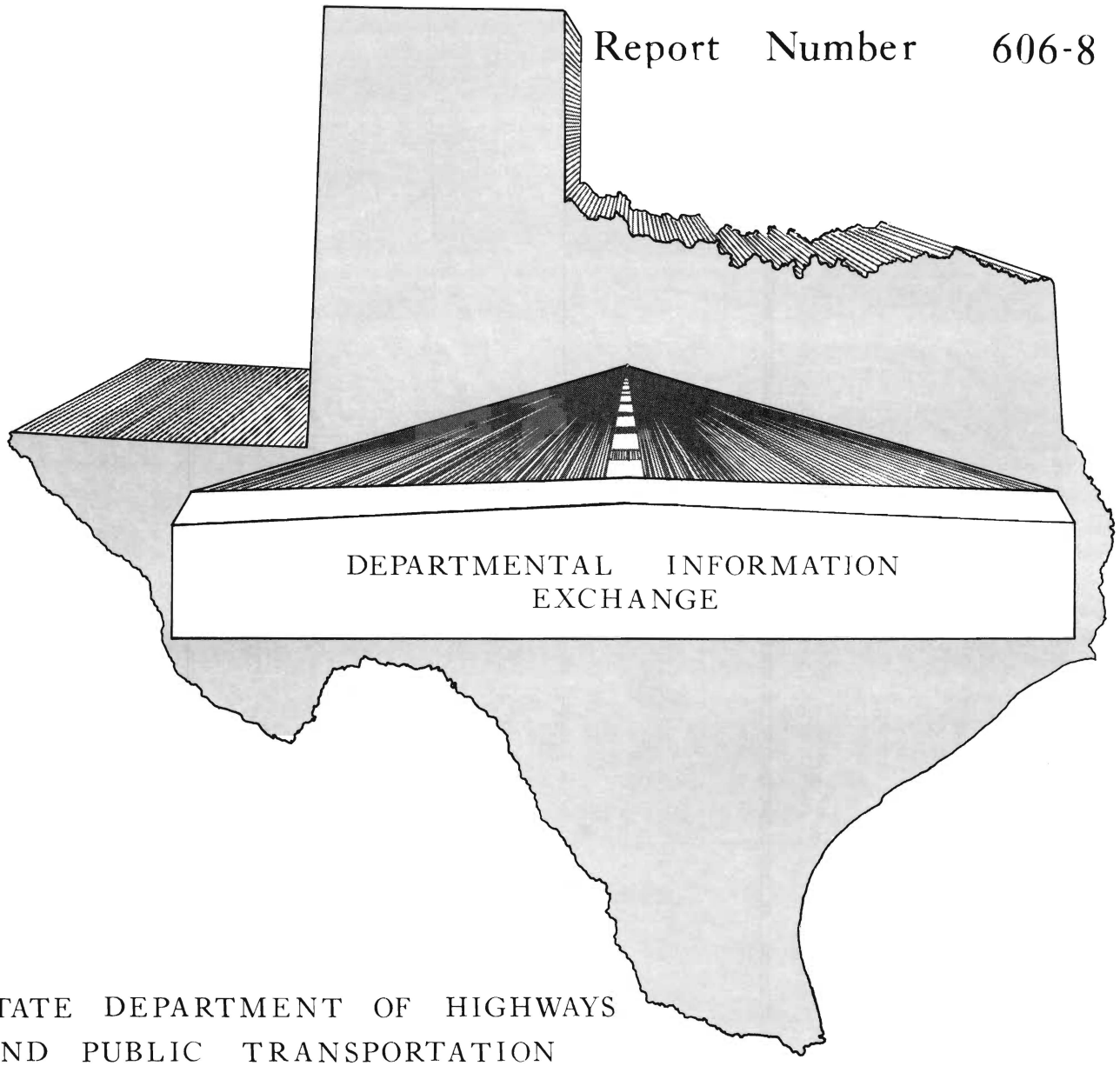
EXPERIMENTAL PROJECTS

EVALUATION OF CRUSHED STONE BITUMINOUS CONCRETE BASE

Report Number 606-8



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

EVALUATION OF CRUSHED STONE BITUMINOUS CONCRETE BASE

Initial Report
for
Evaluation of Experimental
Construction Project

on

Interstate Highway 45
Montgomery County, Texas

Project: IH-45-1(145)098
Control: 675-8-36
From: Walker Co. Line South to 2.5 miles

Project Supervision

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State Department of Highways & Public Transportation

District 12

Conroe, Texas

Work Done in Cooperation With
U. S. Department of Transportation
Federal Highway Administration

Dates of Construction

August 28, 1979 to August 30, 1981

EXPERIMENTAL PROJECT REPORT NO. 606-8

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

The material contained in this report is experimental in nature and is published for informational purposes only. Any discrepancies with official views or policies of the State Department of Highways and Public Transportation should be discussed with the appropriate Austin Division prior to implementation of the procedures or results.

