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hengebru-kontoret / JT

The Basic Bridge Types



Girder



Arch



Truss



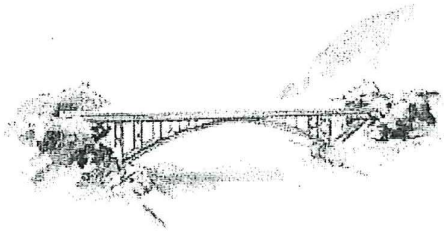
Cable Stayed



Rigid Frame



Suspension



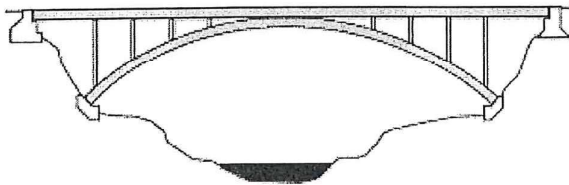
Arch

After girders, arches are the second oldest bridge type and a classic structure. Unlike simple girder bridges, arches are well suited to the use of stone.

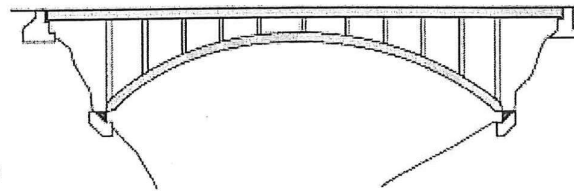
Many ancient and well known examples of stone arches still stand to this day. Arches are good choices for crossing valleys and rivers since the arch doesn't require piers in the center. Arches can be one of the more beautiful bridge types.

Arches use a curved structure which provides a high resistance to bending forces. Unlike girder and truss bridges, both ends of an arch are fixed in the horizontal direction (i.e. no horizontal movement is allowed in the bearing). Thus when a load is placed on the bridge (e.g. a car passes over it) horizontal forces occur in the bearings of the arch. These horizontal forces are unique to the arch and as a result arches can only be used where the ground or foundation is solid and stable.

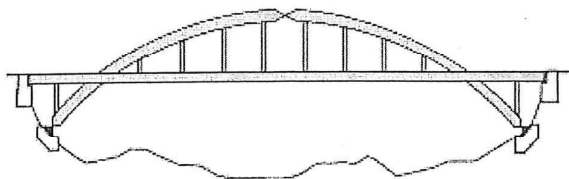
Like the truss, the roadway may pass over (illustration #1) or through an arch (illustration #4) or in some cases both (illustration #3.) Structurally there are four basic arch types: hinge-less, two-hinged, three hinged and tied arches.



The hinge-less arch (illustration #1) uses no hinges and allows no rotation at the foundations. As a result a great deal of force is generated at the foundation (horizontal, vertical, and bending forces) and the hinge-less arch can only be built where the ground is very stable. However, the hinge-less arch is a very stiff structure and suffers less deflection than other arches.

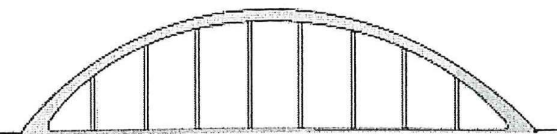


The two hinged arch (illustration #2) uses hinged bearings which allow rotation. The only forces generated at the bearings are horizontal and vertical forces. This is perhaps the most commonly used variation for steel arches and is generally a very economical design.



The three-hinged arch (illustration #3) adds an additional hinge at the top or crown of the arch. The three-hinged arch suffers very little if there is movement in either foundation (due to earthquakes, sinking, etc.) However, the three-hinged arch experiences much more deflection and the hinges are complex and can be difficult to fabricate. The three-hinged arch is rarely used anymore.

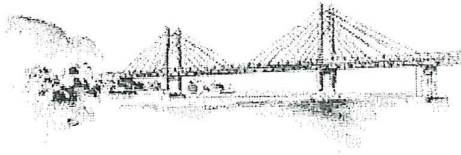
The tied arch (illustration #4) is a variation on the arch which allows construction even if



the ground is not solid enough to deal with the horizontal forces. Rather than relying on the foundation to restrain the horizontal forces, the girder itself "ties" both ends of the arch together, thus the name "tied arch."



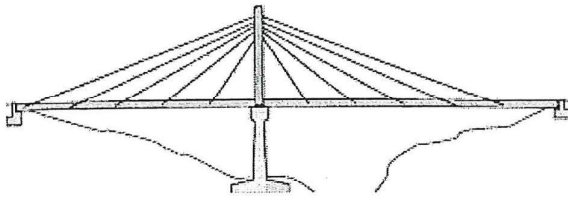
Cable Stayed



Cable Stayed

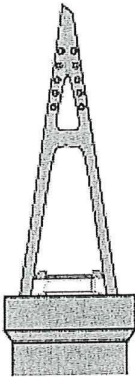
A typical cable stayed bridge (illustration #1 & 2) is a continuous girder with one or more towers erected above piers in the middle of the span. From these towers, cables stretch down diagonally (usually to

both sides) and support the girder.



