14 EVALUATION

14.3 NOTATION

a the length of end split, crack or check measured into the span from the centreline of the support to the tip of the split, mm.

A_v the area of transverse shear reinforcement perpendicular to the axis of a member within a distance *s*, mm^2.

s_{m1} Maximum allowable spacing below which the section is considered as having full transverse reinforcement, mm.

s_{m2} Maximum allowable spacing above which the section is considered as having no transverse reinforcement, mm.

The following revision is made to the notations:

R_f is changed to " R_f - factored resistance of the structural component, kN".

14.6 MATERIAL STRENGTHS

14.6.3 Strengths Based on Date of Construction

14.6.3.1 Structural Steel

Commentary: *Further information on steel grades may be found on the CISC website, specifically at the following URL:*

http://www.cisc-icca.ca/historical_steels.html

14.6.3.3 Reinforcing Steel

In Table 14.6.3.3, revise the Date of Bridge Construction as follows:

- 1914 – 1955 revised to 1914 – 1972
- 1956 – 1978 revised to 1973 – 1978

All other dates remain the same.

Commentary: *The Dates of Bridge Construction and the corresponding minimum yield strengths of reinforcing steel, fy, specified in S6-00 were erroneously based on the values given in 1983 Edition of OHBDC instead of those from the OHBDC 3rd Edition. The lower minimum yield strengths specified by OHBDC 3rd Edition are considered to be more representative of actual minimum yield strengths for reinforcing steel in wide scale use from 1956 to 1972.*

14.8 TRANSITORY LOADS

Evaluation loading shall be defined by the Ministry of Transportation on a project-specific basis.

Commentary: *Loadings that differ from the CL1-W loadings specified in Section 14.8 may be specified by the MoT on a project-to-project basis.*

14.8.1 NORMAL TRAFFIC

Truck axles and portions of uniformly distributed lane load that reduce the load effect shall be neglected.

14.8.2.3 Permit - Controlled (PC)

The weights and spacing of the axles shall be verified by measurement.

Commentary: *If the distribution of the load between the axles is statically determinate, the axle loads may be determined by measurements of the magnitudes and locations of the weights of the various vehicle components (payload, transporters, connection hardware, etc.) and subsequent computation of the axle loads using statics.*

If the vehicle is required to travel down the centreline of the bridge some transverse eccentricity of the vehicle should be assumed in the bridge load evaluation. A transverse eccentricity of between 300 and 600 mm may be appropriate depending on the type of transport equipment used.

14.11 TARGET RELIABILITY INDEX

If consented to by the Ministry, on low volume road bridges with AADT per lane of less than 500 and ADTT per lane of less than 100, the reliability index, β, used to determine the evaluation live load factors for Normal Traffic can be reduced by 0.25. However, the reduction in β should not be applied if the level of truck weight enforcement at the location is low and it is suspected that the number and size of overloaded vehicles is significantly higher than normal. No reduction is permissible for the reliability index used to determine evaluation dead load factors or permit vehicle live load factors.

Commentary: *The evaluation live load factors for Normal Traffic loadings contained in Section 14 are based on Highway Class A traffic volumes, ADT per lane of >4000 and ADTT per lane of >1000. Although the evaluation live load factors are relatively insensitive to variations in the ADTT, very large reductions in the ADTT can slightly reduce the required live load factors. The occurrence of an extremely heavy truck is less likely as the total number of trucks in the population decreases. For Normal Traffic, the reduction in the required live load factor for a reduction in the ADTT from >1000 to <100 is equivalent to a 0.25 reduction in the reliability index, β.*

Low volume roads may be subject to a lower level of truck weight enforcement which could encourage both a greater percentage of overloaded vehicles and higher levels of overload on the vehicles. Such conditions would counteract the benefits of having a low number of trucks operating on the route.

14.11.2 Element Behaviour

Commentary: *Steel in tension at net section shall remain in Category E1 but, for evaluations, the new resistance adjustment factor specified under Clause 14.13.2 of this Supplement shall be applied to the axial tensile resistances determined in accordance with Clauses 10.8.2(b) and 10.8.2(c).*

The axial tensile resistances for effective net sectional areas, A_{ne} and A'_{ne}, specified in Clause 10.8.2(b) and (c) contain a 0.85 reduction factor to account for the reduced warning of failure that may be provided if fracture occurs on the net section prior to yielding of the component on the gross section. The provisions of Clause 14.11.2 address the same issue by effectively increasing the factored loadings on components that provide little or no warning of failure.

