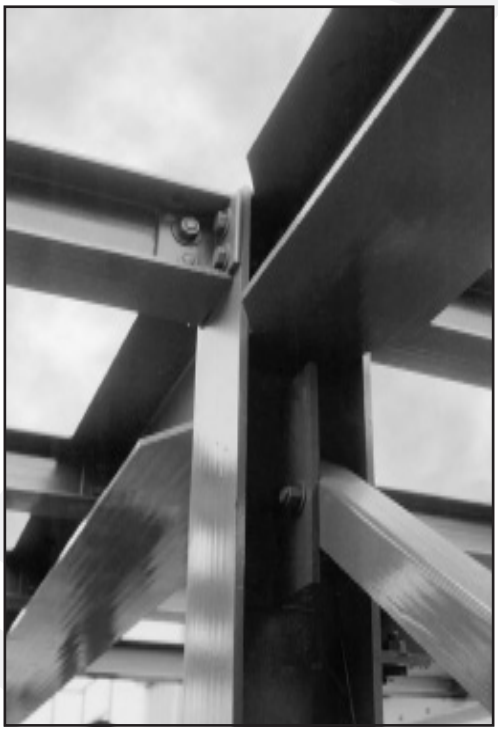
SECTION 19

FABRICATION



Look for this blue line in the left margin of the Design Manual documents. This line shows you where the latest update has been made.

GENERAL FABRICATION CONSIDERATIONS

Fabrication with **EXTREN®** structural shapes is similar to working with wood, aluminum and other comparable materials. Strongwell has available an extensive *Fabrication and Repair Manual* that can be provided upon request to fabricators and contractors unfamiliar with fiberglass fabrication. Some of the more common questions concerning fabrication with **EXTREN®** are:

Q. Do I need special tools?

A. The tools and methods are the same, but since fiberglass is very abrasive, standard bits and blades wear quickly and will need frequent resharpening or replacing.

Q. What types of blades and bits work best?

A. Carbide tip blades and bits are preferred. Diamond tipped or coated blades are best, allowing faster speeds and longer tool life.

Q. Can **EXTREN®** be punched and sheared?

A. Yes, but material thickness should be limited to 3/16" for punching and 1/4" maximum for shearing. Punches and shears work best if the blade is tapered to permit the cutting edge to penetrate a small amount of the material at any one time.

Q. Can **EXTREN®** products be formed or bent?

A. No, **EXTREN®** cannot be bent, rolled or pressed as can steel shapes and plates.

Q. Fabrication can be very dusty. Is the dust harmful?

A. Although the dust is non-toxic and presents no serious health hazard, it can cause skin irritation. The amount of irritation will vary from person to person and can be reduced or eliminated by use of a protective cream. A coverall or shop coat and gloves will add to the operator's comfort.

Q. What other general fabrication practices should be observed?

A. Machine ways and other friction producing areas should be kept clean. Fiberglass chips are damaging abrasives.

Avoid excessive pressure when sawing, drilling, routing, etc. Too much force will rapidly dull tools and create excessive heat that can scorch the fiberglass.

Do not generate excessive heat in any machining operation. Excessive heat softens the bonding resin in the fiberglass resulting in a ragged rather than clean cut edge.

Support the fiberglass material rigidly during cutting operations. Shifting may cause chipping at the cut edges. Proper support will also prevent warping.

Always seal any cut surfaces or edges of the fiberglass shape with a compatible resin before reporting the job complete.

Fastenings and connections are an important part of both the fabrication and design process. See **CONNECTIONS** later in this section.

CONNECTIONS

INTRODUCTION

Connections of **EXTREN**® shapes and plates may be structural or non-structural. Structural joints — beams to beams, beams to columns, columns to floor, plate on grating (for composite action), etc. — must transmit design loads. Examples of non-structural joints might be coverplates of a foam cored insulating panel or a coverplate epoxied to fiberglass grating (for a walking surface).

Structural connections usually employ mechanical fasteners, adhesive bonding or a combination connection utilizing both. The strongest joint between pieces of **EXTREN**® shapes is obtained by using a combination of mechanical fasteners with adhesive applied to the mating surfaces.

Selection of the connection method is usually determined by:

- The required capacity of the joint
- Joint reliability
- The available space for the joint
- The types of members to be joined
- Suitability of joint for fabrication, especially high volume production work
- Service environment
- Need for disassembly
- Aesthetics desired

COMBINATION MECHANICAL AND ADHESIVE JOINTS

As was stated earlier, the best joints for most structural applications are combination joints. These joints offer the advantages of both types of connection. Adhesive bonding affords the joint good distribution of stresses, reduced effects of stress concentrations (at the holes) and increased joint stiffness while the mechanical fastening provides reliability, reduces the effect of peel and tension in eccentric joints and also provides the necessary clamping force to allow the curing of the epoxy. The table of allowable loads for clip angle at beam ends was developed using combination joints.

MECHANICAL CONNECTIONS

Mechanical connections utilize some type of mechanical fastener to join parts of fiberglass assemblies. Some of the more common types of mechanical fasteners are:

- Bolts with washer and nut (steel, stainless, monel, etc.)
- Threaded rod and nuts (steel and fiberglass **FIBREBOLT**®)
- Screws (self-tapping, and thread cutting)
- Rivets (blind rivets, drive rivets, solid rivets — available in many materials including steel, stainless, aluminum, nylon, etc.)
- Spring clips
- Nails
- Staples
- Threaded inserts with bolts
- Threaded holes with bolts

NOTE: Strongwell recommends the use of stainless steel fasteners to eliminate the corrosion problem associated with regular steel fasteners.

