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Biaxial Bending of Steel Angle Section

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Abstract : Structural steel angles have a wide variety of application .However; steel angles have not received the attention comparable to heavy shapes such as wide flange sections. For steel angles flexural buckling strength is the basic design strength, while the torsional flexural buckling strength is computed in many codes by modifying the design procedure for flexural buckling strength. Generally single steel angle sections are not used as steel beam to support loads over it. In some cases when single angle steel sections are used as beams to support distributed loads which cause biaxial bending and torsion. The behavior of steel angles may be extremely complicated and the accurate prediction about their strength is very difficult. Many design codes do not have any design rules of torsion. Some recommendations are of limited applications or fail to consider some effect which is thought to be important. Present paper will be based on the biaxial bending of single steel angle section and twisting of angle section.

Keywords: Angle Section, Biaxial Bending, Torsion, Buckling, Displacement

Introduction: Structural steel angles are used in a variety of structures because of the ease with which they can be fabricated and erected into structures or structural components. They are extensively used as primary leg in electrical transmission towers and antenna-supporting towers as chord member in plane trusses as web and bracing members in litigated towers, trusses, open web steel joist and frames.Steel angle sections are commonly used as beams to support distributed loads which cause biaxial bending and torsion, However, many design codes (BSI, 2000, SA, 1998) do not have any design rules for torsion, while some recommendations are unnecessarily conservative (AISC, 1993a,b) or are of limited application, or fail to consider some effects which are thought to be important. This and a companion paper develop an economical approximate method of designing restrained angle section beams under biaxial bending and torsion which is consistent with the philosophy of current design codes.Single angle steel beams are used as lintel to support eccentric loading normal to one flange. This loading does not act parallel to the principle plane, so causes combined biaxial bending and torsion moment, which is not allowed for in most steel design codes. According to Trahair, beams which are restrained laterally and prevented from twisting may fail by yielding or local buckling, and can be designed for the primary bending moments, shear forces or bending forces.The development of a better understanding of the behavior of steel angle section beams requires special consideration of their loading and restraint, and of the analysis of their elastic behavior. Firstly, horizontal restraints of beams with vertical loads acting in the plane of one leg induce significant horizontal forces which modify the elastic stress distribution. These horizontal forces and their effects on the stress distribution need to be accounted for in the elastic analysis of the beam. Secondly, angle section beams are often loaded eccentrically from the shear center at the intersection of the legs as in which case significant torsion actions may result. These torsion actions need to be accounted for in the analysis.

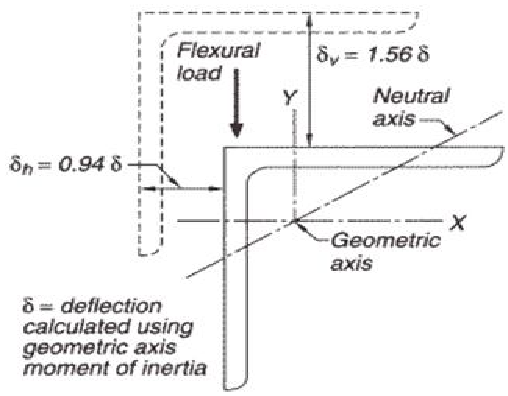

Fig no 1. Deflection of single angle due to load about geometric axis

The strengths of steel angle section beams are related to their section capacities to resist bending, bearing, shear, and torsion actions, and to their member capacities to resist the interactions between biaxial in-plane bending, out-of-plane buckling, and torsion. Very short span beams under distributed loading may fail at the supports, where the shear stresses induced by shear forces and uniform torques are greatest, while long span beams often fail near mid-span, where the normal stresses induced by biaxial bending moments are greatest.In most application steel angles are primarily subjected to axial loads. These axial loads can be concentric or eccentric. Steel angles can fail in flexural buckling torsional-flexural buckling or local buckling. This failure can be eitherelastic or plastic which is treated by many codes and specification as the basic failure mode. The most critical aspect of the column testing under concentric load is its alignment. The member should be placed in the column testing frame in such a way that the longitudinal axis and the line of action of the load coincide.

