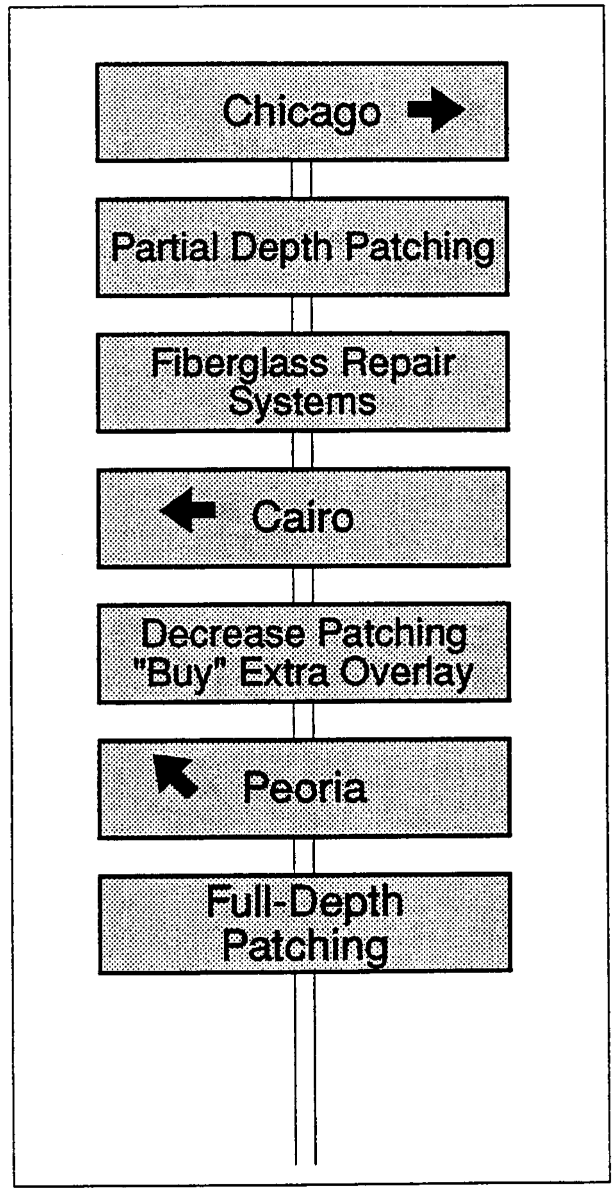
Alternatives To Full-Depth Patching On Resurfacing Projects



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16. Abstract

The vast majority of Illinois' non-interstate network is constructed of jointed Portland cement concrete (PCC). Typically, Illinois' first significant rehabilitation efforts for jointed PCC pavements are in the form of full-depth bituminous concrete or undoweled PCC patches, followed by a 2.5-inch bituminous concrete policy overlay. The full-depth bituminous concrete patches often rut or hump, and the full-depth undoweled PCC patches often settle, rock, or pump, resulting in a rough-riding overlay.

The objectives of this study were to develop alternatives to conventional full-depth patching of PCC pavements on resurfacing projects, to evaluate their performance, and to determine their cost-effectiveness. The following alternatives were studied: full-depth bituminous concrete patches, partial-depth bituminous concrete patches, full-depth undoweled PCC patches, Roadglas (a woven fiberglass repair system marketed by Owens-Corning Fiberglas Corporation) over joints and cracks in lieu of patching, and GlasGrid (a self-adhesive fiberglass mesh produced by Bayex, a division of Bay Mills Limited) over joints, cracks, and patches, all with a 2.5-inch bituminous concrete policy overlay. Reducing patching quantities and applying the "savings" to increasing the overlay thickness was also studied.

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FINAL REPORT

IHR-521

ALTERNATIVES TO FULL-DEPTH PATCHING ON RESURFACING PROJECTS

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TABLE OF CONTENTS

INTRODUCTION

The Illinois Department of Transportation (IDOT) is accountable for approximately 17,000 centerline miles of pavement. Of this total mileage, over 15,000 miles are classified as non-interstate pavements, consisting of U.S. and Illinois marked routes and state unmarked routes (1). These non-interstate pavements are primarily constructed of jointed Portland cement concrete (PCC). As a result of time, traffic, and exposure to the elements, these jointed PCC pavements eventually deteriorate. Typically, IDOT's first significant rehabilitation efforts for jointed PCC pavements are in the form of full-depth bituminous concrete or undoweled PCC patches, followed by a 2.5-inch bituminous concrete policy overlay. The bituminous concrete overlay temporarily restores ride quality; however, the full-depth bituminous concrete patches often rut or hump, and the full-depth undoweled PCC patches often settle, rock, or pump, resulting all too quickly in a rough-riding pavement. Given its volume of non-interstate jointed PCC pavements in need of rehabilitation and the reality of budget constraints, IDOT has to constantly evaluate the effectiveness of its standard rehabilitation techniques.

The objectives of this study were to develop alternatives to conventional full-depth patching of PCC pavements on resurfacing projects, to evaluate their performance, and to determine their cost-effectiveness. To meet these objectives, a literature review was conducted to identify promising alternative rehabilitation strategies. The Central Bureau of Design and several districts were consulted in the developmental stage of the study. Based on this research,the following rehabilitation strategies were selected for further study:

- Partial-depth patches with a 2.5-inch bituminous concrete policy overlay.
- Roadglas (a woven fiberglass repair system marketed by Owens-Corning Fiberglas Corporation) over cleaned and sealed joints and cracks in lieu of patching, followed by a 2.5-inch bituminous concrete policy overlay.
- Reduced full-depth patching quantities, with the savings "buying" a thicker than policy bituminous concrete overlay.
- Full-depth patches followed by a 2.5-inch bituminous concrete policy overlay as the control rehabilitation strategy.

REHABILITATION EVALUATION SECTIONS

Two projects were initially selected as rehabilitation evaluation projects; a third was added at a later date. Figure 1 shows the location of the three projects. All of the projects were bare, jointed PCC pavements that had not previously been rehabilitated. The location, existing condition, and the rehabilitation strategies used for each project are discussed below.

