

cushion as it is felt that weaknesses are less apt to develop due to shifting of the sand cushion. The Borough of Manhattan, New York City, the city of Baltimore, the city of Philadelphia and a number of other localities have recently adopted the cement-sand cushion.

The standard practice with reference to the grout for the joints calls for a 1:1 cement grout mixture. There have been a number of experiments in recent years with a mixture of bituminous material and sand for fillers. These experiments were undoubtedly carried on more extensively in the Borough of Manhattan, New York City, than any other place and to a somewhat limited extent in the city of Philadelphia and other cities.

These fillers consist of different mixtures, ranging from 30 to 40 per cent. of sand mixed with bituminous material—either tar, asphalt or asphalt and tar mixed. In Baltimore, they have obtained very good results with an asphalt filler used in the following method: They pour hot asphalt to a depth of 1 inch, about 1 inch depth of hot gravel, and repour and refill with hot asphalt and hot gravel alternately until the joints are flush. I am informed that this usually takes approximately four pourings. After the joints are filled, the hot asphalt is squeezed over the entire surface of the blocks and hot gravel is then thrown over this before traffic is allowed on the pavement. This gives an asphalt surface of about  $\frac{1}{8}$  of an inch on top of the granite block, giving the street the appearance of a sheet asphalt pavement.

The best results in granite block construction are undoubtedly obtained with the cement grout filler, and it would seem to be good practice in every instance to make arrangements to close the street the additional seven to ten days and construct the pavements with grout fillers. Of course, there are some streets that it is practically impossible to keep the traffic off for this length of time, and in such cases it will be necessary to use the bituminous filler, but there are a number of instances where bituminous filler is used, where the traffic conditions have been such that the street could be closed for a long enough time to use the cement grout filler.

The old method in using cement grout filler was to fill the joints for a certain depth with pea gravel and then pour the cement grout filler. It has been found, however, that better results are obtained by eliminating the gravel entirely and filling the whole joint with the 1:1 mixture, and this method is used exclusively in a number of cities. There has been considerable discussion relative to the best means for mixing the grout. Of course, just as good grout can be mixed by hand as by machine, provided it is given the proper attention, but more uniform results will be obtained by adopting the machine-mixing method, as this eliminates the human element which often is not properly controlled.

The cement grout, of course, must be kept thoroughly agitated until it is poured into the joint, and the blocks should be thoroughly sprinkled before the filler is placed in the joints.

All of these essential details which, carried out to the letter of the law, go to make up a good pavement, appear to be so simple that in many cases the inspector and the workman are more or less lax, the result of which will show in the construction immediately after it is completed or within the next few years. A good job can only be obtained by strict attention to these apparently trivial but very essential details in the construction. The pay of inspectors on highway work usually ranges from \$3.50 to \$6 per day, and most engineers with experience will bear out the statement that a thoroughly capable inspector,

judged by the standard of the average highway inspectors, is worth \$10 per day to the community. A great many of the failures in paving construction are due, not always to dishonest inspection but careless inspection, and it would seem as though this branch of the service has not been given the consideration it should, and if it is necessary to pay \$10 per day to obtain the right kind of inspectors, it would be far better to do so than to lose more than the increase in salary through poor work as obtained through careless inspection.

Of course, it is perfectly obvious that in order to lay good pavements we must eliminate all possible conditions that are liable to result in failure. In doing this, we must also take into consideration the human element and provide for methods of construction that will, as far as possible, eliminate the personal equation entering into the construction; or, in other words, we should not depend any more than is absolutely necessary, in such an essential matter as this, on perfect workmanship.

Some question has been raised relative to the tests for granite block. Some cities specify that the blocks should come from certain definite quarries, or from a quarry that will be acceptable to the engineer. There should be a more definite method in stipulating just what the requirements should be than to leave it up to the personal judgment of the engineer. After making an inspection trip of the different quarries and an investigation of stone laid by those quarries, it has been determined to make the test for the Philadelphia specifications as follows:—

**Compressive Strength.**—The granite shall have a compressive strength of 16,500 pounds per square inch, except when unusually heavy traffic conditions are to be encountered, in which case the compressive strength shall be 20,000 pounds per square inch. It is understood, however, that a strength of only 16,500 pounds will be required unless definitely stated otherwise in the proposal. The toughness shall be not less than 11, as determined by the method employed by the United States Department of Agriculture.

However, it might be stated that these requirements are not entirely satisfactory. Very extensive studies and tests are being made in Philadelphia at the present time to determine upon new standard tests that will insure satisfactory results. Of course, it must be borne in mind that on streets such as West Street in New York, where you have an enormous amount of heavy steel-tired trucking, that it is desirable to use the hardest granite that can be secured, but at the same time not be so hard that it will be brittle and chip, and on such a street it might be desirable to raise the crushing strength to at least 30,000 pounds. However, the New Hampshire and southern granites that test from 15,500 upward are entirely satisfactory for probably 95 per cent. of streets where it is desirable to use a granite block pavement. The Worcester, Mass., pavements, which have been in service upwards of 15 years, and have had practically no money spent on them for repairs, are the softer granites and they have proven entirely satisfactory on heavy traffic streets.

A very important matter in the construction of granite block pavements is the proper ramming of block. Where the specifications do not state the number of rammers that shall be employed to follow up the work of a definite number of pavers you will invariably find that the ramming of the block is neglected and that the contractor will employ just enough rammers to slightly ram each block. Of course, the pay for rammers is about \$3.50 per day, and the fewer the contractor has to employ the cheaper the