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Comparativele Study of Tension Member IS 800:1984 v/s IS 800:2007

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Abstract — **There are various types of Design method such as working State method and Limit State Method. The latest version of the Code of Practice for general construction in steel IS 800:2007 is based on Limit State Method of design. The design concept is totally changed in comparison to earlier IS 800:1984 which is based on elastic method. In the present work, the detailed study of structural components as tension members by designing using Limit State Method and Working Stress Method has been carried out and submitted the comparative study of the same in the form of graphs and charts, which highlights the actual economy achieved by Limit State Method over Working Stress Method for different structural sections. The observations made based on this study are very much useful to the practicing structural engineers.**

Index Terms— IS 800: 2007Limit state method IS 800:1984 Working stress methods, Tension Member

I. INTRODUCTION

A design code should be a set of minimum requirements for any construction covering safety and serviceability. The safety involves life, health, fire and structural stability. The Code may be administered by a county, or state, or city or by a combination of the three.

Essential requirements of an efficient code of practice for design of steel structure:-

- It should be based upon Rational Design Theory.
- The Code should be simple, understandable and easy to use.
- It should be updated regularly to cater the development in the field of research and technology.

As per above discussion of design codes and its essentials we will overview our existing IS: 800 -1984 (Code of practice for use of steel in structures), IS: 800 -2007 as well as Countries and their Design Formats.

A. *Countries and their Design Formats*

- Almost all advanced countries are now taking advantage of efficient code stipulations, and current practice all over the world is based on either Limit State Method (LSM) or Load and Resistance Factor Design (LRFD).
  Following table shows the various major countries and their Design Format.
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Table 1:- Countries and their Design Formats

Countries	Design Formula(For steel Structure)
Australia , Canada , China , Europe ,Japan , UK	Limit State Design(LSM)
U.S.A.	Load and Resistance Factor Design
India a) IS 800 - 1984 b) IS 800 – 2007	 Allowable Stress Design(ASD) Limit State Design

B. *Objectives of Dissertation (i.e. comparatively Study of IS: 800 -1984 and IS 800 -2007)*

- Becoming familiar with new design methodology i.e. “Limit State Design” for design of steel structure.
- Learning as well as understanding the basis (why and how?) of various clauses concerned with different section (such as design of tension member, compression member, flexural member, member subjected to combined forces etc).
- Comparing similarities as well as differences between both codes and also examining the efficient way of designing and if possible finding how best we can incorporate it in our code.
- Searching limitations of both codes and if possible trying to overcome it through detailed study.
- To document step-by step procedure for designing different types of structural elements, clearly highlighting different methodology adopted in two different codes so that it may be helpful for undergraduate student as well as practicing engineer.

- To study economy achieved by designing through both code.

C. About IS 800: 2007:

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Structural Engineering and Structural Sections Sectional Committee had been approved by the Civil Engineering Division Council.

The steel economy programme was initiated by erstwhile Indian Standards Institution in the year 1950 with the objective of achieving economy in the use of structural steel by establishing rational, efficient and optimum standards for structural steel products and their use. IS 800:1956 was the first in the series of Indian Standard brought out under this programme. The standard was revised in 1962 and subsequently in 1984, incorporating certain very important changes. IS 800 is the basic Code for general construction in steel structures and is the prime document for any structural design and has influence on many other codes governing the design of other special steel structures, such as towers, bridges, silos, chimneys, etc. Realizing the necessity to update the standard to the state of the art of the steel construction technology and economy, the current revision of the standard was undertaken. Consideration has been given to the developments taking place in the country and abroad and necessary modifications and additions have been incorporated to make the standard more useful. The revised standard will enhance the confidence of designers, engineers, contractors, technical institutions, Professional bodies and the industry and will open a new era in safe and economic construction in steel.

In this revision the following major modifications have been effected:

- In view of' the development and production of new varieties of medium and high tensile structural steels in the country, the scope of the standard has been modified permitting the use of any variety of structural steel provided the relevant provisions of the standard are satisfied.
- The standard has made reference to the Indian Standards now available for rivets; bolts and other fasteners.
- The standard is based on limit state method, reflecting the latest developments and the state of the art.

The revision of the standard was based on a review carried out and the proposals framed by Indian Institute of Technology Madras (IIT Madras). The project was supported by Institute of Steel Development and Growth (INSDAG) Kolkata. There has been considerable contribution from INSDAG and IIT Madras, with assistance from a number of academic, research, design and contracting institutes/organizations, in the preparation of the revised standard.

