COLD IN-PLACE RECYCLING (CIR) ASPHALT - TECHNICAL SPECIFICATION

Scope - This work shall consist of milling the existing asphalt concrete pavement to the length, depth and width as shown on the plans, sizing the Reclaimed Asphalt Pavement (RAP) material to an evenly graded aggregate blend with a maximum size. The properly graded RAP to be recycled shall then be blended with an emulsified asphalt recycling agent, and other additives, as required by the attached or Contractor's Mix Design, to produce recycled asphalt concrete. This material shall then be placed and compacted in accordance with the Plans and Specifications, and as directed by the Engineer.

Submittals - At the time of bid, the Contractor shall furnish the following information regarding the Cold In-place Recycling (CIR) to the Engineer. Approval of the Contractor or Subcontractor performing the CIR is at the discretion of the Engineer.

1) Emulsion and emulsion supplier. Identification that the proposed recycling emulsion has been successfully used on at least five (5) other CIR asphalt projects in California over the past five (5) years, including project name, agency/owner, project engineer, and construction dates.

2) Description and specification of the proposed CIR recycling unit and support equipment.

3) The Contractor (or Subcontractor) shall have completed a minimum of five (5) CIR asphalt projects in the last three (3) years. Submit project name, agency/owner, project engineer, and construction dates.

4) The CIR recycling unit shall demonstrate the ability to crush and screen the RAP used in the CIR process and remove pavement reinforcing fabric during the recycling process.

5) Verification the CIR recycling unit meets the proportioning requirements of California Test 109 and the applicable Air Quality Control district permits.

6) Quality Control Plan.

Just In Time Training - Attending a 2-hour minimum Just-In-Time Training (JITT) shall be mandatory, and consist of a formal joint training class on cold recycled asphalt materials, required special equipment, placement and compaction methods, and quality control. Construction operations for cold recycling shall not begin until the Contractor's and the Engineer's personnel have completed the JITT. The JITT training class shall be conducted at a project field location convenient for both the Contractor and the Engineer. The JITT class shall be completed not more than 7 days prior to the start of cold recycling operations. The class shall be held during normal working hours. The Contractor shall provide the JITT instructor. The instructor shall be experienced in the construction methods, materials, and test methods associated with construction of cold recycle asphalt projects. A copy of the course syllabus, handouts, and presentation material shall be submitted to the Engineer at least 7 days before the day of the training. The Contractor and the Engineer shall mutually agree to the course instructor, course content, and training site. Just-In-Time Training shall not relieve the Contractor of responsibility under the contract for the successful completion of the work in conformance with the requirements of the plans and specifications.

Mix Design – In an evaluation of the existing roadways suitability as a candidate for CIR, the City performed a mix design(s) utilizing *(insert emulsion name and source)* as the emulsified recycling agent. While the City prefers the Contractor use mix design(s) provided at no cost to the Contractor, the type and quantity of recycling emulsion to be used for construction shall be determined by the Contractor. Should the Contractor elect to use their own mix design(s), the Contractor shall reimburse the City for its mix design(s).

The Contractor shall submit a mix design to the Engineer at least 14 calendar days prior to beginning the recycling operation. The mix design is for informational purposes only and shall be in accordance with the "*Method of Test for Determining the Percent of Emulsified Recycling Agent to Use for Cold Recycling of Asphalt Concrete*" below using representative samples of the asphalt concrete to be recycled obtained directly from streets for this project. Based on the characteristics of the existing asphalt pavement taken from different streets, more than one mix design may be required. The mix design shall be certified by a licensed Civil Engineer experienced in cold recycled pavements. The job mix formula shall meet the criteria of Table 1: *CIR Asphalt Mix Design Requirements* and be approved by the Engineer.

