DESIGN GUIDES FOR

FLITCH PLATE BEAMS AND LALLY COLUMNS

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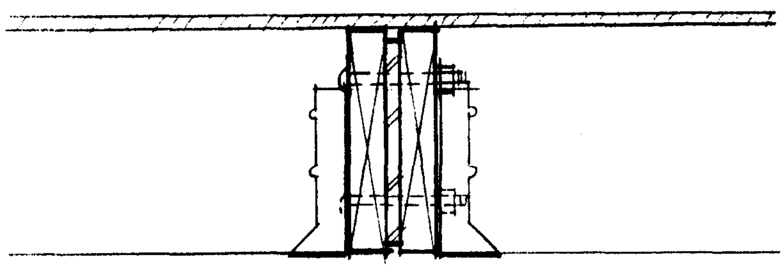
FLITCH PLATE BEAMS IN RESIDENTIAL CONSTRUCTION

Flitch plate beams are composite members which combine the strength and stiffness of structural steel with the versatility of wood. A flitch plate is a steel plate which is sandwiched between pieces of wood and bolted together. They are used in a similar manner to built-up wood girders or headers in residential construction. Flitch plate beams are capable of achieving greater spans and supporting higher loads than built-up wood members.

Unlike engineered wood beams, flitch plate beams can be flush framed with dimension lumber joists without causing shrinkage related distortions to the structure.



The wood side pieces provide lateral support to the slender steel flitch plate and brace the steel against lateral buckling.

With a flitch plate beam, the structural load is shared between the steel plate and the wood side pieces proportional to their relative stiffness. In order to structurally analyze a flitch plate beam, transformed section properties are used which treat the composite section as an equivalent wood member. The following section properties and load tables are based on the wood members being composed of Douglas Fir - Larch #2.

Transformed Section Properties

	I_{TR} (in^4)	S_{TR} (in^3)	M (ft-lb)	M_{steel} / M	V (lb)
(2)-2x8 PL 3/8 x 7	288.9	79.7	6,974	67%	4,176
(2)-2x8 PL ½ x 7	354.0	97.7	8,549	73%	5,104
(3)-2x8 PL ½ x 9	660.5	182.2	18,341	78%	9,395
(3)-2x10 (2) PL ½ x 9	1,397.2	302.1	27,869	79%	12,557
(2)-2x12 PL 3/8 x 11	1,109.0	197.2	14,379	68%	6,681
(2)-2x12 PL ½ x 11	1,360.6	241.9	17,639	74%	8,223
(3)-2x12 (2) PL ½ x 11	2,543.1	452.1	37,901	79%	15,271

I_{TR} transformed moment of inertia
S_{TR} transformed section modulus
M flexural moment capacity
M_{steel}/M portion of load carried by the steel plate
V shear capacity

Structural Properties:

Douglas Fir - Larch #2

E = 1,600,000 psi
F_b = 875 psi
F_v = 95 psi

Steel Plate

E = 29,000,000 psi
F_y = 36,000 psi

Modular Ratio $n = E_{steel}/E_{wood} = 18.1$

Flitch Plate Beam Load Table - Uniform Load (plf)

	Span						
	8′	10′	12′	14′	16′	18′	20′
(2)-2x8 PL 3/8 x 7	872	558	387	250	167	117	86
(2)-2x8 PL ½ x 7	1069	684	475	306	205	144	105
(3)-2x8 (2) PL ½ x 7	2293	1467	906	571	382	268	196
(2)-2x10 PL 3/8 x 9	1324	847	589	432	331	248	181
(2)-2x10 PL ½ x 9	1622	1038	721	530	406	304	222
(3)-2x10 (2) PL ½ x 9	3139	2230	1548	1138	808	568	414
(2)-2x12 PL 3/8 x 11	1670	1150	799	587	449	355	288
(2)-2x12 PL ½ x 11	2056	1411	980	720	551	436	353
(3)-2x12 (2)PL ½ x 11	3818	3032	2106	1547	1184	936	754

deflection criteria: span / 360 at total load

Bolting of Flitch Plates

Adequate bolting is crucial to the performance of flitch plate beams. Since the load is applied to the beam through the wood side pieces, the bolts must distribute to the steel plate the portion of the total load which the plate carries. At the ends of the beam only the wood side pieces rest on the supports. Consequently, bolts at the ends of the beam must transfer the end reaction from the plate to the wood.

