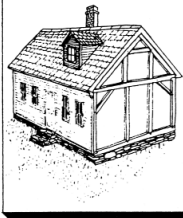


Fallen Arches

by Wm. Ward Bucher



Masonry walls are most likely to fail around the top of window and door openings. This may be because of beam failure, but it probably is a case of arch failure.

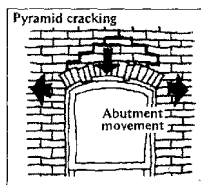
Arches as first used by the Romans rarely failed, because they were semicircular. But as square windows and doors became fashionable, there were more and more arch problems. The flatter an arch is, the more likely

the top of the arch fall downward. Typically, they will jam in the opening after moving 1/4 inch or so. If the abutments continue to spread, however, the bricks may fall out.

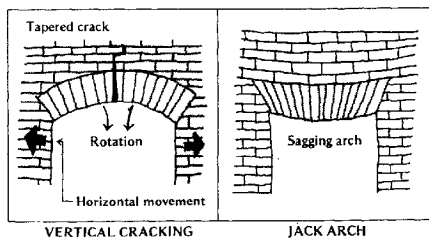
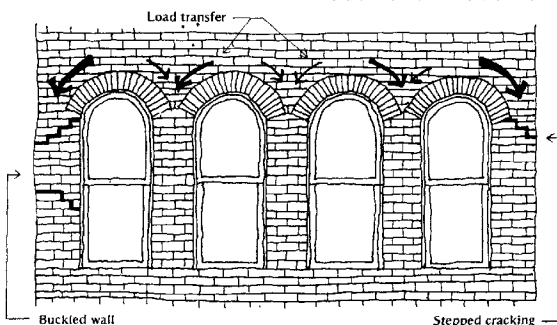
Jack arches are particularly susceptible to this kind of failure. In a jack arch, the bottom is flat and the arch is formed by specially shaped bricks that slant toward each side. Almost every jack arch ever built eventually sags in the middle. This is the result of horizontal movement of the abutments, and insufficient (that is, nonexistent) arch height.

So Why Does It Happen?

Abutment movement is caused by walls that don't have enough mass to push back against the ends of the arch. This may be the result of walls that are too thin or, more commonly,



Abutment Movement



that it will crack over time. Generally, arches that have less than one inch of rise per foot of width will crack unless additional restraint is added.

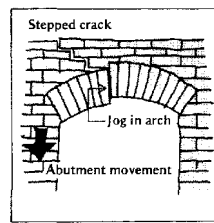
The sideways force of an arch pushes the ends of the arch apart. Any small movement of the ends, or "abutments," of the arch will cause the center to drop and a pyramidal cracking pattern to form above. The way in which the abutment and the arch move will help you identify the cause.

If the abutments move horizontally, the sides of the arch will tilt toward the center and cause a vertical crack that is wider at the bottom. This may also result in a differential movement pattern, in which the sides keep their original shape but the center bricks at

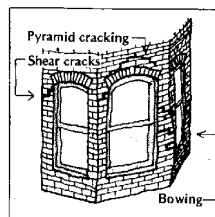
walls that are not wide enough on either side of the arch.

When there is a row of arches in a wall, they all push against each other, and the stress ends up on the last arch in the row. The center arches may stay in place, while the wall at the side of the end arch cracks horizontally at the base of the arch. The push from the arch may also tilt or bow the side wall around the corner from the end of the building.

If one side of the arch falls, the movement can again be seen at the top of the arch. The underside of the arch will have a jog where one half has dropped lower than the other. This jog may be a clean break or it may have several steps at different mortar joints. The suspect in this case is differential settlement.



DIFFERENTIAL SETTLEMENT



BAY

The very shape of the house is a frequent cause of differential-settlement cracks. Many old houses are like rectangular boxes with all sorts of projections: steps, porches, bays, and wings. It's as if the heavy central box sinks into the soil faster than the projections, and the projections are ripped off the main box. Naturally, cracks tend to develop where projections are joined. But cracks often find their way through walls, too, resulting in the stepped pattern of arch failure.

Arch failures are endemic in Victorian bays. The Victorian taste for large windows and narrow corners left most arches with nothing to push against. The cracking pattern commonly includes pyramidal cracking above the arch, horizontal shear cracks at the base of the arch, and sometimes tilting or bowing of the sides of the bay.

