Cold, In-Place Recycling On State Road 38

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INTRODUCTION

In the summer of 1986, The Indiana Department of Highways used cold, in-place recycling to rehabilitate part of State Road 38. The technique used was new to Indiana, but has been used previously in Pennsylvania and other states. The technique allowed widening the pavement and using the existing materials to advantage.

In general, recycling can be an attractive option for several reasons. Costs are often reduced by recycling because the need for new materials is reduced. Cold, in-place recycling can save even more by eliminating the cost of hauling reclaimed material to a central plant and heating it. Recycling reworks the existing materials. This obliterates any established crack patterns, thereby eliminating reflective cracking. In this particular case, recycling eliminates the longitudinal crack which often develops on widened pavements. Also in this case, recycling can correct an existing lack of bond between layers by mixing the pavement into a more homogeneous mass.

THE PROJECT

The recycling was included as part of contract RS-16019. This contract called for the widening and resurfacing of 9.74 miles of State Road 38 in Tippecanoe and Clinton counties. The location of the project is shown in Figure 1. The traffic volume along this road varied from about 2,400 to 3,450 vehicles per day (total ADT).

Fauber Construction Company, Inc., of Lafayette, was the prime contractor on the project. They worked closely with the Trumbull Corporation, from Philadelphia, Pennsylvania, on the recycling.

Pre-construction coring showed about 6 ½ to 7 inches of bituminous pavement in place. The roadway had been wedged and leveled about two years previously. Routine maintenance over the years had also included chip and seal treatments, patching and crack sealing.

On the eastern end of the planned resurfacing project, some of the cores split in two. There was an obvious bond failure between some of the old layers.