IS 800:2007 is based on Limit State Method of design. The design concept is totally changed in comparison to earlier IS 800:1984 which is based on elastic method. The design methodologies for the steel structures namely, working stress design method and limit state design methods are briefly explained. The importance of limit state design method is highlighted. In the present work, the detailed study of structural component as Beam by designing using Limit State Method and Working Stress Method has been carried out and submitted the comparative study of the same in the form of graphs. Index Terms— IS 800:1984 and IS 800:2007, Limit state method (Plastic method), Working stress method (Elastic method).

II. DESIGN ASPECT

A. Limit State Method:-

The Object of limit state design can be Paraphrased as “Achievement of an acceptable probability that a part or whole of structure will not become unfit for its intended use during its life time owing to collapse, excessive deflection etc., under the actions of all loads and load effects.

The acceptable limits of safety and serviceability requirements before failure occurs are called as limit state.

B. Principles of Limit State Design:-

The concept of variability is important because the steel designer must accept that, his performing his design calculation he is using quantities which are not absolutely fixed or deterministic.

The procedure of Limit State design can therefore be summarized as follows:-

- Define relevant limit states at which the structural behavior is to be checked.
- For each limit state determine appropriate action to be considered.

Using appropriate structural models for design and taking account of the inevitable variability of parameters data, verify that none of the relevant limit state is exceeded.

Limit States are classified as

- Ultimate limit state
- Serviceability limit state

Table no.2

Ultimate Limit States	Serviceability Limit States
(yield & buckling)	Deflection
Stability against overturning and Sway	Vibration
Fracture due to sway	Fatigue
Brittle failure	Corrosion

The Ultimate Limit State includes:-

- Loss of equilibrium of the structure as a whole or any of its parts or components.
- Loss of sway of the structure (including the effect of sway where appropriate and overturning or any of its parts including supports and foundation.)
- Failure of excessive deformation, rupture of the structure or any of its parts or components.
- Fracture due to fatigue.

The Limit State of Serviceability includes:-

- Deformation and deflection which may adversely affect the use of the structure or may cause improper
- Functioning of equipment or services or may cause damages to finishes and non-structural members.

C. Limit State Design:-

For ensuring the design objectives, the design should be based on characteristics values for materials strengths and applied loads (actions) which take into account the probability of variation in the materials strengths and in the loads to be supported. The design values are derived from the characteristics values through the use of partial safety factors, the reliability of design is ensured by requiring that,

Design Action ≤ Design Strength

D. Design of Tension Member

1) Introduction

A structural member subjected to two pulling (tensile) forces applied at its ends is called a tension member. Steel tension member are probably the most common and efficient member. These are efficient

Because the entire cross- section is subjected to almost uniform stress.(in other words the whole cross-sectional area is utilized). The stress in such members is assumed to be uniformly distributed over the net section and hence members subjected only to axial tension are supposed to be the most efficient and economical. On the other hand , if some eccentricity exists either due to the member not being perfectly straight or due to some eccentricity in connections, either bending stresses are considered in the design or specifications are provided to account for reduction in the net area.

The strength of these members is influenced by several factors such as length of connection, size and spacing of fasteners, net area of cross section, and type of fabrication, connection eccentricity, and shear lag at the end connection.

2) Behavior of Tension Members:- As per IS 800:2007

Tension members are linear members in which axial forces act to cause elongation (stretch). Such members can sustain loads up to the ultimate load, at which stage they may fail by rupture at a critical section. However, if the gross area of the member yields over a major portion of its length before therupture load is reached, the member may become non-functional due to excessive elongation. Plate sand other rolled sections in tension may also fail by block shear of end bolted regions.

Modes of failure of tension member:-

Following are different modes of tension member

- Gross section yielding
- Net section rupture
- Block shear failure

Gross section yielding

Generally a tension member without bolt hole can resists loads up to the ultimate load without failure. But such a member will deform in longitudinal direction considerably (nearly 10% - 15% of its original length) before failure. At such a large deformation a structure will become unserviceable. Hence in limit state design, addition of gross section yielding in modes of failure must also be considered, so as to prevent excessive deformation of the member.

Net section rupture

When a tension member is connected using bolts, tension members have holes and hence reduced cross- section, being referred to as the net area. Holes in the member cause stress concentration.

Block shear failure

Block shear commonly refers to the tearing of block of material, and it presumes a combination of tension rupture and shears yield or a combination of shear rupture and tension yield. Block shear failure is usually associated with bolted details because a reduced area is present in that case, but in principle it can also be present in welded details.

3) The influence of Residual stresses and connection (Effect of holes):-

Residual stresses develop when the member is formed and are due to the production process. Their origin can be thermal, either developed during solidification of the steel or they can be mechanically induced when trying to produce counter-deflection or straightening the member. The induced stresses are self equilibrated and although they do not affect the ultimate resistance of the member they induce non – linearities in the strain stress behaviour as well as greater deformability.