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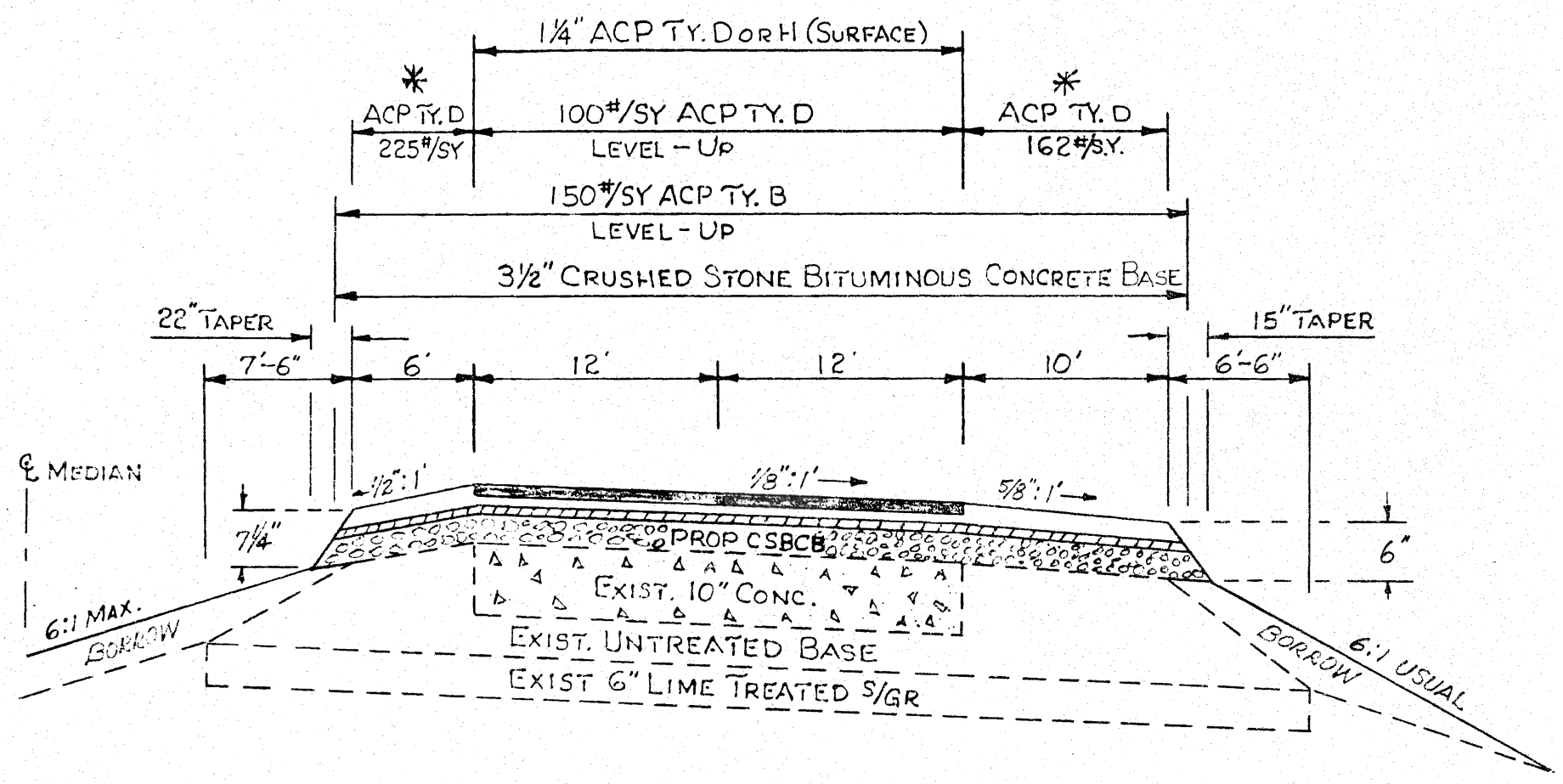
OBJECTIVES

The objectives of this experimental project are to (1) evaluate the performance of Crushed Stone Bituminous Concrete Base as a crack relief layer over the existing deteriorated jointed concrete pavement, (2) evaluate the construction process and the equipment used, and to (3) develop cost data for these construction items.

