

Thin Unbonded PCC Overlay of PCC Pavements on High Volume Roads

Task 1 Report Literature Review

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Chapter 1. Introduction

BACKGROUND

An unbonded overlay refers most often to a Portland cement concrete (PCC) overlay placed on an existing distressed PCC pavement. The two PCC slabs are separated by an interlayer, typically a 1 inch thick HMA that serves a twofold purpose of relaxing built up stresses so that reflective cracks cannot propagate upward, and also as a cushioning layer for the original PCC. An unbonded PCC overlay can restore ride, enhance surface characteristics, restore or improve structural capacity, and extend the life of the pavement structure [4]. This form of rehabilitation is considerably cheaper than total reconstruction and has been successfully used in many states, especially in Minnesota and Iowa. The major drawback of this rehabilitation alternative is bridge clearance, as a reduction of 10 in or more is common. This literature review was conducted in an effort to identify the state of the practice regarding thin unbonded jointed plain concrete overlays (TUBOL JPCP), so that lessons learned from previous studies can be incorporated and built upon in the new cells replacing MnRoad test cell 5.

HISTORY

Concrete overlays in conjunction with a bituminous interlayer have been used as early as 1913 [1]. More recently, unbonded overlays have been used in many states over the last 30 years, generally with reports of good to excellent performance [4].

In Minnesota, some of the earliest documented use of concrete overlays were on TH 12 east of St. Paul in 1955 when a 5 inch thick, 24 foot wide PCC layer was placed over a sand seal, and on TH 169 under SP5209-22, between Saint Peter and LeSeur, when in 1967 a 6 inch thick, 24 foot wide PCC overlay was placed over a 0.1mm polyethylene sheet (bond breaker) [5]. However, the first modern design unbonded overlays were constructed as a research test section, 0.64 miles long on the northbound portion of TH 71, and a complete unbonded overlay project constructed on TH 212 in Glencoe [5].

STATE OF THE PRACTICE

Mn/DOT currently designs and constructs a large number of unbonded PCC overlays and has experienced good to excellent performance from these projects. In

Mn/DOT district 1, TH 53 will be overlaid with a TUBOL in 2008 and possibly be incorporated into this study.

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Chapter 2. Evaluation and Planning

PAVEMENT EVALUATION

Evaluation of the existing pavement is an important step in the design and construction of TUBOL's. Visual distress surveys, core samples, and FWD analyses on high truck volume roadways [4] are necessary to accurately determine the support that the existing slab will contribute. When evaluating the structural integrity of existing pavement, it is important to keep in mind that working cracks and joints with poor Load Transfer Efficiency (LTE) are most critical to reflective cracking in the overlay. The goal of the existing pavement slab evaluation should be to determine the *uniformity* of support and contribution as a *stable* base.

PRE-OVERLAY REPAIR

Usually repairs are required for distresses that cause a major loss of structural integrity, or in areas where there is movement in the subbase that would lead to a non-uniformity of support. Typically extensive surface preparation (except for cleaning) is not required, as the separator layer can be used to “level out” discontinuities and imperfections. In fact some states increase overlay thickness as an alternative to extensive repairs [4]. Generally it is not recommended to place an unbonded overlay over a concrete with extensive materials related problems such as D-cracking, and ASR [13], however this can still be done. The following is a list of distresses that should either be fixed, or not fixed prior to placement of the UBOL.

Fix

- Active Panel movements
- Deviations from existing profile grade, especially at the joints
- Severely deteriorated joints and cracks – use full depth repair [5]
- Broken, or shattered slabs, pumping, tenting – use full depth repair [4]
- Blowups – may occur during construction due to excessive heat retention by the interlayer (should be repaired with a full-depth repair) [6].

