The Comparative Analysis of Strength and Cost of Connections using LSM and WSM Method

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***Abstract*— Connections are very important part of steel structure and are designed more than members in number.The connections are classified as, riveted connections, bolted connection, welded connections.Riveted connections were once very popular and are still used in some cases but designed to follow only Working stress method not on limit state method. In this research paper we did a comparative study of various connections as per IS800:2007 and IS800:1984.In this paper mainly focuses on connections is economical, reliable and have good strength. We talk to bearing strength, shearing strength, and design strength of connection.**

Keywords – Stress, throat, weld, shear, design.

I. INTRODUCTION

A civil engineering designer has to ensure that the structure and facilities he designs arefit for their purpose and Safe and Economical. We all know very well L.S.M (IS800:2007) working on plastic method and W.S.M (IS800:1984) working on Elastic method and both codes are used for analysis and designing for structure element and connections members. In this paper we have analyzed differences between and results of connection members. We have choose ISA100×75×8mm and ISA100×75×10mm angle section for design Welded connections and vary thickness of angle section like 6mm, 8mm, 10mm for analysis differences of results through both L.S.M and W.S.M method for several loading condition. In bolted and Welded connections we analyze which method are safely and suitable for connection members through numerical analysis.

Concept of Elastic Method

In the elastic method of design, many combinations of loads is ascertained and the member are proportioned on the basis of working stress. These stresses should never exceed the permissible as the codal provision.

Working stress ≤ permissible stress

Concept of Limit State Method

For achieving the design criteria, the design shall be based on codal provisions of IS800:2007 values for material strengths and applied loads (actions).

Design action ≤ Design strength

Welding - Welding is the process of connecting and joining two pieces of metal by creating a strong bond between them by heating gases. It is most of the oldest and good methods of joining between two pieces of materials.

II. DESIGN OF WELDED CONNECTION BY LIMIT STATE METHOD

A. Fillet Welds

Permissible stresses - Shear stress shall not exceed more 110MPa or nor as calculated using methods [1].

Effective throat thickness - Shall not be < 3mm and not > 0.7t, Where t is the thickness of the thinner plate. For stresses calculation in fillet welds joining faces inclined to each other, effective throat thickness shall be taken as K times the fillet size as to codal provision, where K is a constant.

Effective length - Shall be the overall length of weld left end returns in case of Fillet welds and shall be the overall length of weld including end returns for Butt welds.

Minimum weld length - Shall be not less than 4 times of size of weld.

Minimum size of weld - Minimum size of weld shall be not less than 3mm.

B. Butt Weld`

Permissible stresses - Stresses shall not more than those permitted in parent metal.

Minimum size of weld - Specified by the effective throat thickness.

Effective throat thickness - Shall be taken as thickness of thinner part joined. For an incomplete penetration, effective throat thickness shall be taken as the minimum thickness of the weld metal common to the parts joined, excluding reinforcement not more than the thickness of the thinner part joined.

III. DESIGN WELDED CONNECTION BY WORKING STRESS METHOD

A. Fillet Welds

Permissible stresses - Shear stress shall not exceed 110MPa.

Effective throat thickness - Shall not be < 3 mm and not > 0.7t, where t is the thickness of the thinner plate. For stresses calculation, the effective throat thickness shall be taken as K times the fillet size, where K is a constant.

Effective length - Shall be the overall length of the weld+ 2(weld size).

Minimum weld length - Shall not be less than 4(size of the weld).

Minimum size of weld - Shall not be less than 3 mm

B. Butt Welds

Permissible stresses - Stresses in weld shall not exceed those permitted in the parent metal.

Minimum size of weld - Size of butt weld shall be specified by the effective throat thickness.

Effective throat thickness - For complete penetration effective throat thickness shall be taken as the thickness of thinner part joined according codal provision.

For incomplete penetration, effective throat thickness shall be taken as the thickness of the weld metal common to the parts joined as codal provision, excluding reinforcement.

IV. DESIGN BOLTED CONNECTION BY LIMIT STATE METHOD (IS800:2007)

Permissible stresses - No particular value is prescribed. Specific Procedure given for calculation of permissible loads (Axial Tension, Shear &Bearing).

Combined shear tension in bolts - No particular value is provided. Procedure given for calculation of permissible loads

Minimum pitch - Shall not be less than 2.5 times the nominal diameter of the bolt.

Minimum edge distance - Should be less 1.7 times hole dia. for sheared or hand flame cut edges, less than>1.5 times hole dia. for rolled, machine-flame cut, sawn and planed edges, from the centre of the hole..