Project Number One

Project number one was located on IL 97, south of Havana, Illinois. Average daily traffic for the two-lane, 5.08-mile section was 2,050 in 1989, with 175 single-unit and 200 multiple-unit trucks. The existing pavement was built in 1938. The 9-6.5-9 thickened edge pavement with 0.75-inch diameter edge bar reinforcement was constructed on grade. The 50-foot jointed pavement cross-section is shown in Figure 2. The majority of the joints and mid-panel cracks were spalled and broken up and some had been patched previously by state maintenance forces. The joints and cracks were faulted as well, creating a rough ride.

A variety of rehabilitation strategies were selected in the design stage, as detailed below. Figure 3 shows the layout of the experimental sections.

Full-Depth Bituminous Concrete Patches - Control

The control section consisted of full-depth bituminous concrete patches followed by a 2.5-inch bituminous concrete policy overlay.

Partial-Depth and Full-Depth Bituminous Concrete Patches

This section replaced some planned full-depth bituminous concrete patches with partial-depth bituminous concrete patches. The most severe distresses and those obviously caused by subgrade problems were replaced full-depth. This section received a 2.5-inch bituminous concrete policy overlay.

Full-Depth Undoweled PCC Patches

This section was intended to contain both partial-depth and full-depth undoweled PCC patches, depending upon the severity of the distress. When it became apparent that the patches would be placed in the fall and the overlay in the spring, partial-depth PCC patching was deleted. This was done to avoid the possibility of having to remove and replace failed partial-depth PCC patches in the spring. A 2.5-inch bituminous concrete policy overlay was placed over the full-depth undoweled PCC patches.

Reduced Patching Quantities/Increased Overlay

A pre-construction field survey yielded a 14.3 percent patching estimate. Patching in this section was intended to be limited to approximately 4.5 percent. The estimated "savings" associated with this reduction "bought" an additional 2.75 inches of overlay, for a total of 5.25 inches of bituminous concrete overlay. Actual patch quantities exceeded the original patching estimate, however. Full-depth bituminous concrete patches were used.

Roadglas

The Roadglas repair system, which consisted of a layer of Roadbond adhesive, Roadglas fiberglass reinforcement fabric, and another layer of Roadbond adhesive, was placed over cleaned and sealed joints and cracks on the bare PCC in lieu of patching. Areas of base failures and severely deteriorated pavement were patched full-depth with bituminous concrete. This section was covered with a 2.5-inch bituminous concrete policy overlay.

GlasGrid

This rehabilitation alternative was added in the spring of 1989. GlasGrid, supplied by Bayex, a division of Bay Mills Limited, was a self-adhesive fiberglass mesh designed to reduce thermal- and stress-related reflective cracking in bituminous concrete overlays over PCC pavements. GlasGrid was placed directly on the bare PCC over joints, cracks, and patches in the southbound lane and over the bituminous concrete binder lift in the same locations in the northbound lane. The GlasGrid sections received a 2.5-inch bituminous concrete policy overlay.

All patches on project number one were placed in the fall of 1988. The Roadglas was placed and covered with a lift of bituminous concrete level binder prior to winter. GlasGrid was placed in the spring of 1989. The remainder of the bituminous concrete overlay was placed in the spring of 1989 after it was determined that the patches were in good condition.

Project Number Two

Project number two was located on U.S. 50, east of Lawrenceville, Illinois. Average daily traffic for the four-lane divided highway was 4,600 in 1989, with 100 single-unit and 600 multiple-unit trucks. The existing 10-inch jointed reinforced concrete pavement with 50-foot joint spacing was built on 4 inches of granular subbase in 1961. The joints and some working mid-panel cracks were spalled and broken. In between the spalled joints and cracks, the concrete was sound.

During the design stage, the District elected to try two rehabilitation strategies as outlined below.

Full-Depth Bituminous Concrete Patches-Control

The District proposed a saw and seal option during the design stage. This technique recognizes that cracks will develop in the overlay over patched areas, and seeks to control those cracks. Joints are sawed in the bituminous concrete overlay over the patch joints during construction and then sealed to prevent raveling and break-up. Since it would have been extremely difficult to track the location of the proposed irregularly-shaped patches through the construction sequence, it was decided during construction to allow the contractor to rout and seal the cracks after they reflected through the overlay. However, the cracks did not reflect through the overlay before the contract was completed, so this technique was eliminated. This section became the control section, with full-depth bituminous concrete patches and a 2.5-inch bituminous concrete policy overlay.

Partial-Depth and Full-Depth Bituminous Concrete Patches

An experimental section of partial-depth bituminous concrete patches followed by a 2.5-inch bituminous concrete policy overlay was planned. Some full-depth bituminous concrete patching was added when the estimated partial-depth patching quantities were exceeded.

The special provision detailing partial-depth patching was inadvertently omitted from the contract document. The contractor was thus allowed to remove the deteriorated concrete with a wheel saw instead of using jackhammers or a milling machine as specified. Although the wheel saw successfully removed the deteriorated PCC without damaging the sound material beneath, it was not capable of producing the desired vertical patch edges. Vertical patch boundaries eliminate the need to feather material at the patch edges, and provide a good surface to compact against.

Construction began in the fall of 1989. All patching was completed in the fall of 1989, but the patches sat open over the winter before the bituminous concrete overlay was placed in 1990.

Project Number Three

Project number three was located on IL 4, between Girard and Nilwood, Illinois. Average daily traffic was 2,800 in 1989, with 125 single-unit and 125 multiple-unit trucks. The existing pavement was a 9-inch jointed reinforced concrete pavement built on grade in 1949. The 100-foot jointed pavement was badly deteriorated. Virtually every joint was badly spalled and broken up, with some joints exhibiting pumping.

