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Prestressed Concrete Bridge with Tendons of Large Eccentricities

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Summary

A model favorable in structural behavior and ease of construction was created based on a design rationale selected for prestressed concrete (PC) girder bridge with external tendon of large eccentricity. For a self anchored suspension PC bridge, possible minimum values were derived for girder depth, area, section modulus, tendon sag and prestressing force. For this type of structure a span length of about 180 m was found to be favorable. A finite deflection analysis suggested that ultimate state of 1.7 times (Dead load+ Live load) is not attained for span lengths larger than 180 m. Load test results for reduced scale specimen were satisfactory for preliminary plans and tests are being continued.

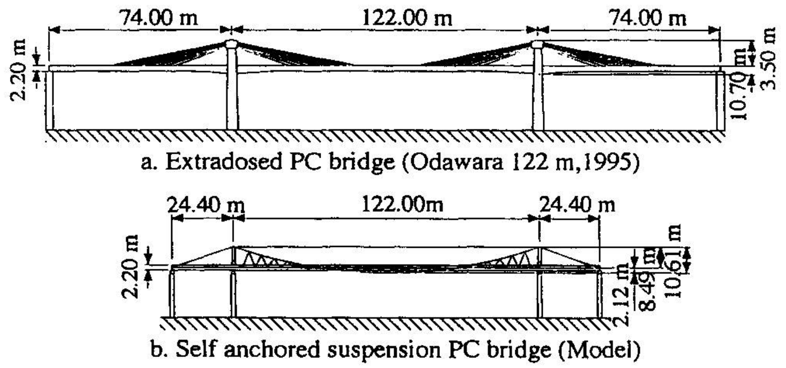

Fig.1 Prestressed concrete (PC) bridges with tendons of large eccentricity

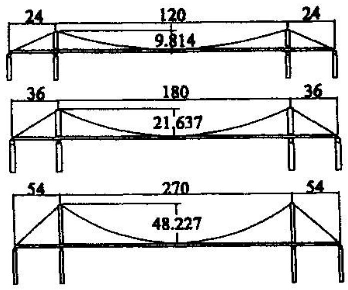

Fig.2 Structure profile shapes derived by stated rationale for varying span lengths

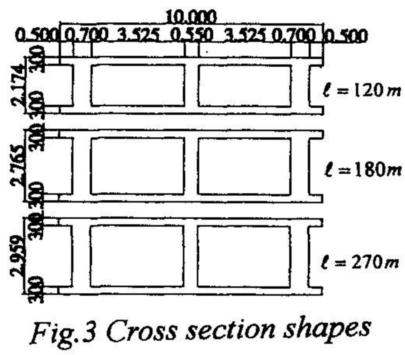

Fig.3 Cross section shapes

1. Proportioning the structure for service load

A model chosen was mono-cable self-anchored PC suspension bridge (Fig.1,b). For an assumed live load of 4 kN/m^2, requirements set for proportioning were; (1) deflection due to live load is 1/1000 of span, (2) maximum fiber stress in concrete beam under extreme moments is 10MPa, (3) ultimate tendon strength is 1900MPa. In a simplified response model the assumptions were; (1) cable profile shape is parabola and remains as parabola after deflection, (2) cable and beam deflection is same at span center only and compatibility is ignored elsewhere, (3) and thus the beam is loaded downward by uniform design load and upward by uniform load from cable.

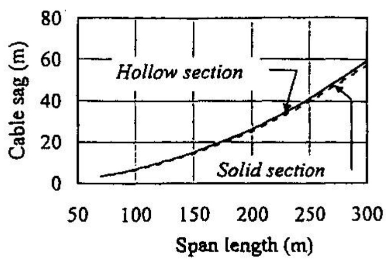

Fig.4 Cable sag

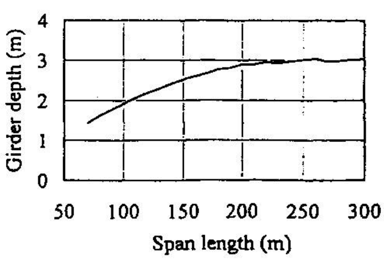

Fig.5 Girder depth

2. Structural characteristic obtained

In view of results shown in Figs.2 through 7, a proportion for a span length of 180m is found to be favorable in terms of response to service load and construction method. A stress increase due to live load in tendon was 7% of initial tension (Fig.6). Tendon is composed of 335 of 15.2mm strands and initial tension is 51,100kN (0.6 times the ultimate). A girder depth of 2.765m (Fig.3) and a height of deviator tower of 21.6m (Fig.2, span-sag ratio is 8.32) are favorable for current state of practice of construction method.