Don't Fix

- Faulting when the interlayer is at least 1 inch thick. Retrofitting edge drains can also reduce faulting progression

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Chapter 3. Design

Typical Unbonded Concrete Overlays are designed as new rigid pavements on a rigid base, assuming an unbonded condition between the layers; consequently the overlay thickness can be determined using an established design procedure for new concrete pavements [4]. Further research that considers the effects of the interlayer and the underlying pavement may reduce the overlay thickness [4]. Unbonded is usually perceived to mean that there is no bond between the two PCC layers, this however is not true, as bonds exist at the upper and lower faces of the interlayer. A certain amount of friction is required between the overlay and the interlayer; otherwise the joints would not form properly, as happened on one of Minnesota's first interlayer projects, which lead to stricter joint depth sawing requirements of $t/3$ instead of $t/4$ [5]. TUBOL'S do not have a rational design method available. The new TUBOL sections at MnRoad are designed to supply data for development of a mechanistic-empirical design method.

OVERLAY THICKNESS DETERMINATION

Portland Cement Association (PCA)

The JSLAB program was used by the PCA to analyze unbonded overlays when an 18-Kip single axle load was placed at the edge of the pavement slab [7]. The underlying assumption was to design an overlay that is structurally equivalent to a new pavement placed on the same subbase and subgrade [7]. Design charts were developed to determine the thickness of the overlay based on the edge stresses, and assuming a modulus of elasticity of 5×10^6 psi for the overlay and between 3×10^6 and 4×10^6 for existing pavements with a slab length of 20 ft. Three design charts were developed based upon the condition of the underlying pavement, with the minimum recommended overlay thickness of 6 in.

1993 AASHTO design guide

The 1993 AASHTO design guide provides step by step procedures for performing a UBOL, however only the thickness determination will be discussed here. The thickness of an unbonded overlay can be determined using equation 3.1, where D_{OL} denotes the thickness of the overlay (in), and D_{eff} denotes the effectiveness of an existing PCC slab (equation 3.2). Note that the AC thickness is disregarded in computing the PCC OL

thickness. D is the existing slab thickness, and F_{jcu} is a joint adjustment factor (1-0.9) to account for deteriorated joints and cracks.

$$D_{OL} = \sqrt{D_f^2 - D_{eff}^2} \quad (\text{Equation 3.1})$$

$$D_{eff} = (F_{jcu})D \quad (\text{Equation 3.2})$$

NCHRP Mechanistic Empirical Design Guide (MEPDG)

The most recent MEPDG software available did not allow the analysis of an unbonded overlay of less than 7 inches thick. However, an analysis using this minimum thickness, and the appropriate conditions at the MnROAD test facility such as traffic and climate yielded a reliability of 0%. These results indicate an overly conservative design, and a need for better UBOL analysis procedures.

DESIGN ENVIRONMENT

Traffic

As with any pavement design, UBOLs must be constructed to withstand the traffic they are expected to carry. Performance data on UBOL show that ranges from 100,000 to 3 million annual equivalent single axle loads (ESALS) have yielded good performance [9]. This is important because ESALS are a major factor in faulting models [9].

Subgrade

The existing pavement contributes to the flexural stiffness, and not to the subgrade support (k). This is supported by recent findings [12], which indicate that the appropriate design subgrade modulus is the modulus of the subgrade, and not an inflated value to account for the stiffness of the existing PCC pavement surface. This is because the new UBOL is part of an overall pavement system that incorporates the existing structure [9]. Incidents where k values were “adjusted” to account for the properties of the existing concrete pavement have resulted in un-conservative (too thin) overlay design thicknesses which have failed prematurely [9].

DESIGN FEATURES

The following design features have been found to have a significant effect on the overall performance and service life of JPCP UBOL. These findings have been combined with an earlier literature search [5] conducted through Mn/DOT's library.

Separator layer or Interlayer

The separator layer is the most critical element in an unbonded overlay design as it provides a shear plane that helps to prevent reflective cracks from deteriorating the surface and prevents mechanical interlocking between the two pavement structures, which allows for independent movement [13]. The separator layer also serves as a “cushioning” layer between the two rigid PCC layers. This is important in reducing stresses from warp and curl. Minnesota's use of a 1 in. thick permeable asphalt stabilized stress relief course (PASSRC) has been found to provide good performance. This drainable material is an effective tool at mitigating the moisture distresses of both joint faulting and pumping. The PASSRC material, as with most interlayers, can be used to smooth and level out the existing PCC surface to provide more uniform surface. This may be a contributing factor that explains why UBOLs often have higher initial ride and deteriorate at a slower rate than newly constructed PCC pavements, according to the Mn/DOT Pavement Management System (PMS) [14].

