Reports and Journals of Asphalt Aggregates

Maclean, D.J., 1968, "A study of the mechanism governing the polishing of stone in road surfaces" Quaterly Journal of Engineering Geology, 1, 135-141.

Abstract:

One of the more important aspects of the work of the Road Research Laboratory is to develop better materials for surfacing roads. By 'better materials' is meant materials having greater resistance to cracking and deformation, greater durability against the effects of weather and greater ability to maintain an even and non-skid surface for traffic.

The surfacing materials in common use are concrete, asphalt and bituminous macadams; these consist of a mixture of mineral aggregates bound together with either Portland cement, bitumen or tar. The Laboratory is therefore concerned with obtaining an understanding of the properties of crushed rock and gravel aggregates that influence the behaviour of these surfacing materials.

This paper describes briefly the research into one important requirement of aggregates used in bituminous road surfacings. This requirement is that the exposed aggregate should not become polished by the action of traffic, since the degree of slipperiness of many types of bituminous surfacing is directly related to the extent to which the aggregate becomes polished.

Hartley, A., 1974, "A review of the geological factors influencing the mechanical properties of road surface aggregates" Quaterly Journal of Engineering Geology, 7, 69-100.

Abstract:

Investigation of the mechanical properties of road surfacing aggregates and particularly of the polishing characteristics has occupied many researchers in recent years. The influence of geological factors on these properties has however not received the same prominence in the literature as the engineering aspects. This paper has been written with a view to gathering together the salient features of the less publicized work.

After reviewing the general requirements of road surfaces the term "roadstone durability" is introduced in the context of surfacing aggregates and the various geological factors likely to influence the roadstone durability are indicated. The influence of petrography upon the strength and the resistance to stripping, abrasion and polishing of roadstones is described together with methods used to assess their potential performance.

Shortage of high quality surfacing materials has resulted in the development of artificial aggregates and some aspects of this work are described.

Kandhal, P. and Khatrı, M., 1992, "Relating asphalt absorption to properties of asphalt cement and aggregates" NCAT Report, pp. 92.

Abstract:

Mineral aggregates used in hot mix asphalt (HMA) mixtures have some porosity and as such tend to absorb some amount of asphalt cement. Several indirect and direct methods for estimating or determining asphalt absorption have been researched in the past. However, there is a need to study the asphalt absorption phenomenon as related to the physical properties of the mineral aggregate and asphalt cement binder.

Eight mineral aggregates of different absorptive characteristics, geologic origin and mineral compositions were selected from the SHRP Materials Reference Libra (MRL). Four asphalt cements ranging from AC-5 to AC-30 grades were also obtained from SHRP MRL. A total of 96 HMA mixtures were prepared and tested for asphalt absorption. Physical properties of aggregates (including pore characteristics) and asphalt cements were determined.

Generally, the asphalt absorption decreased with increase in viscosity (at the mixing temperature) of the asphalt cement. A high percentage of maltene (oil) fraction in asphalt cement is likely to increase the total asphalt absorption possibly due to selective absorption. There appears to be a threshold pore diameter of 0.05 micron in the aggregate below which no appreciable asphalt absorption takes place. The most important pore size range affecting the asphalt absorption appears to be 0.05-0.1 microns.

Kandhal, P., Parker, F. and Mallick, R.B., 1997, "Aggregate tests for hot mix asphalt, state of the practise" NCAT Report, pp. 97.

Abstract:

This Circular contains the 1994 state-of-the-practice for aggregate tests and specifications used by state transportation agencies to control the quality of aggregate for hot-mix asphalt (HMA). The information was generated as a part of National Cooperative Highway Research Program (NCHRP) Project 4-19, Aggregate Tests Related to Asphalt Concrete Performance in Pavements (NCHRP Report 405) and is an unpublished appendix of the project's final report. The information shows the considerable variation in the current aggregate tests and related specifications among the state transportation agencies and the difficulty in accepting any of the current standards on a national basis.

Wu, Y., Parker, F. and Kandhal, K., 1998, "Aggregate toughness/abrasion resistance and durability/soundness tests related to asphalt concrete performance ın pavements" NCAT Report, 98-4.

Abstract:

Numerous tests have been developed to empirically characterize aggregate without, necessarily, a strong relationship with the performance of the final products incorporating these aggregates. This seems to be particularly true for aggregate "toughness and abrasion resistance" and "durability and soundness." The purpose of this research was to identify and evaluate toughness/abrasion resistance and durability/soundness tests for characterizing aggregate used in asphalt concrete and to determine those test methods that best correlate with field performance. Based on a review of literature and specifications, laboratory tests for characterizing aggregate toughness/abrasion resistance and durability/soundness were selected. Sixteen aggregate sources with poor to good performance histories were identified for evaluation with the selected suite of tests. Performance histories of pavements containing

these aggregates in asphalt concrete layers were established through personal contacts with state transportation agencies and performance evaluation questionnaires.

