ISSN 2229-5518

Comparative study for shear design using IRC 112:2011 & IRC 21:2000

B.H.Solanki & Prof.M.D.Vakil

ABSTRACT

Current practice in world for shear design many various practice is going on, As Shear is more critical force than other actions on bridge's members ,new code IRC 112:2011 has improved in shear criteria compare to old IRC 21:2000.This paper presents shear strength, steel required for shear & shear resisting capacity of the member without shear reinforcement for LSM & WSM. Also this paper will shows which combinations of fy grade of steel & fck grade of concrete gives more shear strength so member requires minimum or no shear reinforcement.

KEY WORDS

VEd applied shear force, VRdc shear resisting without shear reinforcement, VRds shear resisting capacity with shear reinforcement.

INTRODUCTION

To design any member for shear, one has to derive shear force very accurately & model that member for shear so that it will act as assumed. IRC 112:2011 changes shear design procedure quite similar to old procedure but equations for each step changed. In old code IRC 21:2000 , shear resisting capacity of member is calculated with amount of longitudinal reinforcement & grade of concrete fck, than difference is check whether applied shear is more than without shear reinforcement or not if it is than it is provided for excessive shear force or if not required than minimum shear reinforcement is provided, but there is no clause for maximum shear reinforcement criteria. In IRC 112:2011 same procedure is followed but VRd,max that is shear strength of the member with shear reinforcement by allowing up to crushing of concrete are different for inclined & vertical type.For box & T section special provisions are given, in short compare to IRC 21:2000 new code IRC 112:2011 has improved a lot in shear design.

BASIS OF DESIGN

Following table shows some major changes in new code, Procedure adopted for calculation of shear steel are same but change in shear resistance are very large.

PARAMETER	IRC 21:2006	IRC 112:2011
Analysis	Not specified	Specified
Min steel Asw	same for both type inclined & vertical.	Different for inclined & vertical
Max. steel Asw,max	Not specified	Specified for both inclined & vertical.
Shear steel design for T-section flange	Not specified	Specified
Min steel depends on	Fy grade of steel only	Takes ratio of fy & fck

METHOD

Tha basic procedure in any reinforced concrete structure for shear is as follows,

1.Analyze structure & derive shear force for your members VkN

2. calculate shear resisting capacity of member with used grade of concrete fck & amount of longitudinal reinforcement. Vc kN

3.Check V-Vc,if it's >0 than provide shear reinforcement for that much shear force.

4.If it's <0 than section doesn't need any design shear reinforcement but provide minimum as per codal provision.

Based on above simple steps charts are carried out which shows shear comparison for WSM & LSM, i.e IRC 21 & IRC 112.

LIMIT STATE METHOD, IRC 112:2011

Equations used are,

1. Clause 10.3.2,page 88

$$VRdc = [0.12K(80 * \rho l * fck)^{0.33} + 0.15 * \sigma cp] * bw * d$$

2. Clause 10..3.3.2, page-90 for vertical shear reinforcement

$$VRds = Asw/s * z * fywd * \cot\theta$$

$$VRd,max = \alpha cw * bw * z * v1 * fcd/(\cot\theta + \tan\theta)$$

$$Asw,max * fywd/bw * s \le 0.5 * \alpha cw * v1 * fcd$$

3. Clause 10.3.3.3,page 91,for Inclined shear reinforcement.

$$VRds = Asw/s * z * fywd * (\cot\theta + \cot\alpha l)$$

$$VRd,max = \alpha cw * bw * z * v1 * fcd * (\cot\theta + \cot\alpha l)/(1 + \cot^2\theta)$$

$$Asw,max * fywd / bw * s \le 0.5 * \alpha cw * v1 * fcd / \sin\alpha l$$

4. Clause 10.3.3.5,page-95, Min. reinforcement ratio

$\rho_{min} = 0.072*\sqrt{fck} /fyk$

WORKING STRESS METHOD, IRC 21:2000

Different equations used for WSM are as follows, annexure a-4 of IRC 112 covers working stress method, it includes

a. Load & load combinations
b. Materials
c. General design requirements.
d. Basic permissible stresses.
e. Shear & torsion
f. Columns & compression members
g. Additional requirements for prestressed members.

