Analysis of Water Proofing and HighStrength Full-Depth Reclamation (FDR) Road

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***Abstract*- Full-depth reclamation (FDR) is a method of building roads that entails completely digging the old roadbed and then reusing or replacing the removed material with fresh aggregate. FDR is a sustainable approach of building roads that can lessen the negative effects of conventional road building techniques on the environment. Due to the fact that it employs recycled or existing materials and requires less excavation, it may also be more affordable than conventional approaches. FDR can also increase a road's capacity for load-bearing and drainage, extending the life of the road's surface.**

Keywords- Stabilized, recycle aggregate, OPC cement, designpavement, etc.

1. INTRODUCTION

A road construction process known as full-depthreclamation (FDR) entails reusing or replacing the existing roadbed material to a depth that is at least100% deeper than the original road surface. Roads that have deteriorated or are irreparably damaged are repaired or rebuilt using this method.

The following steps are often included in the FDR process:

Excavation: The current roadbed is dug up to its full depth, which can entail removing any base layers or pavement in addition to the top layer of dirt and rock.

Recycling of excavated material or replacement with new aggregate: The excavated material is next recycled by crushing and reusing the existing materials in the roadbed. After that, the recycled or substitute material is compacted to produce a stable.

A new road surface is made using the Full Depth Reclamation (FDR) technique, which entails recycling old road components. In an FDR project, the old road surface is removed down to the subgrade, the removed soil is crushed, and the crushed material is then used as the base course for the new road. This method can cut down on the number of fresh materials needed for road building, the amount of waste produced, and the project's overall cost. FDR can be applied to a variety of road surfaces, including asphalt and concrete, and is frequently used for road rebuilding and resurfacing projects.

Full depth reclamation (FDR) is a pavement recycling method that generates a stable foundation by profitably repurposing a pavement's multiple levels and materials. Saving time, money, and resources is accomplished through this method. FDR is a method of repairing damaged bitumen roads by recycling the materials and mixing them with OPC cement to produce a new, stabilized foundation. This FDR handbook covers the uses, advantages, design, building, and testing of the technology.

Fig.1 Current Pavement Issue.

Determining When FDR Is Appropriate

The decision to employ Full Depth Reclamation (FDR) as a technique for building roads depends on a number of variables, including the state of the current road surface, the project budget, and the intended outcome. In general, FDR is suited for road construction projects where a new road surface is sought and the old road surface is in good condition and can be recycled. When a project calls for a low- cost road building technique that uses the least amountof new materials, FDR is a good choice. It is crucial toremember that FDR might not always be appropriate and that the optimal road construction technique for a certain project should be determined by consulting a competent engineer.

Fig.2 Extra patching is more expensive than FDR.

Excessive Patching

When the new foundation course is not properly compacted or the current road surface is not properly prepared, excessive patching is a frequent issue that can arise in Full Depth Reclamation (FDR) projects. When the new base course is not thick enough to sustain the new road surface adequately and small patches of the base course deteriorate over time, generating potholes or other types of road distress, excessive patching takes place.

Before beginning the FDR project, it is crucial to thoroughly prepare the current road surface to avoid the need for unnecessary patching. This can entailfixing any cracks or other sorts of distress that might be present, as well as eliminating any outdated pavement or base course. To make sure it offers enough support for the new road surface, the new basecourse should also be thoroughly compacted.

If there is extensive patching, it may usually be fixed by removing the damaged portion of the road surface and replacing it with new base course or pavement. However, doing so can be expensive and time- consuming. It is usually preferable to avoid the need for too much patching in the first place by adequately preparing the current road surface the new base course, etc.

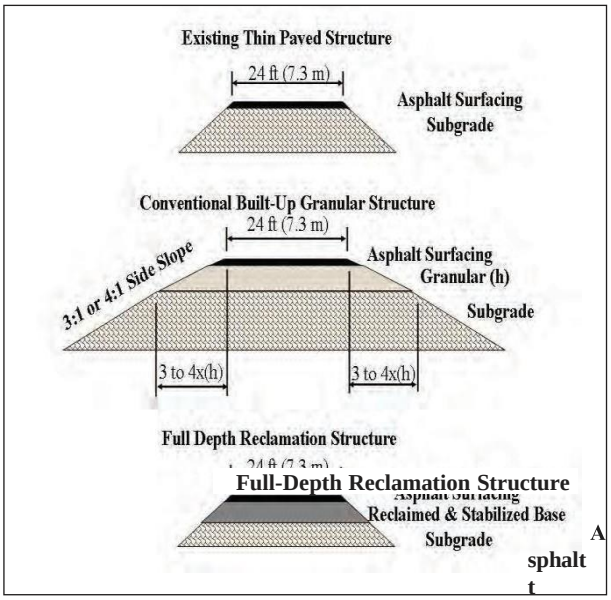


Fig.3 To reduce the pavement by FDR.