Reduced Patching Quantities/Increased Overlay

After the contract was let and awarded, a field check showed that the existing concrete was not sound enough for the doweled PCC patching as designed. The District decided to use full-depth bituminous concrete patches instead. In addition, the District reduced patching quantities from 4.4 percent to 0.8 percent while extending the job limits. The savings were used to patch and overlay portions of the project not originally scheduled for patching or overlay, and to "buy" additional overlay thickness for the remainder of the project. Two sections were monitored: a section scheduled for patching and a 2-inch overlay which was patched and overlaid with 3 inches, and a section scheduled to be patched only which was patched and overlaid with 2.5 inches. Figure 4 compares the designed and as-built rehabilitation strategies.

Construction began and was completed in 1990.

PERFORMANCE OF REHABILITATION TECHNIQUES

Project Number One

Patching quantities for the various experimental sections were calculated after construction, and are presented in Table 1. Patching quantities for the entire job amounted to 12.4 percent. Patching quantities for the experimental sections ranged from 12.1 percent in the full-depth bituminous concrete patching control section to 15.0 percent in the full-depth undoweled PCC patching section. The reduced patching quantities/increased overlay section had 14.9 percent patching in the 1000-foot long survey section. This figure is in line with the 14.3 percent pre-construction patching estimate, but in excess of the 4.5 percent target value. Patching quantities were inadvertently not reduced in this section.

The percentage of reflected cracks, joints, and patches two years after the overlay was placed was calculated from the pre- and post-construction surveys. The results are shown in Table 2. The results are based on 1,000-foot survey sections and should not be considered statistically significant; however, they are useful for a relative comparison of techniques. Only transverse cracks, joints, and patch cracks were considered. At least 50 percent of a full-width crack or joint had to reflect through the overlay to be counted as a reflected crack. Each patch had two transverse cracks, and each patch crack was counted separately. Thus, 50 percent reflected transverse cracks from patches means that, on average, one of the two transverse cracks per patch reflected through the overlay.

Ride quality measurements were taken with IDOT's road profiler, which was modeled after South Dakota's prototype. Surface roughness was measured in inches per mile and the International Roughness Index (IRI) was used to describe the ride quality. The results for the project and the IRI scale can be found in Table 3. In general, all of the sections rode well, although the bituminous concrete patches were noted to be rough riding prior to overlay.

Full-Depth Bituminous Concrete Patches - Control

In the project control section, 23 percent of the transverse patch cracks and 48 percent of the unpatched transverse cracks and joints had reflected through the overlay two years after construction. After two years in service, the section had an average IRI of 95 inches per mile, which translated to a smooth pavement. However, the IRI was developed for use in Third World countries with lower quality roadways, so virtually all of the higher quality roadways in Illinois will test as "smooth" pavements based on that scale.

Partial-Depth and Full-Depth Bituminous Concrete Patches

This section performed comparably with the control section, with 28 percent of the transverse patch cracks and 56 percent of the unpatched transverse cracks and joints reflecting through. However, only 12 percent of the partial-depth patch transverse cracks had reflected through, as compared to 41 percent of the full-depth patch transverse cracks. This section was one of the smoothest sections tested with the road profiler, with an IRI of 80 inches per mile. These results would indicate that the partial-depth bituminous patches were performing at least as good as the full-depth bituminous concrete patches after two years in service.

Full-Depth Undoweled PCC Patches

The full-depth undoweled PCC patch cracks reflected through the overlay at almost twice the rate of the full-depth bituminous concrete patch cracks. In spite of the increased occurrence of reflection cracking, the ride quality after two years was nominally better than that of the control section.

Reduced Patching Quantities/Increased Overlay

Not surprisingly, the additional overlay resulted in less reflective cracking after two years, with only 14 percent of the transverse patch cracks and 22 percent of the unpatched transverse cracks and joints reflected. Ride quality was nominally better than that of the control section. Since the patching quantity in this section (14.9 percent) was greater than that of the control section (12.1 percent), the full effect of the reduced patching quantities/increased overlay tradeoff was not realized.

Roadglas

The Roadglas section performed better than the control, with only 12 percent of the transverse patch cracks and 23 percent of the unpatched transverse cracks and joints reflecting through. The ride quality of this section was one of the smoothest, with an IRI of 80 inches per mile. This section was covered with level binder prior to winter, thus protecting the

Roadglas, patches, and existing pavement from further deterioration. The control section was patched and left bare through the winter.

Of the unpatched transverse cracks and joints, 34 percent of those without Roadglas reflected through, while only six percent of those with Roadglas had reflected. Although these findings would seem promising for the future use of Roadglas, two points must be made. First, previous IDOT use of Roadglas had shown that Roadglas had limited long-term ability in preventing reflection cracking at cracks and joints which experience vertical movement. Second, and more importantly, Owens-Corning no longer manufactures the Roadglas fiberglass repair system, although similar products meeting IDOT's specification are being marketed by other manufacturers.

GlasGrid

Both GlasGrid test sections performed poorly in comparison to the control section. In the section in which the GlasGrid was placed directly on the bare PCC, 72 percent of the transverse patch cracks and 63 percent of the unpatched transverse cracks and joints had reflected through. Fifty-seven percent of the transverse patch cracks and 63 percent of the unpatched transverse cracks and joints had reflected through in the section where the GlasGrid was placed on the level binder. Bayex, the manufacturer of GlasGrid, was aware of its product's performance on this project. Bayex currently recommends that GlasGrid be placed on a lift of bituminous concrete level binder instead of directly on the PCC as was done in one of the test sections. In addition, Bayex currently controls the application of GlasGrid's adhesive, instead of contracting the job out. Material quality problems as a result of adhesive application during production were identified by Bayex as a contributing factor to its performance on this project.

Project Number Two

Patching quantities in the full-depth bituminous concrete patching control section amounted to approximately 10 percent. In the experimental section, 4 percent partial-depth bituminous concrete patching and approximately 3 percent full-depth bituminous concrete patching was done. The percentages of reflected transverse patch cracks were calculated from patch locations as noted in the project field book and post-construction distress surveys.