Table 1: CIR Asphalt Mix Design Requirements

Design Parameters	Requirement
Gradation of Reclaimed Asphalt Pavement (RAP): CT 202	1-inch maximum ≤5% passing No. 200
Asphalt Content of RAP: CT 362 or CT 379 or ASTM D 2172 Method B	Report
Bulk Specific Gravity of Compacted Samples [a, b]: CT 308, Method C	Report
Maximum Theoretical Specific Gravity [b]: CT 309, including provisions of Section J	Report
Air Voids of Compacted and Cured Specimens [b]: CT 367 Part B	Report
Marshall Stability, Cured Specimen [b]: AASHTO T 245 104 ºF (min)	1250 lb
Marshall Retained Stability, AASHTO T 245, 104 ºF based on Moisture Conditioning on Cured Specimen (min) [b, c]	70% [d]
Ratio of Emulsion Residue to Cement (min)	3:1
Raveling Test of Cold Mixed Bituminous Emulsion, ASTM D 7196, 50 ºF (max)	7.0
RAP Coating Test, ASSHTO T59 [e], (min)	Good

Notes:

[a] 4-inch diameter mold compaction based on either 75 blow Marshall on each side or gyratory compactor at 30 gyrations.

[b] Test specimens after 140ºF curing to constant weight between 16 hours and 48 hours.

[c] Vacuum saturation from 55 percent to 75 percent. Water bath at 77 °F for 23 hours, with the last 30 minutes to 40 minutes in 104 ºF water bath.

[d] The Marshal Retained Stability ratio may be reduced to 60%, providing the saturated Marshall Stability is at least 1500 lbs.

[e] Modify ASSHTO T59 using jobsite RAP, emulsified recycling agent and water application rates that have been determined in the CIR mix design and submitted in job mix formula.

During the mix design, the Contractor shall determine the target values for penetration at 25°C and viscosity at 60°C of the emulsified recycling agent to be used in production of the recycled pavement mixture.

Materials

Emulsified Recycling Agent – The type of recycling emulsion to be used shall be determined by the mix design. The recycling emulsion supplier shall designate a technician, knowledgeable and experienced in CIR and approved by the Engineer who shall be at the job site at the beginning of the project to monitor the characteristics and performance of the recycling emulsion. Throughout the job, the Contractor's designated technician will be available to check on the project and make adjustments to the recycling emulsion formulation as required, to insure the emulsion and recycled pavement perform per these specifications. The Emulsified recycling agent shall be a polymer modified rejuvenating emulsion with a latex polymer, rejuvenating agent, and asphalt and shall conform to the requirements of Table 2:

Table 2 Recycling Emulsion Requirements

Tests on Emulsion	**Test Method**	**Requirement**	
		Minimum	Maximum
Sieve test, % of weight sample	AASHTO T59[1]	---	0.1
Residue by distillation, %	AASHTO T59[1]	60	67
RAP Coating Test	AASHTO T59[2]	Good	-----
Tests on residue by distillation:			
Penetration, 25°C, 100g, 5s (Target Value) [3]	AASHTO T49[4]	+/- 25%	
Absolute Viscosity at 60°C, poise	AASHTO T2171[4]	Report Only	

Note: 1 Modify AASHTO T59 – distillation temperature of 177°C with a 20 minute hold.
2 Mix emulsion recycling agent and water rates shall be determined by the mix design and with jobsite RAP.
3 Target value shall be determined by the mix design.
4 Sieve residue from distillation on #20 sieve prior to determining viscosity.

The latex polymer shall be *(insert name)* or approved equal, a product of Polymer Science of America and conform to the following requirements:

Test on Latex Polymer	**Test Method**	**Requirement**
Specific Gravity Min.	ASTM 1475	1.08
Tensile strength, die C dumbbell, psi, minimum	ASTM D412 **(1)**	500
Swelling in rejuvenating agent, % maximum; 48 hours exposure @ 104°F	ASTM D471**(2)** Modified	40% intact film

(1) Tensile Strength Determination: Samples for testing for tensile strength in accordance with ASTM D412 shall be cut using a die dumbbell at a crosshead speed of 20 in/min.

(2) Latex Testing: Suitable substrate for film formation shall be polyethylene boards, silicone rubber sheeting, glass, or any substrate which produces a cured film of uniform cross-section. Polymer film shall be prepared from latex as follows:

Resistance to Swelling: Polymer films shall be formed by using a 50 mil drawdown bar and drawing down 50 mils of the latex on polyethylene boards. Films shall be cured for 14 days at 75°F and 50% humidity. Samples for resistance to swelling in rejuvenating agent shall be 1" by 2" rectangles cut from the cured film. Cut at least 3 specimens for each sample to be tested for swelling. Fill 3- 8 oz ointment tins with at least a ½" deep of rejuvenating agent. Swelling samples shall be weighed and then placed in the ointment tins on top of the rejuvenating agent. Then, add at least another ½" deep of rejuvenating agent over each of the latex samples. The ointment tins shall be covered and placed in an oven at 104°F for the specified 48 hours +/- 15 minutes. The ointment tins are allowed to cool to 75°F and then the latex films are removed from the tins. Unabsorbed rejuvenating agent is removed from the intact latex film by scraping with a rubber policeman and blotting with paper towels. If the latex film does not remain intact during removal from the tins or while removing the unabsorbed rejuvenating agent the sample shall be rejected. After the rejuvenating agent is removed from the samples they are then weighed. Percent swelling is reported as weight increase of the polymer film; report mass increase as a percent by weight of the original latex film mass upon exposure of films to the recycling agent.

The rejuvenating agent shall meet the following requirements:

Test on Rejuvenating Agent	Test Method	Requirement
Viscosity, 140F, CST	ASTM D-2170	50-175
Flash Point, F, COC	ASTM D-92	380 Min.
Saturate, % by wt.	ASTM D2006-70	30 Max
Asphaltenes	ASTM D2006-70	1.0 Max.
Test on Residue	ASTM D2872	
Weight Change, %	ASTM D2872	6.5 Max.
Viscosity Ratio (RTFO/Original)	ASTM D2170	3 Max

The Contractor shall provide current test results and a Certificate of Compliance for emulsified recycling agent at the time of mix design submittal and for each load delivered to the jobsite. During cold in-place recycling operations, the Contractor shall obtain two 1-liter samples of emulsified recycling agent from each load delivered to the project. One sample shall be used for the Contractor's quality control testing. The remaining samples shall be delivered to the Engineer at the end of each working day. Emulsified recycling agent shall be sampled in plastic containers that are clean, dry, and properly sealed. The Contractor shall also "sieve test" each load of emulsion before accepting delivery. Any load, which does not pass the sieve test, shall be refused and not incorporated into the work.

Sized RAP - Existing asphalt concrete pavement shall be cold milled, crushed and screened to conform to the following gradation before mixing with emulsified recycling agent:

Sieve Size	Percentage Passing
1-Inch	100

Rubberized crack filler, pavement markers, loop wires, thermoplastic markers, fabric and other like materials that may be incorporated into the RAP as it is removed from the roadway shall be removed by the screening process. A minor amount of these residual materials that cannot be completely removed from the processed RAP may be incorporated into the recycled mix if the Contractor can demonstrate that those added materials will not adversely affect the performance of the recycled asphalt pavement. Any such materials retained in the mix shall be appropriately sized and blended so as not to adversely affect the appearance or strength of the recycled pavement.

Water - Water may be added to facilitate the uniform mixing of the emulsified recycling agent and the processed RAP. Water added to the recycled asphalt concrete shall be potable, clean and free from deleterious concentrations of acids, alkalis, salts, sugar and other organic or chemical substances. The water shall not contain an amount of impurities that will cause a reduction in the strength of the recycled asphalt concrete pavement. If the water is of questionable quality, it shall be tested in accordance with AASHTO T26.

Additives – If necessary other additives such as cement or lime, in a dry or slurry form may be added to the recycled pavement mixture to meet the requirements of Table 1 and to aid in curing and early strength gain. Any recycling additives used including type, source and percentage used

shall be described in the job mix formula submittal. Include the process for incorporating a recycling additive into the CIR mixture in the job mix formula submittal.

Construction Methods

Weather Limitations – CIR operations shall not be performed during wet conditions or if rain or cold conditions (less than 45°F) are imminent or predicted to exist. "Imminent or predicted" is defined as being forecasted within a 48-hour period on the National Weather Service Web Site http://www.wrh.noaa.gov for the most representative and nearest location listed where recycling is to begin and end.

Recycling and placement operations shall not be performed unless the ambient temperature is a minimum of 45°F and unless the National Weather Service Web Site forecasts that the ambient temperature will be a minimum of 60°F within 3 hours after the start of placement operations and will remain above 60°F throughout the recycling operation until all initial compaction and protection efforts have been completed for that day's run.