Clauses below are used for shear design of the member.

1. Clause A4.6.1 (1), page-254

   $\tau v = V/b*d$

2. Clause A4.6.1 (4),page 257.

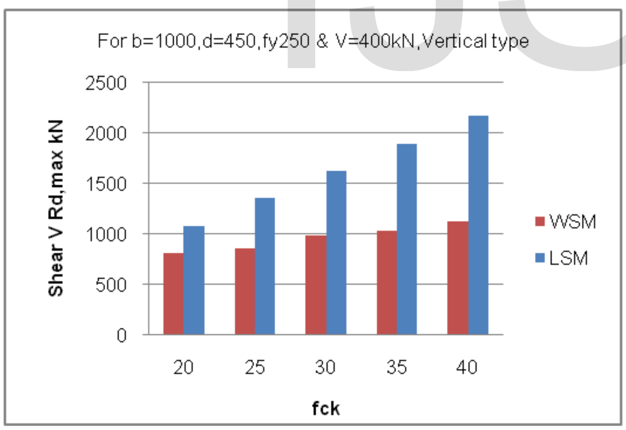
   $Vs = V - \tau c*b*d$

   $Asw = Vs*s/ (\sigma s*d*(\sin \alpha w + \cos \alpha w))$

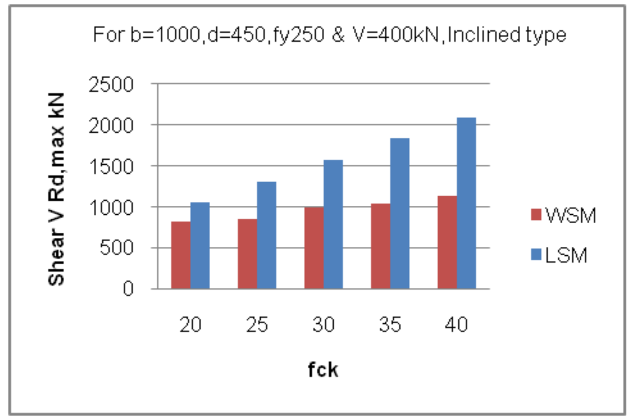
3. Clause A4.6.1 (5), page-258

   $Pw.min = Asw/b*s = 0.4/0.87*fy \leq 415$ MPa.

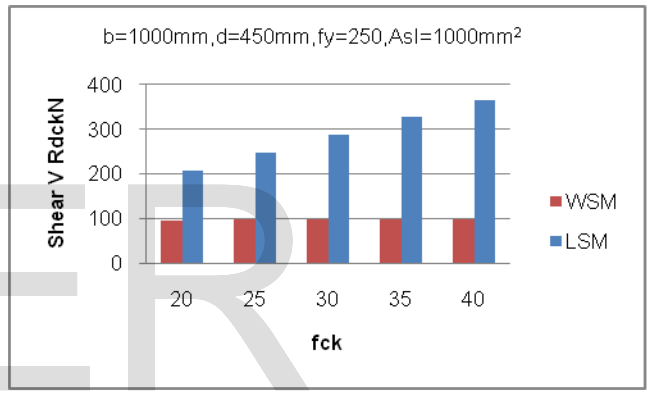
1. Chart shows difference of VRd,max for WSM & LSM,for vertical type shear reinforcement.



