the point at which the connection was made. Although he had implicit faith in his calculations, yet, realizing what must have been the inevitable result of the slightest error, he could but experience a feeling of satisfaction and relief when the miner's pick struck through, and the point was reached where work had been stopped from the other end, nearly two years before.

One million seven hundred thousand brick were used in the construction of the tunnel. These are of the hardest kind, and laid in a cement that when "set" is as hard as the brick itself. The capacity of this tunnel is from sixty to seventy million gallons of water daily. When the fact is stated that the present average daily consumption of water is about six million gallons, it will be seen that the tunnel will be ample to supply Cleveland when it shall have a population of a million.

ON THE SELECTION OF A BUILDING STONE.

BY C. A. EVANS, CIVIL ENGINEER.

This is a subject which has been under the pen of most writers on construction. Yet, notwithstanding this extensive treatment, no general principles have been indicated to direct the selection of a stone for an intended structure. To the engineer, in particular, the selection of materials suitable to the variety of works he executes, is a matter, the importance of which, is of itself evident. It is to elucidate the principles which should guide him in this portion of his labors, that this article has been written.

A continual practice in one direction by reason of some prominent good quality which a stone may possess, often prejudices many builders in favor of the particular class to which it belongs. But an extensive experience in all countries leads to the conclusion that a perfect stone is one which has several good qualities; which is strong, durable, capable of being ornately worked, and of a fine appearance. For engineering works situated in the country, strength and durability are the only points which need be considered. Nevertheless, it is often difficult to obtain a stone which will fulfil even these two requirements. How a stone stands in regard to them, may be determined as accurately as the usual tests admit. No test for durability, however, has yet been discovered which may be implicitly relied upon; yet no known test relating to this point should be omitted by the engineer

if he would remove from his shoulders all blame of future *accidents*. A thorough examination of a stone, comprising that of its quarry, of its structure, of its constituents, leads generally to correct results. The plain character of engineering works in the open country, with their architectural effect depending only upon the proportion and disposition of their masses, does not require stones capable of being dressed as elaborately as those for city structures. For this reason this quality does not play here an important role. As regards appearance, it may be remarked, that the surroundings are usually in harmony with it, of whatever color and texture the stone may be. Therefore, even if circumstances did not compel the engineer to employ the most accessible stone, paying attention only to strength and durability, there would really be no necessity to consider anything else. On approaching a large town, however, regard must be had to *all* the foregoing qualities. The class of work now changes. Here are located shops, depots and dwellings. These will be in contrast with other buildings, and show to advantage or not, according to the good or bad choice of their material. The architectural principles which here govern the engineer become more complicated and numerous, and demand, in consequence, a fine stone. Nevertheless, all should not be sacrificed to architectural considerations. Financial matters demand reflection. It would not be wise to draw from distant sources such a stone, when a good one, though inferior in structure and appearance, exists in the neighborhood. In such a case, the engineer must put up with what nature offers him, and employ a style of architecture which will be most in keeping with his material. But in cities a handsome depot demands a handsome stone. If no quarries in the vicinity furnish it, recourse must be had to others more remote. The expense may be considerable, but it must be borne in mind that an ugly material will make a building doubly so, especially if large and surrounded by better architecture. Should a fine stone not be offered, let brick then be used in preference to an inferior one. Some respect should be paid to the requirements of art.

In selecting a stone for an intended structure in a city, we must be governed in our choice particularly by a consideration of the class of ornaments which are to appear on the building, and by the expression which it is to possess. If the structure is to be decorated with plain large mouldings of a bold outline, then a coarse grained and dark stone may be used. But should it, on the contrary, be embellished with delicate carvings, or with small figures in relief, either on the

mouldings or the plain wall, a light-colored and close-textured stone is required. No dark or coarse-grained stone should be employed in this latter case. For a dark stone will fail to make the shade and shadows of these small ornaments perceptible, thus greatly diminishing their effect. A coarse-grained stone will not admit of fine edges being cut on it, and it is only by such luminous lines that we are enabled to clearly define the shape of the ornaments. For the want of either shade or luminous lines, small figures in relief will often, when viewed from no great distance, appear like lumps raised on the surface of the stone. This is particularly the case after the building has stood for a number of years. On a new building everything is clean. The stones are lighter than the permanent color they will finally assume under the influences of the air, dust and smoke. But the most powerful agent of destruction is the humidity of our climate, under the attacks of which all stones succumb more or less. This is easily perceived on examining their edges. Such an examination will also show that a coarse-grained stone exhibits more plainly the marks of these attacks than a fine-textured one. The particles are comparatively large, and those which are removed leave correspondingly large vacant spaces. Hence it is wrong to carve on such a stone, whatever may be its merits in other respects. Twenty winters will often be sufficient to destroy the edges of ornaments on a coarse-grained stone of great durability. These effects are noticeable particularly when the stone is situated in a place exposed to the prevailing winds and rains, whether in the streets of a city or the open country.

The preceding is a fundamental rule in architecture, yet it is constantly violated. When decoration in a high degree is intended, marble is the most appropriate stone for this class of work. The turn of a leaf carved out of this stone may be distinctly seen placed at the summit of a spire. For the material retains its sharpness of contour, its edges reflect the light, and its shades are visible and effective. In nothing more did that fine race, the Grecians, show their exquisite taste than in the choice they made of this material for their edifices.

Passing now to consider a stone with reference to the expression which its color may communicate to a building, it may be laid down as a general rule, that a light-colored stone is adapted to nearly all buildings, whether of a massive or light, a magnificent or plain character. But structures intended to have a sombre appearance should be built of the darkest stone procurable. Nevertheless, if they are not well designed, the full effect of such a stone will not be brought out.

This material may be used also in combination and contrast with lighter stones, producing quite a picturesque effect. Grandeur of style, however, demands a sameness of color. A medium dark stone gives an air of repose to a building built with it. Still, it should be used either in open situations or in those in which it may receive plenty of light. Hence a narrow street may be considered as an unfavorable situation for its employment.

The finest light-colored sandstones are doubtless those best suited to city purposes. A *good* limestone is also a fine stone in every respect. Some varieties of this stone preserve their color very well. For, being smooth, the dust does not much adhere to them. Many argillaceous stones, on account of their slaty structure, are disagreeable to work, yet they may be advantageously employed. A coarse-grained granite is open to the objections frequently urged against all coarse-grained stones, though some fine-grained varieties, obviating these inconveniences, make fine building stones for moderately decorated structures. But, in general, granites become quite dark with age; and, for close views, as those obtained in a street, they are not, in the opinion of the writer, as effective in appearance as stones the constituents of which are all of an uniform color. For many of the plain works of the engineer, granite may properly be considered as the most desirable material. In basements, particularly in those of depots, it may be introduced on account of its not showing the grease as much as some other light-colored stones. Under the name of granite is here included also that stone known to writers on mineralogy as syenite, and which is especially referred to in the foregoing remarks.

Philadelphia, Oct. 2d, 1873.

St. Gothard Tunnel.—During the month of July the following progress was made at the tunnel: At the west end, at Göschenen, the length of heading driven during the month was 51 metres, making a total of 259 metres driven up to July 31st. The length of tunnel completely excavated was increased from 150 to 200 metres at that end. At the south end, at Airolo, 47 metres of heading were driven, making a length of 266 metres driven up to the end of July. The length of tunnel completely opened out was increased from 214 to 253 metres. The average number of workmen employed during the month of July was 945, and the greatest number employed at the works in one day was 1159.