STATE OF FLORIDA

RUBBILIZATION OF CONCRETE PAVEMENTS

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ABSTRACT

The Florida Department of Transportation (FDOT) is in the process of evaluating rubblizing concrete pavements as an effective rehabilitation technique in eliminating reflected cracks in asphalt overlays on top of concrete pavements. As part of that evaluation, a nationwide survey was performed to gather information about the practices of other DOTs with regard to rubblization and to determine the overall performance of rubblized sections in various states. The survey indicated that most states have a relatively small number of rubblized sections with the exceptions of three states that have over ten sections each. The construction techniques, overlay thicknesses, and field performance varied from state to state. However, it was clear that most states are highly satisfied with rubblization as a good mean for eliminating reflected cracks. Only a few states indicated problems with rubblization due to mainly weak subgrade.

INTRODUCTION

Selecting the optimum rehabilitation strategy for deteriorated Portland cement concrete pavements is an important task facing pavement engineers. Over the years, State DOTs applied asphaltic overlays to concrete pavements to improve ride quality. This overlay technique proved to be effective initially in improving ride quality. However, reflective cracking developed quickly in the asphalt layers which resulted in reducing the effective service lives of asphalt overlays. The solution to this problem was to fracture the concrete slabs to reduce their effective lengths prior to applying the asphalt overlays. In the last decade, cracking and seating as well as breaking and seating gained wide acceptance among state DOTs [1, 2, and 3]. These techniques were designed to initiate cracks in concrete slabs at 305 to 1219 mm (12 to 48 inches) intervals [1]. Cracking the slabs in small panels resulted in less thermal induced movement which resulted in reducing reflected cracks in the asphalt overlay.

Some states including Florida have tried the cracking and seating technique but they found that it was not totally effective in eliminating the reflected cracks. Therefore, the Florida Department of Transportation (FDOT) is currently evaluating the effectiveness of rubblizing concrete pavements. There are several concrete pavement sections scheduled for

rehabilitation on I-10 in West Florida. Selecting the most cost effective rehabilitation technique that can eliminate reflected cracking is a top priority for FDOT.

Rubblizing concrete pavements is a rehabilitation technique utilized by several highway agencies to eliminate reflective cracking in asphalt overlays. It consists of reducing the Portland cement concrete slabs into aggregate bases for new hot mix asphalt pavements. Rubblizing concrete can be accomplished by utilizing resonant pavement breakers which apply a 2000 foot-pound blow at a rate of 44 cycles per second. Seating the broken particles can be then accomplished by applying several passes of heavy rollers.

FDOT performed a nationwide survey on rubblizing to obtain timely information on the experience of other DOTs with regard to rubblizing. This survey was the first step in the evaluation process of rubblization. FDOT will be conducting field studies on the first rubblizing section on I-10. These studies will be helpful in refining the specification, design, and construction procedures for the other potential rubblizing sections in the state of Florida. Since all responding states indicated interest in learning about the results from the survey, this paper was prepared to share information with other DOTs and the paving industry.

OBJECTIVES OF THE STUDY

Copies of the concrete pavement Rubblizing survey were mailed to all 50 State Highway Agencies (SHAs) in January, 1998. The main objectives of the survey were to:

a. Identify states that have rubblized concrete pavements and estimating the number of rubblized concrete pavements nationwide.

b. Evaluate the various specifications used to rubblize and compact concrete pavements.

c. Determine the various pavement design procedures followed by various states and obtain the layer coefficient values assigned for the rubblized pavements.

d. Obtain the range of asphaltic overlay thicknesses applied on top of the rubblized concrete pavements.

e. Obtain edge drain requirements by different states.

f. Obtain information on the field performance of rubblized pavements in various states. DOTs with experience with crack and seat were also asked to compare between Rubblizing and cracking and seating.

RESULTS FROM THE SURVEY

The pavement rubblization survey included eighteen short answer questions aimed at satisfying the objectives stated above above. Thirty eight responses were returned. The responses have been summarized in the

sections that follow.

