ENCYCLOPEDIA ARTICLE

# Highway bridge

A structure that crosses over a body of water, traffic, or other obstruction, permitting the smooth and safe passage of vehicles. In highway transportation systems, the term "bridge" is usually reserved for structures over bodies of water. However, many other structures are generally considered highway bridges. An overhead is a structure carrying a highway over a railroad, and an underpass is a structure providing passage of a highway under a railroad. An overcrossing is a structure carrying a county road or a city street over a state highway, and an undercrossing is a structure providing passage of a county road or a city street under a state highway. A separation is a structure separating into two state highways. A connector ramp is a structure connecting intersecting highways and roads. An interchange is the group of ramps and structures providing connections for traffic between intersecting highways (**Fig. 1**). A viaduct is an elevated structure carrying a highway over streets, railroads, or other features. See also: Bridge; Highway engineering

**Fig. 1** Aerial view of I-105/605 Interchange in California. (*California Department of Transportation*)

Highway bridges can be made of steel (**Fig. 2**), concrete (**Fig. 3**), timber, stone, metal alloys, or advanced composite materials, and may have different structural systems such as girder (beam), truss, arch, cable-stayed, and suspension. See also: Structural materials

**Fig. 2** Steel girder bridge.

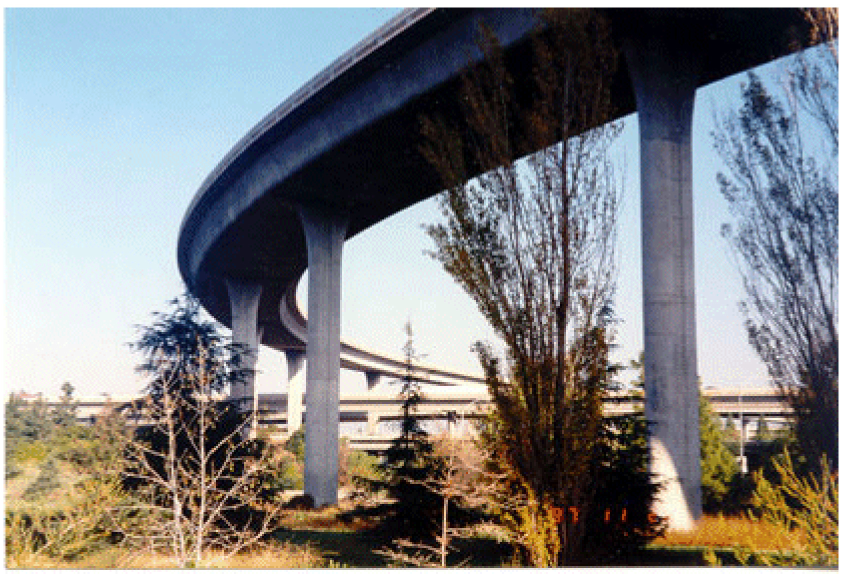

**Fig. 3** Concrete girder bridge.

## Design

Bridge design is a combination of art and science. Conceptual design is usually the first step. Before any theoretical analysis and detailed design proceeds, the designers visualize the bridge in order to determine its function and performance. The conceptual design process includes selection of bridge systems, materials, proportions, dimensions, foundations, esthetics, and consideration of the surrounding landscape and environment. A bridge may be straight or horizontally curved, or have skewed supports. The width of a highway bridge is determined by the number and width of the traffic lanes and the shoulder or sidewalk width, and is typically the same dimension as the approaching highway.

The selection of bridge type is influenced by many factors such as span length, site geology and foundation requirements, design loads, surrounding geographical features, width requirements, clearance requirement below the bridge, transportation of construction materials, erection procedures, and construction cost and duration. The **table** shows the span lengths appropriate for various bridge types. A bridge is required to fulfill its function as a thoroughfare while blending and harmonizing with its surroundings.

| Types of bridges and applicable span length | | |
|---|---|---|
| **Bridge type** | **Span range** | **Leading bridge and span length** |
| Prestressed concrete girder | 10–300 m (33–984 ft) | Stolmasundet, Norway; 301 m (988 ft) |
| Steel I/box girder | 15–376 m (49–1234 ft) | Sfalassa Bridge, Italy; 376 m (1234 ft) |
| Steel truss | 40–550 m (131–1804 ft) | Quebec, Canada; 549 m (1801 ft) |
| Steel arch | 50–550 m (164–1804 ft) | Shanghai Lupu, China; 550 m (1804 ft) |
| Concrete arch | 40–425 m (131–1394 ft) | Wanxian, China; 425 m (1394 ft) [steel-tube-filled concrete] |
| Cable-stayed | 110–1100 m (361–3610 ft) | Sutong, China; 1088 m (3570 ft) |
| Suspension | 150–2000 m (492–656 ft) | Akaski-Kaikyo, Japan; 1991 m (6532 ft) |

