RECYCLING 50 MILES OF BITUMINOUS PAVEMENT SAVES DOLLARS—EXPANDS ROAD PROGRAM

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INTRODUCTION

The national emphasis today is on conservation of natural resources. We in Elkhart County feel that we are one of the forerunners in the practice of this concept. For the past six years, Elkhart County has been recycling bituminous surfaced roadways. This recycled material has been used as a base for bituminous overlays and as a subsurface for a chip-and-seal course. Both techniques have proven to have inherent advantages, depending on the classification of the road. Before we address the why's and how's of recycling as we do it, a little background information is necessary.

Elkhart County is located in the north central portion of Indiana, with the Indiana-Michigan state boundary line as our northern border. The northern half of Elkhart County is sand or gravel or a sand-gravel mixture. In the south half, there is clay, silt, muck and peat. Our basic problem has been to find an economical solution that would work in both of these extremes and still enable us to utilize our monies efficiently.

Elkhart County has more than 1,046 mi. of county-maintained highways of which more than 800 are bituminous surfaced roadways. Some of these bituminous roads are patch on patch as a result of our continuous winter freeze-thaw cycles.

Of these 1,046 mi., we have over 235 mi. of functionally classified highways whose reconstruction is dependent on our annual allocation of road and street, or R&S funds, which averages about $600,000 per year. Again, the equitable and efficient distribution and use of these funds is of prime importance to the taxpayers of Elkhart County.

We have already completed approximately 40% of our functionally classified highway system, and this has been accomplished in six paving seasons. Some of these reconstruction projects have been completed by recycling the existing bituminous pavements.

Elkhart County has 51.8 mi. of recycling, recycling with stabilization, or just stabilization. In Elkhart County projects, we have used the Central Chemical Calveda process, utilizing the chemicals SA-1 and ClaPac/ClaSet.

We started recycling of pavements with these chemicals in 1971 as an experimental program. We felt we had very little to lose and a great deal to gain if the system worked. We had been told that the SA-1 process had certain inherent benefits. It supposedly reclaimed the in-place bituminous materials which meant we could eliminate or greatly reduce the need to transport new materials to the job-site. Since we had already paid for the existing materials, and if we could recycle them, it would and did mean a considerable savings of dollars in rebuilding the roadway.

On our farm to market roads, we recycled and added only a seal coat. On our arterial R&S roads, due to the R&S Board's policy that a seal coat is not considered adequate to cover a road, we had to use the recycled material as a base for an overlay of binder and surface. It is interesting to note that the roads with only a seal coat have proven successful and have survived. Their survival has been proven so dramatically by the fact that patching on these recycled roads has been negligible.

Other reasons for using the SA-1 recycling process are that the chemicals will work on old hot mixes, cold mixes, road mixes, cut-backs or emulsions. The chemicals also reduce the personnel and equipment necessary to rebuild the roadway. Finally, local traffic can be allowed on the roadway during the entire construction process except during the actual application of the chemicals.

Back in 1971 when we started recycling, we weren't really interested in the conservation of our natural resources. But since 1973 conservation has been one of our prime considerations, and we feel we have proven that we can save asphalt, stone, and human resources when recycling our existing bituminous pavements.

We could quote all of the platitudes about conservation and tell you that even in the beginning of our program that these were our prime reasons for recycling. But, let's be honest, our prime concern in 1971 was cost and how recycling might save us money. If we could save enough money on the road program as originally projected, we could expand and add more projects and still stay within our annual allocations. This is exactly what we were able to do because of recycling.

Since 1971 the cost of materials has skyrocketed while our reconstruction budget has remained almost the same, and we are still looking for ways to hold down costs. Even in the face of higher costs, we still have flexibility in our road reconstruction program because we include recycling as a contract bid item. We also bid a wedge binder-leveling course as an alternate, and we consistently reconstruct using chemical recycling. We feel that we are not bound to only one system of reconstruction, and because of this we receive favorable recycling costs compared to new asphaltic materials. In Elkhart County we basically have two major paving contractors who bid on our pavement reconstruction projects. Both have used the recycling technique and both have expressed satisfaction with the results.

