

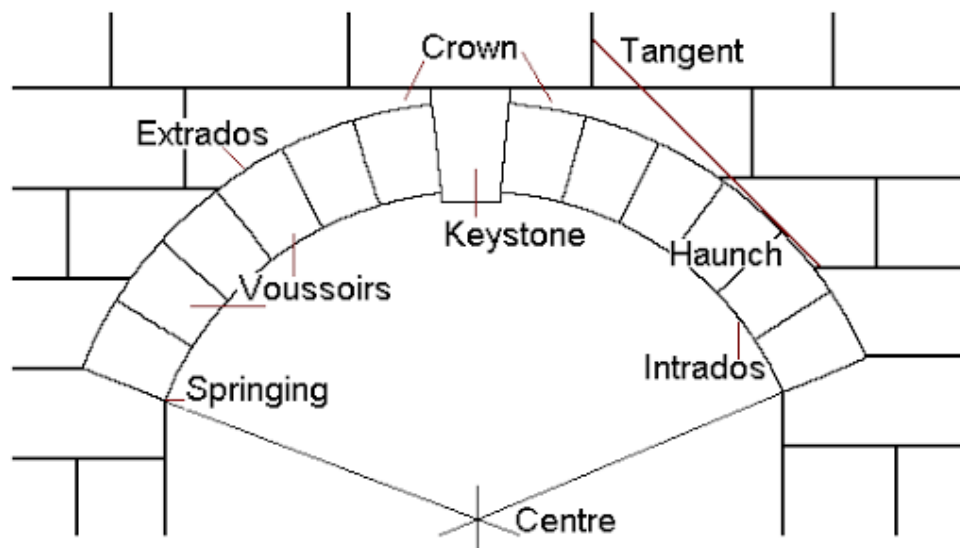
# Architectural Structures : Arches, Walls, Buttresses

Cathedral walls serve a number of purposes. They must be pillared at their base to allow for an open gathering space for worship. Their upper tiers must be windowed to allow air and light into the interior, and they must hold up a roof over a large, open area. Once these requirements are understood, the design principles of Cathedral walls, including their height, layout, roofing techniques, and use of columns and 'arches' can be better understood. Even the purpose of the peculiar 'flying buttresses', which surround most Gothic Cathedrals can be appreciated once the difficulties of holding a large, heavy roof in place are understood.

Many of the building techniques used in Cathedral architecture were first developed and used on a large scale by the Romans during the imperial age. The most important of these were the 'Arch' and 'Vaulted' ceilings. The arch was known as an important architectural technique since ancient times, but the Romans were the first to systematically use the arch to build massive structures on a large scale. Roman aqueducts, bridges, public buildings, colosseums, baths, monuments, and temples all used arches as a means of supporting elevated structures.

## Arches, Vaults and Domes

Arches were invented in order to span an area, or support weight between two pillars. Vaults are cross-supported arches that are used in forming a roof, and domes are a specialized form of vaulting that produces a continuous semi-circular roofline. Although they are used for widely varying purposes the architectural principles behind all are the same. The purpose of all these structures is to direct the weight of a roof or of a load-bearing span towards the pillars supporting the vault or arch. In other words, arches are used to transfer the weight applied above it to its supporting structure. The basic principle is simple, and it can be used in a variety of structures.



Arches were used on a regular basis by ancient architects for a number of purposes, but most often to 1) To create open spaces for doors or windows, 2) to support heavy structures on pillars or piers.

The basic components of an arch are:

- **Keystone**—Wedge shaped stone that forms the apex of a masonry arch.
- **Springer**—Lowest stone on each side of a masonry arch. All the weight the arch supports presses on the springer stone and pushes it down and out (in the direction away from the arch).
- **Vousoir**—Wedge shaped stone used in forming a masonry arch. Springers and keystones are specialized voussoirs.
- **Pier**—Upright structure or pillar that supports an arch.

The diagram above shows a simple arch, but there are many variations, such as a pointed arch, a horseshow arch, or an ogee, that work on the same principles. Most pointed arches are symmetric and have a joint, rather than a keystone at their apex.

## Support Structures: Arcades and Buttresses

The fact that the force on a springer stone pushes it outward, away from the arch means that architects need to figure out a way to counter that force. There are several ways to do this. One is by building arches that counter-balance each other. Another is by buttressing the piers or columns that support load-bearing arches or vaulted ceilings. Clever techniques of using rows of interdependent arches and buttresses are a critically important part of Cathedral architecture.



Bath Abbey features rows of arches and flying buttresses.

**Arcade**—An arcade is succession of arches, each counter-supporting the columns or piers of each other. The outward force imposed on the pier supporting one arch is perfectly offset by the force of the opposing arch, so arcades are extremely stable. They are typically found in churches between the nave area and the aisles. Arcades also form enclosed walkways in cloisters, and interior passageways in churches.

In addition to their use in Cathedral architecture, a great many structures use some form of arcade. Aqueducts, and bridges, for example, are weight bearing arcades.

**Buttress**—A Buttress is structure that pushes back against a pier or pillar that is supporting an arch. The design of a buttress depends on how much force is being exerted and on what direction the pressure is coming from. A wall or pier that is supporting a heavy ceiling, must either rely on a buttress to support it, or it must be extremely thick. Most Cathedrals use buttresses to support columns so that the walls of the cathedral can be thin enough to allow large window areas.

**Flying Buttress**—A flying Buttress is a massive structure that is built away from the pillar that it is intended to support. A supporting arch is then built between the buttress and the pier. Flying buttresses allow for tall piers, large windows areas, and a lighter interior, all characteristic of the Gothic cathedrals of the 12th century.

## Cathedral Wall Design — Elevations

Once one understands the importance of arches, arcades, and buttresses, the plan for wall elevations of Cathedrals makes more sense. Two rows of columns define the main interior of the cathedral, and between these piers are three levels of arches. The ground level arches, separate the Nave or Choir from the covered aisles to the north and south. The upper level arches form the clerestory, or main window area of the church, and the middle row of arches, the triforium, is required for structural support.

- **Clerestory**—Third and uppermost level of a cathedral wall, far above eye level, whose purpose is to let in light or air. .
- **Triforium**—Middle portion of a cathedral wall below the clerestory that contains arches, but is usually windowless (typically because it is opposite the buttresses and lower roof).
- **Vaulting**—Arch shaped structures intended to provide support for curved roof. Vaulting patterns vary from domed roofs to complicated ribbed or barreled ceilings.
- **Tracery**—Stone framework, usually with iron reinforcements, for stained glass windows.
- **Pier**—column or upright support for an arch or vaulted ceiling.
- **Arcade**—Ground level arches separating the Nave and Choir of a cathedral from the northern and southern aisles.