EXPERIMENTAL FEATURES

On this 2.5 mile section of IH 45, with an exception of a 1000-foot control section, approximately 3½" of Crushed Stone Bituminous Concrete Base was placed on top of the existing 10" jointed concrete pavement with contraction joint design. Subsequent layers of 150#/sy HMACP, Ty B Level-up; 100#/sy HMACP, Ty D Level-up; and 1¼" HMACP, Ty D (Surface) were placed over the Crushed Stone Bituminous Concrete Base.

The 1000-foot 40' wide control section was constructed by overlaying the existing jointed concrete pavement with approximately 600#/sy HMACP, Ty D Level-up, and a layer of 1¼" HMACP, Ty D (Surface). Construction procedures and exact location of this section were as directed by the engineer.



* — ONE CRSE. SURF. TREAT. (TY. B)

TYPICAL SECTION

STA. 29+44.65 TO STA. 163+00

CONSTRUCTION REPORT

Crushed Stone Bituminous Concrete Base in Montgomery County

This section of CSBCB was placed on IH 45 from Walker County line South 2.5 miles. The job was completed on August 30, 1981.

This construction report discusses each major item of work necessary to complete the application of Crushed Stone Bituminous Concrete Base (CSBCB) over an existing deteriorated jointed concrete roadway constructed on 6" of lime treated subgrade and 6" of untreated flexible base with untreated flexible base shoulders. This report is divided into 9 parts:

1. Pre-Construction Investigation
2. Repair Exist Pavement Struct (Var. Depth)(Joint Repair)(Item 3134)
3. Repair Exist Pavement Struct (16 in)(Slab Repair)(Item 3135)
4. Undersealing Slabs
5. Repair Exist Pavement Struct (16 in)(Shldrs)(Item 3068)
6. 6 in Pipe Underdrain, etc. (Item 510)
7. Crushed Stone Bituminous Concrete Base (CSBCB)(Item 2075)
8. Ty B, D, & DS HMACP (Item 340)
9. Test Section

IPE 695

Control 675-8-36

IH-45: From Walker Co. Line South to 2.5 Miles

1. PRE-CONSTRUCTION INVESTIGATION

A pre-construction investigation was made on the deterioration of the existing pavement and pavement joints. The severity of the deterioration was documented into three categories listed below as (Light) (Medium) & (Heavy) cracking.

Condition of North Bound Main Lane

Outside Lane		Inside Lane	
Sta. to Sta.	Category	Sta. to Sta.	Category
29 + 44 to 44 + 00	Medium	29 + 44 to 163 + 00	Light & Medium
44 + 00 to 62 + 00	Light		
62 + 00 to 69 + 00	Heavy		
69 + 00 to 88 + 50	Medium		
88 + 50 to 163 + 00	Heavy		

Condition of South Bound Main Lane

Outside Lane		Inside Lane	
Sta. to Sta.	Category	Sta. to Sta.	Category
29 + 44 to 42 + 00	Medium	29 + 44 to 163 + 00	Light & Medium
42 + 00 to 47 + 00	Heavy		
47 + 00 to 50 + 00	Medium (raised elev. of		
50 + 00 to 65 + 00	Medium slab)		
65 + 00 to 68 + 00	Heavy		
68 + 00 to 74 + 00	Light		
74 + 00 to 83 + 50	Heavy		
83 + 50 to 88 + 50	Light		
88 + 50 to 99 + 00	Heavy		
99 + 00 to 107 + 00	Medium		
107 + 00 to 109 + 50	Light		
109 + 50 to 119 + 00	Medium		
119 + 00 to 163 + 00	Light		

2. REPAIR EXIST. PAVEMENT STRUCTURE(Var Depth)(Joint Repair) (ITEM 3134)

This work consisted of repairing existing sections of concrete pavement or asphalt concrete pavement patches by removing the existing material where failures had occurred and replacing it with Ty D HMACP.

Road Application (Item 3134)

Equipment used under this item included two pickups, two heavy duty air compressors (with two air hammers each), front end loader, two dump trucks, one pneumatic roller (25 ton), and a tack truck.

