New Technology Initiatives in Rural Roads and Use of Marginal Materials

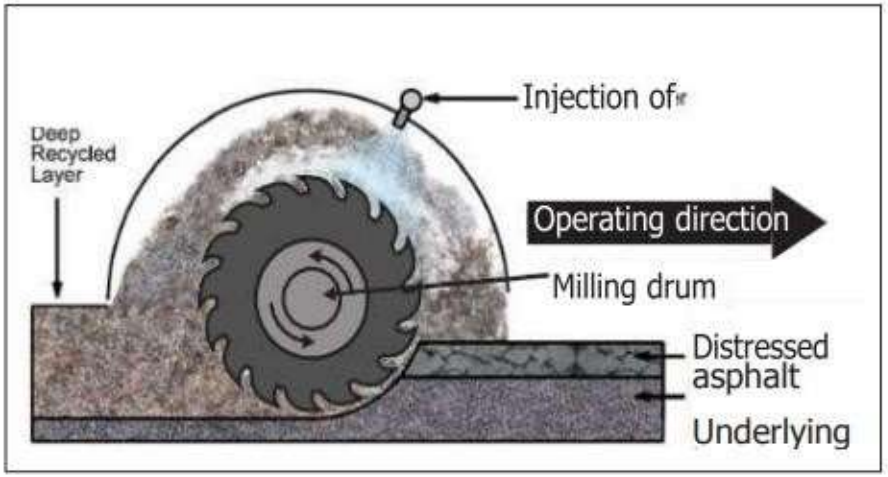
FULL DEPTH RECLAMATION (FDR)

National Rural Infrastructure Development Agency

Ministry of Rural Development

National Institute of Technology

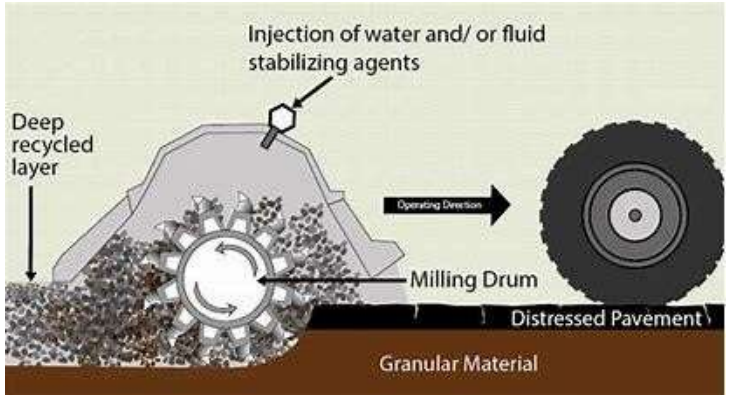
Warangal, Hyderabad



FULL DEPTH RECLAMATION (FDR)