Although mechanical joints provide many advantages (such as conventional fabrication and assembly methods, ease of inspection, option of disassembly, etc.) the designer should be cautioned that improper spacing and edge distances of the bolts could cause a catastrophic failure by tear-out or shear-through. The American Society of Civil Engineers *Structural Plastics Design Manual* — Reference 2 recommends the edge distances (centerline of fastener to edge of material) and minimum pitch dimensions (center to center of fasteners in a line) – see table “Recommended Minimum Fastener Edge Distances And Pitch Ratio Of Distance To Fastener Diameter” shown in this section.

CONNECTIONS

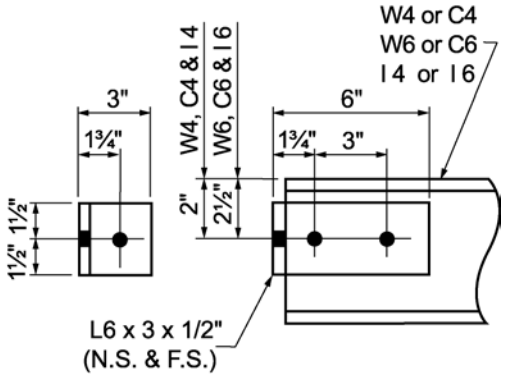
ADHESIVE BONDED CONNECTIONS

A structural adhesive holds fiberglass parts together by surface attachment and can sustain a continuously applied load without excessive deformations or failure. In addition to sealing joints and surfaces, adhesives distribute the joint stresses more evenly. Adhesive bonded joints work best when the adhesive layer is primarily stressed in shear or compression. Direct tensile or peel forces on adhesive joints should be avoided or evaluated with great care.

Additional details on how to utilize adhesive for Strongwell FRP connections can be found in the *Fabrication and Repair Manual* on strongwell.com.

BEAM SHEAR CONNECTIONS

DETAIL FOR W4, W6, C4, C6, I 4 or I 6

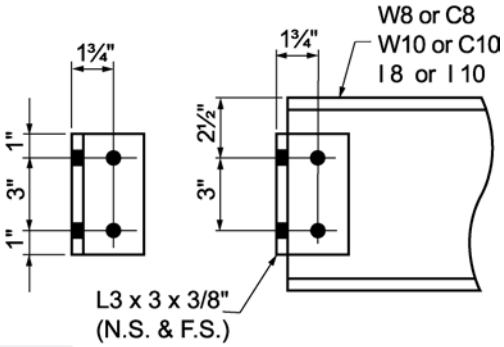


DETAIL 1

BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 3375#
BOLTED ONLY CAPACITY (SEE NOTE #2)

3/8" Bolt & 1/4" Web = 1400#	3/8" Bolt & 3/8" Web = 2110#
1/2" Bolt & 1/4" Web = 1875#	1/2" Bolt & 3/8" Web = 2810#
5/8" Bolt & 1/4" Web = 2340#	5/8" Bolt & 3/8" Web = 3375#

DETAIL FOR W8, W10, C8, C10, I 8 or I 10

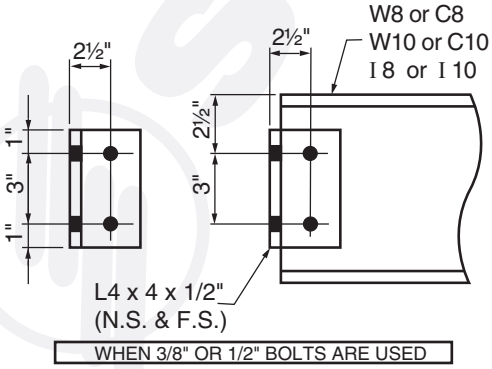


DETAIL 2

BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 4200#
BOLTED ONLY CAPACITY (SEE NOTE #2)

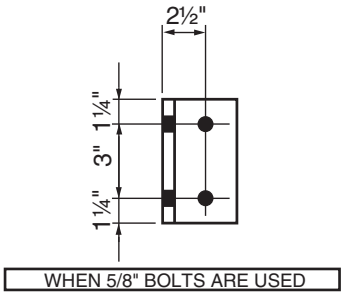
3/8" Bolt & 3/8" Web = 2110#	3/8" Bolt & 1/2" Web = 2810#
1/2" Bolt & 3/8" Web = 2810#	1/2" Bolt & 1/2" Web = 3750#
5/8" Bolt & 3/8" Web = 3515#	5/8" Bolt & 1/2" Web = 4200#

