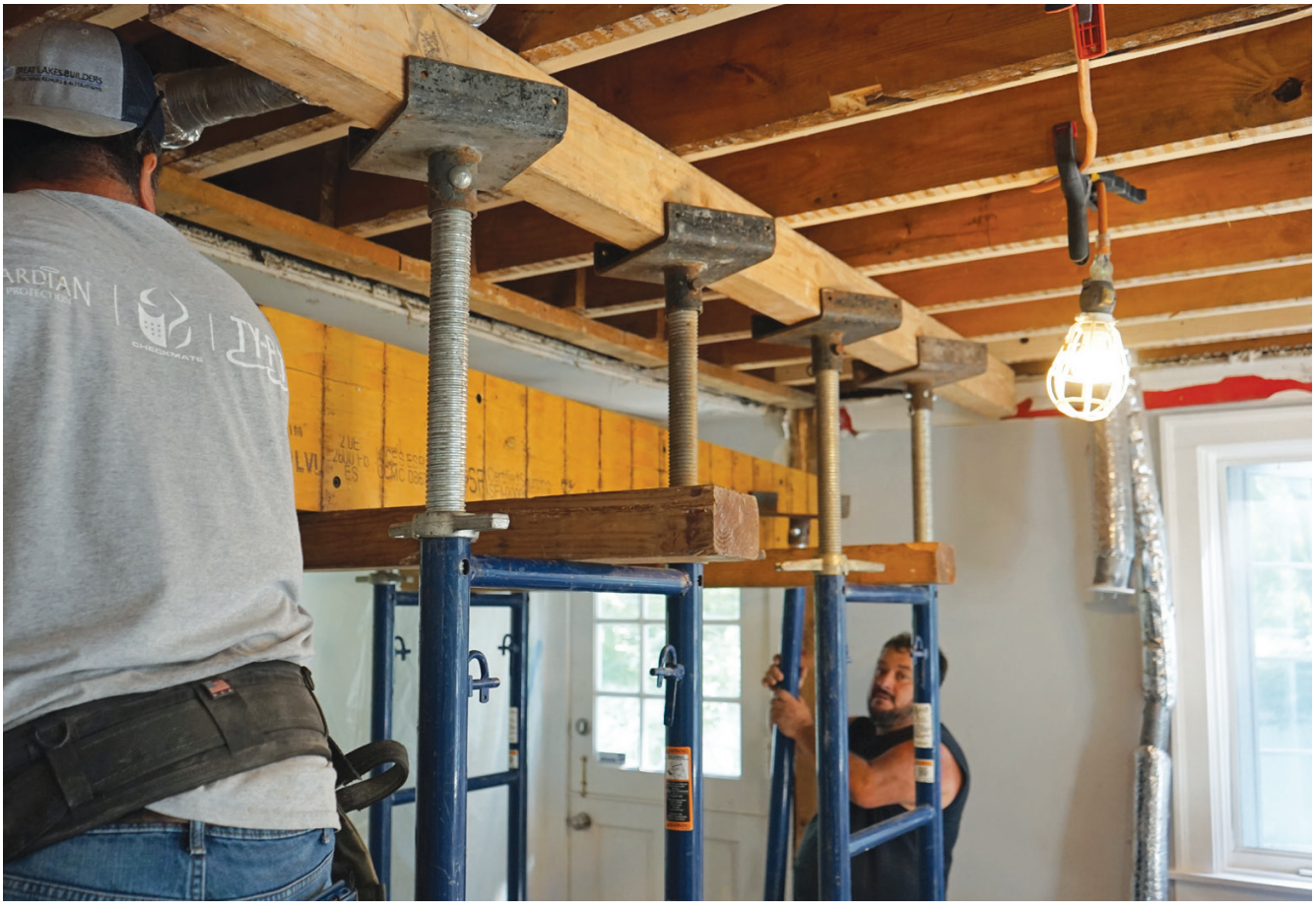


A Study in Broken Load Paths

Repairing the havoc wrought by sloppy prior work

BY JAKE LEWANDOWSKI

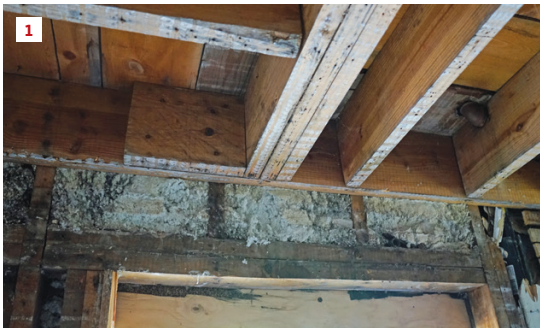
My family's company, Great Lake Builders, specializes in structural repairs in and around Chicago. Many of the homes we work on are similar to the one shown in this article: wood-frame buildings that have outlived their structural capacity. Some of these suffered damage from badly executed floor-plan changes or from mechanical contractors hacking up the structure to retrofit new systems. And many were underbuilt to begin with. This job suffered from all of the above.

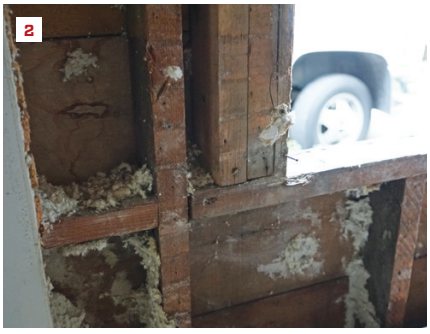
LOAD-PATH ESSENTIALS

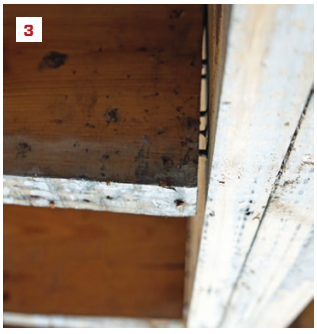
On this job, most of the structural problems could be traced back to breaks in the load path, which can be devastating to the integrity of a building even if it doesn't collapse. The effects go beyond plaster or drywall cracks; they manifest in walls and floors that noticeably sag, in floors that bounce and squeak, and in doors that don't fit their openings and shake the walls when slammed.

