The slump values vary with different classes of work and the following may be taken as a general guide: For mass concrete and heavy reinforced concrete structures the slump varies from 1 to 4-in. It may be necessary to increase the slump to 7-in. for columns, and for thin vertical and confined horizontal structures where adequate ramming of the concrete is not possible. For concrete roads the maximum slump should not exceed 1-in. in order that the necessary strength and wearing qualities may be obtained. Whilst a 7-in. slump is considered as a maximum for good quality mixes, it may be possible to increase this figure to 8-in. for concrete which does not require a high standard of strength. Concrete having a slump less than 2-in. must be well consolidated when placed in position to avoid honeycombing or pore spaces (see p. 35).

COMPACTING FACTOR TEST.—This is another test applied to concrete, but it is only suitable for use in the laboratory. It is related to the workability of concrete, which is defined for this purpose as being the property which determines the amount of work required to compact or consolidate the concrete completely. The compacting factor may be defined as a measure of the density of a concrete achieved by a standard amount of work.

The apparatus used for this test consists of a frame which supports two truncated conical hoppers, one above the other, with a space between. A cylindrical mould, having a detachable base, is placed below these hoppers. Each of the latter has a hinged base which can be shot open.

The upper hopper is completely filled with the concrete immediately after mixing. The hinged door is released to allow the contents to fall into the lower hopper. The base of the latter is then opened and the concrete falls into the cylinder, completely filling it, the excess concrete being struck off level with the top. The compacting factor is then calculated in the following manner: The weight of the container when empty is subtracted from that of the container when full, and this net weight of concrete is divided by the weight of the concrete calculated from the known specific gravities of the cement, sand and coarse aggregate, in the correct proportions, required to fill the cylinder without pore spaces. Thus, if the net weight of the concrete is 125·5 oz. and that of the contents of the cylinder (when no voids are left) is 133·8 oz., the compacting factor will be $\frac{125 \cdot 5}{133 \cdot 8} = 0 \cdot 94$. Experiments have shown that a compacting factor of 0·95 represents a concrete mix of high workability, that of 0·92 a medium workability, and 0·85 a low workability.

This is a useful test for comparing the workability of different mixes of concrete. Each specimen is brought to a standard condition (when deposited from the upper to the lower hopper) and is subjected to a standard amount of work when it falls into the cylinder.

COMPRESSION TEST.—The quality of concrete is generally assessed by its crushing strength. This strength is determined by testing suitably prepared specimens of the concrete in a compression machine.

The form of standard test specimen favoured in this country is the 6-in. cube. This and the standard method of testing are specified in the Code of Practice referred to on p. 29. The cement and fine aggregate, in correct proportions, are first mixed dry until a uniformly coloured mixture is obtained; the coarse aggregate is added and well mixed; the correct amount of water is then added and the composition mixed for at least two minutes. The concrete is tested for consistency by the slump test, described on p. 31, and after re-mixing it is placed in a steel mould of 6-in. by 6-in. by 6-in. internal dimensions. The mould has a steel base plate attached, and both this and the internal faces of the mould must be well oiled before filling to make the joint watertight, prevent sticking of the concrete and facilitate the removal of the cube without damage. The concrete is placed in the mould in three layers of approximately equal thickness, each layer being separately tamped 35 times if the slump is 1½-in. or less (or 25 strokes for wetter mixes) with a 15-in. by 1-in. by 1-in. steel bar weighing 4-lb., after which the surface is carefully smoothed level with a trowel flush with the top of the mould. The mould is then stored in a damp cabinet for twenty-four hours, after which the concrete cube is removed from the mould, marked, and either immersed in water contained in a tank or buried in damp sand until the cube is ready for testing. This protection of the cube, called *curing*, is necessary to prevent evaporation of the water and to provide a favourable condition for the setting and hardening of the concrete. The strength of the concrete is usually taken at either fourteen or twenty-eight days after it has been mixed; occasionally early date strengths are taken at three and seven days, and sometimes the strengths at three months and one year are required.

Test cubes prepared on the site during the progress of the work are kept damp for twenty-four hours and then removed from their moulds. After being marked to distinguish them, they are carefully packed in a wood box, encased in damp sand or sacking and dispatched to the laboratory where they are kept damp until required for testing.

One type of compression testing machine, manufactured by Messrs J. A. Amsler, and of 50-tons capacity, is shown at E, Fig. 9. The concrete specimen is placed on the lower compression plate B attached to the ram or piston which operates within the press cylinder. The upper compression plate A is connected by means of a ball-and-socket joint to the large screw which is operated by the hand wheel W. The screw is adjusted to lower the plate A tightly on to the top of the specimen. Brackets at the right-hand side support the oil pump, subsidiary cylinder X with small piston, pressure gauge and spiral spring. Oil is conveyed by a pipe to the pump from a reservoir fixed to the back of the machine; the pump is connected to the press cylinder by an oil pipe, and a branch (not shown) from this pipe is connected to the subsidiary cylinder X.

After plate A has been tightened down and valve U closed, the pump is operated by raising and lowering the 3-ft. long lever by hand. This forces the oil along the pipe (see arrow "1") into the press cylinder to exert pressure on the underside of the ram. The latter and plate B gradually rise (see arrow "2") to press the specimen against the stationary plate A. Meanwhile the oil forced along the branch pipe to cylinder X presses the piston downwards (see arrow "3") and this extends the spiral spring. This extension of the spring is transmitted to the indicating hand or pointer on the gauge by a steel ribbon tape which is fixed at Y and passed round a pulley fixed to the spindle of the pointer and weighted at V. This causes the pointer to rotate round the dial, the scale on which is calibrated to give direct load readings. The pump is operated and the oil pressure increased, until the specimen is crushed. When this occurs the indicating hand gradually returns to zero, but a loose pointer, which the hand engages as it rotates during the test, remains to register the highest point reached when the specimen failed. This figure, expressed in tons, is converted to pounds and divided by the area of the cross-section of the specimen to give the crushing strength of the concrete in pounds per square inch. The specimen is removed by opening valve U and reversing the hand wheel W; this relieves the pressure on the press cylinder and the weight of the ram forces the oil from the cylinder to the reservoir.

Very little effort is required to hand-operate this machine and the time taken to carry out the test is approximately two minutes, depending upon the strength of the cube (about 1-ton per sq. in. per min.).

For testing specimens requiring comparatively small pressures to crush them (such as timber), the spring on the 50-ton machine is replaced by a lighter one and the dial is substituted by one reading to 20-tons. This type of machine is also made having a capacity of 200-tons. This larger machine is necessary when 6-in. concrete cubes have to be tested, as a 50-ton machine will only test 4-in. cubes at twenty-eight days.