RECYCLED ASPHALT PAVEMENT:

GOOD FOR THE ENVIRONMENT, GOOD FOR THE INDUSTRY

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Fresh out of college in the 1990s, an asphalt producer hired me to develop RAP mix designs at a time when adding RAP to asphalt was a new concept. The plant manager explained that adding RAP into asphalt mixes was the ideal business model because it represented three distinct economic opportunities. First, the plant sells asphalt to a jobsite, then it is paid to take the asphalt back in the form of grindings, and finally the plant is paid yet again when it resells the asphalt as RAP in a new mix. Although the plant manager was focused on the economic value of RAP to his plant, he was ultimately describing the importance of RAP to the sustainability of the asphalt paving industry.

RAP is a pillar of sustainability because it extends the life of finite deposits of natural resources. Incorporating RAP into a mix reduces the cost of producing asphalt. For instance, a plant returning 15 percent RAP into its mix, is buying about 0.5 percent less binder and mining 14.5 percent less rock per ton of finished asphalt. As a result, the plant reduces its dependence on two natural resources. Since a ton of RAP represents a lesser expense than the virgin components it replaces, the cost of producing asphalt with RAP is reduced. Consequently, when asphalt specifications universally allow RAP, consumers benefit from a reduction in asphalt price.

The asphalt industry is progressing to higher and higher RAP contents because of its impact to the economic sustainability of our industry, and

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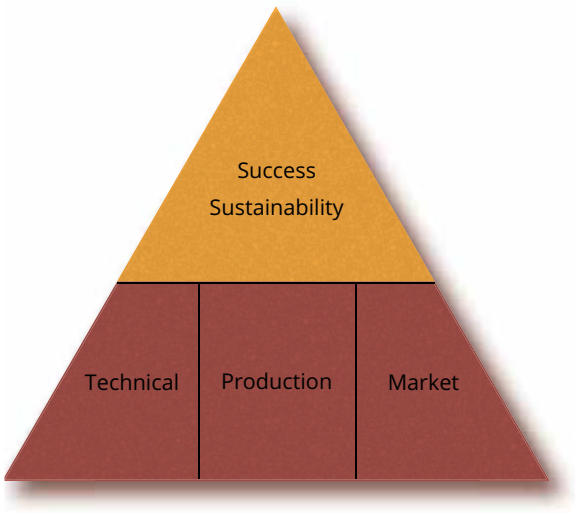
because we have an obligation to be stewards of our natural resources. In 2019, we have the experience and technology needed to progress to higher RAP contents in our asphalt mixes without sacrificing pavement performance. If we build on what we have learned and leverage available technology, we can ensure success.



Think about this success as a pyramid where the base has three fundamental sections that must be in place to reach the top. To successfully incorporate RAP into asphalt, it is critical to address technical considerations, production considerations and market preparations.

TECHNICAL

RAP brings additional asphalt and aggregate into an asphalt mix. RAP binder is not the same as virgin binder, and RAP aggregate is not the same of virgin aggregate. In the technical section of the pyramid, mix designs are adjusted and material blends are modified to account for the properties of RAP used to replace virgin aggregate and binder in a mix.

The binder and aggregate that compose RAP have aged. The binder is very stiff relative to the virgin binder it is replacing. When the stiff RAP binder is not properly accounted for in a mix design, the pavement experiences early-age cracking.

A pavement is subject to tension as it is heated and cooled. When an asphalt pavement is not flexible enough to withstand that tension it cracks. Asphalt binder is what binds our aggregate and is therefore the primary source of tension strength. We need to consider the flexibility of the blend of virgin and recycled binders to ensure success.