Loads on a building must be supported by a complete load path that effectively transfers loads "from their point of origin through the load-resisting elements to the foundation," as it's described in Chapter 3 of the International Residential Code. In general, the load transfer needs to be continuous from roof through walls and headers, as well as floors, beams, and columns, to the foundation. Rafters and joists should align with studs, and all load-bearing walls and floor loads must be supported by foundation walls and footings

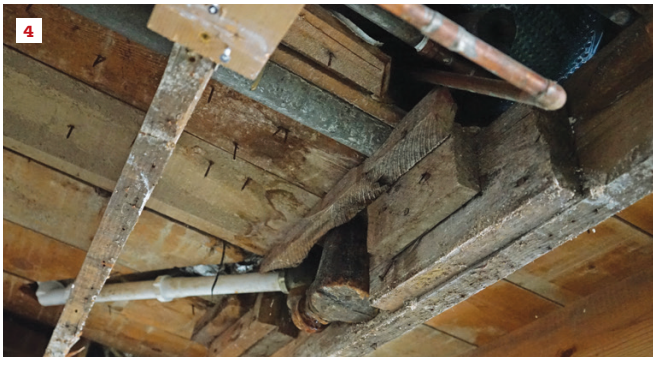
Photos by Jake Lewandowski







This flush beam in the second floor had no bearing on one end, only nails loaded in shear into a ledger **(1)**. The ledger was partly carried by cripple studs, but the header supporting these cripples had no support **(2)**. No joist hangers supported the joists carried by the flush beam **(3)**, and the end nails had pulled away as the beam, which was overloaded on one side, had rolled.



