contractor is responsible, if the cement is not tested and the work supervised by an experienced concrete inspector, the investor is likely to suffer.

Now let us go into the sand question. It is claimed that any engineer or experienced man can tell good sand at a glance. That is impossible. He may be able to tell that it is too fine if it is very much too fine, or too dirty if it is very much too dirty; but beyond that there are no engineers or experienced men who can tell at sight whether this or that sand is good and reliable for strong and dense concrete work.

• All sand contains more or less silt or dirt. The reason for this is that it is composed of small particles of broken rock of different sizes and compositions, coming from different parts. These particles have been washed away or transported from their different sites at different times and settled in layers of different thicknesses in what is now a workable sand bank or deposit. Therefore there is no guarantee or even likelihood of uniformity, and one car load of sand may be first-class and the next of very poor grade for concrete work.

Also the dirt and silt, which are very often injurious to sand for concrete purposes, are bound to be present in some parts of the sand bank; because the small particles of rock that are washed towards the bank will naturally carry with them more or less of this fine material.

The above shows conclusively that in order to be sure of good results, the sand should be tested not only once but continually while the work is in progress.

Besides the avoidance of injurious silt, there is to be considered the size or grading of the sand. It should be well graded, having a certain proportion retained on each sieve from, say, the eighty-mesh to the one-quarter-inch sieve. If all of the sand grains are of nearly the same size, the voids will be too great and unless an additional amount of cement is used, the voids will not be filled. If too fine, the concrete will not be of the required strength. The reason for having sand well graded is so that the fine particles will fill the voids left by the coarser particles, thus reducing them to a minimum.

In order to properly proportion a concrete mixture, it is necessary to determine the voids; without this information, the engineers are working blindly and probably wastefully. Where they are figuring on having a dense concrete for a reservoir, oil tank or foundation, the result is apt to be different; and if the water goes through the wall, concrete once more gets a black eye.

Another very bad fault in some sands, which can not be determined without testing, is that they contain injurious chemicals. Sometimes the drainage from some industrial plant such as a chemical works, soap factory or tannery, though located several miles away, will contaminate a sand supply, rendering it unfit for use in making concrete. As a rule, such contamination is discovered by making three-toone briquettes with the sand under consideration and also with standard sand. A comparison of the results will soon tell whether or not injurious chemicals are present.

## Sand Saturated With Ammonia

Some years ago I had occasion to deal with a very interesting case of the above type. A company decided to build a concrete laundry building in eastern Ontario on the site where an old stable had been standing for years. They tore down the old building and in excavating for the cellar of the new, ran across such nice-looking sand that they decided to use it in the concrete mixture for the new struc-The concrete would ture. They had no end of trouble. not set and the walls fell in. In carrying out an investigation, it was found that briquettes made of this sand would These crumble in the hand after seven days' setting. briquettes were so disintegrated that they could not even be put in the machine to be tested. An analysis was made, and we found that the sand was saturated with ammonia which had percolated through from the horse manure.

As a result of this investigation, the sand had to be taken away from the site of the work, the old concrete thrown out, forms rebuilt, new sand purchased and the work reconstructed. All this delayed the work, cost money for material and labor to replace that wasted, and inconvenienced the owners. A sensible program of testing would have prevented any of this trouble.

I would venture to say that three-quarters of the failures in concrete are due to poor sand; and yet some engineers will not hesitate to state that it is unnecessary to test sand.

So far as stone is concerned, the same argument holds as in the case of sand. In order to regulate the mixing of concrete, the voids must be determined; and in order to get good results, the stone must be clean, strong, well shaped and well graded.

It might well be stated that the best argument for the general inspection and testing of all building and structural materials is that every large corporation such as the Canadian Pacific; the Grand Trunk; the Canadian National Railways; the Montreal Tramways; the Montreal Light, Heat and Power Co.; the Harbor Commissioners of Montreal; the cities of Toronto, Hamilton, London and Peterborough; the departments of the government, provinces, states; the counties and municipalities that are at all progressive; and large private concerns too numerous to mention, all have their materials thoroughly tested before using them. The sooner other engineers and architects make up their minds to have testing and construction supervised by experienced men, the sooner eye-sores, failures and constant repairs to concrete work will stop.

## One City's Hard Luck

Is it through selfishness? I happened to interview the city engineer of one of the larger cities of Canada on the subject of supervising concrete construction and the testing of materials for same. After a long conversation, he agreed that the construction materials should be tested, but turned around and said, "Where do we come in? You will be the party doing the work, and getting the credit. The municipal council will say, 'These engineers of ours are no use if they must get their materials tested and work supervised.' If we were to do that, we might find ourselves out of a job."

Whether it is the effect of the above policy or not, it is hard to say, but this particular city has had constant trouble and very heavy expenditures for replacing defective work; which expenditure has, of course, fallen upon the tax-They erected a fat-stock show building and the payer. whole thing collapsed. Their water-main cracked, and as it was a suction system, sewage, and polluted water were drawn into the mains and contaminated the drinking water. This caused a typhoid fever epidemic that carried off in the neighborhood of a thousand people and forced the city to open emergency hospitals that they had to furnish and provide with doctors, nurses and orderlies. The boiler in one of their municipal buildings exploded, killing one man, injuring others and wrecking the building. A pavement about twenty-five city blocks in length took on the form of a corrugated road and had to be relaid a few years after it was first put down.

It goes without saying that all this trouble cost the city many thousands of dollars, which expense might and very likely would have been avoided had all the materials used in these constructions been tested and the work supervised by someone particularly familiar with each type of construction. Any possible loss of prestige to an engineer or architect through the employment of outside, specialized inspection and testing, could not conceivably injure him as much as one such failure as I have mentioned. In fact, after the failure, some one will ask why he did not have knowledge enough to understand that he needed such specialized service. The family physician does not try to operate on his patient's heart; the city engineer should not think it necessary to pretend that he knows it all either, and the same applies to the outside engineer or architect. Specialists usually pretend to know but one thing, but to know that one thing uncommonly well.

Is it through an economical point of view? With some engineers and architects it is. A good many of them will say that this or that work is not of sufficient importance, (Concluded on page 413)