Swaying Your Thoughts On Structural Engineering

By: Brian Skelcher, DTC Structural Engineer

If you're standing at the bottom of a skyscraper, looking up you might be in awe of its towering size and apparent immobility. However, if you take a trip to the top floor and have a sensitivity to motion sickness, you might start to curse the building's secret ability to sway back and forth. Everyone knows the purpose of structural engineering is to prevent a structure from collapsing. What most people don't know is that a structural engineer is also responsible for making sure the structure is serviceable, or useable, and that usually this requirement controls the final design.

To prevent the collapse of a building, the structural engineer must first analyze and design the structural elements for strength. Design based on strength ensures that structural elements will not break and the building will remain standing during construction, occupancy, strong winds, heavy snow, and earthquakes. Although the building and its elements will not break, they will move, bend, flex, and sway, all commonly referred to as deflections. The structural engineer's next job is to assess these deflections for how they will impact the building's serviceability. Excessive deflections can cause problems with a building's employees or residents and with collisions between structural elements and architectural or mechanical features.

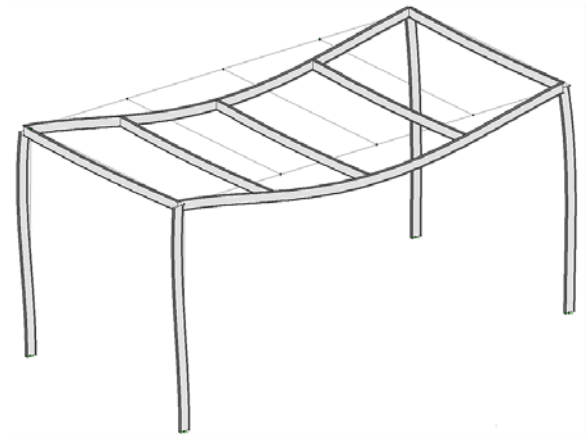

Figure 1: Exaggerated deflection of structural elements.

Employee and Resident Perception

Using the above mentioned skyscraper as an example, if we design for strength alone, then the building would deflect several feet in each direction on a windy day. While this design would be safe from a strength standpoint, the employees or residents would be subjected to an uneasy feeling of swaying back and forth. By imposing a serviceability limit for maximum deflection we end up using stiffer building elements and surpassing the strength requirements to meet the deflection requirements, thus limiting the amount of sway and the perceived negative impact on the end user.

Another form of discomfort users feel is floor vibrations as their colleagues walk by. Someone might feel the floor "bouncing" and believe they are in danger of the floor collapsing. While the strength of the structural elements may be adequate to prevent floor collapse, a serviceability limit ensures the stiffness of the structural elements is enough to keep any vibrations below the perception threshold. In essence, we are designing not only with the safety of others in mind, but also for comfort.

Collisions with Architectural & Mechanical Features

Many architectural features are either directly or indirectly connected to the structural elements of a building. While structural elements, such as steel beams, may be able to deflect several inches without breaking, architectural features connected to these elements, such as brick and glass, can't. This means if buildings were only designed for strength, their brick veneers would crumble and their glass windows would shatter. Again, in

this situation, it is important to impose a serviceability limit on the deflection of the structural elements so that they will not overstress any architectural features.

The same holds true for structural elements colliding with mechanical features. An efficient building design requires every spare inch of building space to be put to use. This means, hidden between the ceiling and floor, structural beams need to cohabitate with mechanical ducts, pipes, conduits, etc. By limiting the deflection of structural elements, we can place mechanical features closer to the underside of steel beams, and minimize ceiling space between floors.

Conclusion

If you find yourself admiring a skyscraper, or any building for that matter, take a minute to think about all the structural considerations that went in to its design. At first glance it might seem to just be standing there, fighting the constant pull of gravity or resisting stormy weather and seismic events. However, it's also serving the employees or residents that occupy it every day and protecting the architectural and mechanical features that make it fashionable and functional. Design for strength is first and foremost but design for serviceability is what makes a structure useable.