The results of the ride quality testing are summarized in Table 4. Initial ride quality tests were taken with IDOT's Bureau of Public Roads-type Roadometer and measured using the Illinois Roadometer Roughness Index. Subsequent tests were taken with the road profiler. Although both the roadometer and road profiler use the same unit of measurement, the results are not directly comparable.

Full-Depth Bituminous Concrete Patches - Control

Seventeen months after the overlay was placed, and 24 months after the patches were placed, approximately 60 percent of the transverse patch cracks had reflected through the overlay. Some slight humping of the patches was observed. In April of 1991, the section had an IRI of 96 inches per mile, which is in the smooth category. The ride quality did not seem to be affected by the slightly humped patches.

Partial-Depth and Full-Depth Bituminous Concrete Patches

Approximately seven percent of the partial-depth patch transverse cracks reflected through the overlay in seventeen months. The partial-depth patches seemed to be reflecting through the overlay at a slower rate than the full-depth patches in the control section. Again, some slight humping of the patches was observed, but the ride quality was not affected. The ride quality of the partial-depth and full-depth bituminous concrete patch section was comparable to that of the control section.

Project Number Three

The final patching quantity on this project was 0.8 percent as compared to the 4.4 percent estimate. Both the 2.5-inch and 3-inch overlay sections had 0.8 percent patching quantities. Since no portion of the project was built as originally designed, there were no control sections to accurately gauge the effectiveness of the patching/overlay tradeoff.

The percentages of reflected transverse patch cracks were calculated from patch locations as noted in the project field book and post-construction distress surveys. One year after construction, 78 percent of the transverse patch cracks in the 2.5-inch overlay and 100 percent of the transverse patch cracks in the 3-inch overlay section had reflected through. Ride quality testing, conducted with the road profiler one year after construction, yielded IRI's of 68 inches per mile in the 3-inch overlay section, and 75 inches per mile in the 2.5-inch overlay section. Both sections fell into the smooth pavement category. Little difference in performance was noted between the two sections.

REHABILITATION COST-EFFECTIVENESS

Project Number One

The costs of the various rehabilitation strategies used on project number one were converted to a uniform cost per 2-lane mile basis. These costs are summarized in Table 5. A comparison of these costs showed that the full-depth bituminous concrete patching control and the partial-depth and full-depth bituminous concrete patching sections had the lowest costs, at $133,100 and $135,900 per 2-lane mile, respectively. The "reduced" patching/increased overlay section was the most expensive alternative on this project at $216,800 per 2-lane mile. These costs reflected the actual patching and overlay quantities, which varied by section as noted in Table 5. A more direct cost comparison may be made by comparing strategy costs on a square yard basis as shown in Table 6. Square yard costs ranged from $45 for Roadglas to $56.30 for full-depth undoweled PCC patching. The Roadglas and partial-depth bituminous concrete patching costs may not be representative, however, due to the small quantities involved and the experimental nature of the work.

Based on the percentage of reflected cracks, joints, and patch cracks and ride quality measurements, the full-depth bituminous concrete patching control section and the partial-depth and full-depth bituminous concrete patching section were among the best performers, making them the most cost-effective alternatives used on this project. The full-depth undoweled PCC patches reflected through the overlay at twice the rate of the full-depth bituminous concrete patches. The full-depth undoweled PCC patches at $56.30 per square yard were also approximately 10 percent more expensive than the full-depth bituminous concrete patches at $51.05 per square yard. The reduced patching quantities/increased overlay section was effective at retarding reflective cracking, but as the target patching quantity was exceeded, costs rose. If the patching quantities had been kept to the target value, this strategy would have been among the more cost-effective alternatives. The Roadglas was effective in preventing early reflective cracking, but it is no longer being marketed. Alternative fiberglass systems need to be tested to determine their long-term effectiveness. Finally, the GlasGrid was not effective at retarding reflective cracking, and would have been costly had Bayex not donated the material for the test section.

Project Number Two

The bid price for both the partial-depth and full-depth bituminous concrete patches was $65 per square yard. Since the District did not supply the special provision detailing partial-depth patching during the bidding process, the contractor was not sure what was required, and so bid the two items the same. Costs for approximately 10 percent full-depth bituminous concrete patching and a 2.5-inch bituminous concrete overlay ran $332,400 per 4-lane mile; costs for four percent partial-depth and approximately three percent full-depth bituminous concrete patching and a 2.5-inch overlay were $272,000 per 4-lane mile. Pavement in the partial-depth and full-depth patch section may have been in better condition. Since approximately the same number of patches were placed in both sections, however, the fact that the partial-depth patches were smaller than the full-depth patches was most likely the contributing factor to the strategy price differential.

Based on the initial data, the performance of the partial-depth and full-depth bituminous concrete patching section was better than that of the full-depth bituminous concrete patching control section, making it the more cost-effective strategy. As contractors gain experience with partial-depth bituminous concrete patching, the price will probably stabilize at a level somewhat lower than full-depth bituminous concrete patching.

Project Number Three

Cost-effectiveness was difficult to gauge on this project, since there were no control sections. However, a cost analysis of the major items, as shown in Table 7, illustrated the importance of applying engineering judgement in the field. A field check showed that by reducing the amount of patching and switching from doweled PCC patching (which was not realistic given the condition of the pavement) to full-depth bituminous concrete patching, additional overlay thickness could be bought. The savings bought 1.5 to 3 inches of overlay for over 59 percent of the project not originally scheduled for overlay, and an additional inch of overlay for approximately 41 percent of the project scheduled for a 2-inch overlay. Initial performance results indicated the decision to cover up and protect the deteriorated pavement with additional overlay was correct. Additional time is needed to determine the long-term effects of the reduced patching quantities/increased overlay tradeoff.

