Importance of Higher Strength Steel Wire in Ultra Long Span Designs

William C.BROWN
Manging Director
Brown Beech & Assoc.
London, UK

Stafford CRAIG
Consulting Engineer
Brown Beech & Assoc.
London, UK

Summary

Studies in preparation are showing a requirement for ever increasing spans. The Messina bridge design has a clear span of 3300m and has demonstrated that the inherent aerodynamic problems associated with longer spans can be efficiently overcome. This work looks into the performance of bridge wire for such spans and beyond to demonstrate the advantages of enhancing current wire properties.

1. The influence of cable size on span

Practical considerations would indicate that a single cable diameter of around 1.25m is a reasonable limit in size to ensure good quality compaction. Thereafter multi cables - 2 or perhaps 3 at each side of the bridge will be required. (For a variety of sound reasons, only lines of cables at the sides of the deck should be seen as practical solutions for long spans). Thus the maximum weight may be seen in fig.1 as multiples of 8 tonnes/metre i.e. 16, 32, 48 etc., with the cost per metre of bridge rising accordingly.

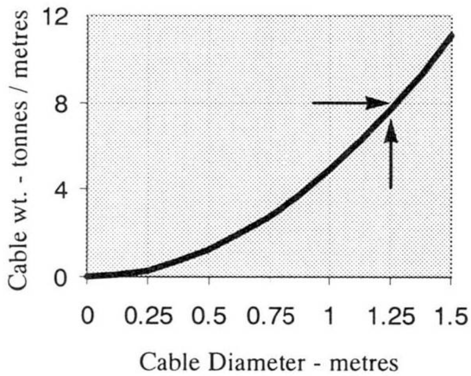

Fig 1 - Relationship of Cable Weight & Diameter

Next we have to look at what this means in terms of span, wire quality, traffic loading, deck weight and most importantly, aerodynamic stability.
Following the loss of the first Tacoma Narrows bridge, deck weights have tended to increase with span, principally to overcome problems associated with aerodynamics. A notable exception was the introduction of the Severn box in 1966 and now the design for the 3300m Messina Crossing has again reversed this trend. With its inherent stability, it sets a pattern for the future ultra-long crossings.
For the purposes of this note the suspended dead weight per traffic lane, including surfacing is therefore taken as 2.5 tonnes/lane. With a minimum of 6 lanes, this gives a deck weight of 15 tonnes/metre of bridge or with live load, 20 tonnes/metre. These are practical objectives for a stable steel deck following the Messina example.

2. Wire strength

However, the suspended structure and traffic has to be carried by the steel cable wire, with the available residual capacity after supporting its own weight and maintaining appropriate reserves for safety and durability. The quality of wire is clearly important. Fig. 2 indicates the influence of span and sag on residual capacity for current production wire (160 kg/mm2). The optimum value of the sag to span ratio depends on several influences - material, seizmic conditions etc but can be expected to lie between 1:10 - 1:11 (Messina for example is set at 1:11) and for this purpose of comparison is taken as 1:10.5.

We can now see the effect of varying the wire strength as shown in fig.3. This demonstrates the clear advantage of higher strength wire in the longer spans. A further refinement is to curtail wires over portions of the span where the force is less in the central region. The effects are shown and become more significant for the larger spans.

