Use of Lightweight Aggregates in Flexible Pavements

What is Lightweight Aggregate

Lightweight aggregates are produced by processing certain shales, clays, or slates, to small size particles and firing these particles in rotary kilns at a temperature of some 2000°F. Gases given off during the process cause bloating which produces the light weight. The high temperature converts the materials to ceramic-like particles containing numerous disconnected voids. For purposes of this discussion, the term “lightweight aggregate” refers only to shales, clays and slates produced by the rotary kiln method.

Advantages

Although lightweight aggregates were developed for concrete for building construction to reduce dead load, research and full scale trials show two distinct advantages of lightweight aggregates in flexible pavements.

First, pavements made with lightweight aggregates have a high skid resistance. The high skid resistance present immediately after paving is due to the rough surface texture of the aggregate. Lightweight aggregates are outstanding in their ability to retain their skid resistance under traffic. Pavements made with certain natural aggregates, primarily certain limestones, dolomites, and gravel will polish under the action of traffic and lose a large percentage of the initial skid resistance. Lightweight aggregates do not polish as they wear. Under wear, fresh cells are exposed which have sharp ceramic-like edges which continue to show a high skid resistance.

The other distinct advantage of lightweight aggregates is that when lightweight aggregates are used in seal coats and surface treatments, breakage of glass from “flying” stones is practically eliminated. Seal coats and surface treatments are made by spraying a layer of hot liquid asphalt, covering it with a layer of aggregate, and rolling the aggregate into the sprayed asphalt. Many miles of this type of pavement have been constructed and are providing a very useful service. However, it is practically impossible to embed all the stones in the asphalt on any surface of this type. Much of the windshield and headlight breakage experienced by motorists occurs when one of the loose stones is picked up by a tire and sent “flying” into a windshield. Numerous tests conducted at Texas A & M University show that glass

Lightweight aggregate coverstone for seal coats eliminates this menace
Lightweight aggregate exhibits superior skid resistance in Texas field trials.
breakage is almost non-existent with lightweight aggregate. As any rifle buff knows, the striking force of a bullet is a function of the weight of the bullet and the speed at impact. Lightweight aggregate weighs approximately half that of conventional aggregates. This light weight plus the higher wind resistance of the rough surface textured particle lowers the speed at impact. The resulting striking force is too small in most instances to break a windshield or a headlight. The rough surface texture also bonds to the asphalt better so there are fewer “flying” particles.

Lightweight aggregates also have a subsidiary advantage in that less tons of lightweight are required for a given volume than for conventional aggregates.

Characteristics

Lightweight aggregate particles are highly textured and as noted previously, have a rough surface texture. Although the loose particles can be crushed easier than a dense natural rock particle, lightweight aggregate, when bonded to the asphalt, presents a tough, durable pavement. Lightweight aggregates consistently pass Los Angeles abrasion requirements and other quality tests.

Because of the production processes, lightweight aggregates are available in different sizes from about one inch to dust that will meet practically any grading requirement in this range.
Design and Construction Procedures

The design and construction of seal coats and asphalt paving mixtures with lightweight aggregates follows conventional procedures. Recognition must be given to three characteristics: (1) it is light in weight, (2) individual loose particles can be crushed if subjected to high stress (research has shown this to be no problem in usage) and (3) the specific gravity of the particles varies with the size of the particles. It can be seen from the following discussions that these characteristics create no serious problems.

Seal Coats and Surface Treatments

The determination of quantities of asphalt and cover stones required for seal coats and surface treatments follows essentially the same procedures as used for conventional aggregates except for the light weight. The determination can be made quite simply by conventional seal coat and surface treatment design procedures. Construction procedures are the same as with other aggregates except all rolling to seat the cover stone into the asphalt should be done with pneumatic rollers since steel wheel rollers tend to crush sharp corners and edges which should be left to add skid resistance. Due to good adhesion, practically no excess of coverstone is required to effect good coverage.
The chart illustrates some of the results of a Texas A & M University study. An air-powered gun assembly whereby aggregate pellets are "shot" by air pressure was used in this investigation.

Comparison of windshield damage
lightweight aggregate vs. crushed limestone
Lightweight aggregates have been used in asphalt paving mixtures in Texas, Louisiana and other states with complete success. Lightweight asphalt mixes are currently being tested in Alberta, Canada with very promising results. A 100 per cent lightweight mix will be slightly harsher than one using lightweight coarse material and natural sand. However, the 100 per cent lightweight mix (½” to dust) will usually be more expensive while yielding a higher quality. A typical lightweight-natural sand mixture by volume is as follows:

50% Lightweight aggregate ½-inch to No. 10
50% Natural Sand

A competent, qualified laboratory should be used for specific mix designs.

Grading Curves Showing Weight Percent Vs. Volume Percent

Determination of the proper asphalt content follows the same procedures as with conventional aggregates. Generally the volume of asphalt required for mixes made with lightweight aggregates will be the same as for conventional aggregates; however, since asphalt content is usually reported as a percent of the weight of the mix, the asphalt content may appear to be high. Actually the gallons of asphalt required to pave a given area and depth with a lightweight mix will be no higher than with a conventional mix.

As noted earlier, the specific gravity of the lightweight particles increases as the particle size decreases. This requires determination of specific gravity for the gradation being used rather than determining the specific gravity for the source of aggregate as is done with a conventional aggregate. Lightweight aggregates can be mixed in the usual manner, laid with a conventional paver, and rolled with the usual rollers, both steel wheeled and pneumatic.

Base Courses

The most outstanding development in the field of flexible pavements has been the use of hot-mix asphalt base for the full depth of flexible pavements with the base placed in lifts up to 6”. This procedure is producing foolproof high quality pavements everywhere it is being used. Hot-mix asphalt base is essentially the same as conventional asphalt paving mixtures except that more economical aggregates are used. Lightweight aggregates can be used readily in hot-mix asphalt bases and in many areas will be competitive. Mixtures with low asphalt contents have been developed and appear satisfactory for this purpose.
Growing Use

Although lightweight aggregate was developed for the building industry, its use in pavement construction is growing rapidly. Initial trial sections were constructed in the mid 50's. The research at Texas A & M University that showed less automobile glass damage provided a stimulus to the use of lightweight aggregates for seal coats in the 60's and now the use of lightweight aggregate for seal coats is common practice in the South. Asphalt paving mixtures have been constructed in both Texas and Louisiana and are performing very well. As of 1967, there were approximately 2000 miles of roads paved with lightweight aggregate in Texas and substantial mileage in both Louisiana and Mississippi.

Lightweight aggregate has a proven place in flexible pavement construction.