AD 408:
Effective length of cantilevers

SCI has recently been contacted regarding the effective length of cantilevers and the effective length factors applied for destabilizing loads which are tabulated in Figure 3.2 of SCI publication P360[1]. The effective length factors were queried when compared with the factors tabulated in Table 14 of BS 5950-1[2]

This AD note demonstrates that the information given in P360 and BS 5950-1 are identical but presented differently.

In P360, a simplified formula for the non-dimensional slenderness of a doubly symmetric I-section beam, taken from NCCI SN002[3] is given as:

$$\bar{\lambda}_{LT} = \frac{1}{\sqrt{C_1}} UVD\bar{\lambda}_z\sqrt{\beta_w}$$

The effective length factor for destabilising load is parameter *D*. The minor axis non-dimensional slenderness $\bar{\lambda}_z = \lambda_z/\lambda_1$ and $\lambda_z = kL/i_z$ where *k* is an effective length parameter applied to the length of the beam *L* which takes different values depending on the restraint conditions. The remaining terms are defined in P360 Section 2.3. The combined effects of support conditions and destabilizing load are therefore allowed for in the product *kD*.

P360 Figure 3.2 repeats guidance given in NCCIs SN009[4] on the effects of common restraint conditions and destabilizing loads for cantilever beams. The restraint conditions identified are identical to those presented in Table 14 of BS 5950-1. This table (without diagrams) is repeated below. The values of the coefficients in the column for normal loading are the same as the corresponding *k* values in P360.

Restraint Conditions		Loading Conditions	
At support	At tip	Normal	Destabilizing
a) Continuous, with lateral restraint to top flange	1) Free	3.0*L*	7.5*L*
	2) Lateral restraint to top flange	2.7*L*	7.5*L*
	3) Torsional restraint	2.4*L*	4.5*L*
	4) Lateral and torsional restraint	2.1*L*	3.6*L*
b) Continuous, with partial torsional restraint	1) Free	2.0*L*	5.0*L*
	2) Lateral restraint to top flange	1.8*L*	5.0*L*
	3) Torsional restraint	1.6*L*	3.0*L*
	4) Lateral and torsional restraint	1.4*L*	2.4*L*
c) Continuous, with lateral and torsional restraint	1) Free	1.0*L*	2.5*L*
	2) Lateral restraint to top flange	0.9*L*	2.5*L*
	3) Torsional restraint	0.8*L*	1.5*L*
	4) Lateral and torsional restraint	0.7*L*	1.2*L*
d) Restrained laterally, torsionally and against rotation on plan	1) Free	0.8*L*	1.4*L*
	2) Lateral restraint to top flange	0.7*L*	1.4*L*
	3) Torsional restraint	0.6*L*	0.6*L*
	4) Lateral and torsional restraint	0.5*L*	0.5*L*

Table 14 Effective length L_E for cantilevers without intermediate restraint

If the values in the last column of the table below left (equivalent to *kDL*) are divided by the corresponding values in the third column (equivalent to *kL*), then the destabilising parameter *D* can be derived. The result of this exercise is presented below. An additional column giving the values of *D* from P360 is included in the table for comparison.

Restraint Conditions		Loading Conditions		
At support	At tip	Normal	Destabilizing	*D*
a) Continuous, with lateral restraint to top flange	1) Free	*3.0L*	2.50	2.5
	2) Lateral restraint to top flange	2.7L	2.78	2.8
	3) Torsional restraint	2.4L	1.88	1.9
	4) Lateral and torsional restraint	2.1L	1.71	1.7
b) Continuous, with partial torsional restraint	1) Free	2.0L	2.50	2.5
	2) Lateral restraint to top flange	1.8L	2.78	2.8
	3) Torsional restraint	1.6L	1.88	1.9
	4) Lateral and torsional restraint	1.4L	1.71	1.7
c) Continuous, with lateral and torsional restraint	1) Free	1.0L	2.50	2.5
	2) Lateral restraint to top flange	0.9L	2.78	2.8
	3) Torsional restraint	0.8L	1.88	1.9
	4) Lateral and torsional restraint	0.7L	1.71	1.7
d) Restrained laterally, torsionally and against rotation on plan	1) Free	0.8L	1.75	1.75
	2) Lateral restraint to top flange	0.7L	2.00	2.0
	3) Torsional restraint	0.6L	1.00	1.0
	4) Lateral and torsional restraint	0.5L	1.00	1.0

Effective length factors for cantilevers without intermediate restraint

It can immediately be seen that the effective length factors for destabilising load included in P360 are the BS 5950-1 values rounded to two significant figures except in one case where three significant figures are adopted and the values are identical.

In fact the effective lengths of cantilevers assumed in design to EC3 were adopted from those in BS 5950-1.

References

1 SCI P360 Stability of steel beams and columns (2011)
2 BS 5950-1:2000 Structural use of steel in building – Part 1
3 NCCI SN002 Determination of non-dimensional slenderness of I and H section (2005)
4 NCCI SN009 Effective lengths and destabilizing load parameters for beams and cantilevers – common cases (2005)

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