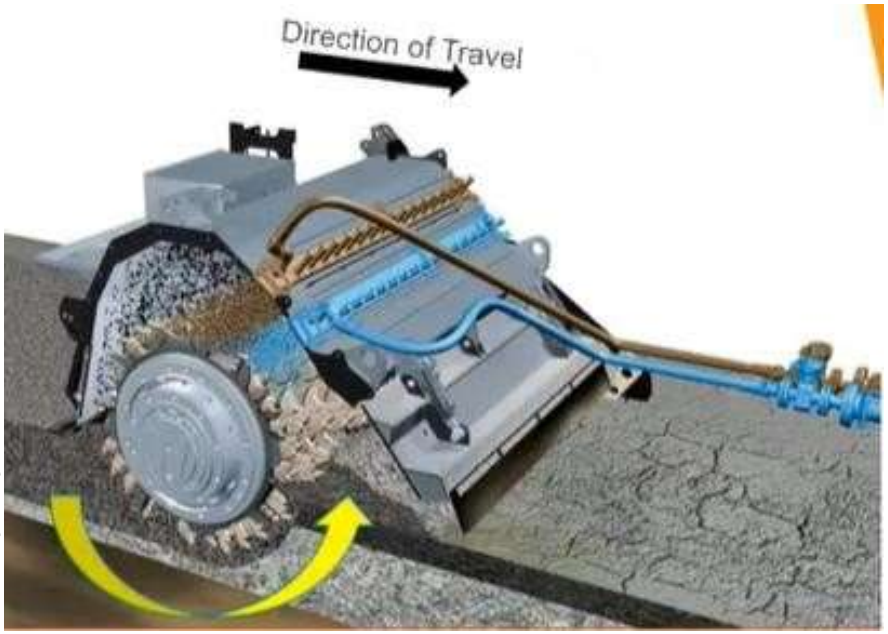
FULL DEPTH RECLAMATION

- Full Depth Recycling (FDR) is employed for constructing economical and long lasting new pavements by recycling existing distressed flexible pavements
- "FDR is a pavement rehabilitation and up-gradation technique where in bituminous and underlying pavement layers of predetermined thickness are excavated, pulverised and blended with a binder and compacted; to act as a bound or hardened base course of the new pavement"
- Different types of additives, such as asphalt emulsions, and chemical agents, such as calcium chloride, Portland cement, fly ash, and lime, are added to obtain an improved base.



FULL DEPTH RECLAMATION

- Basically, FDR is a cold mix recycling process in which different types of additives such as foam bitumen, bituminous emulsions and chemical agents such as cement, fly ash, and lime, including commercially available cementitious stabilizers are added, mostly in-situ, and compacted to obtain an improved base
- most pavement distresses are treated, hauling costs are minimized, significant structural improvements can be made (especially in base), material disposal problems are eliminated, and ride quality is improved



- Pulverization should produce minus 40 mm size and should conform to the gradation as per IRC 37 for the purpose of stabilization
- The Sand Equivalent (SE) value from the combined materials should not be less than 30%
- Emulsion content, in case of bitumen stabilization should be such that indirect tensile strength in dry and wet conditions (100 mm specimen) is more than 225 KPa and 100 KPa respectively and voids in the range of 6-8%
- Resilient modulus for all stabilized material should be in accordance with the IRC 37
- Stabilization should be done in-situ with suitable plants and equipment. Where it is not possible to have these plants and equipment (for smaller jobs), WMM plant can be used for mixing.
- normally performed to a depth of 100 mm to 300 mm.
- The train of equipment consists of recycling machine hooked to a water tanker and steel drum roller with pad foot shell.

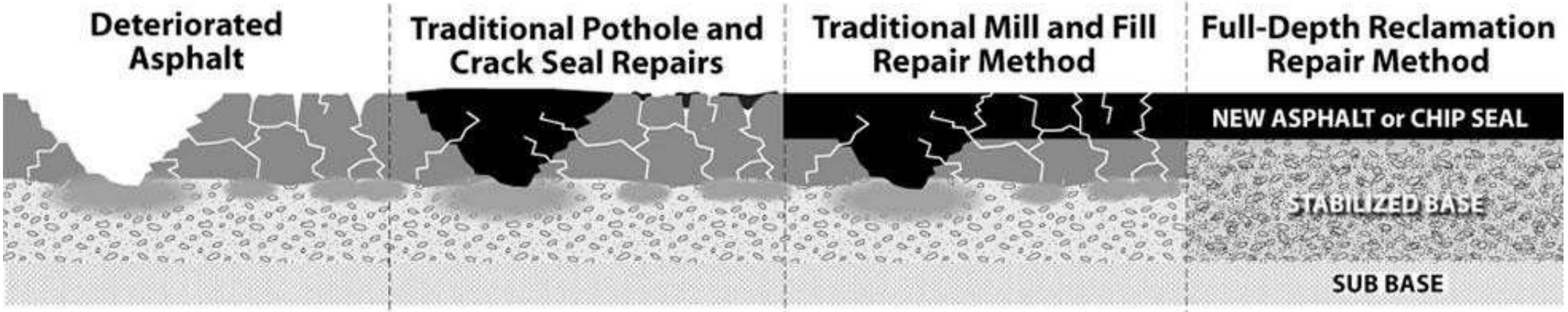
RECOMMENDED FOR

- Damaged pavement that is beyond resurfacing
- Pavements with deep rutting, load- associated cracks, non load- associated thermal cracks, reflection cracks and maintenance patches such as spray, skin, pothole, and deep hot mix
- Problems with subbase/ subgrade
- Flexural distress in wheel lanes
- Increase structural design of roadway
- Widening of existing roadway

ADVANTAGES OF FDR

- Significantly improve the structure of pavement without altering the geometry and shoulder
- Restore old pavement to the desired profile, eliminate existing wheel ruts, restore crown and slope, and eliminate potholes, irregularities, and rough areas
- Eliminate alligator, transverse, longitudinal, and reflection cracking. Ride quality can be improved
- Frost susceptibility may be reduced.
- Production cost is low, and only a thin overlay or chip seal surfacing is required on most projects.
- Engineering costs are low.
- Materials and energy are conserved, and air quality problems resulting from dust, fumes, and smoke are eliminated. The process is environmentally desirable, since the disposal problem is avoided.

