

# U.S. 40, Indiana's First Hot Mix Recycle Project

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The project location is on US 40 from 9th Street in Terre Haute to the Junction of SR 340 at the west edge of Brazil.

The project is divided into three sections for this presentation.

Section one is from 9th Street in Terre Haute to the railroad underpass just east of Bourne Avenue. Pavement removal was only in this section. The removal was 3 to 6 in. in depth. Repaving was 180 lb./sq. yd. of recycled binder and 120 lb./sq. yd. of No. 11 surface (virgin materials). This section was ideally suited for recycling. The original street was paved with brick. It had been resurfaced several times in the last forty years, so the curb was disappearing and drainage was becoming a problem. Reflective cracking was common in areas where new lifts had been placed in recent years. Recycling offered a means to:

- (1) restore the bitumen to acceptable penetration and viscosity levels.
- (2) correct for aggregate gradation and strength deficiencies.
- (3) eliminate reflective cracking by removing the old material.
- (4) restore curb height and eliminate drainage problems.

Section two is from the railroad underpass to the Junction of SR 46. There was no removal in this section. Repaving was 180 lb./sq. yd. of recycled binder and 120 lb./sq. yd. of No. 11 surface (virgin materials).

Section three is from the Vigo-Clay County line to the Junction of SR 340 at Brazil. There was no removal in this section. Repaving was 180 lb./sq. yd. of recycled binder and 70 lb./sq. yd. of HAE Type IV Surface (virgin materials).

The district obtained cores which were evaluated in the Bituminous Lab. Milled samples were obtained at three locations using a Galion grader equipped with a cutting drum.

These samples were analyzed by extraction test for bitumen content and gradation. Abson recovery tests were made and the salvage bitumen was tested for penetration and viscosity.

It was decided from the analysis of the cores and the milled samples that only the top 3 in. of the pavement would be used for recycling. This was the most uniform material, the lower portion was an open graded material with some being limestone and some was uncrushed pea gravel.

Mix design studies were made with various percentages of RAP and virgin aggregates, i.e.: 14-2 sand, No. 8 and No. 9 gravel, No. 8 and No. 9 limestone and new asphalt (100 and 150 pen.) and also with two rejuvenators.

The following are the most vital parts of the special provisions:

New Aggregate (NA): The new aggregates shall be crushed stone, crushed gravel, crushed slag, natural sand, slag sand, or a combination of two or more of these materials.

The recycling agent (RA) shall be softening agent, flux oil, rejuvenator, asphaltic emulsion rejuvenator (AER), or soft asphalt cement. The recycling agent or the residue from the asphaltic emulsion rejuvenator shall conform to the following specifications:

**TABLE 1  
RA AND AER RESIDUE SPECIFICATIONS**

Smoke Point, °F, min. (AOCS Cc-9a-48)	260
Flash Point, COC, F, min. (ASTM D92)	400
Solubility in Trichlorethylene, Percent (ASTM D 2042)	+ 97.5
Viscosity Ratio, $\frac{\text{TFOT Viscosity @ 140}^\circ\text{F}}{\text{Original Viscosity @ 140}^\circ\text{F}}$ (ASTM D1754)	3 max.

In addition, asphaltic emulsion rejuvenator shall meet the following requirements of ASTM D244:

**TABLE 2  
AER SPECIFICATIONS**

Storage Stability, 24 hrs. max. %	1.0
Sieve text, max. %	0.1
Residue by evaporation, min. % (ASTM D244)	68.0

The emulsion may be manufactured from a soft asphalt cement or may be a combination of an asphalt cement and an acceptable softening agent. The residue portion of the RA or AER shall be considered to be the amount remaining after distillation or evaporation.

The recycled asphalt concrete mixture shall be a homogeneous mixture of reclaimed asphalt pavement material, new aggregate and new bituminous material.

The percent of new aggregate is not fixed by these special provisions: however, a range of 30 to 55 percent of reclaimed asphalt pavement material will be required to be used in the recycled asphalt mixture. The percentage of new aggregate shall be between 45 to 70 percent of the recycled asphalt mixture.

The recycled asphalt concrete mixture shall be within the following composition limits:

Sieve Size	Total % Passing, Wt.
1	100
3/4	80-100
1/2	60- 90
3/8	48- 78
4	30- 54
8	18- 40
16	10- 30
30	5- 22
50	2- 14
100	1- 9
200	0- 6
Asphalt Content	4.3 - 5.3% wt. of total mix

Mixture Design was:

Hveem Design

Stability, 35 minimum

Swell, 0.03 in. maximum

Air Voids, 4-8%

37-47% passing No. 4 sieve

Combined Asphalt - Salvage bitumen and new bitumen shall meet requirements of AP-5 (60-70 pen.) or AC-20 (2000 ± 400 poises)

These special provisions were end result specifications that allowed the contractor to select the materials and methods which would accomplish the desired results.

The percentage of reclaimed asphalt pavement (RAP) could be from minimum of 30 percent to a maximum of 55 percent. A continuous drum mixing plant or a batch plant could be used. Emulsion or asphalt cements could be used.

A pre-letting conference was held for interested bidders on April 7, 1981. Special provisions were explained, discussed and questions answered.

Contract letting date was April 21, 1981, low bidder was Wabash Valley Asphalt Co.