States with Rubblizing Experience

Out of the thirty eight responses to the survey, twenty one states indicated having experience in rubblizing pavements. These states are listed based on their two-letter codes in table 1. In order to determine the extent of rubblizing experiences of various states, they were asked to list the number of rubblizing sections in their states. Table 2 summarizes the answers to this question. It is clear from Table 2 that Michigan, New York, and Pennsylvania have the most extensive experience with rubblizing. It should be mentioned here that unlike most of the other states, Pennsylvania applies concrete pavements on top of most of the rubblized concrete. Table 2 also indicates that most of the responding states have less than five rubblizing sections indicating low to moderate expertise in this type of rehabilitation technique.

Designing Rubblized Pavements

All responding states were asked to specify the design procedure they normally follow for designing rubblized pavements. Table 3 shows the summary for this question. As indicated in Table 3, the majority of the states rely on the AASHTO design procedure [4]. Only three states indicated their usage of the NAPA design procedure which was developed exclusively for rubblized pavements [5].

The AASHTO design guide requires the determination of a layer coefficient for the rubblized concrete. This coefficient was found to vary between 0.1 and 0.3. Table 4 summarizes the values used by different states. There appears to be no trend in selecting the layer coefficient for rubblized concrete. The 0.1 is less than the 0.14 normally used by several agencies for untreated base materials. On the other hand, the 0.30 is the highest value that is normally used for stabilized base materials.

States were also asked about the methods they follow to determine these layer coefficients. As shown in Table 5, aggregate type, shape, and size was one of the most widely used factors in determining the layer coefficients. Normally if a high quality aggregate was used in the original concrete, then a higher layer coefficient would be warranted. Some states indicated that deflection measurements are normally utilized in establishing layer coefficients. However, no details were provided on the procedure followed to establish these values. Tables 4 and 5 indicate that more guidelines should be developed for determining layer coefficients for rubblized pavements.

Table 6 summarizes the thicknesses of asphalt layers on top of the rubblized concrete as applied by various states. This table shows a wide range between 76 and 330 mm (3” and 13”). The variations in layer coefficients as well as operating conditions resulted in this wide range of asphalt thicknesses. However, someone might question the cost

effectiveness and assumptions made to result in 13” of asphalt on top of the rubblized pavement.

Construction Techniques

All participating states were asked about the acceptable concrete particle sizes after rubblization. Most states indicated requiring the majority of particles between 25.4 and 76.2 mm (1” and 3”). In addition, states indicating accepting some particles to be larger than 76.2 mm (3”) underneath the steel reinforcement or near the edges of concrete where it is hard to break the concrete. The maximum acceptable particle sizes are summarized in Table 7.

After rubblizing the concrete, compaction is important in insuring a stable base underneath the overlay. Table 8 summarizes the compaction techniques followed by various states. The majority of states indicated using the combination of pneumatic and vibratory steel rollers. These states would apply one or two passes with the vibratory roller, followed by one or two passes of the pneumatic roller, and finished with one or two passes of the vibratory roller. Two states indicated using very heavy (35-50 tons) pneumatic rollers only for compacting rubblized concrete. On the other hand, seven states indicated using vibratory steel rollers only.

Table 9 shows how the majority of states added edge drain to the rubblized pavement prior to rubblization. Some states indicated the need to

add the edge drain a few weeks prior to rubblization to insure the dryness of the materials. Only two states add the edge drain after finishing the rubblization. Five states indicated that edge drain was not installed on rubblized pavements.

Performance of Rubblized Pavements

As shown in Table 10, most states did not have any distresses or major problems in rubblized pavements. A few states had some longitudinal and transverse cracking. Two states had failed sections due to weak subgrade and two more had severe rutting also due to weak subgrade support.

Table 11 shows how almost all states indicated they believe that rubblizing is more effective in reducing reflected cracking than cracking and seating. A few states did not answer this question due to either not having cracking and seating experience or due to the fact that their rubblizing sections are relatively new.

When states were asked about the overall performance of rubblized pavements, most of them indicated excellent to good performance. Only four states indicated mixed success due to either weak subgrade or under designing the asphalt thickness.

