Effect of grouting on the fatigue strength of post-tensioned concrete beams

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Effect of Grouting on the Fatigue Strength of Post-Tensioned Concrete Beams

Influence de l'injection des câbles sur la résistance à la fatigue des structures en béton précontraint

Einfluss des Einpressmörtels auf die Ermüdungsfestigkeit von Spannbetonkonstruktionen

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In the Structural Research Laboratory at the Technical University of Denmark tests have been carried out in order to investigate

The fatigue strength of prestressing wire.

The fatigue strength of anchorages for prestressing wire and tendons.

The influence of bond on the fatigue strength of post-tensioned concrete beams.

The research project was carried out under the supervision of S. Gravesen and E. Skettrup. N. J. Jørgensen and F. Petersen assisted in the beam tests.

For most prestressing systems the fatigue strength of the anchorages is much lower than the fatigue strength of the tendons. However, it should nevertheless be possible to utilize the fatigue strength of the tendons provided that the following three conditions are fulfilled:

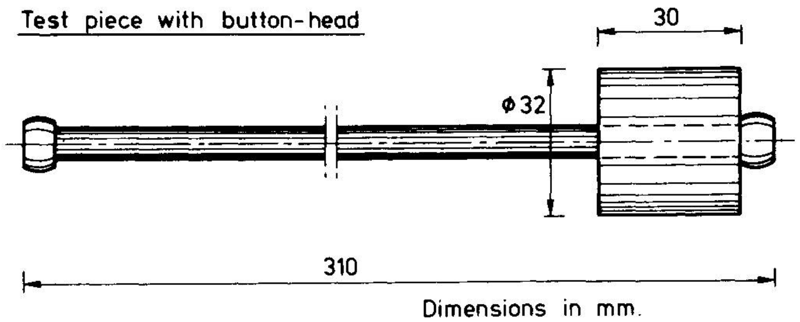
The anchorages should be placed in zones where the stress variations are small, for instance, in the vicinity of simple supports.

The ducts for the tendons should be grouted after the tensioning.

The grout should be able to transfer stresses of a magnitude which is sufficient to ensure a reliable bond between tendon and concrete.

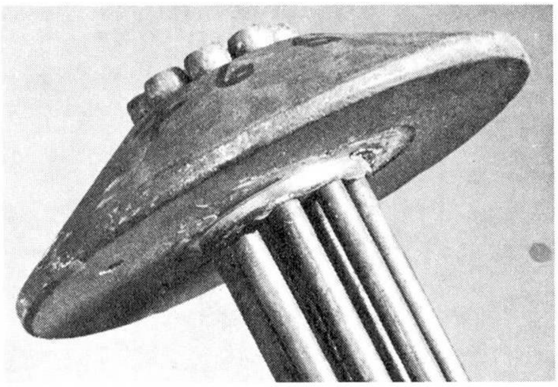
The test results have not yet been published. A brief description will be given in the following.

Fig. 1.



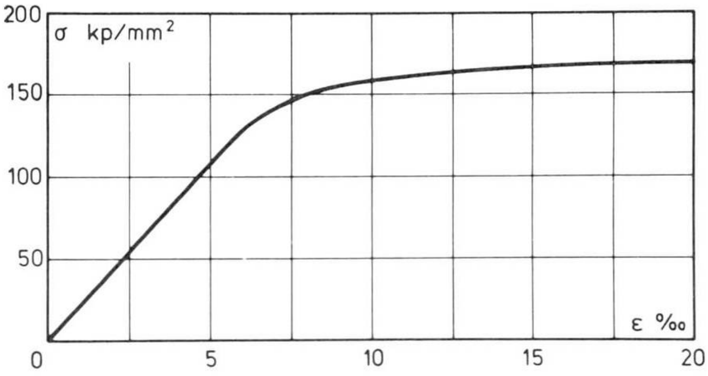
One prestressing system tested in our laboratory used button heads on the wires (see Fig. 1). These heads were made by pressing the ends of the wires so that the diameter was locally increased. When the wire is threaded through holes in the anchor plates the button head will anchor the wire to the plate (see Fig. 2).

Fig. 2.



A stress-strain curve for the wire is shown in Fig. 3.

