This month’s Steel Quiz takes a look at approximate second-order analysis as covered in Appendix 8 of the AISC Specification (www.aisc.org/2010spec).

1 The displacement indicated by dimension #____ in Figure 1 results in a P-Δ effect and the displacement indicated by dimension #_____ results in a P-δ effect.

2 Equation (A-8-1) from the AISC Specification is shown below (Question 4). \( M_{nt} \) corresponds to the moments shown in Figure ____ and \( M_{lt} \) corresponds to the moments in Figure _____. (Choose between Figures 2 and 3.)

3 True or False: Gravity loads do not generate sidesway reaction forces.

4 In Equations (A-8-1) and (A-8-2) shown below, the \( B_1 \) multiplier account for ______ effects and the \( B_2 \) multiplier account for ______ effects (choose between P-Δ and P-δ).

\[
M_r = B_1 M_{nt} + B_2 M_{lt} \quad (A-8-1)
\]
\[
P_r = P_{nt} + B_2 P_{lt} \quad (A-8-2)
\]

5 True or False: The \( B_1 \) multiplier should be taken as 1.0 for members that are not subject to compression.

6 True or False: When using the direct analysis method and calculating \( B_2 \), the first-order inter-story drift, \( \Delta_{sw} \), in Equation (A-8-7) should be determined based on an analysis using reduced stiffness as covered in Section C2.3.

\[
P_{\text{e,story}} = R_m \frac{HL}{\Delta_H} \quad (A-8-7)
\]
1. Dimension #1 results in a $P$-$\Delta$ effect and Dimension #2 results in a $P$-$\delta$ effect. $P$-$\Delta$ effects are the effects of loads acting on the displaced location of joints or nodes in a structure. $P$-$\delta$ effects are the effects of loads acting on the deflected shape of a member between joints or nodes.

2. Figure 3, Figure 2. The moments in Figure 3 correspond with $M_{nt}$, the first-order moment with the structure restrained against lateral translation. The moments in Figure 2 correspond with $M_{l}$, the first-order moment due to lateral translation of the structure only. For structures where gravity load causes negligible lateral translation, $P_{n}$ and $M_{n}$ are the effects of gravity load and $P_{l}$ and $M_{l}$ are the effects of lateral load.

3. False. Sidesway can occur under gravity loads, and ignoring this in sensitive structures can lead to significant errors in the second-order moments. This is especially true for frames with unsymmetrical framing and/or loading.

4. $P$-$\delta$, $P$-$\Delta$. The $B_1$ multiplier is used to account for $P$-$\delta$ effects. The $B_2$ multiplier is used to account for $P$-$\Delta$ effects.

5. True. This is stated in Section 8.2 of the AISC Specification.

6. True. Section 8.2.2 in the AISC Specification states that the first-order inter-story drift, $\Delta_{nt}$, is "computed using the stiffness required to be used in the analysis (stiffness reduced as provided in Section C2.3 when the direct analysis method is used)."