The intent of both these provisions was to individually provide an additional margin of safety against this type of failure. Applying both of these provisions for evaluations results in the component being penalized twice for the same behaviour. To remove this double penalty, a new resistance adjustment factor has been developed to remove the reduction in the component resistance while maintaining the increased factored loadings. The new resistance adjustment factor is specified under Clause 14.13.2 of this document.

14.11.4 Important Structures

For structures that could affect the life safety of people under or near the bridge, or are essential to the local economy, or are designated as emergency-route bridges (as defined in Clause 4.4.2), a value of 0.25 greater than that given in Table 14.11(a) or 14.11(b) shall be used if so directed by the Ministry

Commentary: *Typically, unless a higher than normal level of reliability was a requirement during the original design of a bridge, the bridge should not be evaluated as an "Important Structure". However, a bridge could be classified as being an "Important Structure" if failure of the structure represents an unusually high level of risk to life, isolation of a community for an extended period of time or severe economic consequences.*

Risk to life is the basis for the levels of reliability specified for the evaluation of bridges and typically the reliability index, β, should only be increased when a very large number of people are at risk, such as on long span bridges.

However, in S6-00, the β for longer span bridges has been increased in a "hidden" way, since the lane loading given in Section 3 is considered to be somewhat conservative for longer spans.

Economic impacts resulting from the failure of a bridge are usually secondary to the risk to life issues. Therefore, a bridge should only be classified as an "Important Structure" for economic reasons if the type of bridge component failure being considered results in total closure of the bridge to traffic and no reasonable detour routes are available and it is impractical to restore at least temporary access in a reasonable timeframe (less than two weeks as a guideline).

When assessing whether or not a bridge should be classified as "Important", consideration should be given to the expected type and extent of damage to a bridge component resulting from an overload. If the damage can be quickly repaired or only results in a partial closure of the bridge to traffic, the bridge should not be considered as "Important".

Note that permit controlled (PC) loads are permitted to operate at a reduced reliability index, β, compared to other types of traffic, due to the reduced risk to life (driver of PC truck typically the only one at risk). However, on an economic basis, this corresponds to a higher probability of loss of use of the structure for PC vehicles than posed by other types of traffic. Therefore, MoT should give greater consideration to classifying a bridge as "Important" for PC vehicles than for other types of traffic.

14.13 RESISTANCE

14.13.1 General

14.13.1.2 Concrete Deck Slabs

14.13.1.2.2 Simplified Method

Revise the paragraph to read:

If all of the requirements (a) to (e) of Clause 14.13.1.2.1 are satisfied, the value of the Loss of Prestress, R_r, shall be taken from the following expression:

$R_r = Ø_{md} R_n$, where $Ø_{md} = 0.5$

14.13.1.5 Shear in Concrete Beams

Delete clause and replace with:

For evaluations concrete sections shall have their shear resistance calculated in accordance with Clause 8.9.3, except as modified in Clauses 14.13.1.5.1 and 14.13.1.5.2.

14.13.1.5.1 Transverse Reinforcement Area and Spacing

In lieu of Clauses 8.9.2.3 and Clause 8.14.6, the transverse reinforcement requirements shall apply as follows:

1. The section shall be considered to satisfy the minimum transverse reinforcement requirements if:

   a. $A_v \geq 0.15 f_{cr} \dfrac{(b_v s)}{f_y}$ and;

