Stabilized Aggregate Road Surface Supports Super Heavy Haul

Electrical power providers and power grid operators are being challenged to keep up with America's growing energy demands. The widely distributed new wind and solar farms that are now adding renewable energy to the system necessitate major expansion of the electrical substations that distribute the electricity being collected from the high voltage power lines out to their customers. Large transformers are required for these expansions and they are also inventoried on site at the substations for quick replacement in case a transformer malfunction occurs. Pictured above on a paved road is a heavy haul that involved moving the first of two transformers of over 200 tons each. The heavy haul truck, with the transformer unit loaded on board, had a Gross Vehicle Weight (GVW) of over 325 tons. This heavy haul rig supported the load of the transformer and the transport trailer on 96 load bearing tires loaded to near their maximum load bearing capacity of 6,000 pounds each. Add to this two puller trucks and two pusher trucks, three of which were weighted down with concrete slabs to provide extra traction. The final stage of the transformer move would be over an unpaved road running up a hill to the substation. Note that the total weight of the cargo and special transport trailer exceeded the maximum legal load limit for a single truck on an interstate freeway by a factor of more than eight times, so total horsepower and traction were both important concerns.

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An extremely stiff and stable road is essential for successful delivery of these very expensive and weighty pieces of equipment. With a steep grade to climb and relatively weak native subgrade soils to traverse, the project engineer specified an eight-inch thick EMC SQUARED® Stabilized Aggregate surface course for the final section of the substation access road. An eleven-inch thick stabilized aggregate surface course was specified for construction of the lower section of road to bridge over a sandy area where the road detoured around a sand dune. The stabilized aggregate mixture for this project incorporated recycled asphalt pavement (RAP) millings mixed in with the virgin crushed aggregate material.

The transport of these 200 ton transformers from the rail siding where they were delivered on special 12 axle train cars up to the electrical substation drew a large audience. The EMC SQUARED Stabilized Aggregate surfaced road was up to the task. The stabilized aggregate layer remained stiff and without any visible deformation as the loads were moved along the road. Testimonial to just how solid the stabilized aggregate layer was under the heavy haul truck, observers commented that they noticed loud popping sounds as pieces of aggregate scattered on top of the rock-solid stabilized road shattered under the impact of the heavily-loaded tires as the transport truck progressed up the road to the substation destination.

The performance of this EMC SQUARED Stabilized Aggregate road surface mixture (minus the asphalt millings content) was well proven in previous service. A similar EMC SQUARED Stabilized Aggregate mixture was used for the construction of over 100 miles of Military Supply Routes (MSR's) that are currently in service at Fort Bliss, where convoys of military battle tanks and other tracked tactical equipment operate directly on the stabilized aggregate running surfaces. These roads also support convoys of heavy transporter trucks with GVW's over 120 tons when transporting tanks and other tactical equipment over these same stabilized roads when training exercises are planned to take place at the more distant training ranges.

These heavy loading applications for the EMC SQUARED Stabilized Aggregate materials validate the outstanding results of the laboratory testing conducted at the Western Regional Superpave Center (WRSC) and the predictions that these stabilized aggregate materials would provide excellent performance under the worst case conditions possible for a material used in road pavement structural sections - the severe service conditions of supporting slowly moving super-heavy loads. The predictions are included in a report based upon a testing program that was conducted at the WRSC, one of the most state-of-the-art asphalt materials testing facilities in the United States, using Dynamic Modulus and Repeated Load Triaxial (RLT) testing. Reaching nearly 500,000 psi modulus values after only a week of curing time while retaining elastic behavior, the aggregate materials treated with the EMC SQUARED Stabilizer product exceeded the 50,000 psi modulus values typical for high quality aggregate base course materials by a factor of approximately ten times. The laboratory testing also measured the effects of variations in temperature on the EMC SQUARED Stabilized Aggregate materials, evaluating them from below freezing up to very hot conditions of 130°F, and found that they retained full strength and elastic behavior regardless of temperature conditions. Based upon the results of the stabilized aggregate material in the Dynamic Modulus and RLT testing series, the report concluded that it was a very stable material that could be expected to resist permanent deformation very effectively and without excessive stiffening and risk of shrinkage cracking. A summary report of the WRSC testing program follows this series of pictures of the heavy transformer move. The report favorably compares the performance of the economical EMC SQUARED Stabilized Aggregate material with that of typical Hot Mix Asphalt materials.

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Primary haul truck cabled to puller truck as 200+ ton transformer is transported up steep grade.

Heavy haul truck ascending grade with pusher truck in view at rear.

