0.0025 for temperature stress in addition to the steel for shear. Expressing this as a formula for ratio of steel gives

$$p_0 = \frac{h_t F}{18.8 f_s} + 0.0025 \qquad (9)$$

Small rods spaced 6 to 10 inches apart except in the upper part of the stack where the spacing may be greater are advised.

The spacing of hoops in many of the chimneys already built has been 18 inches to 36 inches, but as such chimneys have frequently cracked quite seriously, more recent designs have called for 8 or 9 inch spacing through the entire stack.

Design of Hollow Circular Beams. The analysis of a hollow circular reinforced concrete beam whose thickness, compared relatively with its diameter, is small, is similar in principle to that of a chimney. In this case the weight of the member acts in the same direction as the external forces, so that in formulas (7) and (8) W the weight in the axial direction, is zero. The forces of compression, P, and tension, T, are equal. The area of steel and the thickness of shell are therefore obtained from formulas (7) and (8), pages 771 and 772, by making $W = O$.

APPENDIX IV

METHOD OF COMBINING MECHANICAL ANALYSIS CURVES

In Chapter XI the method of forming mechanical analysis curves is discussed, and approximate rules are given for combining individual curves to form the curve of the mixture. More exact methods, which also illustrate the principles, are given in the following pages, taking up first simple cases and then the more complicated ones.

Case I. Curves which meet, but do not overlap. In Fig. 246 are shown three curves, No. 1, No. 2, and No. 3, representing ideal grades of sand and stone, which may be combined in such proportions that the curve of the mixture will be of the ideal form required. The problem requires the determination of the percentages of each of the three materials which when combined will form a mixture whose curve is nearly the ideal. In order to prove that the percentages found will produce the resultant curve, and also to illustrate the theory of the mixture, the resultant curve will be first plotted and described in a very elementary manner, and afterwards by the method of ratios which would be employed in practice.

Curve No. 3 represents a material all of whose particles will pass through a sieve having holes 2.00 inches diameter and all of whose particles will be retained on a sieve having holes 0.75 inch diameter. Stone represented by curve No. 2 lies between diameters 0.75 and 0.25 inch, while the material of curve No. 1 is all finer than 0.25 inch, that is, is all under $\frac{1}{4}$ inch. Curves No. 3_1 and No. 3_2 are referred to later.

The curve *OebA* is first plotted* as a parabola. Although the latest tests indicate that the best curve is a combination of an ellipse and a straight line,† the parabola will illustrate the principle of combination as well as any other, and so for this problem we may assume now that the required theoretical mix of materials lies in this parabolic curve. This is equivalent to saying that the desired theoretical mixture of materials is such, that at any ordinate

* CONSTRUCTION OF THE PARABOLA.

D = largest diameter of stone
d = any given diameter
P = per cent. of mixture smaller than any given diameter

The equation of the parabola is

$$d = \frac{P^2 D}{10000}$$

The parabola can be constructed in any of the numerous ways given in text-books, the writer finding it easiest to use a slide rule. Set D on the B scale of the rule opposite 100 on D scale, read any value of d on the B scale opposite any corresponding value of P on the D scale.

†"Laws of Proportioning Concrete," by William B. Fuller and Sanford E. Thompson, Transactions American Society of Civil Engineers.

