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Fatigue Tests for Predicting the Serviceability of Composite Bridges

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Summary

This paper abstract presents a part of a Ph.D. work on the fatigue behaviour of cracked RC slabs. It aims at verifying the fatigue resistance of slabs cast in situ and presenting cracks due to restrained shrinkage, as is the case of many composite bridges. The paper mainly treats the influence of cracks on the general behaviour of slabs, on stress distribution in steel bars after failure and on shear transfer mechanisms near through-going cracks. The experiments performed and the results are presented on 6 slabs constitute a major part of this study.

Keywords: Fatigue – reinforced concrete – slabs – tests – crack – serviceability – restrained shrinkage - composite bridges.

1. Introduction

This paper presents the ongoing research of a Ph.D. thesis at the "Ecole Nationale des Ponts et Chaussées" sponsored by Jean Müller International representing ASFA (French highway agencies association), the French road administration, the French Railway Company (SNCF), and the LCPC. Transverse cracks were observed on a significant number of composite bridge slabs. These through-going cracks appear at an early age with low concrete strength and considerable shrinkage. The connections between the steel girders and the concrete slab create tensile stresses exceeding the concrete strength. This study deals with inflection point zones where the shear forces due to heavy traffic are high. In these area the crack spacing variation is 0.25-0.50 m. The crack width were often 0 to 0.3 mm and sometimes 0.5-0.6 mm. A test program was established to acquire data regarding the influence of transverse cracks on the behaviour of slabs. Six RC slabs were tested to estimate the fatigue safety margin and the shear transfer degradation mechanisms: aggregate interlock, dowel action, fatigue of steel bars near transverse cracks.

2. Test presentation.

The experimental program included tests on six 5000x2900x180 mm RC slabs. The slabs were simply supported on two steel beams 4500 mm in length. The transverse and longitudinal steel bar ratios were respectively 1.2% and 0.6% of the concrete section. The characteristic strength of this concrete is 35 MPa. The initial state of damage is obtained by a tensile test conducted seven days after concrete is casting. This test allows the control of the crack width. Four parallel jacks

applied a uniform tensile. Longitudinal rigidity of the slab was deduced from LVDT sensors. The widths required were 0.5 mm for the first five slabs and 0.3 mm for the sixth. At the end of the test, when the steel bars were plasticised, the cracks had variable width and a 150-300 mm spacing. The consecutive load cycles reduce the longitudinal rigidity to the steel bars. The position and the spaces between the cracks were influenced by the presence of the steel bars.
A dynamique jack, shown in figure 1 applied the fatigue load. The load is concentrated on a steel plate between two major cracks. A the cyclic load representative of heavy traffic was applied on the first two slabs, varied from 10 kN to 86 kN. This load was repeated 10 million times representing one hundred years of heavy traffic on a French Highway. A S-N curve is used and helped to reduce the number of cycles by increasing the fatigue load.

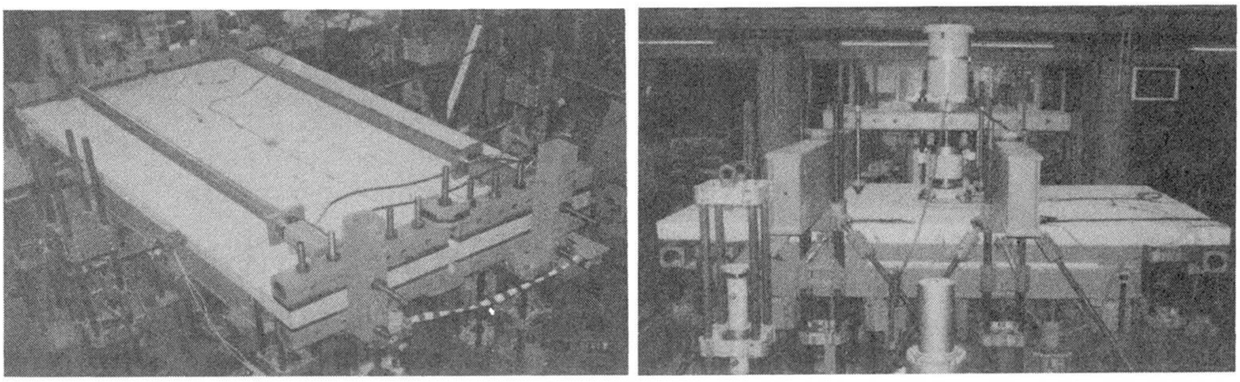

Fig 1: Illustration of tensile and fatigue tests.

3. Results and discussion

For the last slabs the fatigue load was increased up to 160 kN and 200 kN to show failures. No fatigue of shear transfer mechanisms was observed. Flexure is the fatigue failure mode. Figure 2 shows the influence of two steel bar failure on the displacement in the middle of the slab. The failures appeared only in the transverse bars in the middle of the slab. A static test was performed at the end of the fatigue test of the slab 2 and 5. Under static load, the shear load is critical. In the paper the results are commented and discussed.

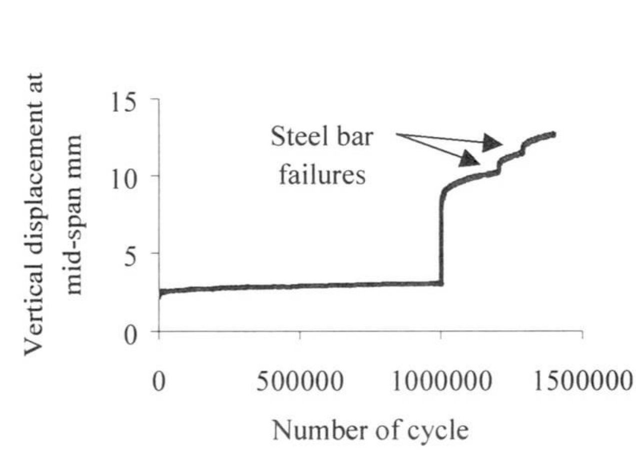

Fig 2-Maximal displacement of the slab 5 as a function of the number of cycles