

COLD IN PLACE RECYCLING

PROCESS DESIGN OVERVIEW

1 SCOPE

Cold In-Place Recycling is a rehabilitation process whereby the existing pavement is reprocessed without the presence of heat during the recycling process. There are two separate processes used; Cold Central Plant Recycling (CCPR) and Cold In-Place Recycling (CIR). We will be discussing only the CIR process here. The CCPR process is discussed in the Cold Mix Asphalt section.

The advantages of Cold In-Place Recycling are as follows:

- Conserve resources by reusing aggregates and asphalt in the existing pavement
- Energy conservation
- Pavement materials disposal reduced or eliminated
- Reflective cracking is delayed or reduced
- Improvement of crown or slope
- Pavement maintenance costs are reduced

1.1 DEFINITIONS

Cold In-Place Recycling:

Cold in-place Recycling (CIR) is a rehabilitation treatment consisting of the cold milling of the existing pavement surface (typically 50-125 mm), screening, remixing with asphalt emulsion, Portland cement or other modifiers to improve properties, followed by lay-down and compaction of the reprocessed material in one continuous operation. Due to the nature of cold in-place recycling a surface of some sort must be placed over the recycled mixture. Depending on structural and traffic the overlay can be one or more lifts of hot mix or a single surface treatment or surface types in between.

2 MATERIALS

2.1 Recycling Additives:

2.1.1 Asphalt Emulsions:

A number of different types and grades of asphalt emulsions can be used in Cold In-Place Recycling. The proper emulsion to be used is based on a number of factors; environmental conditions (temperature and humidity), time of year, and the existing road conditions. All these conditions affect the emulsion to be used. Typically the most common emulsions used are High Float types, CSS-1, CMS-2 (polymer versions included) as well as proprietary products.

2.1.2 Rejuvenators:

The rejuvenators are typically cationic emulsions combining a process oil with water. They can be used by themselves or in a combination blend with an asphalt emulsion. When using rejuvenators more detail has to be done during the mix design stage.

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PROCESS DESIGN OVERVIEW

2.2 Recycled Asphalt Pavement (RAP):

The recycled asphalt pavement (RAP) is created by the grinding of the existing pavement. Depending on the process the RAP material may be further processed through a screening and crushing operation. Typically the maximum particle size is 37 mm. The milling machine can control the gradation of the RAP through speed, milling head direction as well as the existing pavement condition.

2.3 Modifiers:

There are different modifiers that can be used in the CIR process. Besides the asphalt emulsion or recycling agent, aggregate may be added to improve gradation, stability or cross slope. Portland cement or lime in dry or slurry form can be added to improve early strength, cohesion and resistance to moisture damage.

3 DESIGN CRITERIA

In order to design a mix to satisfy the objectives of the project the existing pavement must be investigated for structural adequacy, thickness, slope and cross-fall as well as the visual appearance. Based on these criteria a proper design can be developed. In most instances the design procedure developed by Wirtgen is the accepted method of design. This design procedure is well laid out in the Wirtgen Cold Recycling Technology Manual.

The following is a guide to the design procedure:

- Obtain samples of RAP from field
- Determine RAP gradation, binder content, gradation of extracted aggregate, and aged binder
- Select amount and type of additional aggregate if required
- Select type and grade of recycling additive
- Estimate recycling, additive demand
- Determine pre-mix moisture content for coating
- Test trial mixtures, initial curing properties, final curing properties, and moisture sensitivity
- Establish job mix formula
- Make adjustments in field

RAP samples: Representative samples should be taken. Areas where differences in type and texture of existing pavements should be noted. Proper sampling procedures should be followed and enough material taken to ensure representation.

RAP properties: Gradation of RAP as well as the extracted gradation should be obtained to help in deciding if new aggregate is needed. The asphalt content should be determined and the recovered asphalt properties obtained such as penetration and viscosity. Knowing these can help in deciding what recycling additive to use as well as limiting quantities.



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New aggregate: Most CIR projects do not require new aggregates. New aggregate can be justified if the RAP is high in binder content or improved structural capacity is needed. Typically crusher run aggregate is used. In some instances straight coarse aggregate can be used to increase the coarse fraction.

Type and grade of recycling additive: The most common recycling additives used in CIR are asphalt emulsions and recycling agents. Polymer versions have been used as well to reduce rutting, improve early strength and aid in reducing thermal cracking.

