COLD IN-PLACE RECYCLING

GENERAL INFORMATION AND RESOURCES

SCOPE

Cold in-place recycling is a rehabilitation process wherein existing pavement is reprocessed without the presence of heat. There are two separate processes used in cold in-place recycling: cold central plant recycling (CCPR) and cold in-place recycling (CIR). Only the CIR process will be discussed in this document. The CCPR process is described in the “Cold Mix Asphalt Process Design Bulletin.”

The advantages of cold-in-place recycling are as follows:

- conserves resources by reusing aggregates and asphalt in the existing pavement
- conserves energy by minimizing the trucking of material to and from the jobsite
- the disposal of pavement materials is reduced or eliminated
- reflective cracking is delayed or reduced
- improvement of the crown or slope
- pavement maintenance costs are reduced

DEFINITIONS

COLD-IN-PLACE RECYCLING

CIR is a rehabilitation treatment that involves the cold milling of an existing pavement surface (typically 50 to 125 mm), screening of the recovered material, and remixing said material with an asphalt emulsion, Portland cement, or other modifiers in order to improve properties. This process is followed by the laydown and compaction of the reprocessed material in one continuous operation. Due to the nature of CIR, an additional surface must be placed over the recycled mixture after it is applied to the road. Depending on the expected traffic load and the existing structural condition of the pavement surface, this additional surface can be one or more lifts of HMA, a single surface treatment, or various other types of surface.

MATERIALS

ASPHALT EMULSIONS

A number of different types and grades of asphalt emulsions can be used in CIR. The type and grade of emulsion to be used is based on a number of factors: environmental conditions (temperature and humidity), time of year, and existing road conditions. The most common emulsions used are high-float types, CSS-1, CMS-2, and proprietary products, including their polymer-modified formulations.

REJUVENATORS

Rejuvenators are emulsions that combine a rejuvenating oil with water. Rejuvenators can be used alone or blended with an asphalt emulsion. Extra steps are required in the mix design stage when using rejuvenators.

RECLAIMED ASPHALT PAVEMENT (RAP)

Reclaimed asphalt pavement (RAP) is created by grinding existing pavement. Depending on the process, RAP material may be further processed through a screening and crushing operation. The maximum particle size is typically 37 mm. The condition of the existing pavement in addition to the milling machine’s speed and milling head direction can control the gradation of the RAP and .

COLD IN-PLACE RECYCLING

GENERAL INFORMATION AND RESOURCES

MODIFIERS

There are different modifiers that can be used in CIR. Besides the asphalt emulsion and/or the rejuvenators, virgin aggregate may be added to improve the gradation, stability, or cross slope of the final mix. Portland cement or lime in dry or slurry form can be used to improve the material's early strength, cohesion, and resistance to moisture damage.

DESIGN CRITERIA

In order to design a mix that satisfies the objectives of the project, the existing pavement must be investigated for structural adequacy, thickness, slope, and cross-fall as well as for visual appearance. In most instances, the design procedure developed by Wirtgen will serve as the accepted method of design. This design procedure is laid out in the "Wirtgen Cold Recycling Technology Manual."

The design process is performed as follows:

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

RAP SAMPLES

Representative samples should be taken. Any areas where differences in the type and texture of existing pavements are observed should be noted. Proper sampling procedures should be followed and enough material should be taken to ensure an accurate representation.

RAP PROPERTIES

The gradation of the RAP as well as the gradation of the extracted material should be obtained in order to decide if new aggregate is required for the mix. The RAP's asphalt content should be determined as well as its recovered asphalt properties such as penetration and viscosity. Understanding these factors can help in deciding which recycling additive to use as well as limiting the quantities of material required.

NEW AGGREGATE

Most CIR projects do not require new aggregates. New aggregate is only justified if the RAP is high in binder content or improved structural capacity is needed. Crusher run aggregate is typically 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 and thermal cracking as well as to improve early strength.

COLD IN-PLACE RECYCLING

GENERAL INFORMATION AND RESOURCES

ASPHALT EMULSIONS

The most common types of asphalt emulsions used in CIR are cationic and anionic mixing grades. Slow-setting emulsions work well with dense-graded aggregates and aggregates with high fines contents. The compatibility of the emulsion and the RAP is important as the emulsion is there to provide binding properties, initial strength, coating, and to control the breaking time.

RECYCLING AGENTS

The recycling agents used in CIR are typically cationic rejuvenators. Combinations of recycling agents and asphalt emulsions are becoming common as they provide both rejuvenation as well asphalt-binding strength to RAP material. Because the rejuvenation process requires time to work, the design process is more complicated and requires more testing of the mechanical properties of the mix when recycling agents are involved.

CHEMICAL ADDITIVES

Portland cement, lime, and Type C fly ash can used as recycling additives. These agents provide improved early strength, rutting resistance, and moisture damage protection. Cement and lime can be used in combination with asphalt emulsions.

PRE-MIX MOISTURE CONTENT

The use of water is critical to CIR mixes, serving two distinct purposes: aiding the recycling additive in coating the RAP and aiding compaction in the field. Precise quantities of water are required to ensure the proper coating and compaction effort of the mix in the field. The total moisture content is the total of the recycling additive used, the pre-mix moisture added, and the moisture already present in the RAP material.

TRIAL MIXTURES

In order to establish the optimum amount of recycling additive needed in the mix trial, batch testing must be carried out in the laboratory. A number of trials must be done with varying quantities of recycling agent (typically between 0.5 and 3.0% in 0.5% increments). The total moisture content is always maintained in the trials: as the recycling additive varies, so does the pre-mix water. The compaction of the CIR mix is typically done using 75 blow Marshall compaction at 40°C. This value recreates density values comparable to those found in the field.

CURING

During the design stage, the compacted mixture has to lose moisture in order to develop its maximum strength. This can be accomplished in the laboratory by curing compacted mixture samples at an elevated temperature (typically 60°C) for 24 to 48 hours.

STRENGTH TESTING

Strength testing using Marshall stability and flow tests should be done to ensure that the mix has adequate strength. Although it is difficult to remove all moisture, the bulk specific gravity should be tested. Approximate volumetric properties can be determined from compacted specimens. Air voids should lie between 9 to 14%. The moisture susceptibility of the mix should be tested. Typically, the AASHTO T283 “Resistance of Compacted Bituminous Mixture to Moisture Induced Damage” method is used. Other tests involving moisture conditioning are also used.

COLD IN-PLACE RECYCLING

GENERAL INFORMATION AND RESOURCES

JOB MIX FORMULA (JMF)

After all testing, the JMF can be established. The JMF is typically determined by air voids, strength tests, appearance, and moisture susceptibility. The JMF should specify the amount of 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 but field adjustments may have to be made as conditions warrant.

RECOMMENDED PERFORMANCE GUIDELINES

In order to conduct a well-designed, high-quality CIR, the following guidelines should be followed:

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

RESOURCES AND REFERENCES

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, 2012
4. “Report on Cold Recycling of Asphalt Pavements”, Task Force 38, AASHTO/AGC/ARTBA, March 1998