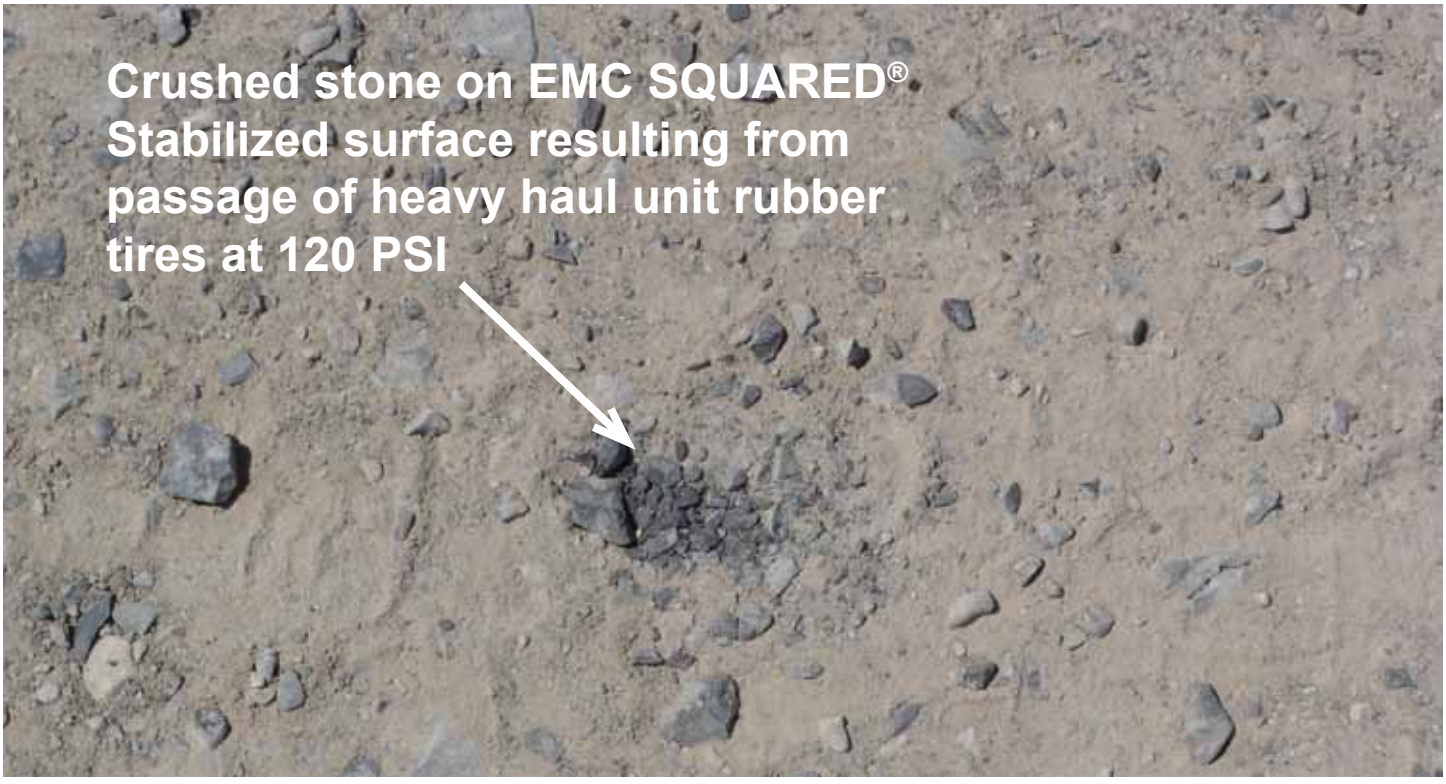
View of EMC SQUARED® Stabilized Aggregate road after passage of heavy truck.

Close up of EMC SQUARED® Stabilized Aggregate road after passage of heavy haul truck

Stabilized Aggregate road bridging sand subgrade under heavy load as road detours around sand dune area.

Stabilized Aggregate road providing stiff and solid platform for heavy load.

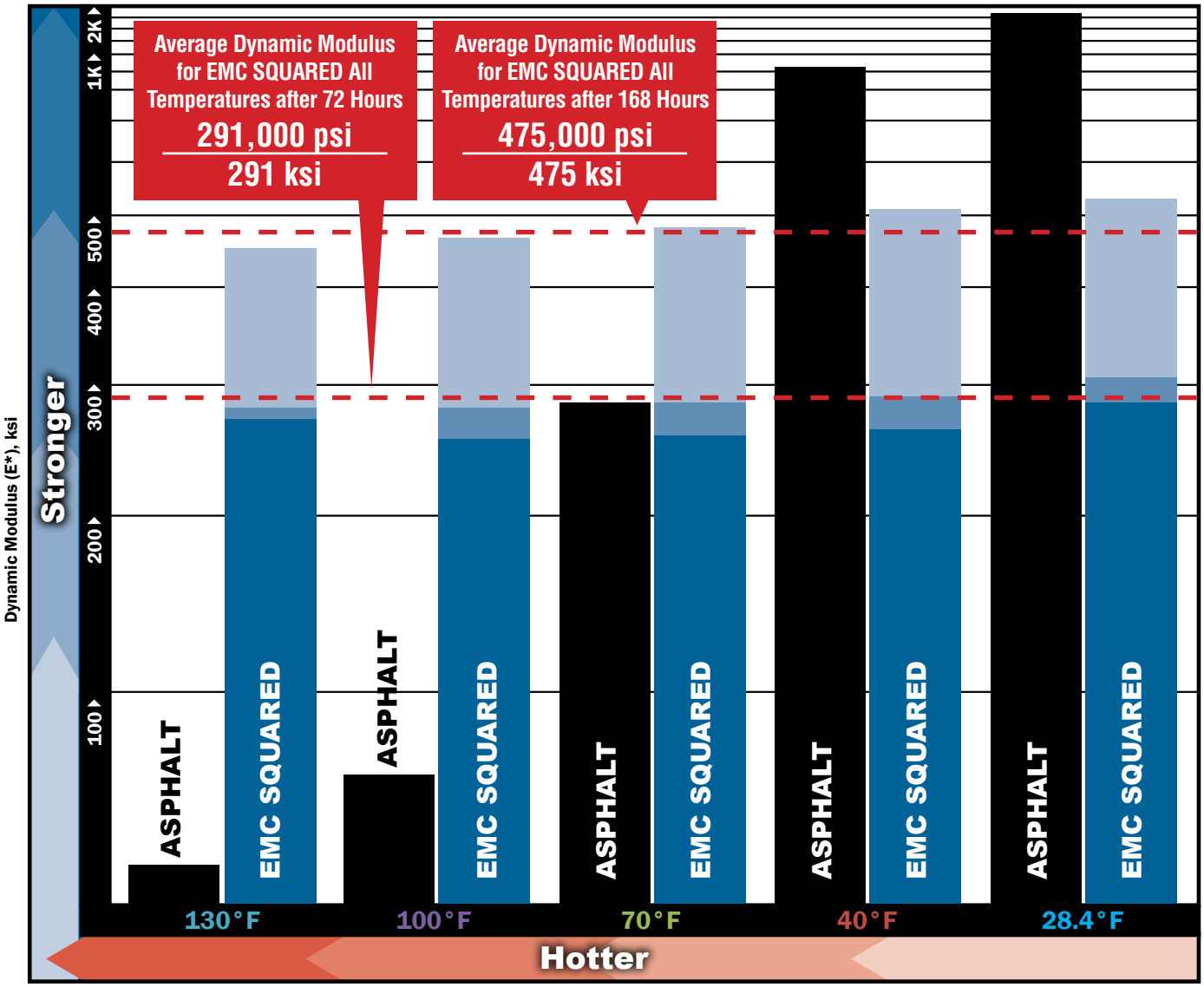
Testimonial to just how solid the stabilized aggregate layer was under the heavy haul truck, observers commented that they noticed loud popping sounds as pieces of aggregate scattered on top of the rock-solid stabilized road shattered under the impact of the heavily-loaded tires as the transport truck progressed up the road to the substation destination.



COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Dynamic modulus is the main input required for design of Hot Mix Asphalt (HMA) pavements using the nationally recognized AASHTO Mechanistic-Emperical Pavement Design Guide (MEPDG). HMA pavement materials are viscoelastic in nature and their dynamic modulus values vary dramatically in response to changes in loading rate and temperature. For example, HMA materials exhibit much lower modulus values (significant strength loss) as pavement temperatures increase. In contrast, dynamic modulus testing shows that EMC SQUARED Stabilized Aggregate materials retain a relatively consistent dynamic modulus (consistent strength) through the full range of loading rates and temperature changes, indicating elastic rather than viscoelastic behavior. Cold-mixed EMC SQUARED Stabilized Aggregate materials have the further advantage of gaining strength with additional curing time.

Typical Dynamic Modulus Data for HMA Mixture and EMC SQUARED Stabilized Aggregate Mixture



The above chart references data from a report by Peter Sebaaly, Ph.D., P.E. University of Nevada, Reno, Director of the Western Regional Superpave Center. The original charts are provided on the following pages of this document.

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

The viscoelastic behavior of Hot Mix Asphalt (HMA) pavement materials is again illustrated in the two Figures below, as the modulus of the HMA material drops from a strength of over 1,000,000 psi when evaluated at a temperature just below freezing to a modulus value of less than 10,000 psi when tested under slow loading conditions at a temperature of 130°F. For the purpose of pavement design using the AASHTO (MEPDG) method, the variations in the behavior of a viscoelastic pavement material related to various combinations of loading frequency and temperature are presented as a Dynamic Modulus (E*) Master Curve.