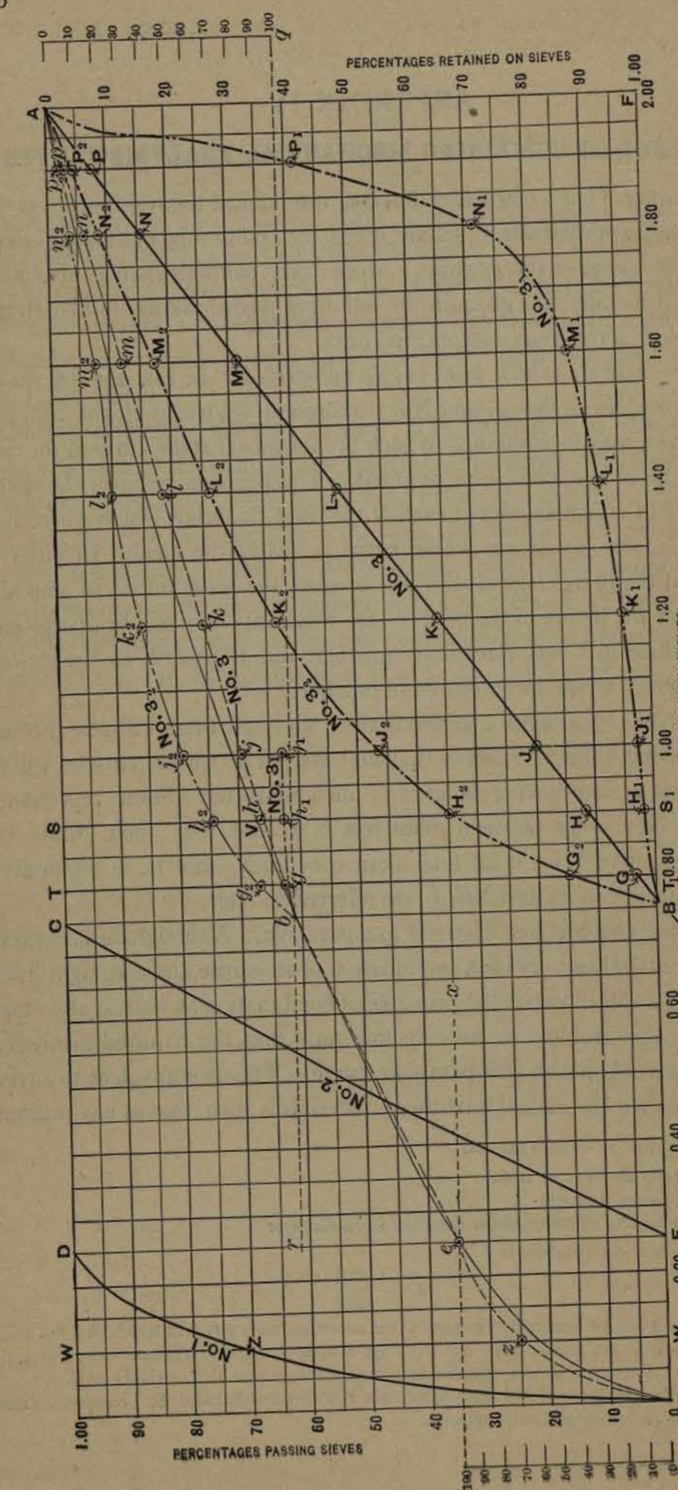

FIG. 246.—Diagram Illustrating Method of Combining Curves which do not Overlap. (*See pp.* 775 *to* 782.)

or vertical line cutting the parabola, the proportion or percentage of the ordinate below the intersection represents the percentage by weight of the mixed materials which passes a sieve the diameter of whose openings corresponds to the given ordinate, and the percentage above the curve represents that percentage which is too large to pass through this sieve. The parabola shows, for example, that 87% of the mixture of materials should pass a 1.50-inch sieve, 71% should pass a 1-inch sieve, 49% a ½-inch sieve, and so on.

We may now take up the stone curves in succession to determine what percentage by weight of each should be used, so that when they are combined, the mixture will be as nearly as possible like that called for in the parabola.

The chief difficulty in the method of determining the percentages of each material lies in combining the individual curves so as to form a single curve which represents the mixture. This involves drawing on the same piece of paper two different lines, each of which exactly represents the composition of the same lot of stone, that is, the exact per cent. of each size of stone in the lot. For example, as is explained below, on Fig. 246, lines *BKA* and *bkA*, each accurately represents the percentage composition of the same batch of stone, namely, No. 3, and the full meaning and value of these diagrams cannot be understood until it is clear how the same values can be accurately represented on the same diagram by two such totally different curves.

In the first place it is seen that the ordinates, that is, the vertical lines in the diagram, are divided into 100 parts representing percentages. It is clear, therefore, as the divisions are relative, that the diagram would accomplish the same results and curves could be drawn accurately representing the percentages passed and retained by the different sieves, whether the distance from 0 to 100 on the ordinates were, say, three times as large as it is, or whether it were only ¼ or ⅛ of the present length. All that is needed is to divide these vertical lines, whether they are long or short, into 100 parts and let each division represent 1%.