DETAIL FOR W8, W10, C8, C10, I 8 or I 10



WHEN 3/8" OR 1/2" BOLTS ARE USED

DETAIL 3



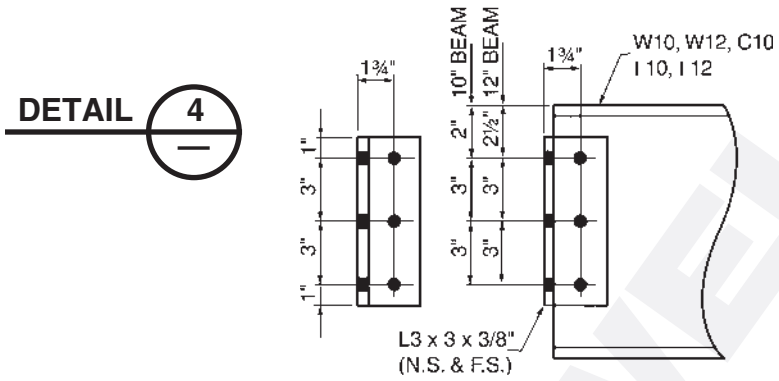
WHEN 5/8" BOLTS ARE USED

BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 5600#
BOLTED ONLY CAPACITY (SEE NOTE #2)

3/8" Bolt & 3/8" Web = 2110#	3/8" Bolt & 1/2" Web = 2810#
1/2" Bolt & 3/8" Web = 2810#	1/2" Bolt & 1/2" Web = 3750#
5/8" Bolt & 3/8" Web = 3515#	5/8" Bolt & 1/2" Web = 4680#

BEAM SHEAR CONNECTIONS

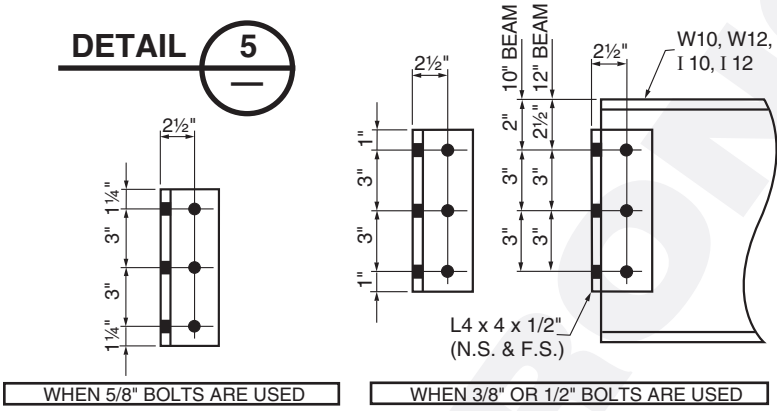
DETAIL FOR W10, W12, C10, C12, I 10 or I 12



BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 6700#
BOLTED ONLY CAPACITY (SEE NOTE #2)

3/8" Bolt & 3/8" Web = 3160#	3/8" Bolt & 1/2" Web = 4220#
1/2" Bolt & 3/8" Web = 4220#	1/2" Bolt & 1/2" Web = 5620#
5/8" Bolt & 3/8" Web = 5270#	5/8" Bolt & 1/2" Web = 6700#

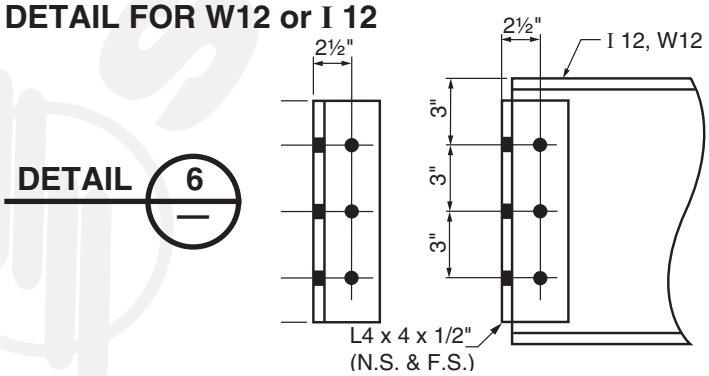
DETAIL FOR W10, W12, C10, C12, I 10 or I 12



BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 9000#
BOLTED ONLY CAPACITY (SEE NOTE #2)

3/8" Bolt & 3/8" Web = 3160#	3/8" Bolt & 1/2" Web = 4220#
1/2" Bolt & 3/8" Web = 4220#	1/2" Bolt & 1/2" Web = 5620#
5/8" Bolt & 3/8" Web = 5270#	5/8" Bolt & 1/2" Web =7030#

DETAIL FOR W12 or I 12



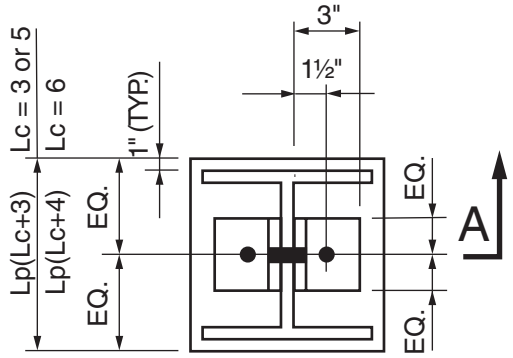
BOLTED AND EPOXIED CAPACITY (SEE NOTE #1) - 11250#
BOLTED ONLY CAPACITY (SEE NOTE #2)

3/8" Bolt & 1/2" Web = 4220#
1/2" Bolt & 1/2" Web = 5620#
5/8" Bolt & 1/2" Web = 7030#