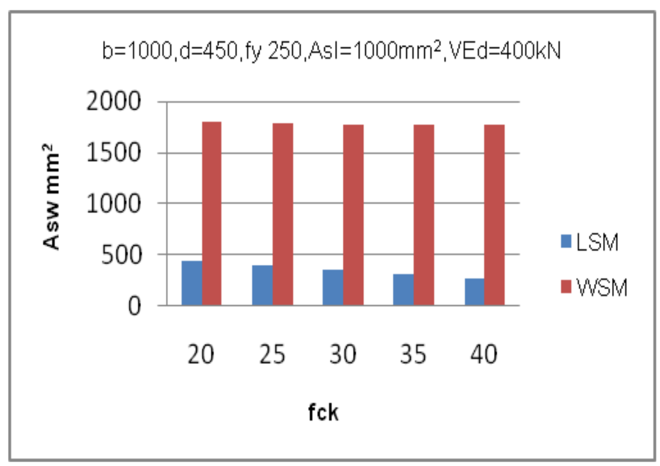
2. Chart shows difference of VRd,max for WSM & LSM,for Inclined type shear reinforcement.



3. Difference between WSM & LSM of VRdc for varying grade of concrete.

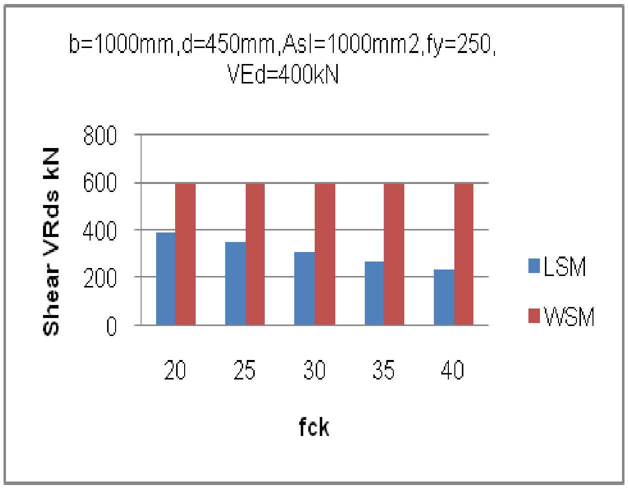


4. Chart for change in Required shear steel for WSM & LSM, for varying grade of concrete.

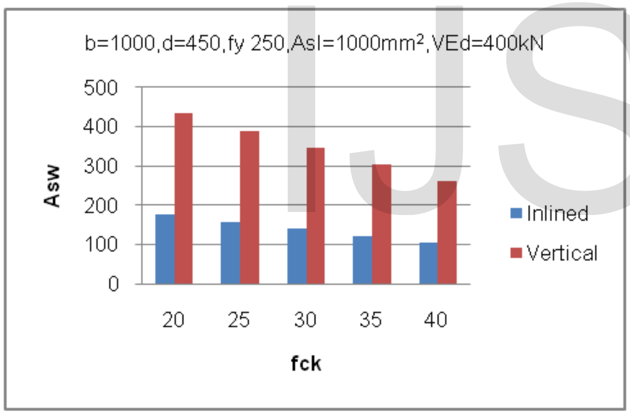


5. This chart shows the difference of VRds for varying grade of concrete for WSM & LSM.

ISSN 2229-5518



6. Change in Required shear steel for varying grade of concrete, for inclined & vertical type for LSM.



CONCLUSION

Based on above charts we can conclude,

1. By observing 1st & 2nd chart ,Ultimate shear resisting capacity of the member with shear reinforcement that is VRdmax is noticeably large compare to WSM, & It's constant as fck is increased in WSM but increases gradually in LSM by keeping all other parameters same.

2. In 3rd chart Shear resisting capacity of the member without shear reinforcement make large difference in LSM compare to WSM, for same cross section, longitudinal reinforcement, & grade of steel fy.

3. 4th & 5th charts shows that design shear force required for different grade of concrete are almost same in WSM but it's decreases as grade of concrete increases in LSM, as so difference between LSM & WSM for VRds design shear force for shear reinforcement is also considerably large. Very les Aws is required in LSM compare to WSM.

4. In 6th chart, Inclined reinforcement are more economic compare to vertical one about 50% in LSM,by keeping all other parameters same.

