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Whitetopping Construction And Early Performance In Illinois

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16. Abstract

Seven experimental whitetopping projects were constructed in Illinois between 1998 and 2001. Three of these projects included the rehabilitation of intersections, while the remaining four were a rehabilitation of mainline pavement. The three intersection projects include whitetopping of both existing bituminous pavements and existing concrete pavements (thin bonded concrete overlay). All four of the mainline pavement projects were a rehabilitation of an existing bituminous pavement.

This report summarizes the construction and early performance of all seven projects. Details of the design, construction methods, construction costs, and early performance are addressed. Visual distress surveys and sounding of the overlay for delaminations have been conducted on an annual basis for performance.

Initial performance reviews for the four mainline pavement projects indicate excellent results. Performance reviews for the whitetopping portions of the intersection projects indicate good performance. Performance reviews for the thin bonded concrete overlay portions of the intersection projects indicate poor performance.

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Construction Report

WHITETOPPING CONSTRUCTION AND EARLY PERFORMANCE IN ILLINOIS

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ABSTRACT

Seven experimental whitetopping projects were constructed in Illinois between 1998 and 2001. Three of these projects included the rehabilitation of intersections, while the remaining four were a rehabilitation of mainline pavement. The three intersection projects include whitetopping of both existing bituminous pavements and existing concrete pavements (thin bonded concrete overlay). All four of the mainline pavement projects were a rehabilitation of an existing bituminous pavement.

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EXECUTIVE SUMMARY

Whitetopping and thin bonded concrete overlays were investigated as rehabilitation methods of moderately distressed bituminous concrete mainline pavements and intersections. The Illinois Department of Transportation funded seven different experimental projects. Four of these projects were constructed on state maintained highways, while the remaining three were constructed by three separate county highway departments.

Four of these projects are considered entirely whitetopping, one is entirely a thin bonded concrete overlay, and the remaining two are a combination of whitetopping and thin bonded concrete overlays. The four entirely whitetopping projects were constructed on mainline pavements, while the remaining three projects were constructed at intersections. Design information was gathered from the American Concrete Pavement Association's Engineering Bulletin, *Whitetopping – State of the Practice*, and from the local chapter of the American Concrete Pavement Association.

Milling of the existing bituminous surface was done on six of the seven projects to remove any surficial distresses and provide a level construction platform. The necessary full-depth and partial-depth patches were placed in the underlying original pavement. Construction of the intersection projects included concrete placement by hand, while the mainline pavement projects were paved with a slip-form paving machine. Partial-depth joint saw cutting began as soon as the initial set of the concrete was reached and no chipping occurred during the sawing process. Locations with planned full-depth joints were typically sawed to full-depth the following day and filled with a hot poured joint sealant.

Initial performance reports based on distress surveys and a sounding test for debonded areas indicate mixed results. The mainline pavement whitetopping projects have shown excellent results to date. Very few cracks or areas of debonding have been identified through annual surveys. The intersection pavement whitetopping projects indicate good results to date. Approximately 10 to 20 percent of the panels have cracked or exhibit a loss of bond with the underlying bituminous material. The thin bonded concrete overlay

projects have shown poor results to date. Approximately 50 to 60 percent of the panels have cracked or lost their bond with the underlying concrete.

Early conclusions indicate that the use of thin bonded concrete overlays at intersections should be avoided. Milling of the existing bituminous surface for increased texture is important when placing a whitetopping overlay. In addition, timely construction and proper project staging should be utilized to accommodate the travelling public.

Based on the early performance of these projects, it is recommended to mill the existing bituminous surface to remove surficial distresses and increase texture before placing a whitetopping overlay. It is also recommended to minimize the use of thin bonded concrete overlays at intersections.

INTRODUCTION

The repair of pavement distress at intersections and areas of slow moving traffic has troubled state and local transportation departments for many years. Problematic distresses of bituminous concrete surfaces include rutting, shoving, corrugations, and fatigue cracking. The use of whitetopping has been proposed as a potential solution to restore the ride quality for these areas.

Whitetopping consists of a Portland cement concrete (PCC) overlay of an existing bituminous concrete surfaced pavement. The existing pavement may be a bituminous concrete overlay of a rigid (PCC or brick) pavement, a full-depth bituminous concrete pavement, or a bituminous concrete pavement over granular base.

Conventional whitetopping is a PCC overlay of at least 4 inches, while an ultra-thin whitetopping is between 2 and 4 inches thick. The new concrete overlay is typically sawed partial-depth into square panels. The dimensions of these panels in feet are 1.0 to 1.5 times the thickness of the overlay in inches.

A bonded concrete overlay (BCO) consists of placing a thin layer of concrete directly on top of an existing PCC pavement. The existing PCC pavement surface is textured so that the new overlay will bond with it to form a monolithic slab.

This report covers the site selection of seven experimental feature projects in Illinois, and the construction of those projects. Initial pavement conditions, design details, and construction costs are also included. Finally, a brief description of the early performance of each project is provided.

PLANNING AND DESIGN

In 1997, the Illinois Department of Transportation (IDOT) began investigating the use of whitetopping as an intersection repair method. The Bureau of Materials and Physical Research (BMPR) made a formal request of the IDOT districts to submit potential projects for whitetopping repair. As a result of this request, four projects were submitted and selected for construction. Three of these projects included intersection rehabilitation, and one was mainline pavement rehabilitation. Two of these projects were entirely whitetopping, while two of them were a combination of whitetopping and bonded concrete overlays.

In addition to IDOT's experimental whitetopping projects, several county highway departments also experimented with whitetopping through IDOT's experimental features process. An experimental feature project is a federal aid project incorporating the use of one or more experimental materials or construction processes. These materials and/or processes are normally those that have not been sufficiently tested to merit complete acceptance. Clay, Piatt, and Cumberland Counties have constructed whitetopping projects. All three of these projects were a rehabilitation of mainline pavement. Table 1 lists all of the experimental feature projects and details of their construction.

IDOT has not developed a standard design procedure for a whitetopping overlay thickness. The American Concrete Pavement Association (ACPA) has developed a design procedure for both conventional and ultra-thin whitetopping overlays. These design procedures were used as a guide for designing all of the whitetopping and thin bonded concrete overlays presented in this report.

Table 1

Whitetopping Experimental Feature Projects

Project Location	Route Number	Project Length	Construction Date	Overlay Thickness	Overlaid Surface
Decatur	U.S. 36	Intersection	April 1998	3.5 inches	1/3 PCC 2/3 Bit. Conc.
Decatur	U.S. 36	Intersection	April – May 1998	3.5 inches EB 2.5 inches WB	PCC
Carbondale	U.S. 51	Intersection	June – July 1998	3.5 inches	1/2 PCC 1/2 Bit. Conc.
Tuscola	U.S. 36	0.8 miles	May 1999	4 – 7.5 inches	Bit. Conc.
Clay County	CH 3	7.85 miles	August 1998	5 inches and 6 inches	Bit. Conc.
Piatt County	CH 4	4.94 miles	September – October 2000	5 inches	Bit. Conc.
Cumberland County	CH 2	3.54 miles	September 2001	5.75 inches	Bit. Conc.

CONSTRUCTION OF STATE MAINTAINED WHITETOPPING PROJECTS

DECATUR – U.S. HIGHWAY 36 AND OAKLAND AVENUE

The first experimental feature whitetopping project was constructed at the intersection of U.S. Highway 36 and Oakland Avenue in Decatur. This project included rehabilitation of the two eastbound lanes on U.S. Highway 36 only. A combination of ultra-thin whitetopping and thin bonded concrete inlays were used. Construction took place in April of 1998.

The existing bituminous concrete surface in the eastbound lanes was severely rutted and displayed a significant amount of cracking distress. The rut depth exceeded one inch in several locations of the outer wheel path, as shown in Figure 1. Cracking distresses included longitudinal and transverse cracks, as well as some minor block cracking. The existing surface was constructed in 1986, and consisted of a 1.25-inch bituminous concrete resurfacing of a previous bituminous concrete surface.

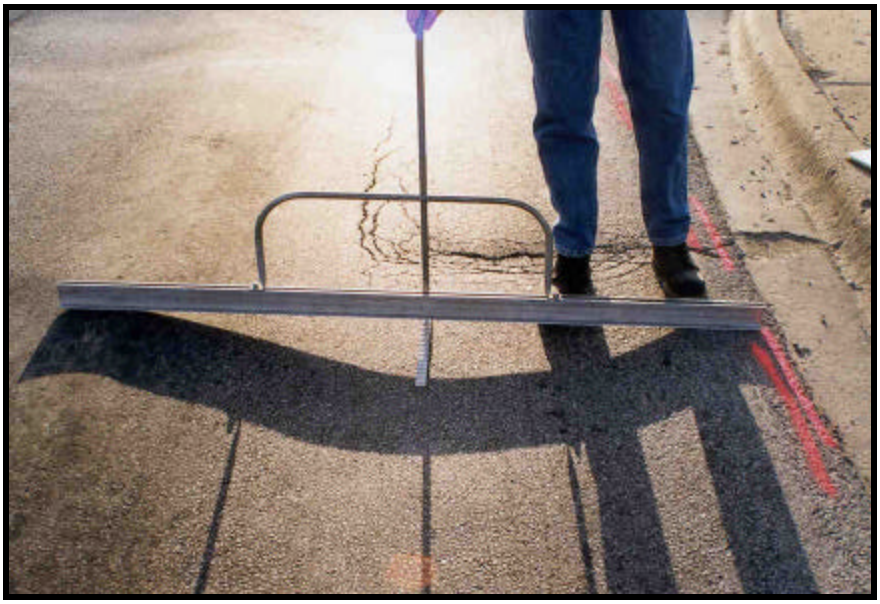


Figure 1. Existing Bituminous Pavement Rut

The western one-third of the existing pavement is concrete as shown in the typical cross sections of Appendix A. This section is considered a thin bonded concrete inlay, while

the remainder of the project is considered whitetopping. The transition from bituminous to concrete pavement is not a uniform joint, as shown in Figure 2. In addition, some small areas of the original brick pavement and the concrete widening were exposed after milling off the bituminous surface.

Figure 2. Bituminous To Concrete Pavement Transition

Pavement preparation began by milling 3.5 inches of the existing bituminous surface. This was followed by brooming and high pressure water cleaning of the milled surface. One full-depth and one partial-depth patch were also placed in the existing pavement before the inlay. The full-depth patch (Figure 3) was located at the west end, while the partial-depth patch (Figure 4) was located near the east end of the project.

Figure 3. Full-Depth Patch

Figure 4. Partial-Depth Patch

A portion of the milled surface was dampened with a spray mister immediately before placement of the 3.5-inch concrete inlay. The concrete was placed by hand and finished with a vibratory screed followed by floating and hand finishing. The full-depth and partial-depth patches were placed monolithically with the concrete inlay. The surface was textured with an artificial turf drag, and coated with a white pigmented curing compound. Figure 5 illustrates the paving process.

Figure 5. Paving Process

The concrete mixture for this project was a plain concrete mixture incorporating the use of an air entraining agent, water reducer, and superplasticizer. The complete mixture design may be found in Appendix B.

Once the concrete inlay reached initial set, and could support the weight of the saw and operator without disturbing the final finish, partial-depth saw cutting commenced. These saw cuts are 1.25 inches in depth, and were placed over contraction joints, major cracks of the original pavement, the outside edges of the two patches, and at equal distances between these features. The spacing in feet was not to be less than 1.0, nor more than 1.5, times the overlay thickness in inches (3.5 to 5.25 feet). The saw cuts were done in the longitudinal and transverse directions, with an average panel dimension of 3.6 feet by 4.3 feet. The completed saw cuts may be seen in Figure 6. After complete curing, the inlay was sawed full-depth at the contraction joints, major cracks of the original pavement, outside edges of the two patches, and widening joints. These full-depth saw cuts were then sealed with a hot-poured joint sealer. The partial-depth saw cuts were left unsealed.

Figure 6. Completed Partial-Depth Saw Cuts

The construction activities for this project were completed within five working days. The eastbound lanes were closed to traffic on Monday morning, and the existing bituminous pavement was milled. On Tuesday morning, various preparation tasks were completed:

removal of the pavement at the west-end of the project for the full-depth patch, setting up forms, and pavement cleaning. The concrete inlay was placed Tuesday afternoon, with partial depth saw cutting that evening. The full-depth saw cuts were completed on Wednesday and sealed Friday morning. The intersection was reopened to traffic on Friday afternoon.

Daytime high temperatures ranged from 60 to 75 °F for the entire week, with low temperatures in the middle 40s. There was one small rain event on Monday afternoon; however, the remainder of the week was dry and sunny.

A few minor problems were encountered during construction of this project. The existing pavement had a large dip at the intersection with Oakland Avenue. The contractor placed forms to take out the dip, however this resulted in a thick area of pavement with the surface of the new inlay higher than the adjacent Oakland Avenue. Temporary bituminous ramps were placed in this area to match the elevation of the concrete inlay. These ramps were permanently removed in a later contract that involved resurfacing this portion of Oakland Avenue.

The decision of whether or not to mist the existing pavement just ahead of the paving operation was also a problem. The special provision specified that dampening of the existing surface should precede paving. However, an American Concrete Pavement Association (ACPA) representative challenged this practice due to the mild temperatures during the paving operation. The argument centered on the additional moisture inhibiting the bond between the inlay and the existing pavement. After much debate, the decision was made to stop dampening the surface prior to paving. Approximately 20 feet of the original pavement was dampened before placement of the concrete inlay.

DECATUR – U.S. HIGHWAY 36 AND COUNTRY CLUB ROAD

The city of Decatur also contains a thin bonded concrete inlay project at the intersection of U.S. Highway 36 and Country Club Road. This project was built under the same contract as the intersection of U.S. Highway 36 and Oakland Avenue. The eastbound and westbound lanes of U.S. Highway 36 were rehabilitated as part of this project. Construction took place in April and May of 1998.

The existing bituminous pavement was severely rutted in both directions, with the most severe rutting in the westbound direction. The existing overlay also displayed a frequent amount of reflective transverse cracking from the underlying concrete pavement. In addition, there was a small amount of longitudinal cracking and block cracking noted. Figures 7 and 8 are photographs of the typical distresses noted before rehabilitation of the intersection. The existing surface was constructed in 1988, and consisted of a 1.25-inch bituminous concrete resurfacing of a previous bituminous concrete surface.

Figure 7. U.S. Highway 36 And Country Club Road (Looking West)

Figure 8. U.S. Highway 36 And Country Club Road (Looking East)

This project was completed in two stages, with Country Club Road closed to traffic during both stages. Stage 1 involved rehabilitation of the driving lanes in both the eastbound and westbound directions. Stage 2 involved rehabilitation of the passing lanes in both the eastbound and westbound directions. No rehabilitation was completed to any of the turning lanes, or any portion of the approaches of Country Club Road.

The eastbound and westbound driving lanes were milled down to bare concrete at the start of stage 1. The depth of milling was 3.5 inches in the eastbound direction, and 2.5 inches in the westbound direction due to a different bituminous concrete overlay thickness. The milling was followed by brooming and high pressure water cleaning of the milled surface. Four full-depth and three partial-depth patches were placed in the eastbound driving lane. Three full-depth and seven partial-depth patches were placed in the westbound driving lane. These patches were placed at areas of severe transverse cracking and durability cracking of the underlying concrete pavement. The boundaries for these patches were determined by visual identification of the distressed area. Material was removed for partial-depth patches with the milling head, while the full-depth patches were jackhammered. Figures 9 and 10 are typical examples of a full-depth and partial-depth patch.

Figure 9. Full-Depth Patch

Figure 10. Partial-Depth Patch

Concrete placement occurred on two successive days. The westbound direction (2.5-inch inlay) was paved first, followed by the eastbound direction (3.5-inch inlay). The concrete was hand placed, and finished with a vibratory screed, float, and hand finishing. The full-depth and partial-depth patches were placed monolithically with the inlay. The concrete surface was textured with an artificial turf drag, and coated with a white pigmented curing compound.

Stage 2 included the milling of the eastbound and westbound passing lanes down to bare concrete. The milling was followed by brooming and high pressure water cleaning of the milled surface. Four full-depth and three partial-depth patches were placed in the eastbound direction. Four full-depth and eight partial-depth patches were placed in the westbound direction. These patches were also placed at areas of severe transverse cracking and durability cracking of the underlying concrete pavement. The method of boundary determination and pavement removal was the same as mentioned above.

Once again, the concrete was placed on two successive days, with the eastbound passing lane paved first. The concrete placement, finishing and curing were identical to the procedure used for the driving lanes. The complete mixture design for this project may be found in Appendix B.

Partial-depth saw cutting of the inlay commenced on all four concrete pours once the initial set of the concrete was reached. Saw cuts were made over contraction joints, major cracks of the existing pavement, the outside edges of patches and at equal distances between these features. The saw cuts are 1.25 inches in depth. The partial-depth saw cut spacing in feet was not to be less than 1.0, nor more than 1.5, times the inlay thickness in inches. This equates to a range of 2.5 to 3.75 feet for the westbound lanes and 3.5 to 5.25 feet for the eastbound lanes. The saw cuts were done in the longitudinal and transverse directions, with an average panel dimension of 2.95 feet by 3.85 feet in the westbound direction and 3.85 feet by 4.5 feet in the eastbound direction. Full-depth saw cuts were placed over the edges of patches and most transverse cracks of the existing pavement. Full-depth saw cuts were filled with a hot-poured joint sealant.

Construction of stage 1 was completed in five working days. The westbound driving lane was milled and cleaned on Monday. This lane was poured on Tuesday, while the eastbound driving lane was milled and cleaned. The eastbound lane was poured on Wednesday. Full-depth saw cutting and sealing was completed for both lanes on Thursday. The lanes were opened to traffic on Friday. Stage 2 construction was also completed in five working days. The same sequence of events was used to complete the construction of these lanes.

The weather did not cooperate with the construction of this project. Daytime high temperatures for the construction of stage 1 fell between 45 and 55 °F. Rain fell after the completion of the pour in the westbound driving lane. This lane had to be covered with plastic, and the initial set of the concrete was delayed for several hours. The partial-depth saw cutting of this lane was also delayed. Spotty rain events continued through the following morning, however the eastbound driving lane was poured in spite of the rain.

