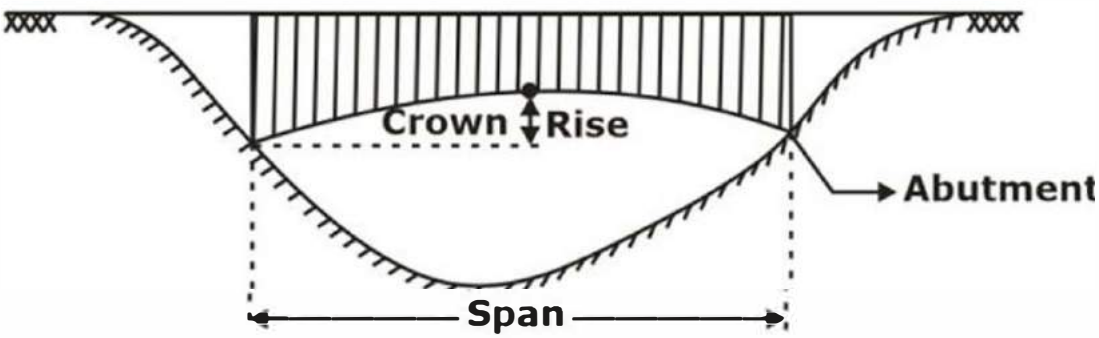
Types of Arches

Different types of arches can be classified based on their shape, material used, number of hinges, etc. Based on the shape of the arches, they can be classified into a circular arch, parabolic arch, semi-circular arch, Flat arch, segmental arch, horseshoe arches, etc. Based on the materials used for the construction, it can be classified as Stone arches, Ashlar arches, Rubble arches, etc.

Based on the number of hinges, Arches can be classified as three and two hinged arches. These arches are used in the structure based on their requirement. Three hinged arches are the determinate structures, while two hinged arches are the indeterminate ones. These types of arches will be discussed further in this article.

What are Arches?

Arches are the structures used in the world of construction. Uses of arch structures have many advantages in the construction sector. An arch structure can resist its dead weight due to its proper design. Arch structure induces a negative bending moment, which helps to counteract the effect of external load acting over it. In an arch structure, some normal thrust, shear force and bending moment act on a particular section. Here a typical arch bridge structure is shown below.



Typical Arch Bridge

Different Types of Arches in Houses

In houses, arch structures are used to transmit loads from above structures. Arch structures are preferred due to their advantages. House arches can be provided based on their shape and suitability of use at the given condition of structures.

Flat arches, Segmented arches, Semi-circular arches, Horse Shoe arches, Elliptical arches, etc., can be used to construct house structures. These arches are used in the construction of houses based on their suitability and effectiveness of this. Some other types of arches can also be used to design houses.

Types of Arches Based on the Shape

Arches can be classified based on their shape, size, number of hinges used, etc. So, based on the number of hinges available in the structure, it can be classified as three hinged arch or two hinged arches.

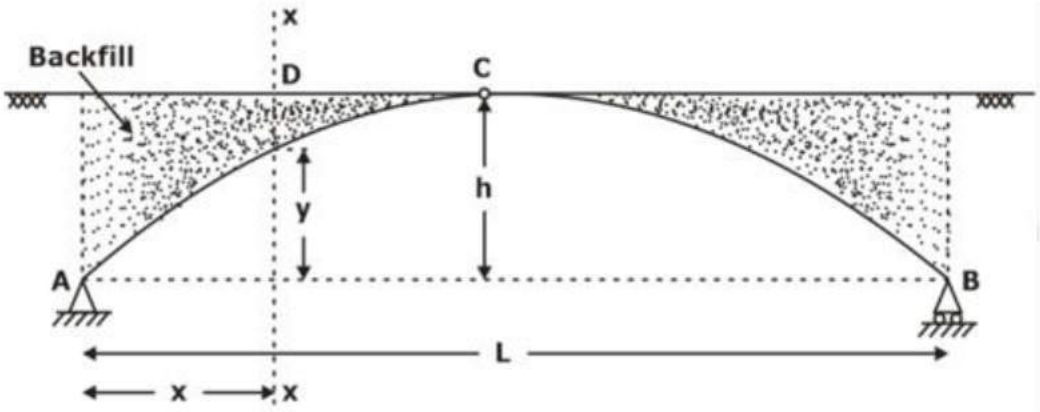
These two types of arches can be further classified based on their shapes, which may be circular, parabolic or elliptical shapes. These shapes can be used in structure based on the loading criteria and suitability for the construction.