Load is transferred between the steel plate and the wood side pieces by a combination of shear through the bolts and friction between the steel and wood. The magnitude of the load transferred through friction is a function of the tightness of the bolts. Washers should always be used under the nuts. The nuts should not be tightened so much that the wood crushes under the bolt head or washer. As the lumber seasons and shrinks, the bolt tension and the friction forces will diminish.

Carriage bolts with either ½" or 5/8" diameter are commonly used with flitch plates. Larger diameter bolts are not readily available through lumber yards or hardware stores.

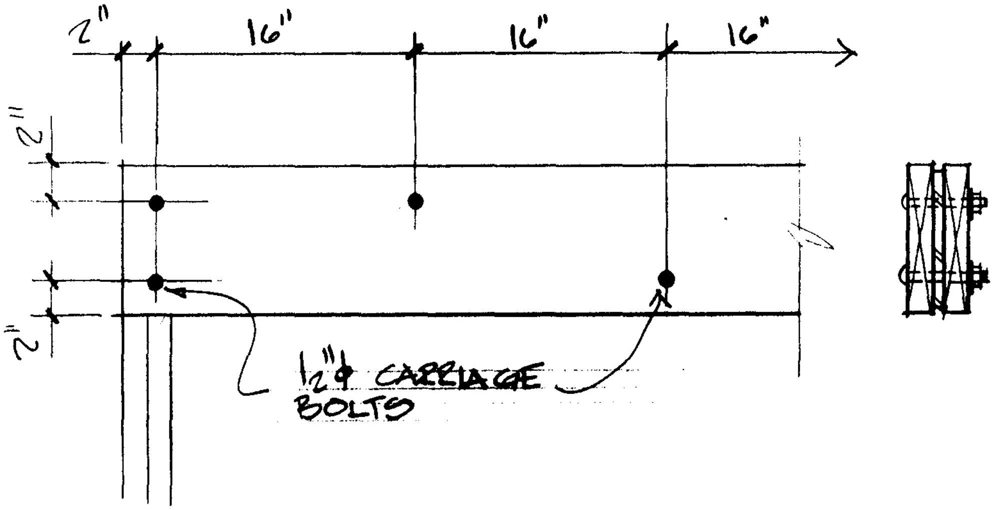
The bolt holes should be drilled or punched in the steel plate. Flame cut bolt holes do not allow uniform bearing for the bolt. Bolt holes should be 1/16" larger than the bolt diameter.

Where wallboard or wood trim is applied directly to the face of a flitch plate beam, it is desirable to counterbore the nuts into the wood side pieces. Since counterboring reduces the amount of bearing for the bolt, the depth of the counterbore should not exceed the thickness of the nut and washer.

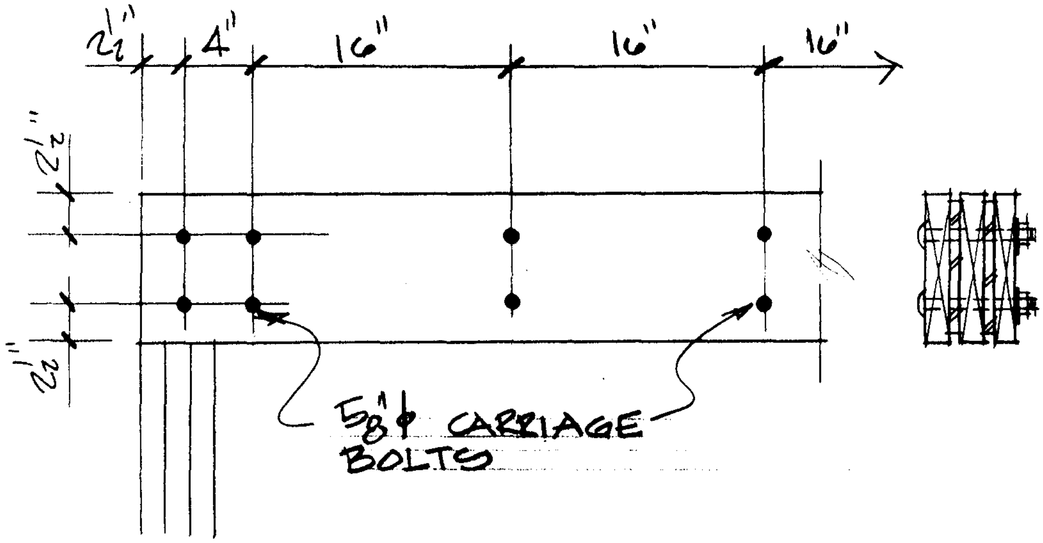
Bolts should not be positioned closer than 2" to the end or edge of the wood members for ½" diameter bolts and not closer than 2 ½" for 5/8" diameter bolts.

