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Review Article

The criteria for selection of sites for bridges

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Abstract
Bridge is a structure which provides a passage to people, vehicles, railways or pipelines to cross various obstacles to travel. Engineers build bridges over obstacles such as lakes, rivers, canyons, and dangerous roads and railway tracks. Without bridges, people would need boats to cross waterways and would have to travel around canyons and ravines. The first bridges were made by nature itself — as simple as a log fallen across a stream or stones in the river. The first bridges made by humans were probably spans of cut wooden logs or planks and eventually stones, using a simple support and crossbeam arrangement. Some early Americans used trees or bamboo poles to cross small caverns or wells to get from one place to another. A common form of lashing sticks, logs, and deciduous branches together involved the use of long reeds or other harvested fibers woven together to form a connective rope which was capable of binding and holding in place materials used in early bridges.

1. Introduction

The Arkadiko Bridge is one of four Mycenaean corbel arch bridges part of a former network of roads, designed to accommodate chariots, between Tiryns to Epidauros in the Peloponnese, in Greece. Dating to the Greek Bronze Age (13th century BC), it is one of the oldest arch bridges still in existence and use. Several intact arched stone bridges from the Hellenistic era can be found in the Peloponnese in southern Greece. The greatest bridge builders of antiquity were the ancient Romans. The Romans built arch bridges and aqueducts that could stand in conditions that would damage or destroy earlier designs. Some stand today. An example is the Alcántara Bridge, built over the river Tagus, in Spain. The Romans also used cement, which reduced the variation of strength found in natural stone. One type of cement, called pozzolana, consisted of water, lime, sand, and volcanic rock. Brick and mortar bridges were built after the Roman era, as the technology for cement was lost then later rediscovered.

The Arthashastra of Kautilya mentions the construction of dams and bridges. A Mauryan bridge near Girnar was surveyed by James Princep. The bridge was swept away during a flood, and later repaired by Puspagupta, the chief architect of emperor Chandragupta I. The bridge also fell under the care of the Yavana Tushaspa, and the Satrap Rudra Daman. The use of stronger bridges using plaited bamboo and iron chain was visible in India by about the 4th century. A number of bridges, both for military and commercial purposes, were constructed by the Mughal administration in India.

Although large Chinese bridges of wooden construction existed at the time of the Warring States, the oldest surviving stone bridge in China is the Zhaozhou Bridge, built from 595 to 605 AD during the Sui Dynasty. This bridge is also historically significant as it is the world's oldest open-spandrel stone segmental arch bridge. European segmental arch bridges date back to at least the Alconétar Bridge (approximately 2nd century AD), while the enormous Roman era Trajan's Bridge (105 AD) featured open-spandrel segmental arches in wooden construction.

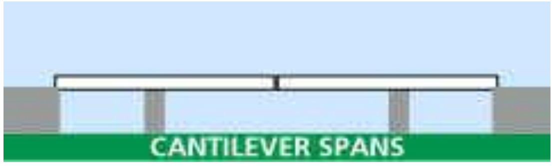
2. Bridge Component

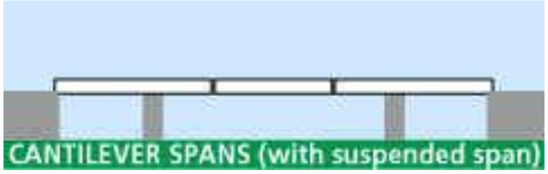
The majority of bridges are held up by at least two supports set in the ground. The distance between two adjacent supports is called a span of a bridge. The supports at each end of the bridge are called abutments, and the supports that stand between the abutments are called piers. The total length of the bridge is the distance between the abutments. Most short bridges are supported only by abutments and are known as single-span bridges. Bridges that have one or more piers in addition to the abutments are called multi-span bridges. Most long bridges are multi-span bridges.

In special cases, like in a pontoon bridge no piers or abutments are provided. It is supported by pontoons (flat-bottomed boats) or other portable floats.

There are three main components of a typical bridge in general namely

1) Superstructure
2) Substructure
3) Foundation





1) Substructure:

a) Abutments at the extreme ends of the bridge.
b) Piers at intermediate supports in case of multiple span bridges.
c) Bearings and pedestals for the decking.

2) Foundation:

a) These include foundations for both abutments and piers. Foundations may be of the type open, well, pile, etc.

Apart from the above, river training works and the approaches to a bridge also form a part of a bridge works.

3. Selection of bridge site:

It may not be possible always to have a wide choice of sites for a bridge. This is particularly so in case of bridges in urban areas and flyovers. For rivers bridges in rural areas, usually a wider choice may be available.

3.1 The characteristics of an ideal site for a bridge across a river are:

- A straight reach of the river;
- Steady river flow without serious whirls and cross currents;
- A narrow channel with firm banks;
- Suitable high banks above high flood level on each side;
- Rock or other hard in erodible strata close to the river bed level;
- Economical approaches which should not be very high or long or liable to flank attacks of the river during floods; the approaches should be free from obstacles such as hills, frequent drainage crossing, sacred places, graveyards, or builtt up areas or troublesome land acquisition;
- Proximity to a direct alignment of the road to be connected;
- Absence of sharp curves in the approaches;
- Absence of expensive river training works; and
- Avoidance of excessive underwater construction.

For selecting a suitable site for a major bridge, the investigating engineer should make a reconnaissance survey for about one km on the upstream side and one km on the downstream side of the proposed bridge site and should journey along the road for about one km on either side of the road from the bridge site in order to form a general impression of the landscape and to decide on the type of structure best suited to the site. Care should be taken to investigate a number of probable alternative sites and then decide on the site which is likely to serve the needs of the bridge at the least cost. A brief description of the reasons for selection of a particular site should be furnished in the investigation report along with salient details of alternative sites investigated and rejected.