Maximum pitch - Shall not exceed 32×thickness of thinner outside of plate or 300mm whichever is less.

Maximum edge distance - Shall not exceed 12tε, where t is the thickness of the thinner router plate, and $\varepsilon = \sqrt{(250/fy)}$

V. DESIGN BOLTED CONNECTION BY WORKING STRESS METHOD (IS800:1984)

Permissible stresses

Axial tension 120MPa
Shear strength 80MPa
Bearing strength 250MPa
Combined shear tension in bolts -
Individual stresses should not exceed the pre define values and combined stress ratio should not exceed 1.40.

Minimum pitch - Shall not be less than 2.5 times the nominal diameter of the bolt

Minimum edge distance - Distance from the centre of hole to the edge of a plate shall not be less than that specified in Table 8.2 in code IS800:1984 When two or more parts are connected and joined together, a line of bolts shall be provided at a distance of not more than 37 mm+ 4× thickness of thinner plate from the nearest edge in mm. In case of work not exposed to weather, this may be increased to 12t.

Maximum pitch - Shall not exceed 32 times of thickness of thinner outside plate or 300mm whichever is less

Maximum edge distance - No specific criteria are mentioned.

VI. NUMERICAL ANALYSIS

A. Welded Connection By Limit State Mathod

Consider a single angle section ISA 100×75×8mm. Some axial load applied on a section interval like 140kn, 160kn, 180kn, 200kn, 220kn at a 20kn load interval.10mm gusset plate used.

$f_{wd} = f_{wn} / \gamma_m$ and $f_{wn} = fu/\sqrt{3}$

Where fu = smaller of the ultimate stress of the weld and the parent metal and

γ_m= partial safety factor (=1.25 for shop welds and = 1.5 for field welds)

f_{wd}= L×t× fu/(√3×1.25)

t= 0.75×s

t= thickness of weld.

S=3/4×t

Thickness of weld is 8mm than s= 6mm.

Take partial safety factor= 1.25

Table I. Length of weld for ISA100×75×8mm by LSM

Load(KN)	F_{wd}(KN)	L_w(mm)	L_1(mm)	L_2(mm)
140	210kn	264	182	82
160	240kn	302	208	94
180	270kn	340	234	106
200	300kn	378	260	118
220	330	415	286	129

This table values show the result for welded connection for ISA 100×75×8mm single angle section. Now change the thickness of section and consider ISA100×75×10mm single angle section and calculate value for this section and show in table.

t= 0.7×s = 0.7×7.5 = 5.25mm

Table 2. Length of weld for ISA100×75×10mm by LSM

LOAD	F_{wd}(KN)	L_W(MM)	L_1(MM)	L_2(MM)
140kn	210kn	212	144	68
160kn	240kn	242	164	78
180kn	270kn	272	185	87
200kn	300kn	302	205	97
220kn	330kn	332	226	106

B. Welded Connection By Working Stress Method

Consider single angle section ISA 100×75×8mm and same loading applied on a angle as applied in LSM.

Min. size of weld=0.75×8=6mm

S=0.7×6×110=462N

Max length of end weld=2×31=62mm

Strength of end weld=62×462=28.64KN

Table III. Length of weld for ISA100×75×8mm by WSM

Load (KN)	P_1 (KN)	P_2 (KN)	L_w(mm)	L_1(mm)	L_2(mm)
140	63.16	76.83	303	137	166
160	69.36	90.63	346	150	196
180	75.56	104.43	389	163	226
200	81.76	118.23	433	177	256
220	87.96	132.03	476	190	286

Now change the thickness of plate 10 and consider a single angle section ISA 100×75×10mm.
t=0.75×10 = 7.5mm
S=0.7×7.5×410 = 577.5N.
Max length of end weld=2×31.9 = 68.1mm
Strength of end weld= 68.1×577.5 =36.84KN.

Table IV. Length of weld for ISA100×75×10mm by WSM

LOAD (KN)	P_1 (KN)	P_2 (KN)	L_w(mm)	L_1(mm)	L_2(mm)
140	69.75	70.25	243	121	122
160	76.13	83.87	277	132	145
180	82.51	97.49	312	143	169
200	88.89	111.11	346	154	192
220	95.27	124.73	381	165	216

The above table shows the variation of length of weld through LSM and WSM show for ISA 100×75×8mm and ISA 100×75×10 mm respectively.

