were tested at each age of 7, 30, 60, 90 days and 1 year, and five beams at each age of 30, 60 and 90 days.

The Olsen testing machine of 100,000 lbs. capacity, owned by the city of Toronto, was used for practically all cylinder tests, except those in which the tests of the previous age showed an average strength per cylinder of . over 80,000 lbs.

The Riehle machine of 200,000-lb. capacity, owned by the University of Toronto, was used whenever it seemed probable that the strength of the cylinders would exceed the capacity of the smaller machine. All tests of beams were made upon the 100,000-lb. capacity machine. The vertical movement of the Olsen machine was about 0.016 in. per minute, while that of the Riehle machine was about 0.02 in. per minute.

The edges of all test cylinders were slightly rounded by grinding them with a carborundum brick before testing. When placed in the testing machine the ends of the



Fig. No. 10.—Relative Compressive Strengths of Test Cylinders,  $1:2\frac{1}{2}:5$  Mix. Based on Compressive Strength of Sand No. 1 at 90 Days

cylinders were bedded with sheets of heavy beaver board, having a thickness of 7/32 in., to secure an even distribution of the load. It is believed that this use of beaver board gave quite as consistent and accurate results as would have been secured with plaster of Paris or similar material. A considerable saving of time was effected in this way.

In all cylinder tests a spherical-seated bearing block was used.

All beams were tested with a concentrated load at the centre. The end bearings and centre block through which the load was applied were semi-cylindrical in shape. The bearings upon the concrete were padded with narrow strips of beaver board.

For all tests of cylinders, the maximum load at ultimate failure was recorded. For all tests of beams, the load recorded was that judged to have caused the failure of bond between the steel and concrete. This so-called "critical" failure, especially in beams of the fourth and fifth consistencies, was more or less difficult to detect, since it was shortly afterward followed by the sustaining of an increased load due to the mechanical bond produced by the bent bars.

During the period of making tests the Riehle machine was twice disabled in connection with other tests. The time involved in the securing of repair parts, together with the testing of accumulated materials mainly for war purposes, disarranged to a considerable extent the time schedule of the cylinder tests.

## **Results of Tests**

The unavoidable "overdue" tests just referred to, rendered it advisable that the results obtained be reduced to graphical form, in order to permit of the making of direct comparisons. The results of all tests are, therefore, shown graphically rather than in tabulated form.

Tests for Grading of Sands.—Fig. 8 shows the compressive strengths obtained from the tests of the cylinders in which the specially graded sands were used. The

TABLE III.—ACTUAL GRADINGS OF SANDS Sample from Mixer

Sieve No.	Percentage retained on Sieve. Sand No.											
	<u>1</u> in	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0.0	0.0	0.0	0.0
8	8.5	15.0	17.0	11.5	15.5	23.0	14.0	19.0	17.5	18.5	19.0	20.0
10,	8.0	5.5	8.0	6.0	3.5	6.0	4.0	3.0	10.0	6.0	6.0	4.0
20	20.0	28.5	32.0	22.0	25.5	30,0	23.0	23.5	23.0	30.0	30.0	31.0
30	14.0	11.5	13.0	20.0	19.0	12.0	13.0	15.0	14.5	9.0	12.0	13.0
40	15.0	11.5	12.0	17.0	13.0	13.0	15.0	14.5	10.5	10.0	12.5	14.5
50	14.5	12.0	10.0	6.0	4.5	3.5	15-6	13.5	18.0	11.0	10.0	12.0
80	15.0	-12.5	5.5	12.5	10.0	8,0	10.5	9.0	5.5	11.0	. 6.5	4.0
100	3.0	2.0	1.5	2.5	3.0	2.5	3.0	2.0	1.0	3.0	2.0	1.0
100 (passing)	2.0	2.0	1.0	2.0	2.0	2.0	2.0	1.5	0.5	2.0	2.0	0.2
Total	100.0	100.5	100.0	99.5	99.5	100.0	100.0	101.0	100.5	100.5	100.0	100.0
Voids	30.0	29.60	30.06	30.6	31.0	29.10	29.10	29.26	30.53	27.66	27.51	30.2

rather inconsistent condition shown, wherein sand No. 1 gives greater strength for a  $1:2\frac{1}{2}:5$  mix than for a 1:2:4 mix, is not easily explained. No errors were found in the proportioning of the mix. The cylinders for both



Fig. No. 11.—Compressive Strengths of Test Cylinders of Different Consistencies

mixes were made early in April, 1916, so it is possible that conditions of temperature may have materially influenced results. The grading of the sand is favorable