Aggregate properties from laboratory tests were correlated with field performance. The Micro-Deval and magnesium sulfate soundness tests provide the best correlations with field performance of asphalt concrete, and are recommended for characterizing aggregate toughness/abrasion resistance and durability/soundness.

Raisanen, M., Kupiainen, K., Tervahattu, H., 2005, "The effect of mineralogy, texture and mechanical properties of anti-skid and asphalt aggregates on urban dust, stages II and III" Bullettin Engineering Geology Environment, 64, 247–256.

Abstract:

Urban road dust is formed during wintertime when cars use studded tyres and when anti-skid aggregate particles are being crushed under tyres. A road simulator fitted with studded and friction winter tyres was used in three test series in order to investigate dust formation at tyre and pavement interface with various anti-skid materials and tyre types. The bedrock and glaciofluvial anti-skid aggregates tested had variable mechanical–physical and mineralogical properties. A special emphasis was put on the particle size distribution of anti-skid materials and on asphalt aggregate characteristics. The proportions of particles <10 lm from asphalt vs anti-skid aggregate was defined with SEM/EDX. The results of this study indicate that the particle size distribution is the most important property of anti-skid aggregates, and that the wearing process of asphalt pavement ''is not homogenous'' with friction and studded tyres, and with various anti-skid aggregates. The mechanical–mineralogical relationship between anti-skid and asphalt aggregates is one decisive factor in PM10 formation and these properties affect the proportions of PM10 (antiskid vs asphalt aggregate). Friction tyres and anti-skid aggregates with lower average hardness compared to asphalt aggregate cannot wear harder minerals (e.g., quartz) of the pavement aggregate homogeneously.

White, D.T., Haddock, J.E., Rismantojo, E., 2006, "Aggregate tests for hot mix asphalt mixtures used in pavements" NCHRP Report-557.

NCHRP Project 4-19, "Aggregate Tests Related to Asphalt Concrete Performance in Pavements," recommended a set of performance-related aggregate tests for evaluating aggregates for use in hotmix asphalt (HMA) pavements.Performance indicators considered in the research included permanent deformation resulting from laboratory traffic loading (both with and without stripping), fatigue cracking, and surface defects (e.g., raveling, popouts, and potholes). The performance relationships were developed based on tests performed using the Superpave Shear Tester (SST) and the Georgia Loaded Wheel Tester (GLWT); however, the relationships were not validated.

As part of their results, the NCHRP 4-19 researchers recommended a follow-on experiment for additional research to achieve validation. The proposed research involved tests of both coarse and fine aggregate uncompacted voids as well as the flat or elongated particle test, 2:1 ratio (FOE21). These three tests were to be validated for their ability to predict HMA rutting and fatigue performances. Additionally, particle size analysis and methylene blue values (MBV) of the HMA mixture aggregate fraction smaller than the 0.075-mm sieve (p0.075) were to be tested to validate their ability to predict rutting in HMA mixtures. The researchers further suggested that the MBV of the fine aggregate be validated for ability to predict moisture susceptibility of HMA. Finally, the results of Micro-Deval (MDEV) and Magnesium Sulfate Soundness ($MgSO_4$) tests on aggregates were to be evaluated for predicting HMA toughness and durability.

The object of this research was to use accelerated pavement testing techniques to conduct the rutting, fatigue, and moisture susceptibility validation experiments identified in NCHRP Project 4-19. For each aggregate test, a descriptive ranking indicating how well it relates to HMA performance is given. Also, an attempt has been made to suggest appropriate tests for given combinations of climatic conditions, materials, and traffic loads.

A literature review was completed first and was used to guide the research team in selecting five coarse and six fine aggregates for use in the study. The selected aggregates were tested and used in various combinations to produce five coarse-graded and six fine-graded mixtures that were then tested or rutting characteristics in the accelerated loading facility. The five coarse aggregates covered a wide array of aggregate types and properties; each was combined with a common natural sand to produce the five coarse-graded mixtures. The six fine aggregates also represented various aggregate types and properties; each of these was combined with a common coarse aggregate to produce the six fine graded mixtures.

On completing the rutting tests, six of the original eleven mixtures were chosen for accelerated testing to determine their fatigue characteristics. The mixtures were chosen so as to represent a wide range of aggregate and mixture characteristics. Although the rutting testing proceeded well, problems were encountered with the fatigue testing. Construction of the conventional flexible pavement sections in the accelerated loading facility proved to be more difficult than anticipated. Lack of temperature control in the facility also made it difficult for the test slabs to exhibit fatigue signs during the test, at least two mixtures exhibited excessive rutting before showing signs of fatigue.