SUMMARY AND RECOMMENDATIONS

Illinois' standard rehabilitation strategy for deteriorated, bare, jointed PCC pavement calls for full-depth bituminous concrete or undoweled PCC patches and a 2.5-inch bituminous concrete overlay. The objectives of this study were to develop and evaluate the performance of alternatives to full-depth patching on resurfacing projects. The following alternatives were studied:

- full-depth bituminous concrete patches and a 2.5-inch bituminous concrete policy overlay as the control rehabilitation strategy.
- partial-depth bituminous concrete patches with a 2.5-inch bituminous concrete policy overlay. Full-depth bituminous concrete patches were also used in areas exhibiting base failure.
- full-depth undoweled PCC patches followed by a 2.5-inch bituminous concrete policy overlay.
- reduced full-depth bituminous concrete patching quantities with the savings buying a thicker than policy overlay.
- Roadglas (a woven fiberglass repair system marketed by Owens-Corning Fiberglas Corporation) over cleaned and sealed joints and cracks in lieu of patching, followed by a 2.5-inch bituminous concrete policy overlay. Full-depth bituminous concrete patches were also used in the most severely distressed areas.

- GlasGrid (a self-adhesive fiberglass mesh produced by Bayex, a division of Bay Mills Limited) over joints, cracks, and patches and a 2.5-inch bituminous concrete policy overlay. On half of the installation, GlasGrid was placed on the bare PCC, and on half of the installation the GlasGrid was placed on top of the bituminous concrete binder lift.

Combinations of these strategies were tested on three projects. Reflective cracking and ride quality measurements were used to determine the effectiveness of the various rehabilitation strategies. Costs were then calculated to compare cost-effectiveness. Among the three projects studied, the full-depth bituminous concrete patching control strategy and the partial-depth and full-depth bituminous concrete patching alternative proved to be the best performing and most cost-effective strategies tested. The partial-depth bituminous concrete patches reflected through the overlay at a slower rate than the full-depth bituminous concrete patches and rode at least as well. Limited data on one project showed that the full-depth undoweled PCC patches reflected through the overlay at a faster rate than the full-depth bituminous concrete patches. Cost-effectiveness data for the reduced patching quantities/increased overlay strategy were mixed, but the early benefit of the increased overlay thickness in retarding reflective cracking was readily apparent. Although initial data from this study showed Roadglas to be effective in retarding cracking over unpatched cracks and joints, previous research had found Roadglas to have limited long-term ability to withstand vertical movement at joints and cracks. In addition, Roadglas is no longer marketed. Finally, GlasGrid was found to have limited effectiveness in retarding reflective cracking. Bayex, GlasGrid's manufacturer, is currently marketing a new version of GlasGrid.

Based on these findings, the following recommendations are offered:

- The continued use of full-depth bituminous concrete and undoweled PCC patches is warranted. Patching costs are a function of the availability of materials and contractors' experience levels. Patch performance is dependent upon patch selection and adherence to the appropriate specifications. Although IDOT cannot always control patching costs, IDOT can influence patch performance. Timely scheduling of rehabilitative efforts, proper selection of patch location, and strict adherence to specifications should help alleviate rough-riding overlays due to rocking, humping, and settling patches.

- Use of partial-depth bituminous concrete patches appears to be promising. Patch locations should be judiciously selected; areas of base failure and severely distressed pavement should be patched full-depth. As contractors gain experience with partial-depth bituminous concrete patching, lower patching costs should result. Use of a wheel saw to create the patch opening should be studied further.

- Field trials of partial-depth PCC patching in lieu of full-depth undoweled PCC patching are needed.

- The concept of buying increased overlay thickness by reducing patching quantities merits additional study. Based on the preliminary findings of this study, this concept has been incorporated into the current IDOT resurfacing policy. Use of this strategy should be limited to carefully selected projects to determine long-term effectiveness.

- Roadglas is no longer marketed. Alternative fiberglass repair systems should be field tested on their own merits to determine their cost-effectiveness and long-term ability to prevent reflection cracking over unpatched cracks and joints subject to vertical movement.

- The newly marketed version of GlasGrid should be field tested to determine its effectiveness at retarding reflective cracking.

REFERENCES

1. Illinois Department of Transportation. FY 1992-96 Proposed Highway Improvement Program. Illinois Department of Transportation, Office of Planning and Programming, Springfield, Illinois, April 1991.

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The contents of this paper 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 official views or policies of the Illinois Department of Transportation nor the Federal Highway Administration. This paper does not constitute a standard, specification, or regulation.

Trademark or manufacturer's name appear in this report only because they are considered essential to the object of this document and do not constitute an endorsement of product by the Federal Highway Administration or the Illinois Department of Transportation.

TABLE 1: PROJECT NUMBER ONE PATCHING QUANTITIES

Description*	Patching, %
Entire Job	12.4
Full-Depth Bituminous Concrete Patches-Control	12.1
Partial-Depth and Full-Depth Bituminous Concrete Patches	12.3 (9.1% Full-Depth 3.2% Partial-Depth)
Full-Depth Undoweled PCC Patches	15.0
Reduced Patching Quantities/Increased Overlay Test Section	14.9
Roadglas Test Section	14.6
GlasGrid Test Sections	14.7

*All sections had 2.5" overlay unless otherwise noted.

TABLE 2: REFLECTIVE CRACKING ON PROJECT NUMBER ONE

Description[a]	Reflected Transverse Cracks from Patches,[b] % (as of 6/91)	Reflected Transverse Cracks from Unpatched Cracks and Joints, % (as of 6/91)
Full-Depth Bituminous Concrete Patches-Control	23	48
Partial-Depth and Full-Depth Bituminous Concrete Patches Test Section	28-All Patches 41-Full-Depth 12-Partial-Depth	56
Full-Depth Undoweled PCC Patches Test Section	41	57
Reduced Patching Quantities/ Increased Overlay (5.25") Test Section	14	22
Roadglas Test Section	12	23-All cracks, joints 34-Without Roadglas 6-With Roadglas
GlasGrid on PCC Test Section	72	63
GlasGrid on Level Binder Test Section	57	63

[a] All sections had 2.5" overlay unless otherwise noted.

[b] Each patch had 2 transverse cracks and each was counted separately; i.e., 50 percent reflected transverse cracks from patches means that, on average, 1 of the 2 transverse cracks per patch reflected through the overlay.