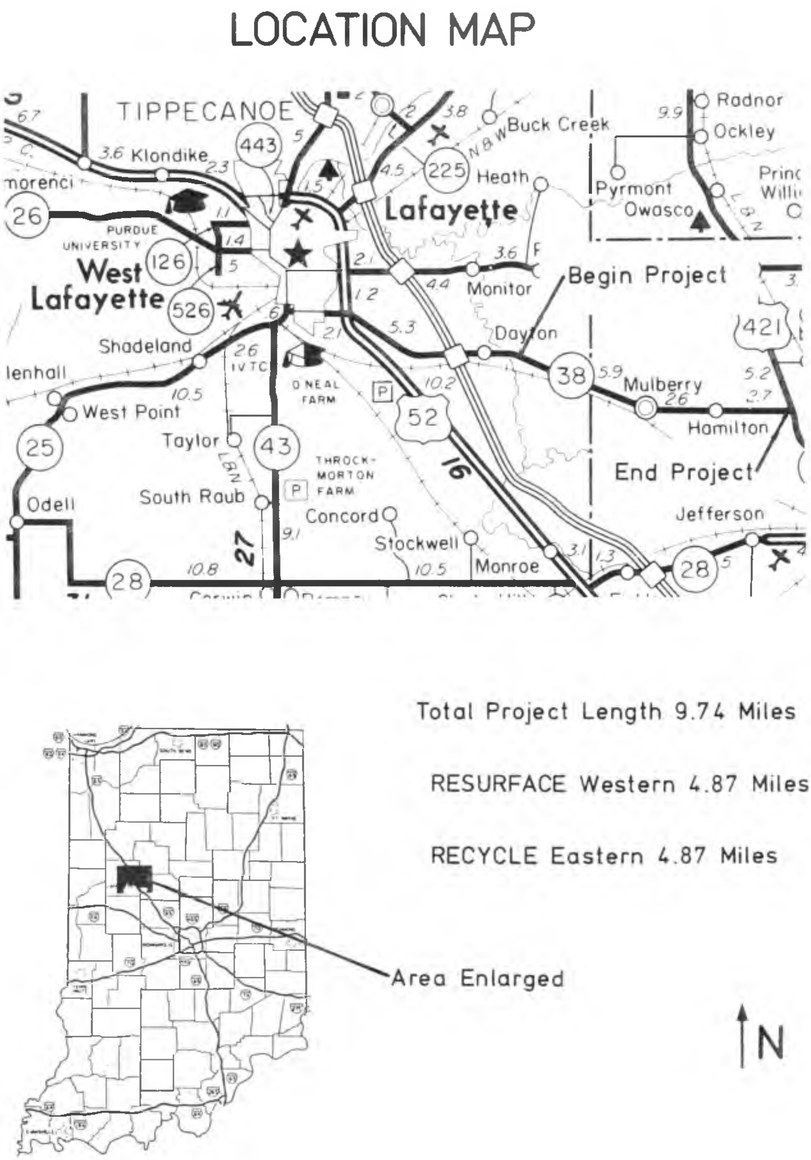

Figure 1.

In light of the poor bonding on the eastern half of the project, experimental use of cold, in-place recycling was recommended. IDOH personnel had seen a demonstration of the technique and thought that this was an ideal use for it. A five-year research project was designed to evaluate the recycled pavement. The pavement with recycled base will be compared to a pavement with conventional widening and resurfacing. Cross sections of the two pavements are shown in Figure 2.

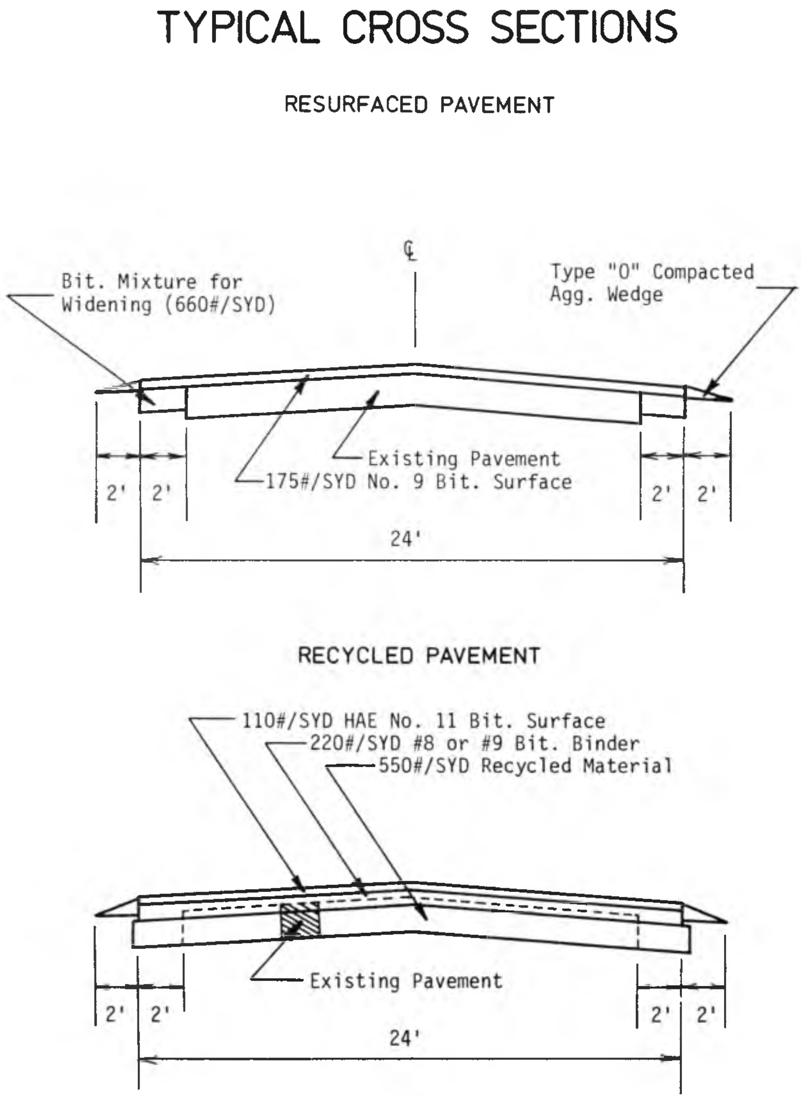

Figure 2.