Referring now to Fig. 246, the percentage composition of the No. 3 lot of stone is represented by line *BKA*. This lot of stone contains no stone smaller in diameter than 0.75 inch and none larger than 2.00 inches. Running vertically upward from *B* on the 0.75-inch line to *b* where it crosses the parabola, we see that the parabola from *b* to *A* also represents a lot of stone none of which is smaller than 0.75 inch and none larger than 2.00 inches, and we can look upon this lot of stone for the moment as entirely separated from the rest of the mixture which the whole parabola represents. If we wish to find the exact percentages of the various sizes of stone which are in the portion or lot represented by the portion of the parabola from b to A, all that is necessary is to draw the horizontal line rq through the point b, then divide the vertical distance from A to rq into 100 parts, so as to obtain a new set of horizontal lines or abscissas representing percentages. Now if we start at the base line rq and follow up any one of the vertical lines or ordinates until it meets the parabola, and then follow horizontally to the right along the line which intersects the parabola at the same vertical line or ordinate point, the reading on the new smaller percentage scale will give us the per cent. of stone in the lot bA which is larger than the diameter represented by this ordinate, etc. For example, taking intersection of 1.00 ordinate with the parabola and running across we find that 75% of the lot is coarser than 1 inch diameter.

It is desirable to see how nearly the stone in lot No. 3 agrees with the theoretical lot of stone called for by section bA of the parabola. In practice, the comparison may be made most readily by ratios with the aid of the slide rule, as is described more fully below, but the reasoning will be more clearly understood if the plan described in the last paragraph is followed.

Taking first curve No. 3 we may redraw it on the same smaller scale as the portion of the parabola bA is drawn, that is, it may be constructed on rbq as a base line instead of on the zero coördinate BF. Since the vertical per cent. line between q and A has been divided into 100 parts, this section of the diagram may be used instead of the original per cent. divisions extending from A to F. A piece of paper the length of Aq may be divided into 100 parts and placed with its upper or 0 end in line with the upper line CA of the diagram. The vertical distance from the line CA to the various points G, H, J, K, etc., may be read by the eye and replotted, — with the assistance of the small scale, — as g, h, j, k, etc.

It is evident then that the broken line $bghjkA$ represents (referring to the small percentage scale Aq) lot No. 3 of stone as accurately as line $BGHJKA$ represents the same lot of stone referring to the larger percentage scale AF.

Stone curve No. 3, however, would never, in actual practice, be an absolutely straight line from A to B. It would be in all practical cases an irregularly curved line, similar, for instance, to some of the actual stone curves shown in Fig. 71, p. 199, or it might be either convex like the curve No. 3_2, Fig. 246, or concave like No. 3_1. These curves may be redrawn in exactly the same way as curve No. 3, and if the lower end of each is assumed to start at point b where the new base line or bq crosses the parabola, we should have for No. 3_2 the new curve $bg_2h_2j_2$, etc., and for No. 3_1 the curve whose beginning is shown by bh_1j_1, etc. Thus again

it is seen that the stone curves No. 3_2 and No. 3_1 on the original full-size diagram are accurately represented also by the curves $bg_2h_2j_2$, etc., bh_1j_1, etc., drawn to the smaller scale on the same piece of paper.

Thus far only the principles involved in understanding the curves and replotting them have been considered. The result at which we are aiming is the determination of the percentage of each material which will be required in the final mixture of the aggregates. Let us first take for this curve No. 3. The curve of stone No. 3 ends at B, which indicates that all of this stone is larger in diameter than 0.75 inches (although about 4% of it, for instance, is smaller than 0.80 inches in diameter). Now following up from B on the vertical line which represents 0.75 inches in diameter until we come to the parabola at point b, we see that the parabola demands that $\frac{bB}{CB}$ or $\frac{61}{100}$ or 61% of all the stone and sand in the entire mixture of stone and sand shall be smaller than 0.75 inches in diameter, and conversely that $\frac{bC}{CB}$ or $\frac{39}{100}$ or 39% of the mixture shall be larger than 0.75 in diameter. No. 3 stone is the only one of the three lots of stone which is larger in diameter than 0.75 inches, and therefore 39% of this grade of stone should be used in making up the mixture.

These ratios give us a clue to the method of plotting the curves to the smaller scale with the aid of the slide rule, instead of employing the longer method of actually dividing the spaces into 100 equal parts. The principle in each case is exactly the same. By the method of ratios the curve bkA would be plotted from the knowledge that $\frac{Cb}{CB} = \frac{Tg}{TG} = \frac{Sh}{SH} =$, etc. The distances Tg, Sh, etc., may be read directly from the slide rule or from the equation which follows from the preceding, viz., that $Tg = \frac{TG \times Cb}{CB} = \frac{96 \times 39}{100} = 37\%$, and so on.

