$

Bearing failure of the aft shear clip:

Margin of safety = M.S =  $\frac{P_{bru}}{P_{sk}} - 1$

$P_{bru}$  = ultimate bearing allowable of the material



$$p_s = 1/2P_1 = (v_{12} + p_{12}) = (v_{22} + p_{22})/2$$

$$M.S. = \frac{P_{bru}}{P_{sk}} - 1$$

$$p_s = 1/2P_2 = (v_{52} + p_{52}) = (v_{62} + p_{62})/2$$

$$p_s = P_1 = P_2$$

By isolating each support clip once again, in the plane of the closure beam web, we obtain the shearing forces in equilibrium.

$$V_3 = v_4 = V/2$$

$$v_7 = v_8 = V/2$$

$$P_3 = p_4 = M/H$$

$$p_7 = p_8 = M/H$$

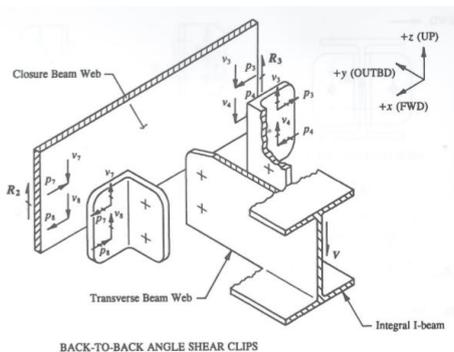


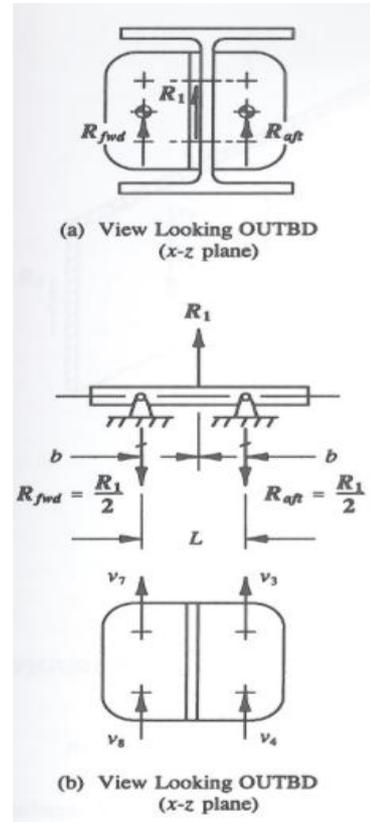
FIGURE 5-13 Transfer of load through back-to-back angle shear clips (Type B).

This figure shows the horizontal and vertical system of shearing forces in the plane of the closure beam web. From these distributions following failures can be predicted:

1. Shearing failure of the closure beam rivets,

2. Bearing failure of the closure beam web, and
3. Bearing failure of the shearing clips.

Our third support member, tee clip (type-C). To know how it is more efficient first we find out that how much of the reaction shear  $R_1$  is reacted by each rivet group.



Since the support is symmetrically loaded, one half of the reaction shear  $R_1$  is reacted by each rivet group. Unlike others, a tee clip is structurally better design because it develops no bending moments at the centroid of each rivet group, the support is statically in equilibrium.

$$v_3 = v_4 = \frac{R_{aft}}{2} = \frac{R_1}{2} = \frac{R_1}{4}$$

$$v_7 = v_8 = \frac{R_{fwd}}{2} = \frac{R_1}{2} = \frac{R_1}{4}$$

$$v_5 = v_6 = V/2$$

$$p_5 = p_6 = M/H$$

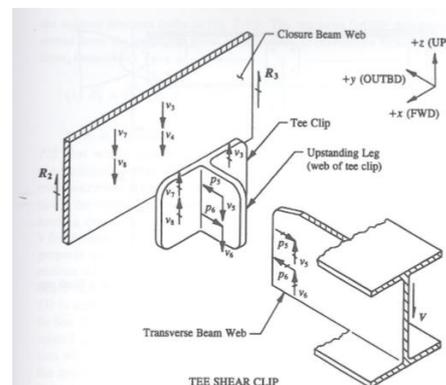


FIGURE 5-16 Transfer of load through a tee shear clip (Type C).

The resultant shearing forces are:

$$p5 = (v52 + p52)1/2$$

$$p6 = (v62 + p62)1/2$$

#### **4. Conclusion:**

- Shear clips are principally used as support structure for the purpose of joining together one structural member to another. It is the most utilized type of joining two parts together.

Shear clips are used to attach stringers to ribs. The tee clip is the most efficient one. Since the fasteners are of the same size

and strength, their resultants are of the same magnitude, that is,

$$P1 = P2$$

#### **5. References:**

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