

ROAD SURFACE TECHNOLOGY

ANALYSING THE LATEST TECHNOLOGY, PRODUCTS & SERVICES

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WORLD HIGHWAYS
ROUTE TO SUCCESS



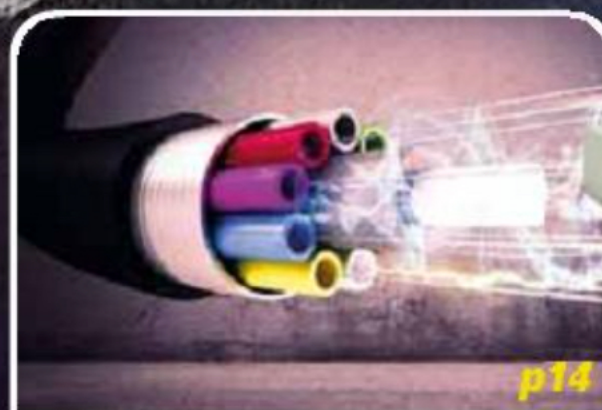
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RESTORING RAP BINDER FUNCTIONALITY USING RELIXER

Krishna Srinivasan* explains how ReLIXER, an elixir of green bio-based oils formulated by Sripath Technologies, has been successfully used as an asphalt rejuvenator and recycling agent in high-RAP mixes

To accommodate the expanding economy and population, the global network of roadways continues to grow and the industry generates over 750 million tonnes per year of recycled asphalt pavement (RAP). This has prompted many countries to adopt and embrace the circular economy concept. Increasingly, several industry experts and regulatory agencies urge or mandate the use of high-RAP mixes with the intent to minimise the need for virgin bitumen and aggregates.

As a bituminous road pavement ages, there is no appreciable change in the quality of the

aggregate component. On the other hand, the bitumen oxidises and changes both physically and chemically, making the bitumen binder stiff and brittle with age. It is well recognised that for high RAP mixes with greater than 25-35% RAP, a rejuvenator or recycling agent is frequently needed to help soften the aged bitumen and restore its functional properties.

Without a rejuvenator, RAP does not significantly contribute any active binder to the mix. The RAP particles then behave like a black rock. An ideal asphalt recycling agent or rejuvenator softens the aged bitumen, restores the functional properties of the aged bitumen and aids workability

and compactability of the asphalt mix. Importantly, it delivers the required roadway performance and durability.

The expectations of an ideal rejuvenator are shown in figure 1. The rejuvenated RAP binder reduces the need for virgin binder in the mix. The key characteristics of one such ideal rejuvenator – ReLIXER, from Sripath Technologies - are outlined in table 1.

ReLIXER is called a “green” agent because it is a material intentionally made from substances derived from living - or once-living - organisms. It is designed to rapidly penetrate RAP particles and restore the functional balance of properties of the aged RAP bitumen. ReLIXER helps reduce the amount of virgin bitumen and aggregates needed and reduces the overall cost of the mix. It is highly efficient at low dosing levels, non-hazardous, safe to handle and easy to

Four mixes with high levels of RAP and RAS – reclaimed asphalt shingles - were evaluated by a contractor in the US; each mix was evaluated with and without ReLIXER

Figure 1: Expectations of an ideal rejuvenator



incorporate in a mix plant.

It also helps lower greenhouse gas emissions and generates an overall lower carbon footprint. High-RAP mixes with ReLIXER are easier to pave and deliver outstanding roadway performance and long-term durability.

The product has been routinely used to pave roads in North America and Asia since 2015. As well, trials have been conducted or are pending in Australia, Europe, South America and Africa.

HIGH RAP/RAS IN US

Four mixes with high levels of RAP and RAS – reclaimed asphalt shingles - were evaluated by a contractor in the mid-Atlantic region of the US. Each mix was evaluated with and without ReLIXER. Mix 1A and Mix 1B, both contained 40% RAP. Mix 1A contained no recycling agent, while Mix 1B was dosed with 0.28% of ReLIXER, by mix weight.