Typical Dynamic Modulus Data for HMA Mixture

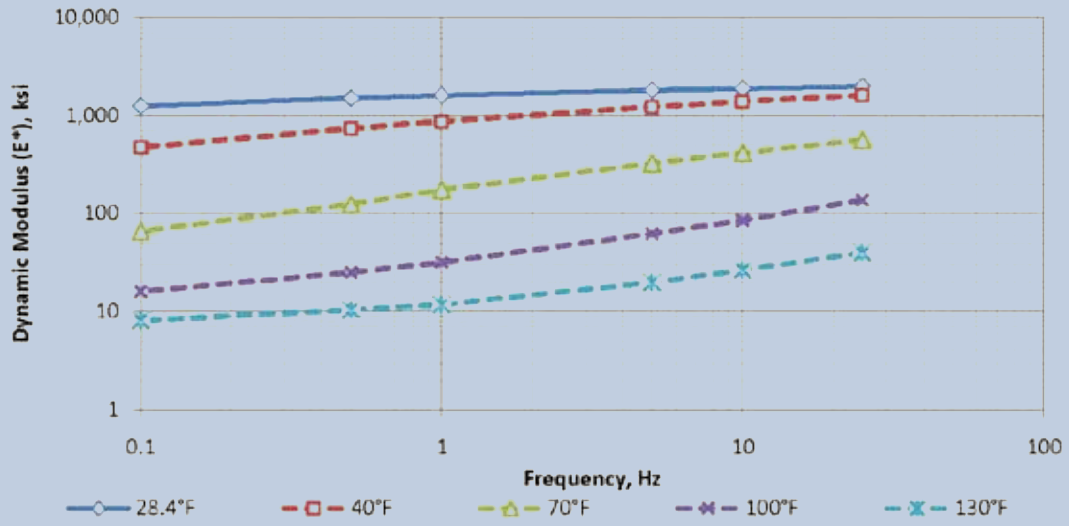

Figure 8

Dynamic Modulus E* Master Curve for HMA Mixture

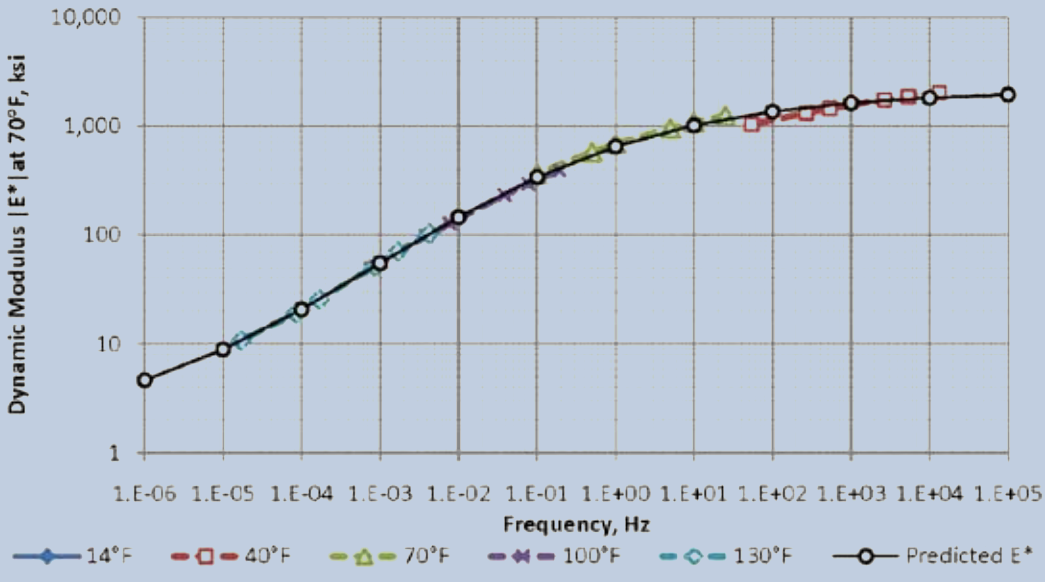

Figure 4

The above figures are from a report by Peter Sebaaly, Ph.D., P.E. University of Nevada, Reno, Director of the Western Regional Superpave Center.

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Dynamic Modulus of EMC SQUARED Stabilized Aggregate Cured for 24 Hours @ 140°F