Inadequate Pavement Structure

When the new foundation course is not properlycompacted or the current road surface is not properly prepared, inadequate pavement structure is a frequent issue that can arise in Full Depth Reclamation (FDR) projects. When the new base course is not thick enough to offer enough support for the new road surface or whenthe current pavement or base course is in poor condition, inadequate pavement structure may result. As a result, the lifespan of the road may be drastically shortened and potholes, cracks, and other sorts of road distress may emerge.

Before beginning the project, the existing road surface must be carefully prepared in order to avoid inadequate pavement structure in FDR projects. This can entail fixing any cracks or other sorts of distress that might be present, as well as eliminating any outdated pavement or base course. To make sure it offers enough support for the new road surface, the new base course should also be thoroughly compacted.

In the event that there is an issue with the pavement structure, it is usually possible to fix it by removing the damaged portion of the road surface and installing new foundation course or pavement in its place. However, since this procedure can be expensive and time- consuming, it is usually preferable to avoid an inadequate pavement structure altogether by adequately preparing both the new base course and the current road surface.

Serious Damage or Base Failure

In Full Depth Reclamation (FDR) projects, majordamage or base failure can happen if the new base course is not compacted adequately or the current road surface is not properly prepared. Serious damage or base failure happens when the old base course is unable to sustain the new road surface adequately and the old pavement or base course is in poor condition. As a result,the lifespan of the road may be drastically shortened and extensive cracks, potholes, and other sorts of road distress may emerge.

It is crucial to carefully prepare the existing road surface before beginning the project in order to avoid significant damage or base failure in FDR projects. This can entail fixing any cracks or other sorts of distress that might be present, as well as eliminating any outdated pavement or base course. To make sure it offers enough support for the new road surface, the new basecourse should also be thoroughly compacted.

The afflicted portion of the road surface can often be removed and replaced with new pavement or basecourse in the event that substantial damage or base failure occurs. To avoid major damage or base failure altogether, it is usually best to carefully prepare both the new base course and the current road surface. This can be a costly and time-consuming process.

Special Considerations When Using FDR

Full Depth Reclamation (FDR) is an economical and environmentally responsible way of building roads that has the potential to offer a number of advantages, such as shortened construction times and costs, enhanced traffic flow, and increased safety. When employing FDR, there are a number of additional particular considerations that must be made, such as:

Soil quality: The soil quality being used for FDR is a crucial factor. To make sure that the base course is strong enough to sustain the new road surface, the soilshould be assessed for its strength and compaction characteristics. Additional materials may then need to be added.

Climate: The FDR project may be impacted by the local climate in the area where it is being carried out. To avoid water pooling and causing damage, for instance, it could be required to incorporate more drainage measures to the new road surface in locations with heavy rainfall.

Drainage: A successful FDR project depends on gooddrainage. The new road surface should be slanted to encourage drainage, and it might be necessary to include drainage features like culverts or catch basins to stop water from building up.

Traffic: The FDR project may also be impacted by the traffic in the area where it is being carried out. To guarantee the security of drivers and construction workers, temporary traffic control measures may be required.

Maintenance: To guarantee that FDR initiatives continue to function well over time, ongoing maintenance is required. This could involve regular checks, fixes, and resurfacing.

Overall, FDR is a flexible and economical approach ofbuilding roads that can offer a number of advantages. To guarantee the project's success, it is crucial to take into account the unique aspects mentioned above.

Table 1 - Features of Flexible Pavement Comeback Strategies.

Solution	Advantages	Disadvantages
Thick Structural Overlay	• Provides newpavement structure • Quick construction • Only moderate traffic disruption	• Elevation change can present problems for existing curb and gutterand overhead clearances • Large quantity ofmaterial must be imported • High cost alternative
Removal and Replacement	• Provides newpavement structure • Failed base andsubgrade are eliminated	• Highest cost alternative • Old materials must bedumped
Recycling Surface, Base and Subgrade with Cement (Full-Depth Reclamation)	• Fast constructioncycle • Local traffic returns quickly	• May require additional effort tocorrect subgrade problems • Some shrinkage cracks may reflect through bituminoussurface

2. DESIGN

A road construction technique called full-depth reclamation (FDR) involves grinding and recycling the base materials and current road surface in order to reuse them to produce a new road surface.