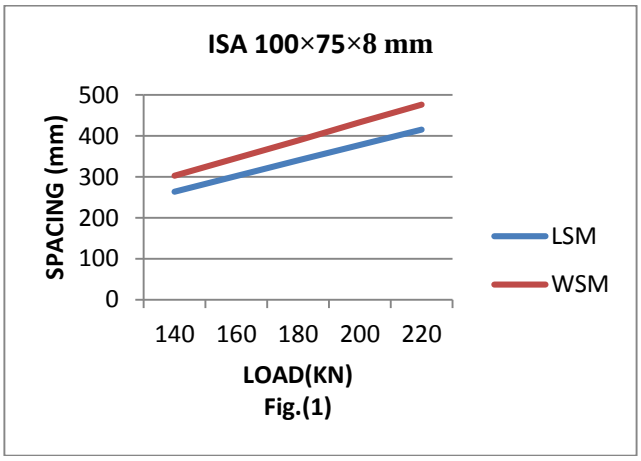

Fig I. Graph for Length of weld for varying loading

The above graph shows the variation in length of weld for single angle section by both LSM and WSM method.

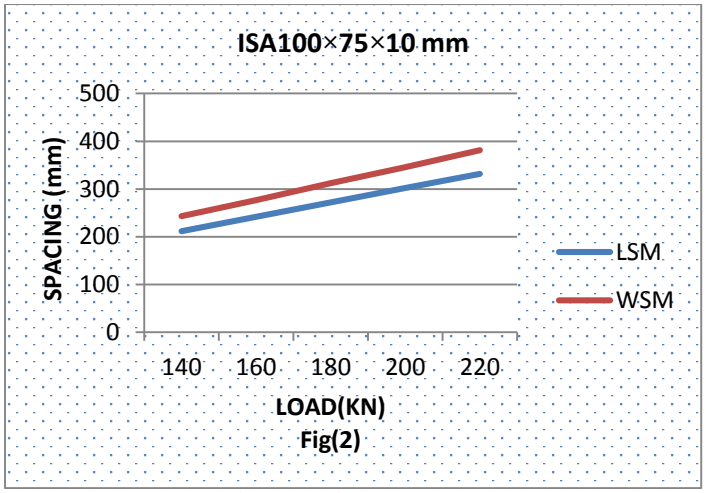

Fig II. Graph for length of weld at varying loading

The above graph represents variation in length of weld through LSM and WSM method for ISA 100×75×10mm angle section.

C. Bolted Connection By Lsm

Take dia of bolts is 16mm and 18mm and determine shearing and bearing capacity.

V_{npb} = 2.5dtfu
f_u = ultimate tensile stress of the bolt and the ultimate tensile stress of the plate
d = nominal diameter of the bolt
t =The thicknesses of the connected plates.
Set load interval 20 an dia 16mm and 18mm.

Calculation show by table.
d=16, bolt value=29, Kb=0.49
d=18, bolt value=36.67, Kb=0.41

Table IV. No of bolts at a varying loading condition by LSM

Load (KN)	D(mm)	No of bolt	Min pitch(mm)	Min edge distance(mm)
70	16	3	40	30
90	16	4	40	30
110	16	4	40	30
130	16	5	40	30
70	18	2	50	30
90	18	3	50	30
110	18	3	50	30
130	18	4	50	30

D. Bolted Connection By Wsm

Shear=100mpa, Bearing=300mpa,
Shearing capacity=Area×100Mpa
For 16mm, shearing capacity=60.31KN
For 18mm, shearing capacity=76.34KN
Bearing capacity=Area×300Mpa
For 16mm, bearing capacity=20.01KN
For 18mm, bearing capacity=25.44KN

Table V. No of bolts for varying loading by WSM

Load (KN)	Dia (mm)	No of bolts	Min pitch(mm)	Min edge distance(mm)
70	16	4	40	30
90	16	5	40	30
110	16	6	40	30
130	16	7	40	30
70	18	3	45	30
90	18	4	45	30
110	18	5	45	30
130	18	6	45	30

The above table shows the number of bolts at different loading condition for 16 diameter of bolt.

