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Study on the shear lag effect: Review Paper

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ABSTRACT

Shear lag effect increase as we move away from the section thereafter, the effects becomes predominant specially for the unsymmetric structures. The force transmission between the structure and patch occurs through bond layer, via shear mechanism, invariably causing shear lag.

INTRODUCTION

The uneven stress distribution occurring in tension member adjacent to a connection, is referred to as shear lag effect. It reduces design strength of the member. Common research methods for shear lag effect are energy variation method, analogy-bar method and numerical analysis method. It is assumed shear lag only changes distribution of normal stresses inside cross-section, but not change the longitudinal distribution of internal forces. Shear lag creates loss in resistance in tension member connected by part of its cross-section. Shear lag, results in a considerable increase of the longitudinal stresses.

PRINCIPLE: Energy variation method

MODELS:

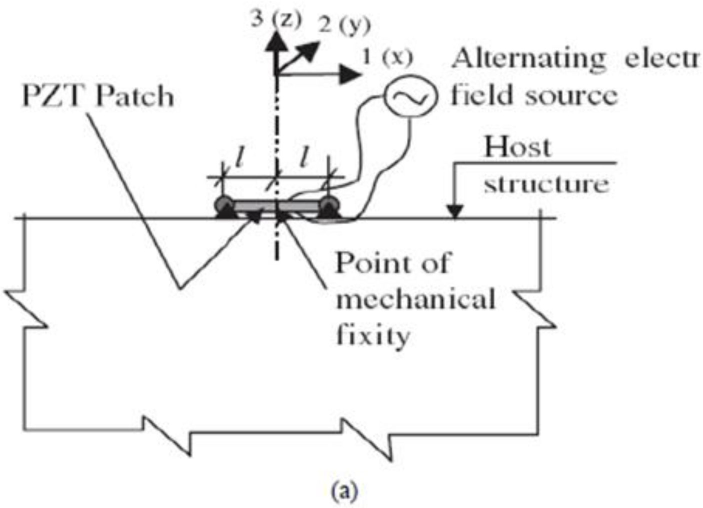

Fig. A PZT patch bonded to the structure under electric excitation (Bhalla, 2004)

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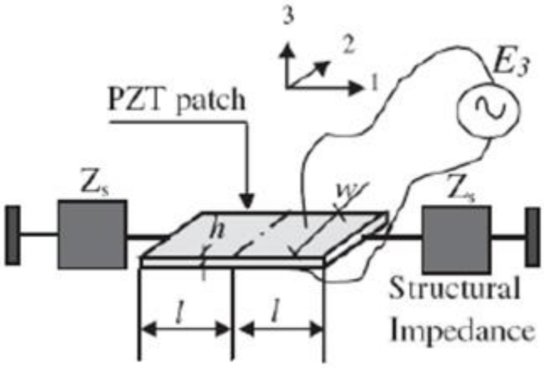

Fig. Interaction model of PZT patch and host structure (Bhalla, 2004)

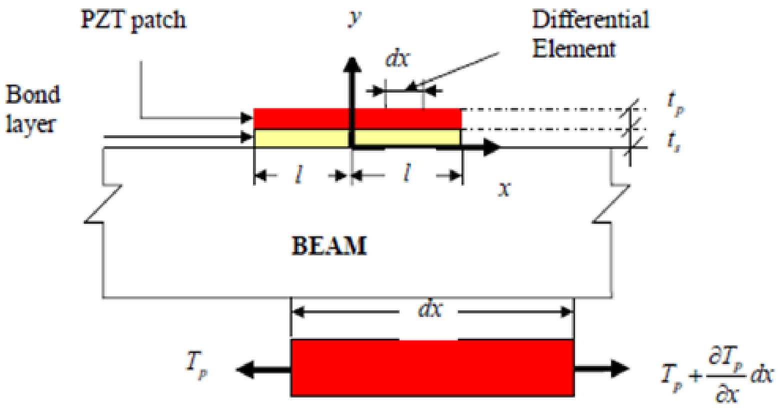

Fig. A PZT patch bonded to a beam using adhesive bond layer (Bhalla, 2004).

HOT ROLLED MEMBERS

Chesson and Munse (1963) [1] investigated a wide range of truss type tension members using both test results obtained from their own and others experiments. Kennedy and Sinclair (1969) [2] investigated influence of edge distance and end distance on net section efficiency. Test results showed that minimum edge and end distances were required to develop yield strength of cross section. March (1969) [3] conducted a series of tests on single angle members in tension and compression. Hardash and Bjorhovde (1985) [4] tested 28 specimens to develop improved design method for gusset plates. Shear stress was found to be dependent on connection length and block shear capacity equation, which includes the connection length factor, was developed. Murty et al. (1988) [5] summarized design approaches for computing ultimate strength of bolted single angles in accordance with following five specifications: the American Association of State Highway and Transportation Officials, the American Institute of Steel Construction, American society of Civil Engineers, the Canadian Standards Association, and the British Standards Institute. Epstein(1992) [6] performed experimental study on double-row, staggered, and unstaggered bolted connections of structural steel angles. Gaylord (1992) [7] suggested that net effective area of tension member was a function of four factors: steel ductility, fabrication methods, connection efficiency, and shear lag effects. Wu and Kulak (1993) [8] conducted an experimental program to investigate the shear lag effect on single and double angle tension members. Gross et al (1995) [9] tested ten A588 Grade 50 and three A36 steel single angle tension members with various leg sizes that failed in block shear. Test results were compared with the AISC-ASD and AISC-LRFD equation predictions and it was observed that code treatments accurately predict failure loads for A36 and A588 specimens.

