the greatest amount of time and, both from a statistical and monetary standpoint, shows least return.

Many sanitarians of late contend that sewage disposal is not a problem until the discharge of sewage into a stream imperils the safety of public water supplies. The limit of permissible pollution, however, is without definition so long as it is contended that even heavily polluted water supplies can be treated so that they are fit for domestic consumption. The worst, or best, example of the latter might be Niagara Falls, N.Y.

It would appear that, lacking definition of what one might call tolerable pollution, the individual case must control the situation. The state regulations defining the standards of sewage effluents almost invariably arise through requirement for water of acceptable purity for industrial rather than domestic use. This indeed is the history of the Rivers Pollution Prevention Act although the opposite was true for the Thames Conservancy Act.

Generally speaking it is not to the advantage of any state to issue arbitrary regulations defining the standard of sewage effluents. The individual situation should be given consideration in all cases. Certain areas will have their own standards, depending upon the general uses to which the water is put. Treaty obligations, inter-state commerce obligations and general public health must all be considered before reaching a conclusion.

Management of Experimental Stations

So much for the major activities of the engineering service of a state or provincial board of health. There remain the special functions grouping themselves around the main five vested in such boards. It is only a few years ago since ardent disciples of the septic tank could convince state boards of health that here at last was a solution of all difficulties with reference to sewage disposal. This day is fortunately past and lip service is now at a discount, which may be largely attributed to the magnificent service to the country of the various state and municipal experimental and testing stations investigating sewage and water purification problems.

There exists a question as to whether the operation of experimental stations is the function of a state board of health or of a state university. It must be admitted that the experience gained during the operation of such plants is of the greatest assistance to the board's engineering service. Naturally, being more cognizant of these problems, it would appear that the sanitary engineer is the logical person to direct the activities of such stations, but on the other hand the benefits of research should not be withheld from the educational institutions. The proper arrangement doubtless would be for the stations to be jointly operated by the engineering service and by the educational institution, the state board of health having the majority representation so that it may direct the activities along the lines most beneficial to the state. I think this might even be cited as the sixth item on the program for engineering services of state and provincial boards of health,—that is, the joint operation with educational institutions of testing and experimental stations with reference to processes for the purification of water and sewage. This might be expanded to include methods for the reduction of garbage and disposal of privy wastes.

Should the State Design?

In the activities which have been outlined, the engineering service very soon becomes a well of information and an inspiration to the young municipal engineers. The fact that many of the smaller municipalities and almost all of the larger ones are now more fully appreciating the value of trained municipal engineers, leads me to raise a question: May we anticipate that the engineering services of the state boards of health will become consultative bodies, especially as to the design of water-purification and sewage-disposal works?

There can be no doubt that with reference to those things demonstrated in the experimental station, the state is, in fact, capable of designing. More especially is this evident when the staff and organization of the municipal engineer may be used for detailing. The question arises: Is it right or advisable for the state to assume this function?

This question is bound to be very acute in the course of the next few years. On the part of the state and municipality there is a certain long-suffering due to a good deal of encroachment on the field of consulting engineers by those advertising as such and lacking the specific qualifications. On the part of the consulting engineer there is a feeling that he cannot well enter into competition with the state, especially where the state is prepared to offer its services free or at a nominal charge. If the consulting sanitary engineer is to be superseded, there should be a definite forward movement of municipalities in favor of state offices assuming consultative capacities, and coincident with this the announcement of a definite program for the exchange of information.

The logical consummation of such a function on the part of the state would be for the engineering service to organize the co-operative effort by which the state becomes the repository of the collective efforts of its municipalities.

MINERAL AGGREGATES FOR BITUMINOUS PAVEMENTS*

Serious Shortage of Suitable Sands and Fillers—One-Third of all Failures Likely Due to Unsuitable Mineral Aggregate—Requisite Physical Properties

By Wallace L. Caldwell
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ENGINEERS in charge of road and pavement construction are to-day facing a vital problem which must be solved if great road-building programs are to be carried out. That problem is the serious shortage of road-building materials, particularly aggregates for bituminous pavements. We must encourage in every possible way the development of new supplies of such materials, but, at the same time, we must not overlook the quality of these materials. This shortage has already resulted in the development of new sources of supply, but the slightly increased production has by no means met the demand. Some of the new materials being sold and used are far from satisfactory, and will undoubtedly cause a number of failures within the next few years.

The writer is connected with a number of current projects, and on nearly every contract difficulty is being experienced in securing sufficient supplies of satisfactory aggregate materials. In order to overcome the delay caused by this shortage, available but inferior materials are being offered. Delays are costly and inconvenient, and, therefore, a decided tendency to permit the use of unsuitable aggregate materials has been noted on the part of both contractors and city officials. It will invariably be found that the use of such materials will eventually be much more costly than any ordinary delay.

The public, and even some city officials, consider the bitumen to be the one important element in a bituminous pavement, but engineers familiar with pavement construction are aware that the mineral aggregate is of much greater importance. Many failures can be attributed to the use of inferior aggregates, but only a comparatively few to the use of an inferior bituminous cement.

The writer has investigated a large number of failures of different types of bituminous pavement, and has endeavored to differentiate the causes and percentage of failure. The percentages given below are not of universal application, but represent approximately the causes of failure encountered in the writer's investigation. The failures considered are failures of the wearing surface as distinct from failures caused by improper subgrade and foundations.

*Paper read at the last meeting of the American Society for Municipal Improvements.