Flitch Plate Beams

Design Guide

By Jim DeStefano, P.E.

Flitch plate beams have been commonly used with wood frame construction for over 75 years. Despite the popularity of these hybrid structural elements, structural design guidance has been conspicuously absent from engineering literature. That is, up until now.

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 that is sandwiched between pieces of framing lumber and bolted together. They are used in a similar manner to built-up wood girders or headers in residential and light commercial 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 proportionally to their relative stiffness. In order to structurally analyze a flitch plate beam, transformed section properties are used that treat the composite section as an equivalent wood member. The section properties indicated in *Table 1* are based on the wood members being composed of Douglas Fir - Larch #2 as well as laminated veneer lumber (LVL).

The flexural strength of flitch plate beams using Douglas Fir side pieces is controlled by the bending stress in the wood, while the strength of flitch plate beams using LVL side pieces is controlled by the bending stress in the steel.

No load duration factor was applied to the allowable bending stress. The allowable stress was adjusted by the appropriate size factor. A repetitive member factor was applied to the allowable bending stress of double flitch plate beams since these members contain three wood pieces.

The shear capacity indicated in *Table 1* is the shear strength of the wood alone since the full beam reaction must be transferred through the wood side pieces at end bearing supports.

The values in *Table 1* are based on the steel plate being A36 steel. This is a reasonable assumption since steel plates are not readily available in Grade 50 steel. Be sure when specifying flitch plates to indicate that the plate is made of steel. Some builders believe that flitch plates can be made out of plywood.

Bolting of Flitch Plates

Adequate bolting is crucial to the performance of flitch plate beams. Since the load is applied to this composite beam through the wood side pieces, the bolts must distribute that portion of the load that the steel plates will be carrying. At the beam end bearing supports, 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.

Flitch PL Section Properties

	I_{TR} (in^4)	S_{TR} (in^3)	M(ft-lb)	M_{steel}/M	V_{wood} (lb)	n	Wood	Steel
(2)–2x8 PL ⅜x7	289	79.7	7,173	67%	2,610	18.1	Douglas Fir - Larch #2 E = 1,600,00 psi F_b = 900 psi	ASTM A36 F_y = 36 ksi
(2) –2x8 PL ½x7	354	97.7	8,793	73%	2,610			
(3) –2x8 (2) PL ½x7	661	182.2	18,851	78%	3,915			
(2)–2x10 PL ⅜x9	611	132.0	10,890	68%	3,330			
(2)–2x10 PL ½x9	748	161.7	13,340	74%	3,330			
(3)–2x10 (2)– PL ½x9	1,397	302.1	28,649	79%	4,995			
(2)–2x12 PL ⅜x11	1,109	197.2	14,790	68%	4,050			
(2)–2x12 PL ½x11	1,361	241.9	18,142	74%	4,050			
(3)–2x12 (2)– PL ½x11	2,543	452.1	38,994	79%	6,075			
(2)–LVL 1¾x9½ PL ½x9	715	158.9	20,776	64%	6,320	15.3	E=1,900,000 psi F_b = 2,600 psi	
(2)–LVL 1¾ x11⅞ PL ½x11	1,337	243.1	31,784	64%	7,900			
(2)–LVL 1¾x14 PL ½x14	2,549	364.0	47,593	69%	9,310			