The binders in asphalt mixes that contain RAP will be composed of a blend of flexible virgin binder and stiff recycled binder. The Asphalt Institute provides general guidelines for PG binder grade adjustments when designing asphalt mixes with RAP. If an asphalt mix contains 15 percent or less RAP, no virgin binder grade adjustment is recommended. If an asphalt mix has more than 15 percent, but not more than 25 percent RAP, the recommendation is to decrease the high temperature and low temperature performance grade of the virgin binder by one grade.[1]

This means if a pavement is to be built where the weather and traffic require a PG64-22 to be used in the mix, then a design with 15 percent to 25 percent RAP would utilize a softer PG58-28 in lieu of a PG64-22. This replacement, sometimes called grade bumping, ensures the blend of virgin and recycled binders has similar flexibility to a PG64-22.

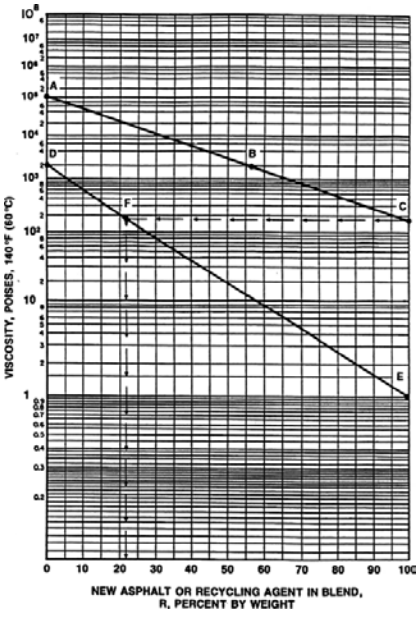

IMAGE COURTESY OF TXAPA

The Asphalt Institute recommends further investigation for mixes above 25 percent RAP. At these additional rates, the properties of RAP need to be measured and compared to virgin binder properties to estimate the resulting blended properties.

THE BALANCED MIX DESIGN CONCEPT

One approach is to use blending charts to estimate the properties of two binders blended together. Here is an example chart from the Federal Highway Administration used to estimate the viscosity of a blend of binder and a recycling agent.

Blending charts are being replaced with performance tests for several reasons. Performance tests are empirical methods of



THE PRIMARY CONCERN WITH RAP IN ASPHALT IS MAINTAINING FLEXIBILITY TO RESIST CRACKING. ASPHALT MUST BE BOTH FLEXIBLE ENOUGH TO RESIST CRACKING AND STIFF ENOUGH TO RESIST RUTTING.