FULL-DEPTH RECLAMATION (FDR)
COMPARISON TO TRADITIONAL METHODS



- Alligator Cracking
- Potholes
- Rutting
- Shoving
- Insufficient Base

- Potholes Fill Unevenly
- Crack Seal Has Short Life
- Insufficient Base Problem Still Not Addressed
- Less Stable Road Structure

- Cracks Reflect Through Surface
- Same Potholes Soon Reappear
- Expensive
- Temporary
- Base Still insufficient

- At Least 50% Less Expensive
- A Minimum of 200% Faster
- Increased Load Bearing Capacity
- More Permanent Repair
- Smoother Roads

FDR

Mill & Fill

Overlay

APPLICABILITY OF FDR

- FDR is very much suitable for rehabilitation of roads, when existing road pavement is to be upgraded after completion of its design life to increase its structural strength, with or without additional widening so as to cater for increased number of load repetitions (higher MSA).
- When the existing bituminous pavement has excessive distress (distress in more than 50 per cent of the paved area in various form like excessive cracking, deformation like deep rutting or shoving, slippage, extensive potholes and patching, raveling, base or sub-base failure which require pavement reconstruction
- When the existing road pavement comprises of low grade materials like brickbats, soft aggregates, marginal materials, etc., which need to be replaced with new pavement layers like GSB, WBM/ WMM, etc., for reconstruction of such roads

TYPES OF FDR

- **Pulverization**
- Mechanical Stabilization
- Chemical Stabilization
- Bituminous Stabilization

- Most economical FDR Discipline
- Accomplished with a single pass
- In-situ pavement layers & pre- determined amount of underlying materials are pulverized and mixed
- Used when the quality of pulverized material and designed wearing surface is sufficient to support the anticipated loads
- Moisture (water) for achieving density is the only material added
- No stabilizer

TYPES OF FDR

- Pulverization
- **Mechanical Stabilization**
- Chemical Stabilization
- Bituminous Stabilization

- Utilize pulverized asphalt pavement as aggregate base
- Add imported aggregate or RAP and mix to create a stronger base or for grade improvement
- Used to improve cross- slope, profile/ grade corrections and/ or widening without sacrificing section thickness
- Can be used in combination with chemical or bituminous stabilization

TYPES OF FDR

- Pulverization
- Mechanical Stabilization
- **Chemical Stabilization**
- Bituminous Stabilization

- Uses at least one of the following stabilizing agents:
  - Portland cement (Dry or Slurry)
  - Hydrated Lime or Quicklime (Dry or Slurry)
  - Type C Fly Ash
  - Kiln Dust: Cement (CKD), Lime (LKD)
  - Calcium Chloride
  - Other Chemical Products
- Dry stabilizers should be applied ahead of the reclaimer on top of the pre-pulverized material -using a calibrated spreading unit
- Slurry stabilizers can either be dispersed ahead of the reclaimer or injected into the reclaimer or injected into the reclaimers cutter housing using the onboard material spray bar

TYPES OF FDR

- Pulverization
- Mechanical Stabilization
- **Chemical Stabilization**
- Bituminous Stabilization

- With cementitious or pozzolanic additives, strength is gained through the cementing of material particles and aggregate together in the reclaimed layer
- Strength gain is governed by the type of materials being stabilized along with the type and amount of stabilizer used
- Too high application rate can result in:
  - Strengths that adversely affect the flexibility of the stabilized material
  - Decreased ability to manage repeated loading
  - Shrinkage cracking

TYPES OF FDR

- Pulverization
- Mechanical Stabilization
- Chemical Stabilization
- **Bituminous Stabilization**