Air hammers were used to remove any unstable material. The depth of the repairs varied from 6" to the full depth of the concrete slab. Tack Coat (RC-2) was applied to the concrete and asphalt surfaces of the area that was removed. Repair areas were filled with Ty D HMACP, then rolled with the pneumatic roller. Most repair areas were brought to grade in two lifts of HMACP.

Problems Encountered (Item 3134)

Problems occurred when trying to determine which old patches should be replaced. Some of the old patches that appeared stable were not repaired. However, as construction proceeded, these patches had deteriorated to a point that they had to be replaced also.

The major problem encountered with repairing existing pavement sections was the water seepage from the adjacent pavement after the excavation of the unstable material. The tack coat could not be placed until the concrete surfaces were dry. Removing the water from the repair section often slowed down repairs. An air hose and air compressor were used to dry out the wet areas.

3. REPAIR EXIST. PAVEMENT STRUCTURE(16 in)(Slab Repair) (ITEM 3135)

This work consisted of repairing the existing sections of concrete pavement and/or asphaltic pavement where failures had occurred by removing the old pavement and replacing it with reinforced steel and concrete. These failures were due mainly to previous pavement blow-ups. Most of these repair sections extended across the entire travelway and averaged approximately 8 feet in length. The longest section was almost 15 feet in length.

Road Application (Item 3135)

Equipment used under this item included one pickup with a heavy duty air compressor and two air hammers, one tractor mounted air hammer, two dump trucks, one front end loader with back hoe, one flat bed truck, a cutting torch for reinforcing steel, and an immersion type vibrator.

Material used under this item:

Ty III Cement
½" Re-Bar
Hydra Set
Curing Compound

Areas were determined and marked where the concrete slab was to be removed. The small air hammers were used at each end of the section so as to remove the concrete and leave a foot of undamaged existing steel. Care was taken not to break the bond of the steel in the adjacent concrete slab. The tractor mounted air hammer was then used to break up the remaining concrete in the section to be repaired. The ten inches of concrete and six inches of untreated base were then removed.

After straightening the one foot of protruding steel on each end, one half inch reinforcing steel was tied on six inch centers longitudinally and

transversely for reinforcement. On the shoulder side of the slab, a wooden (plywood) form was placed to retain the concrete. Prior to the placement of concrete, each face of the existing concrete was painted with a rich grout to assure maximum bond. Class C concrete with Ty III cement was used for this item. The specifications required that all of the pavement area removed had to be replaced in the same day. Hydra Set, a low shrinkage accelerator admixture equivalent to Cel-Set, was used in conjunction with the Type III cement to accelerate the initial set time. This allowed the repaired areas to be opened to traffic within 4 to 5 hours after the concrete had been placed. The manufacturers recommended dosage was one pint of Hydra Set per sack of cement for air temperatures above 70°F, and one quart of Hydra Set per sack of cement for air temperatures below 70°F. The Hydra Set was added to the concrete when it was received on the job. Once the Hydra Set was added, the concrete was placed and vibrated within approximately 20 minutes in order to prevent loss of workability. Immersion type vibrators were used to insure consolidation of the concrete. Concrete was screeded off to the elevation of the old pavement and left with a rough broom finish.

Problems Encountered

The main problem encountered was trying to maintain the one foot minimum lap length of reinforcing steel (wire mesh). The existing reinforcement had rusted or deteriorated so badly it would break if special precautions were not taken during the concrete removal. This caused additional work in breaking back concrete to get the 1' minimum of steel.

The Type III cement, being a Hi-early cement, plus the added accelerator, caused the concrete to obtain its initial set faster than normal. This made

it a must to finish the surface without delay.

4. UNDERSEALING SLABS

Upon completion of the pavement patching, a limited amount of asphalt slurry underseal was placed on the north and south bound main lanes. The underseal was used on approximately ¼ of the project at the areas with the most severe pumping.

The undersealing of the slabs on this job was done by state forces. The purpose for this undersealing was to fill the voids between the 6" of untreated base and the 10" of concrete pavement.

The undersealing material was a mixture of one cubic yard of select sand, 30 gallons of RC-2, 3 sacks of cement, and 58 gallons of water.

Road Application

Determining the areas that required undersealing was done by two methods. Some of the areas that needed to be undersealed could be determined by examining the pumping action along the outside edge of the concrete pavement. Previous pumping action showed stains of the iron ore base coming from underneath the pavement onto the shoulders. Another method was using a steel bar for a sounding rod. Hollows or voids were located by bouncing this heavy bar on the slab. Usually where there were hollow spots there would be evidence of cracking and settling.