This actual plotting of the curves may be unnecessary, in fact, it is usually unnecessary for an experienced calculator, as the percentages can be obtained and the general direction of the curve estimated by inspection.*

*It is evident that neither of the two batches or lots of materials shown by curves No. 3_2 and No. 3_1 are so well adapted to form a parabola as curve No. 3 Curve No. 3_2 would more nearly fit the parabola than it now does if its new curve were plotted slightly lower so that it would cross the parabola at a different point and a larger percentage of it would be required for the mixture. If it crossed the parabola at V, the percentage of it to use could be found by plotting it in this new location and taking for the percentage the vertical distance from C to the end of the curve, or what is the same thing, taking the percentage as $\frac{SV}{SH_2} = \frac{33}{65} = 51\%$.

The next curve in order is No. 2. We note that this lot of stone is the only one of the three whose particles lie between 0.25 inches diameter and 0.75 inches, and that therefore all of the stone called for by the parabola between these two sizes must be supplied from No. 2 lot. Following down from the upper end, C, of No. 2 to the parabola at b and up from the lower end E to the parabola at e and drawing horizontal line ex, we see that the proportion of No. 2 stone which is called for by the parabola is represented by the distance between the lines rq and ex or by line re, and we have the ratio $\frac{re}{DE} = \frac{26}{100} = 26\%$, as the percentage of the weight of the No. 2 material to the total weight of the mixture.

Plotting curve No. 2 in its new location as a part of the mixture we have the dotted line eb as representing the No. 2 material after it becomes a part, that is, 26%, of the mixture. The upper end must join the line bA because we are now plotting a curve which represents a mixture of the two materials, No. 3 and No. 2, and the mixture must be represented by one single, continuous curve. We may consider rb and ex as two base lines, divide the vertical distance between them into 100 parts, and then plot the percentages downward from rb, equivalent on the small scale to the percentages downward from DC to the original No. 2 curve CE, as described on page 198, or we may take ratios, as described on page 200, and using the slide rule set DE (100) on De (65) and on any vertical distance from DC to the line CE, we may read the distance from rb to the resultant curve eb. In practice, the line rb need not be plotted, but each ratio as it is obtained may be added to the per cent. already found for the No. 3 material to obtain the distance down on the ordinate for the final curve of the mixture, as shown on page 787.

The required percentage of material No. 1 may be obtained by deducting the sum of the percentages of No. 2 plus No. 3 from 100, or by inspection of the parabola and the curve of the portion of the final mixture already plotted, $ebkA$. From the location of the point e it is evident that 35% of the total mixture of the material must pass a 0.25-inch sieve. Since No. 1 is the only material whose particles are finer than this, it is evident that this percentage of the total mixture must be entirely formed by No. 1. In other words, the percentage of No. 1 to the total mixture of 100 parts is 35%. To plot the curve OD as a part of the mixture, we may divide the distance eE into 100 parts, and plot the percentages, or we may take the slide rule and set Ee on DE, that is, 35 on 100, and read the correspond-

