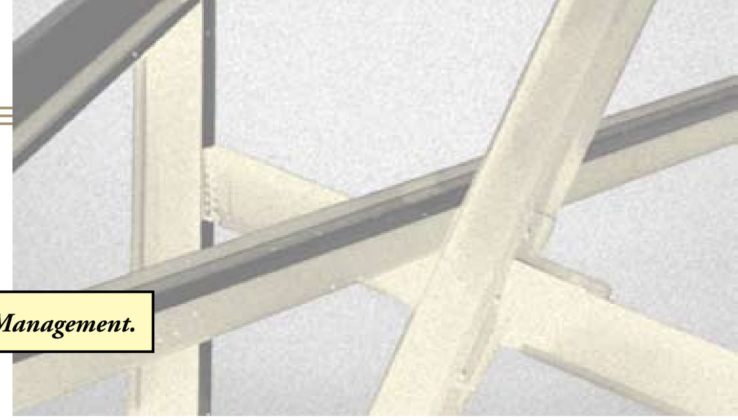

The Beams Are Too Bouncy?

By James C. Parker, P.E.

This article is part of a series related to the CASE Foundations for Risk Management.

If you practice structural engineering long enough, you will likely find your firm embroiled in a situation of controversy sooner or later. You may even be blamed as causing the problem. Our experience suggests when this happens, it's best to: 1) objectively evaluate what happened and your role; 2) get involved with finding the solutions; and 3) follow-through to close out the project. The following story describes one situation where these steps proved to be a reasonable course of action.

A firm was the structural engineer for a two-story commercial building in a prominent urban neighborhood. The design had undergone significant neighborhood scrutiny throughout the project approval process, especially the two street-facing facades. The final design included precast panels that emulated a formal cut stone bearing wall structure that was to meet the neighborhood's aesthetic requirements while staying within the developer's budget.

The structure was relatively simple and straight-forward: shallow foundations, braced steel frame, ground floor slab-on-grade, composite metal deck and steel beams for the second floor, and steel bar joists and metal roof deck for the roof framing. The precast panels were to bear on the foundation wall and stack, relying on the steel frame for lateral stability only, and were to include a four-foot-high parapet. The parapet panels spanned over large window openings, bearing on panels below and achieving lateral stability in part from steel posts that projected from the roof framing behind them. Initially, the steel posts were extensions of the columns. However as the final panel layout design became available and the joint layout dictated additional out-of-plane support points, posts were added off the spandrels as well. Kickers from the bottom flange of the spandrel beam to the underside of the roof framing provided rotational restraint of the spandrel at each of these posts within the spans.

The client was the developer and owner of the property, had a long-standing relationship with the tenant of the property, and understood the tenant's standards and requirements for a long-term lease. The Firm frequently worked with this owner/developer for this tenant, along with the same architect and general contractor. These relationships were based on all parties' abilities to quickly respond to the tenant's dynamic needs.

All parties knew the process: start fast and work in parallel with the neighborhood approvals committee and tenant to meet their different requirements. Fast-track the structure, knowing many changes would occur due to local market conditions, the tenant's emerging requirements, and the developer's desires to pursue all value engineering opportunities no matter when in the process they were identified.

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First, the moment frames were revised to braced frames to reduce the steel weight, since structural steel costs were at a relative peak. Then, after the steel structure was released for fabrication and the foundations were under construction, the tenant demanded removal of a column to generate a covered loading dock within the footprint of the building. The client directed the Firm to use as much of the steel framing that was already detailed, if not fabricated, and to incorporate W40 sections the contractor could source on short notice.

The Firm also was directed to redesign the roof framing, as the contractor wanted the roofing to be installed as quickly as possible. Now, the steel spandrels at the roof would support the precast parapets instead of the parapets stacking on the lower precast panels. The parapet panels would run by the roof spandrel, extending below the spandrel by about a foot and above it by about four feet. Brackets from the top of the spandrel beams would support the panel weight, and out-of-plane anchors at the top of the steel posts would resolve the eccentricity. The spandrel beams were checked for flexural strength and stiffness. The kicker system was checked for the wind loads on the parapet and it was determined that the system had the strength for the additional demand from the eccentric load on the spandrel beams.