In Elkhart County we have a bonding requirement that may be unique. We require a two- or three-year-total-cost maintenance bond on each of our projects, and neither contractor has been reluctant to bond our recycling projects.

Another cost factor, as far as a county recycling program is concerned, is that we could use our existing county equipment to do the recycling and stabilizing. We did purchase two honey wagons, or for you nonfarmers, liquid manure spreaders for applying the chemicals. We equipped them with gasoline powered pumps mounted on the front end so we could fill them at any ditch or stream nearby. Otherwise, they were not changed. We already had a grader with scarifiers, a pulvimixer, roller, and a chip-spreader. With this equipment, we were ready to go into the recycling business. In 1976, we did almost 9½ mi. of recycling with our own county personnel.

In addition to utilizing existing equipment, we advocate recycling for the following reasons:

1. Base failures, as manifested by alligator cracking of the pavement surface, can be corrected through recycling. In many instances recycling eliminates the cause of the failure instead of merely concealing it under an asphalt overlay, only to have the cracking pattern reflect through the new overlay. Thus, a secondary benefit of recycling is a very significant reduction in the occurrence of reflection cracks in an asphalt overlay which has been laid over a recycled base.
2. Pavement profile and crown defects are readily and inexpensively corrected through recycling. We find it desirable to correct an excessive crown by recycling for two reasons:

   a. Asphalt leveling courses and the resutling 4- to 8-in. drop-off at the edge of the pavement are eliminated.
   b. Consequently, the elimination of the thick pavement edge also reduces the amount of aggregate required to construct properly sloped and stabilized shoulders.
3. Separate pavement widening operations are eliminated. The new HAC binder and/or surface courses are laid to the desired width over the recycled base in one operation. Also, the very common reflective crack which occurs over the longitudinal widening joint is eliminated.
4. Additional chemical stabilization of silt and/or clay subgrades is very compatible with recycling because the same equipment is used for both processes. Since the underlying gravel base is already exposed through recycling only one more operation is required to expose and chemically treat the subgrade.
5. Roadside drainage work is also very compatible with recycling as again the same equipment can be used for both operations. Combining required roadway widths (including shoulders) and proper drainage into a limited right-of-way presents a major problem in the reconstruction of our county roads. Specifically, we are continually faced with severe sideslopes which present both a safety and an economic problem. The large amount of aggregate required to construct suitably sloped shoulders on these sideslopes is a very expensive plus adequate stability is nearly impossible to achieve. However, last year we surmounted this problem by taking advantage of the complimentary relationship which exists between recycling and drainage work.

   The motor grader would recut the roadside ditch and pull the spoil material up onto the recycled, stabilized base. A pulvi-mixer would then pulverize the sod and soil clumps into a gradable texture. This material is then bladed down onto the sideslope and wheel-rolled by the motor grader. Aggregate shoulders are constructed on the reshaped slope. We find that the decreased sideslope provides a stable base upon which to build the shoulders, and we use much less aggregate in the process.

RECYCLING MATERIALS, EQUIPMENT AND PROCEDURES

Materials

Our recycling program utilizes an accelerated reduction oxidation process chemical called SA-1. It is completely water soluble, and when diluted, 1 part to 1,000 parts of water exhibits a pH between 1.8 and 1.9. Although it is a caustic solution, it will not have a deleterious effect on plant life.

SA-1 functions primarily as an asphalt dispersant which is utilized in two areas. First, in recycling pavements, the surface asphalt goes into solution when subjected to SA-1 and may be readily mixed into the underlying aggregate base. Secondly, SA-1 will also break down and disperse liquid asphalt so that a uniform coating of asphalt on each soil particle will be achieved with less effort than a standard mix-in-place process. This is especially important when we add additional liquid asphalt to a recycled base. In addition, SA-1 burns the undesirable organic contents out of the aggregate base, thus increasing the compactibility, general stability, and the internal drainage characteristics of the base material.