Although the interlayer may reduce the stresses induced through dynamic and environmental strain such as traffic loadings and slab warp/curl, the underlying rigid pavement is much more stiff than traditional base materials, which may compromise its' ability to relax built up stresses. In addition the relaxation properties of the HMA interlayer change significantly with temperature, behaving more rigid during winter periods. It has been shown that this interlayer can reduce the slab warp/curl of the underlying existing pavement as the temperature differential is decreased significantly due to the increased insulation from the sun.

The use of chip, sand or slurry seals as a separator layer are not recommend, as they do not provide sufficient separation to prevent reflective cracks [9]. However, slurry seals were found to be effective if there is insignificant faulting in the underlying pavement [5]. Polyethylene sheets, roofing paper and curing compounds are not recommended for use as a separator layer.

According to NCHRP Report No. 415 the interlayer properties should be such that they fulfill the following goals: (1) separate the pavements, (2) maintain a sufficient bonding and friction (between the new and existing PCC slabs) so that joints can form in the new overlay, (3) provide for a level-up layer, and (4) be cost effective. The authors note that the most successful interlayer system is an HMA layer at least 1 inch thick.

Jointing

Voigt et al [11] recommended that joint spacing for UBOLs be less than, or equal to 15 feet. Another recommendation [9] was that the spacing should be the same as a conventionally designed JPCP on a stiff lean base course. A maximum l/L of 4.5 to 5.5 is recommended, which is lower than the 6 to 7 range recommended by Mn/DOT [5], where L is the slab length, and l is the radius of relative stiffness (stiffness of the slab relative to the foundation calculated with Westergaard's equation, 1926) [7].

$$l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}} \quad (3.1)$$

E = Modulus of Elasticity of PCC

h = Slab thickness

k = Modulus of subgrade reaction

μ = poisson's ratio for PCC (usually taken as 0.15)

L = dimension of length (ft)

In general dowels were not recommended when traffic levels were less than 0.8 million 18-kip ESALS per year. Mcghee [15] and Engstrom [5] recommend that overlay joints be mismatched from those of the underlying pavement by 2 – 3 ft. The mismatched joints should provide for enhanced load transfer, reducing the need for mechanical load transferring devices such as dowels [11]. However, “Many states do not mismatch the joints, and have not reported any adverse effects” [13] and “FHWA performance reviews indicate that nearly all undowelled pavements fault significantly in 10-15 years” [15]. In addition mismatched joints may increase construction costs, as the joint spacing would vary considerably. Most studies concluded that the decision to mismatch joints should be evaluated on a project by project basis.

The new MnROAD TUBOL test cells will have a slab length of 15 ft, which has been found through numerous studies to provide good performance. However, due to the slab being relatively thin (4"-5"), the l/L will be much higher (at least twice) than the range recommended by Engstrom [5]. The underlying pavement has 20 ft joint spacing with skewed joints, so joint mismatch will vary, and every 60 ft the joints will line up. The test cell will not use dowels, or have tied shoulders. The absence of dowels could become a significant issue as the overlay is subjected to a high number of ESAL loadings due to the interstate traffic. If significant early faulting occurs, alternative dowel types such as flat plate dowels may be retrofit to help improve the load transfer efficiency and reduce further faulting of the overlay.

Sub-Drainage

Studies in California and Wyoming have reported reduced pumping and joint faulting attributed to the use of a drainage layer in UBOLs [9]. A permeable AC interlayer with edge drains was found to improve overall performance, validating Minnesota practices with the PASSRC interlayer system. There were no references found which used strip/wick drains orientated perpendicular to the pavement structure in conjunction with PASSRC designed as the new MnROAD TUBOL cell 5.