As seen in table 2, the addition of ReLIXER dramatically improves the viscosity, the low-temperature true grade and the penetration values. As the total recycled bitumen content (ABR) is increased from around 45% for Mix 1 to around 82% for Mix 4, the benefits of rejuvenation, as seen in the extracted binder properties, are dramatic and evident (see table 2).

ReLIXER not only effectively restored the functional balance of properties to the aged bitumen, but it allowed for lower virgin bitumen additions to the mix. Based on this extensive test matrix, the contractor developed customised mixes for specific paving jobs and has been routinely using ReLIXER in high RAP mixes.

ReLIXER is the only rejuvenator approved for commercial use by the Illinois State Toll

Table 1: Key characteristics of an ideal rejuvenator

Environmentally friendly	ReLIXER	User friendly
<ul style="list-style-type: none"> • Blend of green bio-based oils • No burden on food sources • No volatile organic compounds • Lowers greenhouse gas emissions • Lowers carbon footprint 		<ul style="list-style-type: none"> • Highly efficient at low dosing levels • Easy to incorporate into a mix plant • Non-hazardous & safe to handle • Compatible with all grades of bitumen & RAP from around the globe
<p>Excellent roadway performance</p> <ul style="list-style-type: none"> • Restores functional balance to RAP bitumen • Improves crack-resistance properties • Confers excellent durability 		<p>Helps reduce mix cost</p> <ul style="list-style-type: none"> • Designed for high RAP mixes • Reduces virgin bitumen requirements • Reduces need for fresh aggregates

Highway Authority for its Illinois Tollway, a 475km-network of six tolled highways within the US state. The highways range from six to 12 lanes and are subject to high traffic and extreme weather conditions. Illinois experiences average winter temperatures of -12°C, average summer temperatures of 30°C, annual snowfall between 350-975mm and rainfall around 800-1200mm.

As part of the approval process, Sripath collaborated with the University of Wisconsin, S.T.A.T.E. Testing, Plote Construction and the Illinois Tollway Authorities. Close to 5,000 tonnes of a 40% ABR mix was produced to lay down eight lane-kilometres of top, base and shoulder courses on US Interstate I-88 and I 294 highways and some private roads in the area. ReLIXER additions of 2% and 3.6% by total bitumen content were evaluated. As a comparison, a softer bitumen mix was also

evaluated. A robust, balanced mix design protocol was adopted for this trial.

The disc-shaped compact tension (DCT) fracture energy test has been shown to discriminate between asphalt mixtures with respect to their thermal cracking potential. Mixes with RAP and ReLIXER demonstrated superior fracture toughness; their DCT values were 497J/m² for the mix with 2% ReLIXER and 544J/m² for one with 3.6% ReLIXER.

This compared to only 435J/m² for the softer bitumen mix. The Hamburg rutting resistance results were 8.70mm and 8.77mm, respectively, for the two high RAP mixes compared to 6.34mm for the softer bitumen mix. The high RAP mixes also showed superior DTc properties; direct tension-compression (DTC) test on cylindrical samples. Thus, ReLIXER was very effective in penetrating the RAP particles and rejuvenating the aged bitumen.

Table 2: ReLIXER rejuvenated high-RAP mixes on US road

Sample	RAP-5% PG 110-9 Binder %	RAS-20% Post Con. Binder %	Total RAP/RAS %	Virgin Bitumen %	ReLIXER (mix. wt.%)	Recycled Bitumen Content %	High Temp. True Grade °C	Low Temp. True Grade °C	Viscosity cps @ 135 °C	Softening point °C	Pen dmm
Mix 1A	40	0	40	2.50	0.00	44.4	82	-14	8,500	81	16
Mix 1B	40	0	40	2.15	0.28	45.1	76	-22	3,000	61	32
Mix 2A	30	5	35	2.50	0.00	50.0	98	-15	9,500	87	12
Mix 2B	30	5	35	2.15	0.28	50.7	87	-24	3,100	65	30
Mix 3A	45	5	50	1.60	0.00	67.0	94	-7	12,500	83	10
Mix 3B	45	5	50	1.20	0.45	66.3	83	-21	3,800	59	28
Mix 4A	50	10	60	0.90	0.00	83.3	104	-6	47,600	106	4
Mix 4B	50	10	60	0.90	0.90	81.4	80	-23	4,800	69	30

→ Furthermore, the contractor was able to reduce the overall mix cost by limiting the amount of virgin bitumen needed for the job. At the same time, the high-RAP mix with rejuvenation met all specifications and targets established by the state highway authorities.

