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13. Alm Bridge in Upper Austria

Owner: Amt der Oberösterreichischen Landesregierung

Design: Hans Reiffenstuhl, Ö. Univ. Prof. Dipl. Ing. Dr. techn.

Contractor: Allgem. Baugesellschaft A. Porr AG

Subcontractor for the post-tensioned reinforcement: Vorspanntechnik Gesellschaft mbH, Salzburg

Subcontractor for the post-compressed reinforcement: Reiffenstuhl Druckspanntechnik Gesellschaft mbH, Salzburg.

In 1977 a 76 m single span bridge for road traffic was built in Upper Austria. The main feature of this prestressed concrete bridge is the use of a new structural element, that of postcompressed reinforcement. It consists of high strength steel bars of round cross section which at first lie unbound in sheaths. After hardening of the concrete and stressing of some of the conventional tendons the bars are stressed in compression by means of hydraulic jacks, then anchored in the structure and grouted.

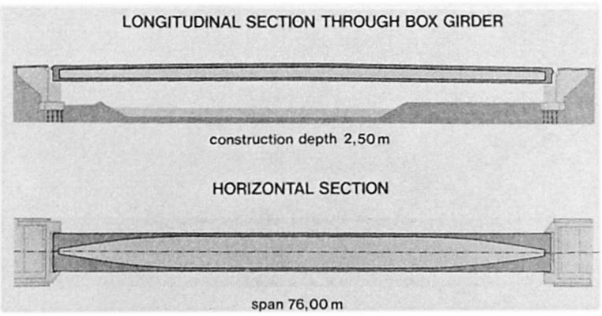

Fig. 1: Alm Bridge, longitudinal sections

Mode of action

The mode of action of the postcompressed reinforcement is shown in fig. 3. The upper and the middle beams develop stresses at midspan under the named effects drawn at the right side of the beams.

The lower beam is armed with postcompressed reinforcement. The compressive force of the high strength steel bar, introduced into the beam by end anchorage (fig. 3) produces tensile stresses uniformly distributed over the depth. The forces due to deflection of the bar push upward and cause bending stresses of the same sign as the bending stresses due to conventional prestressing.

Adequate use of both post-tensioned and postcompressed reinforcement leads to a large bending moment counteracting external loads, with only a small portion of normal force due to prestressing. By means of the postcompressed reinforcement it is possible almost to double the bending moment capacity of a cross section of ordinary prestressed concrete.

Anchorage

Although the option of a combined anchorage of two tendons and one compressed bar in one plate was available, single anchorage of each compressed bar was chosen for the reason of easy access. (fig. 4)

The compressed bar (diameter 36 mm S 1080/1320) transfers its force by means of a thread and nut into the anchor plate. The plate is fixed in the beams's concrete by means of 8 buttonheaded cold-drawn stressing steel wires (diameter 12.2 mm, S 1370/1570 with undulated ends). The anchorages of the postcompressed bars have to be placed in such a manner that they cannot push out the surrounding concrete. This is easily done, e.g. by setting the anchorages of the bars between anchorages of tendons. The anchorage used in the Alm bridge is designed for 13.5 MN ultimate load.

Fig. 2: Completed bridge

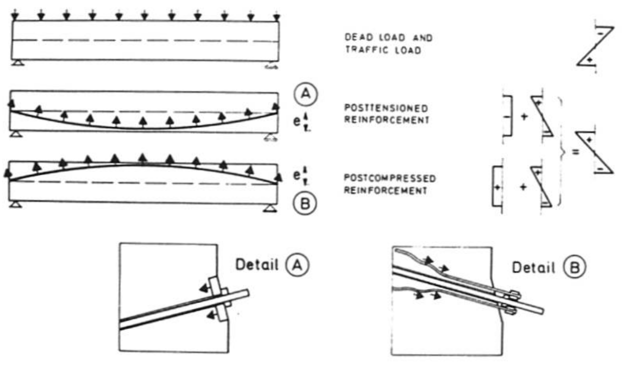

Fig. 3 Mode of action

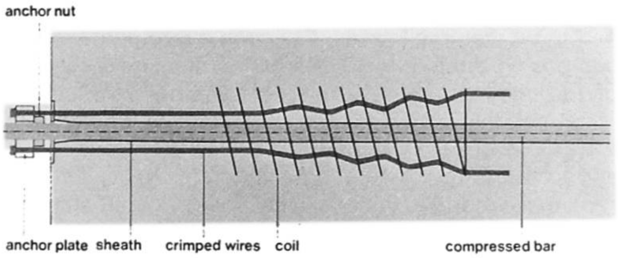

Fig. 4 Anchorage

Friction of the compressed rod in the sheath

The dominant demand for groutability of the sheath does not allow narrow round sheath which would be satisfactory with respect to friction and buckling stability of the highly compressed bar. Intensive investigations led to a specially swaged sheath (patent pending). It is made of an ordinary sheath swaged locally to an oval shape in such a way that the minor axis of the oval allows only very little lateral play to the bar. The minor axes of two successive ovals are perpendicular to each other. The distance between two corresponding swagings is much less than the buckling length of the bar. These equally situated swagings are so closely spaced that a reasonably curved bar under compression does not notably deflect to form a wave line, and thus a great increase of friction is avoided. Precise swaging is done by a small machine specially designed for this purpose.

