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CENTRAL CLAIMS

A network arch with a simple slab lane usually saves half the steel compared to equal spans.

In the future, the world's most slender arch bridge will most likely remain a network arch.

FUNDAMENTALS

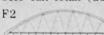
For trusses and tied arches esthetic reasons

F1 GTTTTTTTTTTTTT

limit the distance between upper and lower chord.

Thus saving of weight can be achieved mainly by reducing bending and by avoiding a high length/depth ratio of compression members.

The most economical diagonals are tension members. When there is live load on part of the span, tension members can relax (dotted



......

lines) and thus transform part of the truss into part of a bowstring arch with inclined hangers.



STEEL WEIGHTS OF ROAD BRIDGES BOLSTADSTRAUMEN BRIDGE, Norway 600 B Weights of network Cable-stayed 400 = University of Houston, 1978. Weights of other bridges from: Max Her-zog: Stahlgewichte mo-200 \$ Structural steel 44t Prestressed steel 7t derner Eisenbahn- und 3 Strassenbrücken, Der Span 100 200 300m Stahlbau 9/1975.

same maximum force.

For ease of fabrica-

tion the arch should be

part of a circle. This

also contributes to e-

qually small max. bend-

ing moments along the

The lane should be a

slab spanning between

the concrete edge

beams, which can be

enlarged to act as traf-

fic barriers protecting

the hangers. These

beams contain the pre-

stressing cables that

counteract the tensile

force in the lower

edge beams.

chord.

When many hangers

relax bending moments

in the chords are big-

ger than when the span

acts like a truss. The

normal forces in the

chords, however, are

smaller than maximum

because the live load is

only on part of the span.

To avoid too big

bending moments due

to relaxation of han-

gers, hangers must not

be too steep. To avoid

too great distances be-

tween points of sup-

port more hangers can

be introduced. This will

allow more slenderness

in arch and lane. The

reduction of chord

depth greatly reduces

OPTIMAL DESIGN

High-strength materials

should be used. Hangers

secondary stresses.

F3

should be placed equi-ERECTION distantly along the arch The two network archand along the middle es in Norway were portion of the lane. F5. built on a timber struc-This gives the best supture resting on wooden port of the arch and piles, see photo. Cableminimum bending mostayed erection has ments in the chords. F4 Further all hangers can have the same crosssection, and nearly the

been used many times in Japan.

Better still it seems to utilize the fact that the arch and hangers of the network arch, supplemented by a temporary lower chord, will have enough strength and stiffness to support the lane while it is being cast. This temporary steel structure can be floated into place or lifted into place by big cranes.

In cold climates ice can be used for erecting or moving the temporary structure.

25×3.9m F5 A B

83.75 m/2

Length of span

Depth of arch and lane

Per Tveit, dr.ing.

Built 1963

Aalborg University Centre, Denmark

Ξ

05

83.75

.5 + .42

91

LATEST RESEARCH Two bridges, F5, A and B, having the same cross-sections and spanning 200 m, have been designed according to Danish codes to study optimal arrangement of hangers.

Slenderness =

Nonlinear calculation showed that the tension in the lower chord caused a 15-20% reduc- structural steel, 192t tion of max. bending in the edge beam. The hanger arrange-

ment A gave 8% smal-

ler bending moment in the edge beam, 2% smaller max, stress in the arch, and 9% smaller max. hanger force. For bridge A live load on half the span with many hangers relaxing. is about equally critical for the arch as max. load on the whole span. Steel weights are 416t prestressing steel, 62t ribbed bars. Complete calculations will be published later.

F6 038.0451.3m/2 Hangers ($A = .0015 \text{ m}^2$) 01% .016 $15 \, \text{m}/2$.6/2.£ £ Arch and lane cross-sections

< III -</p> POSTERS

NETWORK ARCHES Per Tveit, dr.ing. Aalborg University Centre, P.O. Box 159, DK-9100 Aalborg, Denmark

Network Arches Made Exclusively from Concrete

In Vienna several engineers, most of them from Austria, asked why I was using steel in the arch of network arches, when stresses due to axial forces were about 9 times as big as the bending stresses. I answered that I had been using steel because I was afraid of high costs of scaffolding. Since the arch of a network arch is relatively light there is not much money to be saved by replacing the steel by concrete. The arch bridge with inclined hangers is the forerunner of the network arch. In the twenties and thirties concrete arches were used for more than 70 of these bridges.

While listening to the session on "Trends in big bridge engineering" it struck me that network arches with arches made of concrete could be competitive for long bridges like the "Long Key Bridge" and the "Seven Mile Bridge". For each span it would be best to cast the lane slab and traffic barriers in one piece reinforced in two directions by means of pre-tensioned wires. See fig. 1. To cut scaffolding costs it would probably be best to cast elements of arches with pre-tensioned windbracing on the ground. Joints would have to be cast after the arch elements were put in place above the lane.

Preliminary calculations for a 100 m span carrying a 10 m wide lane give .42 m³ concrete ($f'_{ck} = 50 \text{ N/mm}^2$) and 70 kg steel, mostly wire, per m² of lane. Such a span would weigh about 1000t, and after installing of hangers they can be lifted from the prestressing bed and rolled sideways to a quay. If sufficiently big floating cranes are not available for placing the spans on the piers, one pontoon at each end of the span could be used. If the lane of the bridge is to be less than 10m above sea level, it seems economical to slide the spans sideways from pontoons to piers, See fig. 2. During this sliding process, pontoon and pier must be fastened to each other, and the buoyancy of the pontoons must be adjusted to compensate for the shifting of the weight of the span. Finally the hydraulic jacks intended for possible changing of permanent bearings, would be used for removing the steel rail and installing the permanent bearings.

For a long bridge the above arrangement would have these advantages: Low weight and a high degree of prefabrication, which would give low labour and materials costs and good control of workmanship.

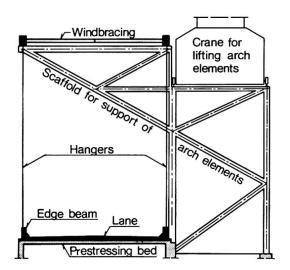


Fig. 1. Cross-sections of rig for casting of the lane, edge beam and joints in arches.

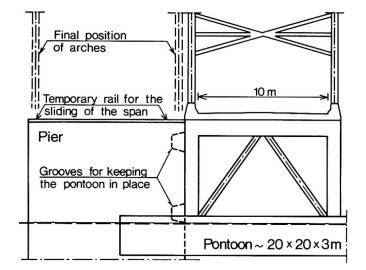


Fig. 2. Pontoon and pier with the span on the pontoon ready for transfer.