mortar with the alluvial soil they had dug out of the foundations, just because it was ready to hand. Ground bricks and ashes have a tendency to make lime more hydraulic in its properties, and mine dust, which is the refuse from iron ore at the calcining ovens, has a most excellent effect, provided that it be thoroughly ground and mixed with the lime in the grinding pans, so that the particles may be small enough to effect the desired chemical union. It may be here remarked that all those materials which, when mixed with lime, render it hydraulic, must have been subjected either to subterranean or artificial heat previous to slaking.

There are many ways of slaking mortar. The common plan is to throw water on the heap of shells; another is by immersion, that is, dropping the shells in a basket amongst water, and quickly drawing it out again; another is to allow it to slake spontaneously by exposure to the air, as is often done by farmers when used for the land. In slaking mortar care must be taken that no more water is used than what will cause the lime to fall to a dry powder, that is, not more than the lime will absorb, but still sufficient to cause sufficient disintegration. If more water be added, then setting immediately commences, which is more or less rapid according as the lime is more or less hydraulic. After slaking the shells the resultant powder ought to be kept for some time under cover, in order that the particles may have time to get completely disintegrated. A week is probably sufficient for this purpose. When the slaking process is accomplished, the resultant powder may be mixed with the sand and other ingredients, with sufficient water to render the mass plastic.

Another plan is to grind the lime before slaking along with the mine dust or puzzuolana, and in that case the mortar may be used immediately after slaking, indeed the slaking and mortar making form one operation The grinding dry is a more expensive, but perhaps it is the best plan, as I believe a good deal more benefit will be got out of the puzzuolana if mixed with the lime before it is slaked. Then in the method of slaking, first, it is necessary to grind the mortar after water is applied, in order that the mine dust may be reduced, and the grinding action has the effect of destroying the angularity or sharpness of the sand, thereby reducing the tensile strength of the mortar by depriving the sand of the dovetailing effect which is due to its angularity. Again, a great amount of heat is caused by the motion of the heavy grinding wheels moving at a considerable velocity, and that heat may have some deteriorating effect upon the setting properties of the mortar. In the case of a quick-setting cement grinding is positively the worst thing possible, for it disturbs the setting when it is actually going on; and if a cement be continually mixed up for as long time as it would take to set, and get hard if left alone, it would be found that it would be completely destroyed. A case in point occurred last year on a new graving dock work, where the cill had to be taken out because it was leaking and therefore likely to give way when the pressure of the water was brought to bear upon it. The contractor pleaded that the fault in the work was in the cement, which had been specified to be ground for fifteen minutes after water was applied, thereby destroying the setting properties of the cement, which would have set within the stated time of fifteen minutes had it been let alone. The case came to arbitration, and the arbiter decided that the specification of the cement mortar was impracticable, and relieved the contractor of all responsibility. This shows how careful engineers require to be in drawing out their specifications, and that a complete knowledge of the materials to be used is indispensable.

The safest plan is to grind the cementing materials dry, and then slake and mix up the mortar by one operation in a pug mill. By this means we have the lime and puzzuolana or mine dust thoroughly mixed and reduced to powder, which admits of the water getting at every particle whenever applied and then the sand, which is added with the water when in the pug mill, is preserved in all its angularity and sharpness. If, however, this latter plan be adopted, the mortar must be used soon after being mixed up, not longer than twenty-four hours for lime or half an hour for cement; but then, again, there is a risk in using it too soon, because, if the particles of lime are not properly slaked before being placed in the masonry, "blowing" may occur, that is, those unslaked particles will draw in water, and swell up, causing the stones to be shifted out of their positions.

It is also interesting and useful to know what quantity of mortar or concrete is to be expected from a given quantity of materials measured separately—in other words, the contraction in mortar making—since it is only by information on this contraction that we can deduce a theory by which the quantity and cost of mortar can be calculated.

The cost of mortar plays a very considerable part in the expense of masonry, and if engineers or architects do not define the proportions in their specifications, I do not think it can be expected that builders can make reliable estimates; and it is impossible to expect first-class mortar when the offerer is not told it is required to be so, for in a competing estimate he will make it up as if a cheap mortar were to be used. The perfection of mortar must be when every particle of sand is imbedded in a matrix of cementing material and no more, in the same way as obtains in a piece of sandstone. If, therefore, we can get at the amount of voids that exist in a given quantity of sand, that ought to be the quantity of lime required to thoroughly incorporate the given quantity of sand A cubic foot of sandstone weighs from 130 lb. to 170 lb., and as much of dry loose sand weighs 88 lb.; so that assuming the cementing material of the sandstone to be of the same specific gravity as the particles of sand in it, the amount of space in loose sand ought to be from 40 to 50 per cent. of the whole bulk. In corroboration of this I may give a note of some experiments taken out of Vicat's work on cements which were carried out by ascertaining the amount of space by measuring the quantity of water the sand licked up, without increasing the bulk, the results were that gravel of $\frac{3}{4}$in. diameter (beans) had 50 per cent. of void, gravel or coarse and, $\frac{1}{10}$ in. to $\frac{2}{10}$ in., had 42 per cent. of void, sand of $\frac{1}{20}$ in. diameter had 40 per cent. of void, sand of $\frac{1}{100}$ in had 33 per cent. of void, powder or very fine sand 30 per cent. of void.

Thus it will be seen that the spaces vary from 30 per cent. to 50 per cent. of the bulk of the sand. To be safe, therefore, no mortar ought to have less lime in it than 50 per cent. of the bulk of sand, that is two of sand to one of lime. Now if a mixture of two of sand to one of lime be tried the resultant mortar is nearly equal to the sand, just what we ought to expect from the theory already stated. The water seems all to be absorbed by the lime, and does not bulk provided there is not an overdose of it.

THE SAINT GOTHARD TUNNEL.

The accounts of the progress of this great work to the end of March are satisfactory. According to the accounts of the Swiss Federal Council the driftway had been driven on March 31 to the extent of 252 metres, enlarged to its full size along 210 metres, and the masonry finished over a distance of 103 metres. The average number of men engaged in the work during the month was 617, and the maximum number 813. On the Gœschenen side the tunnelling is through granite, or a hard gneiss, more or less faulty, and full of fissures. On the last day of March the first experiment in mechanical perforation was made with the machines of MM. Dubois et François. The operation took place on the Airolo side, through a schist in beds of unequal thickness. At the distance of 148 metres from the mouth the temperature of the air was 13° c. and of the water 70° c., the air outside the mouth of the tunnel showing a temperature of 7°; at 162 metres the air rose to 17° c., when the outer air showed 9°.

The infiltration, which was trifling at first, grew in proportion as the increase of the mica and the diminution of quartz, and the frequency of argillaceous beds between the mica schist, all of which circumstances, of course, diminish the consistency of the soil excavated. The quantity of water augmented considerably at the point of 164 metres; a stream broke in at the rate of more than sixteen gallons per second, and disintegrated the rock to such an extent that several slips occurred, and the work was suspended in consequence for some days. At the end of March the out-fall of water at the mouth of the tunnel was found to be equal to about nine gallons per second.