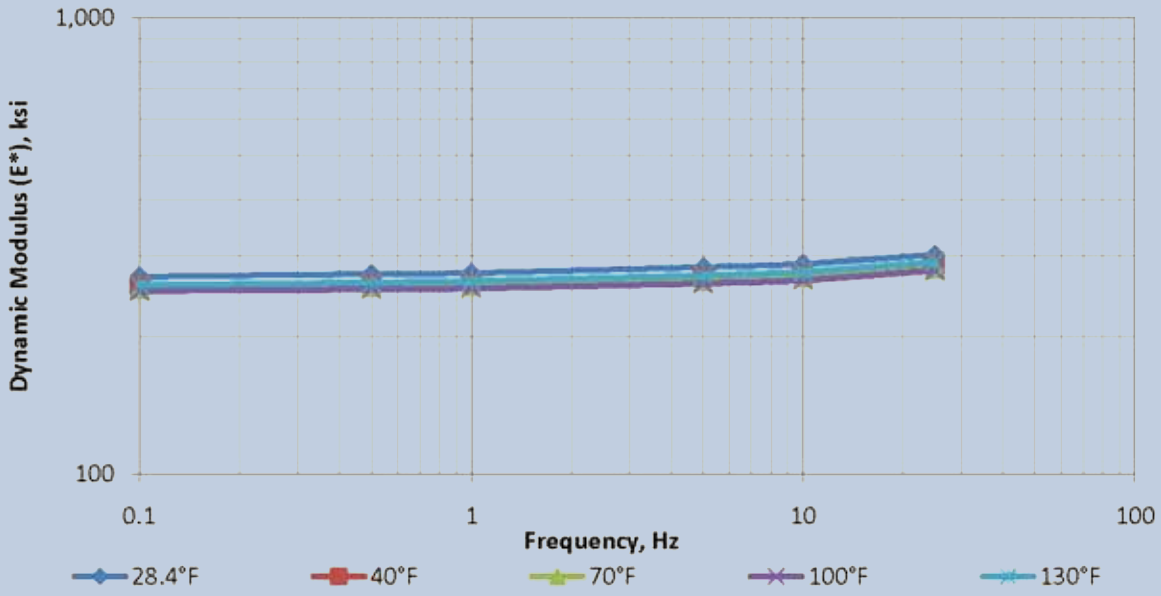

Figure 7

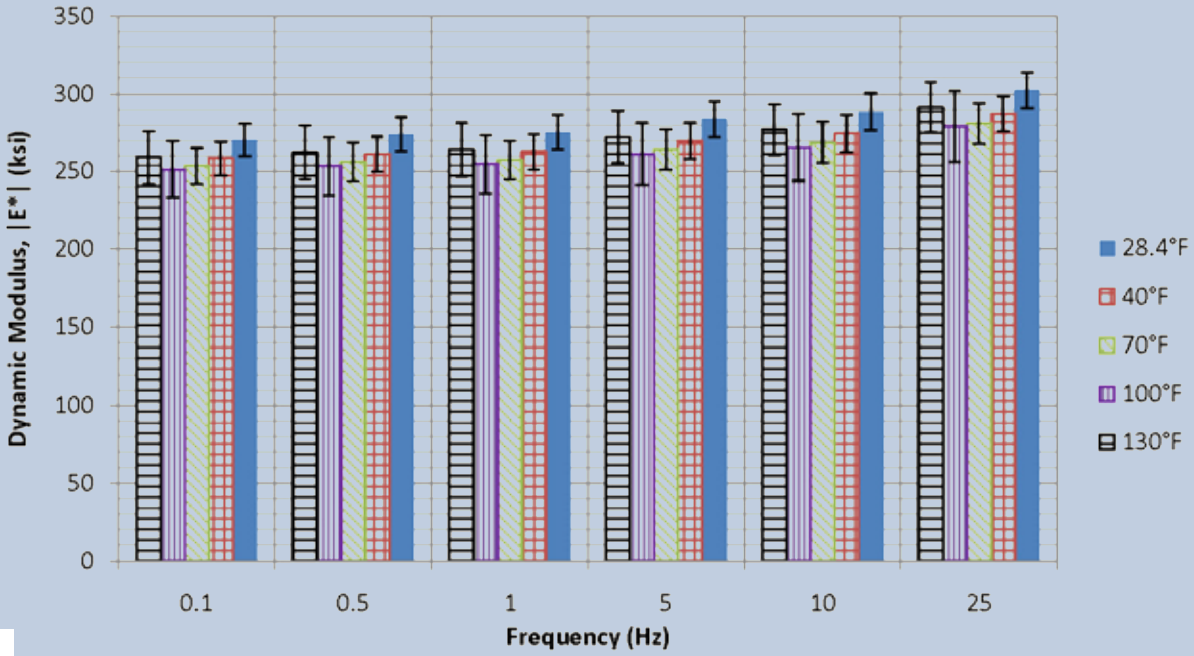

Figure 10

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Dynamic Modulus of EMC SQUARED Stabilized Aggregate Cured for 72 Hours @ 104°F

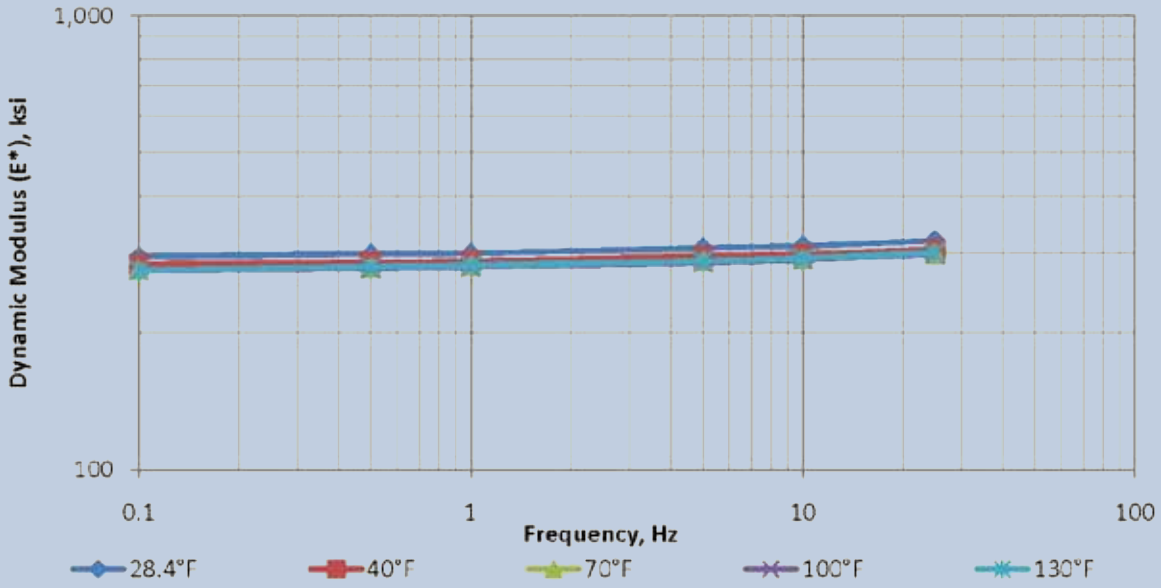

Figure 6

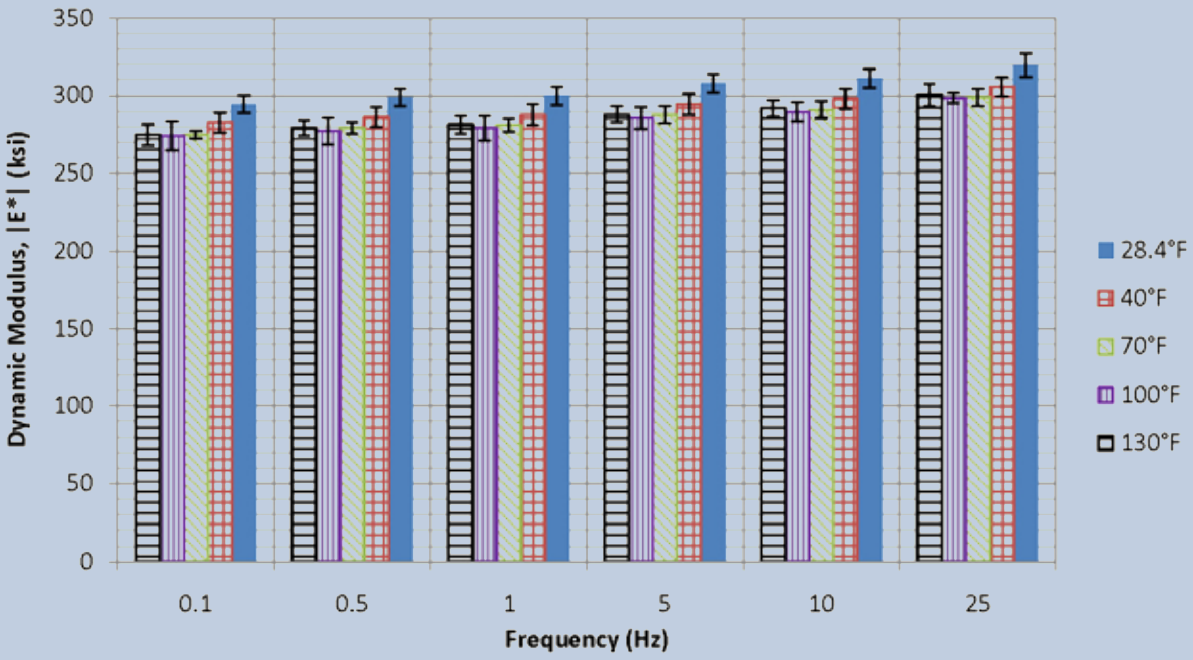

Figure 9

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Dynamic Modulus of EMC SQUARED Stabilized Aggregate Cured for 168 Hours @ 104°F