Recycling operations shall be ceased if actual ambient temperatures drop below 60°F anytime after the initial 3-hour window following start-up. In the event CIR operations are initiated and weather conditions deteriorate soon after, it is then a requirement that all traffic stay off the recycled mat until weather conditions improve (temperature rises and humidity drops) and the recycled section has "cured" sufficiently for secondary compaction to take place in accordance with the ***Cure and Maintenance*** requirements of this specification. The Contractor will be responsible for maintaining and protecting the recycled surface. Any recycled asphalt surfacing damaged by inclement weather shall be replaced by the Contractor at the Contractor's expense as directed by the Engineer.

All CIR mixing and placement operations shall be completed a minimum of 2 hours before sunset to allow for compaction and protection operations.

Milling, Sizing and Mixing - The recycling train shall be capable of milling and crushing the existing asphalt pavement. The equipment used for mixing the RAP with the emulsified recycling agent and any additives shall be capable of producing a homogeneous and uniformly coated recycled pavement mixture. The equipment used for placement of the recycled pavement mixture shall be capable of placement to the lines, grades, and requirements specified in these special provisions and shown on the plans. The Contractor shall have available on the site of the work all equipment and materials to be used for recycling operations.

The pavement milling machine shall be self-propelled. The primary milling equipment shall have a minimum 12.5-feet cutter capable of removing the existing pavement to the depths shown in the plans. Milling equipment shall be equipped with automatic depth controls capable of maintaining the cutting depth to within ¼-inch of the desired depth, and shall have a positive means for controlling cross slope. The milling operation shall not disturb or damage the underlying material. The use of a heating device to soften the pavement will not be permitted. A smaller milling machine may be used to mill the shoulders and miscellaneous areas.

The RAP shall be sized using crushing and screening equipment capable of producing reclaimed asphalt pavement to the size required. After the crushing and sizing, the recycled material shall be processed in a mixing unit capable of processing the sized RAP, emulsified recycling agent, water

and any additives to a homogeneous mixture to produce recycled asphalt concrete. The mixing unit shall be equipped with a belt scale for the continuous weighing of the RAP and a coupled/interlocked computer-controlled liquid metering device. The mixing unit shall be an on-board completely self-contained counter rotating twin shaft pugmill appropriately rated by the manufacturer for the production levels used by the Contractor. The liquid metering device shall be capable of automatically adjusting the flow of emulsified recycling agent to compensate for any variation in the weight of the RAP introduced into the pugmill. Emulsified recycling agent shall be metered by weight of RAP using a mass flow, coriolis effect, type meter that will accurately measure the amount of emulsified recycling agent to within 0.5 percent of the amount required by the mix design or as adjusted in the field and approved by the Engineer. The recycle train shall have an independent source of water to properly disperse the emulsified recycling agent. Automatic digital readings shall be displayed for both the flow rate and total amount of RAP, emulsified recycling agent, and additives in appropriate units of weight and time.

The emulsified recycling agent, additives and water shall be incorporated into the graded RAP at the initial rate determined by the mix design and approved by the Engineer. Adjustments in the rate of emulsified recycling agent, additives and water shall be determined by the Qualified Technician and made as necessary based on the coating, compaction and breaking properties of the recycling emulsion. Sampling variations and mix design may determine the necessity of different levels of emulsified recycling agent and/or additives in various sections of the project.

During the CIR process, the Contractor shall furnish the following information to the Engineer on a daily basis:

1) Certified weight tickets of emulsion delivered to the project location.

2) A summary of quantity of CIR product manufactured each day.

When a paving fabric is encountered during the cold milling operation, the CIR Contractor shall make the necessary changes in equipment or operations so that incorporation of the shredded fabric in the recycled material does not effect the performance parameters of the recycled asphalt concrete, or inhibit placing or compaction of the CIR pavement. No fabric piece incorporated into the recycled section shall have any dimension exceeding a length of 2-inches. The Contractor shall be required to remove and properly dispose of oversized pieces of paving fabric as directed by the Engineer. Similarly, loop wires, pavement markers, rubberized crack fill materials, thermoplastic marking materials, milled concrete, and other materials that may be incorporated into the RAP through the milling process shall be removed from the recycled material unless the Contractor can demonstrate that minor amounts of residual materials that remain will not compromise the integrity of the recycled asphalt.

Mixing and Spreading of Cement and Lime - Cement or lime slurry shall be produced at the jobsite as required by these specifications. The Contractor shall provide the Engineer with batch logs daily. Lime or cement slurry may be added directly to the pugmill or sprayed over the cutting teeth of the milling machine.

