TERRA Transportation Engineering and Road Research Alliance
Partnering for Roadway Innovation
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Full-Depth Reclamation (FDR)

Full-depth reclamation is a technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended, resulting in a stabilized base course. Pavements that have experienced base failure are considered ideal candidates for FDR. Further stabilization may be obtained through the use of available additives, which include cement, fly ash, lime, foamed asphalt, and asphalt emulsions. A new surface course is placed on the recompacted base.

Research Highlights

- Three MnROAD test cells are being constructed as part of the Phase Two Initiative to evaluate the properties and performance of three variations of FDR using asphalt emulsion stabilization. The results will be used to **develop the best-cost design procedures** to achieve the strength and flexibility needed for a pavement.
- FDR, with or without stabilization, is **among the most common methods used to rehabilitate roadways** in Minnesota. (Mill and overlay (M&O), overlay, and cold in-place recycling (CIR) are other options.)
- Researchers surveyed more than 100 rehabilitation projects in Minnesota and developed a set of **decision checklists**—covering geometrics, pavement condition, surface rating, and structural adequacy—for choosing a rehabilitation procedure. Based on the structural checklist, for example, FDR is recommended if an existing hot-mix asphalt (HMA) thickness (< 3.5 inches) and subgrade stiffness (<5000 psi) are not adequate to support CIR equipment.
- FDR technology can be used to depths of 12 inches or more, though the most typical applications involve depths of 6 to 9 inches. As a result, FDR **eliminates all distress areas** as well as the potential for reflective cracking.
- Potential advantages of full-depth reclamation include conserving aggregate material and **reducing the cost** of reconstruction materials.
- When properly compacted, the resilient modulus (strength of mixtures) containing various percentages of recycled bituminous material is **comparable to the measured characteristics of pure aggregate materials**. This makes FDR an attractive option for roadway reconstruction, especially in cases where the availability of suitable fresh aggregate materials is limited.
- The **stiffness and strength of the reclaimed base varies** depending upon the amount of recycled asphalt pavement (RAP), the properties and amount of the base, the type and condition of the base and sub-base, and the amount and type of additive.
- FDR has been adopted as **the preferred recycling technique** in the United States and many other parts of the world, and continues to gain in popularity.
- FDR is generally suitable for lower-volume roads that may only require a simple surface treatment over the resulting stabilized base course, or at most a thin HMA wearing course. However, FDR is growing in popularity **for use on city streets and medium-volume roadways**, and has been used on major highways, including interstates.
- It is common to use FDR as an unbound base in greater Minnesota. Injecting **emulsion or fly ash as a stabilizer** for the reclaimed materials further improves the overall pavement strength and resistance to moisture ingress.

Quick Facts

The FDR process is quick and efficient, evolving from a single machine to a train-type operation, resulting in more uniform materials. A self-propelled reclaimer (with a system capable of adding a stabilizing agent) pulverizes and mixes the asphalt and base material to create a strong new base. A grader, a water truck, and various compactors typically follow the reclaimer. Shortly after the last compactor completes its pass, the road can usually be opened to traffic until the contractor is ready to apply the final surface treatment.

Implementation

- The Mn/DOT Materials and Road Research section provided expertise and support to the City of **Shoreview, Minnesota**, for implementing an FDR project with stabilized base on some of its neighborhood roads during the 2007 construction season. The goal was to provide greater continuity of pavement structure thicknesses, equivalent or better pavement strengths, and improved resistance to moisture issues. The condition of the roads prior to the 2007 reconstruction was highly variable due to previous construction methods as well as variations in the subgrade soil structure. This project determined that FDR can be used on urban streets.
- A 4-mile stretch of road with a 9-ton capacity—between the **Minnesota counties of Dodge and Goodhue**—was reconditioned using FDR processes.

Implementation continued on back

Implementation (continued)

- Reconstruction of a 6-mile segment of **Freeborn County** Road 46, east of Albert Lea, Minnesota, was completed in 2007 using FDR, saving an estimated $200,000 on the $3 million project. Recycled concrete from another project was added to reclaimed asphalt and aggregate from the original roadway to help support 7 inches of new concrete pavement and create a 10-ton roadway.

- Two field projects used cementitious fly ashes mixed with water for stabilizing recycled pavement materials and road-surface gravel to form a base during reconstruction of a city street in **Waseca, Minnesota** (in 2004) and construction of a flexible pavement in a segment of gravel country road, CR 53 in **Chisago County, Minnesota** (in 2005). These projects demonstrate that fly-ash stabilization provides an effective and economical means of providing a base for asphalt paving using existing roadway materials.

- **Ramsey County and other Minnesota agencies** have used FDR and CIR for about 20 years, accumulating a wealth of consistent pavement data for use in establishing their construction, rehabilitation, and maintenance programs.

- Several FDR projects have been planned for the 2008 season by **MnDOT and local agencies**.

Partners

- Minnesota Local Road Research Board (LRRB)
- Federal Highway Administration (FHWA)
- Transportation Research Board (TRB)
- Strategic Highway Research Program (SHRP)
- Industry representatives, including contractors and material providers

For More Information

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About TERRA

The Transportation Engineering and Road Research Alliance, or TERRA, brings together government, industry, and academia in a dynamic partnership to advance innovations in road engineering and construction, including issues related to cold climates. More about TERRA is online at www.TerraRoadAlliance.org.

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For Further Reading

- *Pavement Rehabilitation Selection* (Report MN/RC-2008-06, LRRB)
- *Resilient Modulus and Strength of Base Course With Recycled Bituminus Material* (Report MN/RC-2007-05, Mn/DOT/LRRB)
- *Rehabilitation of City Streets: A Case Study* (MnROAD, February 2008)
- *Demonstration of Ash Utilization in Low-Volume Roads* (Report MN/RC-2007-12, LRRB)
- *Basic Asphalt Recycling Manual* (BARM)
- "Rebuilding by Reclaiming? The FDR Process" (*Better Roads* magazine, July 2001)
- "What is Full-Depth Reclamation?" (*Better Roads* magazine, July 2001)
- MnROAD Web site
- Green Roads Web site
- Pavement Interactive Web site
- Asphalt Recycling and Reclaiming Association (ARRA) Web site
- Asphalt Emulsion Manufacturers Association Web site
- Asphalt Institute

Links to these publications are on the TERRA Web site at www.TerraRoadAlliance.org