The Firm thought it had successfully managed all the changes until an urgent call came from the site. The erector had set the first precast parapet panel and then ceased erecting because "the beams are too bouncy." The erector had cable-stayed the first panel and sent the other pieces back, as there was no space for storing the precast pieces on the congested urban site. True to form, the client was pushing for a retrofit design and already suggesting that the Firm notify their insurance carrier, as this delay was "costing a fortune."

The Firm's principal-in-charge and the project manager drove to the site immediately. Simultaneously, the team double-checked the design of the spandrel beam. Upon arriving at the site, it was discovered that the issue was not deflection of the spandrel beam as originally thought. Instead, the issue was one could stand behind the parapet at the roof and get the parapet to sway back-and-forth out of plane a couple of inches by pushing laterally at its top in a rhythmic fashion. The kickers were installed as designed; however, it became obvious the geometry of the kickers was such that even the slightest flexibility of the metal deck and bar joists allowed rotation of the spandrel beam-kicker assembly and lateral displacement at the top of the parapet.

Double-checking of the design calculations confirmed the designs of the spandrel beams and kicker assemblies met strength and Code requirements. The calculations had checked all the components that resisted the vertical reaction from the kicker. However, the Firm had not looked closely at the deflection since the vertical reactions were very small compared to the roof design loads. The geometry was such that the observations at the site could be explained from very small roof framing deflections. The Firm knew the clock was ticking and this was going to be an issue of confidence. They briefly debated, internally, the necessity of doing any retrofit but ultimately proposed to stiffen the system. The Firm explained to the owner their findings of safety, and since they identified a concept to stiffen expeditiously, it was recommended to proceed with a retrofit. The Firm admitted that, although code conforming, they would have designed it differently had they predicted the flexibility and apologized on site that the design had alarmed the erectors.

The owner chose to submit the Firm's findings for peer review to another local engineering firm and the Firm agreed this was understandable. The peer reviewer supported the findings and recommendations.

In addition, the Firm worked with the general contractor to source material that was readily available and that could be incorporated into the retrofit. They went to the site daily to expedite changes through the approval process and to monitor progress. They assisted with requests for information and requests for substitutions/field modifications to facilitate installation and field welding of the new parts. The retrofit was in place within two weeks from the cessation of erection.

The Firm continued to the site for daily progress meetings after the retrofit installation. They wanted to observe the precast panel installation first-hand. Precast parapet panels did not show up at the site immediately. Apparently, the detailing process did not keep up with the final changes to the panel layouts and the locations of the inserts were not accurately coordinated with the locations of the steel posts. More time was needed to re-fabricate concrete panels. It was only by being very involved and at the site every day, that the Firm learned that "their" flexible supports were not the sole cause of the erector ceasing erection!

In the end, there were no lawsuits or claims. The Firm absorbed a significant amount of engineering hours – on the order of 33 percent more than the original project budget. However, by following the three steps – objectively assess the situation, help find the solution, and follow-though with the project – the client still has confidence in the Firms and they have since worked with that client on several other projects.▪

Case Foundations for Risk Management

1) **Culture:** create a culture of managing risk and preventing claims.
2) **Prevention and Proactivity:** act with preventative techniques, don't just react.
3) **Planning:** plan to be claims free.
4) **Communication:** communicate to match expectations with perceptions.
5) **Education:** educate all of the players.
6) **Scope:** develop and manage a clearly defined scope of services.
7) **Compensation:** prepare and negotiate fee that allow for quality and profit.
8) **Contracts:** negotiate clear and fair agreements.
9) **Contract Documents:** produce quality contract documents.
10) **Construction Phase:**provide services to complete the risk management process.

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