- **Asphalt emulsions:** The most common types of asphalt emulsions used in CIR are the cationic and anionic mixing grades. Slow setting emulsions work well with dense graded aggregates and aggregate with high fines content. Compatibility of the emulsion to the RAP is important and the emulsion is there to provide binding properties, initial strength, coating and control the breaking time.
- **Recycling agents:** The recycling agents are typically cationic type rejuvenators. Combinations of recycling agents and asphalt emulsions are becoming common as they provide both rejuvenations as well asphalt binding to the RAP material. Because the rejuvenation process requires time to work the design process is a little more complicated and requires more testing of the mechanical properties of the mix.
- **Chemical additives:** Portland cement, lime and Type C fly ash have been used successfully as recycling additives. These agents provide improved early strength, increased rutting resistance and improved moisture damage protection. Cement and lime have been used very successfully in combination with asphalt emulsions.

Pre-mix moisture content: The use of water is very important in CIR mixes. The water has two purposes in the mixture. The first purpose is to aid in the coating the RAP by the recycling additive. The second purpose of the water is to act as a compaction aid in the field. Accurate quantities of water are required to ensure the proper coating and compaction effort of the mix in the field. The total liquids content is taken as the total of the recycling additive used, the pre-mix moisture added and the moisture present in the RAP material.

Trial mixtures: In order to establish the optimum recycling additive needed in the mix trial batches must be carried out in the laboratory. A number of trials are done varying the quantity of recycling agent (typically between 0.5 and 3.0% in 0.5% increments). The total liquids content is maintained so as the recycling additive varies so does the pre-mix water. The compaction of the CIR mix is typically done using the 75 blow Marshall compaction at a slightly elevated temperature of 40°C. This value seems to give density values comparable to field densities.

Curing: During the design stage the compacted mixture has to lose moisture in order to develop maximum strength. This can be accomplished in the laboratory by curing the samples at an elevated temperature for 24 to 48 hours. Typical curing temperatures are 60°C.



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Strength testing: Strength testing using Marshall stability and flow should be done to ensure adequate strength. Although it is difficult to remove all moisture the bulk specific gravity should be done. Approximate volumetrics can be determined from compacted specimens. The air voids should lie between 9 – 14 percent. The moisture susceptibility of the mix should be performed. Typically AASHTO T283 test “Resistance of Compacted Bituminous Mixture to Moisture Induced Damage” is the most common method used. Other tests involving some kind of moisture conditioning are also used.

Job mix formula (JMF): After all testing JMF can be established. Typically it is determined by air voids, strength tests, appearance and moisture susceptibility. The JMF should specify the percent recycling additive (type and grade), the mix water content and the compacted maximum density at the optimum recycling additive content. The job mix formula is the starting point for the project and field adjustments may have to be made as conditions warrant.

4 RECOMMENDED PERFORMANCE GUIDELINES

In order to construct a proper well designed CIR Mix the following guidelines should be followed:

- Ensure the existing pavement structure is adequate to support expected traffic.
- Evaluate existing pavement for distresses and make sure repairs completed prior to construction
- Ensure that the CIR process is the proper process to be used.
- Determine if a corrective aggregate or other modifiers such as cement is needed.
- The existing pavement should have the recovered asphalt cement evaluated.
- Ensure a proper mix design is done. Use mix design as a guide only
- Field adjustments may have to be made to water content or recycling additive to achieve good coating and workability.
- For proper laydown and compaction paver should be as close as possible milling and mixing unit.
- Heavy pneumatic (30 tonne) and double vibratory rollers (11 tonne) used.
- Compaction starts as mix breaks (turns from brown to black). Could be in 30 min or 2 hours.
- If modifier used compaction begins as soon as mix is placed.
- Breakdown rolling typically done with heavy pneumatic. Intermediate with double drum vibratory, final rolling with vibratory steel wheel roller.
- Rolling patterns should be established at start with use of nuclear gauge.
- Curing of finished mat is required before placement of wearing surface.
- Curing can vary depending on environmental conditions. Typically 10 to 14 days.
- A light fog seal may be needed to prevent surface raveling.
- Typically an HMA wearing surface is placed over CIR. Mix type governed by structural requirements.



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5 RESOURCES

1. "Basic Asphalt Emulsion Manual", Fourth Edition, Asphalt Institute and Asphalt Emulsion Manufacturers Association, 2008
2. "Basic Asphalt Recycling manual", Asphalt Recycling and Reclaiming Association, Annapolis Maryland, 2001
3. "Wirtgen Cold Recycling Technology", 2012 Edition, Wirtgen GmbH,
4. "Report on Cold Recycling of Asphalt Pavements", Task Force 38, AASHTO/AGC/ARTBA, March 1998



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