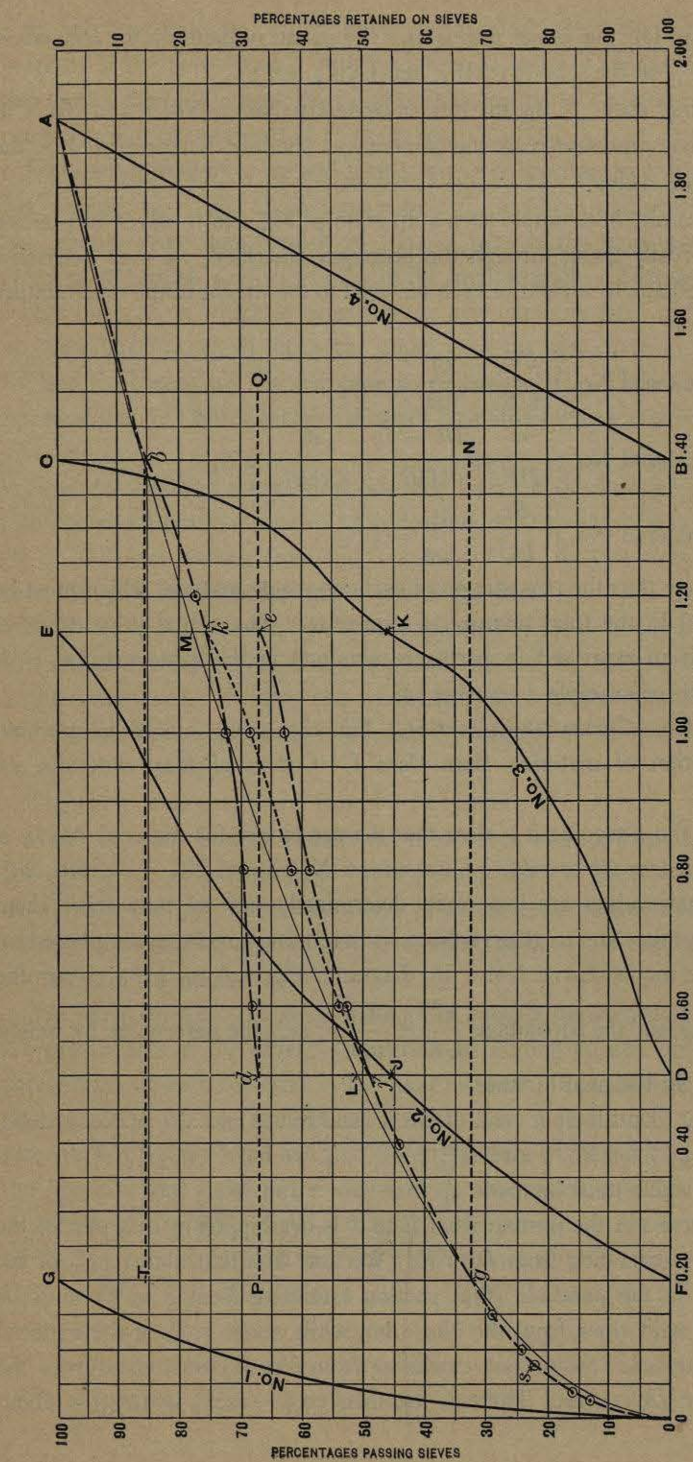

FIG. 247.— Diagram Illustrating Method of Combining Curves which Overlap. (See pp. 782 to 784.)

ing ratios for the other ordinates. Thus, at ordinate 0.10, $DE:eE = ZW_1:zW_1$, or $100:35 = 71:zW_1$, hence $zW_1 = 25$.

The final curve of the mixture of materials No. 3, No. 2, and No. 1 in proportions represented by the percentages obtained is represented by the dotted line *AkbezO*.

To illustrate how simply such a diagram as Fig. 246 is solved in practice without really going through the processes described, we may determine the percentage by weight of each material to the weight of the final mixture as follows:

For material No. 3, $\frac{Cb}{CB} = \frac{39}{100} = 39\%$

For material No. 2, $\frac{re}{DE}$ or $\frac{De - 39}{DE} = \frac{26}{100} = 26\%$

For material No. 1, $\frac{Ee}{ED} = \frac{35}{100} = 35\%$

We have thus the percentages of each aggregate material which must be contained in the total mixture of aggregate. The actual proportions of the concrete expressed in parts are obtained in the same manner as is described for example 2 on page 788.

Case II. Curves which overlap. Fig. 247 shows a more complicated combination of materials than Case I. Curves of four materials are drawn.

From the foregoing it is clear that the percentage for material No. 4 is represented by *Cb* or 14%. Since curves No. 2 and No. 3 overlap each other, their values are less easily determined, and we may leave them and first take No. 1. Curve No. 1 is determined and may be plotted in the same way as curve No. 1 in diagram, Fig. 246, p. 776, giving the curve *Osg*, and the percentage $\frac{gF}{GF} = \frac{33}{100} = 33\%$ the percentage by weight of No. 1 in the final mixture.

Having found the per cent. of No. 1 sand to use and also of No. 4 stone, namely, 33% for No. 1 and 14% for No. 4, we have left 53% of the total mixture which must be made up from No. 2 and No. 3 lots.