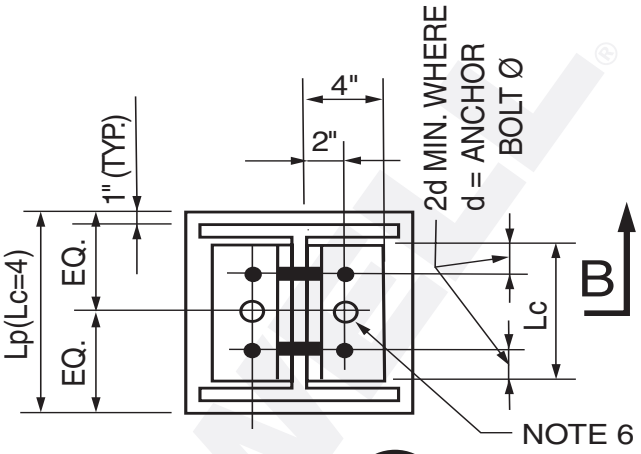
NOTES:

1. Capacities shown controlled by shear thru heel of angle (F_V=4500 psi / 4 = 1125 psi)
2. Capacities shown controlled by bearing around fastener or shear of stainless steel fasteners.
3. The beam capacity must be verified as being adequate.
4. Epoxy and joint preparation in accordance with Section 19 — **FABRICATION** in the Strongwell *Design Manual*.
5. Details 1, 2 and 4 are standard Strongwell fabrication connections. Details 3, 5 and 6 are alternate fabrication connections.
6. Recommended hole diameters: Fastener +1/16".
7. 1/4" stainless steel angles can be substituted for the **EXTREN**® angles shown in the details.
8. The effect on strength of notches, copes or other stress concentrations must be considered.

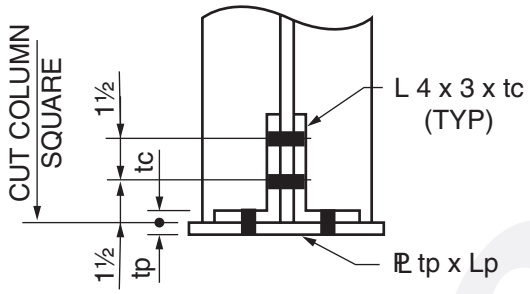
COLUMN BASE PLATES



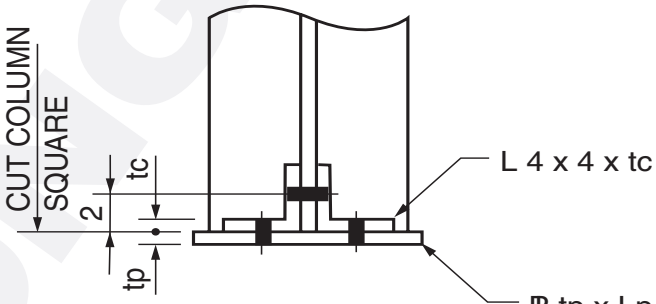
DETAIL 1 (PLAN)



DETAIL 2 (PLAN)



SECTION A



SECTION B

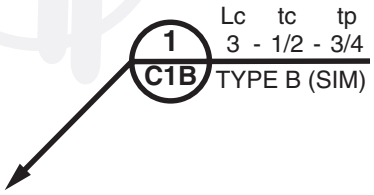
CAPACITIES -LBS				
CLIP		PLATE - tp		
Lc	tc	3/8	1/2	3/4
3	3/8	1325*	1850*	2550
	1/2	1800*	2350*	3375
5	3/8	2100*	2900*	4225
	1/2	2850*	3725*	5625
6	3/8	2550*	3500*	5075
	1/2	3450*	4525*	6750

* BENDING CONTROLS

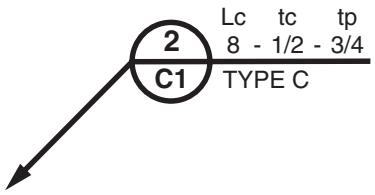
CAPACITIES -LBS				
CLIP		PLATE - tp		
Lc	tc	1/2	3/4	1
6	1/2	2825	4500	6650
	3/4	4400	6650	8750
8	1/2	3675	5800	8525
	3/4	5750	8275	11,350
10	1/2	4525	7125	10,425
	3/4	7075	10,175	13,900

* BENDING CONTROLS

TYPICAL CALLOUT
ON DESIGN DWG.

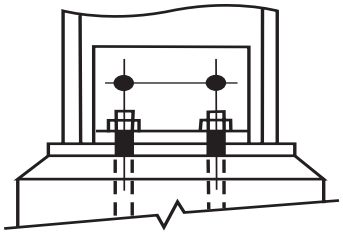


TYPICAL CALLOUT
ON DESIGN DWG.