When the river to be crossed is a meandering river, the bridge should be located at a nodal point, i.e. the location where the river regime is constant serving as a fulcrum about which the river channels swing laterally. To the extent possible, it is desirable to align the bridge at right angles to the river, i.e.to provide a square crossing. Sometimes, a skew crossing which is included to the centre line of the river at an angle different from a right angle has to be provided in order to avoid costly land acquisition or sharp curves on the approaches. A skew bridge usually poses more difficulties in design, construction and maintenance. The location of the bridge in relation to the alignment of the approaches may be decided as below : (a) For bridges of total length less than 60 m, the alignment of the approach will govern; (b) For bridges of total length between 60 m and 300 m, both the proper alignment of the approaches and the requirements of a good bridge site should be considered together in ascertaining the appropriate site; and © For major bridge over 300 m length, the requirements of a good bridge site will govern the alignment.

3.2 Factors to be considered while deciding upon the type of structure for a particular bridge site:

In selecting the type of structure for a particular site, the following factors should be looked into, decided and established:

3.2.1 Geometry:

- Horizontal and vertical clearances available
- Permissible structure depth and support widths
- Scheme for detour or traffic accommodatation during construction period
- Services and utilities including those to be crossed and those to be carried

3.2.2 First cost and ease of maintenance:

- Sub surface conditions available
- Total time of construction
- Construction details - repetitive elements involved in the construction process
- Total cost including approach fills
- Requirements for any future extensions

3.2.3 Safety:

- During construction - to adjacent property, utilities construction-crew, labour and highway/channel traffic
- Minimizing traffic hazard in completed structure

3.2.4 Appearance:

- Similarity to and harmony with adjacent structures
- Extent of blending with the environment
- Use of attractive shapes and surface treatments

3.2.5 In case of waterway crossing - Special requirements to be considered:

- Bridge length, waterway, and pier spacing to accommodate flood discharge
- Backwater effects
- Maintenance of waterway traffic during construction
- Navigational requirements and approvals.

3.2.6 Additional Factors Particularly Associated with Precast Pre-stressed Construction:

- Cost of tooling / additional equipments (framework, cranes etc.)
- Length of production run
- Plant production versus on site production
- Weights of elements
- Transportation and erection costs
- Material production, transportation and erection strategy.

3.2.7 The items which are to be finalized as early as practical are as follows:

- Typical sections and alignment (vertical and horizontal)
- Span lengths and arrangements
- Structure type and span to depth ratios - including type of materials
- Other considerations

3.2.8 Typical Sections and Alignment:

Many bridges are required to be redesigned because of modifications of roadway alignment, changes in the number of lanes, change of waterway clearances, width of shoulders type of kerb and railings, and size of pipelines to be carried. It is necessary that this item be established as early as possible to avoid expensive and time consuming a redesign.

3.2.9 Span Lengths and Arrangement

For grade separation bridges the total length is established by the extent of facility crossing under the structure. Location and type of supports are governed by the foundation conditions, required clearances, safety and aesthetics. Long spans with few supports make the most graceful composition, constitute the least obstruction and are aesthetically more enhancing.

3.3 For river / stream crossings, the span lengths may be dictated by any combination of the following:

- Foundation requirements
- Height of piers
- Waterway area and other hydraulic considerations
- Navigation requirements
- Type of debris expected during flood stages
- Facility of construction
- Economy

4. Conclusions

Before a bridge is constructed, a suitable site is selected based on certain factors which have bearing on the economy and stability of the bridge.

1) At bridge site the reach of the stream should be straight.
2) The site should be geologically sound i.e. it should be away from fault zone, and should have unyielding, non erodible foundation for abutments and piers.
3) At the site, the stream should be narrow with well defined and firm banks.
4) At site the river flow should be without whirls and crosscurrents.
5) At the site there should be suitable high banks above high flood level on each side.
6) The approaches should be economical. They should not bevery high or long or liable to flank attacks of the river during floods. Theyshould be free from obstacles such as hills, frequent drainage crossings, builtup areas, sacred areas as grave yards, or trouble some land acquisition etc.
7) The site should be at reasonable proximity to a directalignment of the road to be connected.
8) There should be no sharp curves in the approaches.
9) Absence of costly river training works, where they are unavoidable they should be executed in dry as far as possible.
10) Avoidance of excessive under water construction work.
11) If it is un-avoidable, necessity for the approaches of the bridge to cross the spill zone of a river, they should (while processing through the spill zone towards the river), face down stream and not up stream. Facing up stream will cause heading up, pocket formation, and danger to the approaches.

Reference Codes

The following is a list of a few selected bridge codes as published by the Indian Roads Congress which may be referred to while designing bridge components so that all the requirements as specified by these codal provisions are met.

[1] IRC:5- 1998 Standard Specifications & Code of Practice for Road Bridges Section

[2] IRC:6- 1996 (reprint 1997) Standard Specifications & Code of Practice for Road Bridges Section II

[3] IRC: 18- 1985 (reprint 1997 with latest amendments) Standard Specifications & Code of Practice for Road Bridges (Post - Tensioned Concrete)

[4] IRC:21- 1987 (reprint 1997 with latest amendments) Standard Specifications & Code of Practice for Road Bridges Section III - Cement Concrete (plain & reinforced)

[5] Victor D.J., "Essential of Bridge Engineering" (2008 Edition)

[6] N. Krishna Raju, "Design of Bridges" (2005 Edition)

[7] http://constructionfield.net/

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