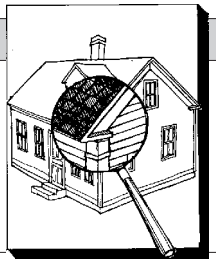

When a Structure 'Hurts,' It Tells You

by Raymond A. DiPasquale

Just as the skeletal frame of the human body supports our flesh, so does the structural frame of a building make possible the physical expression we know as architecture. In all living and man-made things, there is a structure, and there is no question of its importance in the grand scheme of the universe.

Our buildings always start with a hole in the ground. But they soon soar upward with the "sticks" that give them shape and purpose. These "sticks" are the focus of our discussion this month.

Structurally, the most critical time in the early life of a new building is when the framing is being erected. At this point there usually is no "skin" to keep the framing in place, so *it is only through the temporary bracing and guying procedures employed by the contractor* that the framing remains a stable network as it grows.

Because structural judgments about stability are made by the person in the field, the contractor has a tremendous responsibility. The contractor cannot look to the design professional for advice on bracing matters, because the means and methods of construction are the obligations of the builder.

Most builders review and plan the erection and bracing procedures in advance, but we all know that in the rush to complete the project or finish off the day's work without overtime, good practices sometimes are overlooked.

When the professional initially designs the framing members, the assumption is made that the members are laterally stable; in other words, the designer views the structural member in its final position rather than through the many stages of its life. The contractor then has to "fill in the gaps" and take the responsibility for the safety of the structural element from the truck to the final position in the completed building.

Stability and overstressing become the critical issues for the contractor to consider. If these matters are not considered seriously, failures are likely to result.

A Mini Case Study

The Problem: Steel joists were being erected for the roof of an industrial building. The span was 45 feet, the joist spacing was six feet, and bridging was light angle "x" type. The roof deck was 1½' metal, type B.

The problem was created when the metal decking was stacked in bundles on top of the joists before any or all of the joist bridging was in place. It was a Friday afternoon, and the erection crew was anxious to get the deck unloaded from the trucks before they left for the weekend.

They didn't want to temporarily store the deck on the ground first—it would have meant handling it twice—so they stacked it on the joists even though the joists had not been completely erected. In addition, the erection crew did not secure the structure at the end of the day.

When the crew returned to work on Monday morning, they found the deck scattered on the ground, twisted roof joists (some of them hanging vertically from one support) and columns deflected inward with the anchor bolts pulled out of their foundations.

The Cause: During the weekend, high winds acting on the stacks of roof deck created lateral loads on the joists, which had no support in the direction perpendicular to their weak axis *(i.e.,* normal to the joist depth). The joists buckled laterally, rolled, and came off their bearing seat. The beams supporting the joists also deformed laterally in chain-reaction fashion, pulling the columns over with them. The photograph depicts the condition.

Twisted joists on the job site: a lousy way to start the week.

photo by Raymond diPasquale

The Lessons: Structural members, whether steel or wood, fail by overstress in bending or shear (or a combination of both), by lateral instability, or by excessive deflection.

During erection—and before they are finally in place with other members or deck attached to them—they generally fail by lateral instability. Construction loads can cause overstress when heavy materials like masonry are stacked up in small areas of the floor or roof.

The case here is a dramatic example of what can happen when the contractor thinks of the structure as just so many pieces to be put in place in a day, rather than as a total entity or system with characteristics and load capacities that are constantly changing as the structure evolves.

Any structural element that has a different stiffness in two directions naturally will fail in the weaker direction. Trusses, joists and rectangular wood beams are all very weak at the vertical (y-y) axis, so they require temporary support during installation to prevent premature failure.

How to Prevent: Constantly try to empathize with the structure and visualize where it may fail—in other words, look for where it might "hurt." This approach can help you understand the structure as a "living" system and not merely a pile of sticks to be put together according to some plan.

Develop checklists. A good foreman or construction manager always does, because it's the only way to keep track of things. When *you* are in charge of the situation, failures shouldn't happen. ■

Raymond DiPasquale is a failures investigator who has written several articles on the subject of building-system performance.