HIGH-TRAFFIC ROAD

In another example, ReLIXER was used on a 100% RAP project in New York City. A highly used stretch of road subject to much stop-and-go traffic and extreme weather conditions was paved about four years ago. ReLIXER was sprayed directly onto RAP particles at a dosage level of 0.55wt% of mix (percentage by weight, abbreviated wt%) with no virgin binder or aggregates added to the mix. Both laboratory and field core tests were conducted to evaluate the effectiveness of the trial.

The paved road met all the specifications established by the local transport authorities. The 100% RAP mix with 0.55% ReLIXER had 3.9% Marshal Air Voids, a stability of 2,110kN and flow of 9.9mm. The roadway had a rutting resistance of 10.9mm at 10K cycles and 14.6mm at 20K cycles. The fracture toughness as measured by the semi-circular bend (SCB) test showed a JC value of 0.71kJ/m² at 25°C.

Meanwhile, a road in northern India was paved using 50% and 60% RAP mixes with ReLIXER. The customer conducted a field trial, laying down a DBM II base course. The contractor evaluated two mixes, one with 50% RAP with 0.2% ReLIXER and the other with 60% RAP and 0.3% ReLIXER.

The results showed Marshal Air Voids of 3.1% and 3.23%, respectively. The Marshal Stability was 15.2kN and 15.1kN respectively and the flow was 3.1mm and 3.2mm, respectively. The customer now routinely uses high RAP mixes along with ReLIXER for base-course paving applications, not just in the north but throughout India.

BRISBANE, AUSTRALIA

Recently, in Australia, Fulton Hogan and Brisbane City Council organised a successful roadway trial incorporating ReLIXER in a high-RAP mix on a 0.7 lane-km stretch of Old Cleveland Road in Brisbane, Queensland.

A test mix based on a M1000 binder, containing 40% RAP and ReLIXER was paved for comparison against the standard mix of M1000 and 15% RAP. The dosage of ReLIXER for the test mix was selected to achieve properties comparable to the standard mix. The CT Index (cracking test) value for the test mix was determined to



In India, the contractor evaluated two mixes, one with 50% RAP with 0.2% ReLIXER and the other with 60% RAP and 0.3% ReLIXER

be 242 compared to a value of 182 for the standard mix.

Also in Australia, there was the increasing use of high-RAP mixes using rejuvenators in city of Gold Coast, Queensland. As part of their initiative to reduce the carbon footprint and create a more sustainable future, the Australian Flexible Pavement Association (AfPA) recently organised a national high-RAP rejuvenation trial. The trial consisted of paving one control mix and three test mixes, each with a different rejuvenator, on a stretch of Hymix Road in Gaven, City of Gold Coast, Queensland.

The control mix for the trial was an AC14H mix, based on an A15E polymer, modified bitumen (PMB) binder. One of the test mixes at this trial was based on an A15E binder mixed with 40% RAP and ReLIXER. The project demonstrated the effectiveness of ReLIXER in restoring the functional properties of aged bitumen in RAP.

OTHER APPLICATIONS

In addition to being a key ingredient for the recycling and reuse of RAP, ReLIXER is also used for rejuvenating emulsions and roadway repair and maintenance applications. For hot patch mix, a hot mix consisting of 100% RAP and ReLIXER is routinely used to quickly and effectively repair potholes and immediately open the roadway to traffic.

As an example, a city in the northernmost regions of the US state of New York used a hot patch mix consisting of 100% RAP and 0.9% ReLIXER. The mix was heated in a portable box at 120°C for three to four hours. An operator swept the pothole, filled it with the hot patch mix, compacted the mix and opened the road to traffic.

As another example, potholes on a 120km stretch of road in India were recently repaired using a hot patch mix with high levels of RAP and ReLIXER.