In the areas that needed undersealing, holes were star drilled through the 10" concrete pavement. Then asphalt slurry was pumped through these holes into the voids.

Equipment used included a pickup pulling an air compressor, two air

hammers, one dump truck pulling the underseal mixer and pump, and a pickup pulling an asphalt tank.

5. REPAIR EXIST. PAVEMENT STRUCTURE(16 in)(Shldrs) (ITEM 3068)

The purpose of Item 3068 was to repair the untreated base that had been surfaced with an asphalt seal coat where failures had occurred. Old asphalt base material was removed and replaced with hot mix asphaltic material.

Road Application (Item 3068)

Equipment used under this item included a maintainer, broom, pneumatic roller (25 ton), tandem roller (10 ton), two dump trucks, and a front end loader.

Material used under this item was Ty D hot mix asphaltic concrete pavement utilizing RC-2 for a tack coat.

Areas were determined and marked where shoulder repair was needed. The existing failing material was bladed out and hauled to a designated stock-pile. Ty D HMACP was then bladed into the reworked sections in 2" to 4" lifts depending on the depth removed; using the tandem and pneumatic rollers for compaction.

Problems Encountered

None

6. PIPE UNDERDRAIN(Ty 11)(6 in)

The purposes of Item 510 were to provide an outlet for the water that accumulated under the ten inch concrete slab and to drain off any water that penetrated the HMACP layers used to resurface the existing concrete pavement.

Road Application

Equipment used under this item included a Vermeer trencher with 1' wide cutter blade, front end loader with back hoe, flat bed dump truck, 12 ton pneumatic roller, and a dump truck.

Materials used under this item included 6" ABS perforated pipe, filter material (Ty F), RC-2 Tack, and Ty D HMACP.

Drain limits were determined by inspection of the pumping action along the outside edge of the pavement. The Vermeer trencher was used to cut the longitudinal and lateral trenches to grade. The size of the trenches was 12" wide and 18" deep with variable lengths. After the trenches were graded, Ty F filter material and 6" perforated ABS pipe were placed, leaving the gravel approximately 1½" below the 10" concrete surface. The final lift of Ty F filter material was tamped so that the rocks settled into place. Ty D HMACP was then placed over the filter material. The Type D HMACP was compacted with the 12 ton pneumatic roller.

The lateral trenches outside the shoulder limits were covered with the excess dirt that came out of the trench. The remainder of the excess dirt was spread on the slopes.

Problems Encountered

Problems occurred when trying to cut the lateral trenches to the proper ½"/1' slope. The trencher would cut some of the lateral lines too deep and material would have to be replaced and compacted to the proper slope.

One inch of Ty D HMACP was not enough to cover the Ty F filter material. 1½" to 2" of cover is suggested. If the cover of Ty D HMACP was put too thin, the filter material would not hold up under traffic. There were numerous

places where the Ty D HMACP had to be replaced.

7. CRUSHED STONE BITUMINOUS CONCRETE BASE(CSBCB) (ITEM 2075)

The purposes of Item 2075 were to alleviate cracks coming through subsequent layers of HMACP and to act as a relief channel for the water that might penetrate the surface or be purged from underneath the concrete slab.

This item consisted of a base course to be composed of a compacted mixture of mineral aggregate and asphaltic material mixed hot at the mixing plant. The asphalt content was determined by the engineer.

Equipment used under this item:

Cedar Rapids(Rubber tire)(Finish machine)(Model BSF-530)
Tandem Roller(Tampo 10 ton)(Model RS-166A)(Vibratory)
Tack Truck
Broom
Dump Trucks
Weight Batching type plant w/100 ton silo

Materials used under this item:

Tack(RC-2)(.10 gal/sy)(Texaco, Inc.)
Crushed stone bituminous concrete base(Texas Crushed Stone)(Georgetown, Texas)
AC-40(Texaco, Inc.)
Asphalt - AC-40(3% prop.)(2.4% actually used)
Aggregate(Crushed limestone)(97% prop.)(97.6% actually used)

The combined sieve analysis of CSBCB is shown below:

% Retained by Weight

Sieve Size	Combined Analysis	Specification
2½"	0	0%
1½"	52.56	30-65%
3/4"	88.85	80-95%
No 8	97.33	95-100%
No 200	97.48	97-100%
Pass 200	.12	
Asphalt	2.40	

Equipment conformed to Specification Item 292(asphalt stabilized base) (article 292.4 or as directed by the engineer).