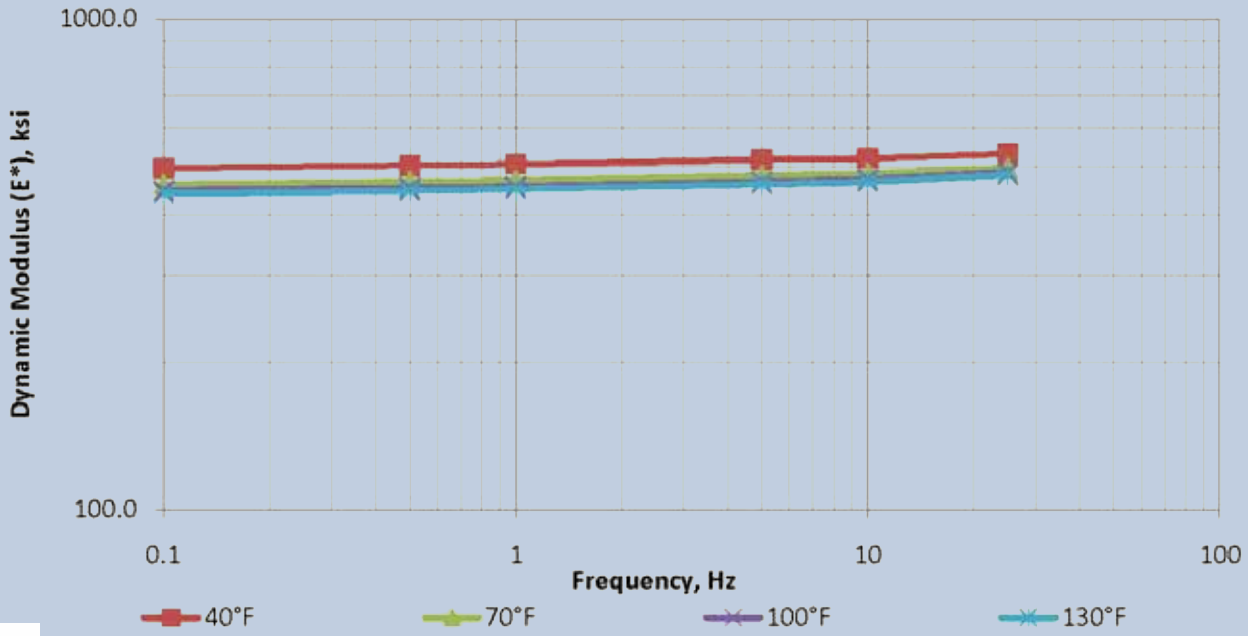

Figure 11

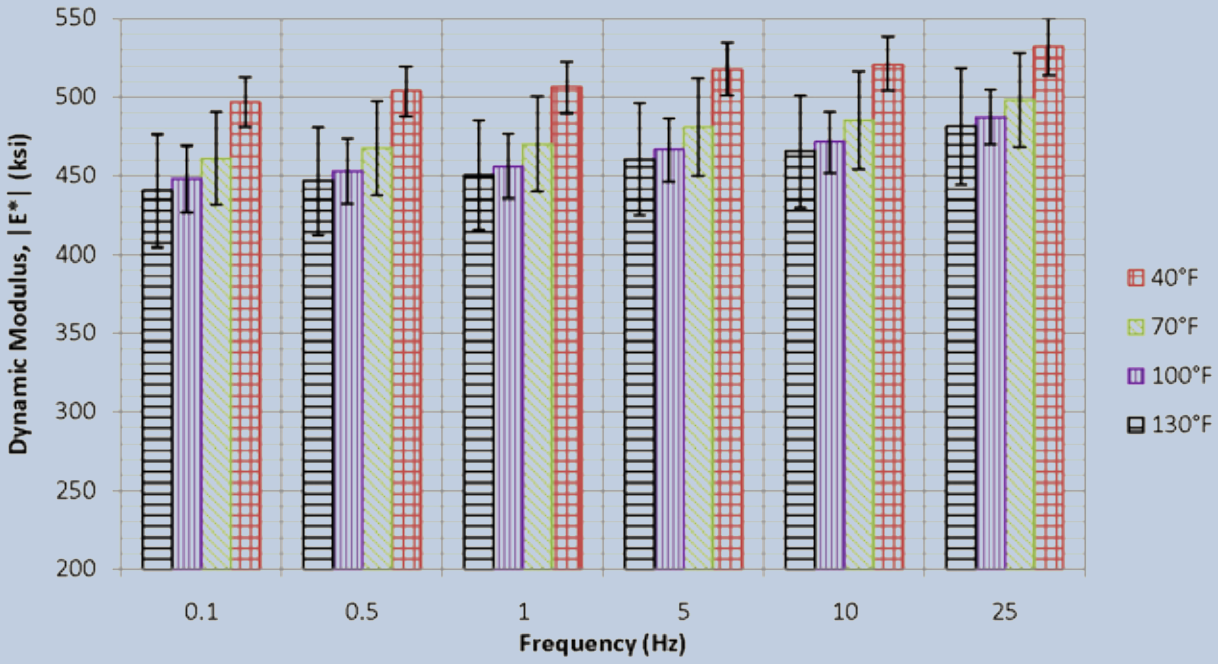

Figure 12

The above figures are from a report by Peter Sebaaly, Ph.D., P.E. University of Nevada, Reno, Director of the Western Regional Superpave Center.