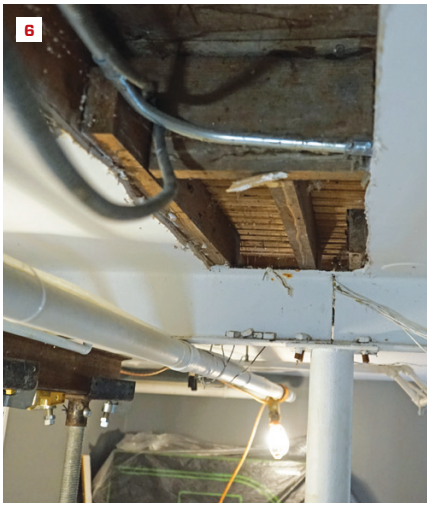
Plumbers over the century had done a good job of carving up floor joists **(4)**. The span and width of this undermount header **(5)** required a double LVL, but the remodelers who installed it to open up the room to the kitchen had used a double 2x12 instead.

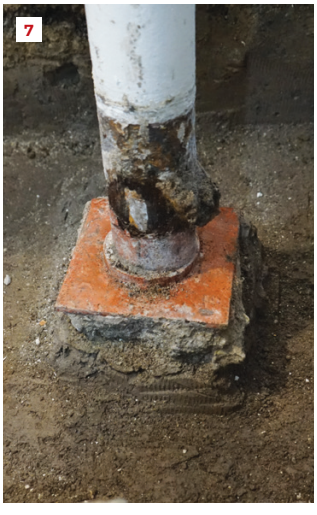
or with beams supported by columns to footings. The alignment of structural members is the best way to effectively transfer gravity loads, but the loads are not all from gravity. Lateral loads and uplift forces require connections between members that are tight (wood-to-wood) and tied securely together with fasteners. In our repair work, we hardly ever toenail permanent connections; we rely exclusively on steel clips, corners, and straps fastened with structural screws.

On this job, we were called in to execute an engineer's design for reinforcing a number of key components in the load path. We addressed five critical areas of the structure:

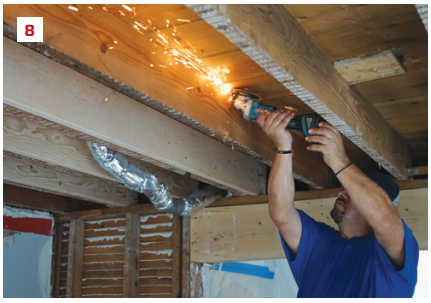
1) Undersized floor joists on the second floor had sagged. In addition, an area of this framing below a second-floor bathroom had been severely chopped up by plumbers.

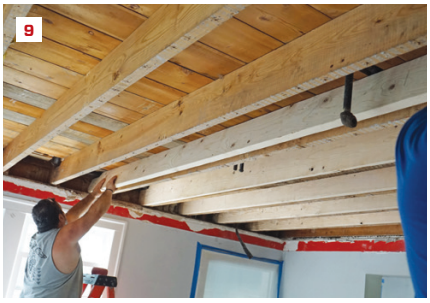
2) A flush beam in the second floor had no bearing at one end. It was simply toenailed into a ledger that was nailed to cripple studs, and the window header that picked up the loads on these cripples had no support

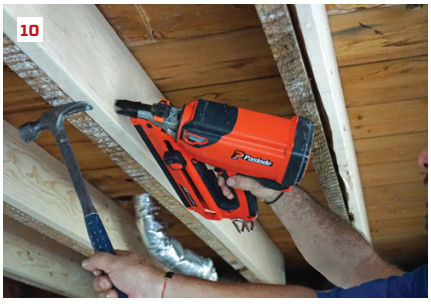


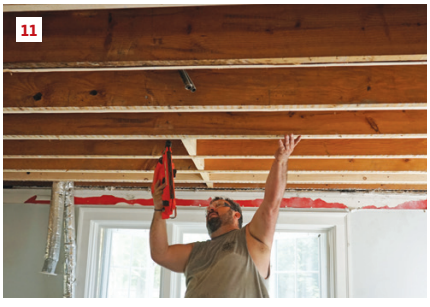


In this joist bay **(6)**, a new steel beam will be installed perpendicular to this basement girder. (It will span to another girder that runs parallel to it). The column supporting this girder had almost no footing **(7)**.

