EFFECT OF VIBRATION, JIGGING AND PRESSURE ON FRESH CONCRETE*

By Duff A. Abrams
Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago

EXPERIMENTAL study of the effect of vibration and pressure on fresh concrete on its strength and other properties is of interest in view of the frequent use of such devices as hand-hammering of forms, or air-hammering, jigging or vibration as an aid in placing concrete. Such methods are particularly applicable to the construction of reinforced-concrete ships and houses, where thin sections and a multiplicity of reinforcing members are of common occurrence. Jigging or vibrating machines are frequently used in concrete products plants. The effect of pressure on fresh concrete is of interest in certain problems of concrete design.

Little attention has heretofore been given to the experimental study of the effects produced by vibration and jigging fresh concrete. A few tests were made in a study of the effect of pressure on fresh cement paste in a confined space by James E. Howard, at Watertown Arsenal. The effect of pressure on the compressive strength and bond was studied by the writer at the University of Illinois in 1913. Since the tests now reported were completed, Prof. F. P. McKibben has published a report on compression tests of concrete columns which set under pressure.

The tests covered by this report were made as a part of the experimental studies of concrete and concrete materials being carried out through the co-operation of Lewis Institute and the Portland Cement Association, and include the following topics:—

1. Different methods of hand-molding of test cylinders.
   - (*a*) Puddling with ⅝-in. round steel bar (varying number of strokes).
   - (*b*) Tamping (tampers of different size).
   - (*c*) Tapping metal forms after puddling.
2. Effect of vibrating fresh concrete (small electric motor).
   - (*a*) Time of vibration varied up to 1 min.
3. Effect of jigging fresh concrete.
   - (*a*) Concrete of different mixes (1:7 to 1:3).
   - (*b*) Concrete of different consistencies (0.70 to 1.25).
   - (*c*) Using aggregate of different grading (fineness modulus 4.00 to 6.50).
   - (*d*) Using aggregate of different sizes (0-28 sand to 0-1½-in. concrete aggregate).
   - (*e*) Using coarse aggregate of different shape (pebbles and crushed stone).
   - (*f*) Effect of rate of jigging (0 to 150 r.p.m.).
   - (*g*) Effect of height of drop (0 to 0.50 in.).
   - (*h*) Effect of length of time jigged (up to 3 mins.).
   - (*i*) Effect of age of concrete before jigging (up to 6 hrs.).
   - (*j*) Jigged with 30-lbs. weight on top of fresh concrete.
   - (*k*) Hand puddling on jigging machine while in operation.
4. Effect of pressure on fresh concrete.
   - (*a*) Using different pressure (0 to 500 lbs. per sq. in.).
   - (*b*) Effect of duration of pressure (15 mins. to 16 hrs.).
   - (*c*) Effect of removal of water by pressure.

This series included 900 compression tests of 6 by 12-in. concrete cylinders at the age of 28 days. All specimens were made from the same materials at the same time, consequently direct comparisons may be made between any two sets of tests.

*Excerpts from paper presented to the American Concrete Institute.

The tests gave conclusive results on many phases of the effect of vibration, jigging and pressure. In some instances the effect is entirely different from what accepted opinion would suggest. Following is a brief summary of the tests:—

Puddling and Tamping

1. Varying the number of strokes from 12 to 50 on each 4-in. layer in the standard method of hand-puddling with a ⅝-in. bar had little influence on the compressive strength of ordinary plastic concrete.
2. In general, the tamping methods used gave lower strengths than hand-puddling.
3. A tamper of large diameter for a given weight was less effective than one of small diameter.
4. Increasing the thickness of the layer from 4 to 6 ins. caused a falling off in strength of about 12% for tamped concrete.
5. Tamping or puddling the first 4-in. layer only caused a falling off in strength of 10 to 13%.
6. Striking the metal form with a steel bar after the completion of moulding by standard method had no effect on the strength of concrete.
7. The "standard" method of hand-puddling, using 25 strokes with a ⅝-in. steel bar for each 4-in. layer of concrete in a 6 by 12-in. cylinder is recommended for laboratory tests of concrete.

Vibration with Electric Hammer

8. Vibration of the specimen after moulding by means of an electric hammer running at 1,000 r.p.m. had little influence on the strength of the puddled concrete up to a period of about 30 seconds. If continued, there was a steady falling off in strength; after 45 to 60 seconds the strength was only 90% of that produced by the standard method of puddling.
9. In general, jigging in any manner with the apparatus used reduced the compressive strength of the concrete, regardless of the height of drop, rate or duration of treatment. Exceptions were found in the dry mixes and those made of aggregates of the smaller sizes.
10. There was little difference in the effect of jigging due to the quantity of cement used.
11. In the very dry mixes the strength, due to jigging for 20 seconds, was increased about 25%.
12. The wetter mixes (relative consistency, 1.10 to 1.25) were reduced in strength 3 to 6% by jigging.
13. Pebbles and crushed limestone as coarse aggregate gave essentially the same results in the jigging tests.
14. The concretes for finer aggregates showed a material increase in strength with jigging in both 1:5 and 1:3 mixes.
15. For aggregate coarser than about ⅜ in., jigging reduced the strength from 3 to 10%.
16. The grading of the aggregates (for a given maximum size) had little influence on the effect of jigging.
17. The greater the drop, the greater the reduction in strength for 1:5 concrete. For a drop of ½ in. the strength was reduced 12%.
18. The faster the rate of jigging, the lower the strength of 1:5 concrete. Using 1½-in. aggregate at 150 r.p.m., the strength was reduced about 13%.
19. The strength of 1:5 concrete fell off rapidly with the duration of jigging. After 2 to 3 minutes' jigging the strength was reduced about 20% as compared with standard method of hand-puddling.
20. Allowing the concrete to stand for a period of time before jigging increased the strength to a slight extent. The maximum increase was found at 2 to 4 hrs.
21. The application of a pressure of 1 lb. per sq. in. during the jigging process (equivalent to a head of 1 ft. of fresh concrete) gave the same strength as standard hand-puddling.
22. Moulding the cylinders by the standard method on the jigging table while it was in motion gave the same strength as standard hand-puddling without jigging.

(Concluded on page 194)