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Steel-Concrete Composite Arch

Arches mixtes acier-beton

Stahl-Beton-Verbundbogen

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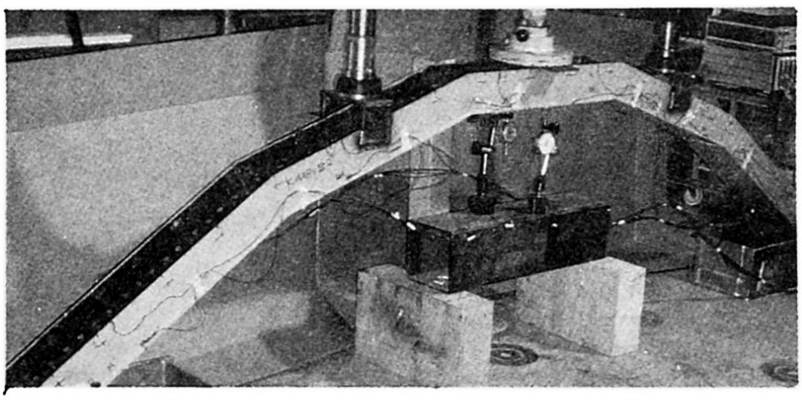
1. INTRODUCTION

Steel-concrete composite structures are widely used as beams, slabs and columns in bridge and structural engineering. Still, as far as the authors know, applications or test results of composite arches are not reported so far. Composite arches have many advantages compared to traditional reinforced concrete or steel arches. The steel section can be used as formwork for concrete and no scaffolding is necessary. The compression capasity of concrete is improved by prevented lateral expansion. Finally, through to bond, even without connectors, a composite action is formed which considerably increases the ultimate load carrying capasity of such an arch.

2. LABORATORY TESTS

To examine the strength and behaviour of steel-concrete composite arches two specimens were tested in the Laboratory of Bridge Engineering of Helsinki University of Technology in spring 1990. The span and the rise of the arches were 3.5 m and 0.7 m, respectively. The cross-section was composed of 6 mm thick steel plates welded together to form a 190 mm wide and 126 mm high U-shaped profile which was filled with concrete (Fig. 1). To the bottom plate 80 mm high studs were attached in pairs at an interval of 100 mm. The side walls were connected by 8 mm diameter threaded steel rods with about 180 mm interval. The structure was hinged at the footings and loaded by three equal point loads at the quater points of the span. The steel grade was Fe 235 and the compression strength of concrete (150 mm cube) was 38.5 N/mm^2 when tested. Vertical deflection at the rise and steel strains were measured.



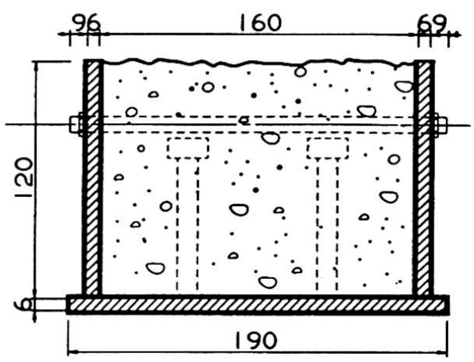


Fig. 1. Loading arrangement and the cross-section of the tested arches.

Test results show a firm behaviour of composite arches to the ultimate load (Fig. 2). The total collapse load of the tested arches was 690 kN and 766 kN, respectively. This means than one arch could easily carry the load of one highway traffic lane. The collapse always occured near the top section between the horizontal rod stiffeners in such a way that the side walls and the bottom slab of the profile buckled out when concrete was crashed due to compression and shear forces (Fig. 3). A light increase of the deflection and strains was noticed just before the collapse.

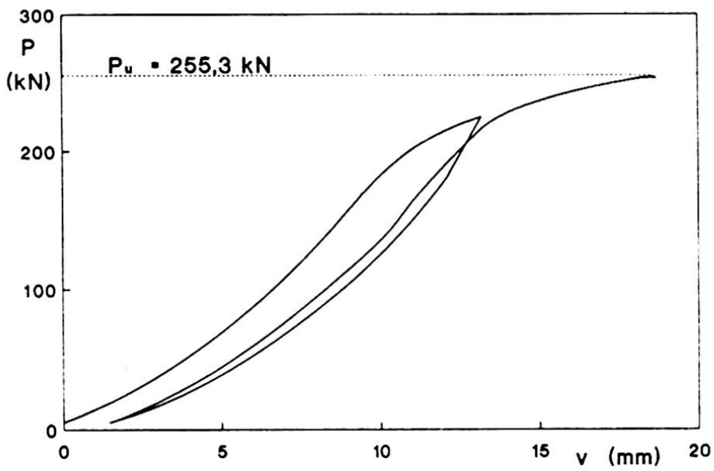


Fig. 2. Mid-span deflection versus load.

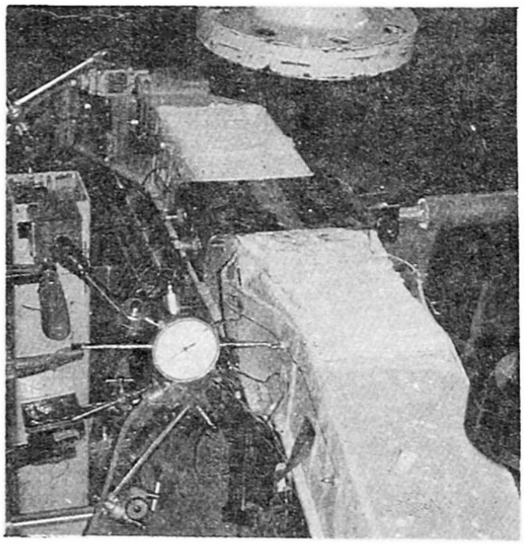


Fig. 3. Typical collapse pattern.

3. APPLICATION

In a recent bridge design competition one proposal, made by a team from the consulting engineering firm Siltatekniikka Oy in Finland, was based on the idea of a composite arch. The span of the arch, which was composed of a steel box filled with concrete, was 260 m (Fig. 4).

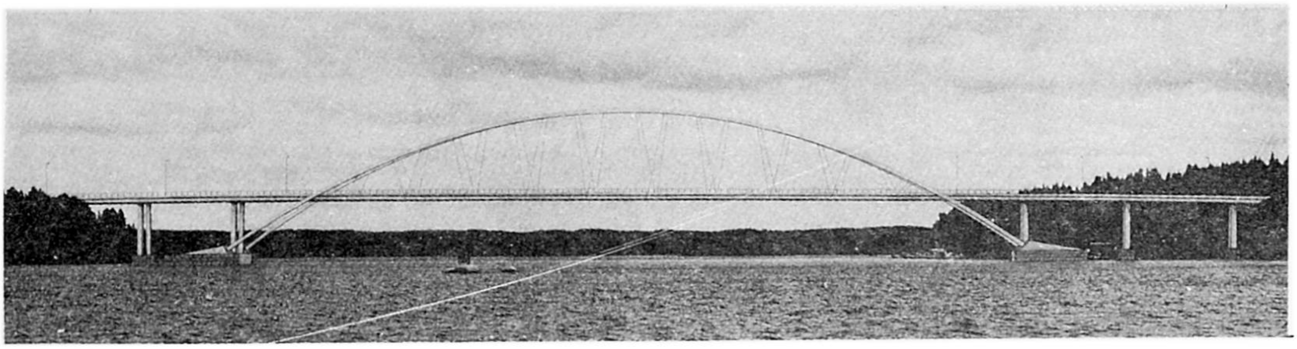


Fig. 4. A proposal for the application of a steel-concrete composite arch.