- Incorporates foamed or emulsified bitumen
- Bituminous stabilizers should be incorporated using the multi- pass process to aid in a more consistent injection rate and better mixing
- Benefits:
  - Cost effective method of improving the strength of a reclaimed material while reducing the effects of moisture
  - More flexible then other base course materials and chemical stabilizers, offers superior fatigue resistance and is not prone to cracking
  - Works well in combination with other stabilizing additives such as additional granular materials, cement or lime

TYPES OF FDR

- Pulverization
- Mechanical Stabilization
- Chemical Stabilization
- **Bituminous Stabilization**

<u>Bituminous Stabilization: Emulsified Asphalt</u>

- Cationic Emulsions are typically used due to their quicker breaking
- Anionic and High Float Emulsions can be used
- Performance of the emulsion and RAP interaction should be verified in the mix design process
- Breaking
- Curing

TYPES OF FDR

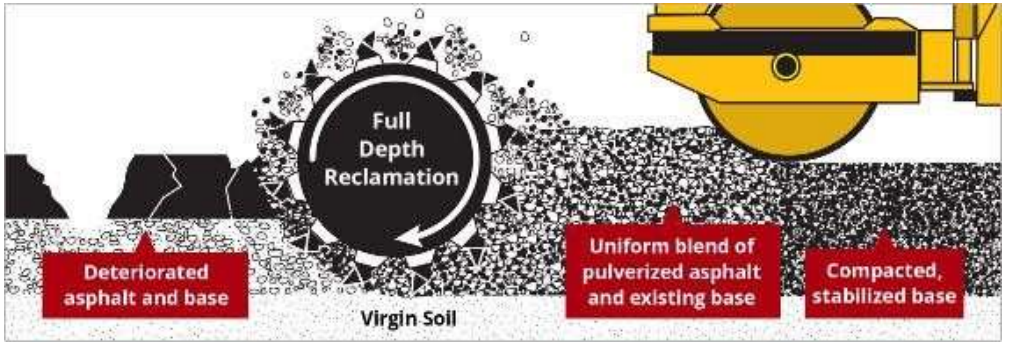
- Pulverization
- Mechanical Stabilization
- Chemical Stabilization
- **Bituminous Stabilization**

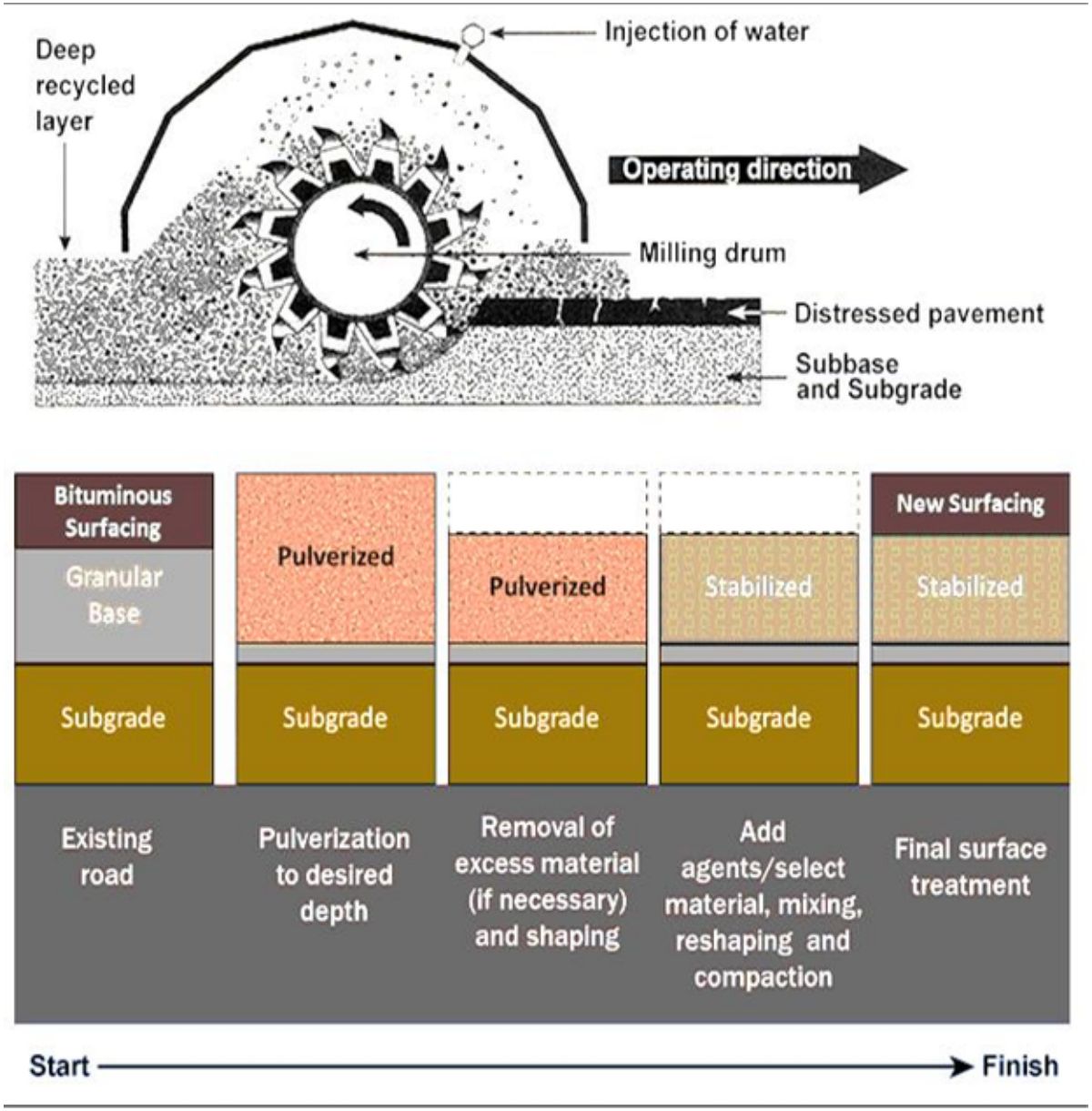
<u>Bituminous Stabilization: Foamed Asphalt</u>

