Nordic Lam Columns - Combined Loads

CHECKLIST: **Nordic Lam Columns - Combined Loads**

To verify that the tabulated resistances are appropriate for the structure being designed, the following questions should be asked (the appropriate modification factor is given in brackets):

1. Is load duration "standard" (K_D)?

K_D is a load duration factor. The tabulated resistances are based on a standard term load (K_D = 1.0), which includes the effects of dead loads plus live loads due to use and occupancy, and snow loads. For other load durations, the specified strength in compression parallel to grain, f_c, shall be multiplied by the appropriate factor permitted by the code.

2. Is the service condition "dry" (K_S)?

K_S is a service condition factor. The tabulated values are based on dry service conditions (K_S = 1.0). For wet service conditions, multiply the specified strength in compression parallel to grain by the following factor:

K_{Sc} = 0.75 for f_c

3. Is the material free of incising and/or strength-reducing chemicals (K_T)?

K_T is a treatment factor. The tables are based on untreated timber (K_T = 1.0). For glued-laminated timber treated with fire-retardant or other potentially strength-reducing chemicals, strength and stiffness capacities shall be based on documented results of tests that shall take into account the effects of time, temperature, and moisture content. For preservative treatment, the treatment factor for unincised glued-laminated timber may be taken as unity.

4. Is the effective length factor, K_e, equal to 1.0 and the effective column length in the direction of buckling equal to the total column length?

If the answer to any of these questions is no, the Column Selection Tables may not be used. Instead, calculate Pr from the formula given in CSA O86-09, Clause 6.5.12. Note that in certain cases the National Building Code of Canada permits a reduction in the loads due to use and occupancy depending upon the size of the tributary area (refer to Article 4.1.5.8 of the 2010 NBCC).

DESIGN

Members subjected to combined bending and axial compressive loads must be designed to satisfy the strength interaction equation, as follows:

$$(P_f/P_r)^2 + M_f/M_r\,[1 / (1-P_f/P_E)] \le 1{,}0$$

where:

P_f = factored compressive axial load
P_r = factored compressive load resistance parallel to grain (refer to the Column Selection Tables, Technical Note T-S07)
M_f = factored bending moment
M_r = factored bending moment resistance (refer to the Beam Selection Tables, Technical Note T-S05)
P_E = Euler buckling load in the plane of the applied moment

$$P_E = \pi^2\, 0{,}87\, E_S I / (K_e L)^2$$

where $E_S I$ is taken from the Beam Selection Tables (Technical Note T-S05), K_e is the effective length factor, and L the unsupported length in the direction of the applied bending moment.

When checking the interaction equation, the compressive resistance Pr is calculated as if only the compressive loads were present. Therefore, it is always based on buckling in the weakest direction.

Nordic Lam Columns - Combined Loads (continued)

ECCENTRICALLY LOADED COMPRESSION MEMBERS

When a load is not applied in the center of the vertical axis of a compression member, the eccentricity will create a moment. At the location where the load is applied (typically the top of the column), there is no deflection and therefore the moment does not need to be amplified. The interaction equation takes the following form:

$$(P_f/P_r)^2 + P_f e/M_r \leq 1{,}0$$

where:

e = load eccentricity, i.e. distance between the centre of the column and the centroid of the applied load

Midway between the location where the load is applied and the column support (typically mid-height of the column), the interaction equation takes the following form:

$$(P_f/P_r)^2 + 1/2\ P_f e/M_r\ [1/(1-P_f/P_E)] \leq 1{,}0$$

LATERAL RESTRAINT

In the case of members of rectangular section subjected to combined loads, the lateral stability factor, K_L, may be taken as unity when lateral support is provided at points of bearing to prevent lateral displacement and rotation, provided that the maximum depth-to-width ratio of the member does not exceed 4:1 if no additional intermediate support is provided, or, 5:1 if the member is held in line by purlins or tie rods (refer to CSA O86-09, Clause 5.5.4.2 for more details). Alternatively, K_L may be calculated in accordance with Clause 6.5.6.4 of CSA O86-09.

COLUMNS WITH SIDE BRACKETS

The 2012 NDS provides a design method that allows calculation of the actual bending stress if the eccentric load is applied by a bracket within the upper quarter of the length of the column, as follows. Assume that a bracket load, P, at a distance, e, from the center of the column, is replaced by the same load, P, centrally applied at the top of the column, plus a side (lateral) load, P_s, applied at midheight. Calculate P_s from the following formula:

$$P_s = 3P\ e\ L_p / L^2$$

where:

P_s = assumed horizontal side load placed at center of height of column, kN

P = actual load on bracket, kN

e = horizontal distance from load on bracket to center of column, mm

L_p = distance measured vertically from point of application of load on bracket to farther end of column, mm

L = total length of column, mm

The assumed centrally applied load, P, shall be added to other concentric column loads, and the calculated side load, P_s, shall be used to determine the actual bending stress for use in the formula for concentric end and side loading.