Cunnigham et al (1995) [10] performed a statistical study to assess American block shear load capacity predictions. Kulak and Grondin (2001) [11] performed statistical study on evaluation of LRFD rules for block shear capacities in bolted connections with test results. Mohan Gupta and Gupta (2002) [12] presented simple equations for predicting the load carrying capacity of single and double angles in tension, for net section failure based on previously published experimental results. Gupta Mohan and Gupta (2005) [13] analysed Indian standard for design of steel structures (IS 800-1984) and found that provisions for design of angle tension members were conservative for single angles when number of bolts were relatively more and less conservative, for single angles and double angles with lesser number of bolts.

COLD-FORMED MEMBERS

Bryan (1993) [14] showed how design expressions may be used to estimate moment capacity and moment/rotation relationship of bolt groups, and how this information be used to give economical design of structural assemblies. La–Boube and Yu (1995) [15] conducted an experimental and analytical study at the University of Missouri–Rolla. Seleim and LaBoube (1996) [16] studied the behaviour of low ductility steel in cold-formed steel connections. Chung and Lau (1999) [17] conducted an experimental investigation on cold-formed steel members with bolted moment connections. Yip and Cheng (2000) [18] performed an experimental program consisting of 23 angle and channel specimens to study the shear lag effect. Rogers and Hancock (2000) [19] investigated failure modes of bolted sheet steel connections loaded in shear. Chi–Ling pan (2004) [20] investigated the shear lag effect on bolted cold formed steel tension members. Valdier Francisco de paula et al (2008)[21], presented experimental results of 66 specimens carried out on cold-formed steel angles fastened with bolts under tension.

NUMERICAL INVESTIGATION

Epstein and Chamarajanagar (1996) [22] developed analytical model for series of single angle tests with staggered bolted connections. Kulak and Wu (1997) [23] conducted finite element analysis to evaluate stress distribution of critical cross section at ultimate load. Epstein McGinnis (2000) [24] conducted second study aimed at refining the tools developed in Epstein's 1996 work. Chung and Ip (2000) [25] investigated finite element modeling of bolted connections between cold-formed steel strips and hot-rolled steel plates under shear. Cem Topkaya (2004) [26] aimed to develop simple block shear capacity equations based on principles of mechanics. Gupta Mohan and Gupta (2004) [27] conducted finite element analysis to evaluate stress distribution in angle at design loads.

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RESULTS:

In a building ,at the ground story columns, shear lag effect is most dominating and most influential because of large magnitude of axial stresses.

Table Shear stress distribution for different frequencies

	SHEAR STRESS (MPa)		
LENGTH(m)	F(101)	F(110)	F(150)
0	0	0	0
0.0001	0.00008	0.00008	0
0.0002	0.00016	0.00016	0.0001
0.0003	0.00024	0.00023	0.0001
0.0004	0.00031	0.0003	0.0001
0.0005	0.00039	0.00038	0.0002
0.0006	0.00046	0.00045	0.0002
0.0007	0.00053	0.00051	0.0002
0.0008	0.0006	0.00058	0.0003
0.0009	0.00066	0.00065	0.0003
0.001	0.00073	0.00071	0.0003
0.0011	0.00079	0.00077	0.0003
0.0012	0.00085	0.00083	0.0004
0.0013	0.00091	0.00089	0.0004
0.0014	0.00097	0.00095	0.0004
0.0015	0.00103	0.00101	0.0005
0.0016	0.00109	0.00106	0.0005
0.0017	0.00114	0.00111	0.0005
0.0018	0.00119	0.00117	0.0006
0.0019	0.00124	0.00122	0.0006
0.002	0.00129	0.00127	0.0006
0.0021	0.00134	0.00132	0.0006
0.0022	0.00139	0.00136	0.0007
0.0023	0.00144	0.00141	0.0007
0.0024	0.00151	0.00147	0.0007
0.0025	0.00166	0.00158	0.0007
0.0026	0.00223	0.00202	0.0008
0.0027	0.00483	0.00419	0.0008
0.0028	0.01679	0.01514	0.0008
0.0029	0.07214	0.07074	0.0097
0.003	0.32914	0.35422	1.4161

CONCLUSIONS:
Shear lag controlled the strength of the angle and plate specimens. For plates connected only by longitudinal welds, connection length had little influence on the experimental shear lag coefficient. The transverse weld in the angle members welded both longitudinally and transversely did not increase the shear lag coefficient as expected. The experimental shear lag coefficients of the longitudinally welded angles and the angles with both longitudinal and transverse welds were equivalent. Shear lag will not control the strength of tension members connected only by transverse fillet welds. Weld shear will be the controlling limit state, regardless of electrode strength or fillet weld size. This conclusion does not apply to

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partial- or full-penetration welds.Due to the small size of the experimental specimens in this study as well as past studies, caution should be exercised when applying the design provisions to much larger tension members. There is a need for some limited confirmatory testing on large tension members designed so that shear lag effects control the strength.

The recommended upper limit for the shear lag coefficient is 0.9.The implementation of the recommended changes to AISC specifications and commentaries would result in a simpler, more uniform approach to the application of shear lag provisions to bolted and welded tension members. The changes should result in fewer questions regarding the application of the provisions.

SUMMARY:

Shear stress distribution is marginally affected by frequency of excitation. Shear stress distribution is practically independent of excitation frequency.

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