Rain and cool temperatures continued, which delayed the construction of stage 2 by one-week. However, during the week of construction for stage 2, there was no rain and high temperatures were in the middle 80’s with sunshine.

Several problems were encountered with the rehabilitation of this intersection. The underlying concrete pavement was in very poor condition. Severe durability cracking

and numerous transverse cracks were discovered after the bituminous surface was milled off. The decision was made to place partial-depth and full-depth patches at some of these locations. However, all of the areas that required patching were not repaired due to a limitation in patching quantities and time constraints. The severe transverse crack in Figure 11 is one of many areas that were not patched.

Figure 11. Severe Transverse Crack That Was Not Patched

New traffic signal detector loops were installed before the milling process. While milling the eastbound driving lane, one of the detector loops was cut. This particular traffic loop was not installed deep enough, and the milling was too deep in this area.

The rain that fell before the paving of the eastbound driving lane was not removed from the patch locations within this lane. This water was forced out of the patch locations by the concrete placement, and then pushed ahead by the fresh concrete. Eventually this water found a crack as an escape path, or was incorporated into the concrete mixture. Figure 12 illustrates a typical patch location that contained rainwater before paving.

Figure 12. Rain Water Within A Patch Location

CARBONDALE – U.S. HIGHWAY 51 AND PLEASANT HILL ROAD

The third intersection improvement project is located in the city of Carbondale. This project includes a combination of ultra-thin whitetopping and thin bonded concrete inlays. Rehabilitation was completed on the northbound and southbound driving lanes, as well as the center turn lane, of U.S. Highway 51. Construction was during June and July of 1998.

Transverse cracking and mild rutting of the bituminous overlay were evident throughout this entire intersection. The original pavement consisted of two twelve-foot concrete lanes, six-foot concrete shoulders, and bituminous concrete widening. Therefore, the center turn lane and a portion of each of the new driving lanes is a thin bonded concrete overlay. The remainder of the driving lanes are considered ultra-thin whitetopping. The layout of the Carbondale project may be found in Figure 13.

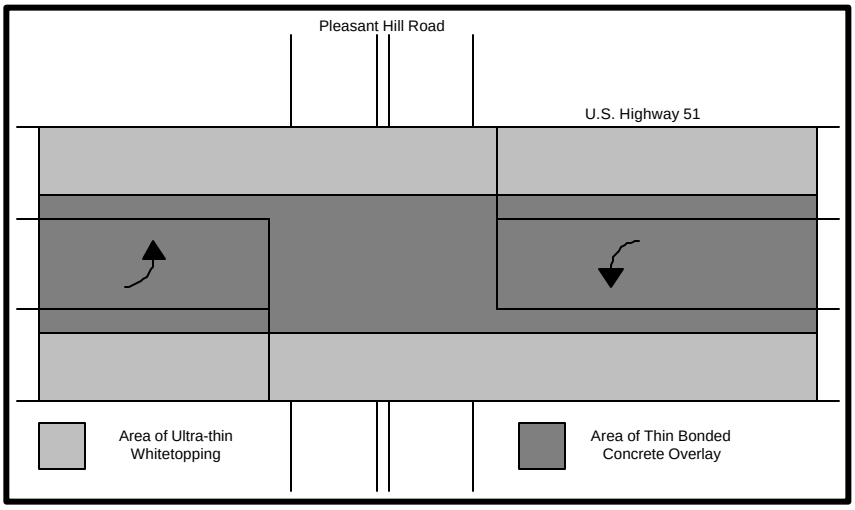


Figure 13. Carbondale Project Layout

The entire intersection was milled during one day to a depth of 3.5 inches. Bituminous ramps were placed at all appropriate locations, so traffic could continue to flow through the intersection. The milled surface was broomed and cleaned with high-pressure water before the inlay placement. No patches were placed in the existing pavement, however new traffic signal detector loops were placed in the existing pavement after milling was complete.

The inlay paving process for this intersection was divided into six stages to accommodate traffic flow. Each of the six stages was roughly the same in size and was formed using two by four lumber. The staging layout may be found in Figure 14. The milled surface was dampened with a spray mister before concrete placement. The concrete was placed by hand and finished with a vibratory screed, straightedge, floating and hand finishing. The surface was textured with a coarse broom, and coated with a white pigmented curing compound. The inlay thickness was 3.5 inches.

Polypropolene fibers, at the rate of three pounds per cubic yard, were incorporated into the concrete mixture for this project to resist the occurrence of early plastic shrinkage cracks. The concrete mixture design was otherwise a typical paving mixture with the use of an air entraining agent and water reducer / retarder. The complete mixture design may be found in Appendix B.

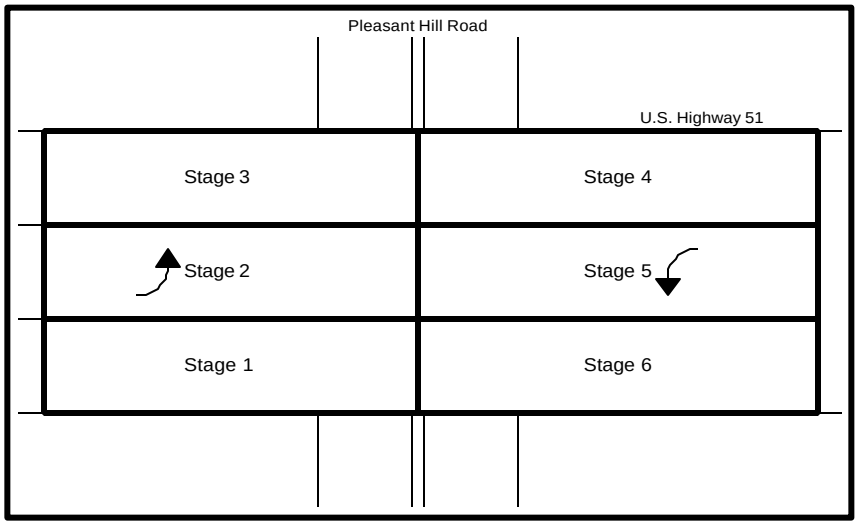


Figure 14. Carbondale Construction Staging

All stages of construction were partial-depth saw cut in the same fashion as the Decatur projects. The spacing of these saw cuts was 8 to 12 times the inlay thickness converted to feet (2.5 to 3.5 feet). The inlay was saw cut in the longitudinal and transverse directions, with an average panel dimension of 3.2 feet by 3.3 feet. The early entry saw used for the partial-depth cuts is shown in Figure 15. Full-depth saw cuts were placed over most transverse cracks and all construction joints in the underlying pavement. Full-depth saw cuts were filled with a hot-poured joint sealant.

Figure 15. Early Entry Saw Used For Partial-Depth Cuts

All construction activities were performed over the course of four weeks, two weeks in June and two weeks in July. The entire intersection was opened to traffic for the July 4th holiday week, which forced a break in construction.

As mentioned earlier, the entire intersection was milled at one time. Therefore, the preparation for each stage of construction required erecting traffic barriers, surface cleaning, and form setting. This process normally took one to two days. The concrete pour and partial-depth saw cutting also took one day to complete, followed by one day to cut and seal the full-depth saw cuts. Once these saw cuts were made and sealed, the stage was opened to traffic. Stages one, two, and three were constructed in late June, with four, five, and six constructed in mid-July.

Daytime high temperatures ranged from 85 to 90 °F throughout this project. There were also several rain events, however no concrete was poured during the rain or on the same day as a rain event.

The hot temperatures required the use of a retarder for this project. The contractor was concerned with the timely opening of the intersection to traffic, and did not use the retarder for stage one. However, after numerous problems with concrete truck delays, quick setting concrete, and the heat during the first pour, the retarder was required for the remainder of the project.

The contractor encountered problems with finishing the concrete surface using only one vibratory screed. The concrete finishers had to drag excess material off the surface of the inlay with both the straightedge and the float to get a smooth surface. Several times throughout the project, the contractor used two vibratory screeds to remedy this problem.

Problems were also encountered with the partial-depth saw cutting, as the contractor started to soon. Noticeable amounts of tearing and spalling occurred along several of the partial-depth saw cuts. The contractor had difficulty determining the ideal time to start the partial-depth saw cutting process. However, the consequences of shrinkage cracking from sawing too late are more severe than the tearing of the saw cuts. Evidence of the saw cut tearing may be found in Figure 16.

Figure 16. Tearing At A Partial-Depth Saw Cut

The staged construction of this intersection created several problems with continuous traffic flow. Several times, the flow of traffic through the intersection would impede the work of the contractor, or vice versa. This was especially true when the center turn lanes were paved. The staging also created confusion with the general public as to which lane was open to traffic. Several times a policeman was present during peak rush hours to direct traffic and prevent accidents.

The temporary bituminous concrete ramps also created problems with traffic flow through the intersection. Several times, the traffic was redirected to an area with no ramp, which resulted in a worn-down edge on the existing pavement. This created some difficulty during paving when concrete was placed directly against the worn down edge, such as the one shown in Figure 17.

Figure 17. Worn-Down Pavement Edge

TUSCOLA – U.S. HIGHWAY 36

The fourth experimental project incorporating whitetopping, and the first mainline pavement, was constructed on U.S. Highway 36 east of Tuscola. This project is considered to be “conventional” whitetopping, with an overlay thickness ranging from four to seven inches. The eastbound and westbound lanes of this rural two-lane highway were rehabilitated. The length of the project is 0.8 miles and it was constructed in May of 1999.

The existing bituminous concrete overlay displayed a frequent amount of transverse cracking and a small amount of longitudinal cracking. The majority of the transverse cracking was considered moderate to high in severity as shown in Figure 18. Evidence of edge deterioration was also noted throughout the length of the project. The existing bituminous concrete surface was seal coated in 1987, however the original construction date for the bituminous concrete overlay could not be determined.

Figure 18. High Severity Transverse Crack

Prior to the overlay placement, 18 partial-depth patches were placed to repair these high severity cracks. The area surrounding the crack was milled out, as shown in Figure 19, and a bituminous patch was placed. Areas of the existing bituminous overlay were also milled out at each end of the project in order to create a butt joint with the existing pavement. The entire length of the project was not milled. The concrete overlay was placed directly on the existing bituminous overlay with no added surface texture given to the bituminous overlay. However, the existing pavement was broomed and cleaned with high-pressure water before the overlay was placed.

Figure 19. Milled Out Area For Bituminous Patch

The overlay process was divided into four stages to accommodate traffic flow and the local businesses and residents. Portable traffic signals were used at both ends of the project to maintain traffic flow in the open lane. The staging layout may be found in Figure 20. The concrete was placed with a slip-form paver and finished with a straightedge, float, and by hand finishing. The surface was textured with a 0.75 inch, uniformly spaced, transverse tine, followed by two coats of a white pigmented curing compound.

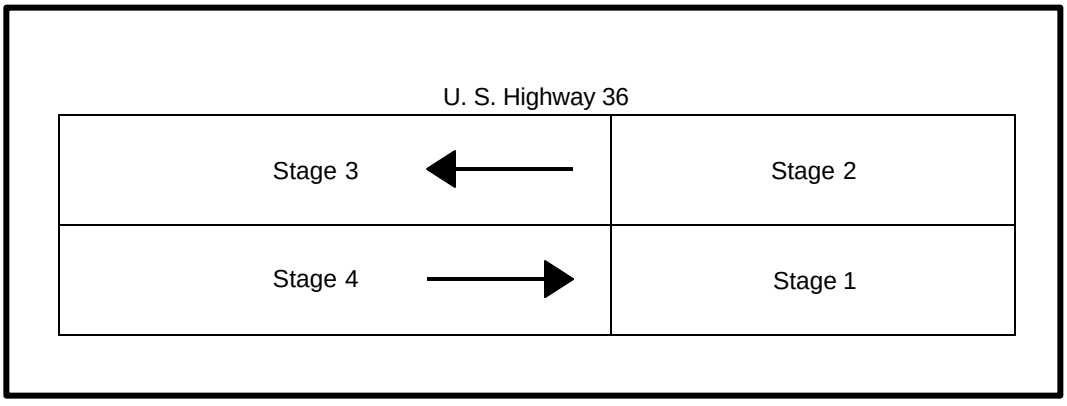


Figure 20. Tuscola Construction Staging

Early entry, partial-depth, saw cutting was also used on this project. The average panel dimensions were slightly larger than the three previous projects. Transverse saw cuts were made every 5.5 feet, with longitudinal saw cuts at the centerline as well as 5.0 feet and 10.0 feet from the centerline. Typical panel dimensions are 5.0 feet by 5.5 feet. These dimensions (in feet) are approximately 0.7 to 1.3 times the thickness of the overlay (in inches). Full-depth saw cuts were placed over most transverse cracks and all construction joints in the underlying pavement. Full-depth saw cuts were filled with a hot-poured joint sealant.

The construction activities for this project were completed in approximately one month. The traffic control set-up, partial-depth patching and preparation for stage one took approximately eight days. The time required to place each stage, saw cut and seal, and raise the shoulder grade to match the new pavement grade took an average of three days. The time required to prepare for each subsequent stage was only two to three days with the actual placement time remaining the same.

The weather for the construction of this project was very good. Daytime high temperatures ranged from 60 to 80 °F over the course of the project. One scheduled pour date was rained out, however this was the only event delayed by the weather.

The first major problem encountered with this project occurred during the paving of stage one. Approximately halfway through this stage, the paving machine broke down and lost all grade control. Several trucks waited one to two hours before unloading due to the breakdown. This concrete was fairly dry, with low air voids, and was very hard to finish. The concrete had a honeycombed appearance as shown in Figure 21.

Figure 21. Honeycombed Appearance Of Concrete

The decision was made to remove this section and replace it. The following day, the contractor used pavement breakers and jackhammers to remove the bad concrete. The removed concrete exhibited a very good bond with the underlying bituminous concrete. In several places, especially around cracks, the bituminous material was fully bonded to the concrete and removed with the concrete overlay. The length of the removal was approximately 220 feet.

This section was formed with two-by-four lumber at the pavement elevation and hand placed. The two-by-four lumber allowed for concrete to flow out under the formwork as shown in Figure 22. This excess concrete created a lot of waste and handwork for clean up.

Figure 22. Concrete Flow Under Form Work

A grinder was utilized for smoothness in several areas of this concrete overlay. The heavy truck traffic on this route from a nearby rock quarry had created several dips and bumps in the existing pavement. The paving machine had difficulty eliminating these dips and bumps while keeping a constant grade. Milling of the existing pavement to a constant grade, prior to placing the concrete overlay, may have eliminated some of this problem.

Problems with traffic control were also encountered throughout this project. The correct timing of the portable traffic signals was difficult to achieve and maintain at times. In addition, driver impatience and the running of red lights during peak rush hours created several head-to-head traffic situations in the open lane. The shoulders were used to allow traffic to pass, and fortunately no accidents occurred.

CONSTRUCTION OF COUNTY MAINTAINED WHITETOPPING PROJECTS

CLAY COUNTY – COUNTY HIGHWAY 3

Clay County is located in the southern portion of Illinois, directly south of the city of Effingham. The experimental whitetopping project is located on County Highway 3, which extends through the towns of Louisville and Sailor Springs. This project included rehabilitation of nearly eight miles of mainline pavement between these two towns. Construction was during August of 1998.

The existing low volume road consisted of a soil cement pavement with an oil and chip surface. The western most quarter of the original pavement was eight inches of soil cement constructed in 1980, while the remainder of the project was seven inches of soil cement constructed in 1960 and 1962. Prior to the whitetopping overlay, the pavement surface appeared to be in good shape. There were some minor cases of pavement edge cracking as shown in Figure 23. In addition, there were some small potholes and minor rutting noted throughout the project. Prior to overlay placement, the original surface was milled to remove these surface defects, increase the bonding surface area, and provide a level construction platform.

Figure 23. Original Pavement Edge Cracking

The concrete overlay was placed with a slip-form paving machine. The construction crew averaged nearly one mile of production every day. The pavement surface was floated, and finished with a burlap drag followed by transverse tining. The majority of the project consisted of a 5-inch concrete overlay, however there is a short control section with a 6-inch overlay. Concrete was placed in one lane at a time, leaving the adjacent lane open for local traffic.

The 5-inch overlay sections were all partial-depth saw cut on 11-foot centers across the pavement. These cuts were done on a 10 to 15 degree skew angle. The 6-inch control section was divided into two different partial-depth saw cut patterns. One half of the control section was transversely saw cut on 15-foot centers. The other half of the control section was transversely saw cut on 5.5-foot centers. This half of the control section also had an additional longitudinal cut at 5.5 feet from the pavement edge as shown in Figure 24. All of the transverse saw cuts were done with the 10 to 15 degree skew angle. None of the saw cuts were sealed.

Figure 24. Partial-Depth Saw Cut Pattern

The paving of this project took approximately 20 working days to complete. There was one 600-foot section that was removed and replaced. This section was inundated with a

flash flood before the proper cure was reached. The remainder of the construction process was uneventful.

The only problem encountered with this project was the ride quality of the finished surface. Several areas where the paving machine experienced difficulty with grade control were not very smooth. The contractor was required to grind the surface in many of these areas. Once the grinding was complete, the ride quality was substantially improved.

PIATT COUNTY – COUNTY HIGHWAY 4

The second experimental county whitetopping project was done in Piatt County, which is directly east of Decatur. The whitetopping project was completed on County Highway 4 which extends east from the town of Monticello to the Piatt / Champaign County line. This project included the rehabilitation of nearly five miles of mainline pavement, and was completed in September and October of 2000.

The original pavement consists of a 7-inch cement aggregate mixture (CAM) base with seven inches of bituminous overlay. The CAM base was constructed in 1969 with the first bituminous overlay (2.5 inches) in 1970. A 0.75-inch hot-mix sand seal was applied to the surface in 1980, and the last bituminous overlay (3.75 inches) was placed in 1989. This original pavement exhibited a significant amount of reflective cracking. These reflective cracks were mounding up in several locations making for a very poor ride quality. Prior to the overlay construction, three inches of the bituminous surface were milled off to eliminate these mounded areas. These millings were eventually used for shoulder improvement later in the project.

The new 5-inch concrete overlay was placed with a slip-form paving machine using a stringline for grade control. The pavement surface was finished with a burlap drag and hand finishing as shown in Figure 25. A longitudinal astroturf drag (Figure 26) was used to give the pavement surface a final wearing texture. This project was staged in order to complete one lane at a time. Paving operations were completed in less than three weeks.