4) Connections (Effect of holes on tension capacity):-

Connections are generally made either by bolting or welding. When several members have to be connected, additional plates must be used which introduce secondary effects due to the moments developed. The holes that are needed to fix the bolt significantly distort the ideal behaviour of the cross – section. Firstly, there is an area reduction and also a distortion in the stresses distribution that induces a non – uniformity in the strain.

As per IS 800:1984

Structural members that are subjected to axial tensile force, any cross – sectional configuration may be used, since the only determinant of strength is the net cross-sectional area. The net sectional area of a tension member is the gross sectional area of the member minus the sectional area of the maximum number of holes. Stresses in a tension member are calculated on the basis of minimum net cross-sectional area available. The reason for considering the net section in the calculation of stresses is the failure of sections with holes.

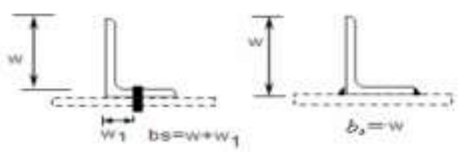
The unit stress in a tension member is increased due to the presence of a hole even if the hole is occupied by a rivet. This is because the area of steel to which load is distributed is reduced and some concentration of stress occurs along the edge of the hole. But for static loading this increase in unit stress is neglected because at yielding, the effect of stress concentration is nullified and tension is therefore assumed to be uniformly distributed over the net section. Although there are some parameter like residual stress and connection which result in a non-uniform distribution of stresses, it is generally assumed that the distribution of stresses in cross-sections of members subjected to axial tensile force is uniform.

5) Codal provisions for design of tension member (METHODOLOGY)

Table no.3

IS 800:1984	IS 800 :2007
The permissible stress in axial tension σ_{at} in Mpa on the net effective area of The section shall not exceed $\sigma_{at} = 0.6\ f_y$ (where f_y = minimum yield stress of steel) [Clause 4.1]	Factored design tension T in the member shall be :- $T < T_d$ (clause 6.1) Where, T_d = Design tensile strength of the member least of T_{dg} , T_{dn}, T_{db} T_{dg} = design strength due to yielding of gross section T_{dn} = design strength due rupture of critical section T_{db} = design strength due to block shear

Table no.4

IS 800:1984	IS 800:2007
Net effective area $=A_{net} = A_1 + A_2 K$ For angles and Tees (clause 4.2) With bolted and welded connection Provide a reduction coefficient to take Account of the unavoidable Eccentricities, stress concentrations etc. In case of single angle connected Through one leg $K = 3A_1 /(3A_1 + A_2)$ A_1 = area of connected leg A_2 = area of outstanding leg In case of double angle connected same side of the gusset plate	For angles (clause 6.3.3) With bolted and welded connection $T_{dn} = 0.9 \times fu \times A_{nc}/\gamma_{m1} + \beta \times A_{go} \times f_y/\gamma_{mo}$ $= \alpha A_n \times f_u/\gamma_{m1}$ α = 0.6 for one or two rivets = 0.7 for three rivets = 0.8 for four or more rivets $\beta = 1.38-0.076 \times w/t \times f_y/f_u \times bs/L$  w and b_s are shown in fig

$K = 5A_1/(5A_1 + A_2)$	A_n = net area of the total cross section A_{nc} = net area of the connecting leg A_{go} = gross area of outstanding leg t = thickness of leg L = length of end connection