In the case of cold patch mix, the blend is typically produced using high levels of RAP (70+%), fresh aggregates, an anti-strip agent and ReLIXER. The mix can be stored in a yard during the off-season months and used to patch potholes when weather conditions do not permit regular paving or repair of roadways.

ReLIXER can be added to hot bitumen and the mixture emulsified using normal emulsification techniques. The rejuvenating emulsion is applied to a road surface using normal application techniques, equipment and practices. Examples of applications include slurry seal, micro-surfacing, scrub seal, chip seal, fog seal, cold-in-place reclamation, full-depth reclamation and cold central plant recycling.

The ReLIXER in the emulsion rapidly penetrates the road surface, rejuvenates the aged binder on the roadway and softens the aged binder. This allows for significantly improved bonding of the next layer to the treated road surface.

LONG-TERM DURABILITY

The impact of ReLIXER on two high-RAP mixes, 25% RAP and 50% RAP, paved as wear layer on a roadway in the US are summarised in table 3.

The 25% RAP mix contained 0.5kg per tonne of ReLIXER and 3.4% of PG 64-22 virgin bitumen. The 50% RAP mix contained 1kg per tonne of ReLIXER and 2.4% of virgin bitumen. The total amount of liquid binder was targeted at around 5.6%. Both mixes

Figure 2: Ageing performance of high-RAP mixes

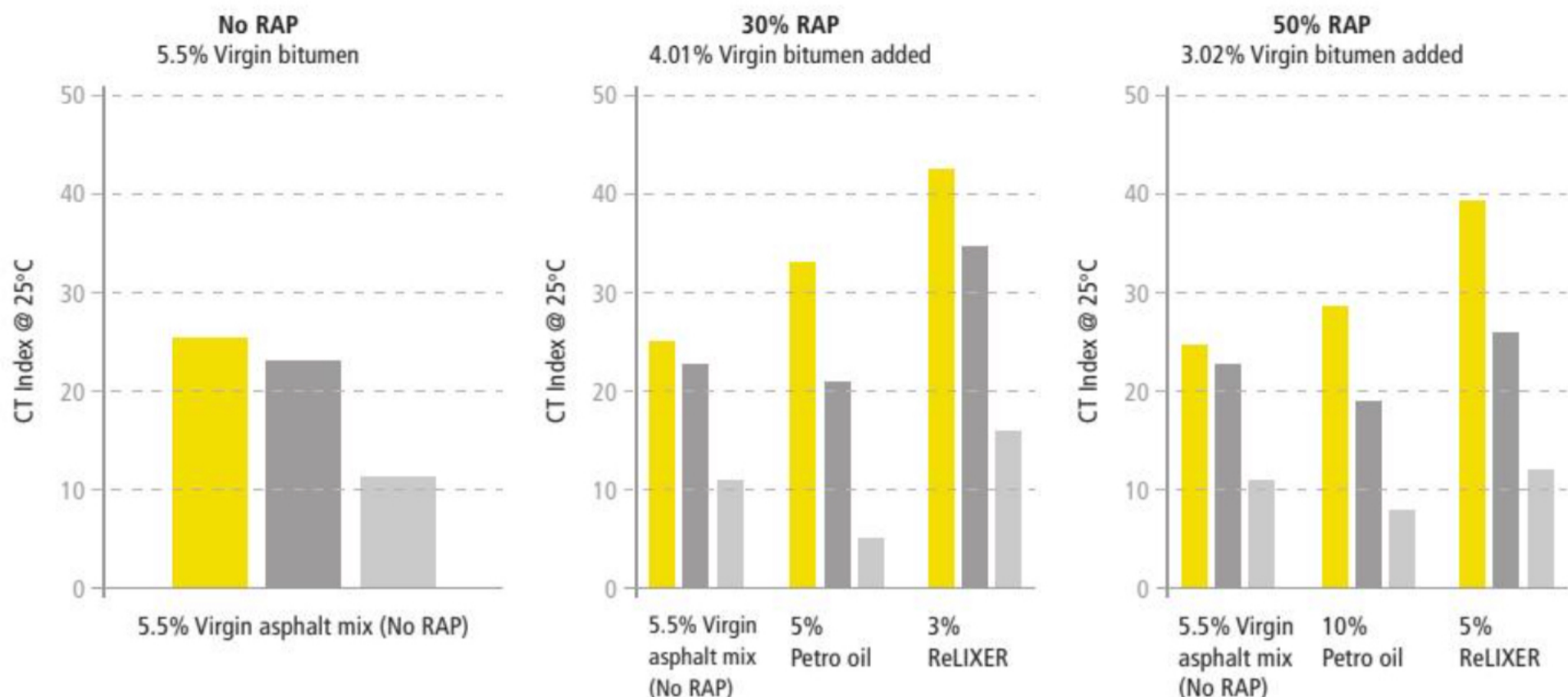


Table 3: Impact of ReLIXER on fracture toughness and rutting performance

Mixture type	25% RAP	50% RAP
ReLIXER, kg/ton of mix	0.5	1.0
Virgin bitumen added, %	3.4	2.4
Rutting: Hamburg wheel-track testing		
Max rut depth, mm	4.19	3.46
Creep slope, mm/1000 pass	-0.11	-0.08
Fracture toughness: Ideal CT test - Short-term aged condition		
Ideal CT index	41.7	64.2
Post-peak slope, kN/mm	-4.9	-4.1
Fracture toughness: Ideal CT test - Long-term aged condition		
Ideal CT index	15.7	26.0
Post-peak slope, kN/mm	-10.7	-7.3

resulted in an excellent balance between rutting resistance and fracture toughness properties, in line with balanced mix design principles (see table 3).

The fracture toughness, Ideal-CT Index, for mixes with no RAP, 30% RAP and 50% RAP were compared for loose-mix oven-ageing times of four hours, eight hours and 16-hours. Mixes dosed with ReLIXER showed superior fracture toughness compared to those dosed with the petrochemical oil. The ageing performance of high-RAP mixes was equivalent to mixes with no RAP (see figure 2).