The western half of the project, from Harding Road to the east side of Mulberry, was widened with 660 #/syd of bituminous base. The pavement was widened from 20 to 24 feet. This half was then resurfaced with 175 #/syd of No. 9 surface.

The pavement was recycled on the eastern half of the project, from the east side of Mulberry to US-421. The existing 10 foot wide lanes were milled to a depth of 6 inches. The reclaimed material was crushed to 100 percent passing the 2 inch sieve while asphalt emulsion and water was mixed in. The material was relaid by a conventional asphat paver in 12 foot wide lanes.

THE RECYCLING PROCESS

The recycling train consisted of a water wagon, emulsion tanker, recycling machine and asphalt paver. Figure 3 shows the recycling train in action.

Figure 3. The supply trucks, recycling machine and paver work closely together in a recycling train.

Water was added to control dust and to help cool the cutter head. Water also facilitated coating and compaction. Two water wagons were needed to keep the recycling train rolling. The final moisture content of the recycled material varied between 3 and 5 percent.

Asphalt emulsion was added to the recycled asphalt pavement (RAP) at about 2 to 2½ percent. This averaged a little under 2 percent residual asphalt added. A medium setting emulsion, AE-150, was used so that it would not break too fast and the mix would remain workable for some time. The selection of 2 percent added asphalt was based mainly on field experience and judgement, with very limited laboratory testing or "design."

The recycling machine was the major piece of equipment used. A downcutting machine was used, so the size of the processed material was controlled by the forward speed of the machine. An up-cutting machine may peel up slabs of pavement which need further crushing. That technique also results in more variation of particle size with changes in temperature. The special provisions for this contract did not disallow the use of an up-cutting machine, but did require that 100 percent of the milled material pass a 2 inch sieve.

The cutter head did most of the work. It chewed up the old pavement to the depth, width, and size specified. Water and asphalt emulsion were added concurrently through separate metered spray bars. The water and emulsion were mixed into the RAP by the cutter head. Visual observations indicated that this particular machine did a good job of mixing the RAP and coating the particles.

The recycled material was carried on a belt out the back of the milling machine. Oversized particles were returned to the cutter head for more crushing. The reclaimed material was discharged into the hopper of a standard asphalt paver.

The special provisions required that the paver be connected to the milling machine with a stiff leg. A solid paving train was required. The stiff leg assured that the paver kept up with the recycling machine. With this technique, no windrowing was necessary, thus reducing material handling.

Standard rollers were used for compaction. Most of the compaction came from a rubber-tired roller. A steel wheeled roller smoothed out the surface.

A test strip was run on the first day of recycling. After 24 passes were put on with pneumatic and vibratory rollers, the density still had not peaked. The temperature increased about 20 °F while rolling the test strip, which may have complicated matters. Ron Walker, the bituminous quality control engineer, terminated the rolling when tiny cracks started to appear. Those cracks indicated the material was being overrolled. Densities were measured by nuclear gauge and ranged around 120-130 pcf.

THE PROBLEMS AND SUCCESSES

"Soft Spots"

The recycled base was left open for seven weeks before the binder was placed. A one-to two-week curing period is normally recommended.

During this time, several "soft spots" appeared in the pavement. The worst of the deteriorated areas is shown in Figure 4. These weak areas were generally in the outer wheelpath. These were cut out and patched with roughly 1 ton of hot mix. The deteriorated areas were generally over soft subgrade in the area near what had previously been the shoulder. The pavement itself did not seem to be failing, but it could not support traffic for weeks over a poor subgrade.

Figure 4. Patching one of the worst deteriorated areas before placing binder and surface.