On curve *FE* the portion from *E* to *J* is overlapped by that part of the *DC* curve extending from *D* to *K*. We note first that about 20% of the material in the parabola (that portion extending from *g* to *L*) must be supplied with stone from the No. 2 lot, while about 10% of the material of the parabola (the portion extending from *b* to *M*) must come from the No. 3, or *DC* curve. There is left then 53% — (20% + 10%) = about

23% of the parabola which must be supplied from the overlapping portions of the two curves. Judging from the general appearance of the two curves it would appear that No. 2 curve contained stone more nearly corresponding to the needs of the parabola than *DC*.

For a trial, therefore, we will give a larger proportion to No. 2 than to No. 3 stone, say, 14% of the remaining 23% to No. 2 and 9% to No. 3. No. 2 stone must then furnish 20 + 14 = 34% of the final mixture and No. 3 must furnish 10 + 9 = 19% of the final mixture. Through *g* draw a base line *gN* on which to construct the new curve for *FE*. 34% higher up draw line *PQ* which forms the upper limit for new curve to represent *FE* and the lower limit for new curve to represent *DC*. Then 19% higher up draw line *bT*, which forms the upper base line for new curve to represent *DC*.

Now, by dividing the vertical distance between the lines *gN* and *PQ* into 100 equal parts, — or else by ratios, taking the slide rule and setting *Pg* on *GF* and reading from the ordinates of *FE*, the distances from the base line *gN* to the points which locate the curve *ge*, — we can readily transfer curve *FE* into the new curve indicated by the dotted line *ge* which is assumed to supply 34% of the stone still needed by the parabola, and in the same way by dividing the vertical distance between the lines *PQ* and *Tb* into 100 equal parts, — or else by taking ratios, — the new *db* curve can be laid down.

The curve from *g* to *j* and from *b* to *k* remains as it is.

With a pair of dividers transfer the distance at each ordinate from base line *PQ* up to curve *db* down to curve *ge*, and add it to the curve. These new points will give the dotted curve *jk* as the exact location of the two batches of stone No. 2 and No. 3 combined, 34% of the one being used and 19% of the other.

The resultant curve, *jk*, may be found in another manner after selecting the percentages of the different materials by adding on any ordinate the percentages of each material in the final mixture. For example, on 1.00 diameter, 26% of No. 3 stone passes a 1-inch sieve, but since No. 3 actually occupies only 19% of the mixture, the percentage of No. 3 stone passing the 1-inch sieve in terms of the weight of the total mixture (which is 100%) would be 19% of 26% = 5%. Similarly, the percentage of the portion of the No. 2 stone in the final mixture which passes a 1-inch sieve is 34% of 88% or 30%. All of the No. 1 material (33%) passes the 1-inch sieve, so this too must be added to the others, and we have 5% + 30% + 33% = 68% as the percentage of the final mixture which will pass a 1-inch sieve.

An inspection of this dotted line *jk* resulting from combining these curves leads us to the conclusion that we should have done rather better to have taken more of No. 2 stone, say, 38% instead of 34%, and 15% of No. 3 instead of 19%, in which case the combined curve would have more nearly corresponded with the parabola. We would have, therefore, as a result of our study the required percentages of material as 14% of No. 4, 15% of No. 3, 38% of No. 2, and 33% of No. 1.

Practical Examples of Proportioning. Having taken up in a very elementary fashion the principles by which curves are drawn and combined, we may take two examples of other combinations of materials liable to be met with in practise.

Example I. — Curves of two materials. Suppose we have for concrete

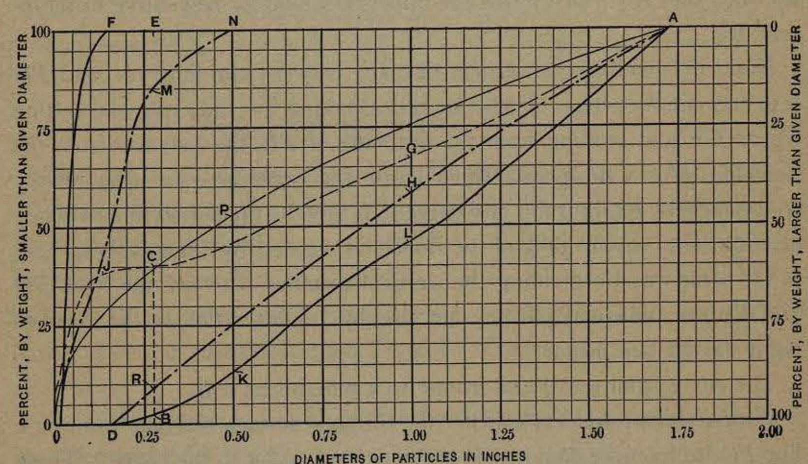

FIG. 248.— Method of Proportioning Two Aggregates. (*See p.* 784.)

the fine sand of Fig. 200, p. 198, to use with the crushed stone of Fig. 70, p. 192, what proportions of each should be employed and how could the mixture be improved?