Equipment

The following represents the minimum equipment which is required for recycling asphalt roadways:

1. Water trucks are used for applying the SA-1 solution and additional water as conditions warrant. In order to recycle 1 mi. of pavement in a continuous operation, a total minimum water truck(s) capacity of 4,000-5,000 gal. is required. As mentioned previously, Elkhart County converted liquid manure spreaders for this purpose. Since our combined capacity is only 2,000 gal., we limit our recycling operations to ½ mi. segments.
2. Motor grader(s) equipped with scarification teeth.
3. A pulvimixer, construction disc, or other suitable mixing device.
4. A roller of either the steel-wheeled or rubber tire variety.

Procedure

Scarification of the existing asphalt road should commence at the beginning of the work day. This is performed by a motor grader using one or two scarification teeth. As the scarification proceeds, additional teeth may be added as conditions warrant. During this initial breakdown process, the teeth should not penetrate further than the depth of the asphaltic concrete in order to lift and break the material. Disturbance of the underlying base should be kept to a minimum at this time. Upon occasion, a D-8 dozer equipped with scarification teeth has been used by local contractors for this operation. Because of the tremendous weight of this machine, the additional crushing action provided by the steel treads is very beneficial in achieving the initial breakdown.

While the scarification is proceeding the water wagons should be loaded with the SA-1 solution. The SA-1 is mixed at a rate of 1 gal. per 1,000 gal. of water. This concentration of solution should be applied to the scarified roadway at the following approximate rates:

Thickness of Asphalt	Gal. of Solu. Per Ft.-Mi. (587 Sq. Yds.)	Additional Gal. of Solu. Per Ft.-Mi. in Clayey or Silty Bases
2 in.	1,000 gal.	1,000 gal.
4	1,500	1,000
6	2,000	1,000
8	2,500	1,000

For softer asphalts such as old pug mill or road mixes, it is important that the ground temperatures are at least in the lower 60's with the air temperature in the mid 70's. When recycling harder hot-mixed asphaltic concrete the ground temperature should be in the mid 70's and the air temperature in the 80° to 90° range. Quicker results are obtained on sunny days as opposed to overcast or cloudy days.

Application of the SA-1 solution should begin as soon as the width of the scarified asphalt is wide enough to accommodate the water truck as shown in Figure 1. The water trucks and grader(s) should now work together as a team with the scarification continuing concurrently with the SA-1 application. All of the solution should be applied before midday in order to achieve optimum results. By the time the SA-1 application is complete, the strip where the chemical was first applied will begin to exhibit evidence of breakdown via chemical action, i.e., softening and crumbling under moderate loads. The grader may now start to windrow the asphalt chunks towards the center of the road. The grader blade should be set at such an angle so as to cause the rear wheels to run on the windrow, or at least upon the edge of it. This crushing action greatly facilitates the breakdown of the asphalt to rubble size as does the mixing action of the windrowing process.

Disturbance of the underlying aggregate base should be kept to a minimum as the base acts as an anvil or platform on which the asphalt is crushed. Many different types and variations of equipment have been used to provide this mechanical assistance. For example, Elkhart County has a motor grader with an ATECO Mark II Compactor-Cutter-Crusher mounted on the rear end. This attachment provides additional mixing and crushing action as it is applied to the windrow. We have also utilized a pay loader by dragging its bucket with excavation teeth

Figure 1. A converted liquid manure spreader applies the SA-1 solution to the scarified bituminous roadway.

on top of the windrow. Local contractors have also used a dozer-towed sheepsfoot roller. The grader and sheepsfoot roller work together as a team, with the grader providing mixing action while the sheepsfoot rides on top of the windrow to further assist in the breakdown.

It is vitally important to keep the asphalt rubble thoroughly saturated with water in order to keep the SA-1 active. Therefore, the water trucks should be applying untreated water to the windrowed material and must be closely coordinated with the grader(s) to insure optimum results. To as large an extent as possible, water should be applied only to the windrow and not to the exposed base. At this point the largest dimension of the asphalt rubble will probably be about 3 to 4 in., and the rubble will be chemically softened enough to pulvimix without jeopardizing the pulvimixer. The windrowing process continues with the grader mixing 3 to 4 in. of the underlying aggregate base into the recycled asphaltic material. The pulvimixer rides on top of the windrow behind the grader. The combined action of the pulvimixer and windrowing the material from side to side across the road insures thorough mixing of the recycled material with the aggregate base plus complete breakage of any remaining asphalt chunks. Windrowing and pulvimixing continues until approximately 95-100% of the recycled asphaltic material passes the 1½ in. sieve.

