Space Gass – Using the Buckling Analysis to Find Effective Buckling Length
The buckling analysis increases the loads until the frame becomes unstable (i.e. until buckling occurs). At this point, the factor by which the loads have been increased is known as the buckling load factor (BLF). For a satisfactory frame, BLF > SF x 1.0, where SF is a suitable safety factor.

The axial force in each member (Pcr) at the point of frame buckling is then calculated from Pcr = BLF x P, where P is the axial force in the member before the loads are increased.

The effective length for each member can then be calculated from Lc by rearranging the Euler buckling formula:

$$P\_{cr}=\frac{π^{2}EI}{L\_{c}^{2}}\rightarrow L\_{c}=π\sqrt{\frac{EI}{P\_{cr}}}$$

Put simply, the effective length of a member is the length of an equivalent pin-ended strut that has an Euler buckling capacity equal to the axial force in the member at the point of frame buckling.

This highlights the fact that the portion of the frame that buckles first determines the BLF and, consequently, controls the effective lengths of all the members in the frame. The buckled portion of the frame may just involve one or two members and may be remote from many of the members that are having their effective lengths controlled by it.

For example, the buckling collapse of the left-hand column of a portal frame due to a heavy load applied to it can control the effective length of the right-hand column which has no such load applied. Consequently, each column would have a different effective length.

It would be ideal if the buckling analysis could increase the BLF beyond the first buckling mode so that the effective length for each member could be based on a buckling mode that involved that member. Unfortunately, this is not often possible because once the frame has reached its first buckling mode, it has generally collapsed and cannot resist any increase in load.

However, if the first buckling mode involves only minor members such as bracing or similar, rather than a collapse of the frame, it may be possible to continue the buckling analysis to a higher-order buckling mode in order to get more realistic effective lengths.

You can see from the above discussion that members which are lightly loaded at the point of frame buckling will get a longer effective length because of their small Pcr (see the equation above). In some cases, this may result in conservative designs, however, there are a few factors that can help as follows:

1. Members that have long effective lengths are generally lightly loaded axially, and these two effects tend to cancel each other out during the design phase.
2. For codes such as AS4100 that don't require it, turn off the slenderness ratio check at the start of the design phase. This is often very effective because, in the slenderness ratio check, a long effective length does not benefit from being canceled out by a small axial force.
3. For sway members, you can limit the effective lengths to a multiple of the actual member length by entering a factor into the "compression effective length ratio limit" field at the start of the design phase. In fact, effective length charts in most design codes limit the effective lengths for sway members to not more than 5.0 times the actual member length.
4. For braced members, you can simply specify them as "braced" in the steel member design data for the direction(s) in which they are braced. This will limit the effective lengths from the buckling analysis to the actual member length.