- Uses neat (non polymer modified) asphalt
- Elevate temperature asphalt (320- 375 ºF) is injected with a small amount of cold water (2% by mass of asphalt)
- The resulting thermal reaction greatly increases the surface area/ volume of the asphalt, thereby decreasing its viscosity and allowing for improved coating of fine aggregates
- Requires a minimum of 5% fines (passing no. 200 sieve)

FDR PROCEDURE

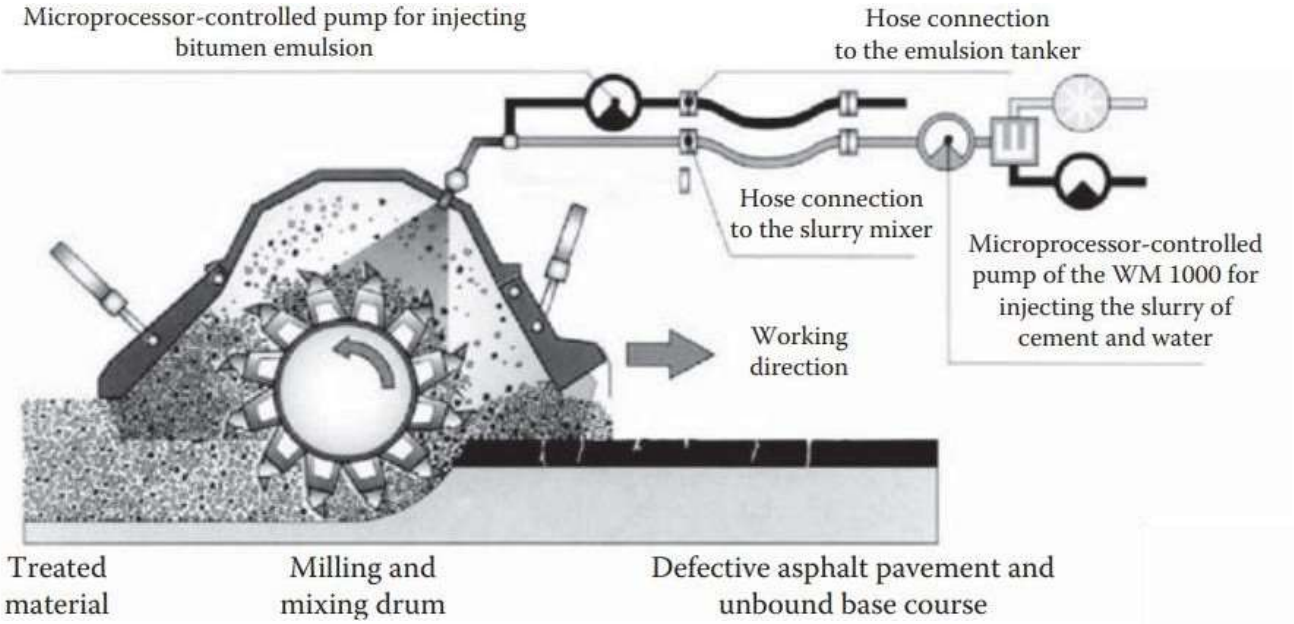
- Analysing existing materials
- Pulverization
  - Monitor Depth of Cut
  - Monitor Gradation
  - Addition of stabilizer
- Initial Compaction (Sheep/ Pad foot)
- Shape material (Grater)
- Final Compaction
- Wearing surface