Thickness of Overlay

According to NCHRP Report No. 415 [9], a 6 in. thick JPCP UBOL is not thick enough to withstand heavy interstate traffic, especially if the underlying pavement is badly deteriorated [9]. The report also noted that improved design procedures are needed, as commonly used procedures have resulted in several major failures, especially in the use of erroneous k values. The new MnRoad TUBOL test cells are designed to test the limits of commonly accepted rules and design procedures, by applying a thin UBOL of 4-5 inches subjected to interstate loading. In 1977 Mn/Dot placed a 5.5 inch UBOL on TH 71 that experienced mid panel cracks, however this was Mn/DOT's first use of UBOL, and these cracks may have been due to other design features such as longer joint spacings, stripping of the interlayer, and use of lime slurry.

Shoulders

It is recommended to make the most use of the structural support provided by the existing shoulders, and for design purposes, to assume that the UBOL will behave in the same manner as a new pavement [9]. The current design of the new MnROAD TUBOL test cells uses bituminous shoulders, which provide less structural support than tied PCC shoulders.

Width of Overlay

There are two different types of widening in PCC pavements; intentional widening for structural purposes, and widening so that the overlay may be placed on a narrower underlying pavement [9]. The intentional widening of the traffic lane overlay slab to move traffic away from the free edge may be very beneficial, as this may reduce edge stresses in the overlay slab. This will also lead to more interior loading thus reducing maximum stresses and deflections typically experienced at the edge. A recent study indicated that an additional 2 ft. of width is equivalent to 1 inch of additional thickness [10]. The new MnROAD TUBOLs will have widened slabs to match the existing test cell 5 widened dimensions.

Chapter 4. Construction

Sources recommend that the interlayer be placed so that it extends past the edge of the existing concrete slab by 2-3 ft., in order to provide support for the paver tracks [9]. If temperature of the asphalt separator layer is greater than 120°F, surface watering, misting, or white washing (with a white pigmented curing compound, or lime slurry) can reduce the temperature to lower the occurrence of early age shrinkage cracking in the new concrete overlay [6, 9]. The white washing should be applied at least one day before paving, or the installation of reinforcement (if any). Minnesota has used lime slurry white wash on past projects, which has been shown to reduce pavement temperatures by 20 to 25°F [5]. Recent evidence has shown that whitewashing may affect the bond between the interlayer and the concrete overlay; in fact the application of this product is often accompanied by warnings not to apply it to the paver trackline in order to prevent loss of traction and drifting [9].

There may be clearance problems associated with UBOL that need to be evaluated, bridge jacking is a possible solution [9].

Subsurface drainage is constructed similar to conventional pavements. Special consideration must be made to ensure that permeable interlayers have access to a drainage system to discharge collected water [9]. The new Mn/ROAD test cells will utilize a unique wick drain design to discharge water that accumulates in the PASSRC layer.

The construction Sequence of UBOL as suggested by Engstrom [5] is as follows:

1. Clean existing pavement and shoulders
2. Install mini-weep drains
3. Install PASSRC
4. Pave unbonded overlay
5. Install pavement edge drains
6. Pave new bituminous shoulder

Chapter 5. Field Performance

NCHRP Synthesis Report No. 415 conducted a literature review, a survey of state highway agencies, and obtained data from the LTPP database in an attempt to establish a relationship between site condition and design factors on overlay performance. They noted some general characteristics that contributed to good UBOL performance such as: thicknesses of at least 7 in., an AC interlayer at least 1 in. thick, and doweled joints [9]. They also noted the general characteristics that contributed to poor performance such as those with thin slabs (6 to 8 in.) and no dowels. An earlier NCHRP synthesis No. 204 noted that UBOL have demonstrated good performance for the past 30 years, and that most failures have been attributed to inadequate thickness of the separator layer, bonding at the interface, non-uniform support conditions, poor load transfer and poor drainage [15].