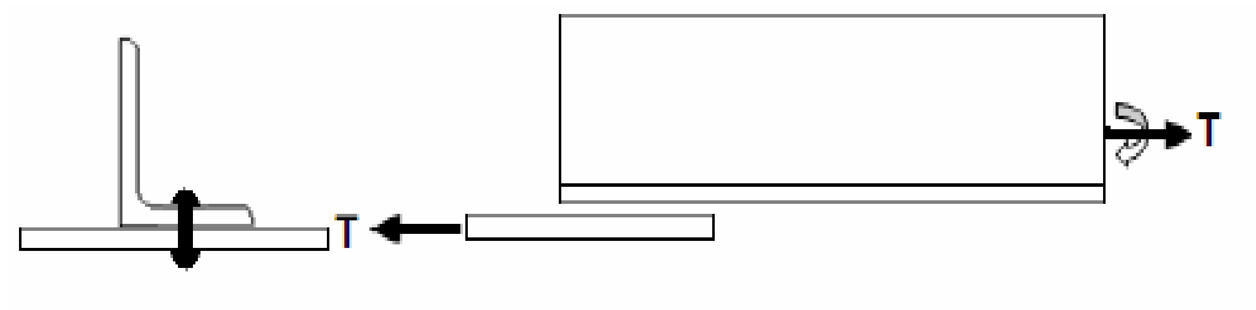


Fig.1 Angle eccentrically loaded through gusset plate

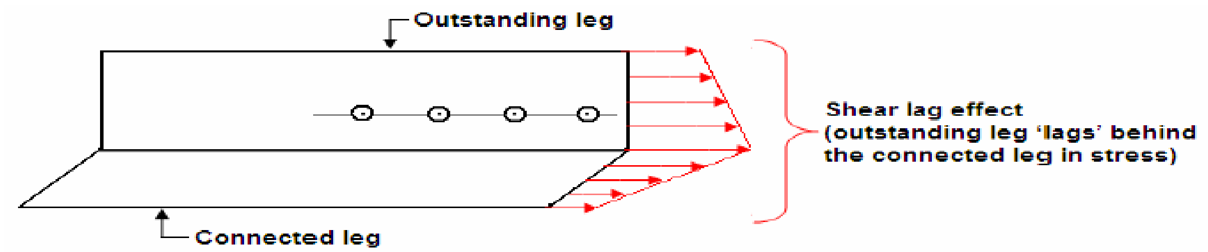


Fig.2 Shear leg effect when angle is connected by one leg

Effect of shear leg:-

The force is transferred to a tension member (angles, channels, or T-section) by a gusset or the adjacent member connected to one leg either by bolting or by welding. The force thus transferred to one leg by the end connection as tensile stress over the entire cross-section by shear. Hence the tensile stress on the section from the first bolt up to the last bolt will not be uniform. The connected leg will have higher stresses even of the order of ultimate stress while outstanding leg stresses may be below the yield stress. Thus transfer of stress from connected leg to outstanding leg will be by shear and because one part Lags behind the other , this phenomenon is referred to as shear lag. However at the section away from the end connection, the stress distribution is more uniform. Hence shear lag effect reduces with increase in connection length.

Therefore to account for eccentric loading due to the shear lag effect the reduction factor β is introduced in IS 800:2007. If we calculate the design strength at net cross section by both codes, we can say that

- IS 800:2007 consider that connected leg of an angle is stressed up to ultimate stress f_u

And outstanding leg is stressed up to yield stress f_y.The reduction factor β is applied

To connected leg strength. The value of β increases with length of connection.

- In IS 800:1984 the reduction factor is applied to net area of outstanding leg to account of effect of unavoidable eccentricities due to shear lag. The value of reduction factor depends upon type of connection with the gusset. The connection should be designed so as to reduce the effect of bending to a minimum due to eccentricities.

III. WORKED EXAMPLE OF TENSION MEMBER:-

The worked example include analysis and design of the tension member by IS 800:1984 and IS 800: 2007

A. PROBLEM BASE ON ANALYSIS OF TENSION MEMBER BY IS: 800:1984

Analysis Problem:-

A Single unequal angle 125 mm x 75 mm x 8 mm is connected to 12 mm thick gusset plate at ends with 6 no. 16 mm diameter rivets to transfer tension as shown in fig. Determine the tensile Strength of the unequal angle section if

(a) Longer leg is connected to gusset plate

(b) Shorter leg is connected to gusset plate

The value of yield stress (f_y)= 250 MPa

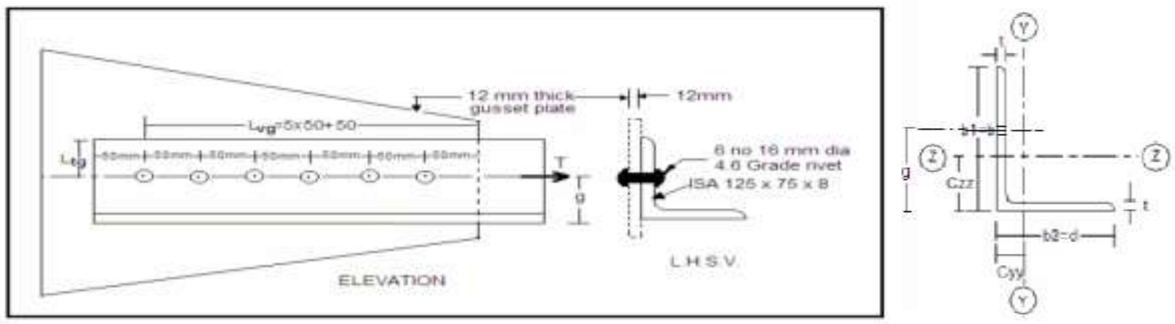


Fig.3

Analysis Steps Reference

Sectional Properties IS Handbook NO. 1

A = 1538 mm^2, Properties of the anglesection

b = 125 mm, d = 75 mm, t = 8 mm, g = 75 mm

Nominal dia. of rivet = 16 mm

Effective dia. of rivet (d) = 16+1.5 = 17.5mm

a) When longer leg is connected to gusset plate **[**Clause 3.6.1.1]