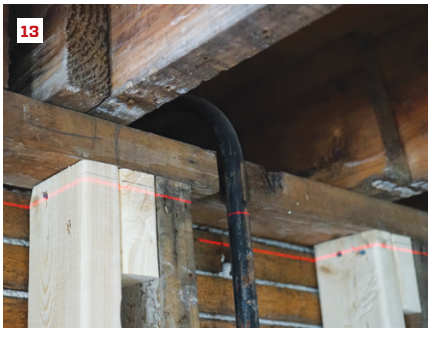


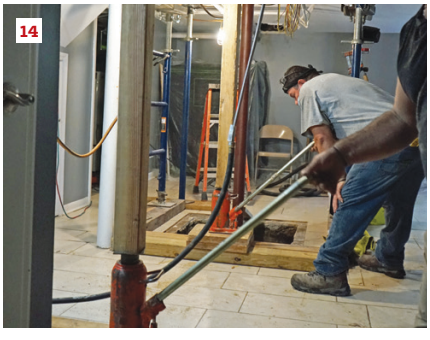


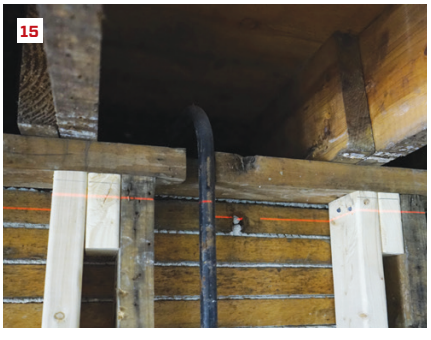


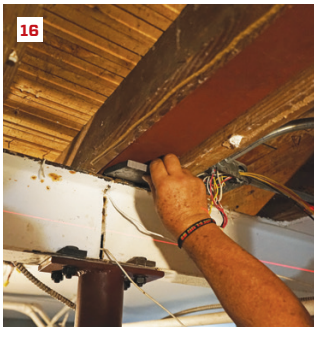


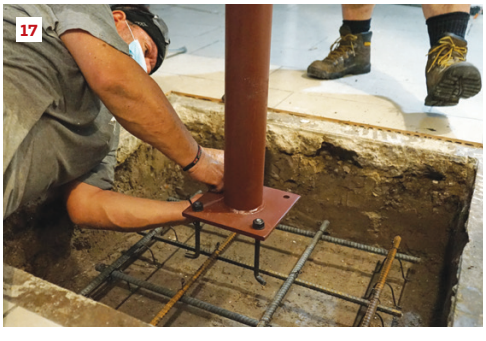
Ernesto Bonilla cuts flooring nails **(8)** so sister joists will fit tight to the existing ones. He and Toby Bonilla roll in sister joists **(9)**; a screw and hammer help pull the sisters flush to the bottom edge of the existing joists **(10)**. Blocking is key to stiffening the floor **(11)**. The studs in this critical wall section **(12)** had bowed and are reinforced before any jacking is done.