Solution.—The curves of the two materials are plotted to the same scale in Fig. 248 as OF and $DBLA$, and then the theoretical curve OCA drawn for convenience as a parabola by the method previously described.

The curve indicates that for a theoretical mix of sizes of aggregate up to $1\frac{3}{4}$ inches, 93% of the mixture should pass a $1\frac{1}{2}$-inch sieve, 76% should pass a 1-inch sieve, 53% a $\frac{1}{2}$-inch sieve and so on.

Where, as in this case, the materials to be mixed are represented by only two curves, no combination of which will make a curve as close to the theoretical as is desirable, there is another limiting condition which was brought

out by the experiments, viz., that for the best results the combined curve shall intersect the theoretical on the 40% line, at C, and that the finer material shall be assumed to include the cement.

In this case, therefore, where the stone and sand curves do not overlap each other, to determine the best proportions of stone and sand, we have merely to take such proportions of each that the resultant curve will pass through the ideal curve at the point C where it crosses the 40% abscissa. This percentage is obtained by taking the ratio $\frac{EC}{EB} = \frac{60}{98} = 61\%$. The percentage by weight of sand plus cement to total aggregate will be 100% — 61% = 39%. The curve of the mixture may now be drawn by replotting the curve $DBLA$ in its new location $JCGA$ and the curve OF in its new location OJ, thus making the combined curve $OJCGA$.

Now decide upon the amount of cement to use in the mix to give the required strength of concrete, say, one cement to eight aggregate (the proportion of aggregate being based on measurement before mixing together the sand and stone), which will make the cement one-ninth or 11% of the total materials. Deducting this from the sand plus cement, we have 39% — 11% = 28% sand, and our best proportions for a 1:8 mixture will be 11 parts cement: 28 parts sand: 61 parts stone, which is equivalent to 1:2.5:5.5. If the proportions are required by volume and the relative weights of the sand and stone differ from the relative volumes, the proportions should be corrected accordingly.

Plotting the analysis curves of the two materials, as described above, shows immediately how to improve the mix. If, for instance, the crushed stone had been better proportioned so as to contain more particles of 0.5 and 1.0 inch diameter, — see curve DHA, — a curve much nearer the parabola could have been constructed. In this case the ratio would have been $\frac{EC}{ER} = \frac{60}{91} = 66\%$ of stone, and the proportions of cement, sand, and stone for a 1:8 mixture, 11:23:66 or 1:2:6, a stronger and a more impermeable mix. A still better mixture would have resulted with the use of coarser sand having a curve similar to the broken line OMN, which with the first material, $DBLA$, would have brought the continuous line of the mixture very much nearer the ideal curve, by using the ratio $\frac{MC}{MB} = \frac{45}{83} = 54\%$ of curve $DBLA$ and 46% of curve OMN. This method thus shows not only the best proportions for given materials, but also the defects in the materials and how to remedy them.

The most valuable use of the method of proportioning by mechanical analysis is in cases where the character of the work warrants employing several grades, that is, several sizes, of stone and sand. Such mixtures are being increasingly employed as engineers and contractors more fully appreciate the necessity of so economically proportioning the materials as to produce a mixed aggregate of the greatest possible density, — that is, with the fewest possible voids, — thereby reducing the quantity of cement and at the same time improving the quality of the concrete, in other words, making both a better and a cheaper concrete.