Figure 1.
Texas Overlay Test

Figure 2.
Disk-shaped Compaction Tension Figure

Figure 3.
Semi-circular Bend

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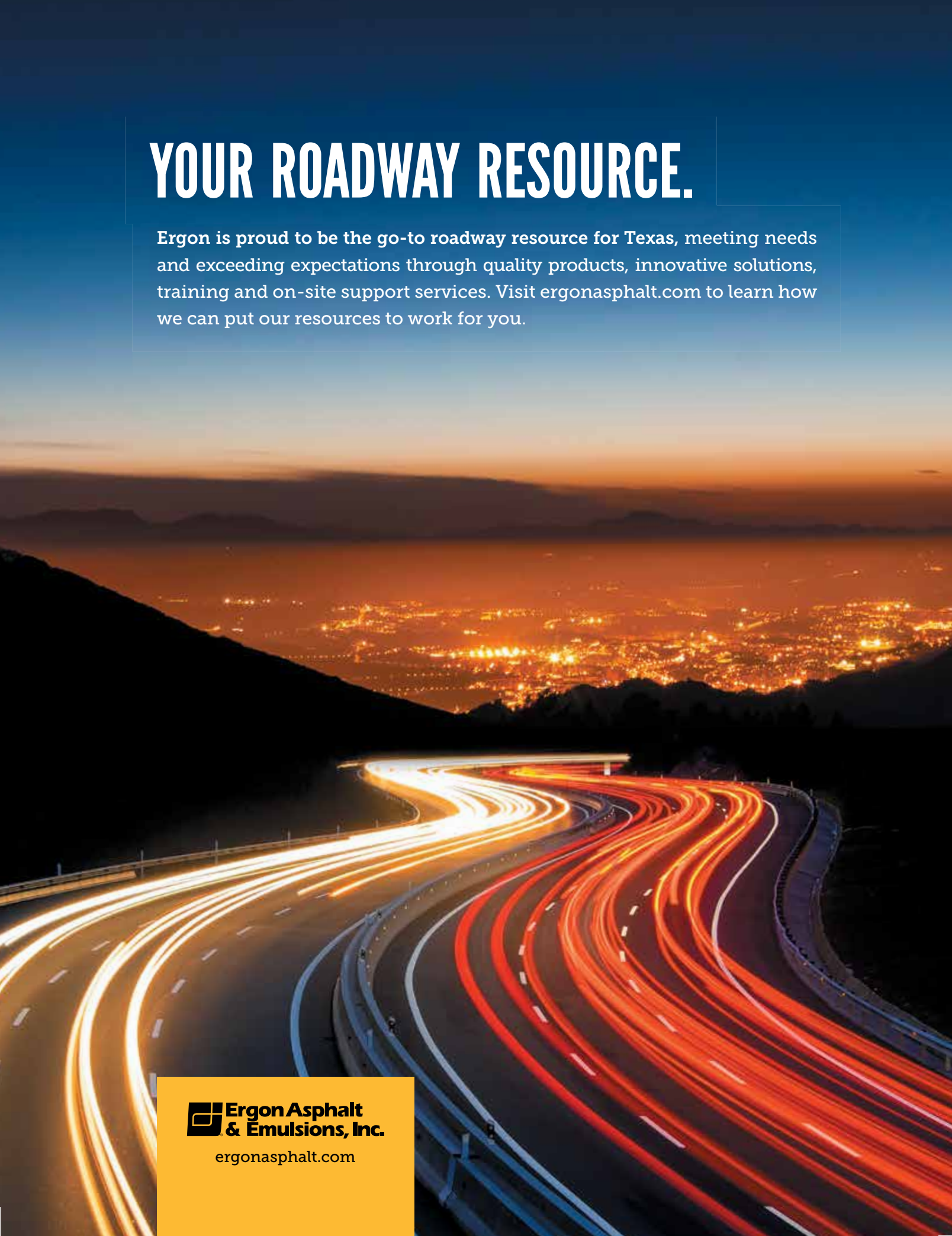
testing asphalt that when calibrated to field performance, can be used to predict performance in the field from the laboratory.

The primary concern with RAP in asphalt is maintaining flexibility to resist cracking. The Texas Overlay Test (Tex-248), the Disk-shaped Compact Tension (ASTM D7313), Semi Circular Bend Test (ASTM D8044), and a few others including the Ideal CT, can be used to determine the cracking resistance of an asphalt mix. All three tests impart some sort of tension load on an HMA sample and measure the response.

Asphalt must be both flexible enough to resist cracking and stiff enough to resist rutting. These tests should be combined with a rutting performance test like the Hamburg Wheel Tracking Test to ensure the reduction in stiffness, and to ensure cracking performance does not go too far, creating a rutting issue. The concept of combining both a cracking and rutting test into the design process is what constitutes a balanced mix design. If RAP contents exceed 25 percent, or if a recycling agent is introduced, or if warm mix additives are included, a balanced design approach should be used.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PRODUCTION

Higher RAP percentage mixes will strain asphalt plants if not properly accounted for in the plant configuration.