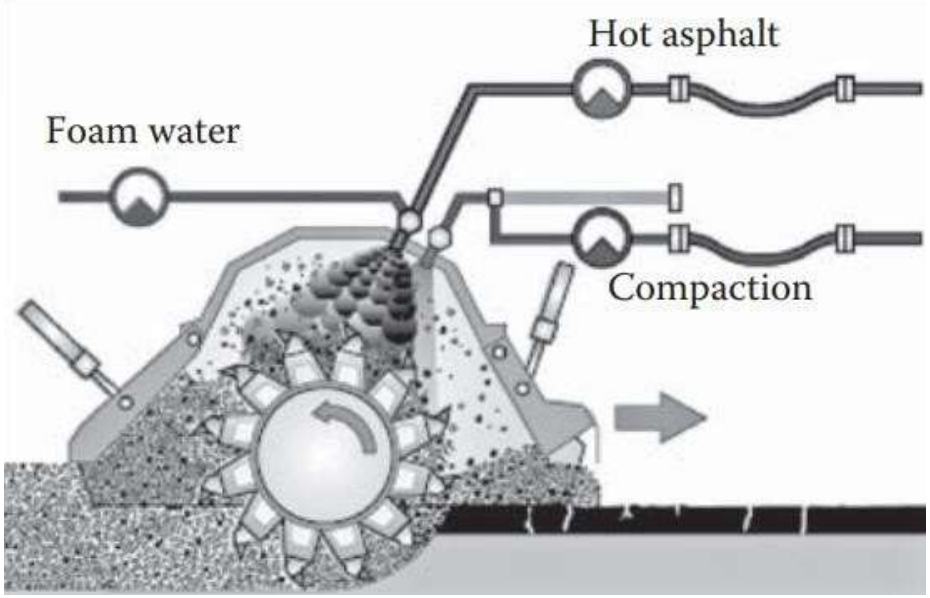

Deep recycled layer
Injection of water
Operating direction
Milling drum
Distressed pavement
Subbase and Subgrade
Bituminous Surfacing
Granular Base
Subgrade
Existing road
Pulverized
Subgrade
Pulverization to desired depth
Pulverized
Subgrade
Removal of excess material (if necessary) and shaping
Stabilized
Subgrade
Add agents/select material, mixing, reshaping and compaction
New Surfacing
Stabilized
Subgrade
Final surface treatment
Start
Finish

FDR PROCEDURES- FOAMED ASPHALT

- Foamed asphalt is being used increasingly in FDR.
- Foaming facilitates better dispersion of the asphalt into the materials to be recycled.
- A small amount of water is sprayed into hot asphalt as it is mixed with pulverized recycled pavement and soil.
- As the hot liquid and water mix, the liquid expands in a mini-explosion, creating a thin film of asphalt with about 10 times more coating potential.
- In modern single-pass equipment, foamed asphalt is created within the equipment in a separate foaming chamber and is directly added to the pulverized road material.