TABLE 3: RESULTS OF RIDE QUALITY TESTING ON PROJECT NUMBER ONE

	International Roughness Index (IRI)[b] In./Mile	
Section[a]	4/90	4/91
Full-Depth Bituminous Concrete Patches - Control	78	95
Partial-Depth and Full-Depth Bituminous Concrete Patches	73	80
Full-Depth Undoweled PCC Patches	74	84
Reduced Patching Quantities/Increased Overlay	68	86
Roadglas	74	80
GlasGrid - On Level Binder NB, on Bare PCC SB	75-NB 66-SB	90-NB 97-SB

a All sections had 2.5" overlay unless otherwise noted.

b

Rating	IRI, IN./MILE
Smooth	0-190
Medium	191-320
Rough	321 or greater

TABLE 4: RESULTS OF RIDE QUALITY TESTING ON PROJECT NUMBER TWO

Section	Roughness Index, In./Mile//Adjective Rating				
	9/89[a] (Prior to Patching, Prior to Overlay)	4/90[b] (After Patching, Prior to Overlay)	6/90[b] (After Patching, After Overlay)	9/90[b]	4/91[b]
Full-Depth Bituminous Concrete Patches-Control	146//Rough	127//Smooth	88//Smooth	90//Smooth	96//Smooth
Partial-Depth and Full-Depth Bituminous Concrete Patches	126//Rough	114//Smooth	92//Smooth	84//Smooth	92//Smooth

a Test taken with Illinois' Roadometer and measured using the Illinois Roadometer Roughness Index

Bituminous Pavement, In./Mile	Adjective Rating
60 or less	Very Smooth
61 - 75	Smooth
76 - 105	Slightly Rough
106 - 145	Rough
146 - 190	Very Rough
191 - 330	Unsatisfactory

b Test taken with Illinois' road profiler and measured using the International Roughness Index

In./Mile	Adjective Rating
0 - 190	Smooth
191 - 320	Medium
321 or Greater	Rough

NOTE: Although the two test methods use the same unit of measurement, the results are not directly comparable.

TABLE 5: COSTS PER 2-LANE MILE ON PROJECT NUMBER ONE

STRATEGY	COST PER 2-LANE MILE, $
Full-Depth Bituminous Concrete Patching (12.1%) and 2.5" Overlay	133,100
Partial-Depth (3.2%) and Full-Depth (9.1%) Bituminous Concrete Patching and 2.5" Overlay	135,900[a]
Full-Depth Undoweled PCC Patching (15.0%) and 2.5" Overlay	159,700
Roadglas (7.2%) and Full-Depth Bituminous Concrete Patching (14.6%) and 2.5" Overlay	186,100[a]
GlasGrid (26.4%) and Full-Depth Bituminous Concrete Patching (14.7%) and 2.5" Overlay	148,700[b]
Reduced Full-Depth Bituminous Concrete Patching (14.9%) and 5.25" Overlay	216,800

[a] The cost of the partial-depth bituminous concrete patching and Roadglas sections may not be representative due to the small quantities involved and the experimental nature of the work.

[b] Does not include cost of GlasGrid, which was donated.

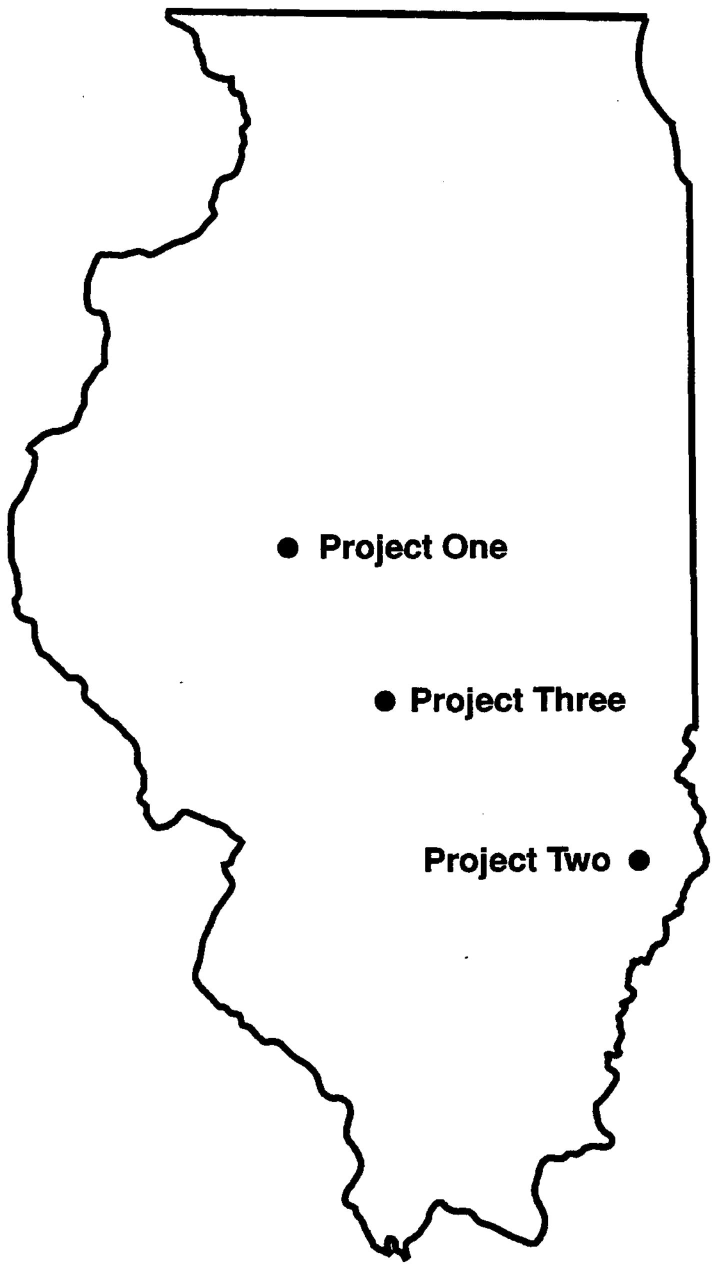
TABLE 6: COSTS PER SQUARE YARD ON PROJECT NUMBER ONE