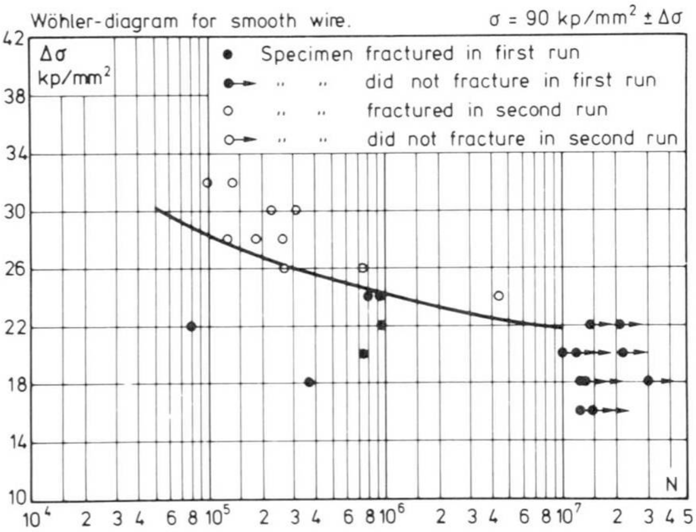
Fig. 3.



Stress-strain curve for the wire

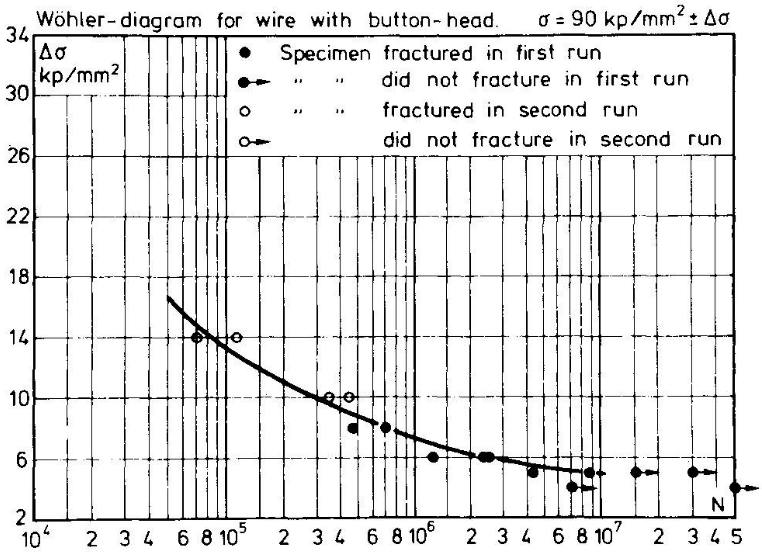
The fatigue strength of the wire proper is illustrated by the Wöhler diagram in Fig. 4.

Fig. 4.



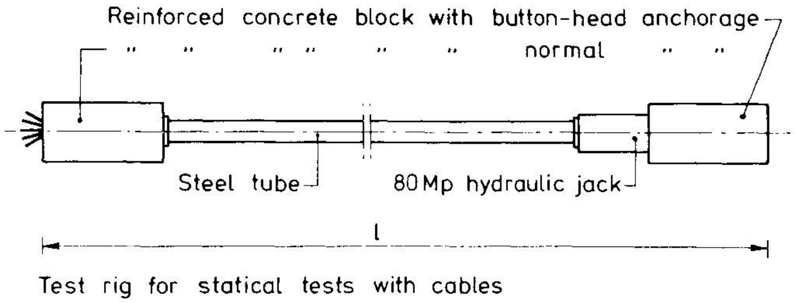
The corresponding diagram for wire anchored with button heads is illustrated in Fig. 5.

Fig. 5.



Static tensile tests were carried out with cables (see Fig. 6). The results of these tests are illustrated in Table 1.

Fig. 6.

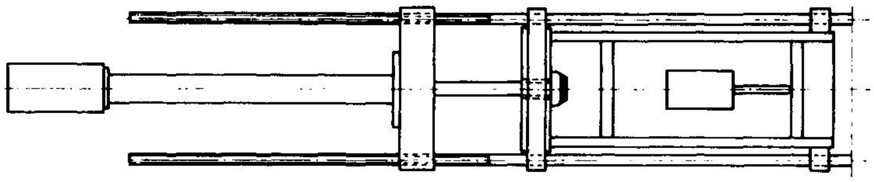


Test No.	Location of rupture	Character	Cable force Mp	Cable stress kp/mm²
1	active anchorage	inclined	68	147
2	-	-	68	147
3	-	-	66	143
4	-	-	72	156
5	-	-	64	139
6	-	-	64	139
7	-	necking	78	169
8	passive anchorage	necking at button-head	76	165
9	active anchorage	necking	79	171

Table 1.

The fatigue strength of the cables were measured in the test rig illustrated in Fig. 7 and the results of the tests are given in Table 2.

Fig. 7.



