STRUCTURAL TYPES

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Summary

Basic structural types used in civil and architectural engineering are reviewed from the viewpoint of their load carrying mechanisms. These are illustrated mainly in the case of bridge structures.

1. Definition of Structure

A structure may be defined as 'any assemblage of materials which is intended to sustain loads'. Since the gravity, wind and temperature effects are loads, the living creations and plants are also structures in the broad sense though they may not always intentionally sustain loads. The wings of bat and a spider's web are the typical tension structures, while the increasing thickness of trunk and branches of a tree toward their supports can be explained by the fact that they are subject to bending and compression caused by the self weight and wind force. However, 'structures' dealt with in the present chapter are naturally restricted to 'civil and architectural engineering structures'. 'Structural types' titled above depend on the load carrying mechanisms of the structure and they are varied as illustrated in Fig. 1.

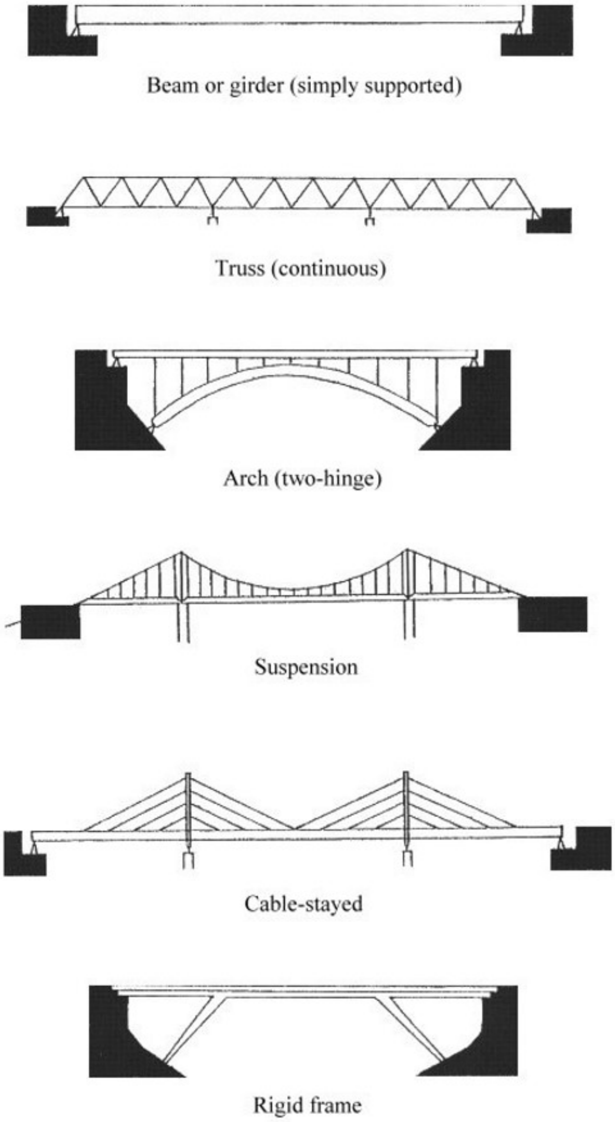

Figure 1: Structural types of bridges

2. Tension Structure

The easiest structural type to think of is a tension structure to resist only tensile force, and of these, the simplest are those which sustain only unidirectional tension as represented by a cable or a thin rod. A cable is the main component of cable supported bridge or suspended roof structures that are classified into suspension and stayed type shown in Fig. 1. Although the load bearing mechanisms are different, the both types have in common the following features:

1. They are generally consisted of cables, deck (in bridge) or roof (in buildings), and towers.
2. The entire structure is much more flexible as compared with other types of structures having the same span length.
3. They look light, elegant and neatly express the given function.

Combination of suspension and stayed cable arrangement, or more complicated cable-net arrangement may be possible though they are not yet popular.