Table 1

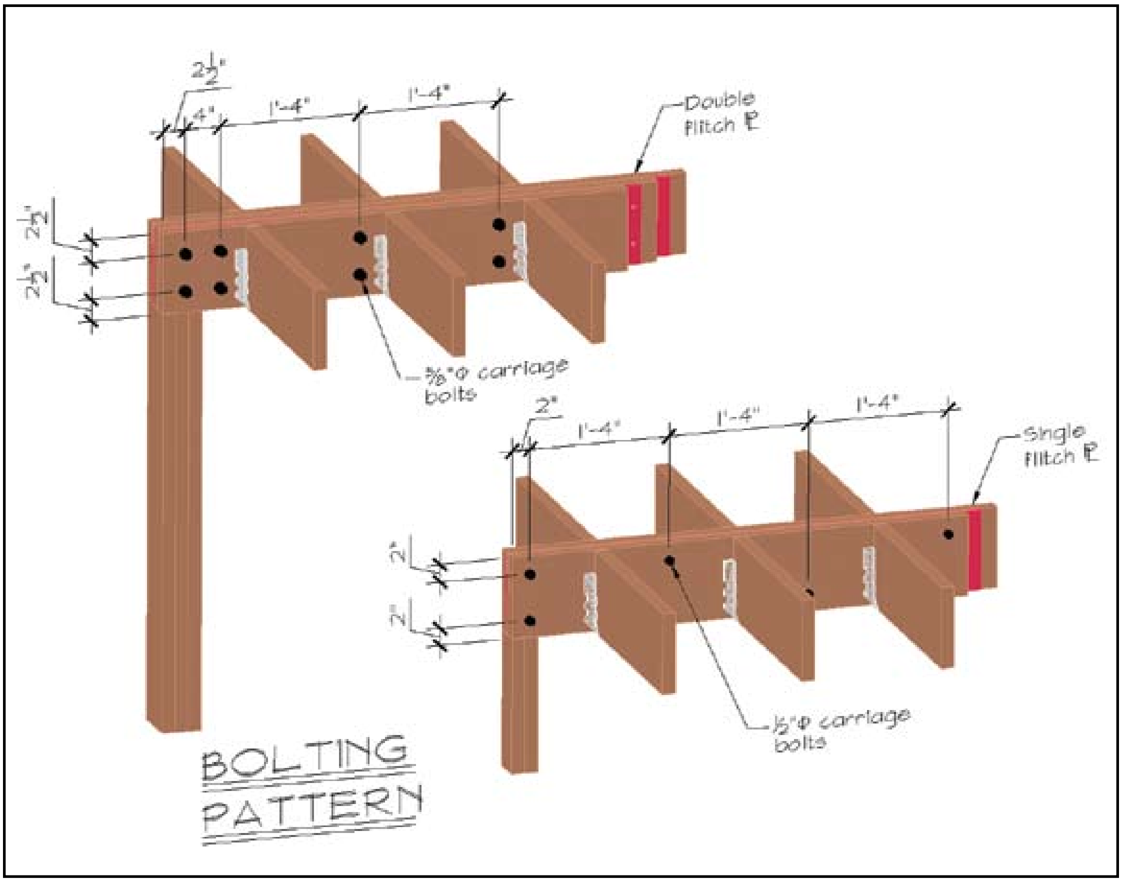

Figure 1: Empirical bolting pattern

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 to the extent 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. Because of this and the fact that determining the magnitude of load transfer due to friction between the wood and steel cannot be calculated with certainty, this bolt friction contribution is usually neglected in the calculations.

Carriage bolts with either ½ or ⅝-inch 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 inch 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 inches to the end or edge of the wood members for ½-inch diameter bolts and not closer than 2 ½ inches for ⅝-inch 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. *Figure 1* indicates a standard bolting pattern for single and double flitch plate beams. The 16-inch spacing of bolts insures that the bolt heads and nuts will not interfere with joists which are also spaced at 16 inches.

Rational Method: The required bolt size and spacing is determined from 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, as a result, will yield conservative results.▪

Design Example

(2)-2x10 & plate ½-inch x 9 inches - Douglas Fir - Larch #2
Span = 12 feet   Uniform load = 700 plf
Calculate the capacity of a ½-inch diameter bolt, with the load perpendicular to the grain, per NDS 2005:
NDS Eq. 11.3-8   z = 945 lb
Calculate the uniform load on the plate:
700 plf x 74% (from *Table 1*) = 518 plf
Calculate the uniform bolt spacing:
(945 / 518) x 12 inches = 21.9 inches >>>> Space bolts at 20 inches o.c.
Calculate the end reaction on the plate:
518 plf x 12 feet/2 = 3108 lb
Calculate the number of end bolts required:
3108 / 945 = 3.29 >>>> Provide 4 bolts at each end of beam

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