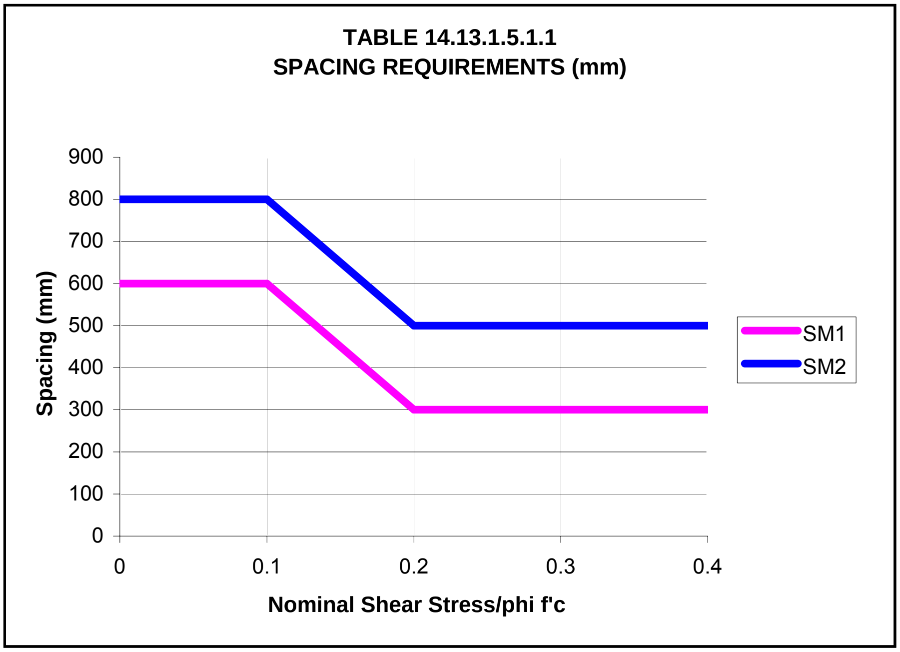
   b. the spacing of the transverse reinforcement is less than or equal to the smaller value of S_{m1} from Table 14.13.1.5.1.1 and 14.13.1.5.1.2.

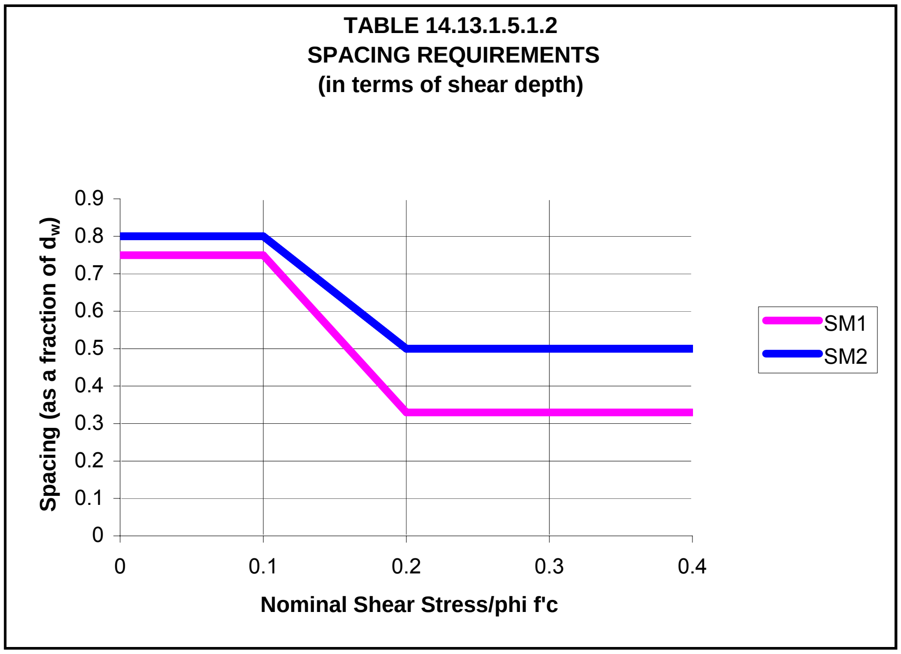
2. The section shall be considered to not satisfy the minimum transverse reinforcement requirements if:

   a. $A_v \leq 0.05 f_{cr} \dfrac{(b_v s)}{f_y}$ or;

   b. the spacing of the transverse reinforcement is greater than the smaller value S_{m2} obtained from Tables 14.13.1.5.1.1 and 14.13.1.5.1.2.

3. For values of transverse reinforcement area or spacing between the above limits specified in Items 1 and 2, linear interpolation shall be used.