Area of connected leg (A_1) = (125-17.5-8/2) x8 = 828 mm^2

Area of outstanding leg (A_2) = (75-8/2) x8 = 568 mm^2

$K = 3A_1/(3A_1+A_2)$ Clause 4.2.1.1

K = 3 x 828 / (3x828 + 568) = 0.814

$A_{net} = A_1 + A_2K$= 828 + 0.814x568 = 1290.35 mm^2

Strength of member = $\sigma_{at} A_{net}$= 0.6x250x1290.35

Strength of member = 193.55 KN

b) When shorter leg is connected to gusset plate

Area of connected leg (A_1) = (75-17.5-8/2) x8 = 428 mm^2

Area of outstanding leg (A_2) = (125-8/2) x8 = 968 mm^2

$K = 3A_1/(3A_1+A_2)$ = 3 x 428 / (3x428 + 968) = 0.570

$A_{net} = A_1 + A_2 K$ = 428 + 0.570x968 = 979.76 mm^2

Strength of member =$\sigma_{at}A_{net}$= 0.6x250x979.76

Strength of member = 147 KN

Conclusion:-Design tensile strength capacity of unequal section will be more if longer leg is connected to gusset plate than if shorter leg is connected to gusset plate.

B. PROBLEM BASE ON ANALYSIS OF TENSION MEMBER BY IS: 800:2007.

Analysis Problem:-

A Single unequal angle 125 mm x 75 mm x 8 mm is connected to 12 mm thick gusset plate at ends with 6 no. 16 mm diameter rivets to transfer tension as shown in fig. Determine the tensile Strength of the unequal angle section if

(a) Longer leg is connected to gusset plate

(b) Shorter leg is connected to gusset plate

The value of yield stress (f_y) = 250 MPa

(Refer same figure as in problem discussed by IS 800:1984)

Sectional Properties IS handbook no. 1

A = 1538 mm2,b = 125 mm, d = 75 mm,t = 8 mm,g = 75 mm , Nominal dia. of rivet = 16 mm

Effective dia. of rivet (d_o) = 16+2.0 = 18.0 mm [Clause 3.6.1]

a) When longer leg is connected to gusset plate

Net area of connecting leg A_{nc}= (125-18-8/2)x8 = 824 mm^2

Gross area of outstanding leg A_{go} = (75-8/2)x8 = 568 mm^2

Gross area of section A_g = 1538 mm^2

Design strength due to yielding of cross section

$T_{dg} = A_g f_y/\gamma_{mo}$ = 1538 x 250 /1.1 [Clause 6.2]

T_{dg}= 349.5 KN

Design strength due to rupture of critical Section

$T_{dn} = 0.9 \times f_u \times A_{nc}/\gamma_{m1} + \beta \times A_{go} \times f_y/\gamma_{mo}$ or [Clause 6.3.3]

$= \alpha A_n$ x f_u/γ_{m1}
α = 0.6 for one or two rivets
= 0.7 for three rivets
= 0.8 for four or more rivets
For our case
α = 0.8, $_{fy}$ = 250 MPa, γ_{mo} = 1.10, γ_{m1} = 1.25
So ,
T_{dn} = 0.8 x (824 + 568) x 410/1.25 = 365.26 KN
Design strength due to Block Shear T_{db}
$T_{db} = A_{vg}$ x $f_y/(\sqrt{3}$ x $\gamma_{m0}) + (A_{tn}$ x $f_u) / \gamma_{m1}$ [Clause 6.4.1]
or = A_{vn} x $f_u/(v3$ x $\gamma_{m1}) + A_{tg} x f_y/\gamma_{m0}$
Where,
A_{vg} & A_{vn} = Minimum gross and net area in shear Along a line of transmitted force respectively
A_{tg} & A_{tn}= Minimum gross and net area in tension From hole to toe of an angle or next last row of bolts In plate
Here :
$A_{vg} = L_{vg}$ x t
A_{vg} = (5 x 50 + 50) x 8 = 2400 mm^2
A_{vn} =(5 x 50 + 50 – 5.5 x 18)x 8 = 1608 mm^2
$A_{tg} = L_{tg}$x t = 50 x 8 = 400 mm^2
A_{tn} = (50 – 0.5 x 18) x 8 = 328 mm^2
Therefore
T_{db} = 2400 x 250 /($\sqrt{3}$ x1.10) + 328 x 410/1.25 = 422.50 KN
Or ,
T_{db} = 1608 x 410 /($\sqrt{3}$ x 1.25) + 400 x 250/1.10 = 395.42 KN
Considering lower value for T_{db} = 395.42 KN
Design tensile strength of ISA 125 x 75 x 8 if longer leg connected to gusset plate
T_d = Least of T_{dg}, T_{dn} , T_{db}
T_d = 349.5 KN [Clause 6.1]