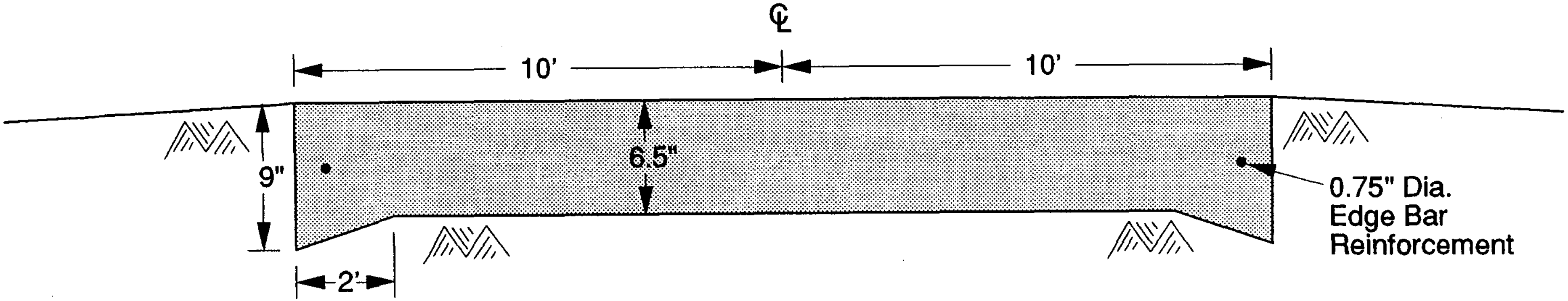
Strategy	Cost Per Square Yard, $
Full-Depth Bituminous Concrete Patches	$51.05
Partial-Depth Bituminous Concrete Patches	$55.35[a]
Full-Depth Undoweled PCC Patches	$56.30
Roadglas	$45.00[a]
GlasGrid	Donated

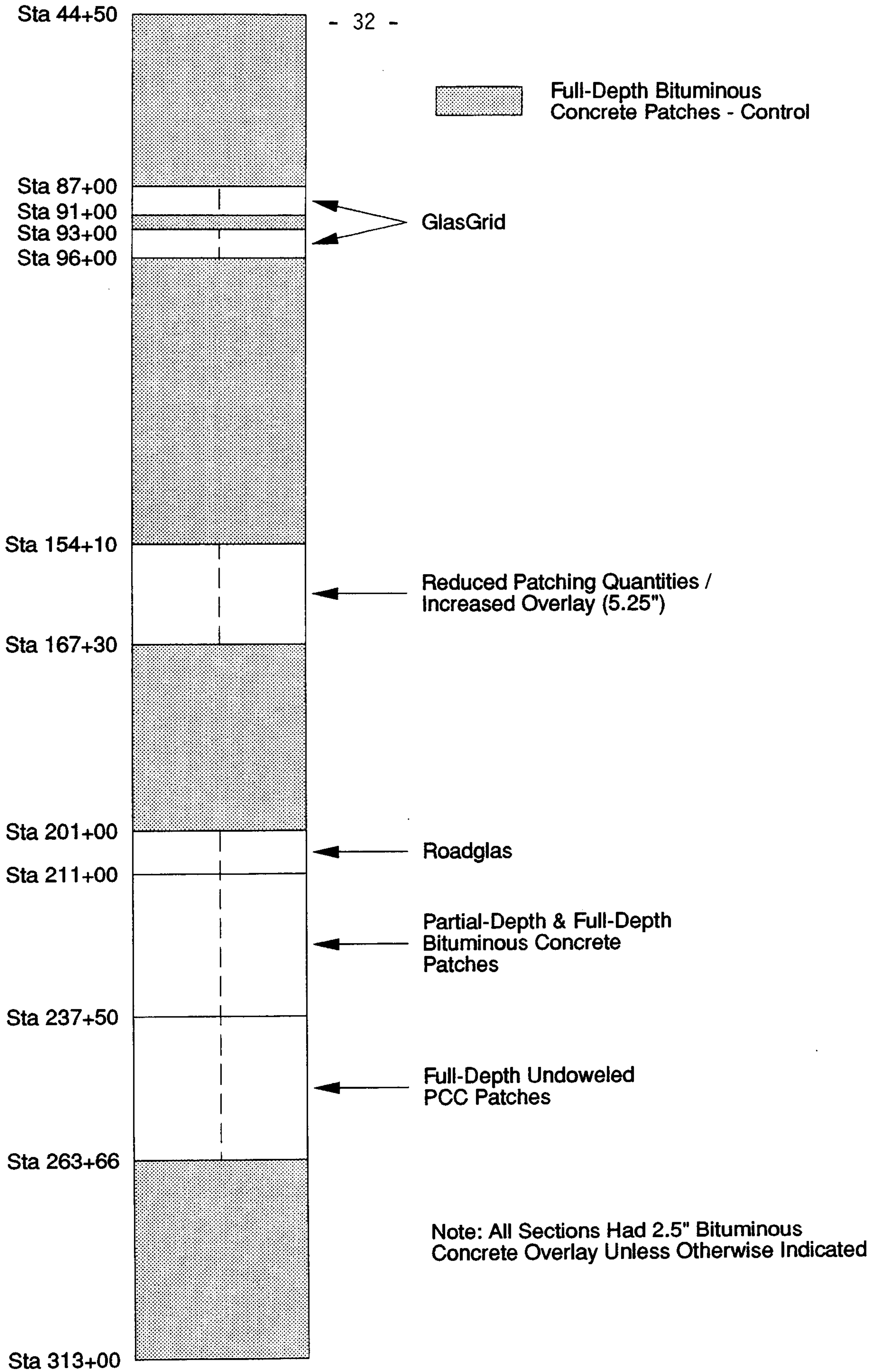
[a] Costs may not be representative due to the small quantities involved and the experimental nature of the work.

