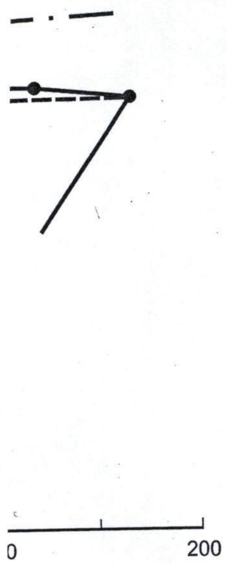

8.6(g) requires that, in
ı, the additional effects
. most cases the actual
mplete load-deflection
ıl. 1969). Methods are
frames, however, sim-

ınbraced or braced, are
he deformed structure
esisting frame, or addi-
ced frame. These addi-
gth of the structure, as
, bending moments and
sis, are produced at all
structures containing a
ame is linked to a shear

d 1989 editions, the de-
by (1) performing a sec-
es, or (2) accounting for
moments by the factor
e included in both of the

Computer programs are now commonly available to perform second-order elastic analyses based on equilibrium of the deformed structure. With these types of programs, the additional moments or forces generated by the vertical loads acting on the displaced structure (the so-called $P\Delta$ effect) are taken into account directly and this method of analysis is the preferred method in Clause 8.7.1. In addition, most second-order programs also account for the reduction in column stiffnesses, caused by their axial loads (Galambos 1968).

The second approach in Clause 8.7.1 is simply to amplify the results of a first-order analysis to include the PΔ effects. With this "amplification factor method", it is necessary to do two first-order analyses, one for gravity loading and the other for translational loading. From the horizontal displacements produced by the factored lateral loads, the amplification factor U_2 may be established. The factored moments or forces, including the effects of side-sway, may then be computed from:

$$M_f = M_{fg} + U_2 M_{ft} \text{ or from } T_f = T_{fg} + U_2 T_{ft}$$

where $U_2 = \dfrac{1}{1 - \dfrac{\sum C_f \Delta_f}{\sum V_f h}}$

It is noted that the 2001 Standard no longer requires an upper limit of 1.4 on the amplification factor U_2. The justification for removing the 1.4 limit is that, when notional loads are applied to all load combinations, the strength predictions for beam-columns compare well with the results of "exact" plastic zone finite element analyses. Nevertheless the designer is cautioned against designing structures that have excessive lateral deformations not only for the ultimate limit state of stability but also for serviceability considerations.

8.7.2 The concept of notional lateral loads is an internationally recognized technique for transforming a sway buckling problem into a bending strength problem. It accounts for the effect of initial imperfections in the columns and for partial yielding at factored load levels. Following the recommendation of Kennedy (1995), the notional load, in S16-01, is now applied to all design load combinations. Thus, the factored lateral force to be used in establishing the value of Δ at the various levels of the building is the summation of the applied lateral force and the notional load and the horizontal reaction to prevent sway from gravity loads. In contrast, in the 1994 Standard, the Δ values were computed only from summation of the notional load and the horizontal reaction from gravity loads.

In Clause 8.7.2, the magnitude of the notional lateral load is the same value as that in the 1994 Standard, viz. 0.005 times the sum of the factored loads contributed by that storey. While there is variation in international standards regarding the magnitude of the notional load coefficient, Clarke and Bridge (1992, 1995) have shown that 0.005ΣP, established conservatively for a flagpole column (Kennedy *et al.* 1990b), is an appropriate value to give adequate prediction of strengths in comparison with "exact" plastic zone analyses. There may be, as stated above, some conservatism in applying this magnitude of notional load to all load combinations in buildings where double-curvature bending of the columns predominates.

The use of the notional lateral load performs several important functions. First, it transforms the bifurcation problem of sway buckling into a bending strength problem. Thus it is applied to all load combinations when the potential for sway buckling exists. Second, because it accounts for the $P\Delta$ moments directly, the use of effective length factors greater than one are obviated and its use allows effective lengths equal to the actual length to be used. At best the effective lengths used for sway buckling analyses are based on elastic analyses that are not appropriate for use with beam-column interaction equations that take into account inelastic material behaviour. Third, when equilibrium is formulated including the notional loads, the girders and beams restraining the columns are designed for the increased $P\Delta$ moments that must exist in them for equilibrium just as the columns are. The use of effective lengths only accounts for increased moments in the columns and then only in an approximate manner with assumed elastic behaviour. Thus although there may be some slight conservatism in using a notional