b) When shorter leg is connected to gusset plate
Net area of connecting legA_{nc}= (75-18-8/2)x8= 424 mm^2
Gross area of outstanding legA_{go} = (125-8/2)x8= 968 mm^2
Gross area of sectionA_g = 1538 mm^2
Design strength due to yielding of cross section
$T_{dg} = A_g f_y/\gamma_{mo}$ = 1538 x 250 /1.1 [Clause 6.2]
T_{dg}= 349.5 KN
Design strength due to rupture of critical Section
T_{dn}= 0.9 x $f_u \times A_{nc}/\gamma_{m1} + \beta$ x A_{go} x f_y/γ_{m0} [Clause 6.3.3]
or
$= \alpha A_n \times f_u/\gamma_{m1}$
α = 0.6 for one or two rivets
= 0.7 for three rivets
= 0.8 for four or more rivets
For our case
α = 0.8,f_y= 250 MPa, γ_{mo}= 1.10, γ_{m1}= 1.25
So ,
T_{dn}= 0.8 x (424 + 968) x 410/1.25
T_{dn}= 365.26 KN
Or,
β =1.38-0.076 x w/t x $f_y/f_u x b_s/L$
in our case
w = 125 -4 = 121 mm , w_1 = 40 mm
b_s= 161 mm , L = 250 mm , f_y= 250 MPa, f_u= 410 MPa , γ_{m0}= 1.10 , γ_{m1}= 1.25
then , β = 0.93
considering the value of β = 0.93
T_{dn} = (0.9 x 410 x 424)/1.25 + 0.93 x (968 x 250)/1.10 = 329.77 KN
Hence take the lower value of T_{dn} = 329.77 KN
Design strength due to Block Shear T_{db}
$T_{db} = A_{vg}$ x $f_y/(\sqrt{3}$ x $\gamma_{m0}) + (A_{tn}$ x $f_u) / \gamma_{m1}$ Clause 6.4.2
Or = A_{vn} x $f_u/(\sqrt{3}$ x $\gamma_{m1}) + A_{tg} x f_y/\gamma_{m0}$

A_{vg}&A_{vn} = Minimum gross and net area in shear Along a line of transmitted force respectively
A_{tg}&A_{tn} = Minimum gross and net area in tension From hole to toe of an angle or next last row of bolts In plate
Here
$A_{vg} = L_{vg} \times t = (5 \times 50 + 50) \times 8 = 2400\ mm^2$
$A_{vn} = (5 \times 50 + 50 - 5.5 \times 18) \times 8 = 1608\ m^2$
$A_{tg} = L_{tg} \times t = 35 \times 8 = 280\ mm^2$
$A_{tn} = (35 - 0.5 \times 18) \times 8 = 208\ mm^2$
Therefore
$T_{db} = 2400 \times 250 / (\sqrt{3} \times 1.10) + 208 \times 410/1.25 = 383.14$ KN
Or ,
$T_{db} = 1608 \times 410 / (\sqrt{3} \times 1.25) + 280 \times 250/1.10 = 368.14$ KN
Considering lower value for $T_{db} = 368.14$ KN
Design tensile strength of ISA 125 x 75 x 8 if longer leg connected to gusset plate
T_d = Least of T_{dg}, T_{db} , T_{dn}
Conclusion from problem [Clause 6.1]
$T_d = 329.77$ KN
Conclusion: - Design tensile strength capacity of unequal section will be more if longer leg is connected to gusset plate than if shorter leg is connected to gusset plate.