There are two methods for determining the required bolt size and spacing, the *empirical method* and the *rational method.*

Empirical Method: a standard bolting pattern is used which has performed adequately in the past. The diagram below indicates a standard bolting pattern for single and double flitch plate beams. The 16" spacing of bolts insures that the bolt heads and nuts will not interfere with joists which are also spaced at 16".



SINGLE FLITCH PL



DOUBLE FLITCH PL'S

BOLT PATTERN

structural calculations. The allowable bolt capacities are calculated based on the *National Design Specification for Wood Construction* (NDS). The load carried by the steel plate is determined and uniformly spaced bolts are provided to transfer this load. The end reaction on the steel plate is then calculated and bolts are provided at the end of the beam to resist this reaction. This method neglects the contribution from friction between the steel and the wood and will yield conservative results.

Design example:

(2)-2x10 & plate ½″ x 9″ - Douglas Fir - Larch #2
span = 12′   uniform load = 700 plf

calculate the capacity of ½″ diameter bolt, load perpendicular to grain per *NDS 1991*

eq. 8.3-2	z = 945 lb
eq. 8.3-3	z = **795** lb
eq. 8.3-4	z = 1059 lb

allowable bolt load is 795 lb

calculate uniform load on plate

700 plf x 74% = 518 plf

calculate uniform bolt spacing

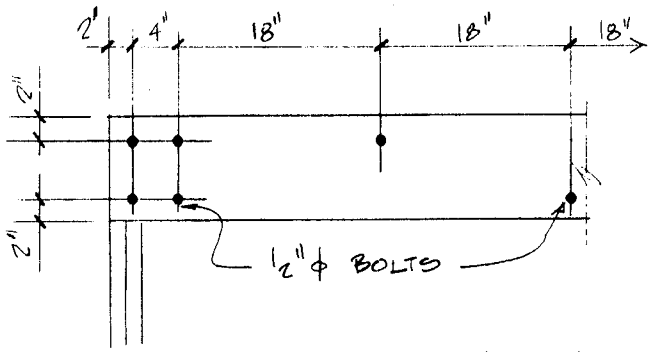
(795 / 518) x 12″ = 18.4″   space bolts 18″ o.c.