MINNESOTA EXPERIENCES

Minnesota has constructed at least 11 unbonded concrete overlays and has learned from each project to improve subsequent projects. Mn/DOT placed its first unbonded PCC overlay on TH 71 in 1977 under State Project Nos. SP3411-41 & SP6509-12. A 5.5 inch thick, 24 foot wide overlay was placed on top of a 1 inch thick, 28 foot wide Mn/DOT 2331 modified plant mixed bituminous separator layer. The jointed plain (unreinforced) concrete pavement (JPCP) had 6:1 skewed joints with dowels, and 15.5 foot effective random joint spacings (13-16-14-19). There were no repairs made to the original pavement prior to overlay, as it was still in relatively good condition. There was also no cleaning performed prior to overlay, however cleaning was recommended for future projects [5]. It was concluded that the overlay may have been too thin as it developed mid-panel cracks, it was hypothesized that the developed cracks were reflected over areas of weak soils. It was also observed that the bituminous stabilized stress relief layer had stripped [5].

The location of the midpanel cracks were not explicitly stated, it has been observed through experimental studies, "...On pavements with random joint spacings, slabs with joint spacings greater than 18 ft experienced more transverse cracking than shorter slabs" [7]. This may have contributed to some of the observed midpanel cracks.

On later Mn/DOT projects this spacing was reduced from 15.5 to 15 ft effective random joint spacing (13-16-14-17) and there were no explicit reports on midpanel cracks for these sections. However the thickness of these sections was also increased, so it is not readily apparent if the crack reduction was due to the increased slab thickness, or the reduced joint spacing.

The addition of a drainage system, and an open gradation for the bituminous separator layer, may have alleviated the stripping of this layer. On later projects these modifications were implemented and no stripping was reported.

From the 11 UBOL projects in Minnesota that were observed, it can be concluded that the Permeable Asphalt Stabilized Stress Relief Course (PASSRC) performed very well, by reducing friction between the slabs, but caused some joints to separate more than 2". This led to stricter requirements for sawing joints to a depth of $t/3$ instead of $t/4$ in future projects.

REGIONAL EXPERIENCES

Illinois

In 1995 the state of Illinois placed a Continuously Reinforced Concrete (CRC) overlay over an existing AC/PCC composite pavement. The surface AC layer had rutting problems, and numerous concrete patches; these distresses had to be corrected using cold milling full depth patches (to the level of the original pavement) and replacement with AC binder in order to provide a level and uniform AC interlayer prior to the placement of the CRC [1]. The AC layer was white washed to prevent excessive heating of the bottom of the newly placed CRC pavement [1, 3]. Illinois chose to use a concrete overlay instead of a bituminous overlay because they have found bituminous overlays to be prone to early distresses when placed on badly deteriorated PCC pavements, greatly reducing the performance and cost effectiveness of rehabilitation. The performance was reviewed in 2002 and although low severity transverse cracking was present, deflections (as measured by FWD), IRI, and visual distress surveys indicate that pavement has been performing well [3]. This was the fourth concrete overlay that the state of Illinois has performed, they have noted that three previous projects have performed well for at least twenty years and recommend that:

1. The overlay and the existing pavements both have the same width, and the surface should be true before the overlay is placed
2. The unbonded overlay was structurally equivalent to a new pavement
3. Unbonded overlays can be a more cost effective option than total removal and reconstruction
4. Increased thickness leads to increased performance [1].

Indiana

Gulen and Nureldin [2] published a comparison of three concrete rehabilitation techniques: fiber modified HMA overlay placed on a cracked and sealed pavement, HMA overlay placed on a rubblized pavement, and an unbonded concrete overlay using a 30mm HMA interlayer. The unbonded overlay was designed using the procedure outlined in the AASHTO 1993 guide, and may have been too conservative (305 mm, 12.5 in). All three projects were located on I-65 in Indiana. Although all three options performed satisfactorily, the unbonded overlay had the best performance concerning reflective crack elimination, improved structural capacity, and good skid resistance and visual survey results. In addition a life cycle cost analysis revealed that the unbonded overlay was the most cost effective assuming a 30 year analysis period, 5% discount rate and neglecting the salvage value, routine maintenance and user costs. It should be noted that the costs are relatively close (\$900 difference between rubblization), and treatment preference could change with slight input modifications [2].