C. PROBLEM BASE ON DESIGN OF TENSION MEMBER BY IS 800: 1984

Design Problem
Design a tension member to carry the design axial tension of 375 KN with riveted connections (Provided rivets in a single row). Use $f_y = 250$ MPa

Design Steps

1.Data P=375kN Riveted Connections
2. Allowable tensile stress $\sigma_{at} = 0.6\ f_y = 0.6 \times 250 = 150\ N/mm^2$ [Clause 4.1]
3. Net cross section area required $= 375 \times 10^3 / 150$
Net cross section area required $= 2500\ mm^2$
Increase the net area about 40% (to Account for rivet hole) to find the gross area.
Gross sectional area required $= 1.4 \times 2500 = 3500\ mm^2$
4. Trial Section
Let us try a Single angle section(longer Leg connected to the gusset plate)
Try ISA 150 x 115 x 15 mm , Sectional area = $3752\ mm^2$, Provide 20 mm dia. rivets.
Gross dia. d = 20 + 1.5 = 21.5 mm
Area of connected legs $A_1 = (150 - 21.5 - 15/2) \times 15 = 1815\ mm^2$
Area of outstanding legs $A_2 = (115 - 15/2) \times 15 = 1612.50\ mm^2$
$K = 3A_1/(3A_1+A_2) = 3 \times 1815 / (3 \times 1815 + 1612.50) = 0.77$ [Clause 4.2.1.1]
Net area provided $= 1815 + 0.77 \times 1612.5 = 3056.63\ mm^2$
Strength of the member =3056.63 x 150 = **458.50 KN > 375 KN**
Hence the ISA150 x 115 x 15 mm Which is safe.

D. PROBLEMBASE ONDESIGN OF TENSION MEMBER BY IS 800: 2007

Design Problem
Design a tension member to carry the design axial tension of 375 KN with riveted connections (Provided rivets in a single row). Use $f_y = 250$ MPa
Design Steps
1. Data P = 375 KN Riveted connections
2. Trial Section $(Ag)req = P \times \gamma_{mo} / f\,y = 375 \times 10^3 = 1650\ mm^2$
Increase in by 5% so that $(Ag)req = 1.05 \times 1650 = 1733\ mm^2$
Let us try 150 x 75 x 8 mm with longer leg is connected gusset plate. IS Handbook no.1
Sectional properties A = $1742\ mm^2$, b= 150mm, d=75mm, t = 8 mm, g = 75 mm

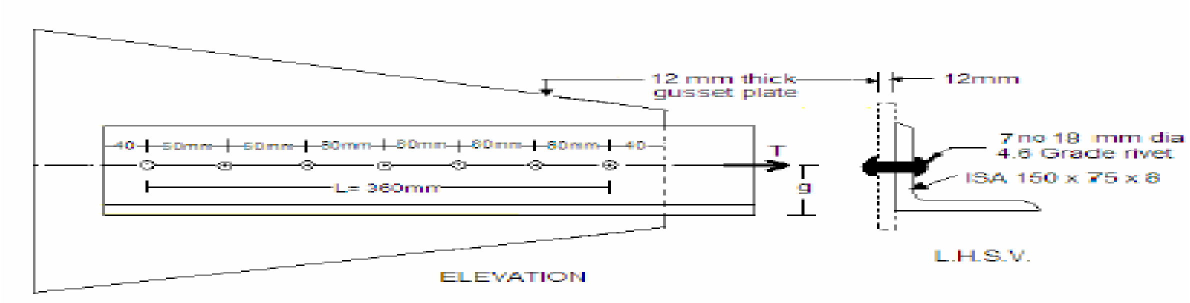


Fig.4

3. Connection design

Diameter of rivet d = 6.03 x $\sqrt{t}$ = 6.03 x $\sqrt{8}$ =18 mm
(To avoid failure of rivet in bearing)
Effective dia. of rivet = 18 + 2 = 20 mm
Rivet value = Shear capacity of rivet in single shear =
Vns = $\pi/4$ x 20^2x 410/($\sqrt{3}$ x1.25) = 59.50 KN
Therefore no. rivet required = 375/ 59.50 = 7
Provide edge distance = 40 mm > 30 mm for 18 mm dia. rivet
Pitch (p):- [Clause 3.6.1]
For tension member max.pitch = 16 x t or 200 mm
Whichever is less, minimum pitch = 2.5 x d [Clause 10.2.3.2]
Hence, provide p = 60 mm
Therefore length of end connection L = 360 mm

