(e) *Gravel* is another very good aggregate and is extensively used. It is hard and durable, and is obtained from river beds, the seashore, and inland deposits which are quarried. The gravel is excavated by hand labour or mechanically. Clay is a common impurity and must therefore be removed by washing. Seashore gravel, if required for reinforced concrete, should also be washed in fresh water so as to eliminate as much as possible of the salts. This is also known as ballast (see below).

(d) *Blast-furnace Slag* (p. 25) is a very uncertain material as a coarse aggregate. Some slags readily disintegrate and are quite unsuitable, whilst others are inert and are commonly used locally in producing concrete of good quality. This is also referred to as " ballast " in districts where it is used (see also (*g*)).

Burnt Ballast is produced by burning clay in a kiln, and the slabs are then crushed and screened. It is a suitable material for coarse aggregate, provided it has been hard-burnt. Under-burnt ballast and that containing sulphur (from the fuel) should not be used.

(e) *Pumice* is a whitish or yellowish material of volcanic origin which is highly honeycombed. It was imported into this country, chiefly from Germany, and used as an aggregate for *lightweight concrete*. This concrete, although relatively weak, is, as its name implies, light and very suitable for partitions (pp. 45-47, Vol. III), covering flat roofs, encasing beams and pillars, and similar purposes where strength is not important. Pumice is crushed. Dust and shaly fragments should be removed. It does not contain sulphur and is inert.

(f) *Breeze and Clinker* are waste materials resulting from the burning of coal. Breeze is obtained from gasworks and coke ovens ; clinker is the mineral matter or ash from furnaces. These materials produced from certain coals, especially when they contain small particles of the coal, are distinctly unsound and should be avoided. They have been responsible for a large number of concrete failures owing to the considerable expansion which takes place when associated with cement. They may also have a large sulphur content, which will cause rapid and extensive corrosion of steel and the spalling off of the concrete. The Recommendations for a Code of Practice for the Use of Reinforced Concrete in Buildings classified these as " prohibited aggregates," and they must not therefore be used for reinforced concrete work or for encasing beams, pillars, etc. However, not all breeze and clinker are dangerous, and on account of their cheapness and lightness, much of it is used for internal concrete block or slab partitions (pp. 45-47, Vol. III).

(g) *Foamed Slag*, which somewhat resembles pumice, is produced from blast-furnace slag by rapidly cooling the molten material with water. It is light in weight owing to its cellular structure and is crushed and graded as required. It is very suitable for the manufacture of partition slabs (pp. 45-47, Vol. III).

(h) *Expanded Slate* is another good lightweight aggregate which has not been extensively used, probably because its cost is higher than that of foamed slag. It is produced by heating waste slate to a high temperature until its thickness is considerably increased. This light honeycombed material is then crushed and graded.

GRADING OF AGGREGATES.—The importance of suitably grading the aggregates in order to obtain a concrete of good quality has been referred to on p. 28. It is therefore desirable that samples of the aggregate should be taken periodically and examined.

These samples should be representative, and therefore several are taken from different parts of the consignment. These are well mixed together and a final test sample obtained. According to the Recommendations for a Code of Practice for the Use of Reinforced Concrete in Buildings,[1] this sample should weigh at least 3-lb. for fine aggregate, 10-lb. for coarse aggregate and 15-lb. where fine and coarse aggregates are to be combined. The sample is then passed successively through a series of nine standard sieves, *i.e.*, 1½-in., ¾-in., ⅜-in., $\frac{3}{16}$-in., No. 7 (0·0949-in. square mesh), No. 14 (0·0474-in. mesh), No. 25 (0·0236-in. mesh), No. 52 (0·0116-in. mesh) and No. 100 (0·0060-in. mesh). It will be observed that the size of opening of a sieve is double (or approximately so) that of the next smaller sieve. The aggregate retained on each sieve is then carefully weighed and the amount passed through each is expressed as a percentage.

The following figures shown in brackets are the approximate limits of material passing through the sieves in respect to fine aggregate suggested in the Report of the Building Research Board for 1936 : $\frac{3}{16}$-in. sieve (100 per cent.), No. 7 sieve (75 to 85 per cent.), No. 14 sieve (50 to 70 per cent.), No. 52 (30 to 55 per cent.) and No. 100 sieve (0 to 3 per cent.).

The following are the suggested limits of material passing through sieves in respect to coarse aggregate of a specified size varying from a maximum of 1½-in. to a minimum of $\frac{3}{16}$-in. ; 1½-in. sieve (95 to 100 per cent.) ¾-in. sieve (35 to 70 per cent.), ⅜-in. sieve (10 to 30 per cent.) and $\frac{3}{16}$-in. sieve (0 to 5 per cent.) ; for ¾-$\frac{3}{16}$-in. coarse aggregate, the suggested limits are : ¾-in. sieve (90 to 100 per cent.), ⅜-in. sieve (20 to 55 per cent.) and $\frac{3}{16}$-in. sieve (0 to 10 per cent.).

An approximate guide for grading is as follows :—

Not more than one-quarter and not less than one-twentieth of the sand of $\frac{3}{16}$-in. maximum size should pass through a No. 52 sieve. Unsuitable grading of the sand is a frequent cause of defects in concrete, and the strength and workability of the concrete depend a good deal upon the percentage of sand which passes through a No. 52 sieve. Thus, an excess of this fine material necessitates the addition of an *excessive amount of water* during mixing and a *decrease in the strength* of concrete results, whilst a deficiency of fine material causes unworkability and harshness. The above Code requires that not more than 3 per cent. by weight of the sand shall pass through a No. 100 sieve. Fine dust must be excluded from the aggregate.

For coarse aggregate of ¾-in. maximum size, not more than two-thirds and not less than one-fifth should pass through a ⅜-in. sieve.

The shape of the particles of aggregate influence the workability of the concrete. Thus, concrete with crushed aggregate having sharp edges will require more water than that made of rounded particles, and therefore the latter

[1] These Recommendations are embodied in the Report of the Reinforced Concrete Structures Committee of the Building Research Board, 1933.