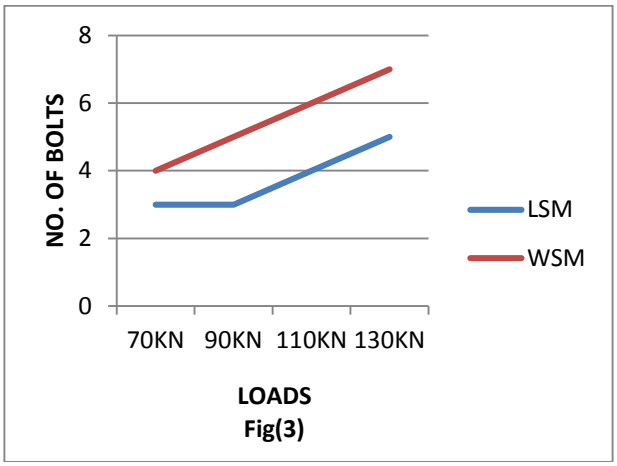

Fig III. No of bolts at varying loading for 16mm dia

This graph also shows the no of bolts at different loading condition for 18 diameters of bolts.

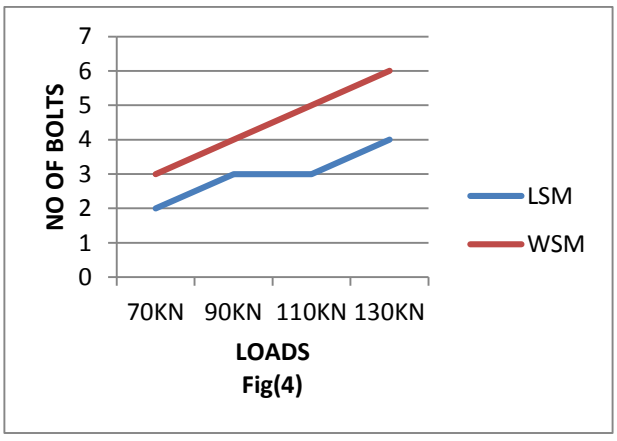

Fig IV. No of bolts at varying loading for 18mm dia

The Graph represents the value of shearing strength and bearing strength for different dia of bolt by LSM method

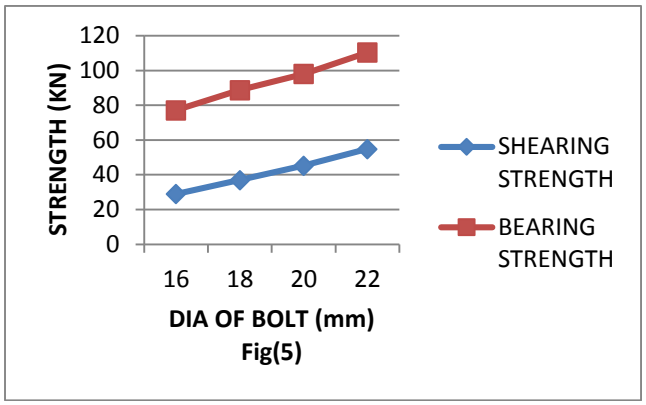

Fig V. Shearing and Bearing strength at varying dia by IS800:2007

The above graph represents the Bearing and Shearing strength at different dia of bolt by WSM method.

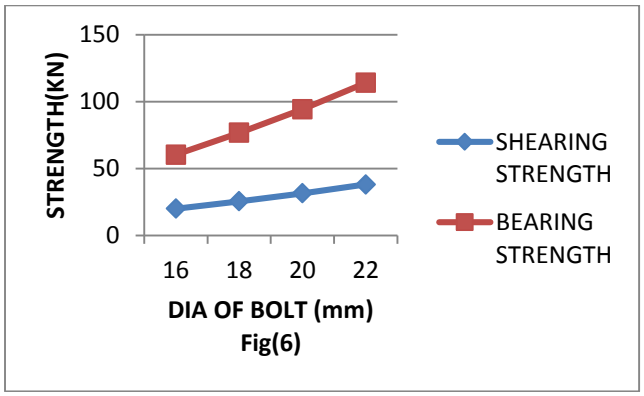

Fig VI. Shearing and Bearing strength at varying dia of bolt by IS800:1984

The above graph shows the strength variation in Bearing and Shearing strength with the suitable number of diameter of bolts.

VII. RESULTS

In this study we found the 30%variation in shearing strength of bolts for 16mm, 18mm,20mm diameter of bolts through both IS800:2007 and IS800:1984 codes. We found the variation in Bearing strength of bolts for 16mm, 18mm,20mm diameter of bolts is 21%, 13%, 3% respectively through analysis between IS800:2007 and IS800:1984 codes. The paper study shows that the bolted connections are 25% economical for 16mm dia of bolt and welded connections are 12% economical through IS800:2007 as compare to IS800:1984..

VIII. CONCLUSION

The process will be done and results show the variation in LSM and WSM both methods values. It means LSM is a more reliable and economical for steel structure as compare to WSM and fulfill criteria of serviceability.

REFERENCE

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