In-depth reclamation?

States need to do more to assure FDR quality

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Full-depth reclamation (FDR) remains a viable, cost-effective tool for pavement rehabilitation by treating the asphalt surface layer and a predetermined amount of underlying materials to provide a stabilized base course.

Proper design work, a good construction specification, proper construction quality control and performance feedback are necessary for a successful project and continuous improvement of the FDR process.

Seven to follow

Based on experience in Texas, for a successful FDR project, the practitioner should, at a minimum, adhere to the following seven steps:

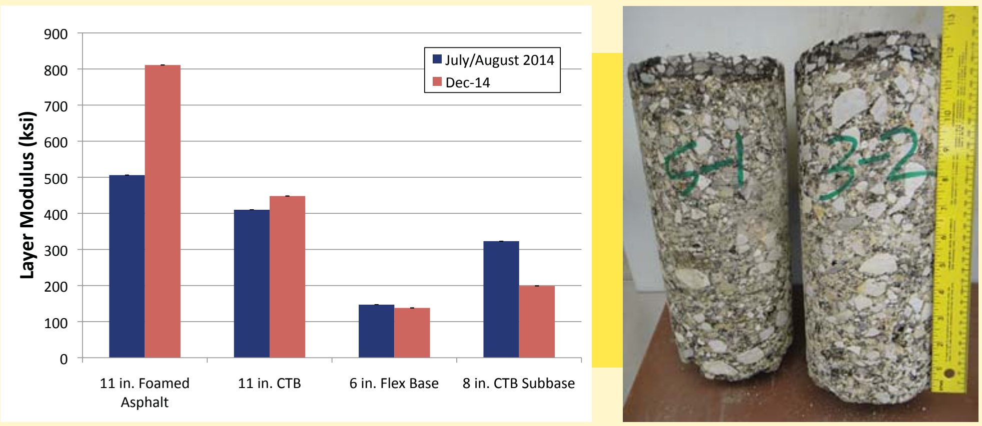
- Evaluate the project history: This step includes a review of the current pavement condition, maintenance treatments performed, existing plans and online soils information to formulate a general overview of the likely sources of distress and subgrade conditions;
- Characterize the existing pavement structure with non-destructive tests (NDT) including ground-penetrating radar (GPR) and falling weight deflectometer (FWD), which provide the practitioner information to identify likely areas of different pavement structures and varying pavement support. Having the ability to define and handle the existing variability is one of the major challenges. This NDT information is used to segment projects and to focus the verification and lab design efforts in the following steps;
- Verify the pavement structure and obtain material samples: During this step, coring and auguring efforts provide the information to verify the existing pavement structure and also generate materials for a laboratory mixture design;

Figure 1. GPR and FWD surveys for FDR project development.

Figure 2. A successful FDR project was opened to energy-sector traffic within two hours after compaction.

Before FDR | Early trafficking of FDR layer | Final in-service pavement after FDR

Figure 3. An example of an FDR field modulus and cores.



- Perform mixture design: In this step, the practitioner must first use available information to determine potential stabilization options and how much underlying materials (and potentially new aggregate base) to include in the FDR mixture. Next, laboratory mixture designs must take place in accordance with the appropriate test procedures to verify that the stabilized mixtures meet strength and moisture susceptibility requirements;
- Perform pavement design: After developing a lab mixture design meeting requirements, traffic inputs and expected structural values for the FDR layer must be used to develop the final pavement thickness design;
- Perform construction quality control: This step must, as a minimum, ensure that construction specifications are followed and the prescribed FDR treatment applied properly and uniformly over the required area and to the required depth. Compaction control, curing requirements and any criteria for opening to traffic also must take place in this step; and
- Conduct performance review and feedback: After construction of a project, stakeholders should review the process, evaluate the performance of the section, and review and take action for areas justifying improvement.

As described below, when these steps are followed FDR continues to provide agencies with cost-effective solutions to upgrading structurally inadequate highways. The technique saves both time and money.

Energy sufficient

Figure 2 shows example pavement conditions from an FDR project completed in 2014 where energy-sector traffic was allowed on the FDR layer two hours after compaction was completed. This project used combinations of cement and foamed asphalt. It performed extremely well, where upfront testing, a proper design, good construction quality and performance monitoring all took place contributing to the project's success.

Figure 3 shows the FDR layer modulus values backcalculated from FWD testing, along with example pavement cores from the FDR treatments used. The modulus values and solid cores illustrate extremely effective stabilization from the FDR process. After 18 months in service this roadway is crack-free and continues to carry very heavy truck traffic.