Steel cables are extremely strong but very flexible. Cables are very economical as they allow a slender and lighter structure which is still able to span great distances. Though only a few cables are strong enough to support the

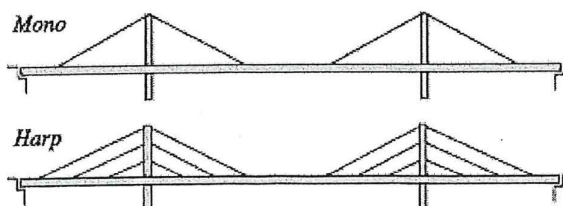
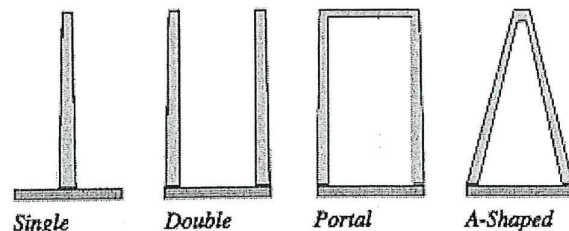
entire bridge, their flexibility makes them weak to a force we rarely consider: the wind. For longer span cable-stayed bridges, careful studies must be made to guarantee the stability of the cables and the bridge in the wind.



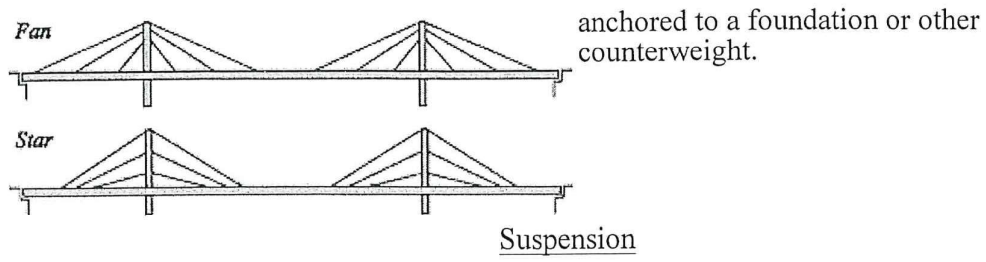
The lighter weight of the bridge, though a disadvantage in a heavy wind, is an advantage during an earthquake. However, should uneven settling of the foundations occur during an earthquake or over time, the cable-stayed bridge can suffer damage so care must be taken in planning the foundations. The modern yet simple appearance of the cable-stayed bridge makes it an attractive and distinct landmark.

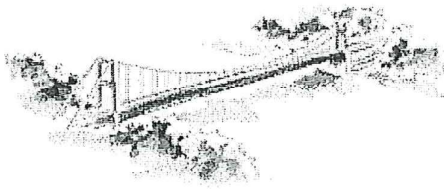
The unique properties of cables, and the structure as a whole, make the design of the bridge a very complex task. For longer spans where winds and temperatures must be considered, the calculations are extremely complex and would be virtually impossible without the aid of computers and computer analysis. The fabrication of cable stay bridges is also relatively difficult. The cable routing and attachments for the girders and towers are complex structures requiring precision fabrication.

There are no distinct classifications for cable-stayed bridges. However, they can be distinguished by the number of spans, number of towers, girder type, number of cables, etc. There are many variations in the number and type of towers, as well as the number and arrangement of cables. Typical towers used are single, double, portal, or even A-shaped towers (illustration #2 & 3.)



Cable arrangements also vary greatly. Some typical varieties are mono, harp, fan, and star arrangements (illustration #4.) In some cases, only the cables on one side of the tower are attached to the girder, the other side being



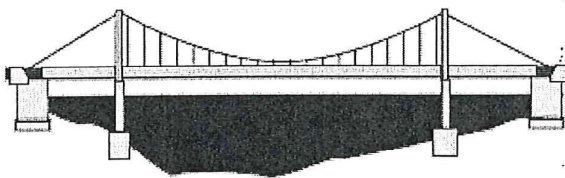


Suspension

Of all the bridge types in use today, the suspension bridge allows for the longest spans. At first glance the suspension and cable-stayed bridges may look similar, but they are quite different. Though suspension bridges are leading long span technology today, they are in fact a very old form of bridge. Some primitive examples of suspension bridges use vines and ropes for cables. The development of metals brought the use of linked iron bars and chains. But it was the introduction of steel wire ropes that allowed spans of over 500m to become a reality. Today the Akashi Kaikyo bridge boasts the world's longest center span of any bridge at 1,991 meters.

