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Extreme Span Suspension Bridges — Structural Systems

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With increasing spans the self weight of the main cables of a suspension bridge plays a more and more dominant role in relation to the total load. Thus, it is essential to choose a sag/span ratio near the quantatively optimized value in order to minimize the amount of cable. This value is generally considerably higher than the value chosen to give adequate stiffness /1/.

In general considerations regarding total cost and deflections will lead to opposite requirements to the sag/span ratio. In the research project described in /2/ it is shown that this effect becomes even more pronounced for extreme spans, such as the 3000 m span investigated. Thus, the traditional way of reducing the deflections through choice of a smaller sag will, in this case, significantly affect the total economy.

The present investigation deals with the problem of improving the deformational characteristics of suspension bridges with extreme spans by modifying the conventional structural system.

The investigation shows that a system with a longitudinally fixed stiffening girder and a central node clamping the main cable to the girder at midspan and having a sag/span ratio of 1:9 will give the same deflection under the critical asymmetric load as a conventional system having a sag/span ratio of 1:12. This leads to a saving in the total amount of steel of approximately 100,000 tons (measured as the equivalent quantity of structural steel), corresponding to saving in the magnitude of 250 million dollars for a bridge with a 3000 m main span. Compared to this saving, the cost of clamping the main cable appears to be negligible.

In the investigation it is also shown that the ratio between the torsional and the vertical frequencies will increase with increasing sag, thus improving the resistance against flutter.

The present investigation forms part of a research project on bridges with extreme spans /2/. The project has been sponsored by the Cowi Foundation and carried out at the Technical University of Denmark in collaboration with Cowiconsult, Consulting Engineers and Planners, Copenhagen.

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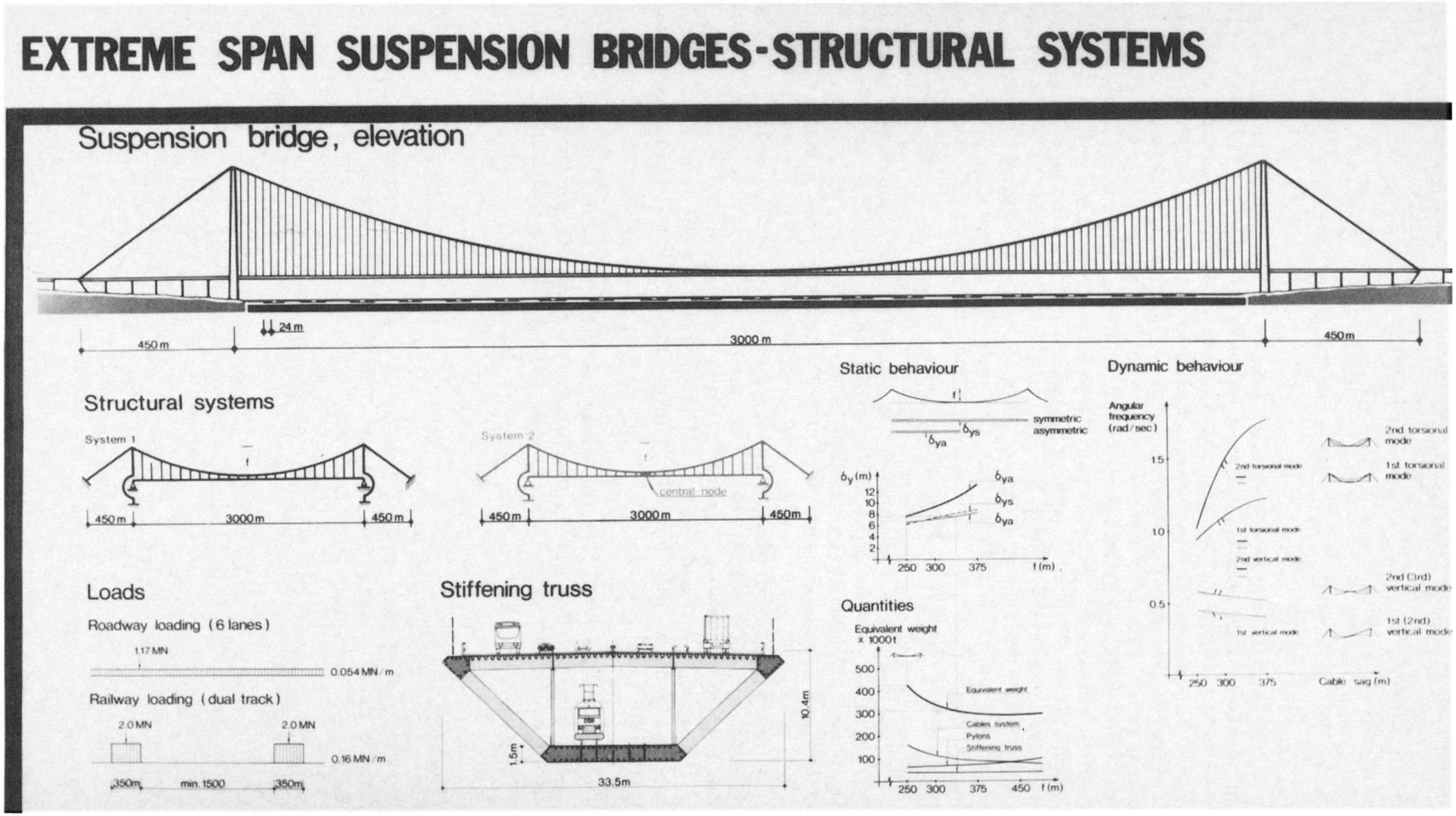
/2/ Niels J. Gimsing, Anders Borregaard Sørensen: Investigations into the Possibilities of Constructing Bridges with a Free Span of 3000 m. Report No. 168, Dept. of Structural Engineering, Technical University of Denmark.


EXTREME SPAN SUSPENSION BRIDGES-STRUCTURAL SYSTEMS
Suspension bridge, elevation
24 m
450 m
3000 m
450 m
Structural systems
System 1
450 m
3000 m
450 m
System 2
central node
450 m
3000 m
450 m
Loads
Roadway loading (6 lanes)
1.17 MN
0.054 MN/m
Railway loading (dual track)
2.0 MN
2.0 MN
0.16 MN/m
350m
min. 1500
350m
Stiffening truss
10.4m
1.5m
33.5m
Static behaviour
symmetric
asymmetric
250 300 375 f (m)
Quantities
Equivalent weight x 1000 t
500
400
300
200
100
Equivalent weight
Cables system
Pylons
Stiffening truss
250 300 375 450 f (m)
Dynamic behaviour
Angular frequency (rad/sec)
1.5
1.0
0.5
2nd torsional mode
1st torsional mode
2nd (3rd) vertical mode
1st (2nd) vertical mode
250 300 375
Cable sag (m)