While countless success stories exist where the FDR process was documented to save both time and money, to continue to improve this process it is important to document and respond to problems encountered in the field. This provides an opportunity for improving the FDR state of the practice and governing specifications. Some potential problem areas recently observed are described below.

Specification awareness

One concern with FDR projects is specification awareness. Construction specifications can range from around 10 to 30 pages in length. Experience oftentimes shows a general lack of stakeholder awareness exists for the actual requirements of these specifications. Specific items often needing highlighting during preconstruction meetings include staffing and quality control roles and requirements, action items for non-conforming areas, curing requirements, and any specific requirements for opening to traffic.

Inspection

Another potential problem in the FDR process is the availability of experienced

Figure 4. Contrast of uniform (left) and non-uniform (right) stabilizer application.

Figure 5. Failure under early traffic due to excessive compaction moisture content.

Figure 6. Local failure due to excessive water at location of disconnecting FDR train.

Figure 7. Material variability in both longitudinal and transverse direction.

and trained inspection forces. With many agencies consistently handling larger workloads with less staffing, action items need to take place ensuring proper inspection is available and occurs during FDR projects. The presence and involvement of a quality inspector significantly contributes to attaining specification requirements and a quality FDR project. One urgent requirement is to develop training schools and perhaps certification requirements for FDR inspectors similar to those available for hot-mix and concrete inspection.

Distribution of stabilizer

During the actual FDR construction process, the uniform distribution of stabilizers remains a potential problem. Figure 4 contrasts a uniform distribution and a non-uniform distribution of cement prior to mixing. In the problem area, the stabilizer does not cover the entire pass width, and even where powder is present the application rate is so low that the layer of additive is semi-transparent.

The varying approaches used by different pavement recyclers to meter and apply stabilizer through the mixing chamber also can create potential problems in attaining proper application rates and uniformity of FDR projects; this potential problem is specifically applicable to slurry, emulsion or foaming treatments.

Moisture management

Management of moisture content also can present significant problems during the construction process. In many construction settings, there are requirements for opening to traffic at the end of each day. Even with applying the proper stabilizer and attaining density, materials at moisture contents well above optimum and not cured out will not withstand early traffic. Figure 5 shows an FDR section that was constructed between four and six percentage points above optimum and failed under early traffic.

Another problem with moisture management can be construction-induced through the handling of the compaction water supply. Figure 6 shows a localized region, at the end of a pass, where the recycling train spilled substantial water over a localized region of the FDR layer during unhooking of the compaction water supply hoses. With the requirement for early opening to traffic, this localized area failed within 24 hours.

Attaining density

Attaining proper density of the FDR layer is critical for performance. FDR projects typically employ stabilization to depths between 8 in. and 11 in., and cases of treating 14 in. in one lift have been documented. Special attention should be paid to proper roller selection and rolling patterns to attain density.

In-situ material variability

A potentially major problem with FDR can occur when the in-situ materials vary considerably. One potential type of variability is reductions in pavement thickness. In some cases the existing pavement may unexpectedly be thinner than the specified

FDR treatment depth. Contamination of the FDR mixture with subgrade should be avoided; this contamination can be especially problematic if the subgrade is expansive clay soil.

Figure 7 illustrates another type of variability where through likely historic roadway widening and maintenance operations, the in-situ materials vary not only longitudinally in pockets down the project, but also across the transverse direction. Such variability can be difficult to fully capture in up-front testing and may result in treating materials not represented by the laboratory design.

Do more

Based on the current state of the practice of FDR and documented potential problems, the following specification items and related practices should be considered:

- Include more frequent checking of the moisture content throughout FDR projects;
- Enforce aerating and drying. Consider including fly ash or chemical lime as a mechanism for drying back materials of excessive in-situ moisture contents;
- Include specification requirements to eliminate preventable spills or ponds caused by the construction process;
- Strengthen the definition of uniformity of stabilizers, and include and use methods for measuring that uniformity;
- Require an independent testing lab for use by the contractor for quality control;
- Establish a recognized training program for inspection of FDR processes; and
- Highlight major elements of the specification at the pre-construction meeting to include staffing, quality control roles and requirements, action items for non-conforming areas, curing requirements and any specific requirements for opening to traffic.

The increasingly common requirement of opening FDR projects to early traffic makes the pavement's operational environment more sensitive to deviations from best practices and design assumptions. Field results prove FDR is up to the task of rehabilitating pavements in a timely and cost-effective manner in challenging conditions. Continuing to improve the FDR state of the practice through thorough upfront testing, proper design, quality construction processes and specifications, and continuous feedback will help this technology continue to maintain safety, mobility and capacity in the transportation system. R&B

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