The following steps are commonly included in the planning of an FDR road:

Surface preparation: Using a milling machine, the existing roadsurface is first cleaned of any debris before being ground to a consistent depth.

Base construction: The ground surface is then covered with a layer of stabilised base material. Numerous techniques, including the use of recycled materials like crushed concrete or asphalt, can be used to accomplish this.

Placing recycled materials: The foundation layer is then covered with the recycled elements that were obtained during the grinding process. These materials may comprise recycled concrete aggregate (RCA) or recycled asphalt pavement (RAP).Compaction: Using large machinery, such as a vibrating compactor, the recycled materials are subsequently compressed to the necessary density.

Placement of aggregate: To create a solid foundation for the new road surface, an aggregate layer is lastly added on top of the recycled materials.

A robust and long-lasting new road surface is produced by combining surface preparation, base building, and material placement processes in the design of an FDR road. FDR can assist in lowering the quantity of garbage produced during road constructions and is an economical and ecologically friendly alternative to conventional road construction processes.

Pavement Design

Yes, I can aid you in designing the FDR pavement. The National Centre for Asphalt Technology at Auburn University developed the pavement design system known as FDR, or Fast Deck Recycled. The system's goal is to offer low-traffic rural roads a viable, affordablesolution.

In the building of low-volume roads, FDR pavementdesign often calls for the use of recycled resources, such as reclaimed asphalt pavement and recycled concrete aggregate. A resilient and flexible pavement surface that can resist the rigours of low-volume traffic is what the technology is intended to give.

Typically, the following steps are included in the FDR pavement design process:

Site preparation: The area is cleared to make way for building, and the soil is checked to see if it is stable and suitable for paver

construction.
Compaction of the soil, removal of any vegetation, and the installation of any necessary drainage systems are all steps in the subgrade preparation process.
Construction of the base course: To create a solid foundation for the pavement, the base course is built by laying a layer of crushed stone or gravel.
Construction of the pavement: A layer of RAP or RCAis spread over the base course, and it is then compacted using a vibrating roller. Then, to create a strong and adaptable pavement surface, a thin coating of asphalt is put to the area.
Surface treatment: The pavement's surface has been improved to make it smooth and skid-resistant. This can entail using a texture treatment or applying a seal coat.

Overall, FDR pavement design is a financially sensible and long-lasting option for rural roads with low traffic volumes. The approach lessens the environmental effect of conventional pavement building techniques while providing a strong and flexible paving surface that can resist the demands of low-volume traffic.

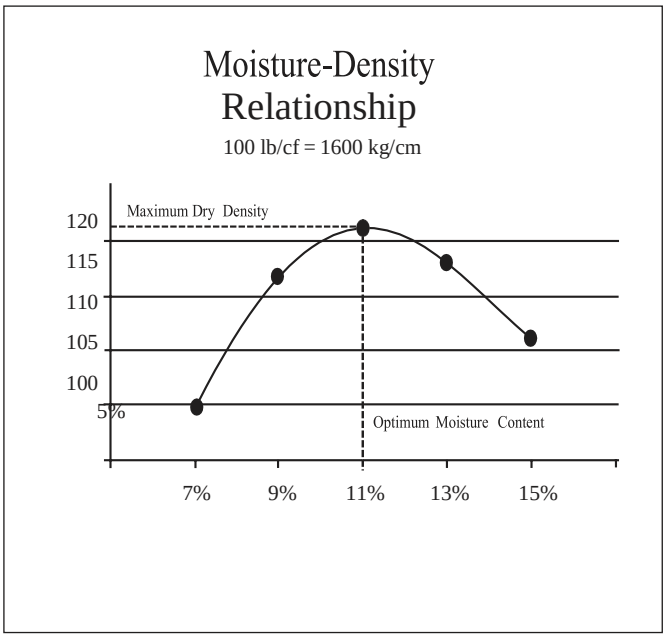


Fig.4 The Maximum Dry Density and Optimum Moisture Content.

