

Rubblization

A Way to Save Time, Money, and Resources

By Dave Newcomb, P.E., Ph. D.

When concrete pavements reach a certain level of deterioration, rubblization of the concrete with an asphalt overlay is the easiest, cheapest, and most effective way to rehabilitate the pavement in the shortest amount of time. Breaking the existing concrete pavement produces a high-quality, interlocked granular base on which to build a long-life asphalt pavement with little chance of reflection cracking and presents an opportunity for speedy construction which reduces highway user delays and lowers life-cycle costs.

By eliminating the large movements of concrete slabs due to temperature and moisture changes, rubblization does away with the occurrence of reflection cracking in the HMA at concrete joints and existing cracks. The rubblization of an existing concrete pavement can be achieved either through the use of high-impact traveling hammers or through high-frequency beams that transmit force and vibration to the slab through a traveling steel shoe. Both methods succeed in breaking the slab and reducing the size of the concrete pieces to less than 9 inches on the surface. Breaking the slabs in-place allows the pieces to remain interlocked, which provides much greater stability than would be found in a typical granular base material. A NAPA-funded study on rubblization found that rubblized concrete slabs generally have a modulus of about 500,000 psi, whereas typical granular base materials have modulus values in the range of 20,000 to 40,000 psi.

In general, the candidate concrete pavement should be in a state that would dictate either complete removal and replacement (the remove-and-replace option) or extensive patching with overlay. This is usually the case when one or more of these conditions are met:

- The concrete requires 10 to 20 percent patching
- Extensive alkali-silica reaction or alkali-chloride reaction cracking is present

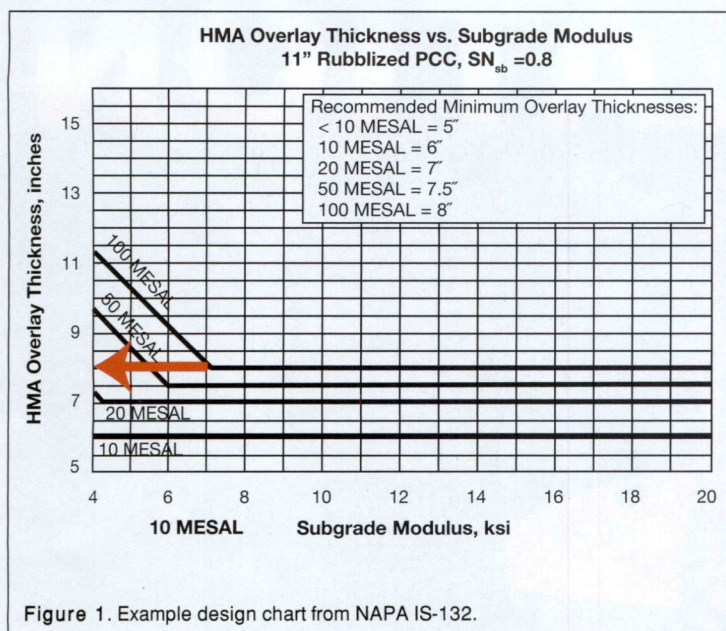
- Extensive durability cracking is evident
- There is sufficient dowel bar locking, resulting in persistent blow-ups or severe cracking
- Reoccurring severe faulting
- Severe longitudinal or transverse joint deterioration

Likewise, there are times when rubblization should not be used, such as in the case of relatively thin concrete slabs (7 inches or less) resting on weak foundations. In cases where there is a need to maintain grade, as with curb and gutter sections, rubblization can be used in conjunction with milling at the curb. Where there are overhead bridges, the original pavement material in the vicinity of the bridge can be removed and replaced, while the pavement is rubblized and overlaid in between the bridges.

Rubblized and overlaid sections should be designed with drainage and traffic demand in mind. The first item of work in a rubblization project should be the installation of edge drains. The edge drain should be placed adjacent to the concrete slab and drained into the ditch at headwalls spaced about 500 feet apart, depending upon drainage requirements. The edge drains will facilitate the flow of water from under the pavement which may be generated during rubblization. The overlay of the rubblized concrete should be designed using an existing procedure such as found in NAPA Publication IS-132, *Rubblization*. It is possible to design a long-life or Perpetual Pavement on the rubblized concrete by assuming a very high level of traffic.