Figure 25. Concrete Finishing Techniques

Figure 26. Longitudinal Astroturf Drag

The entire project was transversely saw cut on 11-foot centers. These transverse cuts were done on a skew angle of approximately 10 to 15 degrees. There is a one half-mile control section on the west end of the project that was transversely saw cut on 5.5-foot centers and longitudinally cut at 5.5 feet from the shoulder. Once again, the transverse cuts were done at the above mentioned skew. None of the saw cuts were sealed.

Several complaints were heard about the time of year that this project was completed. The late season paving made it very difficult for area farmers to move their equipment and harvest their crop. In addition, there were complaints about the traffic control and detours. Many of these problems occurred at night, as motorists would proceed through barricades and into the saw cutting operations.

The contractor also had problems with concrete quantity overruns. The milling machine used a 40-foot ski for grade control and milled the surface to a cross slope. The paving operation used a stringline, which resulted in thick and thin areas of pavement. The suggestion was made for future projects to set one stringline and run both the milling and paving operations off of the same stringline.

CUMBERLAND COUNTY – COUNTY HIGHWAY 2

The most recent whitetopping project was completed in Cumberland County on County Highway 2 between Bradbury and Janesville. Cumberland County is located in south central Illinois, just northeast of Effingham. This project included the rehabilitation of just over 3.5 miles and was completed in September of 2001.

The original pavement at this location consisted of a 10-inch aggregate base with three inches of bituminous surface constructed in 1965. The project was overlaid with an additional 3.5 inches of bituminous material in 1977. The existing surface displayed a significant amount of wheelpath rutting. Longitudinal and transverse cracking were also found throughout the project length. An example of these distresses may be found in Figure 27. Three inches of bituminous material were milled from the surface prior to the overlay placement.

Figure 27. Existing Surface Distresses

The construction of this project took approximately one month to complete. The entire length of the project was overlaid with a 5.75-inch concrete overlay. The concrete overlay was placed with a slip-form paving machine, followed by the normal floating and hand finishing. The surface of the pavement was also transversely tined at a uniform spacing of 0.5 inches as shown in Figure 28. Construction was completed in one lane at a time, allowing local traffic to travel in the adjacent lane.

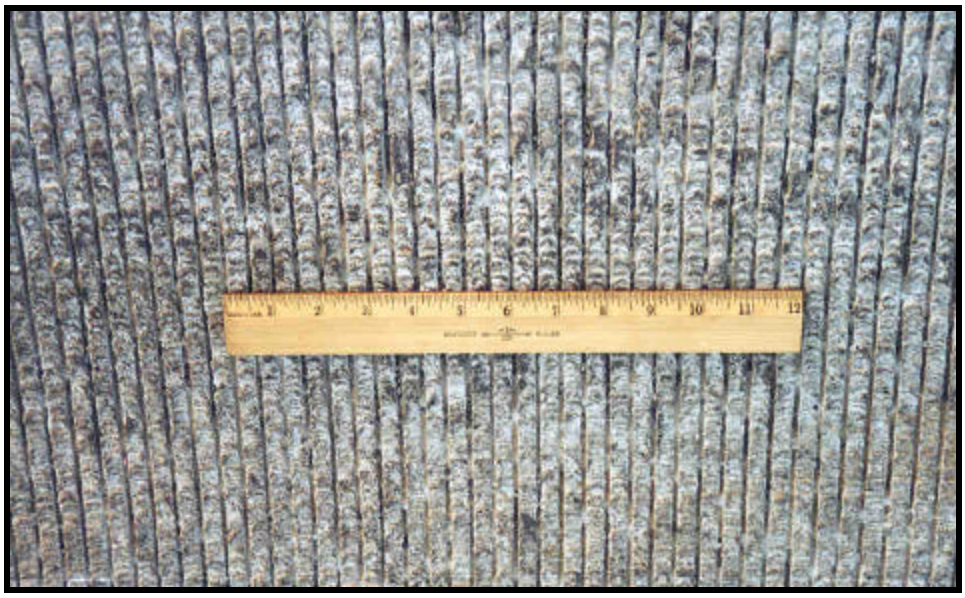


Figure 28. Transverse Tine Spacing

The entire length of this project was also partial-depth saw cut with transverse joints sawed at intervals of 5.5 feet and longitudinal joints sawed at intervals of 6.0 feet. The transverse saw joints were skewed at an angle of 10 to 15 degrees. The transverse and longitudinal saw joints were not sealed.

There was only one problem encountered with the construction of this project. A motorist traveled for a short distance through the non-cured pavement leaving a tire impression (Figure 29). The impression is very shallow and has not caused any problems for the traveling public.

Figure 29. Tire Impression In Finished Concrete

EARLY PERFORMANCE

The performance of all projects has been monitored through visual distress surveys. These surveys were typically completed at six months and one year after construction, followed by an annual survey. Data collected on these surveys includes cracking, areas of debonding, and panel movement. The term panel, as used below, refers to the rectangular dimension outlined by partial-depth and/or full-depth saw cuts.

DECATUR – U.S. HIGHWAY 36 AND OAKLAND AVENUE

This intersection was constructed in April of 1998. Roughly two-thirds of the intersection is considered whitetopping, while the remaining one-third is a thin bonded concrete overlay. Three annual surveys have been completed to date for this intersection. The results in Table 2 indicate the performance to date.

Table 2
U.S. Highway 36 And Oakland Avenue Survey Results

Year of Survey	**1999**	**2000**	**2001**
Number of Panels Over Bituminous	181	181	181
Number of Panels Cracked	4	14	21
Percentage Cracked	**2.2**	**7.7**	**11.6**
Number of Panels Over Concrete	99	99	99
Number of Panels Cracked	63	63	69
Percentage Cracked	**63.6**	**63.6**	**69.7**

The majority of these cracks are low severity. There were seven cracks noted as moderate severity in the 2001 survey. The most common cracking pattern is a transverse mid-panel crack with a few corner breaks and random cracks. Small areas of debonding were found underneath seven panels during the 2001 survey. The longitudinal full-depth saw joint closest to the pavement edge is separating and some faulting is apparent. In addition, the panels within the driving lane appear to be shifting toward the intersection with relation to the outside row of panels. The amount of movement is approximately two inches and can be seen in Figure 30.

Figure 30. Panel Movement

DECATUR – U.S. HIGHWAY 36 AND COUNTRY CLUB ROAD

This entire intersection is considered to be a thin bonded concrete overlay. The intersection was completed in May of 1998. Three annual surveys have also been completed for this intersection, with the results listed in Table 3.

Table 3
U.S. Highway 36 And Country Club Road Survey Results

Year of Survey	**1999**	**2000**	**2001**
Number of Panels Over Concrete	1428	1428	1428
Number of Panels Cracked	695	730	864
Percentage Cracked	**48.7**	**51.1**	**60.5**

A large number of plastic shrinkage cracks were found at the west end of the westbound passing lane within a day after paving. Approximately 75 percent of the cracks listed for the 2001 survey are low severity, 15 percent are moderate severity, and 10 percent are high severity. The most common crack pattern is transverse mid-panel cracking. Seven areas of significant debonding (> 50 ft^2) were found, as well as 18 isolated areas under individual panels. Several areas of significant distress and break-up have been noted at

this intersection. The worst area may be seen in Figure 31, where a significant amount of water was forced out of a partial-depth patch and in front of the concrete overlay by the paving process. This area was replaced with a full-depth patch in the fall of 2001. There has also been one partial-depth bituminous patch placed at a similar area of distress in the westbound driving lane.

Figure 31. Area Of Significant Overlay Break-Up

CARBONDALE – U.S. HIGHWAY 51 AND PLEASANT HILL ROAD

The Carbondale intersection was completed in July of 1998, and it is an even split between whitetopping and thin bonded concrete overlay area. Three annual surveys have been completed for this intersection. The number of cracked panels for each type of overlay may be found in Table 4.

Table 4
U.S. Highway 51 And Pleasant Hill Road Survey Results

Year of Survey	**1999**	**2000**	**2001**
Number of Panels Over Bituminous	906	906	906
Number of Panels Cracked	4	7	9
Percentage Cracked	**0.4**	**0.8**	**1.0**
Number of Panels Over Concrete	906	906	906
Number of Panels Cracked	324	380	293
Percentage Cracked	**35.8**	**41.9**	**32.3**

The decrease in the number of cracks from 2000 to 2001 can be attributed to different personnel performing the surveys. In addition, the 2001 survey was performed on a day of particularly high traffic volume. The center turning lane was very difficult to survey during the 2001 survey.

All of the cracks listed for the 2001 survey are low severity. The most common crack pattern is transverse mid-panel cracking, however, there were 17 longitudinal mid-panel cracks noted. There is one very large area (125 ft^2) of debonding at the south end of the center turn lane. The original concrete surface was not textured with the milling head in this area. In addition, the north end of the northbound driving lane has started to shift in a manner similar to the Decatur project at U.S. Highway 36 and Oakland Avenue. The movement appears to be in the whitetopping panels of the driving lane with regard to the bonded concrete overlay panels of the center turn lane. The movement to date has been less than 0.5 inch.

TUSCOLA – U.S. HIGHWAY 36

The mainline paving project on U.S. Highway 36 east of Tuscola was completed in May of 1999. This project is considered to be a conventional whitetopping project with an overlay thickness ranging from four to seven inches. Two annual surveys have been completed on this project to date. Table 5 illustrates the cracking results from these two surveys.

Table 5
U.S. Highway 36 Survey Results

Year of Survey	**2000**	**2001**
Number of Panels Over Bituminous	4809	4809
Number of Panels Cracked	51	96
Percentage Cracked	**1.1**	**2.0**

Two of the 96 total cracks for 2001 were transverse mid-panel cracks. The remaining 94 cracks were all corner breaks similar to that shown in Figure 32. All of the cracks were low severity, and there is no evidence of debonding at this time.

Figure 32. Panel Corner Break

CLAY COUNTY – COUNTY HIGHWAY 3

The Clay County project was completed in the fall of 1998. The entire length of this project is considered to be conventional whitetopping with an overlay thickness of both five and six inches. Due to the length of this project, three experimental test sections were selected for evaluation and monitoring. Each of the test sections is 1,000 feet long and pertains to a variation in the overlay procedure.

The first test section is in the area of 5-inch overlay with 11-foot skewed transverse joints. The second test section is in the area of 6-inch overlay with 15-foot skewed transverse joints. The last section is in the area of 6-inch overlay with 5.5-foot skewed transverse joints and 5.5-foot longitudinal joints. Three annual surveys have been completed for these test sections. No cracks or distresses have been found.

PIATT COUNTY – COUNTY HIGHWAY 4

The entire project length for the Piatt County whitetopping is considered conventional whitetopping with an overlay thickness of five inches. The project was completed in October of 2000. Due to the length of this project, one experimental section and one control section were selected for evaluation. One annual survey has been completed, and the results of that survey may be found in Table 6.

The experimental section includes all of the panels with 5.5-foot skewed transverse joints and 5.5-foot longitudinal joints. This section is approximately 2,630 feet long. The control section includes 100 panels (50 in each lane) with 11-foot skewed transverse joints. This section is approximately 550 feet long.

Table 6
County Highway 4 Survey Results

Year of Survey	**2001**
Number of 5.5' X 5.5' Panels Over Bituminous	1912
Number of Panels Cracked	9
Percentage Cracked	**0.5**
Number of 11' X 11' Panels Over Bituminous	100
Number of Panels Cracked	0
Percentage Cracked	**0.0**

The nine cracks that were found in the experimental section were all corner breaks. These corner breaks all occurred at a corner of the panel where the skewed transverse joint formed an acute angle with the edge of pavement. The cracks were all rated as low severity.

CUMBERLAND COUNTY – COUNTY HIGHWAY 2

The Cumberland County project was completed in September of 2001. This entire project is also considered conventional whitetopping with an overlay thickness of 5.75-inches. Three experimental test sections have been selected for this project. One test section at both the north and south ends of the project, as well as one test section in the middle of the project at crossroad 1300 N. A six-month survey was completed in May 2002, and the results may be found in Table 7.

Table 7
County Highway 2 Survey Results

Year of Survey	2002
Number of Panels Over Bituminous	1440
Number of Panels Cracked	4
Percentage Cracked	0.3

Each experimental test section contains 120 rows of panels (480 total panels), and is approximately 660 feet long. The southern and middle test sections are located at crossroads to incorporate the action of turning vehicles onto, and off of, the whitetopping. The four panels that are cracked contain a low severity, transverse crack.

PROJECT COSTS

Table 7 illustrates the pertinent construction costs for all of the whitetopping projects. Items included are only those that affect the pavement lanes; milling, concrete placement, and joint sawing.

The table indicates that the price for an individual item heavily depended upon the quantity of that item to be constructed. For example, the price of concrete placement for the mainline pavement projects is nearly half that of the intersection projects. The reduction in cost is even more dramatic for the milling of the existing pavement. In addition, traffic control and congestion are much more difficult to work with for an intersection project.

Some of these projects combined several construction operations into one pay item. Three of the projects have combined the partial-depth and full-depth joint sawing into one pay item, while three other projects included this price with the cost of placing the concrete.

Table 8
Project Construction Cost Information

Construction Item	Cumberland County – County Highway 2 (2001)	Piatt County – County Highway 4 (2000)	Clay County – County Highway 3 (1998)	Tuscola – U. S. Highway 36 (1999)	Carbondale – U. S. Highway 51 & Pleasant Hill Road (1998)	Decatur – U. S. Highway 36 & Country Club Road (1998)	Decatur – U. S. Highway 36 & Oakland Avenue
Pavement Milling 1.5 inches (sq. yds.)			$0.17 (102,283)				
Pavement Milling 3.0 inches (sq. yds.)	$1.11 (50,207)	$1.61 (63,490)					
Pavement Milling 3.5 inches (sq. yds.)					$6.86 (2,147)	$7.23 (2,563)	$7.23 (537)
Concrete Placement 2.5 inches (sq. yds.)						$18.72 (1,216)	
Concrete Placement 3.5 inches (sq. yds.)					$24.87 (2,147)	$21.20 (1,347)	$21.20 (537)
Concrete Placement 5.0 inches (sq. yds.)		$13.85 (63,490)	$12.56 (94,502)				
Concrete Placement 5.75 inches (sq. yds.)	$15.84 (50,207)						
Concrete Placement 6.0 inches (sq. yds.)			$13.89 (6,478)				
Concrete Placement Various (sq. yds.)				$17.69 (10,626)			
Saw Joints Partial-Depth (feet)	*	*	*	$0.72 (36,394)			
Saw Joints Full-Depth (feet)	*	*	*	$2.65 (7,710)			
Saw Joints Combined (feet)					$1.83 (9,921)	$1.15 (9,200)	$1.15 (2,267)
Total Cost (Per Square Yard)	$16.95	$15.46	$12.73 (5”) $14.06 (6”)	$22.08	$40.19	$30.08 (2.5”) $32.56 (3.5”)	$33.28

* Indicates this item was included with the cost of concrete placement.

CONCLUSIONS

Seven experimental whitetopping projects were constructed in Illinois to investigate the potential of this type of rehabilitation for intersections and lower volume pavements. Three of these projects included the rehabilitation of intersections, while the remaining four involved the rehabilitation of mainline pavements. Two of the intersection projects included a hybrid of ultra-thin whitetopping and thin bonded concrete overlays. The remaining intersection was a thin bonded concrete overlay. All four of the mainline pavement projects were conventional whitetopping.

After monitoring construction of these seven projects and evaluating the initial performance data, the following conclusions were made:

1. Intersections with severe bituminous concrete rutting, or related distresses, can be successfully rehabilitated with an ultra-thin whitetopping.

2. Milling of the existing bituminous concrete surface to increase the bonding surface area and texture reduces debonding of the concrete overlay.

3. Grade control stringlines for the milling and paving processes are critical to the final concrete quantities. If the milling process does not follow a stringline, then concrete overruns are common.

4. Timely construction and proper staging of the project will minimize delay and burden to the facility users.

5. Surficial distresses and overlay debonding were dramatically increased in those areas where a thin bonded concrete overlay was placed.

6. Smaller panel sizes will increase the overall cost of the project due to the increased saw cutting cost.

RECOMMENDATIONS

1. Milling of the existing bituminous surface to provide surface texture is recommended.

2. The milling process should be controlled by a stringline to prevent concrete quantity overruns.

3. The partial-depth saw cutting operations should not commence until the concrete has gained enough strength to prevent tearing and spalling of the joint.

4. In hot weather (> 80 °F), misting of the existing pavement surface before the whitetopping overlay is recommended.

5. The construction of thin bonded concrete overlays at intersections, especially those with durability cracking of the existing PCC, is not recommended.

