**REHABILITATION OF CONCRETE PAVEMENTS UTILIZING RUBBLIZATION**

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**ABSTRACT :**

Rubblization is a construction and engineering technique that involves saving time and transportation costs by reducing existing concrete into rubble at its current location rather than hauling it to another location. In road construction, a worn-out Portland cement concrete can be rubblized and then overlaid with a new surface, usually asphalt concrete. Specialized equipment breaks up the old roadway into smaller pieces to create a crushed, high-quality aggregate base for the new pavement. This saves the expense of transporting the old pavement to a disposal site, and purchasing transporting new base materials for the replacement paving. The result is a smoother pavement surface than would be obtained if a layer of asphalt were to be applied to the unbroken concrete surface The technique has been used on roads since the late 1990s, and is also being used for concrete airport runways.

In many respects, the rehabilitation of pavement systems is a more complex engineering task than the design of new pavement systems. Rehabilitation is generally considered to be actions taken that significantly extend the service life of an existing pavement. On the other hand, routine maintenance is considered actions that preserve the existing pavement in order to accommodate present traffic loadings. Pavement rehabilitation requires significant engineering judgment in the evaluation process. The engineer must define the problem, develop potential problem solutions and then2 Transportation Research Circular E-C087: Rubblization of Portland Cement Concrete Pavements select the preferred solution. Rehabilitation of PCC pavements can be done by concrete pavement restoration, reconstruction and by resurfacing. Due to the expense, time and traffic delay involved in CPR and reconstruction, resurfacing of PCC pavements with an HMA overlay is a very appealing option for many agencies. The objective of this paper is to provide an overview of current design and construction guidelines specific to the PCC rubblization process.

**INTRODUCTION**

An asphalt overlay of a fractured concrete pavement is placed to increase the structural capacity of the pavement. Slab fracturing may be done for two reasons: to attempt to mitigate reflection cracking in the overlay, and/or to dispense with pre-overlay repair of a concrete pavement with extensive cracking and/or materials-related deterioration (e.g., “D” cracking, alkali-silica reaction, alkali-carbonate reaction, etc.). Several surface preparation techniques have been used before placing an HMA overlay in attempts to minimize reflection cracking. Some of the most common techniques are rubblization, crack-and-seat, break-and-seat, and saw-and-seal (Hall et al. 2001).

Thompson’s 1989 National Cooperative Highway Research Program (NCHRP) Synthesis of Highway Practice summarized breaking/cracking/seating (B/C/S) practices and technology. Several field investigative studies have indicated that the B/C/S techniques delayed, but did not eliminate reflection cracking (Thompson 1999). The results from a comprehensive investigation conducted by PCS/Law (1991), the National Asphalt Pavement Association (NAPA) study (NAPA 1994), and a nationwide survey conducted by the Florida DOT (Ksaibati et al. 1999) all indicate that rubblization is the most effective procedure for addressing reflection cracking. Rubblization involves breaking the existing PCC slab into pieces (usually ranging from 2 to 6 inches) and overlaying with HMA. It has been concluded that the rubblized PCC behaves like “a high-strength granular base,” with strength between 1.5 to 3 times greater than a high-quality, dense-graded, crushed-stone base in load-distributing characteristics (PCS/Law 1991). The design of the structural overlay thickness for rubblized projects is difficult, as the resulting structure is neither a “true” rigid pavement nor a “true” flexible pavement.

Classical rigid pavement analysis and design is based upon the Westergaard theory, while classical flexible pavement analysis and design is based upon the Burmister multi-layer theory. Based on the assumption that the rigidity of the PCC slabs has been destroyed, the Burmister approach may be used with HMA-overlaid fractured PCC pavement. It has been proposed that the Westergaard approach may be used to evaluate the pre-rubblized PCC slabs, whereas Burmister theory may be used for post rubblization analysis (Bemanian and Sebaaly, 1999). HMA overlay thickness design procedures for rubblized PCC pavements have been proposed by NAPA and the Asphalt Institute, based on the structural number-layer coefficient principles used in the existing 1993 AASHTO design guide. The AASHTO design guide requires the determination of a layer coefficient for the rubblized PCC. This coefficient varies considerably depending on the state agency and the design procedure used, giving rise to a wide range of HMA overlay thicknesses. As a result of the analysis of 19 existing sections, layer coefficient values in the practical range of 0.23 to 0.31 were recommended by PCS/Law in a report dated June 1991. These recommendations are based on results from different states, and they therefore reflect differences in material specifications and construction practices. Thus, there is a need to

estimate the in situ layer coefficient of rubblized concrete pavements in Iowa to provide

recommendations for future design.

**METHODS OF RUBBLIZATION**

Before rubblizing, longitudinal underdrains are installed, if necessary. Underdrains must be in place before rubblizing on interstates and high volume primary routes. Existing HMA overlays are then removed, and a fulldepth saw cut is made to sever abutting concrete pavement that will not be rubblized. The concrete pavement is rubblized using one of the following methods:

1. A Resonant Frequency Breaker (RFB)
2. A Multi-Head Breaker (MHB)

**A .Resonant Frequency Breaker**

The Resonant Frequency Breaker (RFB) is a self-propelled device that utilizes high frequency, low amplitude impacts with a foot force of 2,000 lbs. The foot is located at the end of a pedestal that is attached to a beam and counter weight. The force applied to the pavement is achieved by vibrating the large steel beam connected to the foot. The foot is moved along the concrete surface at the front of the machine. The breaking principle is that low amplitude, high frequency, resonant energy is delivered to the concrete slab, resulting in high tension at the top. Since concrete has low tensile strength, the slab fractures on a shear plane through the pavement. The foot, beam size, operating frequency, loading pressure and speed of the machine can be varied. Using the RFB, the breaking begins at the centerline and proceeds to the outside edge of the pavement. The breaking pattern is approximately 8 in. wide, thereby requiring approximately 18 to 20 passes to break a 12 ft wide lane. The RFB is generally required to operate at a maximum amplitude of one inch to avoid disruption of base and prevent damage to underground structures. The RFB encroaches about 3 to 5 ft onto the adjacent lane to rubblize near the centerline of the pavement. Since the RFB has wheel loads of 20,000 lbs and a total weight of 60,000 to 70,000 lbs, the fractured pavement, shoulder and subgrade must be adequate to support multiple passes of the equipment.