At the end of the survey, the respondents to the survey were given the chance to add any general comments. Some of those comments are

summarized in Table 13. The comment that appeared the most was related to weak subgrade which resulted in problems during the rubblization operation due to the difficulty in breaking the concrete pavements into small size pieces. In addition, poor subgrade resulted in an unstable platform underneath the rubblized concrete which probably allowed the broken pieces to move resulting in surface failure.

CONCLUSIONS

This study concentrated on determining the practices of various state DOTs with regard to rubblization. A survey was prepared and mailed to all fifty states. This paper summarizes the thirty nine replies received for the survey. The following conclusions can be drawn from the survey:

1. Most DOTs responding to the survey requested a copy of the findings indicating a good interest in concrete pavement rubblizing.
2. Majority of states with rubblizing projects have only a small number of projects. Only three states indicated having more than ten rubblizing projects.
3. AASHTO is the most widely used design procedure by state DOTs. Only three states indicated using the NAPA design procedure which was developed exclusively for rubblized pavements.
4. The layer coefficient of the rubblized layer varied between 0.1 and 0.3. This wide range was one of the factors behind the

variability of asphalt thicknesses between 76.2 and 330 mm (3 and 13 inches).

5. Most states indicated the need to add edge drain to the rubblized pavements prior to rubblization.
6. Most states require the majority of rubblized concrete particles to be 25.4 - 76.2 mm (l”-3”) in size. The maximum particle size near the edges and underneath the steel reinforcement could be as large as 381 mm (15”).
7. The combination of pneumatic and steel vibratory rollers are the most widely used for compacting the rubblized concrete. Only two states indicated using pneumatic rollers exclusively on rubblized concrete.
8. All responding states indicated that the rubblized pavements are more effective in reducing reflected cracks than crack and seat pavements. In addition, most states indicated that their rubblized pavements have good to excellent performance.
9. Several states warned against rubblizing concrete pavements on top of weak subgrade. Weak subgrade will create problems during rubblization due to the lack of support. In addition, weak subgrades may result in premature pavement failure.

In summary, almost all DOTs responding to the survey were satisfied with the performance of their rubblized pavements. The high variability in selecting layer coefficients and overlay thicknesses indicate the need to establish clearer guidelines for determining adequate design thicknesses.

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Table 1. States with Rubblizing Experiences

STATES WITH RUBBLIZING EXPERIENCE	STATES WITH NO RUBBLIZING EXPERIENCE	STATES WITH NO RESPONSE
AL, AR, IL, IN, KS, LA, MA MD, MI, MN, MO, MS, NC, ND, NV, NY, OH, OK, PA, VA, WI	AK, AZ, CA, CT, FL, ID, GA, HI, ME, NE, NJ, NM, RI, SD, UT, VT, WA	TOTAL: 12
TOTAL: 21	TOTAL: 17	

Table 2. Number of Rubblizing Sections in Various States.

TOTAL NUMBER OF RUBBLIZING JOBS	STATES	# OF STATES
1	LA, MA, MD, MO, NV	5
2-5	AR, MN, MS, ND, NC, OK, VA, WI	8
6-10	AL, IL, IN, KS, OH	5
MORE THAN 10	MI, NY, PA*	3

* Most rubblized pavements in Pennsylvania have concrete overlays.

Table 3. Pavement Design Procedures for Rubblized Sections As Used By Various States.

DESIGN PROCEDURE	STATES	# OF STATES
AASHTO	AL, AR, IL, IN, KS, LA, MA, MD, MI, MS, ND, OH, OK, PA, WI	15
NAPA	MN, MO, NV	3
OTHERS	NC, NY, VA	3

Table 4. Layer Coefficients Used for the Rubblized Concrete Layer.

LAYER COEFFICIENT	STATES	# OF STATES*
0.1 - 0.15	MI, MD, MS, MO, OH, VA	6
0.16 - 0.20	IN, MI, MN, ND, PA	5
0.21 - 0.25	AL, IL, KS, MA, MI, WI	6
0.26 - 0.30	AR, LA, NC, NV, OK	5
NO RESPONSE	NY	1

* Note: Michigan had responses in three categories.

Table 5. Methods Used by Various States to Determine Layer Coefficients.

