Some tests on beams prestressed by fibre-glass cords*

by Dr. Ing. Stanisław Kajfasz

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I read Dr Kajfasz's paper with great interest, being engaged on a programme of somewhat similar study at Woolwich Polytechnic.

The development of the use of fibre-glass tendons in prestressed concrete is hampered firstly by their susceptibility to damage by abrasion and secondly by the large variation in stress across a loaded section at anchorage zones. Dr Kajfasz concludes that stiff rods of fibre-glass in which fibres are bonded together with polyester resin would prove more promising for future investigations. The fibre-glass I am using is in this form; it has a manufacturer's specified ultimate stress of 150,000 lb/in², a diameter of 0.200 in., and contains 25% by weight of polyester resin. Whilst these rods largely overcome the first difficulty, abrasion, they do not satisfactorily rule out the second.

In short-term loading tests at Woolwich, compression-friction grips have been employed which have made it possible to attain 93% of the manufacturer's specified ultimate stress before failure. In long-term loadings, however, where the rod remained on load for several hours, failure took place when the load chosen was higher than a certain critical value. For the particular material used, that value appears to be approximately $0.6 \times$ ultimate stress.

Professor Rubinsky has stated⁽¹⁾ that his experiments indicated that the load which could be sustained by polyester-bonded fibre-glass rod was dependent upon time. Unfortunately, no details were given.

I suspect but have yet to prove that creep in the polyester resin changes the original stress gradients across a loaded section in the anchorage zone. Thus, the inner fibres are relaxed at the expense of the already more highly stressed outer fibres. At a suitably high load in the rod, this creep is sufficient with time for the outermost fibres to reach their ultimate stress. The failure of single glass fibres in the manner of a chain reaction then takes place, as Dr Kajfasz noted with cords.

Therefore, the rod's performance is greatly dependent upon the physical properties of the bonding agent, particularly with regard to its modulus of rigidity and creep. Until a more satisfactory commercial material is to hand, rod bonded with polyester resin

appears to be sufficient for investigation purposes, provided loads at transfer are kept low. (The beams in my present investigation are pre-tensioned, the stress in the tendon at transfer being $0.45 \times$ ultimate stress.)

It was interesting to compare Dr Kajfasz's value for E for the woven glass cords, 7.1×10^6 lb/in² with the average value of 5.5×10^6 lb/in² which I have obtained with polyester-bonded fibre-glass rod.

Reply by the author

I am grateful to Mr N. F. Some for his interesting remarks concerning long-term loading tests of fibre-glass tendons. I take this opportunity of adding some information on this important problem.

In the relaxation tests of fibre-glass cords⁽²⁾, the specimens stressed to 40 and 60% of the ultimate stress failed after 2, 11, 15, 16, 25, 42 and 50 days. Failure usually occurred in anchorages of the testing arrangement, in one case beyond the anchorages.

Long-term tests were also carried out on eight beams (Nos. 5 to 12) which passed the short-term tests at the Institute of Building Technique in Warsaw. The beams were loaded up to 23–34% of their ultimate load (Figure 1). The results of tests are given in Table I. The calculated mean stress in the fibre-glass tendons was about 16% of the ultimate stress. After 272 or 294 days, the load on the beams was slightly increased and in a short time the beams failed. During the tests, the

Figure 1: Long-term loading test on beams which passed short-term test.

*Pages 91–98 of Magazine No. 35.

Figure II: Width of cracks at intervals throughout long-term tests.

TABLE I: Results of long-term tests.

Beam No.	First load stage			Second load stage		Remarks
	Bending moment (kg m)	Load as a ratio of ultimate load	Duration of loading (days)	Load as a ratio of ultimate load	Duration of increased loading (days)	
5	233	0.23	294	0.31	6	cords failed
6	232	0.29	294	0.35	4	not destroyed
7	252	0.31	272	0.36	51	not destroyed
8	223	0.34	272	0.41	3	not destroyed
9	232	0.26	294	0.32	0	cords failed
10	252	0.31	272	0.36	51	cords failed
11	223	0.30	272	0.36	3	cords failed
12	233	0.29	294	0.39	6	not destroyed

width of cracks was measured at intervals (Figure II).

Thus low stresses also lead to abrupt failure ; as the curves in Figure II indicate, there is no excessive deflexion to give warning. This indicates that the process of destruction may be very slow as a result of the failure of single fibres over a period of time. It seems that, unless a reliable bonding agent becomes available for highly stressed fibre-glass reinforcement, its practical use will be limited if not impossible.

Three out of four beams in which the cords broke were grouted with cement emulsion. This confirms that cement should not be used in direct contact with fibre-glass.

REFERENCES

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