6. The construction of conventional whitetopping for low volume facilities is recommended.

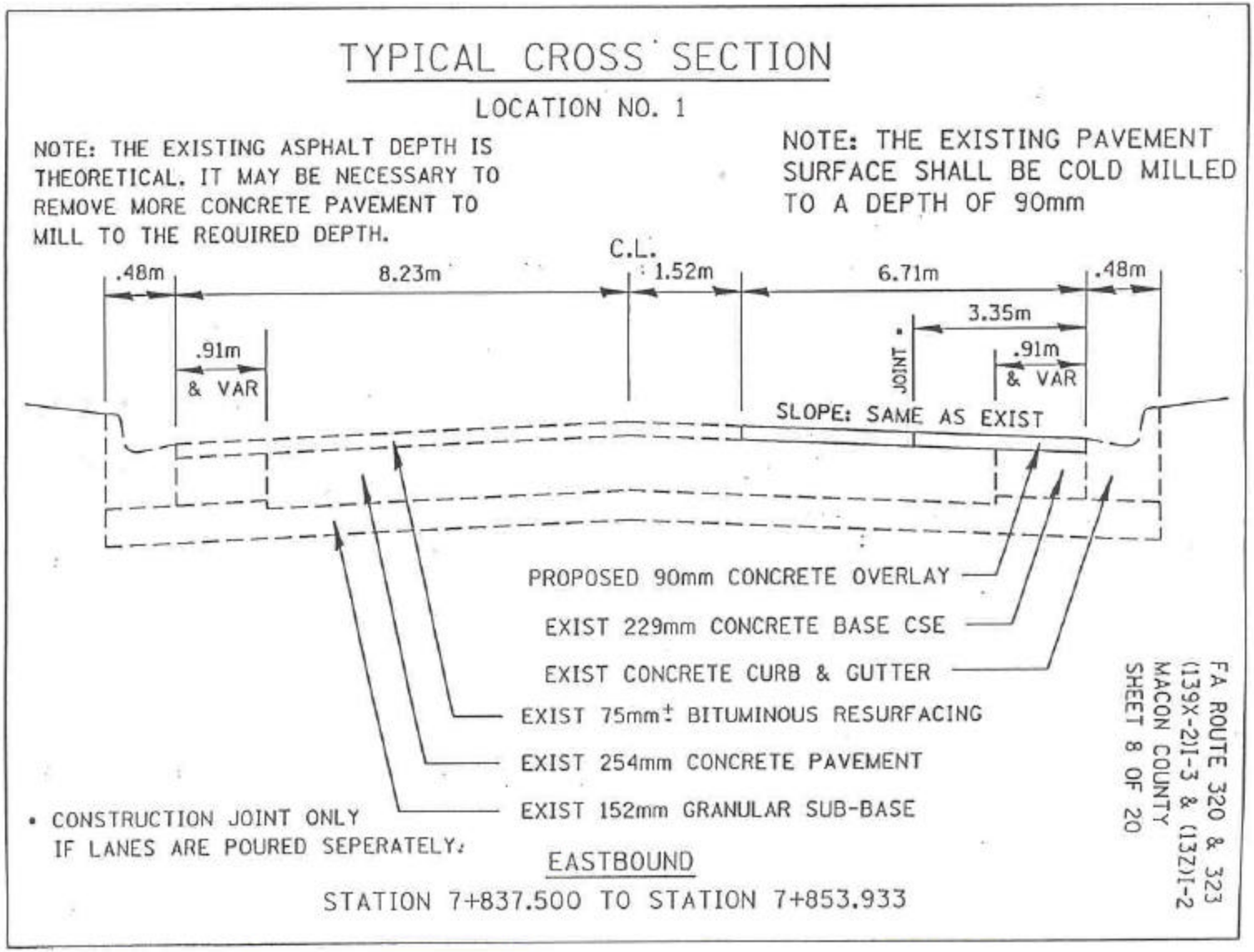
7. The use of skewed joints is not recommended due to the cracking of acute angles within panels.

Appendix

A

Typical Cross Sections

Decatur
U. S. Highway 36 And Oakland Avenue



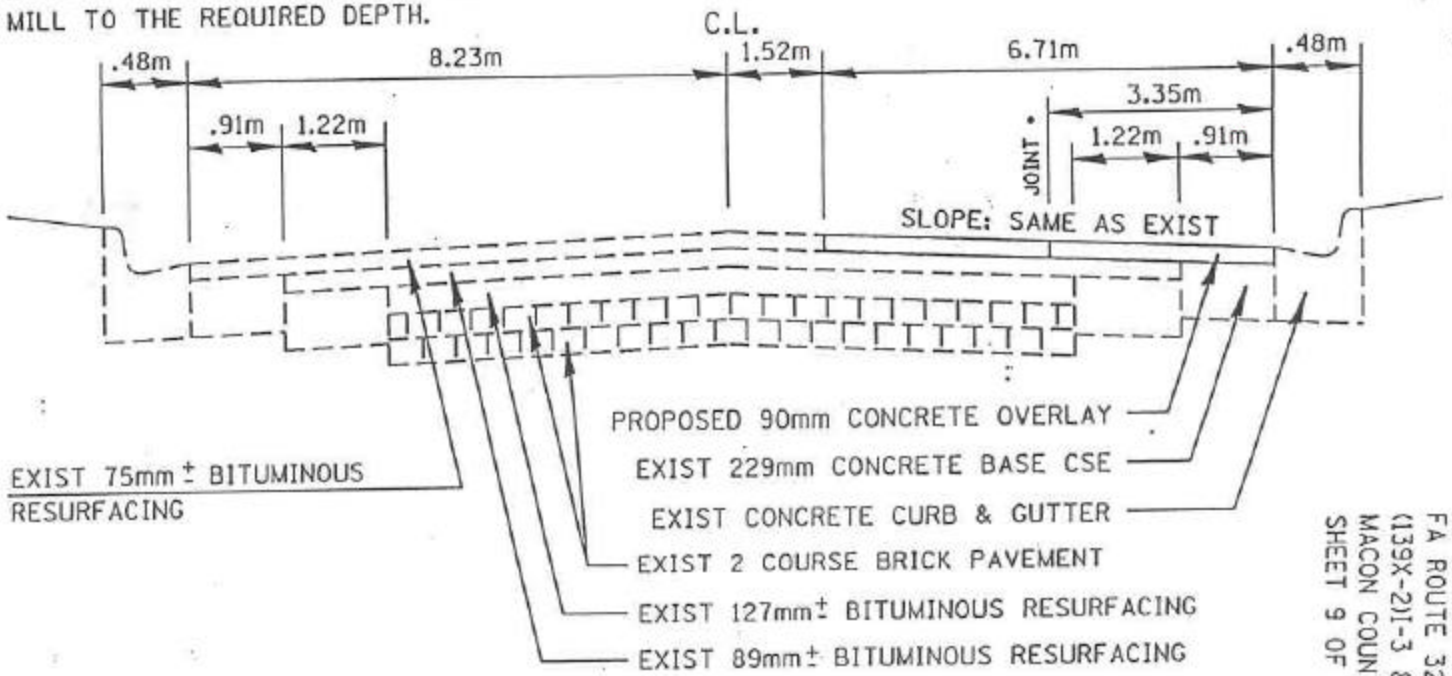
Decatur
U. S. Highway 36 And Oakland Avenue

TYPICAL CROSS SECTION

LOCATION NO. 1

NOTE: THE EXISTING ASPHALT DEPTH IS THEORETICAL. IT MAY BE NECESSARY TO REMOVE MORE CONCRETE PAVEMENT TO MILL TO THE REQUIRED DEPTH.

NOTE: THE EXISTING PAVEMENT SURFACE SHALL BE COLD MILLED TO A DEPTH OF 90mm



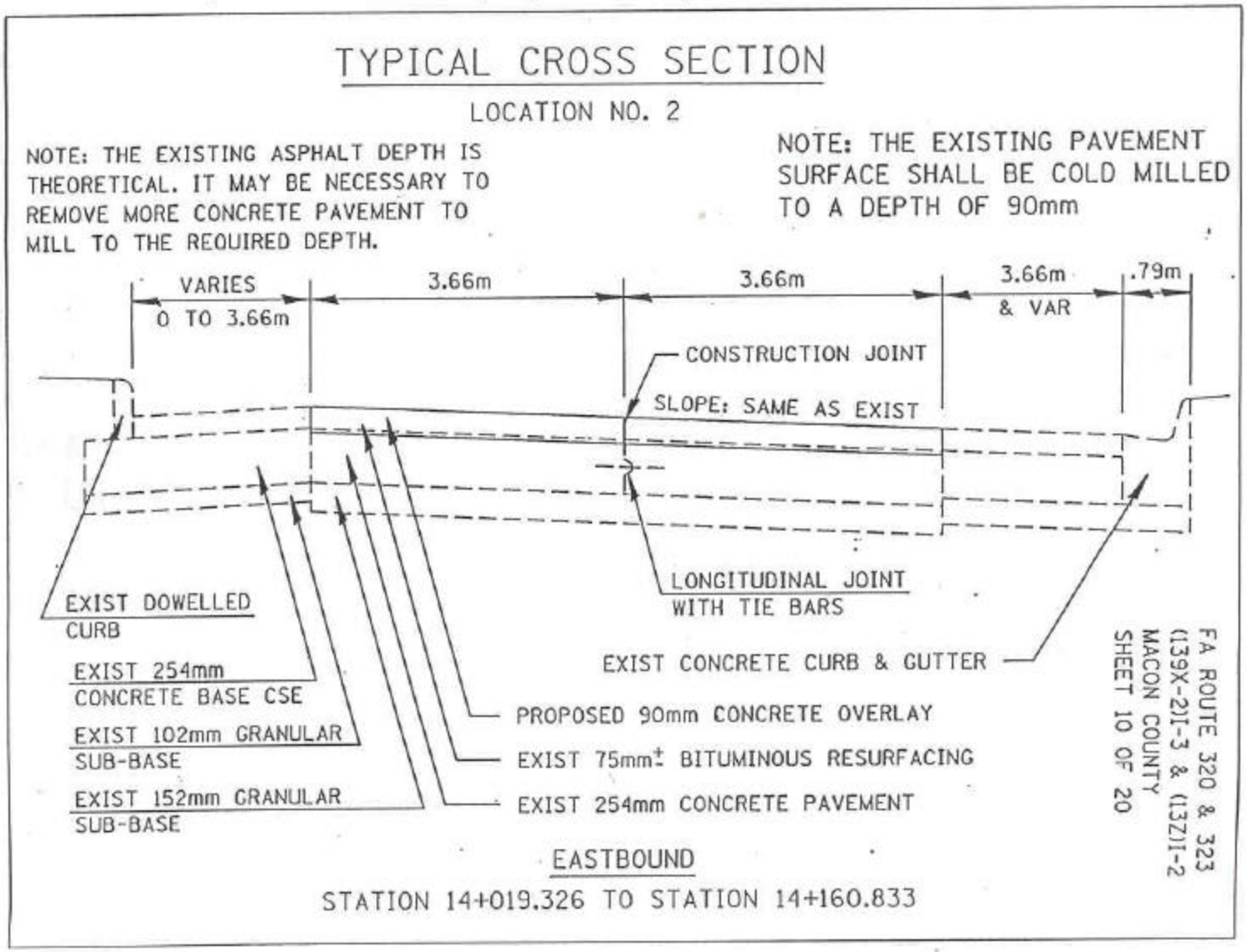
• CONSTRUCTION JOINT ONLY IF LANES ARE POURED SEPERATELY.

EASTBOUND

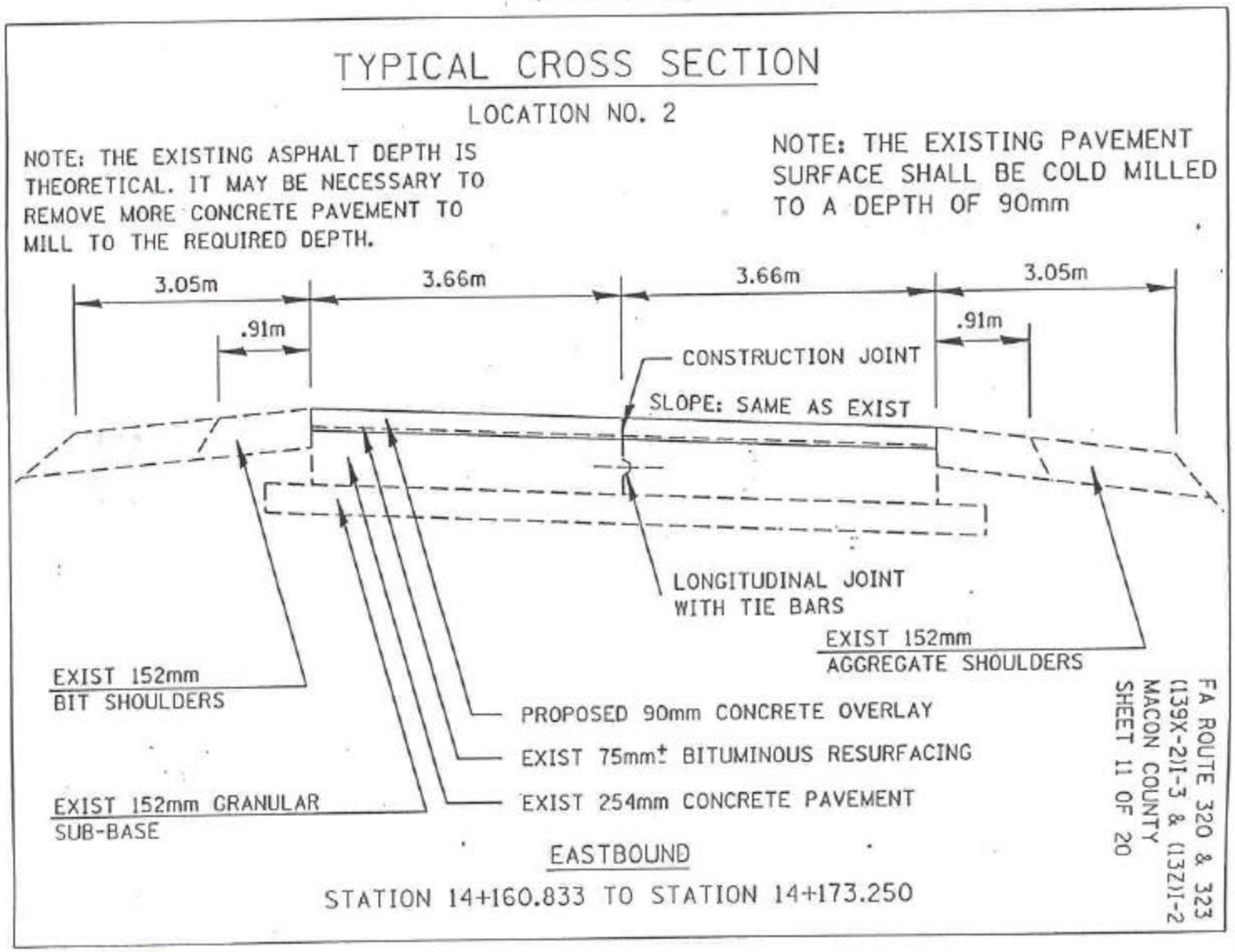
STATION 7+853.933 TO STATION 7+904.500

FA ROUTE 320 & 323
(139X-211-3 & (132)1-2
MACON COUNTY
SHEET 9 OF 20

Decatur
U. S. Highway 36 And Country Club Road
(Eastbound)



Decatur
U. S. Highway 36 And Country Club Road
(Eastbound)



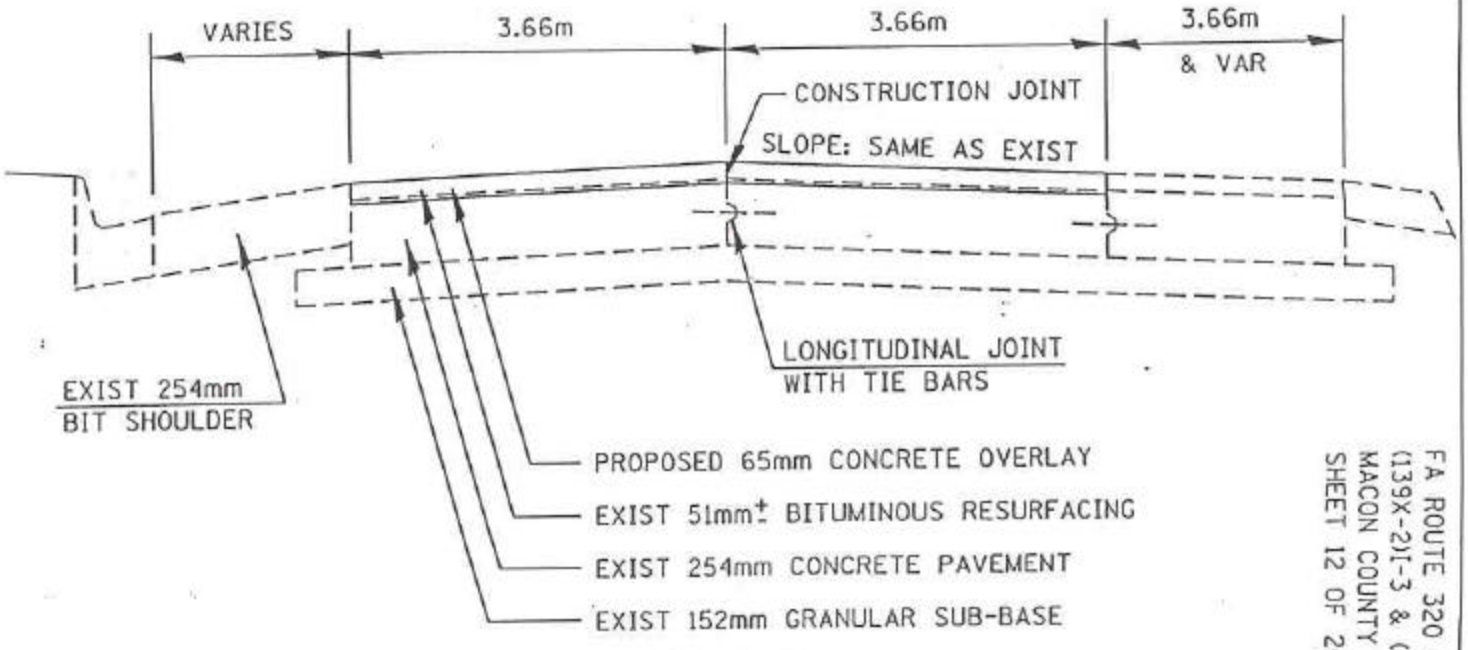
Decatur
U. S. Highway 36 And Country Club Road
(Westbound)

TYPICAL CROSS SECTION

LOCATION NO. 3

NOTE: THE EXISTING ASPHALT DEPTH IS THEORETICAL. IT MAY BE NECESSARY TO REMOVE MORE CONCRETE PAVEMENT TO MILL TO THE REQUIRED DEPTH.