There are several options available to easily incorporate ReLIXER into a mix plant. ReLIXER has a low viscosity and is free-flowing under most conditions. It can also be co-injected into the bitumen feed line, blended into bitumen bulk tanks, sprayed directly onto RAP on a conveyor

or incorporated into a batch-type plant operation.

ReLIXER is environmentally friendly, has neither odour nor volatile organic content. It has low greenhouse gas emissions and a low carbon footprint. It has a high flash point, is non-hazardous to transport and generates no waste by-products. Furthermore, it is safe to handle and requires no special personal protective equipment. It is stable at mix, use and storage temperatures.

ReLIXER effectively helps in reducing the overall cost of an asphalt mix. As an example, a control mix containing 79.5% fresh aggregate, 15% RAP, 5.5% virgin binder and no rejuvenator was assigned a cost index of 1.0. In comparison, a high-RAP Mix containing 56.1% fresh aggregate, 40% RAP, 3.8% virgin binder and 0.1% ReLIXER had a cost index of 0.89.

The lower cost of high-RAP mixes is driven

by the reduced amounts of fresh aggregates and virgin binders in such mixes. Typically, depending on the raw material costs and operational parameters, savings from 5-15% have been achieved by various contractors around the globe. The two mixes in the above example yielded equivalent roadway performance.

In conclusion, selecting an ideal rejuvenator is a balancing act in evaluating and optimising economic viability, environmental and safety issues, conformance to specifications and long-term performance of the roadway.

ReLIXER meets all the key criteria for an ideal recycling agent or rejuvenator. ReLIXER rapidly penetrates the RAP particles to rejuvenate and restore the functionality of the aged bitumen while delivering roadways with excellent performance and outstanding durability. ■



*Krishna Srinivasan, president of Sripath Technologies, established the company in 2006. He has more than 25 years of hands-on experience in the bitumen industry. Srinivasan received his PhD from the Rensselaer Polytechnic Institute in Troy in the US state of New York. Sripath Technologies develops, manufactures and markets bitumen and asphalt additives. Sripath products are marketed by Sripath Innovations in Europe, Bitpath in India and South-East Asia and Sripath Asia-Pac in Australia, New Zealand and Asia-Pacific region.