Figure 2. A motor grader and dozer-towed sheepsfoot roller aid the chemical breakdown by providing both mixing and crushing action.

Blading of the recycled material to the desired width and crown may now proceed. Care should be taken not to mix the native subgrade soils, especially clayey or silty soils, into the recycled base mixture. Generally, due to time limitations, the mixture is spread across the road and left open to traffic overnight. You may decide to let traffic do the majority of the compaction and use a roller to obtain uniform compaction in those areas which are not subjected to direct wheel loads.

Patrolling the area periodically with a grader is necessary if this procedure is followed. More uniform compaction is achieved by pulling the base material back into a windrow on the next day, blading it to the desired width in 2- to 3-in. lifts and compacting it at optimum moisture content with a suitable roller. Elkhart County uses both a rubber-tired and a steel wheel roller for this operation. The compacted base should be left to cure for at least two weeks prior to any additional surfacing.

Recycling allows us to diversify our pavement designs to accommodate a wide variety of traffic conditions. For design purposes our recycled roads are categorized as follows:

Farm to Market Roads—These are recycled by employing one of the following variations to achieve the desired pavement strength:

1. For the higher volume roads additional bitumen is added to the recycled base material during the final mixing process. The amount varies from 0.5 to 1.0 gal. SY depending on the bitumen content of the recycled material versus the desired bitumen content. We have used both MC 250 and AC 20 to achieve our desired bitumen content. The liquid asphalt must be mixed into the recycled material with the pulvimixer while the SA-1 is still active in order to insure uniform coating and a homogenous mixture—see Figure 3. Following compaction and an adequate curing period the recycled road is given a chip-and-seal surface treatment. A recycled pavement with a chip-and-seal surface treatment 4½ years after reconstruction still has a very good riding quality while maintenance has been minimal.
2. Low volume roads are given a penetration coat following the compaction process. Following an adequate curing period, a chip-and-seal surface treatment is applied.

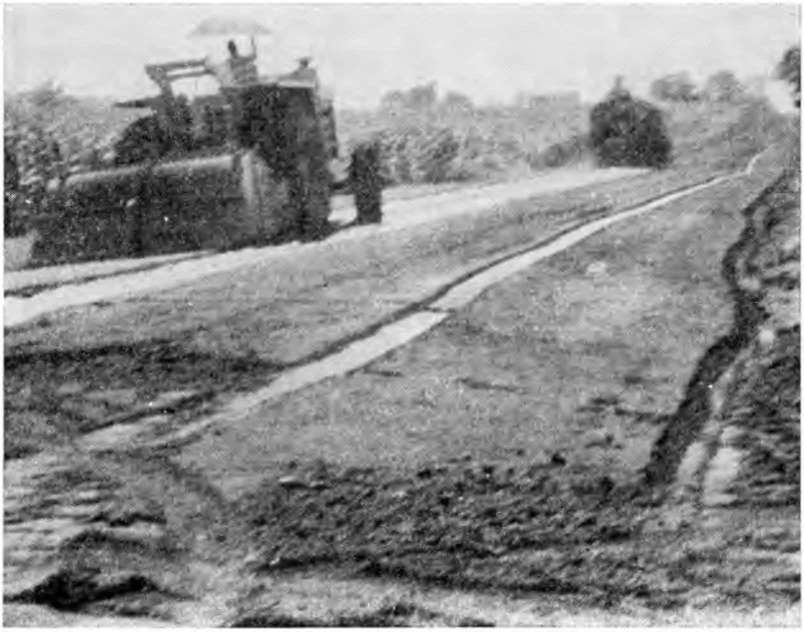

Figure 3. AC 20 applied to the recycled base by a distributor and thoroughly blended with a pulvimixer gives additional strength to this arterial road.