Chapter 6. Maintenance & Rehabilitation

Typical UBOLs perform as standard PCC pavements and require little maintenance.

Generally UBOLs cannot be overlaid due to geometric constraints; however asphalt overlays can be placed as if the UBOL was a concrete pavement. Also, rehabilitation of UBOL is often times easier than conventional concrete pavements as the underlying pavement provides structural support and a good working surface [9]. If the interlayer is intact, then breaking, or rubblization processes can proceed without damaging the underlying pavement [9].

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Chapter 7. Conclusions & Recommendations

Based upon the literature review conducted thus far it is evident that the current design and instrumentation of the new Mn/ROAD TUBOL test cells will incorporate both proven design and construction techniques, as well as new experimental features that will help to advance the state of the art of thin UBOL (TUBOL). The PASSRC interlayer, joints and construction methods to be used have provided success on past UBOL projects. The use of transverse orientated strip/wick drains on a heavily instrumented (TUBOL) subjected to interstate traffic and harsh weather conditions, was not found in the literature. This experiment will either validate current design thicknesses, or provide evidence that current practices are overly conservative. In addition the important strain, deflection, and temperature data gathered will provide invaluable information for future TUBOL design projects, especially those utilizing enhanced mechanistic empirical design methodologies that require calibration. It is therefore recommended, based on literature findings, that the project proceed with no modifications to the current design.

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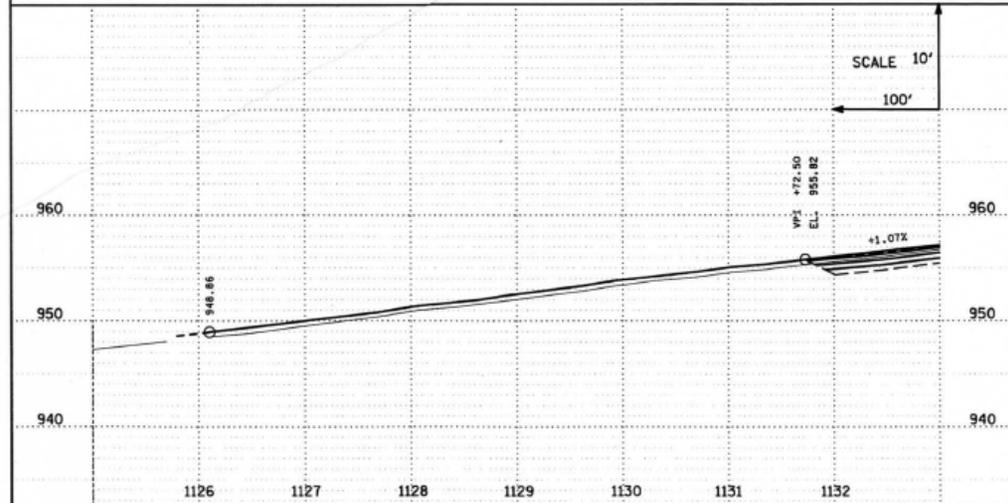
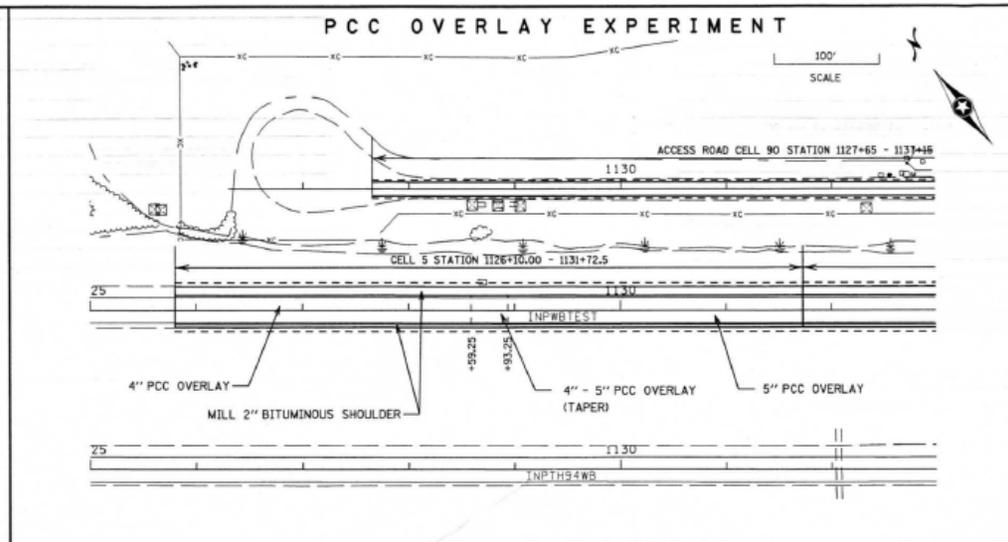
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Appendix A: Construction Plans for New MnROAD TUBOL Test Cells