To illustrate the design for rubblization with an HMA overlay, consider an 11-inch concrete pavement in a condition which dictates that rubblization is an option. The following apply:

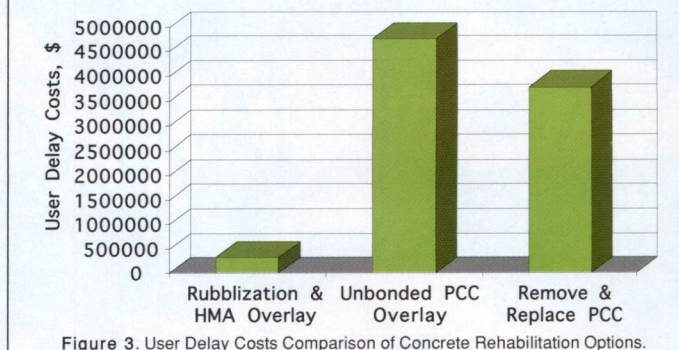
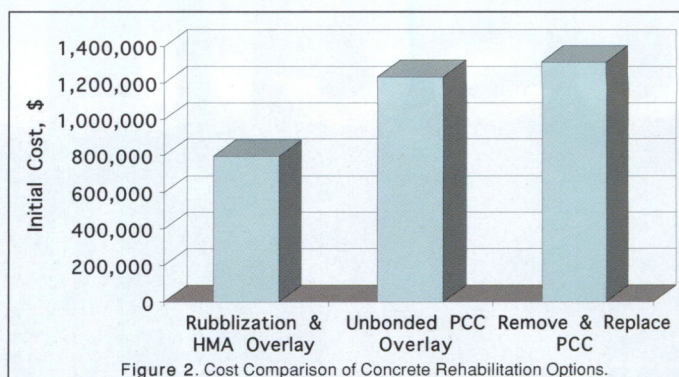
- ADT = 40,000 vehicles
- Perpetual Pavement overlay (very heavy traffic): design for 100,000,000 ESAL
- Two lanes in each direction
- Concrete: 11 inches



- Subbase: 7 inches of crushed stone – Structural Number (SN_{sb}) = 1.2
- Subgrade is in fair condition (subgrade modulus = 12,000 psi)
- Project length = 1 mile

The chart in Figure 1 comes from NAPA IS-132, and it shows that for the subbase and subgrade conditions described above and an 11-inch rubblized concrete pavement, an 8-inch HMA overlay will suffice for very heavy traffic. This could consist of a 4-inch base course, followed by a 2-inch binder course with polymer-modified asphalt and an aggregate with a nominal maximum size of not more than 12.5 mm. The wearing course could be a 9.5- or 12.5-mm mix with a polymer-modified asphalt.

How does the rubblization option compare with other alternatives for initial cost? Typical bid prices from



Oklahoma are used to compare rubblization with an HMA overlay to an unbonded concrete overlay and a remove-and-replace option for the pavement described above. Only the major pavement features are used for this example. The bid items, unit costs, cost extensions for 4 lane miles, and totals are given in Table 1 and illustrated in Figure 2. The unbonded concrete overlay is about 55 percent more expensive and the remove and replace with concrete option is about 65 percent more than the rubblization with HMA overlay.

Table 1. Cost of PCC Rehabilitation or Replacement for One Mile of 4-lane Highway. (Typical 2007 Oklahoma bid prices.)