Productivity

The production rate reflects the learning process that occurred as the local paving crew became accustomed to the method. Productivity is shown in Figure 5. On the first day, overall productivity was just over

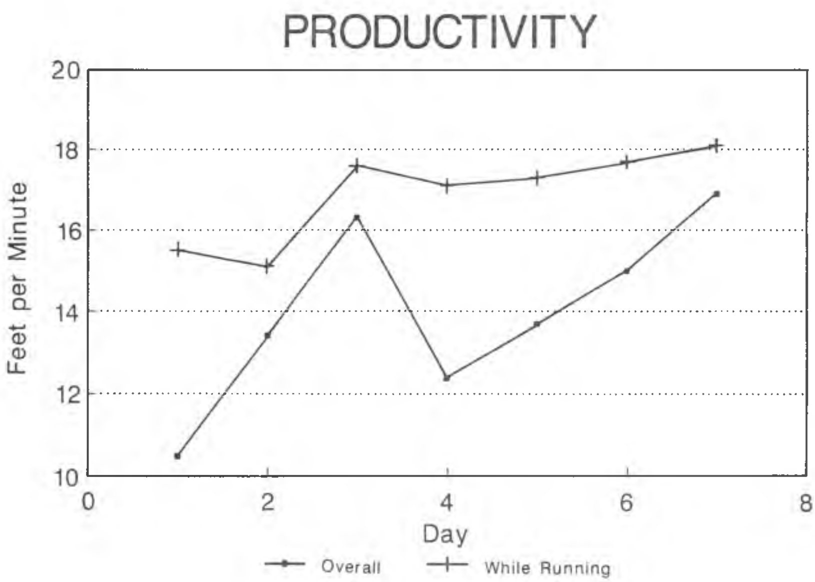

Figure 5.

10 feet per minute (fpm). By the second day, overall productivity increased to over 13 fpm and by the third day it was over 16 fpm. The next three days of recycling were plagued with equipment malfunctions. The resulting downtime cut the overall productivity by 1 to 4 fpm. On the final day of recycling, the overall productivity was up to about 17 fpm. This is equivalent to about 375 tons per hour.

The productivity while running disregards any downtime and represents the forward progress during recycling. On the first two days of recycling, the forward progress was about 15 fpm. By the third day it increased to about 17.5 fpm. The recycling productivity remained above 17 fpm for the rest of the operation.

The efficiency of the operation is the actual percentag eof time during the working day that recycling is progressing. It is, in effect, the ratio of productivity while running to the overall productivity. The efficiency on the first day was 68 percent. By the last day it had increased to 93 percent.

Deflections

Dynaflect deflections were recorded before and after construction on both the recycled and resurfaced sections. Deflections give an indication of the structural strength of the pavement. The Sensor #1 deflection averages and standard deviations are given in Table 1. Figures 6 and 7 show the deflections versus distance.

These deflections indicate several interesting things. First, the before construction deflections and standard deviations for each section were

TABLE 1 Sensor #1 Deflections

PAVEMENT	DIRECTION	BEFORE CONSTRUCTION	AFTER CONSTRUCTION
Resurfaced	EB		
Average Reading		1.44	0.79
Standard Deviation		0.37	0.18
Resurfaced	WB		
Average Reading		1.52	0.84
Standard Deviation		0.42	0.20
Recycled	EB		
Average Reading		1.50	0.73
Standard Deviation		0.38	0.18
Recycled	WB		
Average Reading		1.46	0.71
Standard Deviation		0.40	0.16