METHOD	STATES	# OF STATES*
AGGREGATE TYPE, SIZE, & SHAPE	IL, MD, MI, ND, VA, WI	6
OTHER AGENCIES	IN, KS, LA, MA	4
AGE AND CONDITION	MI	1
PCS LAW	AR	1
AASHTO	IL, NV, OK	3
ENGINEERING JUDGEMENT	MD	1
DEFLECTION	AL, MI, MO, NC, OH, PA	6
NO REPLY	MN, NY	2

* Note: Several states had more than one answer.

Table 6. Asphalt Overlay Thicknesses On Rubblized Concrete.

THICKNESS OF ASPHALT OVERLAY	STATES	# OF STATES*
76.2 - 152.4 mm (3" - 6")	AR, LA, ND, NV, MI, NC, NY, OK, WI, IL	10
177.8 - 254 mm (7" - 10")	AL, IL, IN, KS, MA, MD, MI, MN, MO, MS, NC, OH, OK, VA	14
279.4 - 762 mm (11" - 13")	AL, IN, MI, MO, OH, PA	6

* Note: Several states had responses in more than one category.

Table 7. Maximum Acceptable Particle Sizes for Rubblized Concrete.

MAXIMUM PARTICLE SIZE	STATES	# OF STATES
127 - 203.2 mm (5” - 8”)	AL, IN, MI, MA, MO, MS, NC, ND, OH, OK, VA,	11
228.6 - 381 mm (9” - 15”)	AR, IL, KS, LA, MD, MN, NV, NY, PA, WI	10

Table 8. Compaction Rollers Used on Rubblized Concrete.

COMPACTION	STATES	# OF STATES
VIBRATORY AND PNEUMATIC ROLLERS	AL, IL, IN, KS, LA, MI, MN, MS, NC, NV, VA, WI	12
ONLY STEEL VIBRATORY ROLLERS	AR, MA, MO, ND, OH, OK	6
ONLY HEAVY PNEUMATIC ROLLERS	MD, PA	2
NO INFORMATION	NY	1

Table 9. Edge Drain Treatments.

EDGE DRAIN TREATMENT	STATES	# OF STATES
NONE	MA, MD, NV, VA, WI	5
ADD BEFORE RUBBLIZATION	AL, AR, IL, IN, LA, MI, MN, MO, MS, NC, ND, NY, OH, PA	14
ADD AFTER RUBBLIZATION	KS, OK	2

Table 10. Main Distresses in Rubblized Sections.

DISTRESSES IN RUBBLIZED PAVEMENTS	STATES	# OF STATES*
NONE	AR, IN, MA, MD, MI, MS, NV, NY, PA, VA, WI	11
CRACKING	AL, MI, MN, MO	4
RUTTING	KS, ND	2
FAILURE DUE TO SUBGBADE	OK, NC	2
OTHERS	IL, LA, OH, PA	4

* Pennsylvania had two answers.

Table 11. Rubblization Verses Cracking and Seating.

RUBBLIZING VS. CRACKING & SEATING	STATES	# OF STATES
MORE EFFECTIVE THAN CRACKING & SEATING	AL, AR, IL, IN, KS, LA, MA, MD, MI, MN, MS, NC, ND, NY, PA, VA, WI	17
LESS EFFECTIVE THAN CRACKING & SEATING	NONE	0
NO REPLY	MO, OH, OK, NV	4

Table 12. Overall Performance of Rubblized Pavements.

PERFORMANCE OF SECTIONS	STATES	# OF STATES
EXCELLENT	IL, IN, MA, MD, MS, NC, NV, NY, PA	9
GOOD	AL, AR, KS, MO, VA, WI	6
POOR	NONE	0
MIXED SUCCESS	MI, MN, ND, OK	4
NO ANSWER	LA, OH	2

Table 13. General Comments from Different States Related to Rubblization.

OTHER COMMENTS
Difficult to determine the size of broken concrete particles
Failure due to inadequate thickness
Poor subgrade caused problems
Watch for underground utilities
If new lanes added, use permeable base materials
Do not do it on poor subgrades
Do not operate traffic prior to applying adequate thickness
More projects are scheduled in the near future

LIST OF REFERENCES

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