Occasionally, the cracking pattern can be seen on the inside of the building but not on the outside. In these cases, suspect a wood lintel supporting the interior course of bricks and an arch supporting the exterior course. When the wood compresses or rots, the plaster on the

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inside wall will crack, while the outside arch remains in place. Similarly, the arch and the brickwork above it may collapse without the inside wall falling down.

Buckling failure is another arch problem where abutment movement can be suspected. As the arch moves slightly, the bonds between the bricks or stones break at the joints. The weight of the wall above may push sections of the middle of the arch downward and to the front. This may cause the bricks or stone to rotate from their original position, which further weakens the arch.

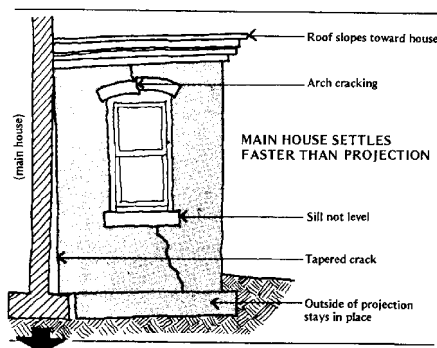
The Cure

In order to solve arch problems, the first step is to stop movement at the ends of the arch. If the movement is a horizontal, spreading one, then tie rods can sometimes be used to relieve the force that is pushing on the wall. A new tie rod will consist of two steel rods that are threaded on both ends, a turnbuckle connecting them in the middle, and cast-iron stars or square steel plates on both ends.

The tie rod is installed as close to the bottom of the arch as convenient. For aesthetic reasons on the interior, this often means putting it in the joist space between floors. The plates or stars are placed on the outside of the side walls, and the turnbuckle at the center is tightened. In most cases, you simply want to stop *further* movement, so the turnbuckle is just hand-tightened.

If the arch failure is due to the ground settling, deal with it as a foundation problem. Once the arch movement has been arrested, the arch can be rebuilt.

Do consider whether the arch even needs to be rebuilt. An arch can be quite distorted without actually failing. Once its movement has been

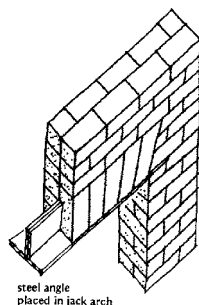
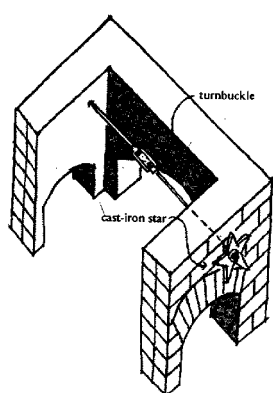
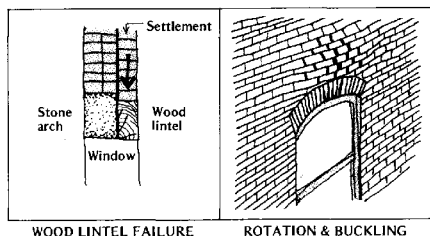


arrested, a bit of repointing may be all that's required.

Once the decision has been made to proceed, make sure the masonry is properly shored up. Falling arches and lintels should be shored up inside the window opening. The support should be designed so the arch is supported all along its length. Plaster or masonry that has cracked enough that it may fall should be removed or well shored up. A four-foot-square piece of plaster—weighing over 125 pounds—could seriously injure someone if it dropped from

with brick. Check your span tables—or talk to your friendly local engineer—to be sure it will handle the load. If the original arch was a jack arch, it is a good idea to use steel angles for support.

Replacing the arch may be more difficult. There are few masons around today who can, or will, produce the thin mortar joints often found on an old building. However, it is important that the joints be duplicated, since a bad patch can ruin the appearance of a masonry building forever.



the ceiling. The plaster can be temporarily held up with plywood.

The next step is to remove the bricks or stones in the "triangle" above the arch. Old mortar should make this job easy: just lift them out. Temporarily shore up under the arch with pieces of wood, and remove the keystone. Watch out—the rest of the pieces will fall onto the shoring.

Where the problem is a wood lintel on the interior, it can be replaced with a reinforced concrete lintel. You may be able to find a precast concrete lintel at a masonry supply house that will fit. Another approach is to install a steel angle and fill the space where the wood was

It's also important that the mason build a *true* arch, not just fill in the space with bricks. I've seen arches replaced with horizontal brickwork that rested on the wood frame of the window below. This will only cause more cracks in the future. So if you are going to take on the project, do so with caution and care. ■

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