Abstract

3-D analyses of CMA in prestressed concrete bridge decks

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One of the most important questions that designers all over the world are dealing with is the safety of the old structures. In the Netherlands, there are a large number of transversely prestressed bridge decks that were built in the last century and need to be investigated for their reserve capacity, if any, against the modern traffic loads. The shear capacity as prescribed by the codes is more conservative in the recently implemented EN 1992-1-1:2005 (CEN 2005) than in the Dutch NEN 6720:1995. As a result, many existing bridges are found to be critical in shear when assessed using the Eurocode. Traditional methods of bridge design are based on conservative flexural theories and it has been discovered that under concentrated wheel loads, the deck slabs mostly fail in punching shear mode rather than the flexural mode. Such behavior is attributed to the development of compressive membrane forces arising from the lateral restraint in the deck slab. Therefore, a 3-D non linear finite element analysis of a 1:2 scale model of a transversely prestressed concrete deck slab between concrete girders under concentrated loads was developed in TNO DIANA 9.4.4 software package to investigate the bearing capacity and to study the development of compressive membrane action (CMA) throughout the loading history. An experimental research was also carried out in the laboratory on the same model.

Six typical cases from the experiments were simulated and it was found that the ultimate load carrying capacity was much higher than predicted by various codes and theoretical methods that do not consider the effect of CMA. The load–deflection behavior, the cracking pattern, the development of compressive membrane forces and the affect of various parameters, like the transverse prestressing level (TPL), the type and position of the loading etc on the bearing capacity were studied. A comparison with the experimental results was also made and satisfactory results were obtained that validated the FEM model.