SYMPOSIUM ON LARGE FATIGUE TESTING MACHINES AND THEIR RESULTS

INTRODUCTION

By John M. Lessells[1]

Most of the knowledge of fatigue which has been made available since Wöhler's[2] pioneer work in 1870 has come from tests on relatively small specimens. Today, there is a marked tendency to carry out fatigue tests on actual components, which has involved in many cases the testing of sections considerably larger than the conventional laboratory specimen. Since prior to Wöhler, tests were conducted by Fairbairn[3] on full-size wrought iron girders, it is evident by the adoption today of full-scale testing we are returning to the views held by some of our predecessors.

This extension of full-scale testing has necessitated the development of large sizes of testing machines, and like all engineering developments, while the use of such machines has solved certain problems, it has also raised others. Notably in this regard, the testing of large specimens uncovered the existence of a size effect on the fatigue strength of plain specimens. There are theoretical grounds for believing that there should be a size effect in either cyclic bending or cyclic torsion due to what Cazaud[4] terms a "supporting effect" of the internal layers of material which tend to oppose the deformation of the surface layers. This supporting effect will depend on the size of the cross-section and will increase with it. Such an effect will of course be nonexistent in the case of cyclic direct stress. Furthermore, a size effect could also be predicted on the basis of a statistical consideration of flaw distribution. Most of the knowledge which we do possess of the effect of size of plain specimens has emerged chiefly from the work of Horger,[5] Peterson,[6] Phillips and Heywood,[7] Dorey,[8] and Mailänder and Bauersfeld,[9] although others have contributed.

[1] President, Lessells and Associates, Inc., Boston, Mass; Chairman of Symposium Committee.

[2] A. Wöhler, "Über die Festigkeitversuch mit Eisen und Stahl," *Z. Bauwesens*, 8, 10, 13, 16, and 20 (1860–1870).

[3] W. Fairbairn, "Experiments to Determine the Effect of Impact Vibratory and Long-Continued Changes of Load on Wrought-Iron Girders," *Phil. Trans. Roy. Soc.*, London, p. 311 (1864).

[4] R. Cazaud, *Fatigue of Metals*, translation by A. J. Fenner, p. 159, Philosophical Library, New York (1953).

[5] O. J. Horger and H. R. Neifert, "Fatigue Strength of Machine Forgings 6 to 7 in. in Diameter," *Proceedings*, Am. Soc. Testing Mats., Vol. 39, pp. 723–737 (1939).

[6] R. E. Peterson, "Fatigue Tests of Small Specimens with Particular Reference to Size Effect," *Transactions*, Am. Soc. Steel Treating, Vol. 18, July–Dec., 1930, pp. 1041–1053.

[7] C. E. Phillips and R. B. Heywood, "The Size Effect in Fatigue of Plain and Notched Steel Specimens Loaded Under Reversed Direct Stress," *Proceedings*, Inst. Mechanical Engrs., Vol. 165, pp. 113–124 (1951).

[8] S. F. Dorey, "Torsional-Fatigue Testing of Marine Shafting," *Engineering*, Vol. 165, March 19, 1948, pp. 268–288; and March 26, 1948, pp. 310–312.

[9] R. Mailänder and W. Bauersfeld, "Einfluss der Pröbengrosse und Probenform auf die Dreh-Schwingungsfestigkeit von Stahl," *Tech. Mitt. Krupp*, Vol. 5, Dec., 1934, pp. 143–152.

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The experimental difficulties connected with the fatigue testing of large specimens are considerable, and the tests are expensive and time consuming. Furthermore, such effects as stress concentration and fretting corrosion of large-size sections may have a different relation to the basic strength than they have in small-size sections. These factors have led to the necessity of testing specific large machine elements, but unfortunately these data have usually a limited application.

As a consequence of the paucity of available data, the subject of size effect remains somewhat controversial, and it is to be hoped that the papers presented as a part of this Symposium, together with the discussion, will aid in the clarification of the role of size in fatigue besides giving us information on new types of large testing machines.

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