Balanced Design
By balancing the structural and functional performance of thepavement while reducing the cost of construction and maintenance, balanced design is a pavement design strategy. For rural roads with low traffic volumes and pavement that needs to be planned for a long service life, the balanced design method is very helpful.
A flexible pavement design system that achieves a balance between the structural and functional performance of the pavement is used in the context of FDR pavement design to implement balanced design. A flexible layer of asphalt is often used in the system, which is then covered by a base course layer that is stable. A firm layer of base course acts as the pavement's foundation, while the flexible layer of asphalt creates a smooth, skid-resistant surface that can survive the rigours of low-volume traffic.
In the context of FDR pavement design, balanced designrefers to the application of a flexible pavement design systemthat strikes a balance between the structural and functional performance of the pavement. Typically, the technique uses aflexible asphalt layer on top of a base course layer that is stable. While the robust layer of base course offers a firm foundation for the pavement.
Because it permits the use of recycled materials like reclaimed asphalt pavement and recycled concrete aggregatein the creation of the pavement, the balanced design technique is particularly helpful for FDR pavement design. This lowers construction costs and lessens the environmental effect of conventional pavement constructiontechniques.
In order to increase the effectiveness and calibre of the pavement construction process, balanced design uses cutting-edge construction methods like laser grading and warm mix asphalt in addition to recycled resources. These solutions can cut down on construction costs and lessen the environmental effect of conventional pavement constructionprocedures.

Overall, balanced design is a sustainable and cost-effective method for designing FDR pavements because it strikes a balance between the pavement's structural and functional performance while lowering construction and maintenance expenses.

Fig.5 Spreading of excess aggregate for formation in FDR procedure.

3. CONSTRUCTION

The following actions are normally taken when building anFDR road:

Clearing the land and checking that the soil is stable andappropriate for building pavements are two steps in the site preparation process. This could entail clearing awayvegetation, digging up soil, and setting up drainage systems. **Construction of the base course:** The prepared subgrade iscovered with a layer of crushed stone or gravel to create thebase course. This layer helps the site's drainage and offers asolid foundation for the pavement.

Placement of recycled aggregate: To create the flexiblelayer of the pavement, recycled aggregate is spread over the Asphalt placement: To create the pavement's wear surface,asphalt is layered over a layer of recycled aggregate. Tomake the asphalt sturdy and robust, it is compacted with avibrating roller.

Surface treatment: The pavement's surface has beenimproved to make it smooth and skid-resistant. This canentail using a texture treatment or applying a seal coat.

Pavement is examined and tested to make sure it complies with the necessary requirements and regulations. In order to assess the pavement's structural performance, testing tools like load cells may be used.foundation course. This layer offers a smooth, skid-proof surface that can handle the strain of light traffic.

In general, an FDR road's construction entails striking a compromise between the structural and functional performance of the pavement and reducing the expense of building and maintaining it. This balance may be attained while minimizing the negative environmental effects of conventional pavement building procedures. This is madepossible by the use of recycled materials, cutting-edge construction processes, and thoughtful design strategies.

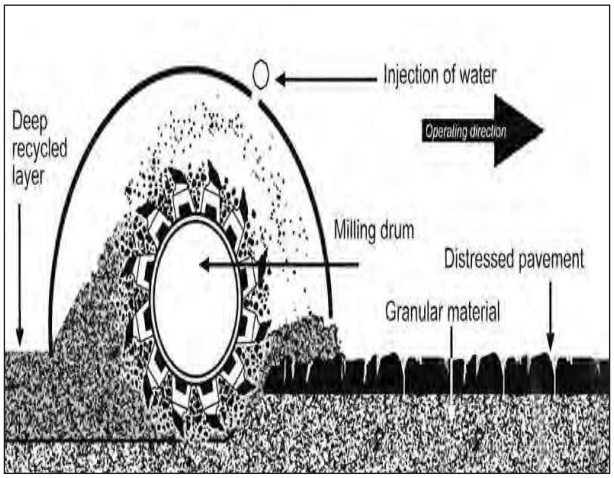


Fig.6 Recycling process.

- **Pulverizing**
- **Grading, Shaping, and Widening**
- **Cement Placement**
- **Mixing**
- **Compaction and Final Grading**
- **Curing**
- **Surfacing**
- **Field Quality Control**

Fig.7 Equipment and on site testing.

