The sodium sulfate test commonly known as Brard's test has been applied to concrete aggregates by a number of different investigators The evidence presented thus far seems to indicate that 5 repetitions of exposure to a saturated solution of sodim sulfate followed by drying is too severe a test for many aggregates which are known to be satisfactory Further study should be given to this type of test and its relation to natural freezing and thawing

In tests of aggregate or researches involving aggregate, extreme care must be used in securing proper samples Unsatisfactory sampling has been responsible for a great deal of puzzling and contradictory test data

CONCRETE EXPOSED TO ALKALI

Field investigations carried out under the speaker's direction during the past 5 years on concrete blocks exposed to highly concentrated sulfate soils and waters in Colorado and South Dakota have shown a remarkable correlation between the resistance of concrete to sulfate attack and its compressive strength at 28 days Factors such as reduced water-cement ratio, increased quantity of cement, better grading of aggregates, more satisfactory curing, etc. which gave concrete of higher strength, also gave concrete of better resistance to sulfate action.

Our tests have confirmed Mr Miller's findings with reference to admixtures and surface coatings A surface treatment of 3 paint coats of boiled linseed oil gave excellent protection up to 5 years.

II BITUMINOUS MATERIALS

Opened by PREVOST HUBBARD
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That portion of the report of the Committee on Character and Use of Road Materials which the speaker has been scheduled to discuss, namely, bituminous materials, is a most excellent brief summary of progress made during the past year and statement of status quo of the more important investigations There is nothing for him to criticise and but little to add to this report except perhaps to enlarge on a few of the points which have been covered and to suggest some additional factors involved in the practical application of the information already secured which are in need of careful and immediate study.

In introducing the subject of laboratory investigations of asphalt

paving mixtures relative to deformation of surface under traffic the report states that:

"Pavement construction details, particularly as to obtaining the best practicable compression of the mixture and uniformity of contour, are to be emphasized, as indicated by these studies as of importance equal to the evolution of a theory of design, in insuring entirely satisfactory service of a bituminous pavement"

It is believed that this feature cannot be too forcibly stressed at the present time and that to obtain the maximum benefit from what we have learned and are learning regarding the design of bituminous paving mixtures it is essential that certain data be secured which will convince both the contractor and the engineer of the extreme importance of controlling certain construction details which are now commonly slighted, with the result that mediocre or unsatisfactory pavements are produced with mixtures entirely adequate to meet local climatic and traffic conditions in so far as design is concerned

In connection with the first factor, that of compression of the mixture secured during construction, laboratory tests have shown that within a certain practical working range of compression the stability of a paving mixture is almost directly proportional to its degree of compression This means that a mixture which is inherently stable if thoroughly compressed may be quite unstable if only partially compressed Attempts to control this factor are shown in most modern specifications by covering the type and weight per linear inch of tread of rollers which are to be used, also the method and rate of rolling These requirements are, however, arbitrary and are based upon the opinion of those who frame the specifications rather than upon data secured by a careful field study of the problem Realizing the ultimate object of detailed requirements for rolling, some specifications also stipulate either that the density of the finished pavement shall not fall below a certain minimum or that it shall be within a certain percentage of the theoretical maximum density which means that the compressed mixture shall contain not over a certain percentage of voids Both of these requirements have their good and bad points which will not here be discussed, but they are undoubtedly a step in the right direction and when enforced insure with greater certainty more uniformly satisfactory service from a given mixture than do the ordinary rolling requirements However, in any individual case, they are so closely associated with the characteristics of the particular mixture used that the limits specified are not applicable to all mixtures With additional information which is being secured through laboratory investigations

it may be possible to adopt a similar requirement which might be standardized for general use, but certainly methods for securing the results which it is attempted to specify are worthy of detail study

In the early days of the asphalt paving industry it was customary to specify the use of a light hand roller for initial compaction, this to be followed with a heavier self-propelled roller of the tandem type. With the devlopment of the industry hand rolling largely has been eliminated, but many specifications today require that initial compaction be secured with a relatively light tandem roller and later compaction with a heavier roller of the same type In recent years a number of engineers who have given considerable study to asphalt pavements have come to believe that initial compaction should be secured with the heaviest roller and that the 3-wheel type is much more efficient in securing maximum compression than is the tandem roller The speaker is heartily in favor of the use of the heavy 3-wheel roller for initial compaction, provided of course, that a tandem roller is used to finish off the work and eliminate the rather deep markings which may be made with the 3-wheel roller That the 3-wheel roller can be satisfactorily used even on fine aggregate mixtures of the sheet asphalt type has been demonstrated time and again, but considerable opposition has been shown by many engineers and contractors to such procedure, because it is contrary to a long-established practice which has undoubtedly produced many excellent pavements The efficiency of rolling is undoubtedly affected by many factors apart from the type and weight of roller and it is possible that variations in procedure may prove both types to be equally satisfactory Field tests should, however, be undertaken to secure definite data on this detail of construction, so that the engineer may be guided accordingly The following outline is therefore suggested as a skelton for further development in connection with any one or more mixtures of given composition, the efficiency of operation to be determined by density tests on samples of the pavement taken during and immediately after compaction.