Schematic of FDR with cement slurry



Schematic of FDR with Foam Bitumen

FDR WITH CEMENT SLURRY

FDR WITH FOAM BITUMEN

FDR PROCEDURE

MACHINERY FOR FDR

- Cement spreader
- Road reclaimer
- Water truck
- Motor grader
- Various types of road rollers
- Machineries for construction of bituminous layer- Hot mix plant, roller, trucks, etc.





CEMENT SPREADER

- Uniform distribution of required quantity of cement
- Can be done in two ways:
  - In dry form over existing pavement
  - In slurry form
- Most suitable: spreading cement in dry form before pulverization
- When specified in contract document, cement spreading can be made manually also
- Keeping in view generation of many man-days of work and the fact that cement spreading through manual labour can be done equally efficiently as compared to cement spreader machine, PIUs can decide the methodology to be adopted for cement spreading while formulating DPRs

ROAD RECLAIMER

- Self propelled, specially manufactured for in- place pavement reclamation
- Sufficient horsepower to excavate and pulverise minimum 300 mm depth of in-situ bituminous pavement having granular or stabilised base/ sub-base in a single pass
- Integrated water injection system capable of varying the flow rate and spraying the water uniformly over the pulverised material which is inside the cutting drum chamber. Reclaimer must have automatic display system to show flow rate of water
- The cutting drums must also have variable speed of rotation, so that they can excavate and pulverise different thicknesses and combination of pavement layers.
- The cutting blades in a reclaimer are made by using tungsten carbide. The cutting teeth are usually arranged in a chevron pattern to reduce the load on the motors and to retain the recycled material inside the drum.

COMPACTION EQUIPMENT

- FDR stabilised layer should be properly compacted so that it gains design strength and to ensure good performance
- Usual practice: compact FDR layer in a single lift, so, thickness of FDR layer to be compacted is quite high
- Combination of different types of heavy duty compactors is required
  - Tamping foot roller also known as Pad foot roller, having a vibratory drum fitted with tamping foot
  - Pneumatic tyred roller
  - Smooth wheeled single drum vibratory roller
  - Tandem roller
- Depending upon the thickness of FDR layer proposed, different rollers are used

- Compaction is critical!!!
- Decision regarding the types of rollers to be deployed shall be based on the layer thickness and the type of material to be compacted
- Typical Compaction sequence:
- Pad Foot/ Sheep Foot Roller
  - Motor Grader
  - Pneumatic Tire Roller
  - Smooth Single or Double Drum Roller in Vibratory Mode
  - Smooth Single or Double Drum in Static Mode

MOTOR GRADER

- Motor grader is used to bring the pulverised mixture to proper lines, level and camber, before and during rolling operations.
- For grading the un-compacted or partially compacted FDR layer, Motor grader should be the preferred equipment, instead of tractor towed grader since it has higher power and it can grade the material after breakdown rolling by pad foot roller.
- Motor graders can also be used to aerate and dry the pulverised mix if it is too wet

OTHER EQUIPMENT/ MACHINERIES

- Water tanker is used for continuously supplying water to reclaimer. So it is tagged in front of reclaimer.
- Water tanker would be again required for curing the FDR layer after compaction.
- Dump trucks and loader may be needed if there is any need to stack or to transport from stacks.
- Apart from these machineries, such road works involve construction of WMM or WBM layer and black top wearing course

WEATHER LIMITATIONS

- FDR should not be performed when the pavement is frozen or freezing temperatures are anticipated within 7 days of the end of FDR placement
- A minimum ambient temperature of 35 ºF (2 ºC) is recommended for chemical stabilizing agents
- A minimum ambient temperature of 45 ºF (7 ºC) is recommended for bituminous stabilizing agents
- FDR should not be performed in moderate to heavy rain

QUALITY CONTROL TESTS OF FDR WITH CEMENTITIOUS MATERIALS

- Strength of subgrade
- Pulverisation and Gradation
- Cement content/Admixture content
- Mixing uniformity
- Moisture content and Density of FDR base layer
- Strength of FDR base layer
- Stiffness of FDR base
- Thickness of the FDR layer base layer

FDR SUMMARY

- Eliminates most of the pavement distress
- Turns a deficient pavement structure into a new homogeneous section with increased structural capacity
- 25 to 50% cost savings compared to other rehabilitation methods
- Same day returns to light traffic
- Sustainable: Reuses 100% of existing materials, conserving non- renewable resources and reducing trucking