Portland cement or lime slurry storage and supply equipment shall have agitators or similar equipment to keep the cement or lime slurry in suspension when held in the slurry feed tank. Cement or lime slurry shall be kept in suspension during transport using agitator equipment.

Dry lime or cement shall be spread upon the existing asphalt concrete surface ahead of the recycling train. If lime or cement is spread ahead of the milling operation, the distance between the spreader and the recycling train shall be reduced appropriately during windy days. In no case shall additives be allowed to remain exposed at the end of the workday. Dust control measures shall be employed to minimize fugitive dust. No traffic other than the recycling equipment shall be allowed to pass over the spread additive until the recycling operation is complete

Paving/Placement – Recycled pavement shall be placed using a self-propelled track-paver having electronic grade and cross slope control for the screed. The equipment shall be of sufficient size and power (minimum 170 hp) to spread the recycled material in one continuous pass, without segregation, to the lines and grades established by the Engineer and according to Plans. Heating of the paver screed is not permitted. A pick-up machine shall be used for transferring the recycled material from a windrow to the receiving hopper of the paver, the pick-up machine shall be capable of removing and transferring the entire windrow of recycled mix in a single pass.

Handwork of CIR pavement shall be minimized and care shall be taken to prevent segregation. The wings of the paver shall be emptied regularly to prevent buildup and to minimize segregation.

Compaction - Compacting the recycled mix shall be completed using self-propelled rollers, complete with properly operating scrapers and water spray systems. Rollers of the vibratory-steel drum and pneumatic tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the mixture.

Compaction operations shall start no more than 15 minutes behind the paver, unless the ambient temperature is below 60 deg F. For each 5 deg below 60 deg F another 10 minutes can elapse before rolling begins, or at the direction of the Qualified Technician and/or Engineer. The number, weight and types of rollers shall be as necessary to obtain the required compaction. At a minimum the following rollers shall be used:

- At least one pneumatic roller with a minimum gross operating weight of not less than 25 tons. Tires on the pneumatic rollers shall be evenly inflated and matched in size and profile so as to maximize compactive effort.

- At least one double drum steel vibratory roller with a gross operating weight of not less than 10 tons with a minimum drum diameter of at least 60-inches.

Rolling patterns shall be established in the field by the Contractor and verified by the Engineer to achieve a maximum density determined by nuclear density testing. A rolling pattern for compaction shall be determined such that no increase in density is shown on successive nuclear density tests (per ASTM D 2950) for any additional passes of the compaction equipment once the maximum density pattern has been identified ("break over point"). Nuclear density testing shall be repeated throughout the time compaction is being completed to continuously verify the compaction is achieving maximum density results by establishing a rolling vs. density chart that shows the progress of densification from initial breakdown compaction through maximum obtainable density at the break over point.

Care shall be taken not to over compact the mat. A Qualified Technician shall be on site and observing all compaction efforts, monitoring density gauge readings, and approving areas as they reach maximum density. The minimum rolling pattern shall be as follows:

- Two complete coverages with the double drum steel vibratory roller immediately after the recycled mix is placed. The first coverage shall be made without the vibratory unit turned on and the second with the vibratory unit operating.
- Two complete coverages with the pneumatic-tired roller shall be made after the initial passes of the steel roller.

- Final rolling, before cure, to eliminate pneumatic tire marks and to achieve maximum density shall be done by the double drum steel roller, either operating in a static or vibratory mode.

The recycled mat shall be continuously observed during compaction efforts. If moisture cracking occurs under the vibratory compaction mode, the vibrators shall be turned off and static rolling only applied. If moisture cracking of the mat continues under static steel rolling, steel drum compaction shall cease, the mat shall be allowed to cure for a time in order for some moisture to escape, and pneumatic rolling commenced, followed by steel rolling to iron out irregularities from the rubber-tired roller(s). This procedure shall be followed until there is no longer any displacement of the mat observed by roller action on the recycled surface.

The selected rolling pattern shall be followed unless changes in the recycled mix or placement conditions occur and a new rolling pattern is established at that time. Any type of rolling that causes cracking, major displacement and/or any other type of pavement distress shall be discontinued until such time as the problem can be resolved. Discontinuation and commencement of rolling operations shall be at the discretion of the Engineer.