Arterial Roads—These are included in the functional classification system and carry a much higher traffic volume than the farm to market roads. One of the following variations is employed to achieve the desired pavement strength:

1. Where a large volume of truck traffic is anticipated, additional bitumen is added to the recycled material during the final mixing process. After an adequate curing period, a very light prime coat is usually applied prior to laying a minimum of 2 in. of HAC binder followed by a 1 in. HAC surface course.
2. Where less truck traffic is expected, a 0.3 gal. per sq. yd. prime coat is applied and allowed to cure prior to laying a minimum of 2 in. of HAC binder. A 1-in. HAC surface course or a chip-and-seal surface treatment is also constructed depending upon the anticipated traffic load.

ADDITIONAL SUBGRADE TREATMENT

As previously mentioned, only one additional operation following the surface recycling is required to expose and chemically treat unstable clay and/or silt subgrades. When we encounter pavement failures caused by an unstable subgrade, we chemically stabilize the subgrade with a two component chemical called ClaPak-ClaSet, which is also a product of the Central Chemical Corporation. When applied to these clay and/or silt soils, ClaPak-ClaSet functions as follows:

1. Reduces shrink-swell characteristics.
2. Provides a moisture equilibrium in the soil structure, thereby reducing frost lensing and subsequent soft spots.
3. Increases wet bearing values.

Procedure

Upon completion of the SA-1 recycling of the old bituminous surface, the recycled base material is windrowed off the one side of the roadway, thus exposing the subgrade. The subgrade is then scarified with scarification teeth on the grader to a depth of approximately 6 in. and to a width of approximately 5 ft. greater than the finished pavement surface. The rate of application of the chemicals is dependent upon the plasticity index of the subgrade soil as shown below:

RATE OF APPLICATION

Type of Soil	Plasticity Index	ClaPak	SA-1	ClaSet
Silts and Loams	0 — 5	5	0.5	
Clay	5 — 15	10	1	5
Clay	15 — 25	15	1	7.5
Clay	25 — 30	20	1	10

(All figures shown are in gal./ft. of width and mile of length for a lift of 6 in. SA-1 is added to accelerate the reaction.)

The amount of water mixed with the chemicals is governed by the moisture conditions encountered in the field. This will range from approximately 750 gal./ft. for a wet subgrade to 2,000 gal./ft.-mi. for a dry subgrade. The chemical solution is applied to the scarified subgrade via the water wagons and pulvimixed until a homogenous mixture is achieved. The treated subgrade is then brought to a good compaction optimum by either adding more water or aerating with the pulvimixer. After optimum moisture content has been reached and treated subgrade is then compacted using a sheepsfoot roller. Following compaction, the recycled material is windrowed over to the opposite of the road, and the other half of the subgrade is treated in a similar manner.

ECONOMICS OF RECYCLING

Recycling has yielded a cost savings of between 10% and 40% when compared to employing an HAC overlay which would have upgraded the deteriorated pavement to a structural strength equal to that of the pavement utilizing the recycled material. The following factors are responsible for this wide variation in cost savings:

1. Recycling production rates are different for each project and are influenced by the following:
    a. Air and ground temperatures—higher temperatures will yield greater production rates.
    b. Amount of sunshine—sunshine accelerates the chemical breakdown of the asphalt and, therefore, increases production rates.
    c. Humidity and wind—affect the amount of water required to keep the material saturated during recycling which may, in turn, limit the length of roadway which can be recycled at one time.

d. Type and thickness of asphalt to be recycled—a thick, hot mixed asphaltic concrete requires more time to recycle than a thin, cold mixed pavement.

2. The scope of work performed on each project in order to provide adequate pavement strength to meet anticipated traffic loads. For example, both the amount of additional asphalt added to the recycled base material or additional HAC binder and/or surface courses constructed over the recycled material increase the bottom line project cost.

SUMMARY

Elkhart County has found that the benefits said to be available by chemical recycling are definitely there. Recycling provides an economical and long-lasting means of rebuilding a farm to market road. Recycling also lowers the cost of reconstruction of a functionally classified arterial road. The continued use, since 1971, of recycling has enabled Elkhart County to proceed with a viable plan for upgrading our local roads and reconstructing our arterials within the fiscal limits imposed by our available funds.