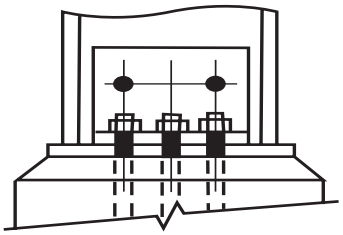


STRONGWELL

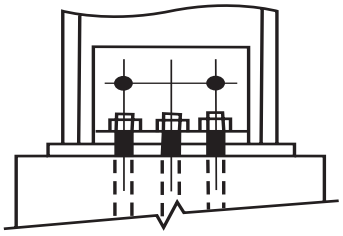
COLUMN BASE PLATES



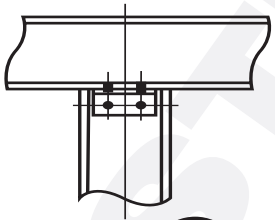
TYPE A
TYPICAL BOLTING



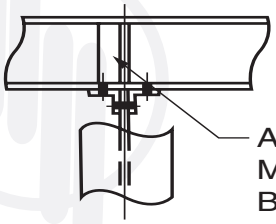
TYPE B
COLUMN ON GROUT
W/ CENTER ANCHOR BOLTS



TYPE C
COLUMN ON FLAT
W/ CENTER ANCHOR BOLTS



DETAIL 3



ANGLE (N.S. & F.S.)
MAY BE REQUIRED TO PREVENT
BEAM WEB BUCKLING
- REF. DESIGN GUIDE - BEAMS

DETAIL 4

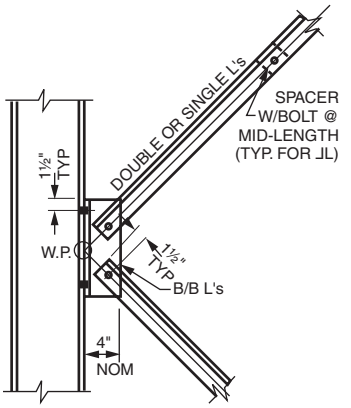
NOTES:

(DEVELOPED WITH TENSION LOADS)

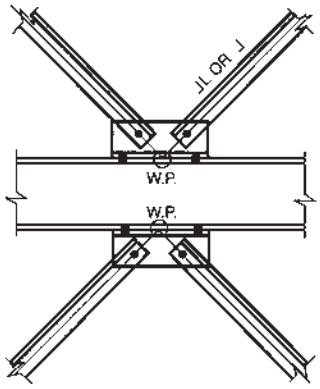
1. Values shown here are based on epoxy and bolted connections. For bolted only connections see Bearing and Shear values shown later in this section.
2. Capacities shown were controlled by shear through heel of angle (F_v=1125 psi) or bending of plate and angle with F_B=10000 psi/4=2500 psi.
3. For columns with combined tension and shear, both of which put shear into the heel of the angle, the total of the tension load + shear load must be less than the capacity listed.
4. Plates shown square Lp required for capacity, but width can vary (i.e. for I-beam columns.)
5. Detail 2 can utilize anchor bolts separate from base plate assembly bolts. Two required, 1/2" dia. minimum.
6. Epoxy and joint preparation in accordance with Section 19 — **FABRICATION**.
7. 1/4" stainless steel angles can be substituted for the **EXTREN®** angles shown in the details.

STRONGWELL

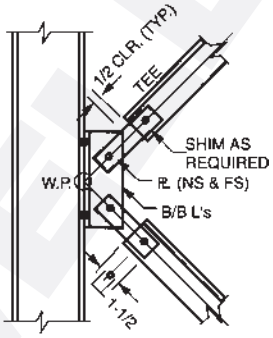
SINGLE/DOUBLE ANGLE & TEE BRACING DETAILS