NOTATIONS

VRdc = Shear resistance of the section without shear reinforcement.

K = 1+√(200/d) ≤ 2.0 where dis effective depth in mm.

ρl = Asl/bw*d ≤ 0.02

where Asl is longitudinal reinforcement in mm2

σcp ≤ 0.2*fcd

bw = width of web in case of t-beam or width of section.

d = effective depth of the section.

VRds = VEd – VRdc = Design shear force.

VEd = Applied shear force.

Asw = design shear reinforcement mm2

S = assumed spacing of stirrups in mm

Z =lever arm=0.9*d

fywd = 0.8*fwk

fwk =yield strength of shear reinforcement.

θ = angle of compression strut

VRd,max = Ultimate shear resisting capacity of the member with shear Reinforcement

Asw,max = maximum shear reinforcement allowed.

fywd = 0.8*fywk

fywk = yield strength of shear reinforcement.

v1 = strength reduction factor for concrete cracked in shear.

= 0.6 for fck ≤ 80MPa.

= 0.9 – fck/250 > 0.5 for fck > 80MPa

fcd = design value of concrete compression strength.

αl = angle of shear reinforcement

αcw = coefficient depends on concrete compressive chord.which is taken 1 here.

ISSN 2229-5518

fck = grade of concrete

V = Applied shear force.

Vs = design shear force for shear reinforcement.

Ʈc = Shear stress resisting capacity of the section without shear reinforcement.

Asw = total cross sectional area of stirrup legs or bent up bars within α distance.

S = spacing of stirrups or bent-up bars along the length of the members.

b = breadth of the member which for flanged beams, shall be taken as the breadth of the web.

σ_s = permissible tensile stress in reinforcement.

αw = angle between the inclined stirrups or bent up bar and the axis of the member, not less than 45^0

Pw,min = Minimum reinforcement ratio.

AUTHORS

1. B.H.Solanki, L.D.College of engineering, Ahmadabad.

bhsolanki@gmail.com

2. Prof.M.D.Vakil,L.D.College of engineering, Ahmadabad.

merooldevarsh@gmail.com

REFERENCES

[1] Chris Hendy, Atkins, Epsom, UK,
Paul Jackson, Gifford, Southampton, UK
Colin George, Highways Agency, Bedford, UK
Steve Denton, Parsons Brinckerhoff, Bristol UK
"EN1992-2: PD 6687-2: RECOMMENDATIONS FOR THE DESIGN OF CONCRETE BRIDGES",
ICE Journals -2010.

[2] S Denton, Parsons Brinckerhoff, Bristol, UK
H Gulvanessian, Independent Consultant, London.
"*UNDERSTANDING KEY CONCEPTS OF EN1990"*
ICE Journals.-2011

[3] Paul Jackson, Gifford, Southampton, UK
Steve Denton, Parsons Brinckerhoff, Bristol, UK
Andrew Porter, Parsons Brinckerhoff, Bristol, UK
"*SPECIFICATION OF CONCRETE BRIDGES"*
ICE Journals.-2009

[4] Paul Jackson, Gifford, Southampton, UK
Graeme Walker, Gifford, Southampton, UK
"*DESIGN ILLUSTRATION – CONCRETE BRIDGE DESIGN"*
ICE Journals.-2010

[5] IRC 112:2011 CODE OF PRACTISE FOR CONCRETE ROAD BRIDGES.

[6] IRC 21:2000 STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR RCC ROAD BRIDGES

[7] IRC 6:2010 STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES.

[8] Limit state design of RCC Structures by P.C.Varghees

[9] Limit state design for RCC structures by A.K.Jain

[10] IS 456:2000 Code of practise for plain & Reinforced concrete.

[11] DESIGN AID SP:16 FOR IS 456:2000

[12] Bridge Engineering by S punnuswamy

[13] Design of Concrete bridges by M.G.Aswani & V.N.Vazirani

[14] Design of concrete structures by C.R.Hendy & D.A.Smith.