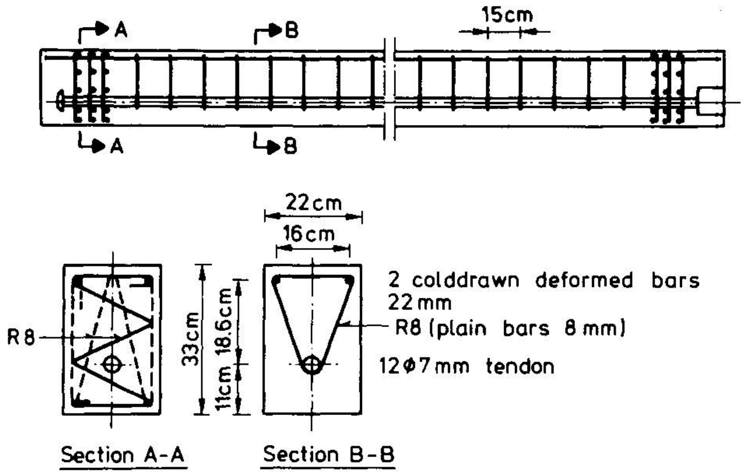
Test rig for dynamic tests

Test No.	Stress and force level		Number of load cycles in millions	
	kp/mm²	Mp		
1	90 ± 4 90 ± 4	41.6 ± 1.85 38.1 ± 1.70	0.829 0.986	First wire fracture Second - fracture
2	90 ± 4	41.6 ± 1.85	1.719	Fracture in two wires
3	90 ± 4 90 ± 4 90 ± 4	41.6 ± 1.85 38.1 ± 1.70 34.6 ± 1.55	0.828 0.944 3.866	First wire fracture Second - fracture No further fractures

Table 2.

Fatigue tests were carried out with 6 post-tensioned concrete beams (see Fig. 8). In order to simulate severe bond stress conditions, a shear span to depth ratio of about 3.0 was adopted.

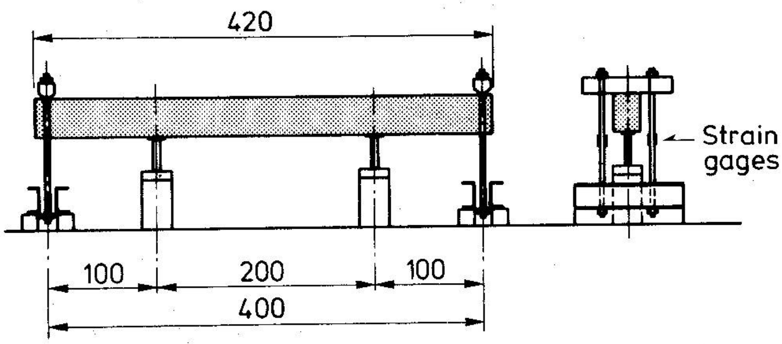
Fig. 8.



In three of the beams the cable duct was grouted whereas the duct was left ungrouted in the remaining three. The beams were subjected to a fatigue load in bending (see Fig. 9).

First a stress amplitude in the tendons of 5.5 kp/mm² in the ungrouted beams and 6 kp/mm² in the grouted beams was adopted. All six beams were subjected to about 2 million load cycles of this magnitude without rupture.

Fig. 9.



Afterwards the stress amplitude was increased to 7,6 kp/mm² in the ungrouted tendons and 7,8 kp/mm² in the grouted tendons, and the beams were subjected to this load until rupture. The number of cycles before rupture is indicated in Table 3.

	Grouted			Ungrouted		
Beam No.	1	3	5	2	4	6
Number of load cycles before rupture in millions	2.02	3.18	2.09	0.26	0.23	0.09

Table 3.

Conclusion.

According to the test results, the fatigue strength of post-tensioned concrete structures with unbonded tendons is low due to the low fatigue strength of the anchorages. If the anchorages are located in zones where the stress variations are small, the fatigue strength of the structure can be increased considerably by grouting the ducts.

SUMMARY

The fatigue strength of post-tensioned concrete structures with unbonded tendons is low due to the low fatigue strength of the anchorages. Tests carried out at the Technical University of Denmark indicate that the fatigue strength can be increased considerably by grouting the ducts, provided that the anchorages are located in zones where the stress variations are small.

RESUME

La résistance à la fatigue des structures en béton précontraint, utilisant des câbles gainés non injectés, est faible, due à la modeste résistance à la fatigue des ancrages. Des essais réalisés à l'Université Technique du Danemark montrent que cette résistance à la fatigue peut être augmentée considérablement par l'injection des câbles, pourvu que les ancrages soient placés dans des zones à faible variation de contrainte dans le béton.

ZUSAMMENFASSUNG

Die Ermüdungsfestigkeit von Spannbeton ohne Verbund ist niedrig, weil die Ermüdungsfestigkeit der Verankerungen niedrig ist. Versuche an der Technischen Hochschule Dänemarks zeigen, dass die Ermüdungsfestigkeit durch Auspressen der Spannkanäle mit Zementmörtel vergrössert wird, vorausgesetzt dass die Verankerungen in Zonen mit niedrigen Betonspannungsvariationen angebracht sind.