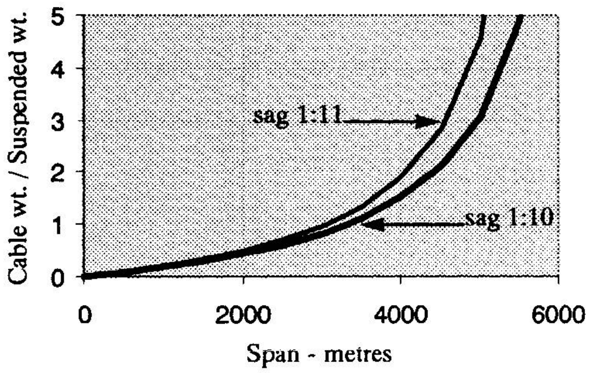

Fig 2 - Influence of Wire

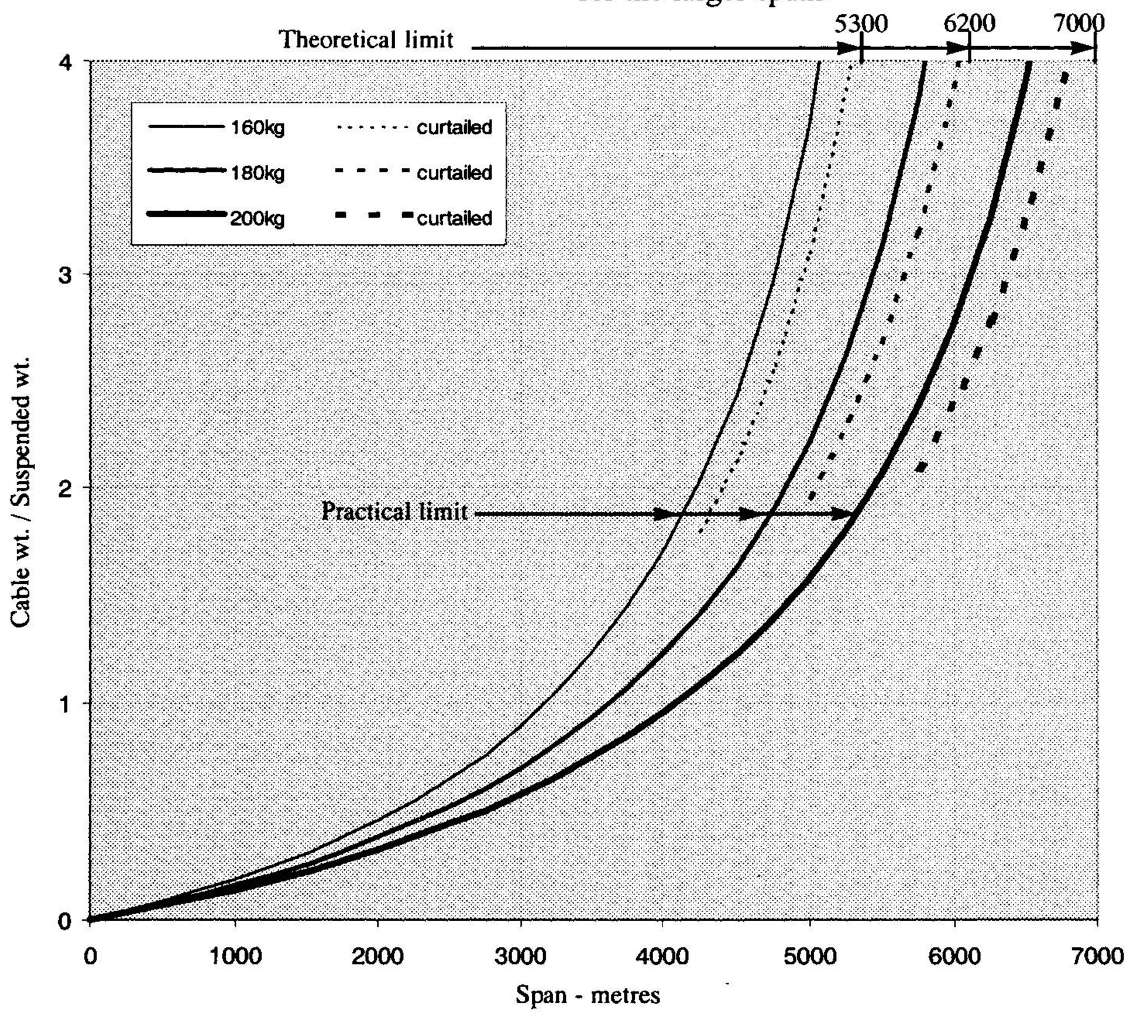

Fig 3 - Influence of Cable Strength