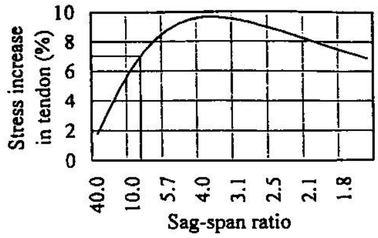

Fig.6 Stress increse in cable due to live load

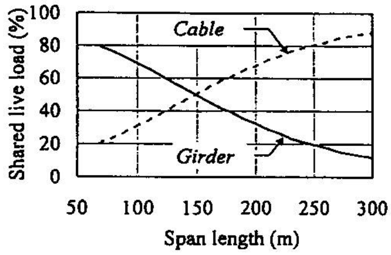

Fig.7 Load shared by girder and cable

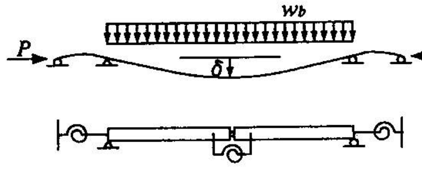

Fig.8 Mechanics model for deflection analysis

3. Finite deflection analysis for ultimate

An assumption of load sharing between cable and beam is same as stated before in Section 1.
An analysis model is as shown in Fig.8. Load carrying capacity of the beam is reduced by axial force component of prestress as deflection increases. However, ultimate strength of 1.7 times (D+L) is attained for span length of 180m as seen in Fig.9.

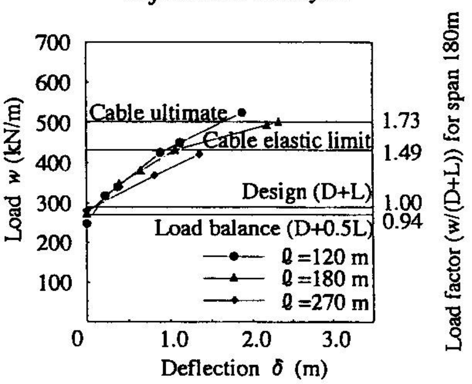

Fig.9 Load vs deflection by finite deflection analysis

4. Load testing model

Similitude of 1/24 scale model (Fig.10) was true for sag-span ratio and girder depth, but it was violated for girder cross section area and section modulus (by factors not exceeding 2) and prestress. For elastic range of tendon, response to load was satisfactory to prediction including deflection (Fig.11) for preliminary stage of test plan.

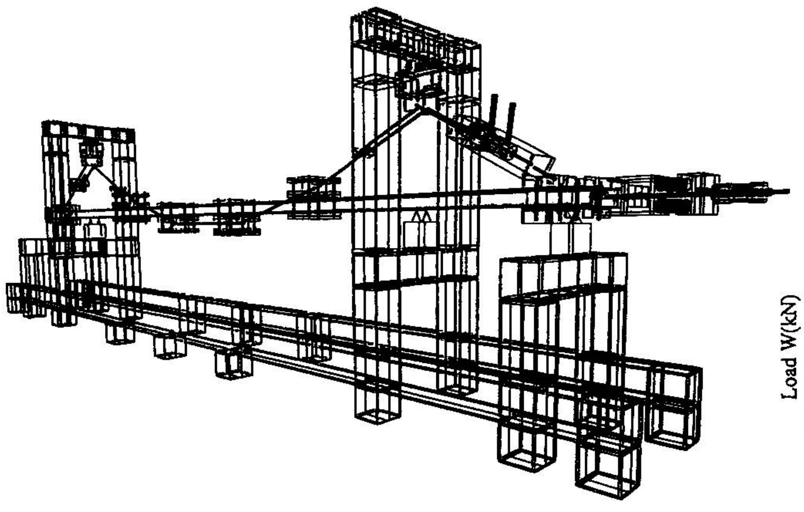

Fig.10 Scheme of load test apparatus (scale 1: 24)

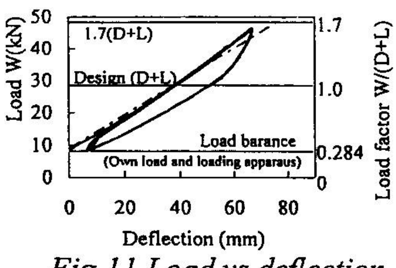

Fig.11 Load vs deflection