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

The Typical Deformation Curve for HMA Mix and the Permanent Deformation Characteristics of the EMC SQUARED Stabilized Aggregate, as shown below, are developed from the results of Repeated Load Triaxial (RLT) testing. RLT testing measures the resistance of a material to rutting and permanent deformation. In comparison to the HMA Mix, the EMC SQUARED Stabilized Aggregate Mix showed only 0.1% permanent axial strain. The report on the testing indicates that the deformation characteristics of the stabilized aggregate are expected to remain constant at all temperatures used in the related Dynamic Modulus testing and that the stabilized aggregate is not anticipated to generate any permanent deformation under a wide range of loading conditions.

Typical Permanent Deformation Curve for HMA Mix

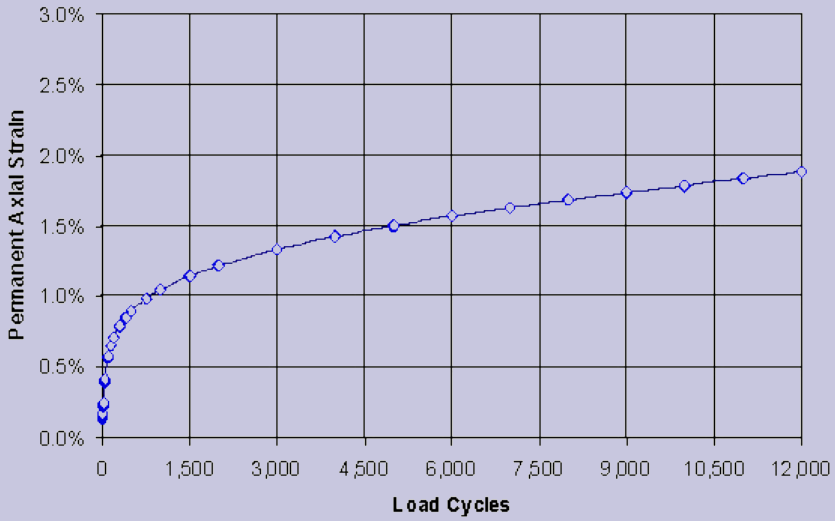

Figure 14

Permanent Deformation Characteristics of the EMC SQUARED Stabilized Aggregate Cured for 72 hrs @ 104°F

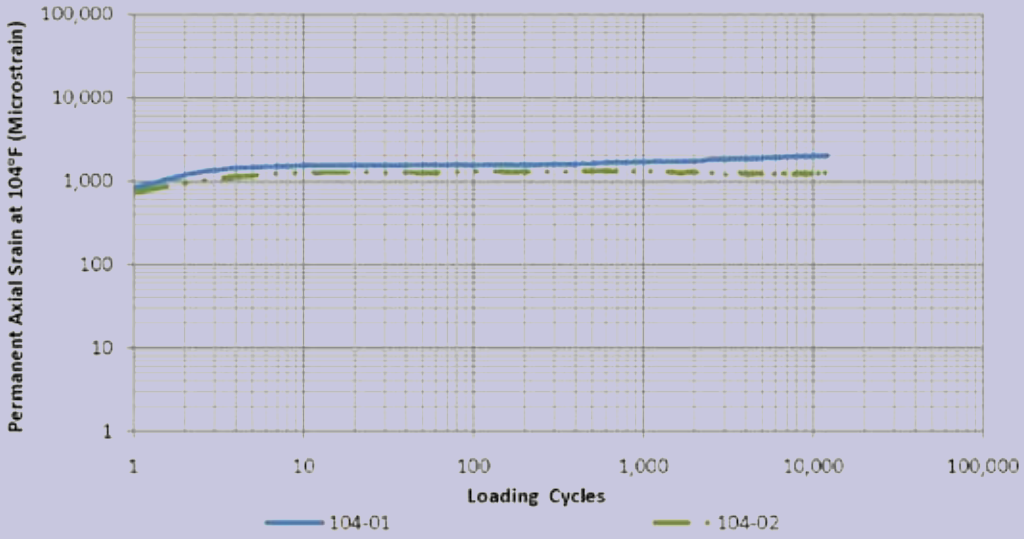

Figure 16

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COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Evaluation of EMC SQUARED Stabilized Aggregate in Pavements/Materials Laboratory

The laboratory evaluation under the direction of Dr. Sebaaly included both Dynamic Modulus (E*) and Repeated Load Triaxial (RLT) testing, the state of the art test methods for evaluating Hot Mix Asphalt (HMA) materials and providing input for AASHTO MEPDG pavement designs. EMC SQUARED Stabilized Aggregate materials exhibit flexible, or elastic behavior, and modulus values most similar to HMA materials. Consequently, those test methods are equally appropriate for evaluation of these stabilized aggregate materials and for pavement design purposes. The study found that the Dynamic Modulus property of the stabilized aggregate after one week of curing was in the range of 450,000 to 500,000 psi and that it was a very stable material that could be expected to resist permanent deformation very effectively and without excessive stiffening and risk of shrinkage cracking. Dr. Sebaaly states "The combination of the elastic behavior of the EMC SQUARED stabilized aggregate material with its good level of long-term modulus makes it an appropriate choice for pavements serving heavy loads at slower speeds (worst case conditions) as well as for pavements subjected to standard loading conditions." Unlike HMA materials, which are weakened by increasing temperatures and slower loading conditions due to their highly viscoelastic nature, the study found that changes in loading frequency and temperature, from below freezing to 130^{O}F temperature, had minimal impact on the modulus of the EMC SQUARED Stabilized Aggregate, and that the EMC SQUARED Stabilized Aggregate can therefore be represented by an average constant Dynamic Modulus property of 475,000 psi (versus the Master Curve required for HMA).