NOTE: THE EXISTING PAVEMENT SURFACE SHALL BE COLD MILLED TO A DEPTH OF 65mm

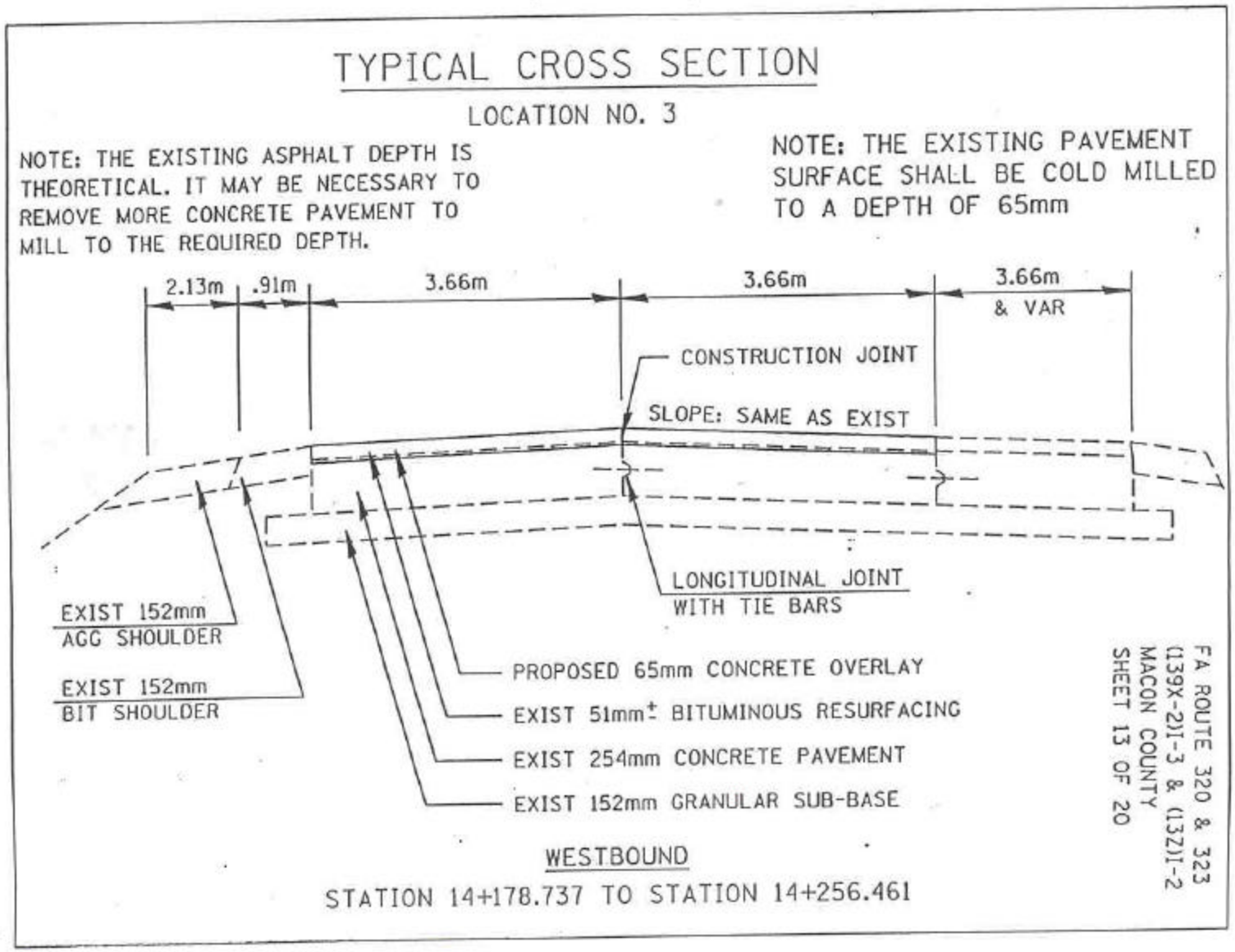


WESTBOUND

STATION 14+117.472 TO STATION 14+178.737

FA ROUTE 320 & 323
(139X-2)1-3 & (13Z)1-2
MACON COUNTY
SHEET 12 OF 20

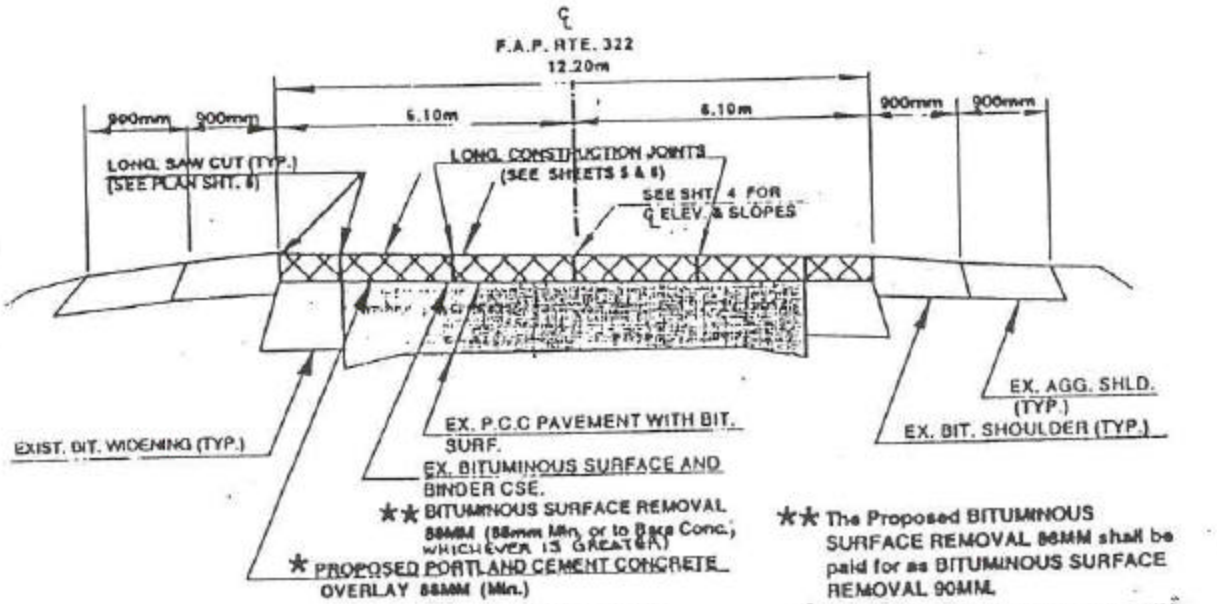
Decatur
U. S. Highway 36 And Country Club Road
(Westbound)



Carbondale
U. S. Highway 51 And Pleasant Hill Road
North Leg Of Intersection

TYPICAL SECTION

F.A.P. 322 (U.S. 51)

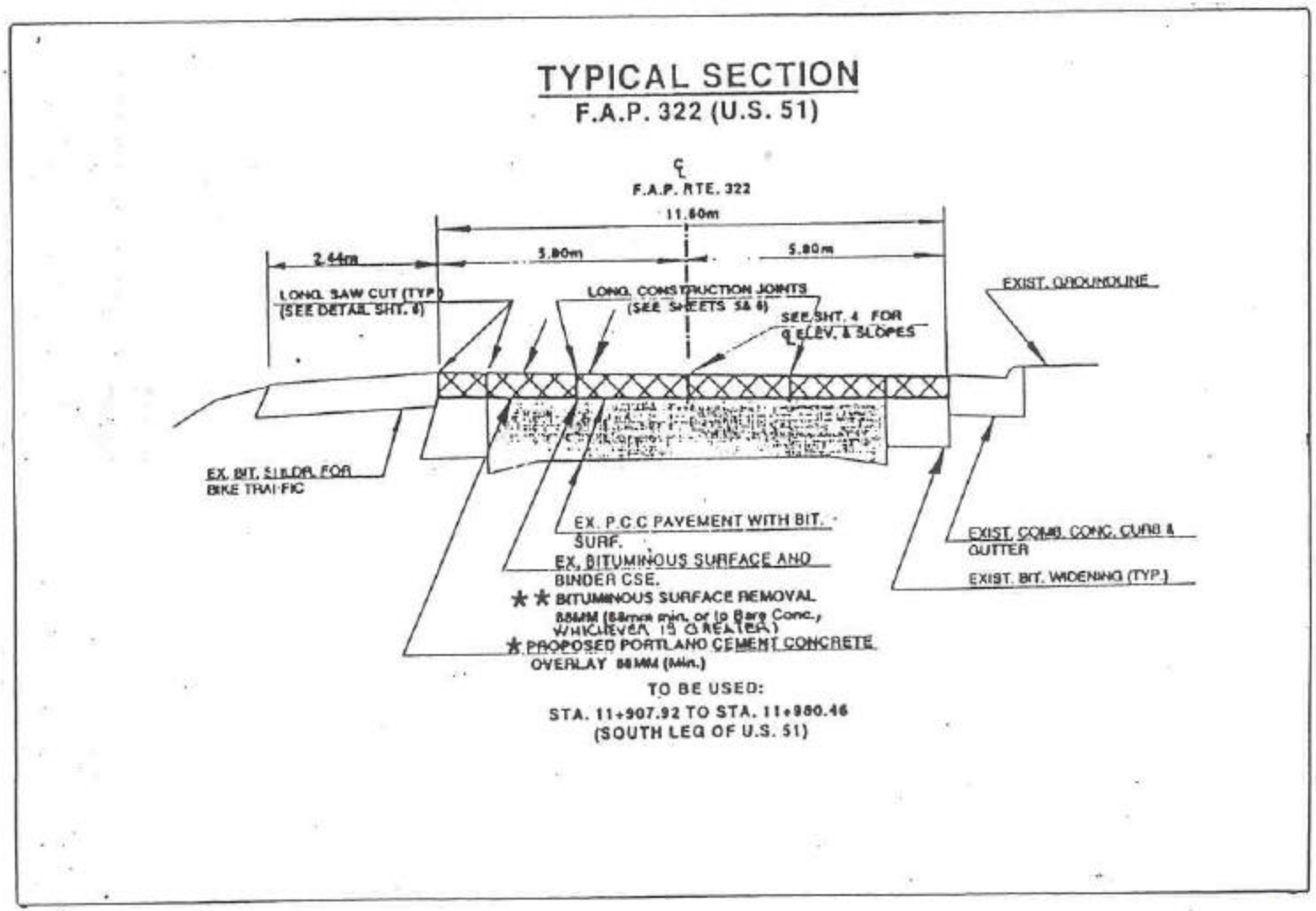


TO BE USED:
STA. 11+980.48 TO STA. 12+055.78
(NORTH LEG OF U.S. 51)

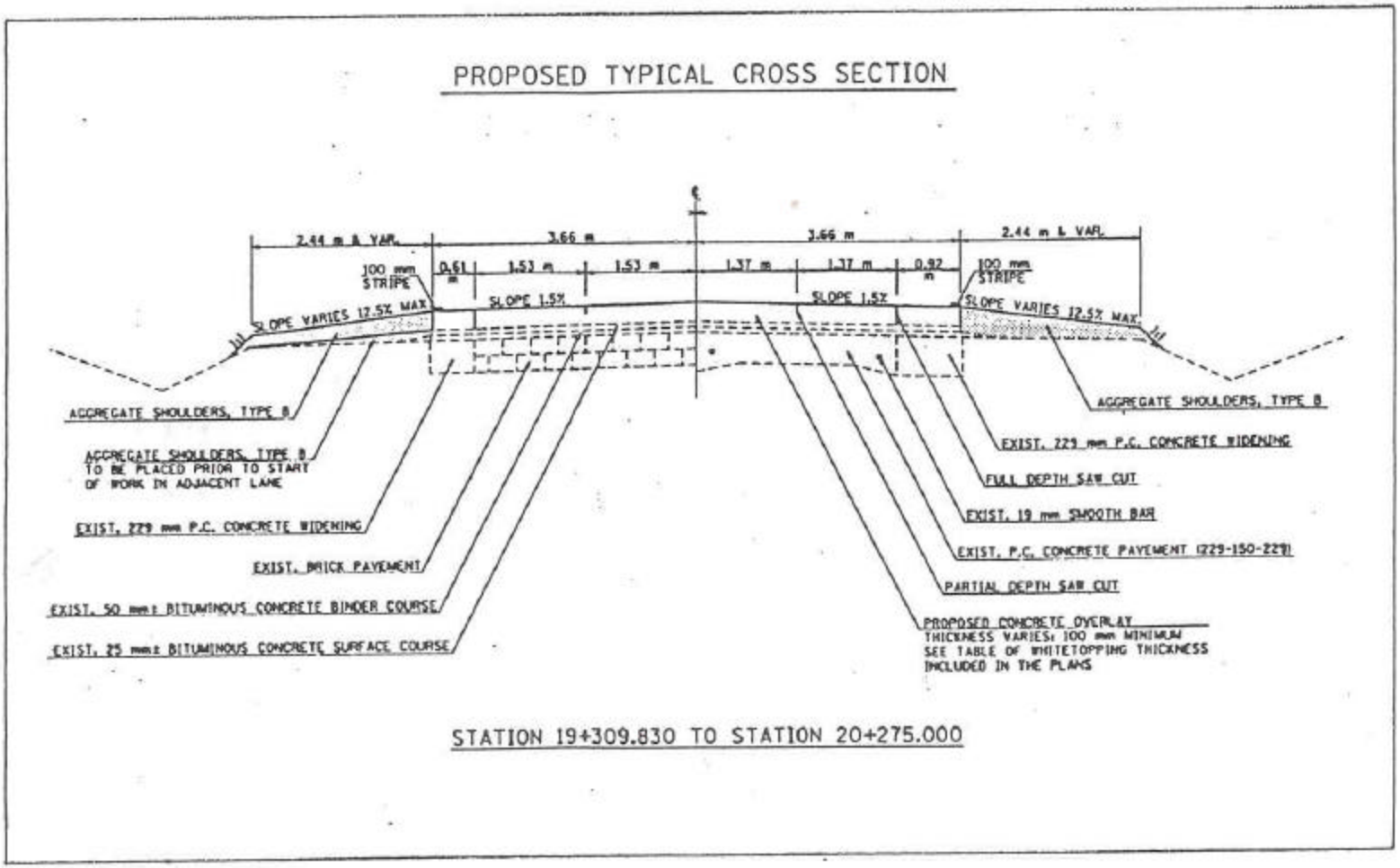
★★ The Proposed BITUMINOUS SURFACE REMOVAL 88MM shall be paid for as BITUMINOUS SURFACE REMOVAL 90MM.

★ The Proposed PCC OVERLAY 88MM shall be paid for as PCC OVERLAY 90MM. The thickness shall be adjusted according to the depth of the SURFACE REMOVAL and as directed by the Engineer.

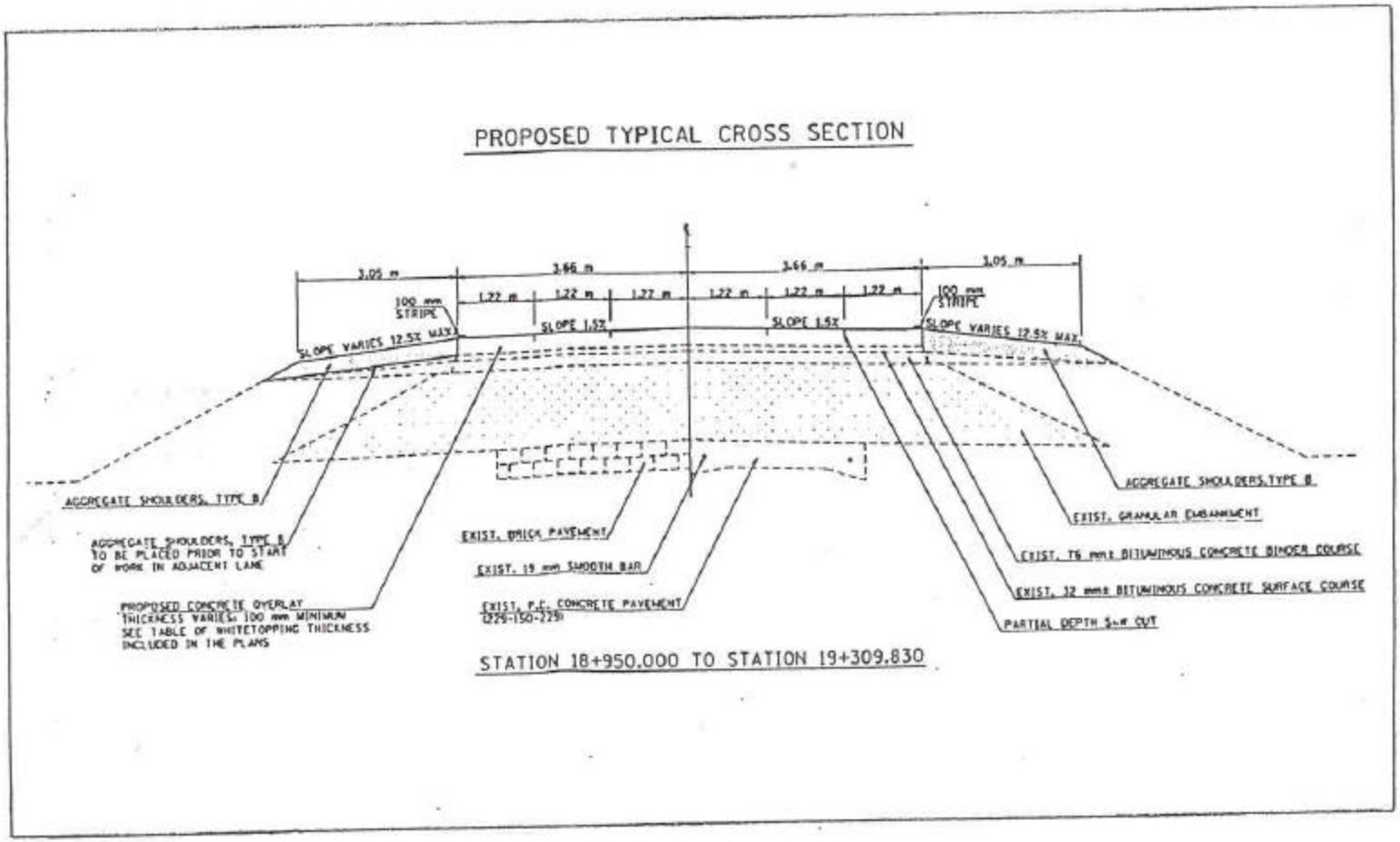
Carbondale
U. S. Highway 51 And Pleasant Hill Road
South Leg Of Intersection