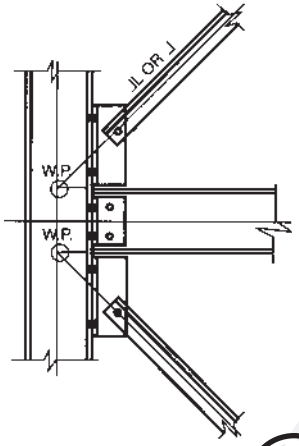
DETAIL 1



DETAIL 4

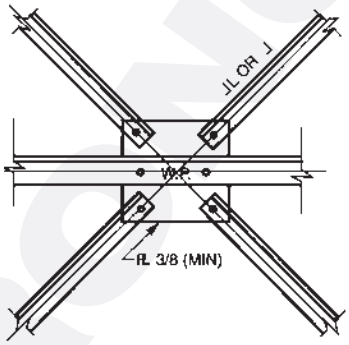


DETAIL 7

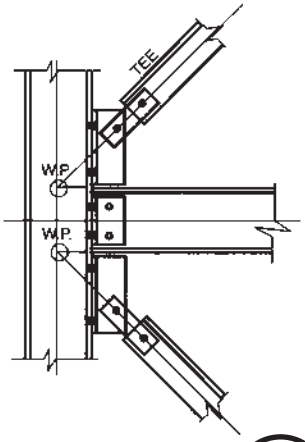


DETAIL 2

SEE ALTERNATE DETAIL 13

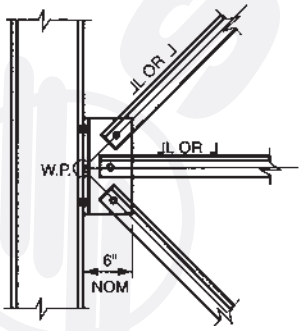


DETAIL 5

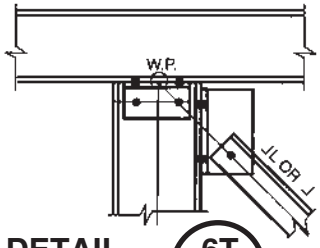


DETAIL 8

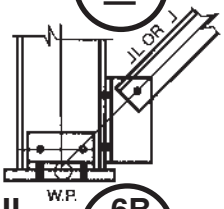
SEE ALTERNATE DETAIL 14



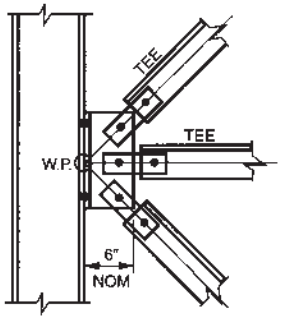
DETAIL 3



DETAIL 6T

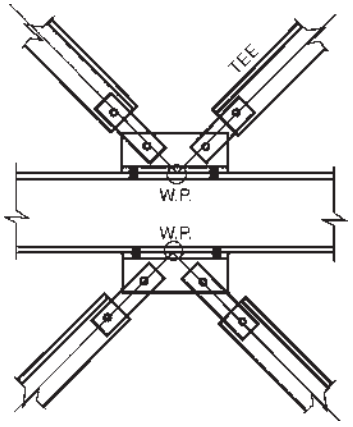


DETAIL 6B

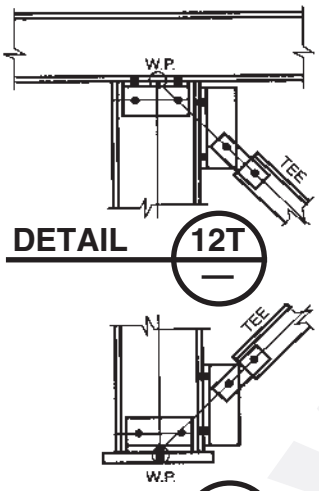


DETAIL 9

SINGLE/DOUBLE ANGLE & TEE BRACING DETAILS

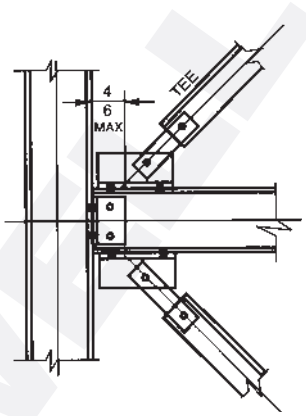


DETAIL 10

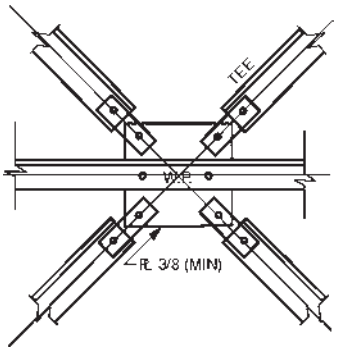


DETAIL 12T

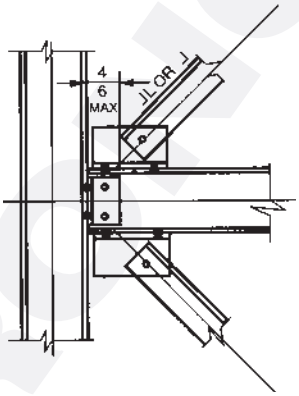
DETAIL 12B



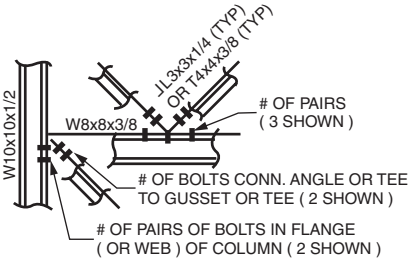
DETAIL 14



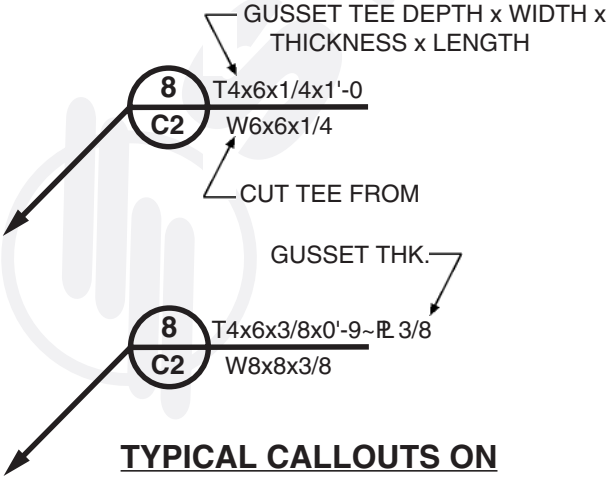
DETAIL 11



DETAIL 13



BOLT CALLOUT FOR ANGLES & TEES



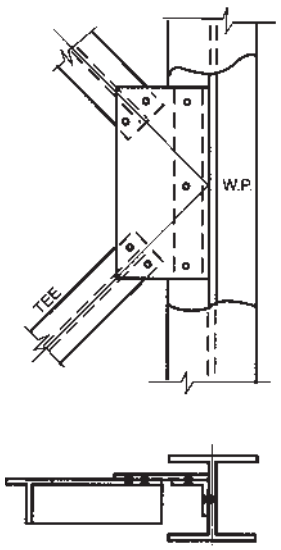
TYPICAL CALLOUTS ON DESIGN DRAWINGS

NOTES:

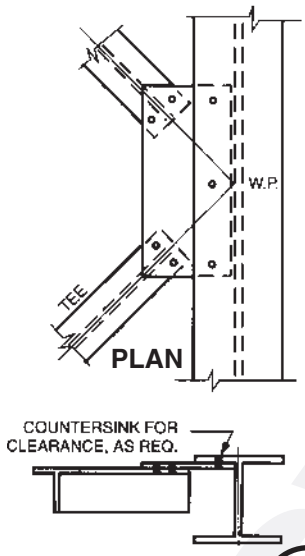
1. These connections are to be used with epoxy. 3/8" dia. bolts only provide clamp until epoxy cures. Ultimate capacity of joint = 1000 psi. For bolted only connections see Bearing and Shear values later in this section.
2. Designer is cautioned to check required area for epoxy with F_{ALL} = 1000/4 = 250 psi and tee thickness with Fv = 4500/4 =1125 psi.
3. Gussets should be symmetrical about WP whenever possible.
4. Epoxy and joint preparation in accordance with Section 19 — **FABRICATION**.

STRONGWELL

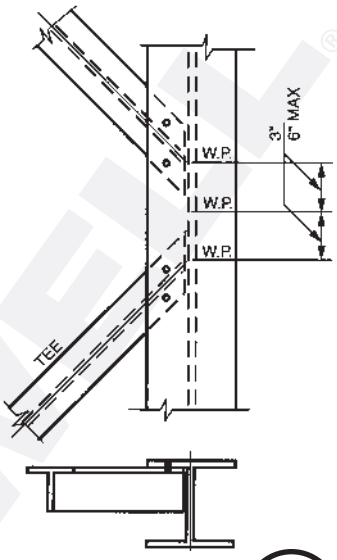
HORIZONTAL BRACING — TEE & ANGLE DETAILS