Construction methods conformed to Item 292 article 292.6 of the specification for asphalt stabilized base.

Road Application (Item 2075)

To determine the asphalt content of the CSBCB, trial batches were mixed through the weigh batch plant at 300°F using varying asphalt contents of 2.5%, 2.7%, and 3%. The batches of 2.7% and 3% appeared to have an excess asphalt content which could cause an unstable mix under traffic in the hotter months of the year. The batch which had the 2.5% appeared to be well coated but not to excess. A truck load of each trial batch was placed using the lay down machine. After placement, the 2.5% asphalt content batch was selected as having the best quality.

Before the 3½" depth of CSBCB could be placed, a permanent lane closure was designed for day and night utilizing a series of advance warning signs, two portable flashing arrow boards, a 750 foot lane closure transition, and reflective vertical panels every 100 feet throughout the work area.

After the entire length of the inside southbound lane and shoulder had been placed, a tapered ramp of Type D HMACP was placed on the approach and departing ends of the CSBCB.

Type B HMACP Level-up was then placed over the tapered ramps and the layer of CSBCB. Once this was completed, traffic was detoured onto the inside lane and the same procedures were followed for the outside lane. The same procedures were used on the northbound lanes excluding the placement of the test section.

The proposed depth of the CSBCB was 3½", but due to the overestimation of the weight of the crushed limestone at the time of plan preparation, we were able to increase the depth placed to 4½" and stay within the limits of the plan quantity.

The Crushed Stone Bituminous Concrete Base was placed with a Cedar Rapids rubber tire lay down machine, model no. BSF-530, equipped with an automatic slope and grade control.

The rolling was done with a ten ton Tampo vibratory roller. The vibratory mechanism of the roller was not used for any appreciable time because of the fracturing affect on the aggregate. It also caused excessive roll out of the material. The normal static roll out of a 12' mat with a 4½" depth of material was approximately 6" transversely on each side of the mat.

The best rolling pattern for the CSBCB was to roll the outsides of the mat first then make the last pass through the center. Normally, one complete coverage was sufficient.

The CSBCB and Ty B HMACP layers for the southbound lanes were placed in the summer of 1980. The northbound lanes and control section were placed in the fall on 1980.

Problems Encountered

The CSBCB material was mixed at the Gaylord plant in Huntsville, Texas and then hauled twenty miles before being placed on the roadway. The CSBCB material having an open texture, plus the long trip, would cause it to cool rapidly. When the trucks were dumped, some sections of the material would solidify. In order to eliminate this problem, it was necessary to use tarps on all trucks. It is also suggested that the asphalt plant be located closer

to the construction site if possible. Most problems of placing the mix were eliminated by maintaining the temperature of the mix within the desired range by close plant control.

It was found on this job that the mix could not be accepted on the road at a temperature above 325°F. The mix at a temperature of 350°F would appear to have been charred. The best regulated temperature for running the mix at the plant was between 275°F and 325°F. By doing so, the temperature would be between 225°F and 275°F after it made the 20 mile trip. Due to the rapid loss of heat, this material could not be detained at the road for long periods of time before placement.

Even at closely regulated temperatures and asphalt percentages, there would be problems with the asphalt and fines accumulating in the bottom of the truck beds. Approximately half of the trucks would have to be cleaned before returning to the plant which would cause a plant shutdown while waiting for the trucks to return. The percentage of asphalt was changed and the mix temperature was changed in an attempt to eliminate this problem. The problem was never totally eliminated. It is suggested that the specifications be changed to allow more fines to be left in the mix to absorb the excess asphalt.

A constant grade was hard to maintain with the CSBCB. Since the material naturally cooled quickly, there would be areas that would consolidate causing a problem of getting an even flow of material to the screed. Any time the depth of material was not kept constant behind the screed there was a grade change in the mix.

8. TY B, D, & DS HOT MIX ASPHALTIC CONCRETE (ITEM 340)

Type B HMACP was used as a level-up course over the CSBCB. This mix was designed to be of a coarse nature so as to bridge the open graded CSBCB.

The proposed rate per square yard for Ty B HMACP on this job was 150#/sy. The final application rate averaged 169#/sy.