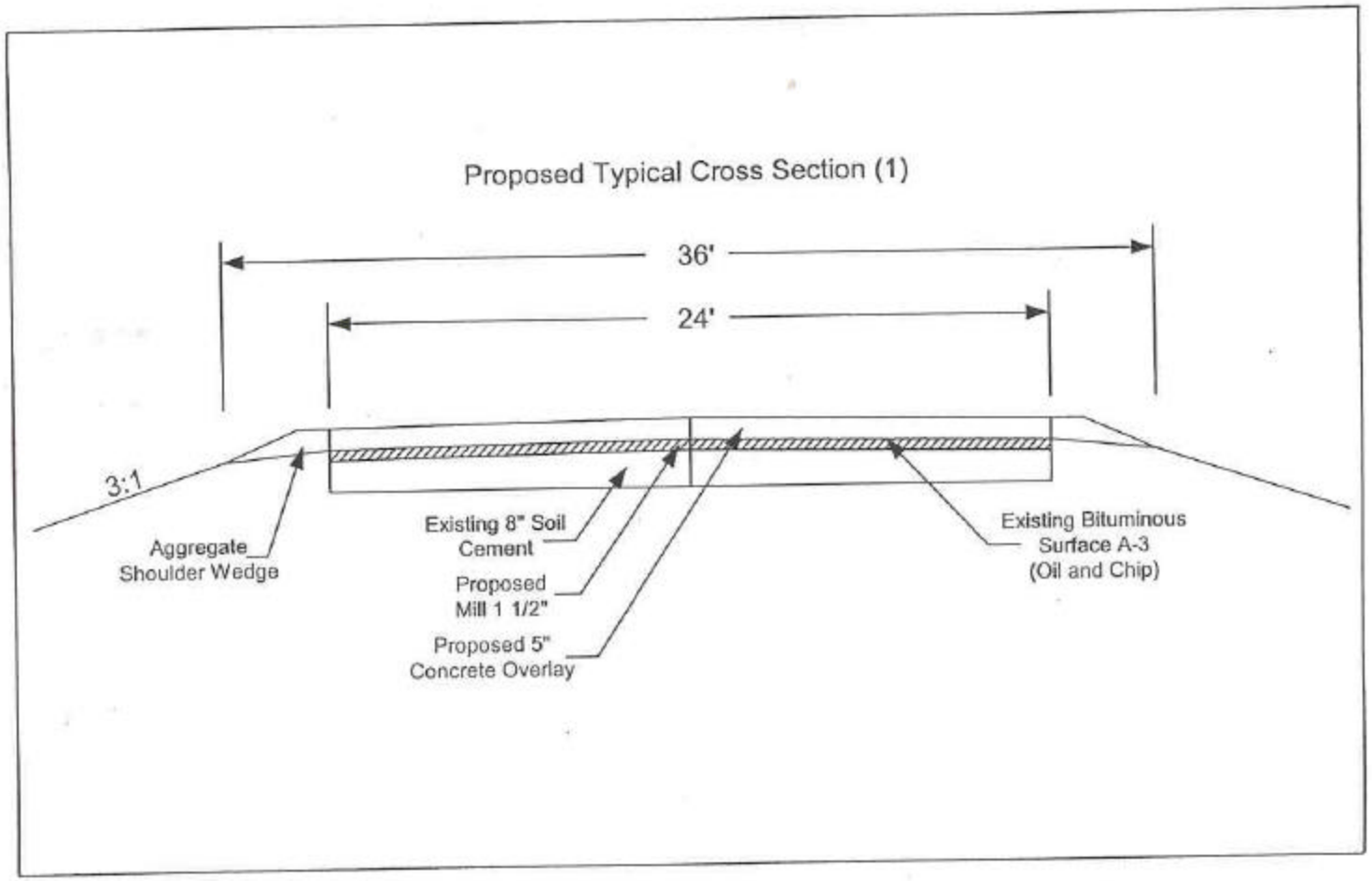
Tuscola
U. S. Highway 36



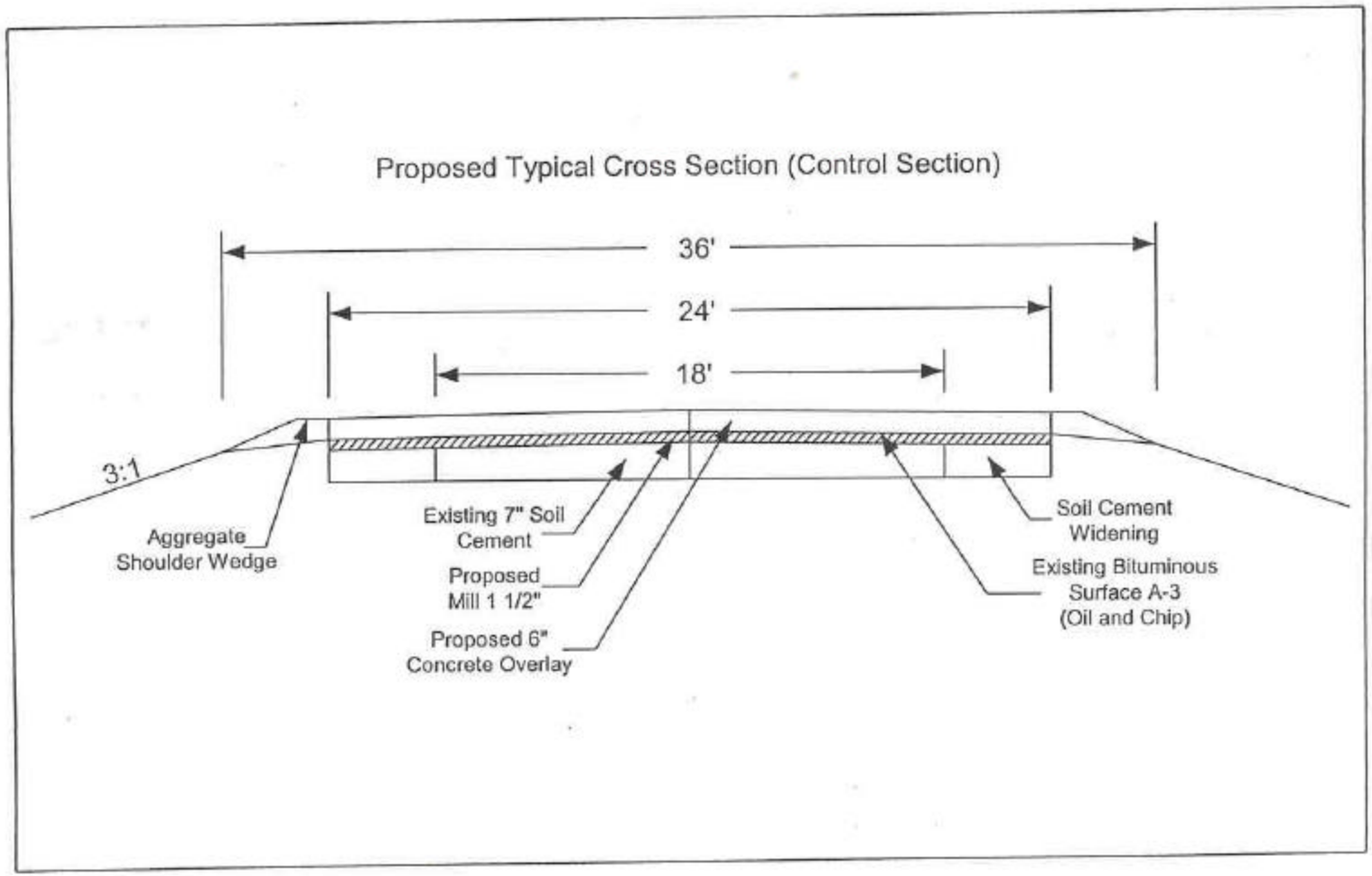
Tuscola
U. S. Highway 36



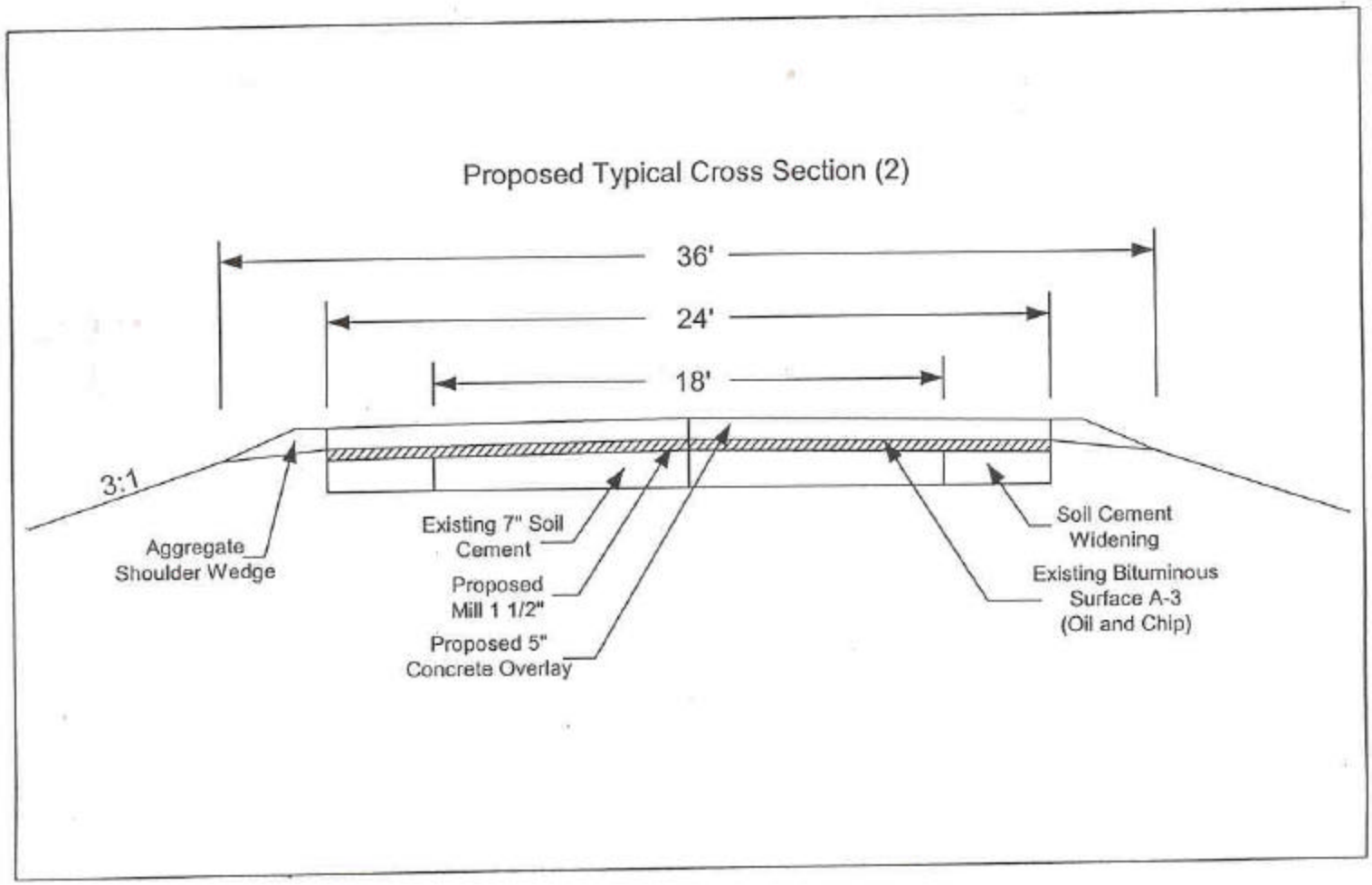
Clay County
County Highway 3



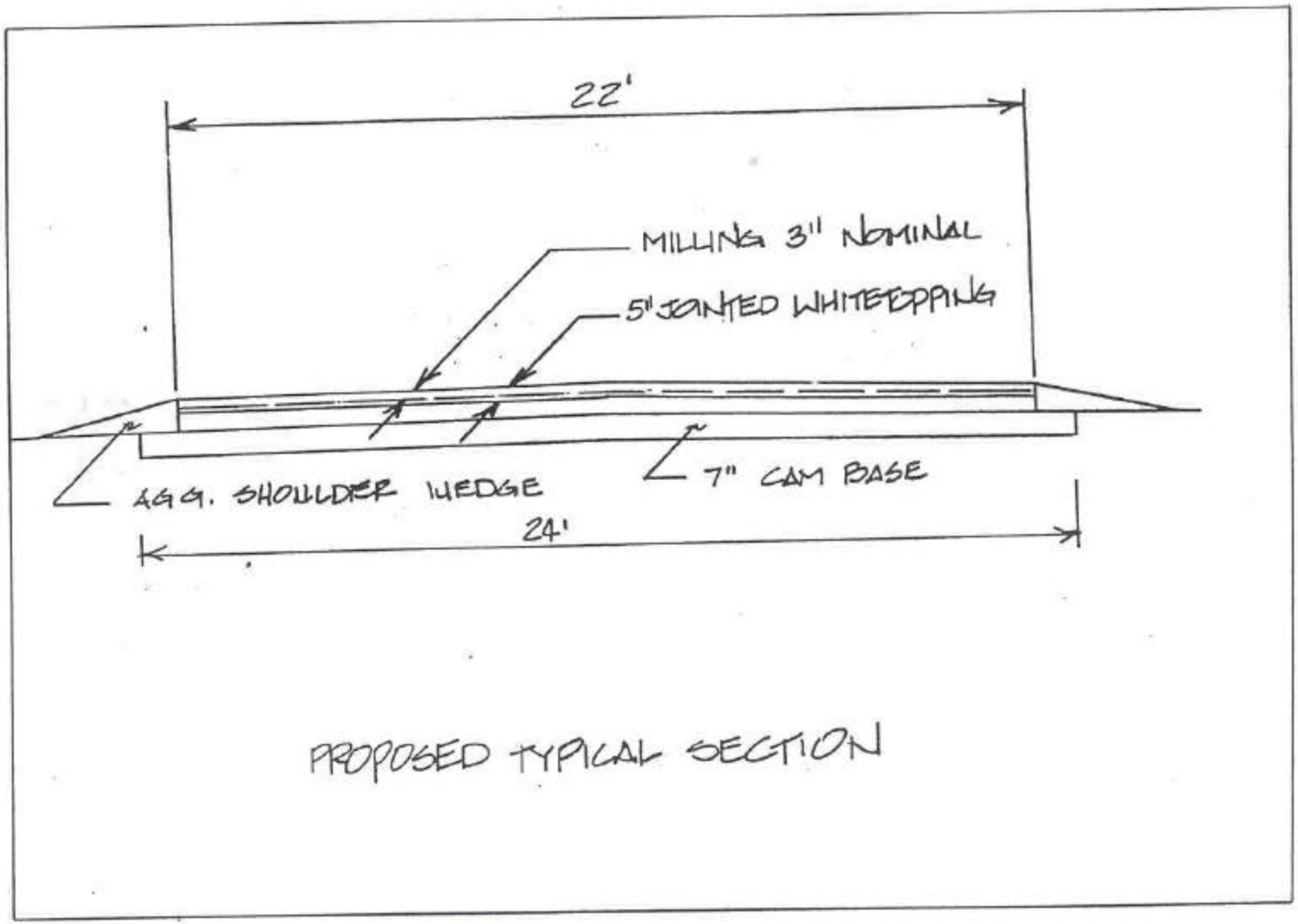
Clay County
County Highway 3



Clay County
County Highway 3

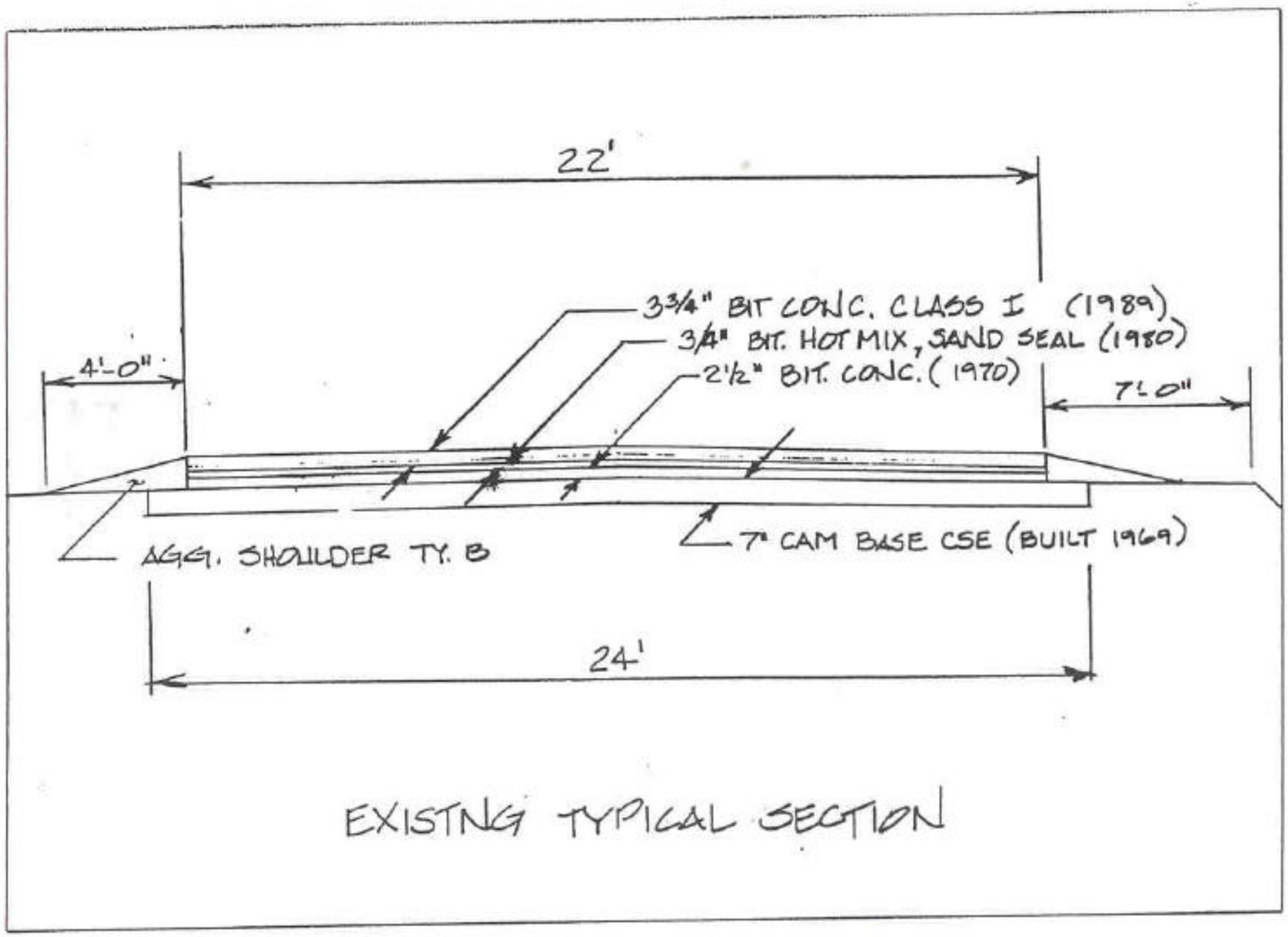


Piatt County
County Highway 4



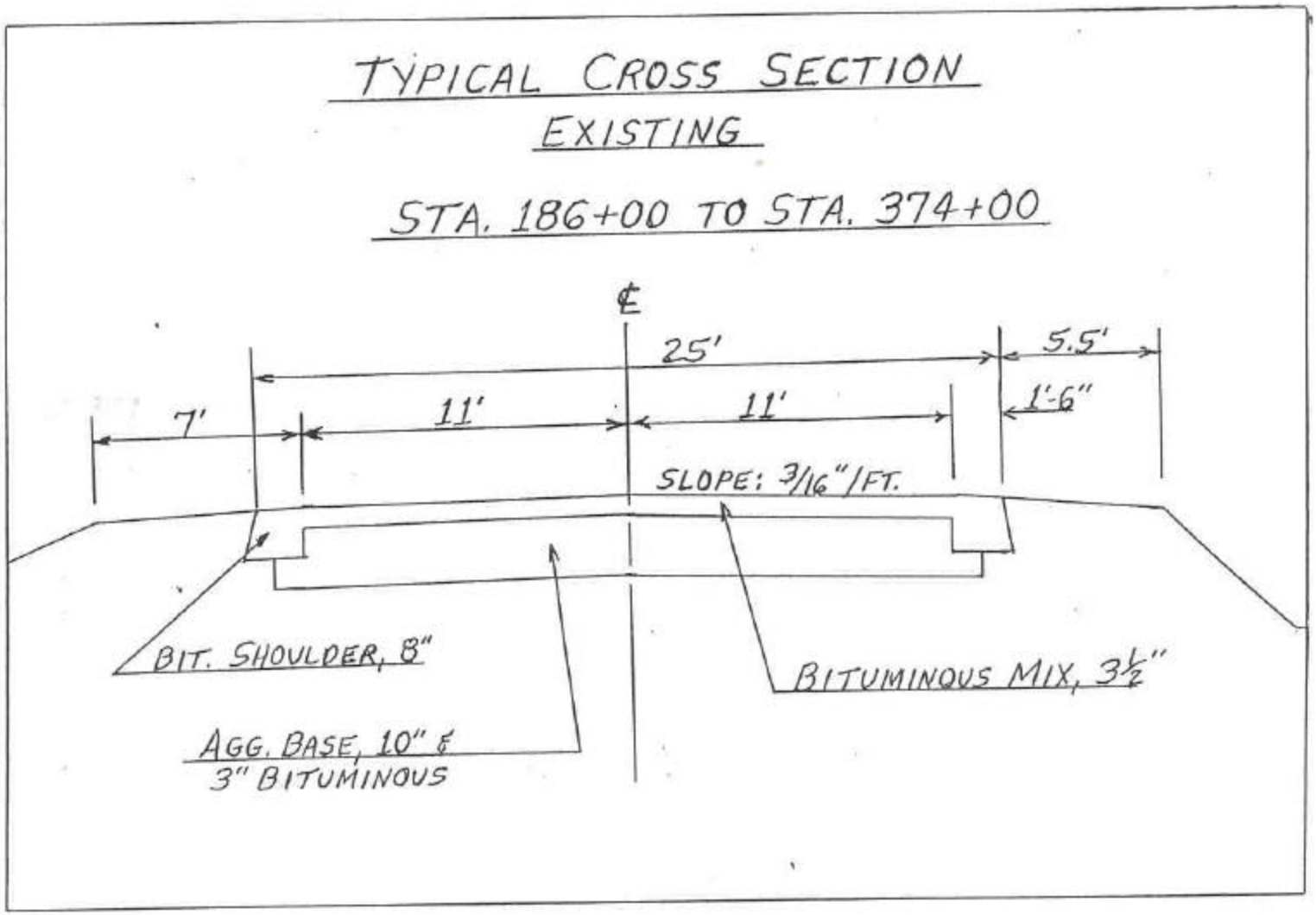
PROPOSED TYPICAL SECTION

Piatt County
County Highway 4

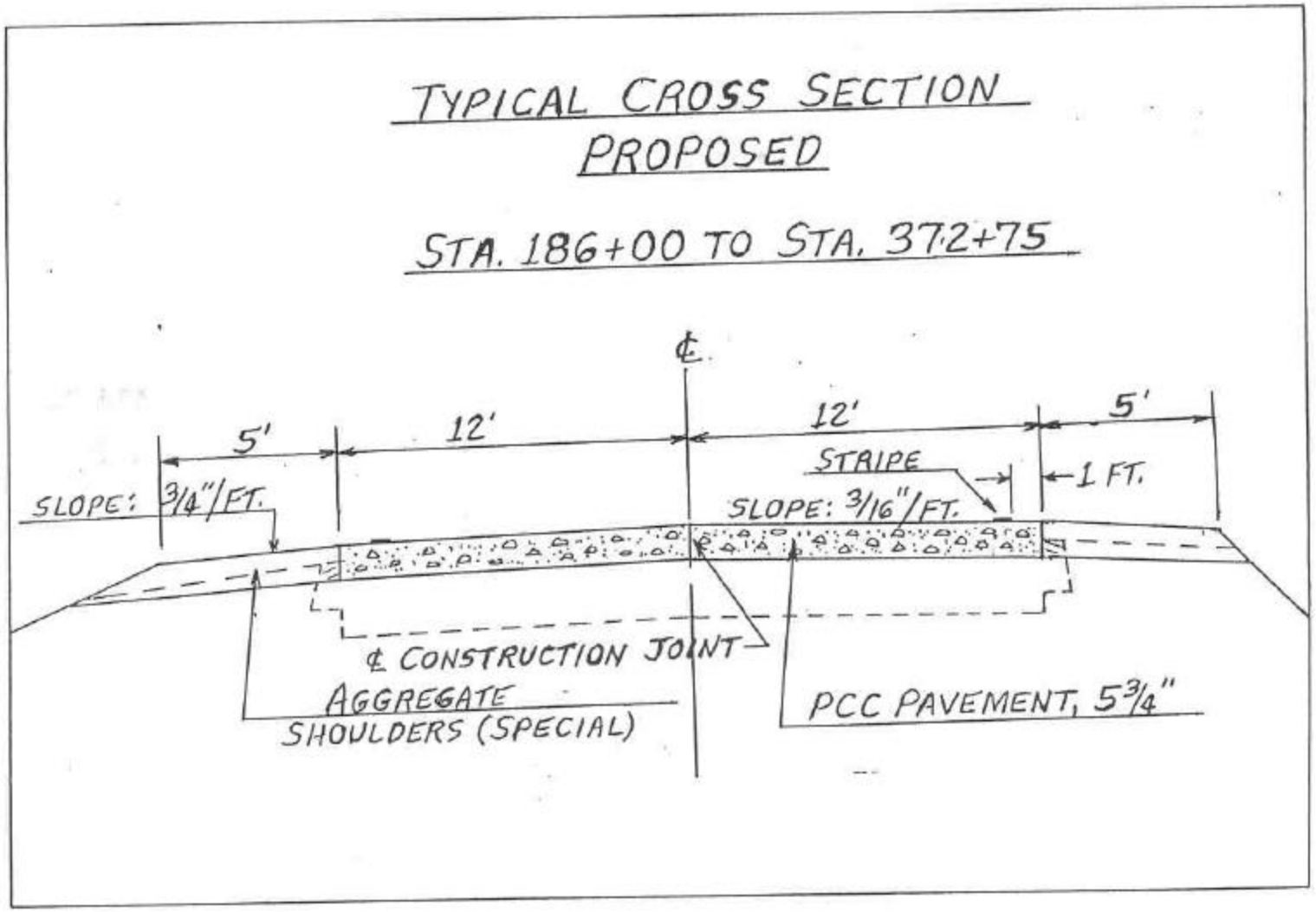


EXISTNG TYPICAL SECTION

Cumberland County
County Highway 2



Cumberland County
County Highway 2



Appendix

B

Concrete Mixture Designs

Mixture Design Information

Component	Decatur - U. S. Highway 36 & Oakland Avenue	Decatur - U. S. Highway 36 & Country Club Road	Carbondale - U. S. Highway 51 & Pleasant Hill Road	Tuscola - U. S. Highway 36	Clay County - County Highway 3	Piatt County - County Highway 4	Cumberland County - County Highway 2