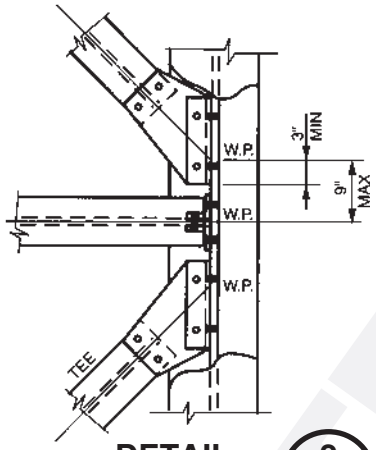
DETAIL 1



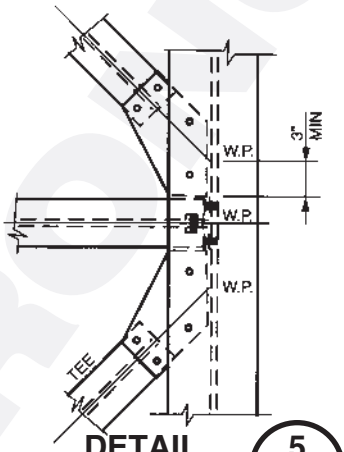
DETAIL 4



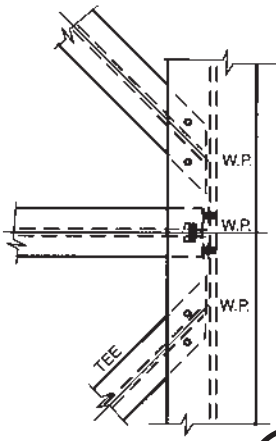
DETAIL 7



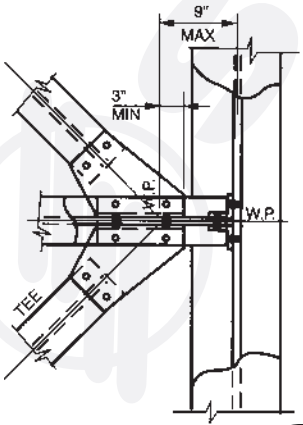
DETAIL 2



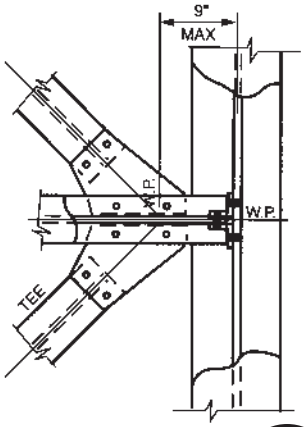
DETAIL 5



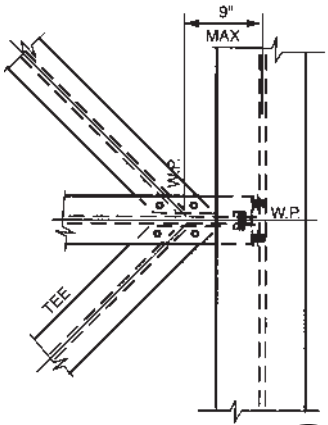
DETAIL 8



DETAIL 3



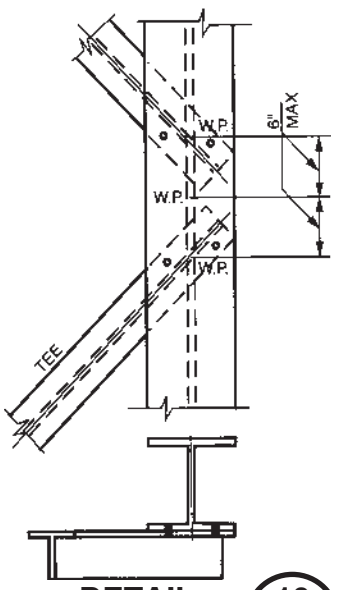
DETAIL 6



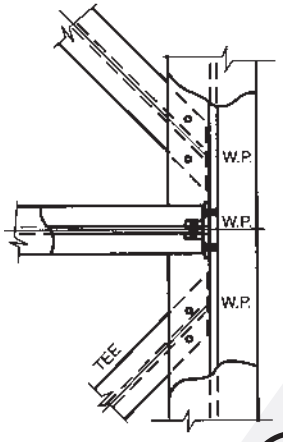
DETAIL 9

STRONGWELL

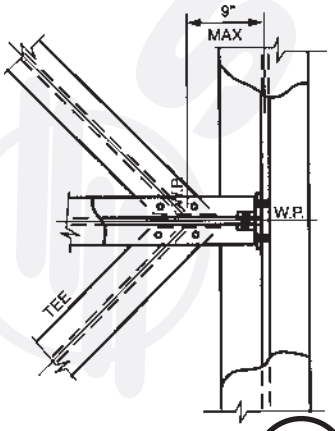
HORIZONTAL BRACING — TEE & ANGLE DETAILS



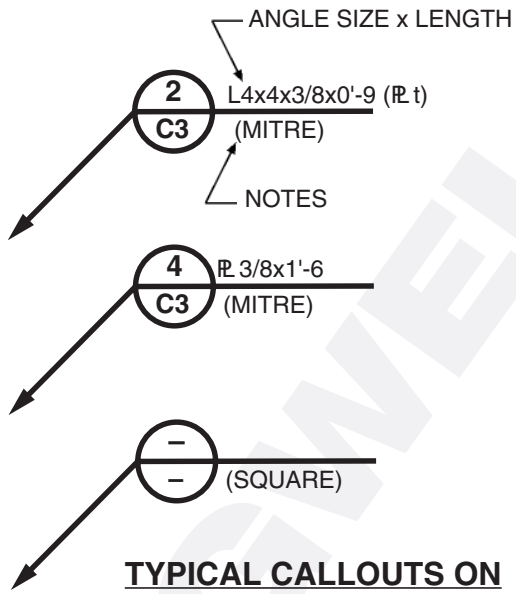
DETAIL 10 —



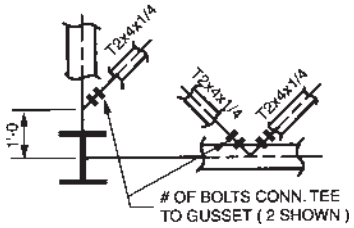
DETAIL 11 —



DETAIL 12 —



TYPICAL CALLOUTS ON DESIGN DRAWINGS



BOLT CALLOUT ON DESIGN DRAWINGS

NOTES:

1. These connections are to be used with epoxy. 3/8" dia. bolts only provide clamp until epoxy cures. Ultimate capacity of joint = 1000 psi. For bolted only connections see Bearing and Shear values later in this section.
2. Designer is cautioned to check required area for epoxy with F_{ALL} = 1000/4 = 250 psi and gusset/tee thickness with Fv = 4500/4 =1125 psi.
3. Gussets should be symmetrical about WP whenever possible.
4. Epoxy and joint preparation in accordance with Section 19 — **FABRICATION**.

THREADED FASTENERS

BEARING

ALLOWABLE LOADS IN POUNDS

FIBERGLASS THICKNESS	BOLT DIAMETER 1/4"	3/8"	1/2"	5/8"	3/4"	1"
1/8"	234	352	469	586	703	938
1/4"	469	703	938	1172	1406	1875
3/8"	703	1055	1406	1758	2109	2812
1/2"	938	1406	1875	2344	2812	3750
3/4"	1406	2109	2812	3516	4219	5625

Allowable load = Allowable bearing stress x bearing area.

EXAMPLE

1/4" thickness with 1/2" dia. bolt

$$\text{Allowable load} = \frac{30{,}000 \text{ psi}}{4} \times .25" \times .50" = 938 \text{ lbs.}$$

NOTE: The above table assumes the bearing stress on fiberglass controls. The designer should verify that no other element of the connection controls.

SHEAR

ALLOWABLE LOADS IN POUNDS

BOLT TYPE	BOLT DIAMETER 1/4"	3/8"	1/2"	5/8"	3/4"	1"
S.S. Single Shear	1473	3312	5889	9204	13254	23562
S.S. Double Shear	2964	6624	11778	18408	26508	47124
FIBREBOLT®, Single Shear	—	400	650	950	1550	3750
FIBREBOLT®, Double Shear	—	750	1250	1875	3000	5000

NOTE: The above table assumes the shear capacity of the fastener controls. The designer should verify that no other element of the connection controls.

RECOMMENDED MINIMUM FASTENER EDGE DISTANCES AND PITCH RATIO OF DISTANCE TO FASTENER DIAMETER

	RANGE	COMMON
Edge Distance - end	2.0 to 4.5	3.0
Edge Distance - side	1.5 to 3.5	2.0
Pitch	4.0 to 5.0	5.0