A pre-construction conference was held on April 30, 1981. The contractor submitted his information and materials which he selected to be used in the mix design for the job-mix formula, i.e.: 50 percent RAP, 50 percent virgin aggregate (No. 9 gravel and 14-2 sand) and AE300R. AE300R is a high float, anionic, maltene-rich emulsion, and

was produced by Bituminous Materials Company at Lawrenceville, Illinois. During the job-mix formula design studies, two trial runs were made through the plant varying the percentages of fine and coarse aggregate (virgin materials) and bitumen content, in combination with the RAP stockpiled at the contractors yard, which was produced during the milling operations.

After tests were made on these trial run samples, the job-mix formula was written 50 percent RAP, 38 percent No. 9 gravel, 12 percent 14-2 sand 1.75 percent (residual) AE300R, 37 percent Passing No. 4 sieve and 4.3 percent bitumen.

Milling operations began in June 1981, using a Barber-Greene Dynaplane RS-40 with a cutting width of 75 in. The first cut was 3 in. in depth. The RAP material was dumped at the plant and placed in the stockpile by a high lift loader without running on the material. The stockpile was not covered and it was found that rain and moisture penetrates the first 2 in. of material and then drains from the stockpile due to a crust formed in the RAP.

A ten year old Standard-Havens hot mix batch plant was modified to handle the recycle material. An additional cold feed bin was added with a scalping screen to remove oversize material from the RAP. The belt from the cold feed deposited this RAP into a chute into the weigh box. The "Minnesota Method" of heat transfer was used in that heat from the virgin aggregates was used to transfer heat to the RAP. The virgin aggregates are drawn into the weigh hopper first and then the RAP. Fifteen seconds dry mix time for heat transfer and blending the RAP and virgin aggregates and 30 seconds wet mix time. Truck loading was from the pug mill and also from storage bins.

Laying the recycled material was not changed from normal practices. A wedge and level course was used to fill in the low and irregular areas in section 1 before the recycled binder material was placed. The recycled binder was layed through a conventional paver. Operators claimed they could not distinguish any difference in behavior between the recycle mix and virgin mix. The recycle mix was applied at the rate of 180 lb./sq. yd. Two three-wheels and a tandem roller were used for compaction. Density control was specified, therefore a test pad was compacted to determine the number of roller passes. Ninety-eight percent of test pad density was required. (One hundred percent test pad density 146.9 lb./cu. ft. and 4.9 percent voids).

Extraction tests were performed on a recycled binder and the RAP from the cold feed belt at the bituminous plant.

Samples which were to be tested in the bituminous lab were obtained as follows:

- (1) RAP from the cold feed belt

- (2) Recycled mixture from the trucks at the plant
- (3) Recycled mixture from the paver hopper

Tests on RAP samples from cold feed belt

P No. 4, 49 to 65, avg. 56  
% bit., 4.1 to 6.0, avg. 5.0  
Pen, 11 to 33, avg. 17

Plant inspector tests of recycled mixture

P No. 4, 30 to 40, avg. 36  
% bit., 4.0 to 4.6, avg. 4.2

Lab tests on plant samples of recycled mixture

P No. 4, 26 to 40, avg. 36  
% bit., 3.5 to 4.5, avg. 4.2  
Pen. 20 to 101, avg. 61  
Stability 23 to 44, avg. 33

Lab tests on paver samples of recycled mixture

P No. 4, 30 to 41, avg. 36  
% bit., 3.6 to 4.6, avg. 4.2  
Pen., 27 to 76, avg. 45  
Stability 29 to 45, avg. 35

Density Control

Nuclear Gauge readings were taken every 1000 ft.  
120 were passing (98% + )  
31 were substantial (96 - 98%)  
1 failed, 95%

Cores were obtained for density and voids every 5000 ft.

12 were passing (98% + )  
9 were substantial (96 - 98%)  
0 failed

Voids varied from 3.6 to 8.4, avg. 6.2

The estimated tons of RAP from the top 3 in. was 14,500, actual 10,962 tons. 10,237 tons of RAP was used to produce 20,474 tons of recycled mixture, 725 tons was lost to oversize scalping and stockpile loss.

6,944 tons was laid in section 1 on July 17 and 18, and August 7 and 8. This section has been covered with 120 lb./sq. yd. of HAC 11B surface.

8,215 tons was laid in section 3 in the east bound lanes, September 9 to 15. 5,314 tons was laid in section 3 in the west bound lanes, October 12 - 16. There was not enough RAP for the west bound lanes, so these were completed with 2,391 tons of HAC No. 9 binder. The HAE

Type IV surface has not been placed.

No material has been laid in section 2. Since there is no RAP remaining for this section the binder lay will be placed with HAC No. 9 binder. When this is laid we will continue our sampling and testing program and use the results of this virgin mixture for comparisons.

When the project is completed an interim report will be issued and we will monitor these sections for three years when a final report will be made.

In conclusion, some points to remember are as follows:

- (1) Recycling offers a means to restructure asphalt pavements, correct for aggregate gradation and strength deficiencies, eliminate reflective cracking by removing the old material, and restore curb height eliminating drainage problems.
- (2) Proper selection of asphalt rejuvenators can restore the properties of aged asphalt.
- (3) Use of asphalt emulsion rejuvenators can reduce heat related problems in hot mix production, both in the dryer damage and heating effects on the bitumen.
- (4) The use of RAP in recycling is economical, on this contract the contractor paid the Department of Highways \$8.06 per ton for the RAP, when recycling is done at 50/50 this is a savings of \$4.03 per ton of mixture.

A special thanks is given to those who helped with the sampling and testing on this project.