The process of determining the percentages of each material is more complicated than where only two aggregates, sand and stone, are used, but it is not very difficult in practice, especially if one is familiar with the slide rule, and, as illustrated in Example 2, the method is more exact than

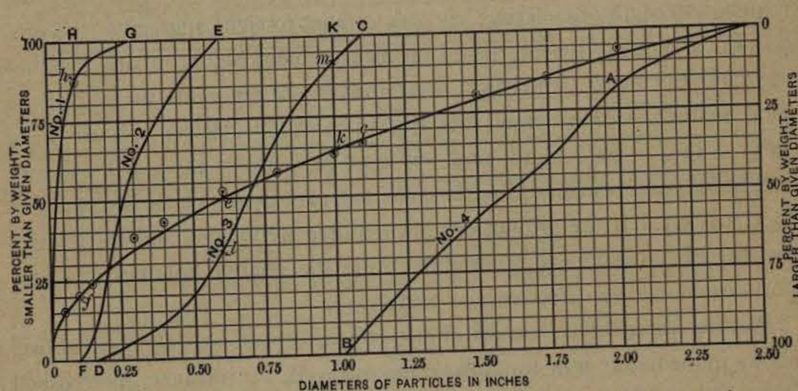

FIG. 249. — Method of Proportioning a Graded Mixture. (*See p. 786.*)

with two materials, for the reason that the resulting curve can be made to more nearly approach the parabola.

Example 2. — Graded Materials. Given the medium sand, represented by curve in Fig. 72, page 200 and the three sizes of crushed stone represented by the curves in Fig. 71, page 198, find what percentage of each will best combine to make the strongest and densest concrete.

Solution. — Since mechanical analysis of each material has already been made, we will immediately replot the four curves on the same scale in Fig. 249 and draw parabola passing through point O and the point at which curve No. 4 reaches 100%. We see at once that percentage of No. 4 stone required is $\frac{Kk}{KB} = \frac{36}{100} = 36\%$. (To be sure, about 8% of No. 4 is overlapped by No. 3, but this is so slight it need not here be considered.)

Let us determine sand curve No. 1 at 0.10 diameter ordinate, since it can be seen by inspection that the portion oh of curve No. 1 very nearly fits the parabola and grains smaller than 0.10 diameter must be supplied wholly from this curve, while the larger grains represented by portion hG are found also in No. 2 curve. Accordingly, we have the percentage $\frac{Fj}{Fh} = \frac{20}{88} = 23\%$.

A part of No. 3 curve, that portion extending from D to l, is overlapped by nearly the whole of No. 2 curve. We can see, however, that No. 3 curve alone must supply 14% of the material in the parabola (that portion extending from e to k). This leaves $100 - (36 + 23 + 14) = 27\%$ of the mixture to be furnished by the overlapping portions of No. 3 and No. 2 in such ratio as best fits the parabola.

From a study of the two curves, we find by inspection and trial plottings that most of the material required would be better supplied by No. 2 curve, since it contains stone corresponding very well to the needs of that part of the parabola extending from j to e. Let us consider 23% as the proper amount of the final mixture to be furnished by No. 2 curve, which would leave $14 + 4 = 18\%$ as the total portion which must be supplied by No. 3 curve.

Now, on any of the ordinates, we can locate points through which a curve may be drawn which represents a mixture of the given sand and stone in the proportions just found, for example:

Ordinate.		% Retained.
1.75	40 x 36%	= 14
1.50	57 x 36%	= 20
1.10	92 x 36%	= 26
1.00	(100 x 36%) + (8 x 18%) = 36 + 1	= 37
0.80	36 + (31 x 18%) = 36 + 6	= 42
0.60	36 + (66 x 18%) = 36 + 12	= 48
0.40	36 + (88 x 18%) + (21 x 23%) = 36 + 16 + 5	= 57
0.30	36 + (93 x 18%) + (40 x 23%) = 36 + 17 + 9	= 62
0.15	36 + 18 + (92 x 23%) + (6 x 23%) = 36 + 18 + 21 + 1	= 76
0.05	36 + 18 + 23 + (30 x 23%) = 36 + 18 + 23 + 7	= 84

These percentages are plotted on the diagram as small circles. The same points would have been obtained if we had begun at the left of the diagram and calculated the percentages passing the sieve.

We find that a curve drawn through these points satisfies the parabola sufficiently well to assume that 23% of sand, 23% of finest stone, No. 2, 18% of medium stone, No. 3, and 36% of the largest stone, No. 4, would make the best concrete mixture out of the given materials.

If 1 : 7 concrete is wanted there would be * $\frac{100}{7} = 14.3$ parts cement, and the proportions would be 14 : 23 : 23 : 18 : 36 or 1 : 1.6 : 1.6 : 1.3 : 2.5 by weight. This would give very nearly an ideal mix, and the resultant concrete would be impermeable and very strong.

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