In addition to the rutting and fatigue tests,five additional HMA mixtures were designed using five of the six fine aggregates and one common coarse aggregate. These mixtures were placed in the accelerated loading facility and tested for rutting in the presence of moisture to determine if the aggregate tests predict moisture susceptibility in HMA mixtures.

Test results showed that the UVA of both fine and coarse aggregates reasonably predict rutting performance of HMA mixtures. The FOE21 test also appears to predict HMA rutting performance. These three tests also may show trends in relation to HMA fatigue performance, but the fatigue data are limited. A minimum coarse aggregate UVA of 40 percent is recommended for traffic less than 100,000 Equivalent Single Axle Loads (ESAL); a minimum coarse aggregate UVA of 45 percent is recommended for traffic of 100,000 ESAL and greater.A minimum fine aggregate UVA of 40 percent is recommended for traffic volumes less than 500,000 ESAL; a minimum fine aggregate UVA of 45 percent is recommended for traffic volumes above this level. An upper limit of 50 percent is recommended for the FOE21 value for all traffic levels.
The MDEV and MGSO4 tests also appear reasonably predictive of HMA performance. Maximum values of 15 and 20 percent for MDEV and $MgSO_4$, respectively, are recommended.

Although the particle size analysis of the p0.075 material and the MBV tests appear to have some performance predictive ability, the relationships were weak. Neither of these tests is recommended for routine aggregate specifications.

Finally, research is suggested to gather additional information about the relationship between the recommended aggregates tests and HMA fatigue performance. Because the relationship between laboratory and in-service fatigue typically is a scaling factor, adequate information can be obtained from a laboratory experiment. Full-scale testing is not required.

Green, P.P., 2007, “Durability testing of basic crystalline rocks and specification for use as road base aggregate” Bullettin Engineering Geology Environment, 66, 431–440.

Abstract:

One of the most important materials for the construction of high quality pavement layers in roads in South Africa is the Basic Crystalline group of rocks. The major deposits of these materials are associated with the dolerites and basaltic lavas of the Karoo Supergroup. Problems related to the in-service deterioration of road aggregates produced from the crushing of these materials, despite their conforming to the necessary specifications, have been experienced in southern Africa for many years. This has usually resulted in the use of more expensive materials being transported further to the road project. Twelve such materials were collected from various parts of southern Africa and tested for their durability using the standard specified tests as well as a range of non-standard and new tests. Based on the results, new test methods and tentative specification limits have been proposed for assessing and predicting the durability of basic crystalline materials obtained by crushing unweathered material sources.

Ibrahim, A., Faisal, S. and Jamil, N., 2007, “Use of basalt in asphalt concrete mixes” Construction and Building Materials, 23 (1), 498-506.

Abstract:

One of the main reasons behind the appearance of early distresses in Jordan roads and the low surface skid resistance is the use of marginal quality limestone aggregate. Large quantities of good quality basalt are available in the Northeastern parts of Jordan. In this research, the possibility of improving the properties of local asphalt concrete mixes by replacing different portions of the normally used limestone aggregate by basalt was investigated. The replacement included total replacement of the limestone by basalt, replacing the coarse aggregate, and replacing the fine aggregate. Results showed that the optimal mix was the mix that had basalt coarse aggregate and limestone fine aggregate. In order to overcome the stripping potential of the optimal mix, 20% of the filler portion of the aggregate, material smaller than 0.075 mm, was replaced by lime. The optimal mix showed superiority, over the tested mixes, in all the evaluated properties, which were Marshall Stability, indirect tensile strength, stripping resistance, resilient modulus, dynamic creep, fatigue, and rutting.

Quadıs, A.S. And Shweily, H.A., 2007, Effect of aggregate properties on asphalt mixtures stripping and creep behavior, Construction and Building Materials, 21, 1886-1898.

Abstract:

The purpose of this paper is to look at some aspects of the effects of aggregate chemical and physical properties on the creep and stripping behavior of hot-mix asphalt (HMA). Two types of aggregates evaluated in this study were limestone and basalt. The effects of the aggregates type were evaluated on three different aggregate gradations and two types of asphalt used in preparing the HMA. The percent of increase in static creep strain of HMA due to conditioning was utilized in this study to assess the stripping.

Test results indicated that unconditioned HMA specimens prepared using basalt aggregate resist creep better than those prepared using limestone. However, after conditioning, mixes prepared using basalt were less resistant to creep strain than those prepared using limestone aggregate. Percent absorbed asphalt was found to be directly related to stripping resistant. Also, mixes prepared using aggregate following ASTM upper limit of dense aggregate gradation presented the highest resistance to stripping. The results of the calculated adhesion work were able to detect the effect of stripping on creep behavior for mixes prepared.