calculate end reaction on plate

518 plf x 12′/2 = 3108 lb

calculate the number of end bolts required

3108 / 795 = 3.9   provide 4 bolts at each end of beam



LALLY COLUMNS IN RESIDENTIAL CONSTRUCTION

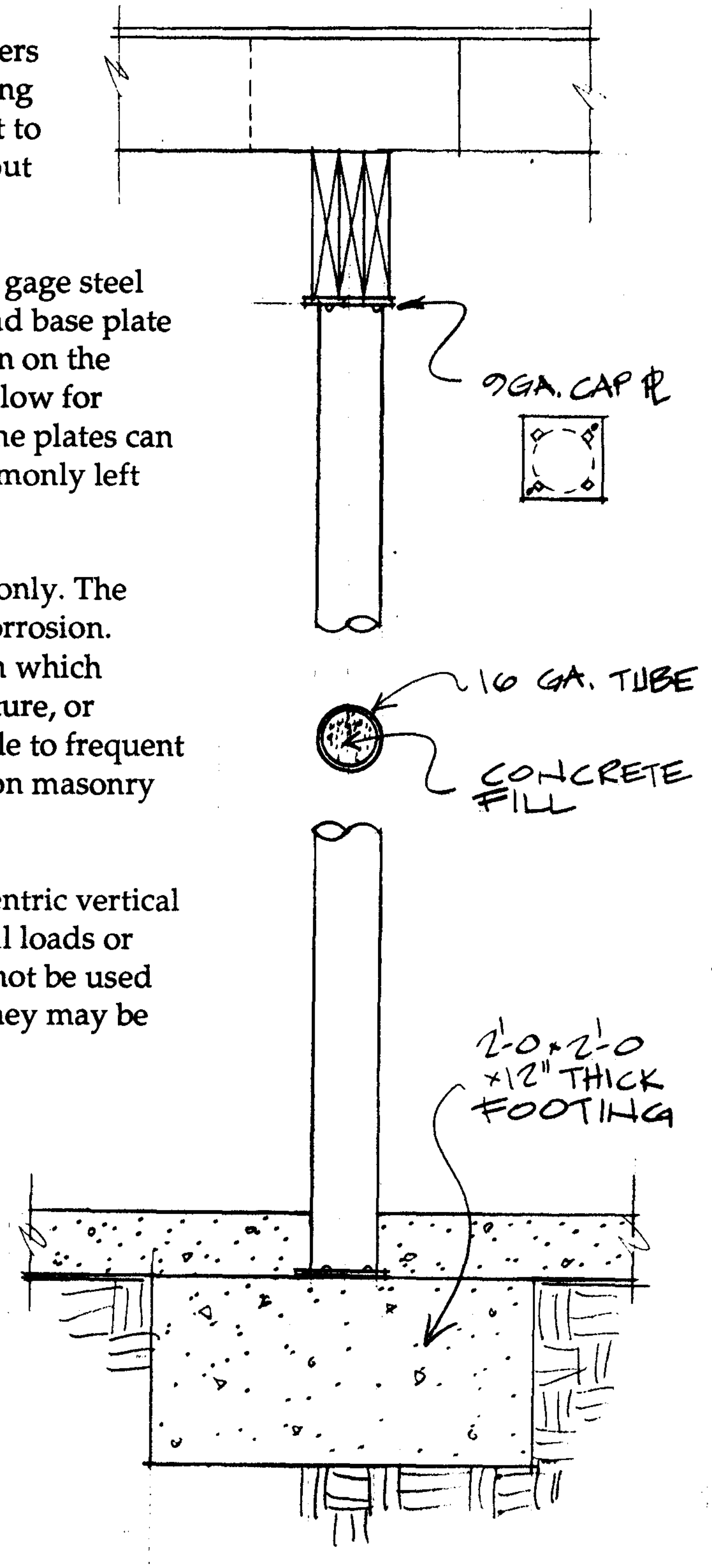
Lally columns are commonly used in residential construction for supporting wood or steel girders. They are available in 3 ½ inch and 4 inch diameters. Lally columns are manufactured from 16 gage steel tubing which is filled with concrete.

Lumber yards and building material suppliers stock lally columns in various lengths ranging from 6 feet to 12 feet. They can be easily cut to exact length in the field by carpenters without the need for any special tools.

Loose cap and base plates fabricated from 9 gage steel are supplied with the columns. Each cap and base plate has four raised lugs which hold it in position on the column. Pre-drilled holes are provided to allow for nailing the plate to the supported girder. The plates can be welded to the column, but are more commonly left loose.

Lally columns are intended for interior use only. The thin outer steel shell is very vulnerable to corrosion. They should never be used in an application which exposes them to the weather, constant moisture, or corrosive chemicals. In basements susceptible to frequent flooding, column bases should be elevated on masonry pedestals.

Lally columns are engineered to resist concentric vertical loads. They are inefficient at resisting lateral loads or flexural forces. Consequently, they should not be used in exterior walls or other situations where they may be subjected to substantial lateral loads.



The allowable axial load for structural columns diminishes with increased unbraced length. The load table indicates the allowable column load in kips (1 kip = 1,000 lb.) for various unbraced lengths.

	Unbraced Length						
	6′	7′	8′	9′	10′	11′	12′
3 ½″ dia.	8.8	8.5	8.2	7.8	7.3		
4″ dia.	11.4	11.1	10.7	10.3	9.9	9.4	8.8

The column loads were calculated based on the *AISC Load and Resistance Factor Design Specification for Structural Steel Buildings (1994 edition).* It is recognized that the column load is never applied perfectly concentric to the column axis. Consequently, the column load was assumed to be applied with a 1 inch eccentricity. To convert ultimate loads to allowable loads, a *live load : dead load* ratio of 4:1 was assumed.

The calculations are based on the following material properties:

steel yield strength $F_y = 33$ ksi
concrete compressive strength $f_c' = 3000$ psi