Since structural cables sustaining only tension force are the most effective use of high strength materials such as steels and fiber reinforced plastics, cable-suspended structures can advantageously span very long distance (c.f. Fig. 2). For example, the longest span suspension bridge is the Akashi Strait Bridge (1991m) in Japan at present and the Messina Strait Bridge (3300m) in Italy under planning, and the cable-stayed bridges are now going to exceed 1000m span, while the longest spans of other structural types are les than 600m.

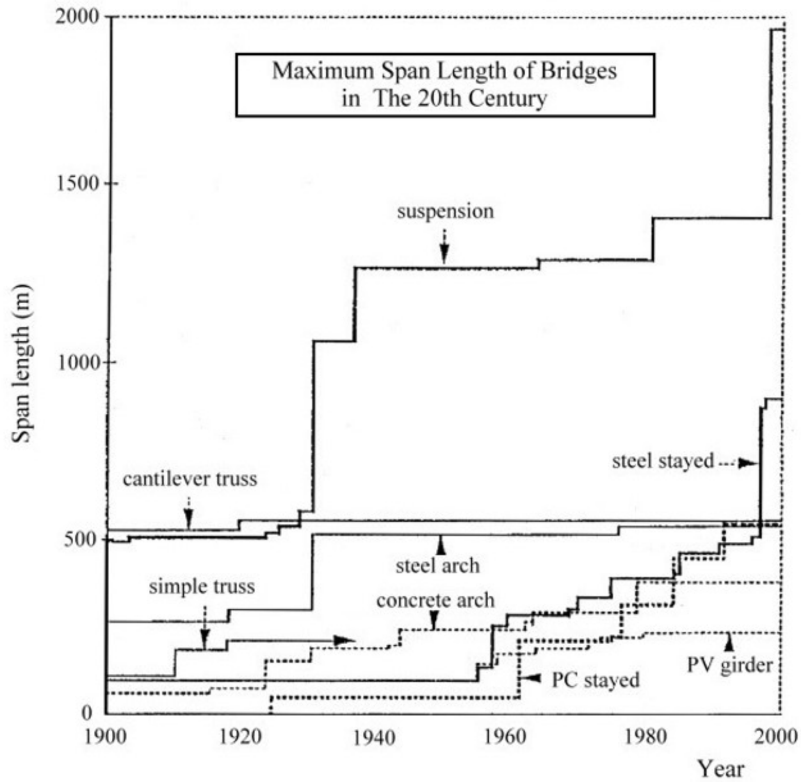

Figure 2: Maximum span length of bridges in the 20^{th} century

A cable is a flexible structural component and changes its form according to external force; e.g. catenary under its own eight, parabola under uniformly distributed gravity loads, and polygon under vertical concentrated loads. Therefore, such stiffening structural component as solid-web girder or truss described later should usually be incorporated to be used for bridges.

Another tension structure extended three-dimensionally is a membrane that is a very thin sheet sustaining only tension. It is used in wide structural application owing to its lightness. When the hems of a membrane sheet are supported by some firm members and further tension stress is beforehand applied, the structural behavior of the membrane is much improved. The roof structure based on the concept of this prestressed membrane is a tent structure having a variety of shapes.

If one or several isolated spaces are enclosed by a membrane, the prestress can be applied by just internal pressure. This constitutes the pneumatic structure (e.g. spherical or lens-shaped air dome). Progress in this area has been outstanding owing to the development of composite materials. The tension structure on the basis of similar principle is a pipe and pressure vessel. Because their shell is subject to tension due to internal pressure from contained gas or liquid, its thickness may be very thin though it is usually made from metals.

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Biographical Sketch

M. Ito, Professor Emeritus, The University of Tokyo, Japan. He taught at three Japanese universities, now a technical advisor at one of the Japanese consulting firms. Specialized bridge engineering. Professor Emeritus of the University of Tokyo, Past President of the International Association for Bridge and Structural Engineering.