Extra care shall be taken to ensure that aggregate from the recycled mixture does not stick to the drums or wheels of the rollers. Water shall be uniformly applied to the wheels and drums, along with mechanical means to keep aggregate from sticking. Sufficient water shall be applied to keep rollers and tires clean, but not so much that water pools or ponds on the recycled surface.

Rollers shall not be started or stopped on uncompacted recycled material. Rolling patterns shall be established so that starting and stopping shall be on previously compacted material or the adjacent, existing surfacing.

Cure and Maintenance – After the completion of compaction of the recycled material, no traffic, including that of the Contractor, shall be permitted on the recycled material for at least two hours. This may be reduced if sufficient care is established for traffic that will not initiate raveling. A fog seal of dilute (1:1) SS-1h emulsion, emulsified recycling agent or equivalent (0.08 to 0.12 gallon per square yard) may need to be applied after initial compaction or after the secondary compaction, as outlined below, to all areas opened to significant traffic depending on curing of the CIR pavement. If necessary to prevent pickup of the fog seal, the recycled pavement surface shall be covered with sand at a rate of 1.0 to 2.0 pounds per square yard. Excess sand shall be removed from the pavement surface by careful sweeping. Sand shall be free from clay or organic material. Fog sealing and/or sanding shall be initiated at the Engineer's direction.

After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. Before placing the final surfacing, the recycled surface shall remain in-place:

- For a minimum of 2 days and until there is less than 2.0 percent moisture remaining in the recycled pavement mixture; or
- A minimum of 10 days without rainfall.

Secondary Compaction - Two complete coverages (minimum), after cure and before placing any AC overlay or other surface seal shall be conducted with the pneumatic and steel drum roller. A rolling pattern shall be reestablished to determine the maximum density of final rolling. Density of the recycled pavement shall be verified behind the secondary compaction by nuclear density gauge. A rolling pattern for the secondary compaction shall be determined such that no increase in density is shown on successive nuclear density tests (per ASTM D 2950) for any additional passes of the compaction equipment once the maximum density pattern has been identified. Nuclear density testing shall be repeated throughout the time secondary compaction is being completed to continuously verify that the secondary compaction is achieving maximum density results. Care shall be taken not to over compact the mat. A Qualified Technician shall be on site and observing all secondary compaction efforts, monitoring density gauge readings, and approving areas as they reach maximum density.

The Contractor shall protect and maintain the recycled surface from nuisance water, other deleterious substances, and/or any other damage. Any damage to the completed recycled material shall be repaired by the Contractor prior to the placement of new asphalt concrete or final surface sealing. Areas damaged shall be excavated to the depth directed by the Engineer and/or filled and compacted with new asphalt concrete. All loose particles that may develop on the pavement surface shall be removed prior to the final surface course. No direct payment will be made and costs shall be included elsewhere for protection and maintenance of the recycled asphalt concrete pavement.

Prior to any overlay with asphalt concrete, the recycled pavement should be carefully swept of all loose material to create a dry clean surface. A tack coat of SS-1h emulsion, emulsified recycling agent or equivalent (0.05 gallon per square yard minimum) shall be applied to all surface areas.

Smoothness – The finished surface and grade of the recycled material shall be checked regularly during placement using a level. The smoothness shall not vary more than ¼ inch from a 10-foot straight edge placed on the surface. The Contractor shall correct humps or depressions exceeding this tolerance. High points may be trimmed if approved by the Engineer in the field.

Material Acceptance

Gradation - A sample shall be obtained for each 500 tons of RAP addition to verify the maximum particle size requirement is being met. The first sample and every fourth sample thereafter shall be compared to the gradation band determined during the mix design by performing a wet field gradation for material passing the 1-inch to No. 4 sieves. The Contractor shall adjust the emulsified recycling agent as needed.

Emulsified Recycling Agent –A Certificate of Compliance from the emulsion manufacturer shall accompany each shipment to the Project. The Contractor shall perform a sieve test in accordance with ASTM D 2444 to verify the emulsion is stable prior to using each load. The Contractor shall obtain two 1-quart minimum samples of emulsified recycling agent from each load delivered to the project. One sample shall be used for the Contractor's quality control testing. The remaining samples shall be delivered to the Engineer at the end of each working day. Emulsified recycling

agent shall be sampled in plastic containers that are clean, dry, and sealed. Each sample shall be labeled with the date and time sampled and the bill of lading number from the delivery vehicle. Emulsion samples shall be retained and protected from damage or contamination by the Contractor until the project is accepted.