Significant data at midspan

bending moments	
dead weight (structure)	M=142.6 MNm
dead load (cantilever caps etc.)	M= 21.4 MNm
traffic	M= 48.9 MNm

Max. Concrete compressive stresses under working loads

under max. working loads:		
after shrinkage and creep	upper fiber	-12.2 MN/m^2
	lower fiber	$+\ 2.0$ MN/m^2
before shrinkage and creep	upper fiber	-13.9 MN/m^2
	lower fiber	$-\ 1.1$ MN/m^2
under dead load and prestress at the time t=0:		
	upper fiber	$-\ 3.9$ MN/m^2
	lower fiber	-14.5 MN/m^2

required concrete quality: 37 N/mm^2 cylinder strength
tendons: 12 strands ½" with 12×0,99 cm^2 cross section
compressed bars: ⌀ 36 mm with 10 cm^2 cross section
prestressing forces at midspan

	t=0	t=∞
tendons	102.4 MN	92.4 MN
compressed bars	43.2 MN	52.0 MN
shrinkage factor		$\varepsilon_s=17\cdot10^{-5}$
creep factor		$\phi=1.80$

(H. Reiffenstuhl)

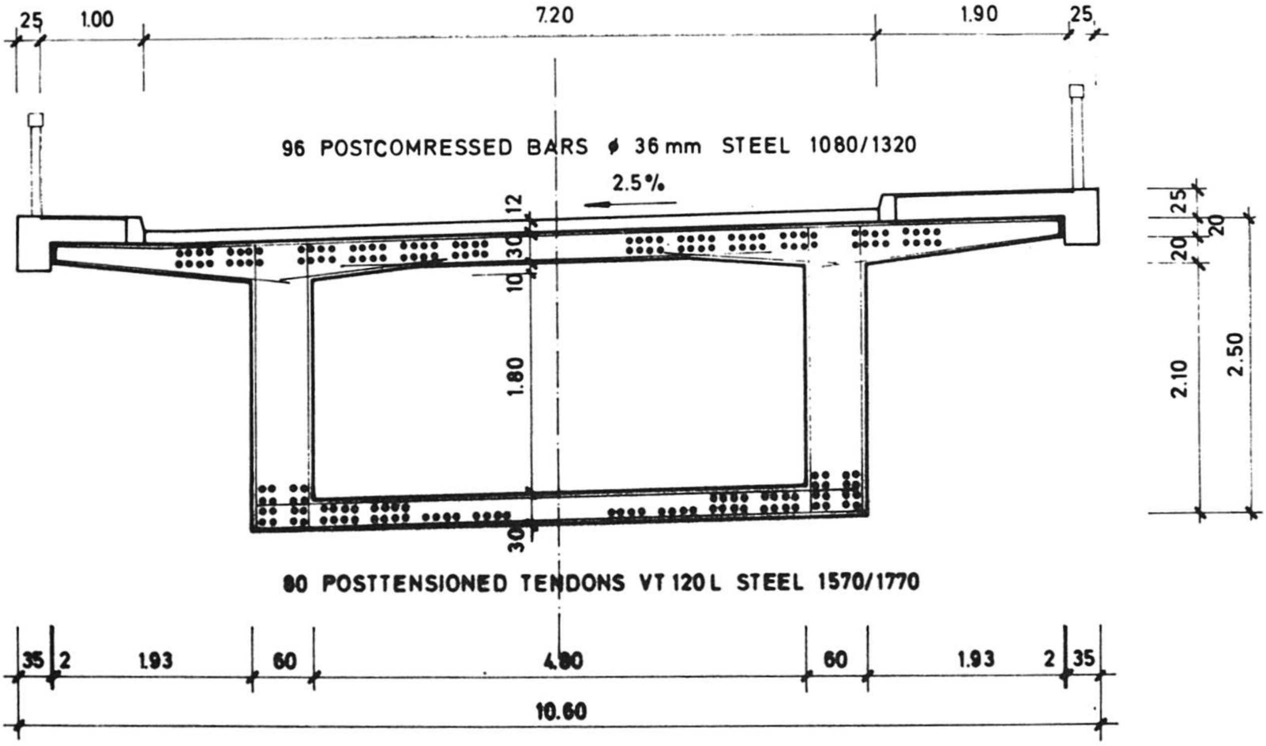

Fig. 5 Cross section at midspan