Rubblize and Overlay			Unbonded Concrete Overlay			Remove and Replace Concrete		
Item	Unit Cost	Extension	Item	Unit Cost	Extension	Item	Unit Cost	Extension
Edge Drain	\$4.00/lf	\$42,240	10% Patching Existing PCC	\$100.00/sy	\$281,600	Remove 11" PCC	40.00/cy	\$344,178
Rubblization	\$1.50/sy	\$42,240	2" HMA Bond Breaker	\$56.00/ton	\$171,494	Place 11" PCC	\$34.44/sy	\$969,830
4" Unmodified HMA @ 145 lb/ft ³	\$56.00/ton	\$342,989	8" Concrete Overlay	\$27.78/sy	\$782,285			
4" Modified HMA @ 145 lb/ft ³	\$60.00/ton	\$367,488						
Total		\$794,957			\$1,235,379			\$1,314,008

The economics reflect actual experience with rehabilitation projects. The state of Arkansas estimated that it saved \$1.3 million per mile on rubblization projects totaling over 318 miles as compared to removing and replacing the existing concrete pavements – that is over \$400 million. The economics of rubblization have led agencies in Wisconsin to have rubblized over 7.5 million square yards of concrete pavement since 1996, and over 3.4 million square yards of rubblization has been done in Michigan in that same time period.

The savings with rubblization with an HMA overlay go beyond just the considerable money saved in construction; it also saves time and money for road users because they spend less time in traffic during the rehabilitation of the road. Using guidance from the Federal Highway Administration (FHWA), road user costs can be calculated according to the user delays, traffic volume, road

capacity during construction activities, construction timing, and work zone length. To examine the impact of these construction activities, consider the 4-lane, 40,000 AADT, one-mile-long project described above.

User costs in this example are taken from the 1996 FHWA Life Cycle Cost procedure and updated according to the inflation rate to 2007 using data from the Bureau of Labor Statistics. These costs reflect vehicle operating costs (including fuel consumption), user delays, crashes, and the cost of taking detours. For this example, passenger vehicles are assigned a cost of \$15.50/hour, single-unit truck costs are \$25.75/hour, and combination truck costs are \$30.90/hour. It is likely that these estimates are conservative, given recent fuel price increases. Obviously, these costs are dependent upon a number of factors for any given vehicle, and they will vary widely. They are used here only as a basis of comparison.



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1982 to 2007 total square yards:

- Rubblization 28 million
- Crack/break & seat 66 million
- Removal breaking 68 million



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In this example, it is assumed that only one lane is shut down at any given time during construction. Of course, timing schemes such as 55-hour weekend shutdowns, cross-overs, and other strategies should be evaluated.

For the rubblization option, the following production rates and timings are used:

- Edge drains: No lane closures
 - Rubblization: 1 lane-mile/8-hr day
 - Asphalt Paving: 2 lane-miles/8-hr day
 - 1st lift: 4 inches of base
 - 2nd lift: 2 inches of binder
 - 3rd lift: 2 inches of surface
- Assume 24-hour closure until completion.

After the second lift of HMA has been placed, the lane could be open, with the third lift being placed during off-peak traffic hours. However, for the sake of simplicity, it has been assumed that a lane closure is in place until the final lift of the HMA has been placed.

For the concrete rehabilitation or reconstruction alternatives, the following are assumed:

- 10 percent patching with rapid curing concrete – 350 yd²/8-hr day - three 24-hr day curing period.
- Concrete removal – 200 yd³/8-hr day
- Base trimming – 1 lane-mile/8-hr day
- Dowel basket installation – 1 lane-mile/8-hr day
- Asphalt bond breaker installation: 2 lane-miles/8-hr day

- Concrete paving: 1 lane-mile/8-hr day – 10 24-hr day curing period to reach 28-day strength

The user delay costs for the three alternatives are shown in Figure 3. The rubblization with HMA overlay has over 10 times less the user delay costs than either concrete alternative. Most of the added expense for the concrete alternatives comes from the curing time for the pavement, so even if the curing time were cut in half, the user costs for the concrete alternatives still would be substantially higher. Regardless of how nebulous one might view the calculation of user costs, there is no doubt that these reflect inconvenience to the traveling public. As such, they should be considered when choosing a rehabilitation option.

When confronted with reconstruction or major rehabilitation of a concrete pavement, the option of rubblization with an HMA overlay is attractive from both the standpoint of construction and user costs. The initial cost of rubblization with an HMA overlay is far less than either applying a concrete overlay or removing and replacing the existing concrete. The impact on highway users for the rubblization with overlay option is an order of magnitude less than either of the concrete rehabilitation alternatives. **HMAT**

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