TABULATED QUANTITIES FOR CELL 5 (STA. 1125+80 TO STA. 1131+72.5)		MPR-610161		
ITEM NO.	ITEM DESCRIPTION	UNIT	TOTAL	
2105	WICK DRAIN	(1)	LN FT	126
2221	AGGREGATE SHOULDERING (CV) CLASS 5		CU YD	121
2221	AGGREGATE SHOULDERING SPECIAL		TON	58
2231	PAVEMENT CRACKING	(2)	LN FT	36
2301	CONCRETE PAVEMENT STANDARD WIDTH 4"	(3) (4)	SQ YD	829
2301	CONCRETE PAVEMENT STANDARD WIDTH 5"	(3) (4)	SQ YD	949
2301	STRUCTURAL CONCRETE		CU YD	224
2301	CONCRETE CORING		EACH	2
2350	BITUMINOUS MIXTURE FOR PERMEABLE ASPHALT STABILIZED		TON	98
2350	ASPHALT CEMENT FOR MIXTURE		TON	3
2357	BITUMINOUS MATERIAL FOR TACK COAT		GALLON	175
2357	BITUMINOUS MATERIAL FOR SHOULDER TACK		GALLON	71
2360	TYPE SP 12.5 WEARING COURSE MIXTURE (4,B)		TON	119

NOTES:

- (1) INSTALL HORIZONTAL STRIP/WICK DRAINS (1" H X 12" W) AT 100' SPACINGS UNDER CLASS 5 AND HMA SHOULDERS. PLACE TO CONNECT WITH AND DRAIN PASSRC LAYER.
- (2) SEE DETAIL ON SHEET NO. 19.
- (3) NO DOWEL BARS OR TIE BARS ARE REQUIRED. 15' JOINT SPACING. SEALING OF PAVEMENT JOINTS IS NOT REQUIRED.
- (4) SEE SPECIAL PROVISIONS FOR SURFACE FINISH REQUIREMENTS.



TABULATED QUANTITIES, PLAN & PROFILE SHEET STA. 1125+80.0 - 1131+72.5 (CELL 5)

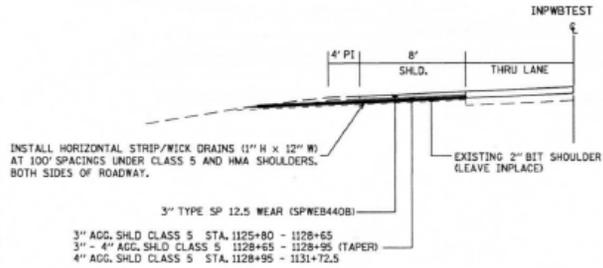
CERTIFIED BY *Timothy R. Claps* L.I.C. NO. 43862
LICENSED PROFESSIONAL ENGINEER

FILE NAME: (S:\prj\19418680\157\des\gn1\0680157_cp115.dwg) 12/4/2007
STATE PROJ. NO. 8680-157 (T.H. 94) SHEET NO. 18 OF 69 SHEETS