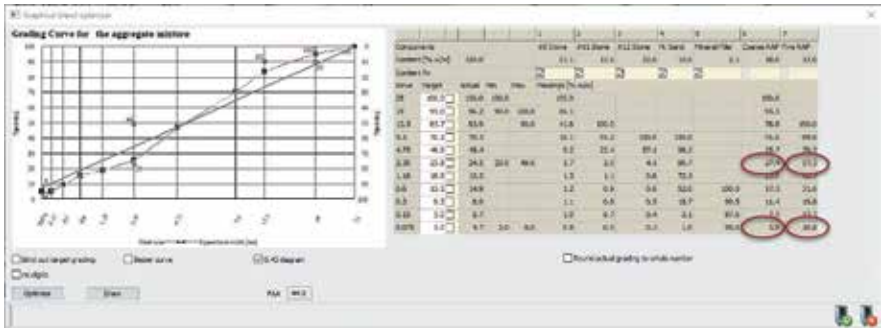
RAP is dried and heated much differently than virgin aggregate. RAP is not heated in the dryer like virgin aggregate. It is added wet to the already dried and heated virgin aggregates. This creates steam and robs heat from the airflow to the baghouse. The rush or flow of steam needs to be accounted for in the air-quality system. Baghouse and duct sizing will typically need to be adjusted. It is also a good idea to keep RAP dry as much as possible in wet climates. A covered area where a small quantity of RAP can drain and remain out of the weather just prior to use is always a good idea.

We rely on the virgin aggregate to dry and heat the RAP. Proper time needs to be given to ensure heat is transferred from the virgin aggregates to RAP. Drum manufacturers have developed ways to heat RAP without exposing it to the flame and increase the time RAP has to heat and dry. Plant modifications will need to be evaluated to accommodate a desired RAP addition level.

When a mix design is developed, we use a blend of aggregate sizes to achieve a desired size distribution for performance. This should not change when we use RAP. At RAP percentages of 15 percent or less, one RAP fraction is sufficient. When RAP percentages approach 25 percent, two RAP fractions will be needed to maintain a consistent gradation.

Here is an example mix design where the blend includes 30 percent RAP. The design incorporates two RAP fractions: a coarse ¾" RAP and a ⅜" RAP. These two products have very different amounts passing the #8 and #200 sieves. This gives the plant a means to maintain the specified gradation. What is equally, if not more important, this difference in aggregate sizing provides a means to manage VMA without adding to or reducing the total amount of RAP in the mix.

Feeding two RAP fractions into a plant helps to maintain consistency in asphalt production. The RAP itself needs to be consistent. A RAP management plan is crucial to ensuring consistent RAP productions.



A RAP management plan should include:

1. Separation of incoming RAP feed into grades.
2. Determination of minimum grade (quality) level for RAP feed, using low-grade feed in base products.
3. Creation of a blending plan during RAP production, blending the highest-quality and lower-quality feed materials into a uniform blend.
4. Determination of desired size fractions for use in asphalt, considering maximum aggregate size of asphalt mixes produced.
5. RAP production quality control with regular evaluation of asphalt content and maximum theoretical specific gravity to ensure consistency.
6. RAP moisture management plan prior to use at plant, which should include a surface that provides for drainage on which RAP can be stockpiled.

MARKET

The last foundation of the pyramid is about establishing a means for consumers of asphalt to verify that the proper pavement quality is being delivered during production.

To ensure success, the market needs to be prepared to accept RAP in their products and feel comfortable they are still receiving the level of quality they've come to expect. Agencies have the job of ensuring our tax dollars are being used to build long-lasting pavement with or without RAP.

NAPA and other organizations have educational information available that describes how to successfully incorporate RAP into asphalt and demonstrates the importance of RAP to asphalt sustainability.

It is imperative that producers and purchasers of asphalt collaboratively determine how to document that asphalt with high RAP content performs the same as conventional mixes without high RAP. This is a big challenge, as implementing change involves potential risks. Specifications should be modified to manage the new risk and set the stage for success.

It is important that we incorporate more RAP in asphalt to ensure the next generation of drivers have smooth asphalt pavements to drive on, and future contractors have an opportunity to build them. Our challenge as an industry is to use our past experience together with new technologies to collaboratively evolve our use of RAP in a way that improves the sustainability of our industry without creating an undue burden on the public, owners and producers. ✪

Reference

1 Asphalt Institute; http://www.asphaltinstitute.org/engineering/frequently-asked-questions-faqs/asphalt-pavement-construction/