4. Tension capacity of section A_{nc} = Net area of connected leg [Table 10.10]
= (150-20-8/2) x8 =1008mm^2
A_{go}= Gross area of outstanding leg = (75-8/2) x8 = 568 mm^2 [Clause 10.2.2]
A_g = Gross area of whole section =1742mm^2 [Clause 10.2.1]
An = Net area of total cross section = Anc+ A go= 1576 mm^2
Design strength due to yielding of gross section
Tdg= Agfy/γmo= 1742 x 250 / 1.1 = 395.90 KN
Design strength due to Rupture of Critical Section
Tdn = 0.9 x fu x Anc/γm1 + β x A_{go} x f_y/ γ_{mo} [Clause 6.2]
or = αAnxfu/γm1 [Clause 6.3.3]
α = 0.6 for one or two rivets
= 0.7 for three rivets
= 0.8 for four or more rivets
T_{dn} = 0.8 x 1576 x 410/1.25 = 413.54 KN
Design strength due to Block Shear
$T_{db} = A_{vg} \times f_y/(\sqrt{3} \times \gamma_{mo}) + (A_{tn} \times f_u) / \gamma_{m1}$
Or = $A_{vn} x f_u/(\sqrt{3} \times \gamma_{m1}) + A_{tg} x f_y/\gamma_{mo}$ [Clause 6.4.2]
Here
A_{vg} = (6 x 60 + 40) xt = 3200 mm^2
A_{vn}= (6 x 60 + 40 – 6.5 x 20) x 8 = 2160 mm^2
A_{tg}= 75 x 8 = 600 mm^2
A_{tn}= (75- 0.5 x 20) x 8 = 520 mm^2
Therefore ,
T_{db} = 3200 x 250/($\sqrt{3}$ x 1.10) +520 x410/1.25
T_{db} = 590.45 KN
Or,
T_{db} = 2160 x 410/($\sqrt{3}$ x 1.25) + 600 x 250/1.10
T_{db} = 545.40 KN
Considering lower value for T_{db}= 545.40 KN
Design Tensile Strength of ISA 150 x 75 x 8 mm [Clause 6.1]
T_d = Least of T_{dg} ,T_{dn}, T_{db}
T_d = 395.90 KN > 375 KN
Hence the ISA150 x 75 x 8 mm which is safe.

Design of Single angle member connected by single row of rivets by both codes

Table no.5

Points	IS 800:1984	IS 800:2007
Section for tensile force p= 375Kn	ISA 150 x 115 x 15 mm	ISA 150 x 75 x 8 mm
Length of end connection	13 no's 18 mm dia. of Rivets p = 60 mm c/c Hence L = 720 mm	7 no. 18 mm dia. of rivets p = 60 mm c/c Hence L = 360 mm
Failure mode	Failure along net cross Section at holes	Yielding of gross section

E. Conclusion: -

- Design tensile strength capacity of unequal section will be more.
- Lower section is required to carry same load as per IS 800:2007 than that of as per IS 800:1984.
- Less number of rivets required are as per IS 800:2007 than that of as per IS 800:1984.
- Length of end connection required is also reduced as per IS 800:2007 than that of as per IS 800:1984.

IV. CONCLUSIONS

- The main objective of this comparative study of IS: 800:2007& IS :800:1984 is to study the Limit State Method for design of steel structure and then compare the design methodology for basic structural element by both codes Following conclusions are drawn and summarized
- **Basis of design**

The design methodology by IS: 800:2007 is based on Limit State and IS 800:1984 is based on Working/Allowable Stress Method . Even though IS: 800 :2007 doesn't disregard the allowable/working stress design format completely but in the section 11 of IS: 800 :2007 it has been proposed that wherever it is not possible or feasible one can adopt the working stress design format

- **Design of Tension member**

It is generally assumed that the distribution of stresses in cross-sections of members subjected to axial tensile forces is uniform. However some parameters like residual stresses and connection which result in a non-uniform distribution of stresses but they don't affect the ultimate resistance of the member. To account for eccentric loading in case of angle connected by one leg due to shear lag effect etc. , the reduction factor ß is introduced in IS 800:2007and a coefficient k is introduced in IS 800:1984with the area of outstanding leg which depends upon the type of connection with the gusset plate.

- In LSD ,in addition to net section failure and block shear failure , yielding of the gross section must also be considered so as to prevent excessive deformation of the member.
- 1.The design of tension member using Angles by Limit state method IS 800:2007 is economical over the working stress method IS 800:1984 which values for 12% to 54%
- **Section classification:-**

IS 800:1984 is based on 'Allowable Stress Method' the extreme fibre stress in the beams is restricted to 0.66 f y. In addition, the 'I' sections rolled in India are found to be at least semi compact in which the section classification for Indian standard 'I' beams have been presented. In other words the flange outstands of the 'I' beams rolled in India are so proportioned that they attain yield stress before local buckling . Because of these two reasons, there was no need for section classification in the design of beams using IS 800:1984. However, in the limit state design of steel beams, section classification becomes very essential as the moment capacities of each classified section takes different values.

IS 800:2007 classify the cross section based on limiting width to thickness ratio of individual plate element to avoid the local buckling and remains silent on this matter about slender class. (As such some of ISA section fails in slender class.)

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