Coarse Aggregate (lbs)	1713 ***	1713 ***	1805 **	1704 **	1814 **	1957 *	1836 **
Fine Aggregate (lbs)	1210 +	1210 +	1008 +	1035 +	1286 +	1220 +	1256 +
Cement (lbs)	705	705	755	755	534	534	575
Water (lbs)	239	239	273	255	244	179	197
Air Entraining Agent (oz/cwt)	1.6	1.6	0.9	0.4	--	1.5	1.4
Water Reducer (oz/cwt)	8.1	8.1	6.6	1.1	--	2.4	0.5
Superplasticizer (oz/cwt)	3.6	4.7					
Polypropolene Fibers (lbs)			3.0				
Batch Weight (lbs)	3867	3867	3841	3749	3878	3890	3864
Water / Cement Ratio	0.34	0.34	0.36	0.34	0.46	0.34	0.34

Aggregate Gradations

	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#16	#50	#100
* CA 07	100	95 ± 5		45 ± 15		5 ± 5			
** CA 11		100	92 ± 8	45 ± 15		6 ± 6			
*** CA 16				100	97 ± 3	30 ± 15	2 ± 2		
+ FA01					100	97 ± 3	65 ± 20	16 ± 13	5 ± 5

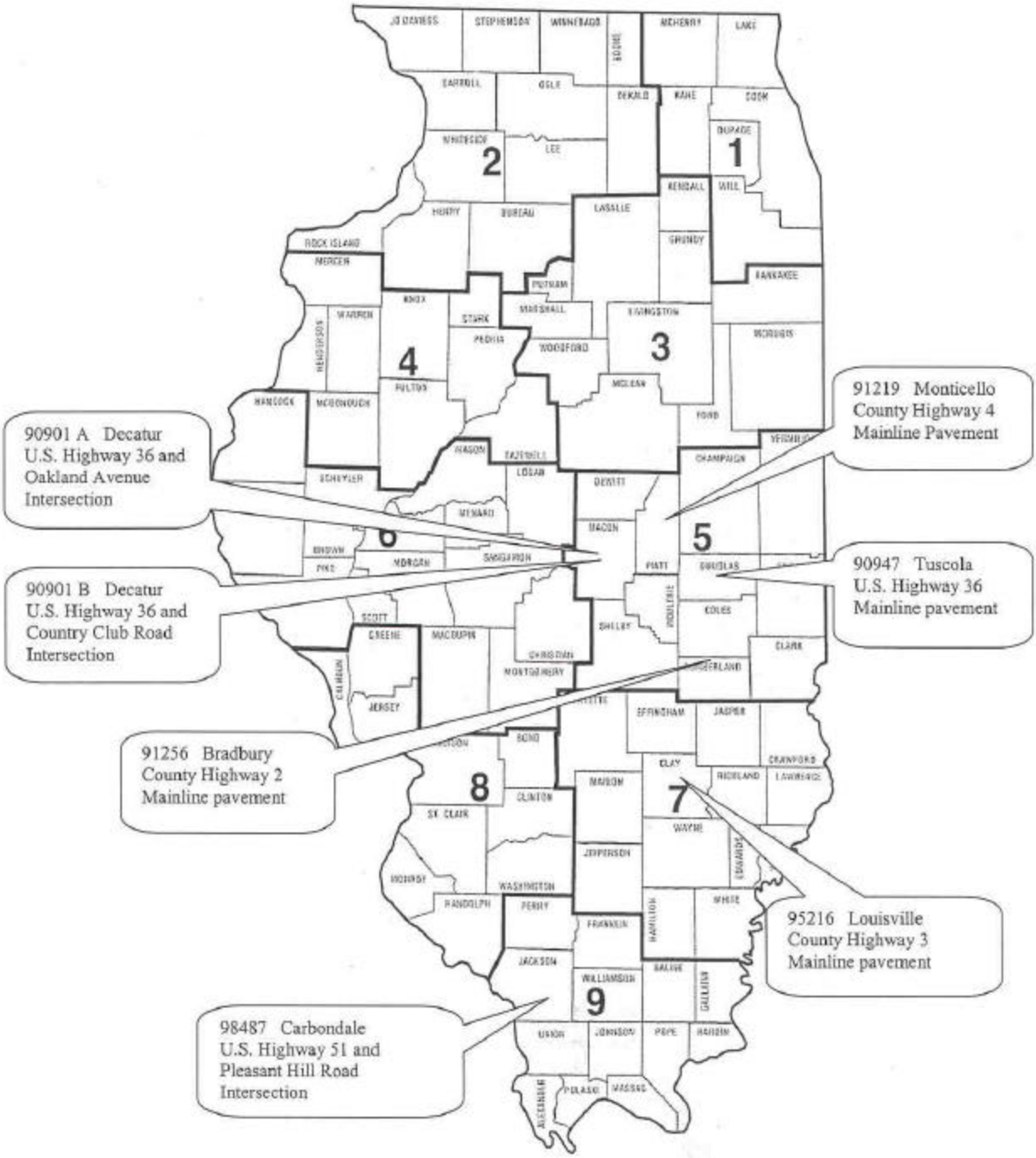
Indicates this product was not used in this mixture.

