- 2nd order analysis (such as an iterative 2nd order analysis or amplified 1st order analysis), including both P-Δ and P-δ
- Notional loads
- Reduced flexural and axial stiffness

3.2.1.2 2nd Order Analysis

To account for the P-Δ effects, the user has the option of either performing a p-delta analysis based on the geometric stiffness method (see the section entitled "P-Delta Effects" in the Technical Notes chapter in the RAM Frame Analysis manual) or by specifying that the B2 factor be calculated and applied (amplified 1st order analysis).

To account for the P-δ effects the user should specify that the B1 factor be calculated and applied (amplified 1st order analysis).

The advantage to these methods (geometric stiffness and amplified 1st order analysis) is that they do not require an iterative analysis and allow the analysis of individual load cases, with the results combined in the load combinations (the principle of superposition can be used).

2nd Order Analysis by Geometric Stiffness Method

In **Criteria – General** in RAM Frame Analysis mode there is an option to perform a P-delta analysis. This analysis employs the geometric stiffness method. The masses used in this analysis are those assigned as part of the floor and roof loads, and self-weight if that option was selected. The mass values are listed in the **Loads – Masses** command in RAM Frame Analysis mode. Those masses are also used in the calculation of building periods and modes and for the generation of seismic story forces. Therefore, those values generally only include the masses associated with Dead Loads. In order to perform an appropriate P-delta analysis the effects of Live Load should be included, therefore a P-delta Factor should be specified such that the factored Mass values are approximately equivalent to the combined Dead and Live Loads. Furthermore, in order for the principle of superposition to be valid, the P-delta effects should be determined at an ultimate value of loads. Thus the P-delta Factor should be additionally increased to account for the load factors.

For example, assume that the Dead Load and Live Load are approximately equal; this means that the Mass value should be factored by 2 for the P-delta analysis in order to account for the effects of both the Dead and Live Load. For LRFD the mass should be further factored by the load combination factors, which for the most conservative combination is 1.2 on both the Dead Load and 1.6 on the Live Load, for an average in this example of 1.4 (note that if the Live Load is greater than the Dead Load, this value should be greater than 1.4, if the Live Load is less than the Dead Load, this value could be less than 1.4). Thus the P-delta factor that should be specified is (1.4)(2.0) = 2.8 For ASD the mass should be similarly factored (1.0 would not be appropriate, 1.6 has been conservatively recommended, hence the P-delta Factor would be (1.6)(2.0) = 3.2). These factors can be refined as appropriate.

An additional benefit of utilizing the P-delta analysis as described is that the effects of "leaning" columns (e.g., the gravity columns that are leaning on the frames for lateral stability) are automatically accounted for.

2nd Order Analysis by Amplified 1st Order Analysis

The requirement to perform a second-order analysis is satisfied by performing a first-order analysis and calculating and applying B_1 and B_2 factors to the design forces as outlined in Section C2.1b of the