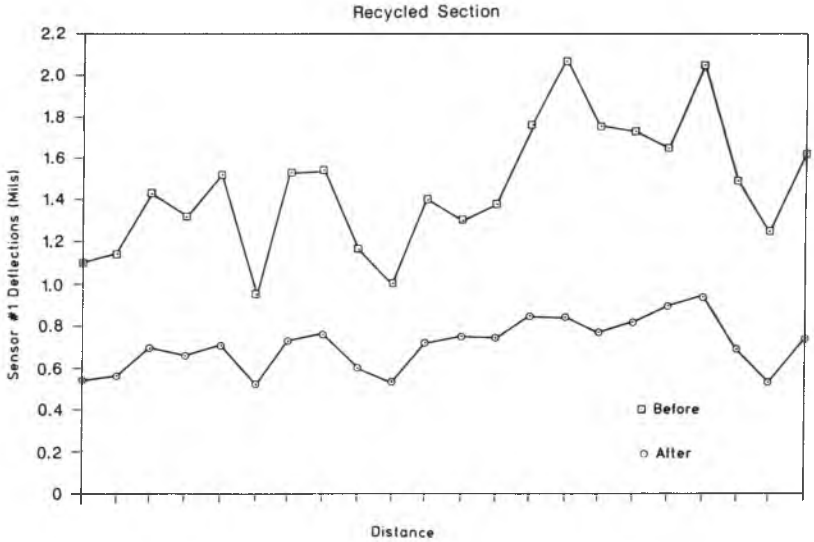

Figure 6. Dynaflect Deflections

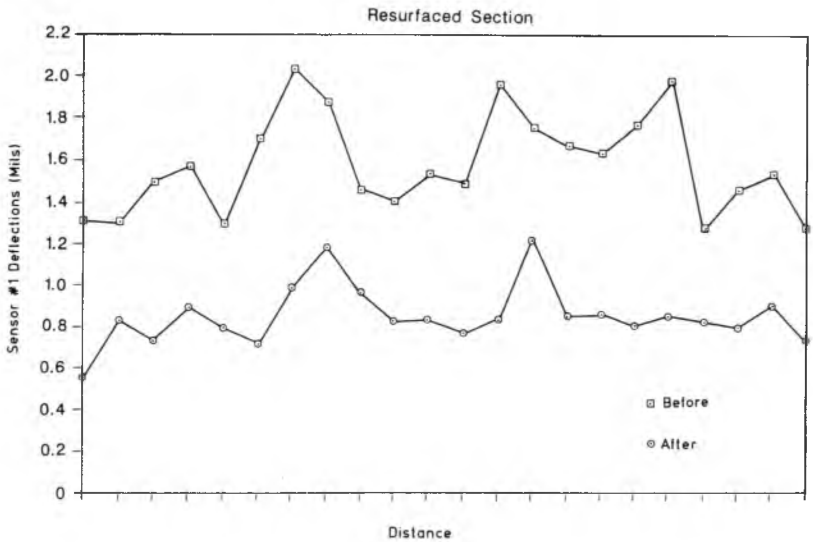

Figure 7. Dynaflect Deflections

comparable. This indicated that the sections were about the same before construction and the experiment was not biased. Second, the deflections after construction were about cut in half on both the resurfaced and recycled sections. The standard deviations were also decreased by about half. Third, the deflections on the recycled pavement were slightly lower than those on the resurfaced section. This is logical since the recycled base had more material placed over it.

Roughness

The pavement roughness was measured in December 1986 with a Cox Roadmeter. The average roughness numbers were 893 for the conventional pavement and 714 for the recycled pavement. The recycled pavement was smoother, at least in part, because two courses of hot mix were placed over the recycled base. Only one course was placed over the existing pavement on the resurfaced section.

Cracking and Surface Distress

Reflective cracks are expected to appear on the resurfaced section within one or two years. There will probably be a longitudinal crack about two feet from the shoulder where the new widening material meets the existing pavement.

This type of cracking is not expected to develop on the test section since the existing cracks were obliterated by recycling. Other distresses may appear, especially if the recycled base does not develop and retain adequate strength to support the loads.

As of the last inspection, two transverse reflection cracks had appeared in the resurfaced section. A faint hint of the widening crack was beginning to appear in some areas. No distress was observed in the recycled section. The patched areas were not detectable.