1 Relative efficiency of a 10-ton 3-wheel roller, a 10-ton tadem roller and a 5-ton tandem roller operating for a given period on a given mixture with a given initial temperature

2 Time efficiency of a 10-ton 3-wheel roller and a 10-ton tandem roller operated continuously over a given mixture with a given initial temperature, tests to be made at regular intervals until the mixture has cooled to approximately atmospheric temperature

3 Effect of temperature of mix upon efficiency of rolling with a 10-ton 3-wheel roller and 10-ton tandem roller, rolling to be conducted for specified intermittent periods during cooling

4 Efficiency of tamping roller as compared with the usual 3-wheel and tandem rollers on the same mixture with different initial temperatures

With regard to the second construction factor mentioned in the report, namely, that of uniformity of contour, there can be no question of the desirability of securing the best possible contour during construction and if this detail had received as close attention in the construction of asphalt pavements as in the construction of certain other types a more decided improvement in quality and resistance to traffic displacement would undoubtedly have resulted. It is true that contour does not in any way affect the inherent character of the mixture as does that of compaction and for that reason its discussion may be somewhat out of place insofar as the principal subject of the committee's report is concerned It is suggested, however, that a stricter demand by the engineer for uniform contour equal at least to that required for any other type of pavement will be well repaid in service results General use of a simple contour testing device such as that adopted by the Ohio State Highway Commission and known as the Bumpometer is suggested, as its constant use during the latter stages of the rolling operation will detect slight surface inequalities which can readily be corrected by the roller before the mixture has become too stiff for ready readjustment

Another detail related to construction which may be mentioned at this time has to do with the efficiency of the usual mixing devices employed at the paving plant Unfortunately the controlling object of most paving plants seems to be that of obtaining the maximum output in a given period of time and the mixing operation for each individual batch is too frequently slighted Construction specifications usually require that the mixing operation shall be conducted for a certain minimum period, depending upon the type of mix and that the mixture shall be thoroughly homogeneous and uniform The minimum allowable period of mixing will be dependent, of course, not only upon the temperature of the mix but upon its composition and it is generally understood that a longer mixing period is required for fine aggregate mixtures than for coarse aggregate mixtures However, with our present knowledge of the wide variations in characteristics of different mixtures of the sheet asphalt type as determined by laboratory tests it is certain that some fine aggregate mixtures will require a longer period of mixing than will others if a uniform product is to be delivered on the job Detailed information should therefore be secured relative to the mixing operation for different types of fine aggregate mixtures as affected by temperature of the mix, time of mixing and size of batch for the usual mixer of given rated capacity

It is only by securing information in connection with the construction of an asphalt pavement such as has been mentioned that the laboratory tests summarized in the committee's report can be made of maximum practical value and this phase of the subject is believed to be of as great importance as immediate continuation of the laboratory investigations In connection with these laboratory investigations the report calls attention to the fact that correlation of service behavior of pavements with laboratory tests results is well under way The speaker has recently been particularly interested in this phase of the subject and with his co-worker, Mr F C Field, has spent considerable time in ascertaining what relation exists between the stability test which they have devised and the service behavior of certain individual pavements selected for study The relation of construction details to service results has been shown to be so closely interwoven in this investigation of the value of a laboratory test that it has been made the principal theme of this discussion

With regard to the laboratory investigations themselves it is believed that one of the most important indications so far secured is that the exact grading of the mineral aggregate probably is of minor consideration and that further development of the voidage theory, taking into account, not only percentage of voids but average size of voids, will result in making available for fine aggregate asphalt paving mixtures many sands which have heretofore been condemned as being unsatisfactory because they did not meet certain arbitrary grading requirements The utilization of certain special types of fillers for some of these hitherto rejected sands gives promise of making them just as satisfactory for sheet asphalt construction as are the sands customarily specified Thus without entering into detail it may be stated that some fine sands which are unsatisfactory for use with the ordinary filler may apparently be made to produce satisfactory mixtures if combined with a much finer filler than has hitherto been customarily used