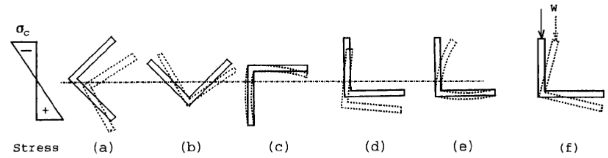

Fig no.2 failures modes of single angle

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Although rarely considered in practical structures, the end conditions during testing can have an influence not only on the capacity in flexural buckling but also on the ultimate load when torsional buckling governs. The resultant line of action of the axial force moves towards the heel, as shown in Fig. 2.Residual stress in steel angels does not often exhibit similar patterns in the two legs. Residual stress in angle of leg size less than 100 mm exhibit less scatter in their distributions. Maximum tensile residual stress occurs at about 40% of the leg width from the head. In general toes of leg have less compressive residual stress than the head portions. The maximum residual stress level in steel angles does not generally exceed 25% of the yield stress. The differences between the maximum yield stress and the minimum yield stress can sometimes be high as 20%.

Although the resistances of I-section webs to shear and bearing actions have been thoroughly investigated, the resistances of angle legs to these actions appear not to have been studied. The principal difference is that while both edges of an I-section web can be modeled as being simply supported laterally by the flanges, each leg of an angle section beam has one edge free. In addition, the elastic shear stress distribution in an I-section web is nearly uniform, but that in an angle section web is very non-uniform. Because of the lack of information on angle section legs, the following sections outline speculative proposals for designing angle section legs against shear and bearing which are adapted from design rules for I-section webs. Proposals are also made for design against uniform torsion. These proposals are generally more economic than those of the AISC MS Design Specification (AISC, 1993a, b), one of the few design codes with specific rules for angle section beams.Consideration is given to the first-order elastic analysis of the biaxial bending angle section beams, including the effects of restraints in a companion paper, and proposals are developed for the moment capacities of angle sections under biaxial bending which approximate the effects of full plasticity in compact sections, first yield in non-compact sections, and local buckling in slender sections.Steel angle section has wide variety of application in steel construction industry. However; steel angles have not received the attention comparable to heavy shapes such as wide flange sections. They can be fabricated and erected into structures or structural component. Generally single steel angle sections are not used as beam to support loads over it. In some cases when single angle steel sections are used as beams to support distributed loads which cause biaxial bending. The behavior of steel angles may be extremely complicated and the accurate prediction about their strength is very difficult. Many design codes do not have any design rules of torsion. Some recommendations are of limited applications or fail to consider some effect which is thought to be important. Present paper will be based on the biaxial bending of single steel angle section. Much of the research into structural steel members over the past century was concerned with the behavior of heavy shapes such as I-sections. Mostly steel angle section can be used as built up section for compression member. In the structural steel industry single angle section has not been used as flexural member who may face biaxial moment. Due this limitation single angle sections have limited used in the structural steel construction industry.In some cases, single steel angle section can be used as flexural member where span is short. By this use of single angle section we can reduce the self-weight of the steel structure without hampering the structure. Study of steel angle sections as flexural member deals mostly with the biaxial bending steel angle section due to different types of loading condition.

Objective ofStudy:

1. Analysisof an angle section as a flexural member byStaad-pro

i) Different sections

ii) End condition, span and loading are constant.

2. Putting relationship between rotation and section dimensions for same loading conditions

Scope of the Study: The scope of this research is bounded with the single angle section which may be equal angle section. Experimental test on single angle section as flexural member is going to take, from which specific relationship is going to predict. The present study focuses on issues related to the accurate prediction ofinelastic flexural ductility exhibited by equal leg, single angle members bent about a geometric axis in such a way, that the horizontal leg is in tension while the outstanding vertical leg is in compression.Staad pro software has been used to calculate approximate deflection & rotation for a beam of different angle sections loaded at the mid span.