The resistance of the EMC SQUARED Stabilized Aggregate material to permanent deformation was evaluated in RLT testing with a finding that under a wide range of loading conditions no permanent deformation is anticipated. Furthermore, even in the worst case conditions for a flexible pavement layer, which are slow moving loads in hot environments, the behavior of the stabilized aggregate "...makes it a good candidate for pavements loaded under such severe conditions." according to Dr. Sebaaly.

As an example of a severe service application, it should be noted that the EMC SQUARED Stabilized Aggregate materials for this laboratory evaluation were sampled during the construction of military heavy haul road projects designed by the U.S. Army Corps of Engineers (USACE). This high-strength stabilized aggregate material was plant-mixed and placed by asphalt paving machines as a surface course, or running surface, to be used by convoys of military battle tanks and other tracked military equipment as well as heavy haul trucks weighing over 120 tons when fully loaded. The EMC SQUARED Stabilizer product, manufactured by Soil Stabilization Products Company (SSPCo), was specified by USACE for stabilization of subgrade soils as well as stabilization of aggregate surface course materials for over 100 miles of heavy haul road construction projects. Of additional interest, the stabilization of subgrade soils eliminated the need to manufacture and transport over 1 million tons of crushed aggregate subbase material that otherwise would have been required for these projects.

The engineering evaluation of the stabilized aggregate materials was conducted under the direction of Peter Sebaaly, Ph.D., P.E., Director of the Western Regional Superpave Center, one of five centers established by the Federal Highway Administration (FHWA) to support the implementation of the Superpave Technology for hot mix asphalt materials. Dr. Sebaaly is also the Director of the Nevada Technology Transfer Center (funded by FHWA and Nevada DOT), and Professor of Civil Engineering in the Civil and Environmental Engineering Department at University of Nevada Reno where the Pavement/Materials Program and materials testing laboratory are located.

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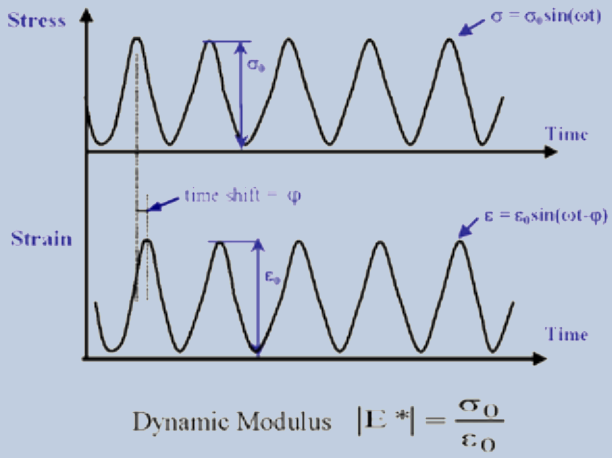
COMPARISON OF TYPICAL DYNAMIC MODULUS AND REPEATED LOAD TRIAXIAL TEST RESULTS FOR HOT MIX ASPHALT (HMA) MIXTURE AND EMC SQUARED® STABILIZED AGGREGATE

Dynamic Modulus Setup

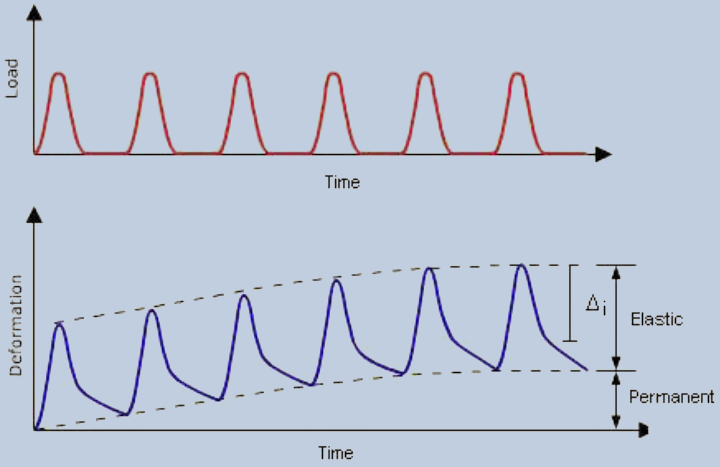
Applied Stress and Measured Strain



Dynamic Modulus $|E^*| = \frac{\sigma_0}{\varepsilon_0}$

Repeated Load Triaxial Setup

Loading and Response



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Soil Stabilization Products Company (SSPCo) is entering our fourth decade as the leading edge stabilization product technology company, setting the standard for economic improvement of soil, aggregate and recycled pavement materials in construction applications. SSPCo has pioneered the implementation of green products in the highway industry. We have proven that clean technology can provide far more sophisticated, effective and environmentally appropriate answers than bulk application of asphalt, cement, fly ash and lime products. The cost-savings and performance advantages of the EMC SQUARED System are contingent upon thorough preliminary engineering reviews, competent designs and specifications, and proper installation.

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