SUMMARY OF TESTS OF BOND BETWEEN CONCRETE AND STEEL.

(Concluded from last issue.)

(28) Pull-out tests made at early ages gave surprisingly high values of bond resistance. Plain bars embedded in 1:2:4 concrete and tested at 2 days did not show end slip of bar until a bond stress of 75 lbs. per sq. in. was developed. Bond resistance increases most rapidly with age during the first month. The richer mixes show a more rapid increase than the leaner ones. The tests on concrete at ages of over one year showed that the bond resistance of specimens stored in a damp place may be expected ultimately to reach a value as much as twice that developed at 60 days.

(29) The load-slip relation of leaner and richer mixes was similar to that for 1:2:4 concrete. For a wide range of mixes the bond resistance was nearly proportional to the amount of cement used. This relation did

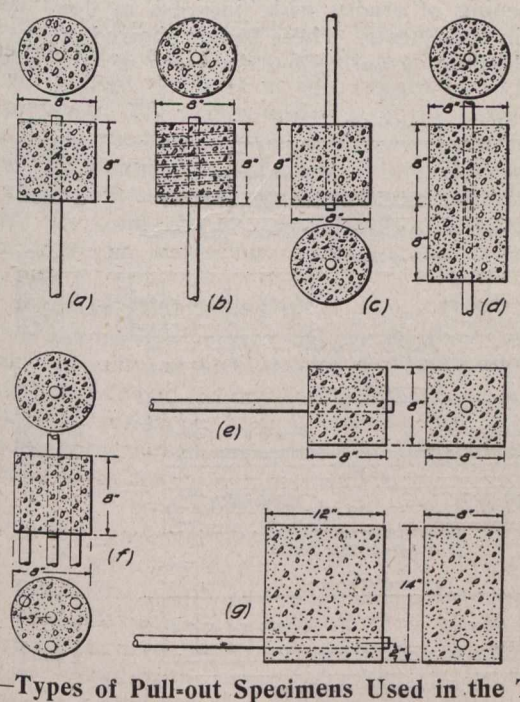

Fig. 1.—Types of Pull-out Specimens Used in the Tests.

not obtain in a mix from which the coarse aggregate had been omitted.

(30) When the application of load was continued over a considerable period of time, or when the load was released and reapplied, the usual relation of slip of bar to bond resistance was considerably modified. The few tests which were made indicate that the bond stress corresponding to beginning of slip is the highest stress which can be maintained permanently or be reapplied indefinitely without failure of bond. The effect of continued and repeated load, impact, etc., may well be the subject of further experimental study.

(31) Little difference was found in the pull-out tests whether the load was distributed over the entire face of the block or over a narrow ring at the centre of the block or around the edge of the face of the block.

(32) Specimens molded in a horizontal position gave lower bond resistance than those molded in a vertical position; when settlement of the bar with the settlement of the concrete was entirely prevented, the bond resistance was reduced to about 60 per cent. of that found for similar specimens which were molded with the bars in a vertical position. Plain bars tested by being pulled in the same or the opposite direction from the settlement of the concrete during setting gave about the same bond resistance, but in the tests of certain deformed bars this was not true.

(33) The term "autogenous healing" is used to designate phenomena observed in pull-out tests and in compression tests of concrete cylinders in which the hardening of the concrete was interrupted by loading the specimen at early ages to its ultimate resistance. Up to an age of one year the bond resistance of specimens stored in damp sand was not affected by as many as four loadings at intervals during the period of storage up to the ultimate resistance. For specimens stored in air and tested in the same way, the bond resistance was less than for damp-sand storage, but the tests showed a steady increase in bond resistance with each loading up to three months. Specimens which had been stored in air for two months before the first test and in water thereafter showed a decrease in bond with each subsequent loading, although the bond resistance in the last test was fairly high. The presence of water apparently permits the continuation of the hydraulic action of the cement for several months after the mixing of the concrete.

(34) Bond resistance of plain bars is greatly increased if the concrete is caused to set under pressure. With a pressure of 100 lbs. per sq. in. on the fresh concrete for five days after molding, the maximum bond resistance was increased 92 per cent. over that of similar bars in concrete which had set without pressure. The greater density of the concrete and its more intimate contact with the bar seems to be responsible for the increased bond resistance. Light pressures gave an appreciable increase in bond resistance. With polished bars the effect of pressure was slight.

(35) As might have been expected, the compressive resistance of concrete setting under pressure was increased in much the same ratio as the bond resistance. At the age of 80 days the initial modulus of elasticity in compression for concrete which set under a pressure of 100 lbs. per sq. in. was about 37 per cent. higher and the compressive strength was increased by about 73 per per cent. over that of concrete which had set without pressure. The density of the concrete, as determined by the unit weights, was increased about 4 per cent. by a pressure of 100 lbs. per sq. in. on the fresh concrete. The increase in strength and density was relatively greater for the low than for the high pressure. A pressure continued for one day, or until the concrete had taken its final set and hardening had begun, seems to have produced the same effect in increasing the strength and elastic properties of the concrete as when the pressure was continued for a much longer period.

(36) Concrete cylinders tested in compression at age of 80 days after having been loaded to failure at 7 days gave compressive strengths nearly as high as those tested for the first time at the same age. Retests of cylinders which had set under pressure gave similar results.

(37) Beams of comparatively short span reinforced with bars of large size were used in order to develop high bond stresses and give bond failures. Most of the beams failed in bond; a few failed by a combination of bond and diagonal tension or by tension in the steel.

(38) The usual method of computing the bond stress in a reinforced concrete beam does not take account of all the phenomena of bond action. Slip of bar due to beam bond action and the presence of anti-stretch slip may be expected to greatly modify the distribution of bond stress over the length of the bar, and otherwise to affect resistance to beam bond stresses. However, the