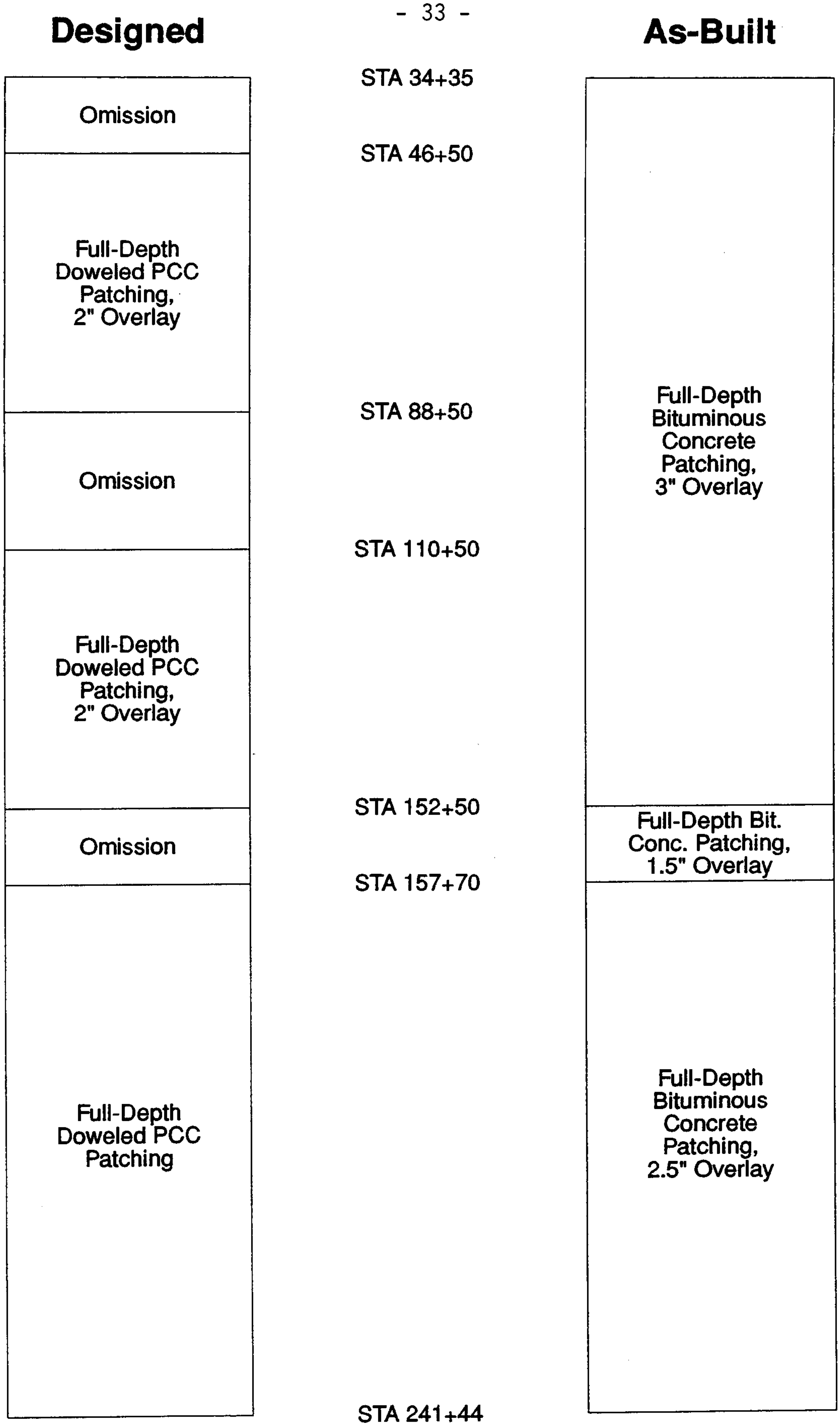
TABLE 7: DOLLAR EFFECT OF CHANGES ON PROJECT NUMBER THREE
- BASED ON FINAL QUANTITIES -

Item		Cost, $
Eliminate 1795 $Yd.^2$ Doweled PCC Patching	-	269,042
Add 412 $Yd.^2$ Full-Depth Bituminous Concrete Patching	+	41,200
Add 2716 Tons Bituminous Concrete Level Binder	+	94,109
Add 2759 Tons Bituminous Concrete Surface Course	+	105,670
Add 3.4 Tons Bituminous Prime Coat	+	1,275
Add 1462 Tons Aggregate Shoulder	+	21,565
Add 24 Tons Aggregate Prime Coat	+	480
Add Temporary and Permanent Pavement Marking	+	4,853
Net Change on Major Items	+	110


Project One
Project Three
Project Two


℄
10'
10'
6.5"
9"
2'
0.75" Dia.
Edge Bar
Reinforcement


Sta 44+50
Full-Depth Bituminous Concrete Patches - Control
Sta 87+00
Sta 91+00
Sta 93+00
Sta 96+00
GlasGrid
Sta 154+10
Reduced Patching Quantities / Increased Overlay (5.25")
Sta 167+30
Sta 201+00
Roadglas
Sta 211+00
Partial-Depth & Full-Depth Bituminous Concrete Patches
Sta 237+50
Full-Depth Undoweled PCC Patches
Sta 263+66
Note: All Sections Had 2.5" Bituminous Concrete Overlay Unless Otherwise Indicated
Sta 313+00


Designed
As-Built
STA 34+35
Omission
STA 46+50
Full-Depth Doweled PCC Patching, 2" Overlay
STA 88+50
Omission
STA 110+50
Full-Depth Doweled PCC Patching, 2" Overlay
STA 152+50
Omission
STA 157+70
Full-Depth Doweled PCC Patching
STA 241+44
Full-Depth Bituminous Concrete Patching, 3" Overlay
Full-Depth Bit. Conc. Patching, 1.5" Overlay
Full-Depth Bituminous Concrete Patching, 2.5" Overlay