A typical suspension bridge (illustration #1) is a continuous girder with one or more towers erected above piers in the middle of the span. The girder itself is usually a truss or box girder though in shorter spans, plate girders are not uncommon. At both ends of the bridge large anchors or counter weights are placed to hold the ends of the cables.

The main cables are stretched from one anchor over the tops of the tower(s) and attached to the opposite anchor. The cables pass over a special structure known as a saddle (illustration #2.) The saddle allows the cables to slide as loads pull from one side or the other and to smoothly transfer the load from the cables to the tower.

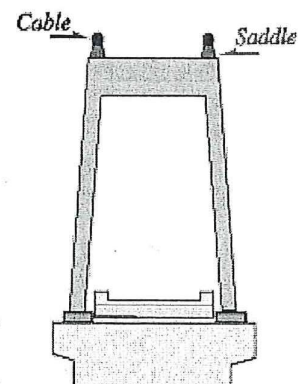


From the main cables, smaller cables known as hanger cables or hanger ropes are hung down and attached to the girder. Some suspension bridges do not use anchors, but instead attach the main cables to the ends of the girder. These self-anchoring suspension bridges rely on the weight of the end spans to

balance the center span and anchor the cable.

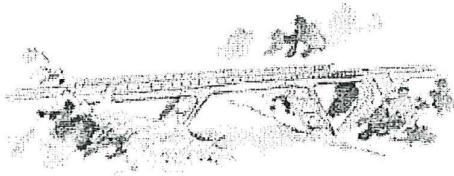
Thus, unlike normal bridges which rest on piers and abutments, the girder or roadway is actually hanging suspended from the main cables. The majority of the weight of the bridge and any vehicles on it are suspended from the cables. In turn the cables are held up only by the tower(s), there is an incredible amount of weight that the towers must be able to support.

As explained in the cable stayed bridge section, steel cables are extremely strong yet flexible. Like a very strong piece of string, it is good for hanging or pulling something, but it is useless for trying to push something. Long span suspension bridges, though strong under normal traffic loads, are vulnerable to the forces of winds. Special measures are taken to assure that the bridge does not vibrate or sway excessively under heavy winds.



The most famous example of an aerodynamically unstable bridge is the Tacoma Narrows Bridge in Washington state, USA. This page on the [Tacoma Narrows Bridge Disaster](#) at the University of Bristol has some excellent photos and short movies showing why aerodynamic stability is important.

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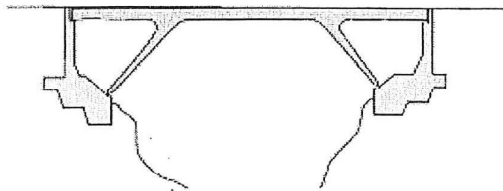
Rigid Frame

Rigid frame bridges are sometimes also known as Rahmen bridges. In a standard girder bridge, the girder and the piers are separate structures. However, a rigid frame bridge is one in which the

piers and girder are one solid structure.

The cross sections of the beams in a rigid frame bridge are usually I shaped or box shaped. Design calculations for rigid frame bridges are more difficult than those of simple girder bridges. The junction of the pier and the girder can be difficult to fabricate and requires accuracy and attention to detail.

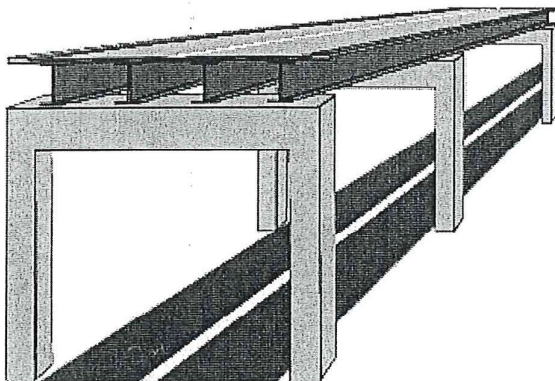
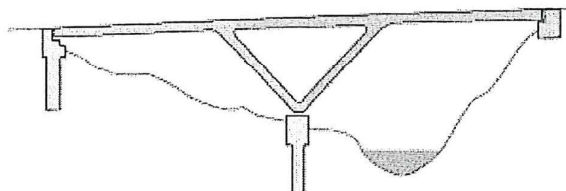
Though there are many possible shapes, the styles used almost exclusively these days are the pi-shaped frame, the batter post frame, and the V shaped frame.



the middle of the river or piers in deep parts of a valley (illustration #1).

The batter post rigid frame bridge is particularly well suited for river and valley crossings because piers tilted at an angle can straddle the crossing more effectively without requiring the construction of foundations in

V shaped frames make effective use of foundations. Each V-shaped pier provides two supports to the girder, reducing the number of foundations and creating a less cluttered profile (illustration #3.)



Pi shaped rigid frame structures are used frequently as the piers and supports for inner city highways. The frame supports the raised highway and at the same time allows traffic to run directly under the bridge (illustration #2.)

Arch