Emulsified Recycling Agent Content – Emulsion content shall be checked and recorded for each segment in which the percentage is changed. Emulsion content changes shall be made based upon if coating and adequate dispersion is not being achieved and if the mix design indicates the CIR pavement will be stable. Emulsified recycling agent content shall be checked from the belt scale totalizer and asphalt pump totalizer, verified by the delivery weight tickets.

Additives –A Certificate of Compliance from the additive manufacturer shall accompany each shipment to the Project.

Additive Content – Additive content shall be checked and recorded for each segment in which the additive is used per the mix design. Additives shall be checked from the scale totalizer and verified by the delivery weight tickets.

Recycled Material Compacted Density - Wet density shall be determined using a nuclear moisture-density gauge generally following the procedures for ASTM D 2950, backscatter measurement. A rolling pattern shall be established such that a maximum density is achieved with the rollers specified, based on relative nuclear density readings.

Method of Measurement

Quantities of the produced CIR pavement shall be measured by the square yards completed and accepted by the Engineer for the depths specified. Emulsified recycling agent and additive weight shall be based upon Certified delivery weight tickets, less any unused portion. Water used in this operation will not be paid for directly and shall be considered subsidiary to the bid item.

Basis of Payment

Payment for CIR shall be made at the Contract unit price per square yard. The price shall be full compensation for all labor, materials, tools, equipment, and incidentals; for doing all the work involved in cold in-place recycling, complete in-place; for milling, screening, crushing, mixing, blending, placing, and compacting the recycled pavement mixture; for protection and maintenance of the recycled layer; for performing all QC testing including mix design; for fog sealing, sanding and sweeping, if necessary; for obtaining measurements and recording results of all tests as shown on the plans and as directed by the Engineer.

Emulsified recycling agent will be paid for at the contract price per ton for emulsified recycling agent. No adjustment of compensation will be made for any increase or decrease in the quantities of emulsified recycling agent required, regardless of the reason for the increase or decrease.

Additive will be paid for at the contract price per ton for additive. No adjustment of compensation will be made for any increase or decrease in the quantities of additive required, regardless of the reason for the increase or decrease.

APPENDIX A –

1. Scope: This procedure is used to determine the percent and grade of emulsified recycling agent to use for recycling asphalt concrete when the cold method of recycling is used.

2. Cold Mix Requirement: The recycled pavement mixture shall conform to the Mix Design Requirements as outlined in Table 1.

3. Sampling and Processing of Existing Pavement Materials: Obtain sufficient RAP samples by coring areas to be recycled, approximately 400 lbs, to be used for mix design purposes. It is recommended to take one core for each lane mile and where visual differences in the pavement are noticed. If cores show significant differences in various areas, such as different type or thickness of layers between cores, then separate mix designs shall be performed for each of the pavement segments. Cut cores to the depth specified for the cold recycling project. Determine asphalt content of the RAP according to CT362 or CT379 or ASTM D2172 Method B. Perform two mix designs, one for each grading, by recombining the RAP material in the laboratory in order to meet the gradation criteria shown in Table 1.

Table 1: **Cold Recycling Gradation Requirements**

Sieve Size	Suggested Target	
	Medium Gradation	Coarse Gradation
25-mm (1")	100	100
19-mm (¾")	95 ± 2	85 ± 2
4.75-mm (No. 4)	50 ± 2	40 ± 2
600-µm (No. 30)	10 ± 2	5 ± 2
75-µm (No. 200)	0.8 ± 0.3	0.3 ± 0.3

Determine gradation of the RAP after crushing and recombining by California Test CT 202 with the exception that drying of RAP samples to constant mass shall be performed at 104±4°F.