**FIGURE: RFB for PCC Rubblization**

**CONSTRUCTION PROCEDURE**

• Remove any existing overlay.

• Install the drainage system 2 weeks (minimum) prior to rubblizing the pavement.

• Saw-cut the full thickness of the pavement adjacent to remaining sections.

• Rubblize the PCC pavement.

• Cut and remove exposed steel reinforcement.

• Proof roll fractured PCC.

• Remove and replace soft areas.

• Roll the rubblized PCC at least three passes.

• Place the HMA leveling course and overlay.

Removal of any existing overlay is necessary to assure consistent fracture of the concrete pavement by allowing the breaking head to directly contact the PCC. This is normally done by cold milling immediately before edge drains/shoulder reconstruction begins for convenience and to avoid excessive drop-off between the lane and shoulder since traffic will usually have to be routed onto the existing traffic lanes at least temporarily during construction.

**B. MULTI-HEAD BREAKER METHOD**

A Multi-Head Breaker (MHB) has a set of drop hammers keyed to impact the pavement in a specific pattern. The drop hammers are located at the rear, allowing the machine’s weight to be supported by unbroken concrete. Full-lane coverage can be achieved in a single pass. The subgrade should demonstrate a minimum Immediate Bearing Value (IBV) of 3 to 5 before rubblizing with either breaker type. The designer may wish to limit the equipment to the MHB for a thin pavement with little or no base course. Contact BMPR if considering any such equipment restrictions. Rubblizing can be performed while maintaining traffic in an adjacent lane, but the resonant frequency breaker may intrude partially into the adjacent lane when rubblizing near the centerline, causing traffic to use the shoulder. Additionally, if temporary lane openings are desired between placement of multiple HMA lifts, then a minimum pavement thickness must bein place before opening the rubblized lane to traffic. This minimum thickness depends on the volume and composition of traffic on the roadway. Vertical clearance at overhead structures, and the presence of buried utilities are important considerations for determining if rubblizing is a suitable rehabilitation alternative. Rural sections without overhead structures are ideal locations for rubblizing. A detailed life-cycle cost comparison of available alternatives should be conducted.



**Fig.: MULTI-HEAD BREAKER METHOD**

**CONSTRUCTION PROCEDURE:**

* Install the underdrain system.
* Remove any existing HMA overlay(s).
* Repair/replace any “unsound” PCC patches either concrete or HMA.
* Rubblize the PCC to meet specification. The surface of the MHB rubblized PCC is typically “flaky” in nature.
* Compact the rubblized slab with a Z-pattern roller to reduce the size of “flaky” particles
* Compact the rubblized PCC with a vibratory roller. (IDOT requires four passes.)
* Compact the rubblized PCC with a pneumatic-tired roller. (IDOT requires two passes.)
* Immediately prior to constructing the HMA OL, compact the rubblized PCC with twopasses of a vibratory steel-wheeled roller. A typical finished rubblized PCC surface ready for HMA paving.

**PROCESS DIFFERENCES**

The two types of rubblization equipment just described operate in completely different modes to achieve the required rubblization of the PCC pavement. The RFB is a high frequency, low amplitude process while the MHB is a low-frequency, high-amplitude process. Research is currently underway to document the effects of the different equipment types on the underlying subgrade integrity, rubblized layer permeability, and effective modulus.

The size of rubblized particles is dependant upon the amount of rubblization energy put into the pavement, the strength of the pavement itself, and the amount of support provided by the subgrade. The size distribution of particles is confirmed by digging test pits through the rubblized pavement, then visually inspecting to confirm project specifications are being met. On light-load airfield pavements, soft spots within the subgrade can be detected by noticing a change of particle size, assuming the rubblization energy and PCC pavement thickness/strength remains constant. When soft or unstable subgrade areas are detected, a solution must be worked out.The solution may be as simple as allowing additional time for the underdrains to work, putting floatation tires on the RFB or changing the drop height of the MHB.

**ADVANTAGES OF RUBBLIZATION**

* Elimination of reflection cracking.
* Improvement in smoothness with the placement of HMA as the new surface.
* Dramatic decrease in construction time relative to PCC reconstruction
* Improved maintenance of traffic.
* Reduction in cost versus reconstruction of PCC pavement.
* Increase in service life of the HMA overlay.
* Improved public relations due to decrease in construction time and work zone delays.

**CONCLUSION**

* As agencies continue to look for cost-effective methods to rehabilitate PCC pavements, it is clear that rubblization offers an excellent tool to the pavement engineers.
* The pavement engineer is able to rehabilitate an existing deteriorated PCC pavement into a long-life HMA pavement very quickly and with minimal disruption to the traveling public.
* In addition, costs are kept to a minimum, the process is no longer experimental. Rubblization of PCC with an HMA overlay works and can provide excellent pavement performance.

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