# PEDESTRIAN BRIDGES UTILIZING HIGH STRENGTH CONCRETE

Jiri STRASKY
Professor & Technical Director
Technical University of Brno, Brno, Czech Republic
Strasky, Husty and Partners, Brno, Czech Republic

## Summary

Possibilities of structures utilizing high strength concrete are shown on examples of proposed pedestrian bridges. These structures are discussed from the point of view of their architectural and structural solution. Also a process of their erection is discussed.

Keywords: pedestrian bridge; aesthetic; structural concepts; high strength concrete, arch, cable, stress ribbon, suspension structure, shell, prestressing, internal tendon, external tendon.

## 1. Introduction

Present technology is able to produce a concrete of a characteristic strength of 100 MPa without significant problems. Using the high strength concrete in structural members resisting the bending can reduce the amount of material and increase durability; however, it is evident that high strength concrete can bring greatest benefits in structures subjected to compression. The above is evident from Fig.1.a that shows the trajectories of principal stresses in a uniformly loaded simply supported beam. The maximum stresses occur only at mid-span section and only in the top and bottom fibres. The beam has a significant amount of dead mass that does not contribute at all to resisting the external loads. It is waist of high quality of material if we using it for the dead load only.

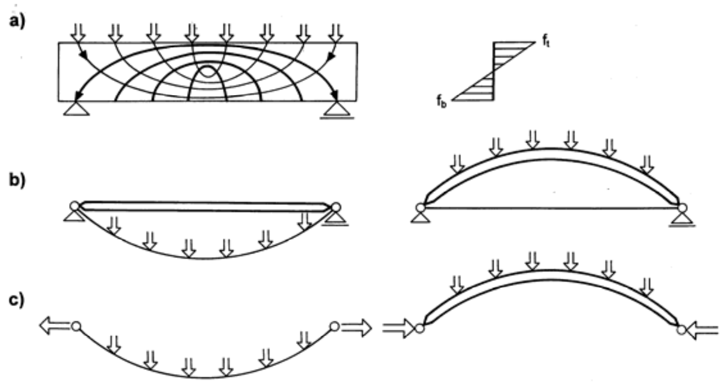


*Fig.1*

From the figure it is clear that if we want to reduce the weight of the beam we have to eliminate as much dead mass as possible and utilize the tension or compression capacities of the structural members. From the beam we can derive a suspension cable or an arch in which the horizontal force is resisted by an internal strut or tie – see Fig.1b; in the case where the foundations are capable of resisting horizontal forces, we can substitute the strut or the tie by stiff footings – see Fig.1c.

Therefore we are trying to develop structures that are primarily stressed by compression stresses. Compression capacity of the high strength structures can be also utilized in directly walked cable structures. It is well known that the cables can be stiffened by dead load, external cables, or by creating a prestressed concrete band (*stress ribbon*) with a certain amount of bending stiffness to guarantee the distribution of local loads and the stability of the overall shape.
The paper describes the following structures:

## 2. Self Anchored Structures

While highway bridges requires straight stiffening girders, pedestrian bridges can have deck in a variable slope. Then compression struts can have a form of the arch and ties can be formed by a cable or a stress ribbon. Following examples present some possibilities.

### 2.1 Johnson Creek Bridge, Oregon

The bridge is formed by a partially self anchored suspension structure of span of 60.80 m. The deck that is in a convex (crest) elevation is supported and post-tensioned by an external cable situated bellow the deck. The deck is assembled of precast segments of a characteristic strength of 80 MPa. Although the deck has an average thickness of 120 mm only, a detailed static analysis has proved that the structure has satisfactory response both for pedestrian and wind loading.

### 2.2 Bridge across the Freeway R3508 near Olomouc, Czech Republic

The bridge is formed by a stress ribbon of two spans that is supported by an arch. The stress ribbon of the length of 79.2 m is assembled of precast segments supported and post-tensioned by external tendons. The geometry of the structure, the load and level of the post-tensioning are designed in such a way that horizontal forces in the stress ribbon and in the arch have the same magnitude. Since the arch footings and stress ribbon anchor blocks are connected by compression struts, the bridge functions as a self anchored structure that loaded the footing by vertical reactions only.

### 2.3 Harbor Drive Bridge, San Diego, California

The bridge is formed by a curved deck that is suspended on inner edge on a suspension cable. The cable is supported by an incline pylon. The span length of suspended spans is 2 x 53.65 m; the plan radius is 170 m. The deck is connected with stairs and ramps to lifts situated on both sides. To reduce the size of structural members and reduce the amount of strands forming the suspension cable, both the deck and pylon are designed from high strength concrete of the characteristic strength of 70 MPa.

### 2.4 Tied Arch Shell Structure

The bridge is formed by a shell of a span of 62 m on which a slender concrete deck is suspended. The shell that is created by projection of two cylindrical shells creates a diagonal arch shell. To check our analysis and find the ultimate capacity of the structure a model of the arch shell in the scale 1:20 was made – see Fig.2. The shell was cast from a high strength concrete of a characteristic strength of 150 MPa.

*Fig.2*

## 3. Earth Anchored Structures

Possibilities of the earth anchored arch and suspension structures are presented on the following examples.

### 3.1 Leamouth Pedestrian Bridge, London, UK

For a design competition for the Leamouth Pedestrian Bridge we developed a three hinge arch in which a deck and supporting structural member form one structure. The span of the arch is 105 m; the rise of the arch is 10.3 m. Since the bridge forms a three dimensional sculptural structure that is primarily stressed by compression, we have worked out a study using an inherent quality of concrete - high compression strength, monolithness and plastic richness.

### 3.2 Study of the Long Span Stress Ribbon Structures

Recently we have also done a very detailed parametric study of the stress ribbon structure of the span of 198 m. The deck was suspended on bearing tendons situated inside the cross section and post-tensioned by external tendons. Four different arrangements of external tendons were investigated: A - tendons were situated directly under the deck, B tendons were situated on both sides of the deck and follow the shape of the stress ribbon, but in a plan they have the shape of a the second degree parabola. C - tendons have the shape of inclined suspension cables, D tendon is situated in the bridge axis below the deck.

## 4. Credits

The Arch Shell Bridge was developed in collaboration with Cezary Bednarski, London, the design of the Leamouth Pedestrian Bridge in London was done in collaboration with Jan Kaplicky, London. The Harbor Drive Bridge is being designed by T.Y.Lin International, San Diego in a collaboration of Strasky + Anatech. The parametric studies, development of the *TERCON* concrete and model tests were performed at the Faculty of Civil Engineering of the Brno University of Technology, Czech Republic. The paper was prepared with the financial support of the Ministry of Education, Youth and Sports, project No. 1M680470001, within activities of the CIDEAS research centre.