The final design process involves structural analysis, member and detail design, and preparation of construction drawings and specifications. Structural analysis commonly involves computer models, which use appropriate material properties, member discretization, boundary conditions, and loads. Members and connections joints are proportioned to carry all possible loads (permanent loads, vehicular live loads, wind loads, and earthquake loads), combined and factored in accordance with the requirements of applicable design standards and codes. Two standards are the American Association of State Highway and Transportation Officials Load and Resistance Factor Design (AASHTO-LRFD) Bridge Design Specifications (2004) and AASHTO Standard Specifications for Highway Bridges (2003) in the United States. **Figure 4** shows the AASHTO "design truck." The variable axle spacing between the 145-kilo-newton loads is adjusted to create a critical condition for the design of each location in the structure. Well-prepared construction documents are biddable, constructable, and cost-effective. See also: Structural analysis; Structural design

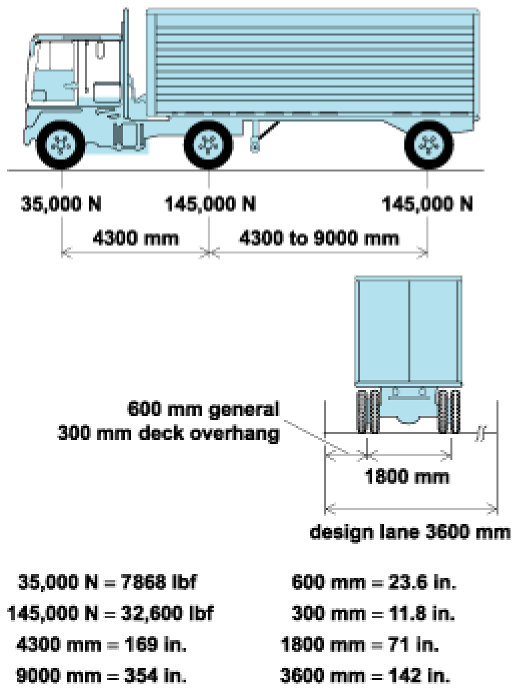


**Fig. 4** AASHTO design truck (load).

## Construction

Bridge construction involves managing the fabrication and erection operations needed for safe and efficient building of the structures in accordance with the construction documents.

A fundamental part of construction engineering is project management (planning, scheduling, and controlling). Planning starts with analyses of the type and scope of work to be accomplished, as well as the identification of construction methods and equipment, and type and size of the work force. Scheduling establishes a sequence of operations and accounts for the interrelation of operations at the job site, as well as allocation of the work force and equipment. Controlling consists of procuring materials in accordance with construction staging, dictating overall construction procedures, engineering inspection, and maintaining complete records of daily operations, payments, and expenditures. Proper planning, scheduling, and controlling prevents costly delays and cost overruns. See also: Construction engineering

## Maintenance

The primary objective of bridge maintenance is to ensure public safety. Proper maintenance also reduces life cycle costs and earns public confidence. Before 1970, components of the United States' highway network exhibited rapid aging. Since then, bridge maintenance programs have evolved into a sophisticated bridge management system.

The Federal Highway Administration (FHWA) requires all state agencies to submit highway bridge data on a Structure Inventory and Appraisal (SI&A) sheet. Bridge data include description of the structure, structural data and history, traffic information, load rating, condition and appraisal ratings, and inspection findings. The information on SI&A sheets is a valuable aid to establish maintenance and replacement priorities, as well as to project the maintenance cost of the highway bridges.

FHWA requires that each public bridge be inspected at a regular interval not exceeding 2 years. Underwater bridge components that cannot be visually evaluated during periods of low flow by tactile means are required to be inspected at an interval not exceeding 5 years. The purpose of the bridge inspection is to obtain the information necessary to properly evaluate the bridge capacity and the adequacy of the bridge.

The major tasks of the bridge inspection are to (1) identify minor problems that can be corrected before they develop into major repairs; (2) locate bridge components that require repairs in order to avoid replacement; (3) identify unsafe conditions, prepare accurate condition reports, and recommend corrective actions; (4) investigate more serious damage and its effect on the structure; and (5) generate accurate bridge records.

## Bridge ratings

The evaluation or rating of existing bridges is a continuous activity of the bridge owners to ensure the public safety. The evaluation provides criteria to repair and rehabilitate superstructures, to issue special permits, and to post, close, or replace the existing bridge.

It is generally believed that when a bridge is designed for the AASHTO design vehicles, and is constructed and maintained in accordance with the contact documents, the bridge will have adequate capacity to handle the actual present traffic. However, changes in details during construction, failure to meet minimum material strength requirements, unexpected settlements of foundation after construction, and unforeseen damage to a member could affect the capacity of the bridge. In addition, old bridges might be designed for a lighter vehicle than the present one, or a different design code.

Sometimes, an industry needs to transport their heavy machinery from one location to another location. These vehicles could weigh much more than the design vehicles, and thus the bridge owner may need to determine the current live-load-carrying capacity, or rating, of the bridge to issue special permits. There are two levels of rating for bridges: inventory and operating. The inventory rating determines the load that can be safely carried by a bridge for an indefinite period. The operating rating reflects the absolute maximum permissible load that can be safely carried by the bridge.

When a bridge is found to have inadequate capacity for design vehicles, engineers look at several alternatives prior to closing the bridge. Possible alternatives include limiting allowable vehicle weight and speed, reducing vehicular traffic volume, restricting vehicles to certain lanes, and recommending repairs to alleviate the problem. In addition, when evaluations show the structure is marginally inadequate, frequent inspections may be recommended to monitor the physical condition of the bridge in the later stages of its life cycle.

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## Additional Readings

- Bridges

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