Appendix

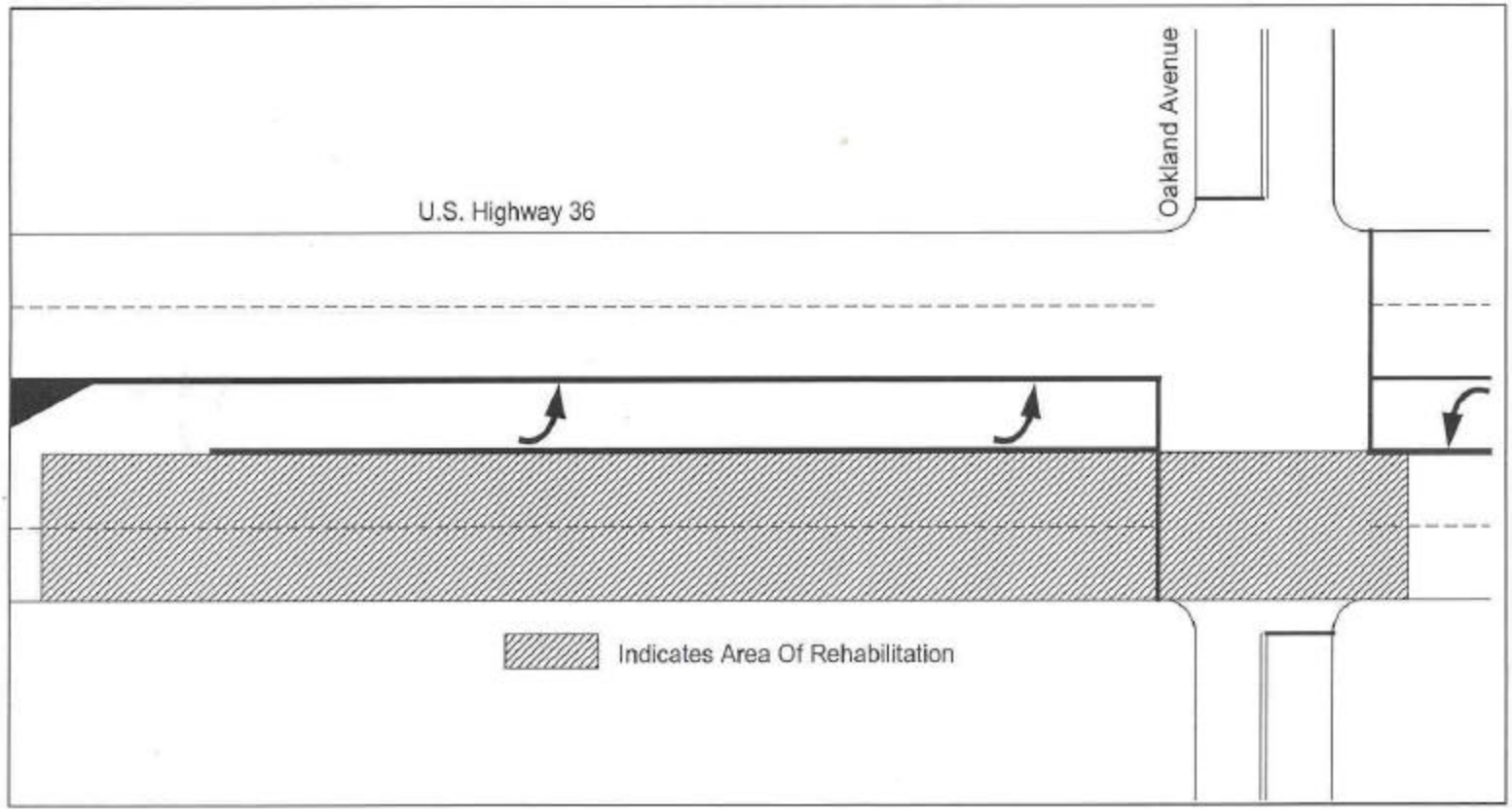
C

Project Layout Maps

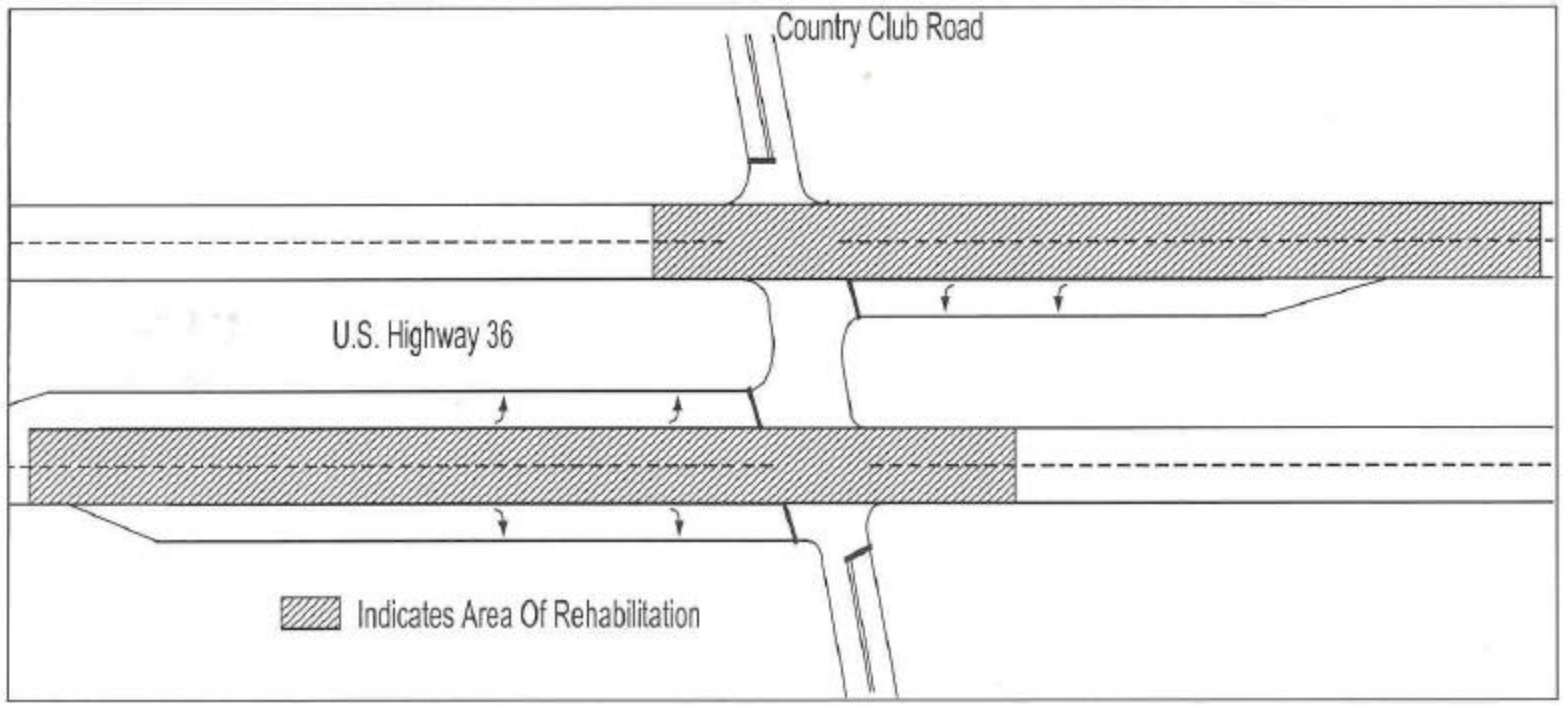
Whitetopping Project Locations



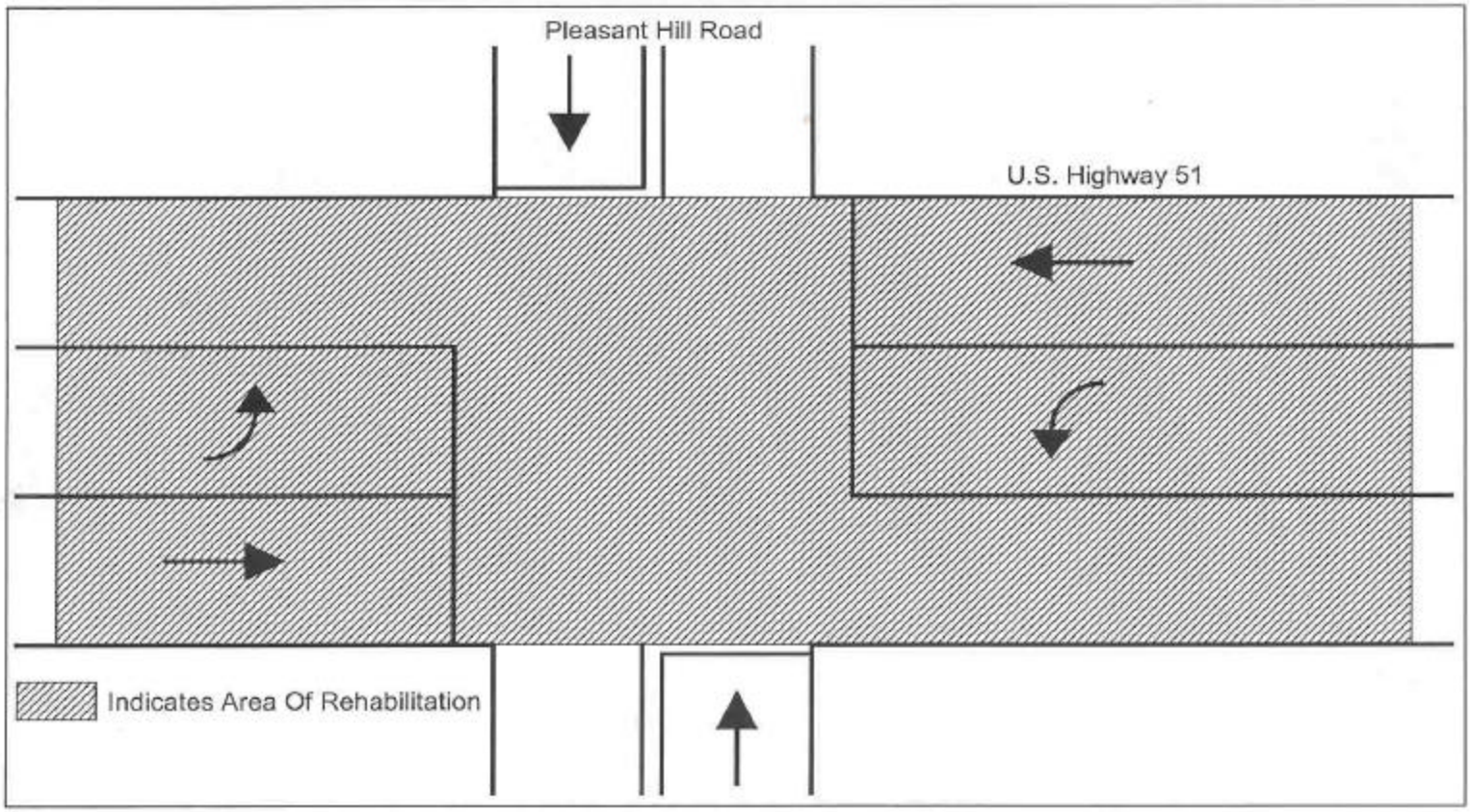
Decatur
U.S. Highway 36 And Oakland Avenue
Project Layout Map



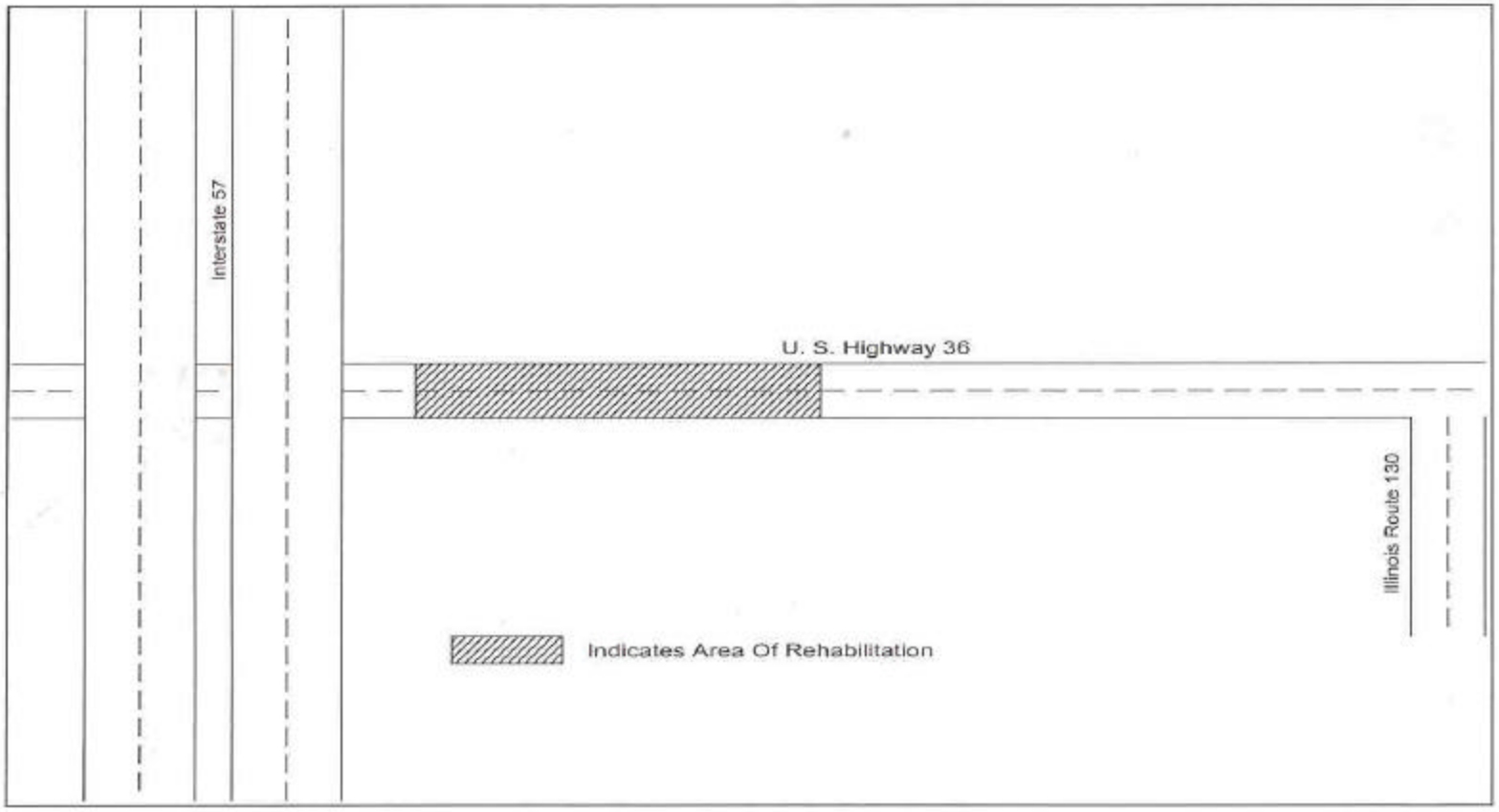
Decatur
U.S. Highway 36 And Country Club Road
Project Layout Map



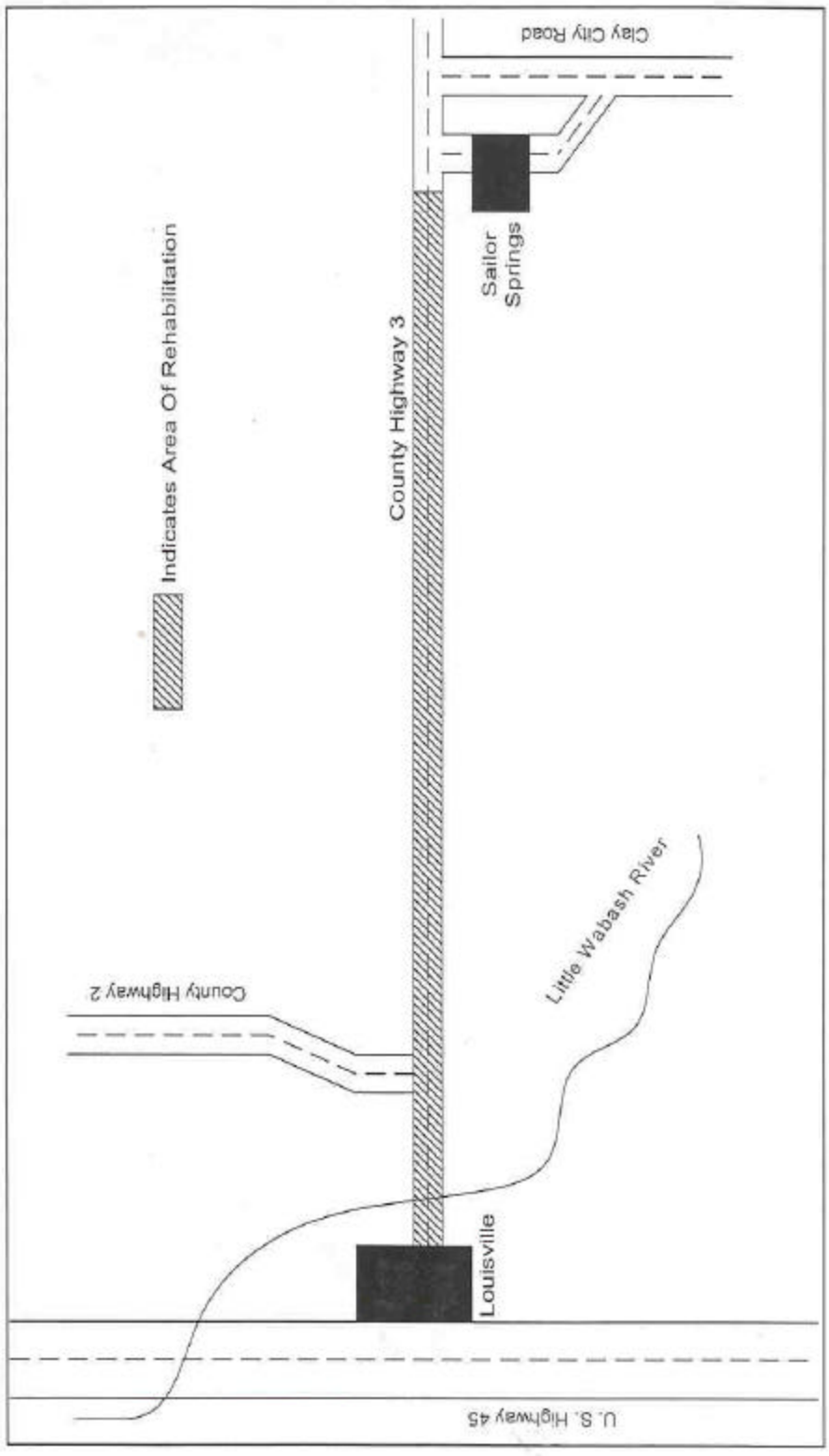
Carbondale
U.S. Highway 51 And Pleasant Hill Road
Project Layout Map



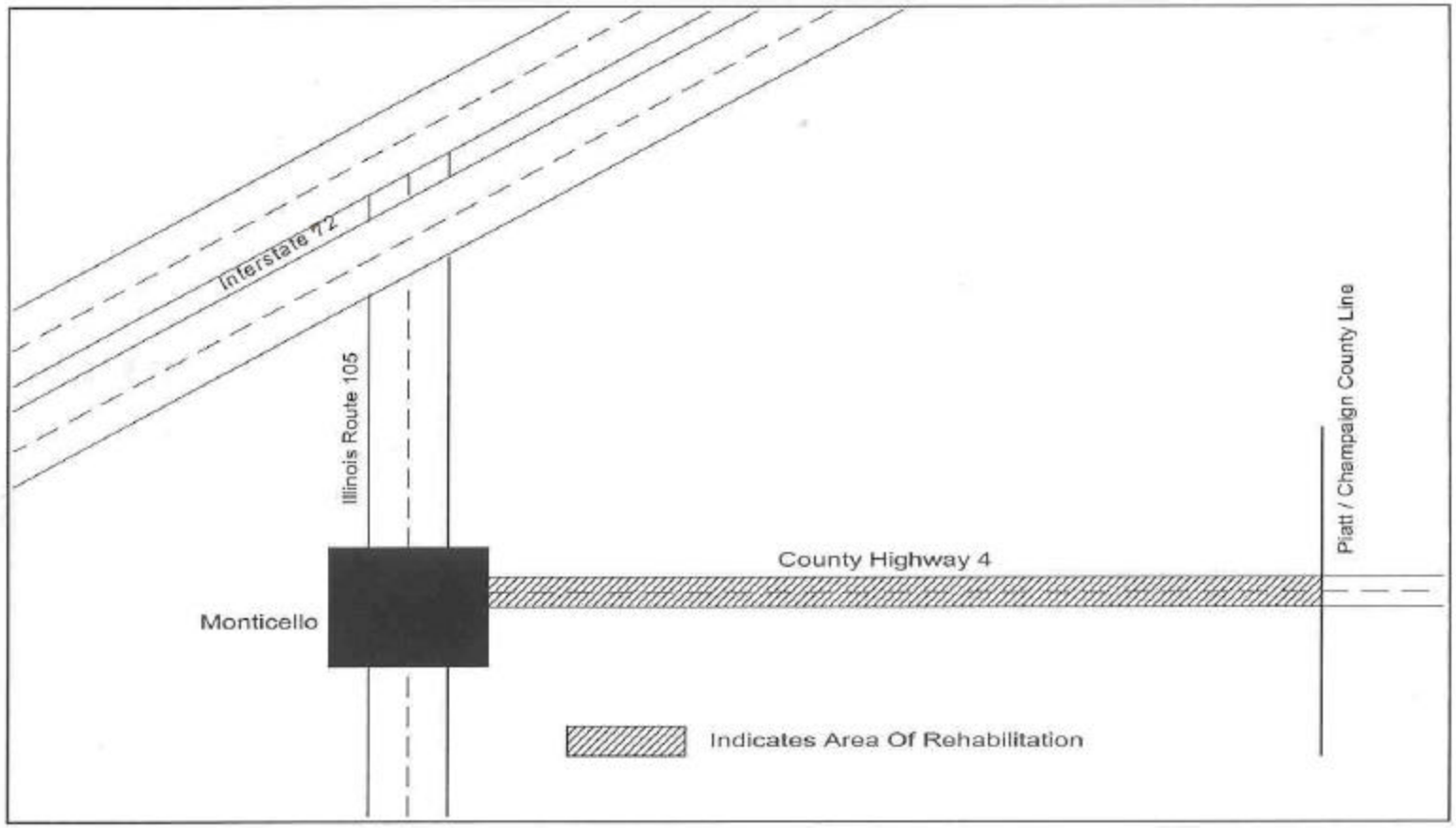
Tuscola
U.S. Highway 36
Project Layout Map



Clay County
County Highway 3
Project Layout Map



Piatt County
County Highway 4
Project Layout Map



Cumberland County
County Highway 2
Project Layout Map