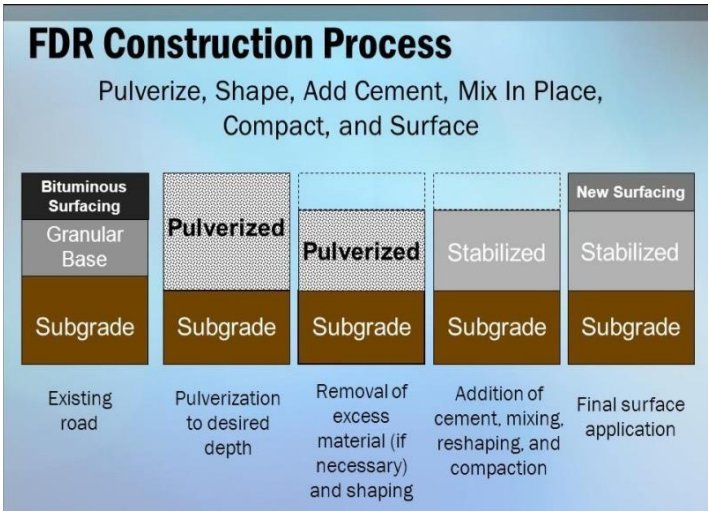
4. EQUIPMENT

The equipment used in Flexible Pavement Design (FDR)technique for road construction typically includes:

1. **Paver:** The paver is used to lay the base course and recycled aggregate layer of the pavement. It is a machinethat moves along the length of the pavement and spreads the material evenly.
2. **Compactor:** The compactor is used to compact the base course and recycled aggregate layer of the pavement. It is a machine that rolls over the material to ensure that it is compacted and stable.

3. **Laser Grading Equipment:** Laser grading equipment is used to ensure that the pavement is graded to the required slope. This equipment uses lasers to measure the elevation of the pavement and adjusts the grading blade to achieve the desired slope.
4. **Cold Planers:** Cold planers are used to remove the existing pavement and prepare the surface for the new pavement. They use a rotating blade to cut through thepavement and remove the surface material.
5. **Asphalt Mixing Plant:** The asphalt mixing plant is used to produce the asphalt used in the pavement. It mixes the asphalt aggregate and binder to produce a consistent mixture that is used to pave the pavement.
6. **Roller:** The roller is used to compact the asphalt layer of the pavement. It is a machine that rolls over the asphalt to ensure that it is compacted and durable.
7. **Load Cell:** A load cell is used to measure the weight of the vehicle on the pavement. It is typically placed atstrategic locations along the pavement and provides real-time data on the weight and load distribution of the vehicles.

5. Comparison result FDR techniqueover old technique of road construction.



Full Depth Reclamation (FDR), a relatively new method of building roads, has grown in popularity recently. FDR has various benefits over conventional soil excavation and disposal techniques.

First of all, FDR lessens the waste produced during road construction. Large volumes of dirt are removed using conventional excavation techniques, and this soil is frequently dumped in landfills. This has detrimental effects on the environment in addition to wasting resources. FDR, onthe other hand, minimises waste and protects natural resources by reusing the existing soil and rebuilding it to its previous depth.
Second, FDR is an economical method. Expensive labour and large equipment are needed for conventional excavation techniques. FDR, on the other hand, employs already- existing resources like labour and equipment, which lowers the overall cost of road building.

Third, FDR lowers the quantity of materials required for roadconstruction. The removal of soil from the site is necessary for traditional excavation techniques, which can be expensiveand time-consuming. In contrast, FDR makes use of the already-existing soil, which reduces the amount of material required for road construction and saves time and money.

6. INSPECTION AND TESTING

Description: To ensure that the work complies with the contract documents, the engineer must conduct the inspections and tests that are considered necessary with the contractor's assistance and cooperation. These examinations and tests could consist of, but not be restricted to:

- Watching every piece of machinery at work in action. Unless the engineer has given his or her approval in writing, only those tools, machines, and techniques matching the specifications of the contract documents may be used.

7. CONCLUSION

In order to create a stable, level surface, the previous dirt must be completely removed, broken up into smaller pieces, and recompacted. This can be accomplished with avariety of tools, including a soil stabilizer or a road milling machine.
FDR can have a number of advantages, including a decrease in the amount of new soil that needs to be dug up, a decrease in erosion and sedimentation, and an increase in the structural integrity of the reclaimed soil. Since the reclaimed soil can be used again on the site or elsewhere, it can also aid in lowering the quantity of waste produced during construction.
Overall, FDR is a cost-effective and environmentally friendly method of building that can help to reduce negative effects on the environment and encourage resource efficiency.

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