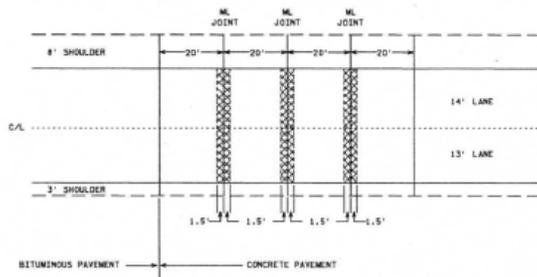
TEST EQUIPMENT

UPON COMPLETION OF PASSRC LAYER, MN/ROAD OPERATIONS REQUIRE 3 WORKING DAYS TO INSTALL INSTRUMENTATION. THE CONTRACTOR SHALL COORDINATE WITH MN/ROAD OPERATIONS DURING PAVEMENT PLACEMENT OPERATIONS FOR THE INSTALLATION OF INSTRUMENTATION.

WICK DRAIN DETAIL
STA. 1126+10 TO STA. 1131+72.5



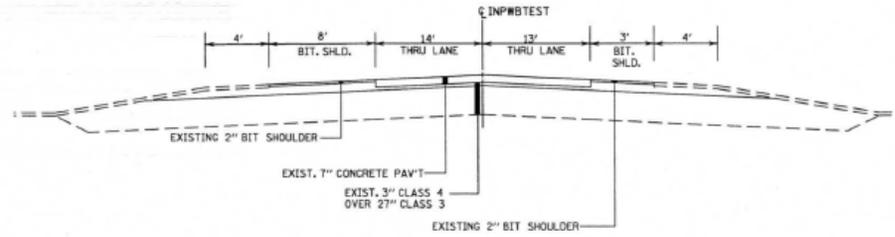
PAVEMENT CRACKING DETAIL



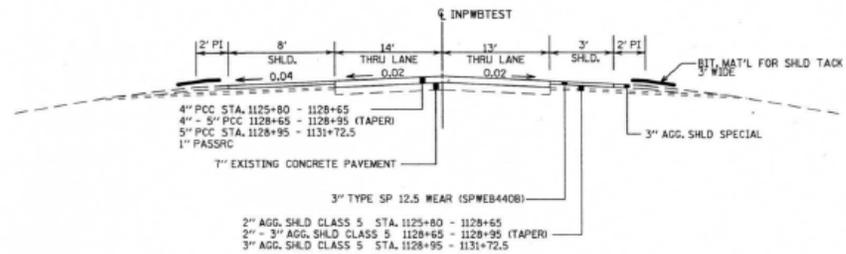
CRACKING PLAN
1125+80 TO 1127+30 INDUCED CRACKING AT JOINTS (8 JOINTS)
1127+30 TO 1128+95 NO CRACKING-CONTROL SECTION (8 JOINTS + 2 TRANSITION)
1128+95 TO 1130+45 INDUCED CRACKING AT JOINTS (8 JOINTS)
1130+45 TO 1131+72.5 NO CRACKING-CONTROL SECTION (6 JOINTS)

NOTE: NO CRACKING ADJACENT TO BITUMINOUS PAVEMENT. CRACKING SHALL BE PERFORMED ON MAINLINE (27' WIDTH) ONLY.

EXISTING CELL 5
STA. 1126+10 TO STA. 1131+72.5



PROPOSED CELL 5
STA. 1126+10 TO STA. 1131+72.5



TRANSITIONS CELL TO CELL MAYBE VARIABLE SEE PROFILE SHEETS.

TYPICAL SECTIONS (CELL 5)

CERTIFIED BY *Timothy R. Olson* L.I.C. NO. 03862
LICENSED PROFESSIONAL ENGINEER

FILE NAME: S:\pr\19418680\157\des\ign\06680157_06115.dgn
STATE PROJ. NO. 6680-157 (T.H. 94)

12/4/2007
SHEET NO. 19 OF 69 SHEETS

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