Three Hinged Arches

The three hinged arches are statically determinate structures, as equilibrium equations alone are sufficient to find all the unknown quantities. These arches are analysed based on the shape of the arch structures. Here analyses for the circular and parabolic arch are given below.

Circular Arch

From the property of a circle, the radius r of the circular arch of the span L and rise h can be calculated. Taking origin at A, the coordinates of any point d on the arch may be defined as



$$\frac{L}{2} \times \frac{L}{2} = h(2R - h)$$

$$\Rightarrow \quad \boxed{R = \frac{L^2}{8h} + \frac{h}{2}}$$

$$x = \left[\frac{L}{2} - R\sin\theta\right]$$

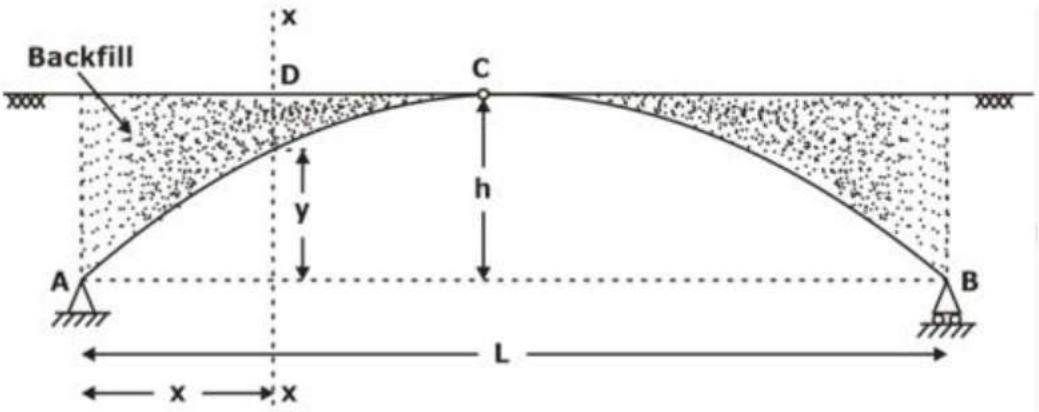
$$y = R\cos\theta - (R - h)$$

$$\Rightarrow \quad \boxed{y = h - R(1 - \cos\theta)}$$

Parabolic Arch

Its equation is given by

$$y = \frac{4h_x}{L^2}(L - x)$$



Bending Moment at the section X-X

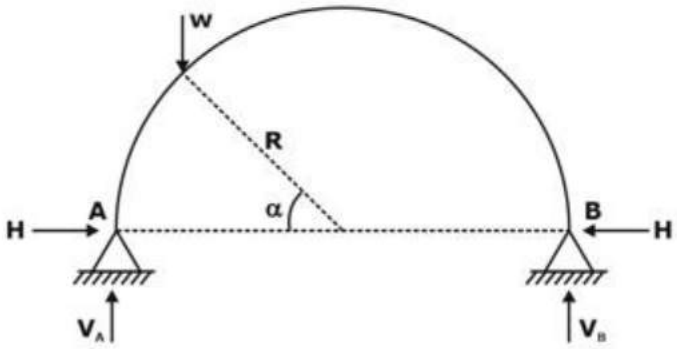
$$BM_{X-X} = +V_A \times x - H_A \times y$$

$$\Rightarrow BM_{X-X} = \text{Beam moment} - \text{H-moment}$$

Compared with a beam of similar span, bending Moment at any section in a three-hinged arch is less by an amount of 'H×y' or Moment due to horizontal force.

Two Hinged Arches

A two-hinged arch is an indeterminate arch. The horizontal thrust in such arches can be determined using Castigliano's theorem of least energy.



Two hinged circular arch

Assuming the redundant to be H,

As per Castigliano's theorem

$$\frac{\partial U}{\partial H} = 0$$

Which gives the following condition

$$H = \frac{\int_0^l \frac{M_x y dx}{EI_C}}{\int_0^l \frac{y^2 dx}{EI_C}}$$

Where

M_x = beam Moment at any section x – x

I_C = Moment of inertia of the arch cross-section at the crown.

(i) Horizontal Thrust in case of circular arch subjected to point load

$$H = (W/\pi)\ Sin^2\alpha$$

(ii) Horizontal Thrust in case of circular arch subjected to UDL

$$H = 4WR/3\pi$$

(iii) Horizontal Thrust in case of parabolic arch subjected to a point load at the centre

$$H = 25WL/128h$$

(iv) Horizontal Thrust in case of parabolic arch subjected to a UDL

$$H = WL^2/8h$$