Commentary: *The limits required for the application of the modified compression field theory are theoretically not as strict as those specified in Clauses 8.9.2.3 and 8.14.6. The minimum area of transverse reinforcement and the spacing limits from Clauses 8.9.2.3 and 8.14.6 are for the control of cracking. This methodology provides a gradual transition in the shear resistance for lightly reinforced members that are often encountered in evaluations.*

14.13.1.5.2 Proportioning of Transverse Reinforcement

For the purpose of evaluation, Clause 14.13.1.5.1 shall apply in lieu of Clause 8.9.3.9.

Provided that the cross section does not change abruptly within a length equal to the member depth, *h*, and the load is applied through the top face of the beam, the amount of transverse reinforcement, $A_v h/s$, may be taken as the total amount calculated within the length *h*. This length shall be measured from the section of interest towards the support.

14.13.1.6 Shear in Steel Plate Girders with Intermediate Transverse Stiffeners

Clauses 10.10.5 and 10.10.6 may be used to compute the shear resistance of steel plate girders with intermediate transverse stiffener plates on one side of the web if the width-to-thickness ratio of the plate does not exceed $400/\sqrt{F_y}$.

Commentary: *The maximum width-to-thickness ratio limit of* $200/\sqrt{F_y}$ *permitted in Clause 10.10.6 assumes uniform compressive stress across the full width of the stiffener. If intermediate transverse stiffener plates are installed on one side of the web only, the outer third of the stiffener resists tension and so the limiting width-to-thickness ratio may be markedly increased (Leitch and Bartlett 1998).*

14.13.1.7 Wood

14.13.1.7.1 Shear

The shear resistance in wood shall be taken from Clause 9.7 except that for members older than 5 years, the size effect factor from Clause 9.7.2 shall be replaced with:

$$k_{sv} = \frac{75}{45\sqrt{d}} \frac{1}{1+2a/d} V^{-0.18} \text{ but } k_{sv} \geq V^{-0.18}$$

Where:

d = member depth

a = the distance measured from the centreline of the support to the tip of the end split.

Where the split does not extend past the centreline of the support into the span, a shall be taken as 0.

Commentary: *The provision for a 5-year age of member ensures that any potential end splits or checks can develop. The shear resistance for evaluated wood members over 5 years old allows for a benefit if the actual presence and length of end splits or checks is measured. The benefit is about a factor of two (actually 1.67) since the design provisions assume a horizontal split does exist and that the resulting section is two half-depth sections. This provision is taken from the OHBDC 1991.*

14.13.1.7.2 Specified Strengths and Moduli of Elasticity

In lieu of Tables 9.11.2 (b) and 9.11.2 (c), the specified strengths and moduli of elasticity for beam and stringer, and post and timber grades shall be obtained from Tables 14.13.1.7.2 (b).

Revised Table 14.13.1.7.2 (b)
Specified Strengths and Moduli of Elasticity for
Beam and Stringer, and Post and Timber Grades, Mpa

Species Identification	Grade	Bending at Extreme Fibre	Longitudinal Shear	Compression		Tension Parallel to Grain	Modulus of Elasticity	
				Parallel to Grain	Perpendicular to Grain			
		f_{bu}	f_{vu}	f_{pu}	f_{qu}	f_{tu}	E_{50}	E_{05}
D.Fir – L	SS No. 1	24.0 20.0	1.1 1.1	16.5 9.0	4.7 4.7	13.0 9.0	11,000 9,500	7,500 6,500
Hem-Fir	SS No. 1	20.0 18.0	0.8 0.8	14.5 10.5	3.1 3.1	13.0 9.0	11,000 10,500	7,500 7,000
S-P-F	SS No. 1	18.5 13.0	1.0 1.0	14.5 10.5	3.6 3.6	13.0 9.0	10,000 9,000	7,000 6,000
Northern	SS No. 1	13.0 9.0	0.8 0.8	10.0 7.0	2.3 2.3	10.0 7.0	7,000 6,000	5,000 4,000

14.13.2 Resistance Adjustment Factors

Replace Table 14.13.2 with the following:

Table 14.13.2

Resistance Category	**Resistance Adjustment Factor, *U***
Structural Steel (ϕ per Clause 10.5.7)	
Plastic Moment	1.00
Yield Moment	1.06
Inelastic Lateral Torsional Buckling (LTB) Moment	1.04
Elastic LTB Moment	0.96
Compression or tension **on gross section**	1.01
Tension on net section	**1.18**
Shear (stocky web)	**1.02**
Shear (tension field)	**1.03**
Bolts	**1.20**
Welds	1.32
Rivets	1.81
Composite — Slab on Steel Girder (ϕ per Clauses 8.4.6 and 10.5.7)	
Bending Moment	0.96
Shear Connectors	0.94
Reinforced Concrete (ϕ per Clause 8.4.6)	
Bending Moment	
$\rho \le 0.4\rho_b$	**1.02**
$0.4\rho_b \le \rho \le 0.7\rho_b$	**0.95**
Axial Compression	**1.06**
Shear (> min. stirrups)	**1.05**
Prestressed Concrete (ϕ per Clause 8.4.6)	
Bending Moment	
$\omega_p \le 0.15$	1.01
$0.15 \le \omega_p \le 0.30$	0.94

Commentary: *Updated statistical information on the resistance of concrete components in shear was provided to the calibration committee subsequent to the calibration of these resistance adjustment factors. These statistics, d=1.15 and V=0.14, are included in Table CA.3.2 of the Calibration Report contained in Appendix A of the S6-00 Commentary. These statistics are considered to be appropriate for use in the derivation of resistance adjustment factors for both shear in cast-in-place and precast concrete when minimum transverse reinforcement requirements of the code are achieved.*

Replace Table C14.13.2 in the Commentary with the following:

Table C14.13.2
δ_R and V_R Values

Resistance Category	δ_R	V_R	Source
Structural Steel			
Plastic Moment	1.13	0.10	Kennedy & Baker (1984)
Yield Moment	1.22	0.10	**Kennedy & Baker (1984)**
Inelastic buckling Moment*	1.16	0.08	Kennedy & Baker (1984)
Elastic buckling Moment*	1.09	0.09	Kennedy & Baker (1984)
Compression	1.05	0.08	Kennedy & Baker (1984)**
Shear (stocky web)	**1.10**	**0.07**	Table CA.3.1
Shear (tension field)	**1.18**	**0.10**	Table CA.3.1
Bolts (tension)	**1.12**	**0.09**	Table CA.3.1
Bolts (shear)	**1.16**	**0.10**	Table CA.3.1
Welds (not base metal)	1.32	0.17	Fisher et al. (1978)
Rivets	1.50	0.11	**CSA (1988), Supplement No. 1**
Composite — Slab on			
Steel Girder	1.10	0.10	Kennedy & Baker (1984)
Bending Moment*			
Reinforced Concrete			
Bending Moment			
$\rho \le 0.4\rho_b$	1.04	0.08	Mirza & MacGregor (1982)
$0.4\rho_b \le \rho \le 0.7\rho_b$	**1.03**	0.12	Mirza & MacGregor (1982)
Axial Compression plus			
bending	**1.02**	0.11	Mirza & MacGregor (1982)**
(no slenderness)	**1.15**	0.14	Mirza & MacGregor (1982)**
Shear (> min. stirrups)			
Prestressed Concrete			
Prestressed beams in			
bending	1.06	0.05	Mirza & MacGregor (1982)**
$\omega_p \le 0.15$	1.06	0.09	Mirza & MacGregor (1982)**
$0.15 \le \omega_p \le 0.30$			

Notes:

* includes stiffened plate girder

** modified from the original reference by the Calibration Subcommittee to account for different resistance factors.

14.17 BRIDGE POSTING

14.17.1 General

Replace the third sentence of the first paragraph with the following:

Posting requirements for a bridge evaluated as being deficient shall be determined by the Ministry of Transportation's Regional Bridge Engineer.

Commentary: *MoT posting requirements and standards vary from those specified in Clause 14.17 of S6-00.*

14.18 FATIGUE

For fatigue in riveted connections, the stress Category "D" shall be used in determining the allowable range of stress in tension or reversal for base metal at the net section of riveted connections.

Commentary: *This category will be useful during the evaluation and rehabilitation of existing riveted bridge structures.*