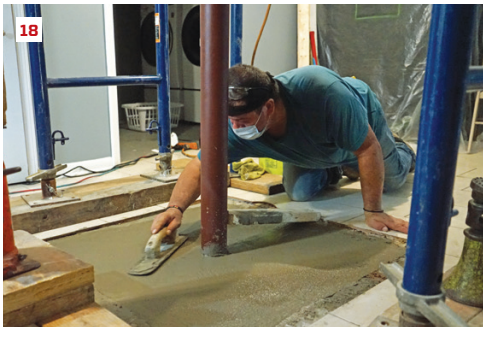






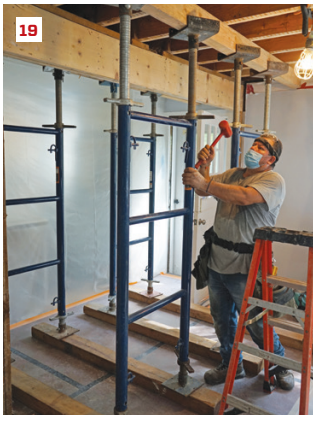


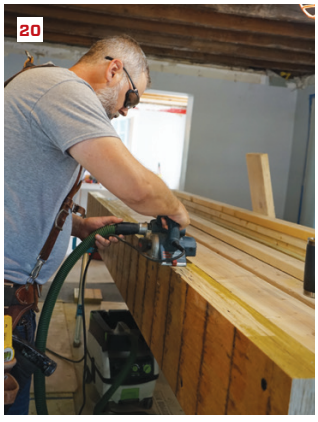


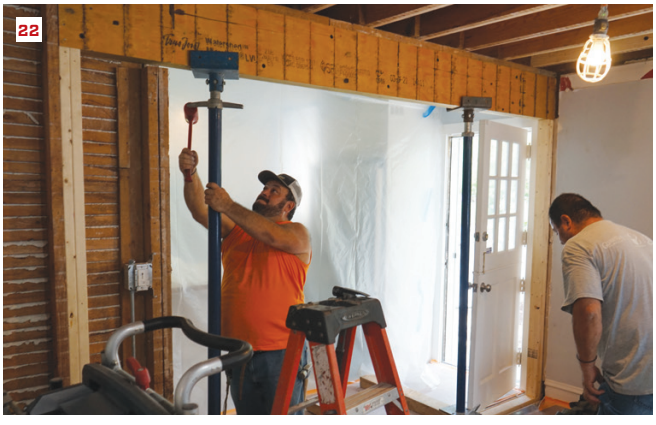


At the top of the wall section described above, the pencil line **(13)** shows the position of a laser before the beam is jacked into position in the basement **(14)**. When the beam is level, the wall has been raised more than an inch **(15)**. Steel shims are placed between the new beam and the old basement girders **(16)**. A new footing is prepped **(17)** and poured **(18)** for the new column.

UNDERMOUNT BEAM

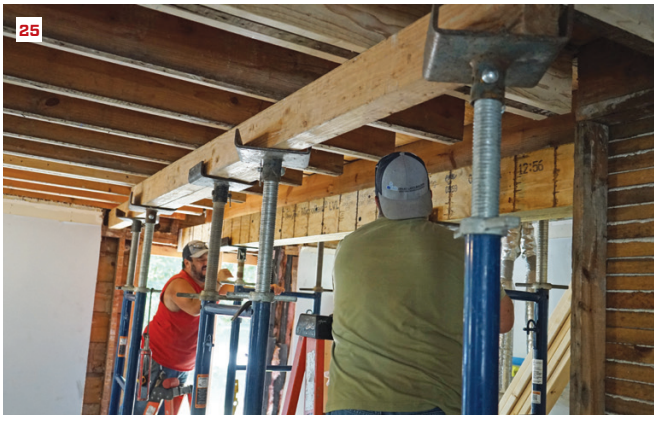


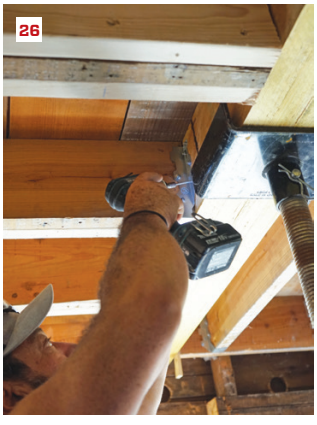




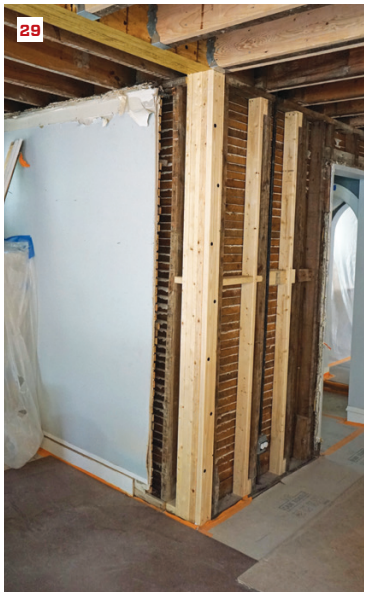
Prior to removing the old undermount beam, the crew erects shoring on each side of the opening **(19)**. The author joins two LVLs with structural screws and planes the top to flush up the two plies to get good bearing on both **(20)**. The beam is lifted into place **(21)**. It extends beyond the corner so the end column **(22)** bears directly on the new basement beam.