Material and Methodology:

Single angle sections can be used as flexural member. Under this topic, different angle section is going to be design by IS 800:2007 for biaxial bending and shear and test under same loading and span conditions. The whole project is based on the loading calculations, deflections & torsional moments of a single equal angle sections. For the calculating the load carrying capacity of a single equal angle section experimental set up is use. This set up helps to know the strengths of an angle sections at various points. In this set up, the frame is prepared to giving load to the angle sections at different points on the angle sections to know where the angle section is deflect in which amount with consideration of application of load on the angle section. This frame of angle sections is act as a beam in a structures so large sizes equal angle sections(110x110,130x130 etc.) is used for the calculating the strength of an equal angle section.

Various angles with their properties used for testing.

Results and Table:

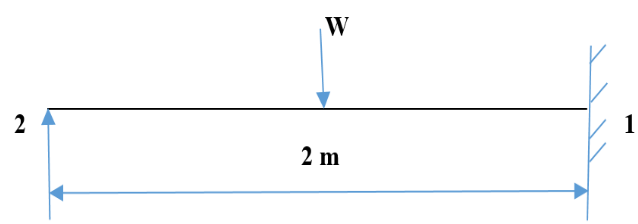

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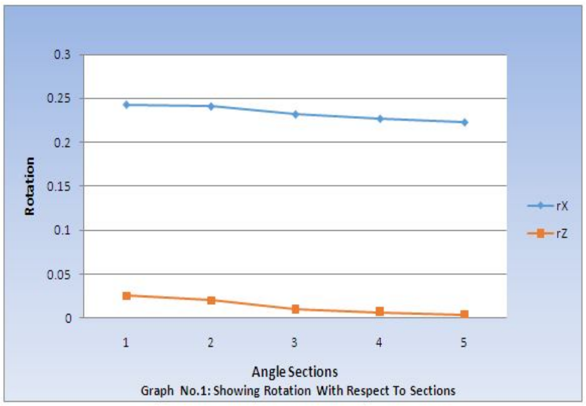
Table no. 1: Rotation values for different angle sections

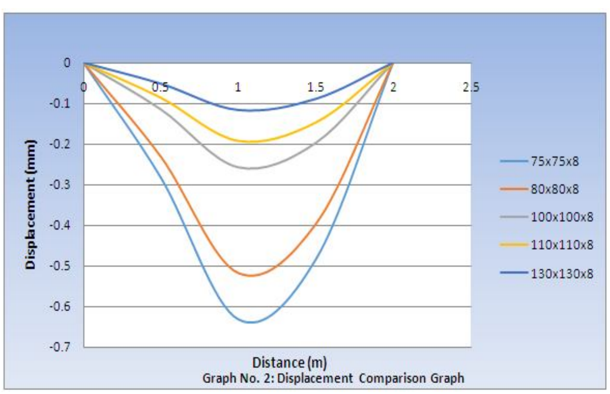
Sr. No	Angle Section	Cxx = Cyy (m)	rX	rZ
1	75x75x8	0.0202	0.243	0.025
2	80x80x8	0.0227	0.241	0.02
3	100x100x8	0.0276	0.232	0.01
4	110x110x8	0.03	0.227	0.007
5	130x130x8	0.035	0.223	0.004



Graph No.1: Showing Rotation With Respect To Sections

Table No. 2: Displacement of different angle sections at different section of span

Distance (m)	Displacement (mm)				
	ISA75x 75x8	ISA80x 80x8	ISA100 x100x8	ISA110x110 x8	ISA130x 130x8
0	0	0	0	0	0
0.5	-0.283	-0.231	-0.115	-0.086	-0.051
1	-0.632	-0.517	-0.258	-0.192	-0.115
1.5	-0.485	-0.397	-0.198	-0.147	-0.088
2	0	0	0	0	0



Graph No. 2: Displacement Comparison Graph

Conclusion:

Single angle section can be used as flexural member. By using single angle section as beam to carry a load, we may reduce the self-weight of the structure. We may get direct sectional dimensions for certain loading and span condition.From graph we came to know that as the size of sections increases there is a increase in moment of inertia and as the value of rotation and displacement decreases, the load carrying capacity of sections increases.

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