4. Mixing: Determine the amount that will produce a 2.4-inch to 2.6-inch tall specimen when compacting 4-inch diameter specimens with either the Marshall compactor based on 75 blows on each side or the gyratory compactor at 30 gyrations for stability testing. Choose three emulsion contents that bracket the estimated recommended emulsion content for all stability testing outlined in Table 1. Select three emulsion contents in either 0.5% or 1.0% increments covering a range typically between 0.5% and 4.0% by dry weight of RAP. Compact 6 samples at each emulsion content for stability testing, 3 for Marshall Stability on cured samples and 3 for Marshall Stability on cured samples for moisture conditioning. Two specimens are required for Theoretical Maximum Specific Gravity according to CT309, Section J, with the exception that loose RAP mixture shall by cured in an oven at 140±2°F to constant weight but no more than 48 hours and no less than 16 hours. Constant weight is defined as 0.05% change in weight in 2 hours. Do not break any agglomerates that do not easily reduce with a flexible spatula. Test both specimens at the highest emulsion content in the design and back calculate for the lower emulsion contents. Add moisture that is expected to be added at the milling head, typically 1.5 to 3.0 percent. If any additives are in the mixture, introduce the additives in a similar manner that they will be added during field production. Mixing of test specimens shall be performed manually or with a mechanical bucket mixer or a combination of the two. Mix the RAP thoroughly with water first, then mix with emulsion. Mix

at room temperature of 77±4°F. One specimen shall be mixed at a time. Mixing time with emulsion should not exceed 60 seconds.

5. Compaction: Compact specimens after mixing. Compact specimens at room temperature of 77±4°F. Compact specimens with a Marshall compactor by applying 75 blows per side for stability testing using 4-inch molds or with a gyratory compactor at 30 gyrations for stability testing using 4-inch molds. Do not heat molds or Marshall compaction hammer. If paper disks are used, place paper disks on the top and bottom of the specimen before compaction and remove paper disks from specimens immediately after compaction.

6. Curing after Compaction: Extrude specimens from molds after compaction without damaging the samples. Carefully remove paper disks if used. Place specimens in 140±2°F forced draft oven with ventilation on sides and top. Place each specimen in a small container to account for material loss from the specimens. Cure compacted specimens at 140±2°F to constant weight but no more than 48 hours and no less than 16 hours. Constant weight is defined as 0.05% change in weight in 2 hours. After curing, cool specimens at ambient temperature a minimum of 12 hours and a maximum of 24 hours. Perform same oven conditioning and volumetric measurements on moisture-conditioned specimens as on other specimens. Perform moisture conditioning on 3 compacted samples at each emulsion content by applying a vacuum of 254 to 660 mm of Hg partial pressure for a time duration required to vacuum saturate samples to 55 to 75 percent. Saturation calculation shall be calculated by comparing saturated surface dry mass with dry mass in air determined. Soak moisture conditioned samples in a 77±2°F water bath for 23±1 hours, followed by a 30 to 40 min soak at 104±2°F.

7. Measurements: Determine asphalt content of the RAP material to be recycled according to CT362 or CT379 or ASTM D2172 Method B. Determine bulk specific gravity of each compacted, cured and cooled specimen according to CT308, Method C. Determine specimen heights according to CT308 Section D2e. Alternatively, the height can be obtained from the SGC readout if the gyratory compactor is used. Determine maximum theoretical specific gravity, CT309, Section J, with the exception detailed in Section 4 of this document. Determine air voids of the compacted and oven-cured samples at each emulsion content according to CT367 Part B. Determine corrected Marshall stability by AASHTO T245 at 104±2°F after 2-hour temperature conditioning in a forced draft oven or by immersing in water bath for 30 to 40 minutes. This testing shall be performed at the same time that the moisture-conditioned specimens are tested. Determine Marshall Retained Stability. The average moisture conditioned specimen strength divided by the average dry specimen strength is referred to as retained stability.

8. Emulsion Content Selection: Choose the design emulsion content that optimizes the performance of the recycled asphalt concrete and meets the requirements listed in Table 1.

9. Raveling Test on Recycled Asphalt Specimens: Determine raveling potential on recycled asphalt specimens in accordance with ASTM D7196.

10. Report: The mix design report shall contain the following minimum information: gradation of RAP, RAP asphalt content, recommended water content range as a percentage of dry RAP, optimum emulsion content as a percentage of dry RAP, amount of additive as a percentage of dry RAP, ratio of emulsion residue to cement, and corresponding density, air void level, Marshall stability, retained stability, compaction method used to determine any reported stability, and raveling at recommended moisture and emulsion contents. Include the emulsion and additive designations, company names and locations; and residue content; and certificates of compliance.