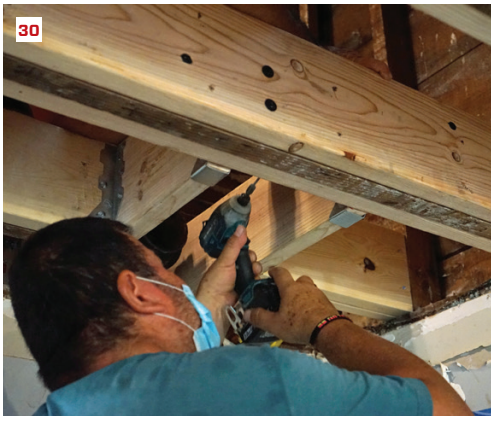
FLUSH BEAM

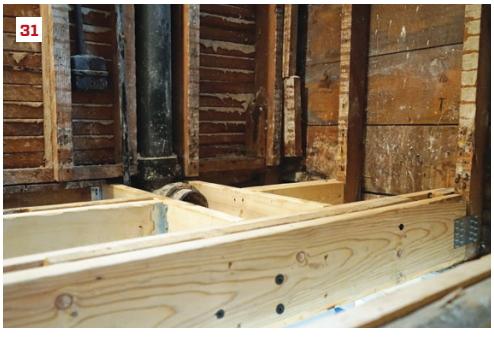




Toby and Ernesto erect shoring on one side of the old flush beam **(23)**. After removing it, they cut through the ledger so the new flush beam will extend over the window **(24)**. They use shoring to lift the beam into place **(25)**. With the beam raised, the joists are secured with joist hangers **(26)**, and a new LVL header is installed with full-length jacks **(27)**.







At one end of the flush beam, the load path from beam to window header to full-height jacks is complete **(28)**. At the other end, the flush beam has full bearing on a corner column **(29)** that bears directly on the new steel beam that spans the girders in the basement. To complete the job of reinforcing the floor system, the joists hacked up by plumbers are headed off **(30, 31)**.

extending to the foundation. In addition, this beam was overloaded on one side and had rolled. The framing predated joist hangers, and the end nails securing the joists to this beam had pulled away.

3) An unsupported bearing wall was failing. It was carrying the other end of the flush beam, as well as a section of the underbuilt second floor, but it had no bearing in the first floor that transferred directly to the two steel girders in the basement.

4) An undermount header that had been retrofit to enlarge a door opening into the kitchen was undersized and unsupported. This beam was in line with the flush beam. For its span and depth, the engineer said it needed to be LVL, but the remodelers who installed it had used dimensional lumber, and one end column did not have bearing that transferred to the basement girders.

5) A steel column that supported one of the basement girders was failing because it had almost no footing.

FROM THE GROUND UP

As a rule, you want to approach a load-path repair by starting at the bottom and then lift the structure from a solid foundation. On this job, we began by excavating for the column footing in the basement. But before jacking, we first needed to sister the undersized floor joists in the second floor. We wanted to create a flat floor system so that when we started to lift the structure from the basement, the floor would rise uniformly and we would be able to accurately measure our progress. This would have been impossible with the extent to which the existing floor sagged.

We also strengthened the unsupported bearing wall section mentioned above. The top and bottom wall plates had sagged at each stud, and the studs themselves were bowed. By reinforcing the wall with additional, plumb studs, we could reliably lift from below, knowing that everything would stay straight and the lifting force would be effectively transferred, raising the structure as a whole.

Before lifting, we installed a new steel beam spanning between the two existing basement girders. This new steel beam was positioned directly under the previously unsupported wall section; it would support the corner column at one end of the flush beam as well as the column at one end of the undermount beam. Jacking up this new beam to level straightened the wall plates and lifted the reinforced second floor as well.

Once the main floor elevation was established, we could install a new flush beam (four LVL plies) and new undermount beam (two LVL plies), as well as rebuild the floor where the plumbers had hacked it up. This required adding headers across joists to carry the loads around the plumbing so we could remove the cut-up joists. It was painstaking work, as it's difficult to screw off framing hardware in such tight spaces. Nevertheless, it's critical to follow through with tight joints and all holes in the hardware filled with screws.

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