"ELS" — EMPA’s new revolutionary testing machine

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For many years, the testing of heavy steel cables has been an important task of the Swiss Federal Laboratories for Materials Testing (EMPA). In addition to the routine investigation of small and medium sized cables (as employed for cable cars), it is often necessary to test very heavy specimens having extremely high strengths. Since the machines available up to 1960 could produce a maximum force of only 1 MN, which did not suffice, efforts were made to develop a stronger testing machine. After a period of improvised solutions, a fundamentally new concept was introduced. The testing machine "ELS" (= Experiments with Long Specimens), developed and built at EMPA, has successfully accomplished its trial tests.

BACKGROUND

Technical advances have led to the increased application of high-strength building elements. The spans of suspension bridges are continuously growing; more daring concrete structures are possible only thanks to prestressing with enormous forces; a recent application is the anchoring of offshore structures.

The impressive progress made in the 1960's and 70's is illustrated when one recalls the response of the experts when asked what forces for testing would be necessary in the foreseeable future. A survey performed at the beginning of this period yielded the answer, "5 MN for the next 20 years". One of the first high caliber machines was then installed at EMPA in accordance with this requirement (fig. 1). However, already in 1969, the cables of the Mannheim cable-stayed bridge had to be tested with fatigue loading of up to almost 7 MN. And in 1978, a leading prestressed concrete expert envisioned 25 MN as a nominal value for his branch for the coming decade!

It was initially decided to "make do" with improvised solutions: On the one hand, the existing strongfloor was set up for fatigue tests up to about 7 MN. In addition, a reversal set-up was conceived to enable the existing 20 MN compression testing machine to be used for tensile tests (figs. 2 and 3). Although both solutions have proved suitable until the present, they are nevertheless problematic. The installation on the strongfloor has "tied up" much of the available space for the last 15 years. The reversal set-up leaves much to be desired with respect to the length and accessibility of the specimens. In order to solve these problems and remain competitive, it was necessary to conceive a high-performance machine capable of meeting future demands. A goal of 30 MN was established already in 1973.

At first glance, the realization of such an ambitious plan seemed to be pure utopia, since the purchase of a machine of this class would cost several million Swiss francs. Considering the priorities of EMPA, such an expenditure could not be justified. In view of this situation, it was decided, contrary to normal policy, to
risk constructing the machine ourselves. In making this decision, we took into account that several EMPA staff members are highly qualified in testing machine design. Further, we had specific ideas of some revolutionary innovations whose realization would enable a decisive cost reduction.

DESIGN CONFORMING TO THE TEST SPECIMEN

The design proceeded from the concept that every tensile element (whether cable, prestressing tendon, rod, tube or chain) in practical use must somehow be anchored at its ends in order to take up its load. Indeed, the anchoring elements (the "heads") are subjected to the service load and consequently should be part of the specimen. Taking this approach, the bulky and complicated gripping devices common to conventional designs become superfluous. It is merely necessary to provide suitable bearing surfaces for the heads, which are considered as integrating parts of the specimen. Since a realistic cable test requires a certain minimum specimen length, it is also possible to avoid the technical complication of the usual adjustable crossheads. Instead, it suffices to place horseshoe-shaped spacers between the specimen head and the bearing surface, thus permitting adaptation of the machine to the specimen length (fig. 4).

The handling of heavy (and sometimes flexible) specimens is one of the main problems for the user of a large testing machine. Easy accessibility with a crane is desirable. In order to fulfil this requirement, it was decided to design the machine to have a horizontal axis. Furthermore, the two crossheads which transfer the load from the actuators to the specimen heads were fabricated for the first time using two-part sandwich construction. Thus, after removing a small number of bolts (not load-transmitting), the upper half of each crosshead can be removed with the crane. The entire test space becomes open; so the main difficulty of inserting a heavy body is avoided (figs. 4 and 5). In addition, with a view towards saving material, the crossheads were constructed in triangular form having optimized geometry.

The above-mentioned necessity of a certain minimum specimen length could be taken advantage of in another...