part. The true tensile strength is about 10 per cent. of the compressive strength.

Shear strength: The strength of concrete in direct shear is relatively high, as distinct from indirect shear such as in a beam with diagonal tension where the concrete may break with a shearing stress equal to a much lower value.

Direct shear strength is from 50 to 60 per cent. of the compressive strength, whereas an indirect shear equal to 5 to 10 per cent. may cause fracture.

Watertightness

Concrete can be made practically impervious to water by proper proportioning and mixing and placing. Leakage through concrete walls is usually caused by poor workmanship and occurs at the joints between two successive days' work and through cracks caused by contraction. New concrete may be bonded to old by wetting the old surface, plastering it with neat cement mortar, and then placing the concrete before the neat cement has set. Contraction cracks are almost impossible to prevent entirely, though a sufficient amount of reinforcement may reduce their width to permit only seepage of water.

To get the best results either a quaking or mushy consistency should be used, the concrete must be placed carefully to leave no visible stone pockets, and the entire structure should be made without joints and preferably in one continuous operation. A very wet mix will cause porous concrete.

The best waterproofing agent is an additional proportion of cement in the mix. For maximum watertightness mortar and concrete may require more fine material than would be used for maximum strength, though too much fineness will give porous concrete unless the cement content is increased. Gravel produces more watertight concrete than broken stone under similar conditions.

Patented compounds are available for producing watertight concrete, but under most conditions results as good may be obtained for less cost by increasing the percentage of cement in the mix.

Membrane waterproofing, consisting of asphalt or tar with layers of felt or tarred paper, may be advisable in certain cases.

Immunity Against Fire

The immunity of concrete against fire is apparent from its non-combustible nature and its low value of heat conductivity. Being non-combustible, it can be used where fire risk is great (for example, for petrol stores) and its low heat conductivity makes it useful for the protection of combustible material from a source of heat.

Workability

Any material used for construction must be readily workable. Concrete is particularly suited in this respect, as it is worked in a plastic state, the particular properties of the finished product being brought about by chemical change.

Effect of Oil

Mineral oils applied externally do not injure concrete. Animal fats and vegetable oils, however, tend to disintegrate concrete unless it has thoroughly hardened. Concrete resists the attack of diluted acids after it has thoroughly hardened, but is disintegrated by strong acids. Green concrete is injured by manure, but is not affected after it has thoroughly hardened. Electrolysis injures concrete under certain conditions, and electric currents should be prevented from reaching it.

Sea water attacks cement and disintegrates concrete unless the concrete is made with the very best materials under the best conditions. Deleterious action is greatly accelerated by frost. To prevent serious damage the concrete must be made with a rich mix (not leaner than 1:2:4) and with exceptionally-good, well-graded aggregates and must be allowed to harden thoroughly before it is touched by sea water.

Though there is no essential difference in the strength of concrete mixed with fresh or sea water, the latter tends to retard the setting slightly and may increase the tendency of the reinforcement to rust. Fresh water should be used where possible and in every case mixing water must be clean.

After the setting and curing period concrete continues to harden and does not attain full strength until nearly a year old. Table 2 shows the strength of ordinary Portland cement concrete at various ages.

Methods of Working Concrete

The methods of working concrete should be arranged so that they interfere in no way with the chemical action which forms the finished concrete.

If concrete is to be used as a construction material, the nature of the structure will be the deciding factor in the proportion of mix, the choice of aggregate, and the method of moulding the plastic concrete. The proportion of the mix will vary with

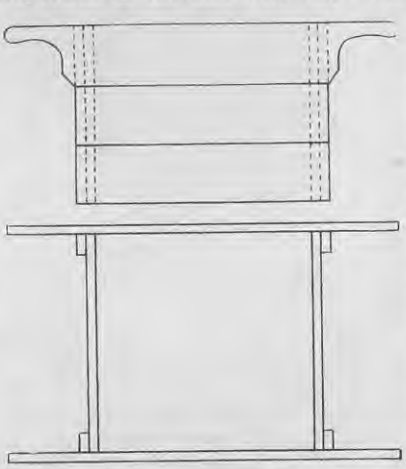

Fig. 1—Construction of a measuring box. The cubic capacity will depend on the volume of materials being mixed at the one time. Upper—Elevation. Lower—Plan.

TABLE 2—STRENGTH OF ORDINARY PORTLAND CEMENT CONCRETE AT VARIOUS AGES

(1:2:4 Laboratory Test Cubes)

Age	Compressive strength lb./sq. in.	Approximate percentage of hardness
28 days	4,000	60
3 months	5,700	85
6 months	6,300	95
1 year	6,600	100

the strength requirements of the structure. The choice of aggregate will depend on whether the finished structure is moulded in thin or thick sections and whether the concrete is reinforced or mass.

The method of moulding the plastic concrete will depend on whether the structure is above or below ground and whether an arch, a slab, or unit articles such as blocks, fence posts, troughs, etc., are being made. This also influences the state of plasticity in which the moulding can be carried out. Details of the best mixes for specified usage will be given in later articles in this series.

Whatever the construction and the corresponding variation of mix, aggregate, and method of moulding, the method of working the concrete is the same in every case and may be done either by hand or by machine.

As the hardening of the plastic mixture is dependent on chemical action, the mixed ingredients must be uniformly distributed to ensure that action is uniform throughout, and this can be accomplished only by adequate mixing.

Hand Mixing

Hand mixing should preferably be carried out on an even, non-absorbent surface. A concrete floor or slab offers an ideal surface, but if there is not one available, a surface of timber can be constructed. The area chosen for mixing must be twice the size of the area required to accommodate one mix.

If up to $\frac{3}{4}$ cub. yd. of materials is being mixed at one time, an area of not less than 12ft. x 12ft. should be provided; for smaller quantities the area can be proportionately less. Straight planks $1\frac{1}{2}$in. or 2in. thick should be laid side by side either on levelled ground or on 3in. x 4in. bearer timbers so that a firm, reasonably level surface is obtained. A shovelful of sand should be scraped over the boards to fill up any spaces between their edges.

As the proportioning of aggregates for all farm concreting operations will probably be done by volume, one or more measuring boxes will be necessary. The size of the boxes will depend on the volume of materials being mixed at any one time. If 1 cub. yd. is being mixed and the mix is 1:2:4, one box about 1/6 cub. yd. in volume would suffice. If a large amount of mixing is to be done, two boxes can be provided, one for the cement and sand and the other for the coarse aggregate. In this case the volume of the box for the aggregate would be four times the volume of the box for the cement and sand or 2/3 cub. yd. Fig. 1 shows the general construction of a measuring box.