Ty D HMACP was used for a second level-up course. The proposed rate per square yard for this job was 100#/sy on the main lanes. The final application rate on the main lanes was 134#/sy.

Ty D Surface HMACP was used for the finished surface. The proposed depth of this material was 1¼ inches. The final application rate averaged 134#/sy.

9. TEST SECTION

A test section 1000 feet long and 40 feet wide was constructed by overlaying the existing jointed concrete pavement with approximately 600#/sy HMACP, Ty D level-up, and a layer of 1¼" HMACP Ty D or H Surface. This test section was placed on the northbound main lane from Sta. 90 + 30 to Sta. 100 + 30. The Ty D HMACP was placed in three lifts.

EVALUATION

The objectives of this project were to evaluate primarily the performance of CSBCB as a crack relief layer over the existing deteriorated jointed concrete pavement, the construction process, and to develop the cost data.

The performance of the roadway will be closely monitored and any unusual changes in the surface along this project will be called to the attention of the Resident Engineer.

A post construction inspection was made at the completion of this project. There will be an annual condition inspection conducted by the Resident Engineer's office and reported for a minimum of three years. If a longer reporting period is necessary, the annual inspection will be continued.

To conduct this annual inspection, the entire length of the job has been stationed. The stationing was placed on the southbound lanes (outside 10' shoulder) every 100 feet. The northbound lane was stationed every 500 feet. At each station there is a PK nail driven with a disk. Stationing runs from north to south from Sta. 29 + 44 to 163 + 00. The annual inspection will cover the same joint inspection and any other conditions that may develop.

POST CONSTRUCTION INSPECTION

This job was completed on August 30, 1981.

This survey was taken on October 8, 1981.

All joints on the north and south bound main lanes were surveyed.

The survey showed that 60% of all the joints in the southbound main lane have cracked through and that 39% of the joints in the northbound lane have cracked. Only 50% of the joints in the control section have cracked through. It is significant to note that in the southbound lanes, of the joints that have cracked, 40% have cracked on both lanes, while of the northbound lanes only 9% of the joints have shown through both lanes.

There is significantly more reflective cracking of the crack relief layer in the southbound lane that was placed in the late summer of 1980 than of the northbound lanes that were placed in the early winter of 1980.

The southbound lanes had gone through the temperature change from hot to cold whereas the northbound lanes were placed while the weather was cool. Also, the southbound crack relief material had been subjected to traffic for approximately 5 to 6½ months before the final courses of hot mix were completed.

The northbound crack relief material was subjected to traffic approximately 3 to 4½ month. This contributed to loads being on the crack relief layer without the benefit of the final 2¼ inches of pavement. This should be avoided and the sequence of work should require all of the layers to be placed in a shorter time frame.

I am of the opinion that the crack relief layer can be used to an advantage. There should be a more durable material used in place of crushed limestone. All layers of the material should be placed before the lanes are open to traffic.

CONSTRUCTION COST

The contract price of this project was $2,868,902.29. The final cost of this project was $2,783,083.30. The average cost of this project for a four lane highway per mile was $1.1 million.

Itemized below are the final quantities and the unit cost of the items discussed in this report.

ITEM	DESCRIPTION	UNIT	FINAL QUANTITIES	CONTRACT PRICE
131	Borr(Del)(Ord Comp)(Ty C Cl 2)	C.Y.	19,767	$ 10.75
3134	Repair Exist. Pav Struct(Var Depth)	S.Y.	1,230	65.00
3135	Repair Exist. Pav Struct(16 in)	S.Y.	650	83.50
3068	Repair Exist. Pav Struct(16 in)(Shldr)	S.Y.	877	42.00
510	Filter Matl(Ty F)	C.Y.	707	35.00
510	Unddr Excav	C.Y.	887	6.00
510	Pipe Unddr(Ty 5, 9, 10, or 11)(6 in)	L.F.	15,866	5.90
340	Asph(AC)	Ton	955	39.45
340	Aggr(Ty B)	Ton	9,930	39.45
340	Aggr(Ty D)	Ton	11,235	37.97
340	Asph(AC)(Surf)	Ton	248	135.00
340	Aggr(Ty D or H)(Surf)	C.Y.	2,628	79.70
*2075	Aggr	Ton	19,166	42.95
*2075	Asph(AC-40)	Ton	456	42.95
5301	Barrcd, Signs and Traff Handling	Mo.	10	11,000.00

*Crushed Stone Bituminous Concrete Base