PROJECT COSTS

Experience in Indiana has shown that the first time a new process or material is used, the costs are high. As contractors gain experience with the new item, the costs decrease. For this project, the recycling subcontractor had to come in from Pennsylvania for a relatively small job. The costs for the recycled section were, not surprisingly, higher than for the conventional pavement.

The 4.87 mile section that was widened and resurfaced conventionally cost about $250,000. The 4.87 mile section that was recycled cost about $450,000. The unit prices directly related to the recycling were: milling, $2.20/syd; trenching, $0.20/lft; AE-150 $150.00/ton.

If this recycling technique is used more often in Indiana, the costs will very likely decrease. Also, if the recycled pavement lasts substantially longer than the conventional pavement, the extra initial expense may be worth it.

WHAT WE LEARNED

This was the first use of cold, in-place recycling in Indiana. We had a lot to learn. The experiences we gained on this project will help us on any cold, in-place recycling jobs we do in the future.

One basic thing we learned was to use what we already know. Recycling, in this case, was used to widen the road. Our standard specifications require that, when widening a pavement, the subgrade under the widened portion be rolled with a trench roller. When recycling and widening in one step, we should also require that the subgrade be rolled. Compacting the subgrade with a trench roller could have eliminated some of the troublesome soft spots.

The amount of time this type of pavement is left open should be limited. Some curing time is essential to let the emulsion develop its strength. The moisture added to the material should also have some time to escape. Prolonged traffic action, however, can weaken or abrade the pavement. A wearing course should be placed between one and two weeks after recycling.

The efficiency of the recycling operation can be enhanced by matching the capacities of the two water wagons. This will eliminate the time wasted when the small truck runs out of water while the large one is still being refilled. Other downtime due to mechanical breakdowns can never be entirely eliminated.

Steps can be taken to improve the smoothness and vertical alignment of the pavement. Wedging and leveling to correct alignment problems before recycling will improve the finished pavement.

CONTINUE TO WATCH

The evaluation of this pavement will continue until 1992. During the intervening years we will continue to monitor changes in the strength of the pavement sections by Dynaflect deflections. We will also look at changes in the roughness of the pavements. The ride quality will deteriorate if the pavement is starting to fail. Visual inspections every year will detect surface distress, cracking, rutting and other signs of trouble.

One more item we will watch with interest is the increase in traffic on this section. The original intent was to evaluate this recycling technique on a fairly low volume road. State Road 38 really filled the bill. Since then, the northeast corner of I-65 and SR-38, about 5 miles from the recycled site, was selected as the site for a new Subaru-Isuzu plant. The traffic volumes on SR-38 are bound to increase substantially.

OPTIONS

One advantage of this recycling technique is that it is very versatile. There are many ways to modify the materials and technique to apply it to different situations.

1. Use more exotic binders. Other states have used modified asphalts in recycling. The emulsions can be modified by the addition of polymer additives or rejuvenating oils and by the use of foamed asphalts.

2. Add virgin aggregate. If the existing pavement includes bad aggregate, or if there is not as much material present as is needed, virgin aggregate can be spread ahead of the recycling machine. This new aggregate is then mixed in and coated with the rest of the material.
3. Improve granular bases. This option might be especially attractive to county highway departments. The existing gravel roads or prepared granular bases can be upgraded to bituminous pavements by recycling.
4. Use with double chip seal. Again, this option might be especially good for county highway departments. On low volume roads, a hot mix wearing course may not be necessary. A double chip seal has been used successfully in Pennsylvania.

CONCLUSIONS

In conclusion, the cold, in-place recycling technique used on SR-38 was very interesting. The technique was quite efficient and required a minimum of equipment and material handling. The resulting pavement was smoother and stronger than the conventionally widened pavement. Both smoothness and strength were enhanced by the additional thickness of new material placed over the recycled pavement. Some reflective cracking is beginning to develop on the conventional pavement.

Initially, then, the recycled pavement is performing better than the conventional pavement. We will continue to monitor this road, with great interest, to see if that trend continues.