APPLICATION OF
CIPR – COLD IN PLACE RECYCLING

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Application of CIPR as pavement rehabilitation and stabilization with cement

INTRODUCTION

Road plays an important role in the communication system of mankind. From the early form of the road structures to modern design approaches, road provide a mean of safe and economical for transportation for good and people.

Pavement deteriorates in time because of sun and weather. The experience shows that the cost of maintenance is in correlation with the volume of repair needed. Traditionally, the curative maintenance is only carried out when the pavement showed visible defect and curative patching will then be carried out.

By the time the curative maintenance is carried out, a higher budget will be needed. For the road to perform functionally and structurally with significant cost saving, conservation of natural resources and minimizes traffic disruption using Cold in place recycle is a best choice in order to:

Crocodile crack, Depression and Patching.

- Focus on rehabilitation rather than expansion of road network
- Focus on cost-effectiveness of approaches
- Minimize the use of non-renewable materials & energy

COLD IN PLACE RECYCLING AND STABILIZATION WITH CEMENT

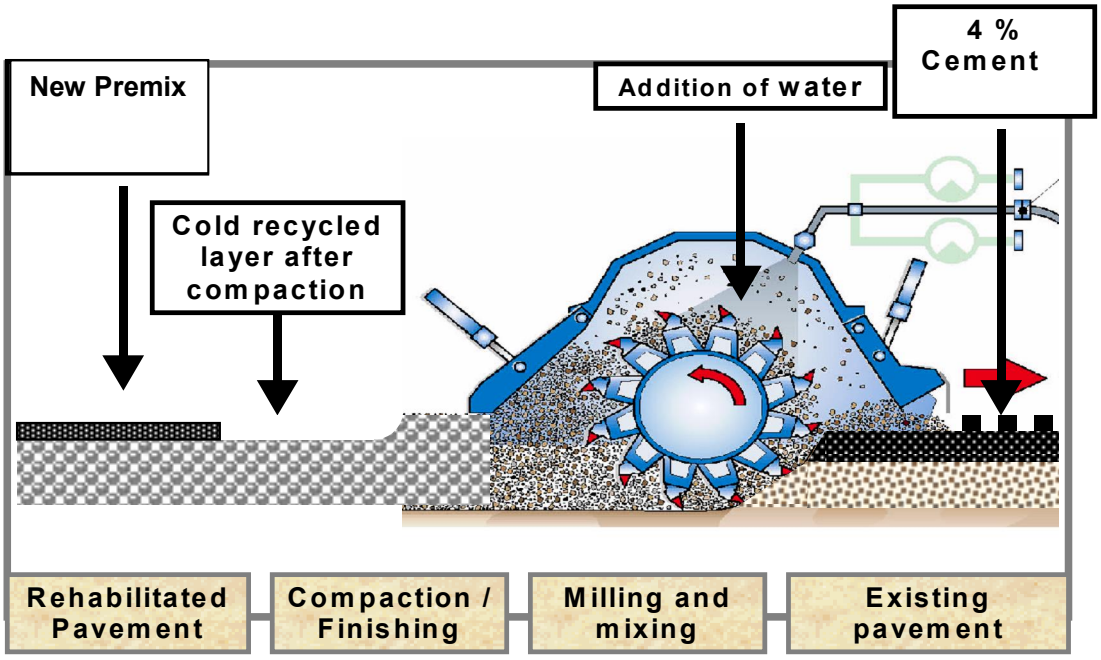
1. DEFINATION

Cold-In-Place Recycling: In-situ breaking up of existing pavement using specialist plant by means of crusher, pulverizing or blended into gradation and re-compact to become a new pavement layer

Cement Stabilization: Addition of cement as stabilizer to the mechanically blended material to obtain improved strength and material properties

- Recycling 100mm to 300mm depth
- 4% (2% - 6% allowed) Ordinary Portland Cement to MS522, by weight
- Minimum 7-days strength: 2.0N/m2

CIPR CONTEXT DIAGRAM

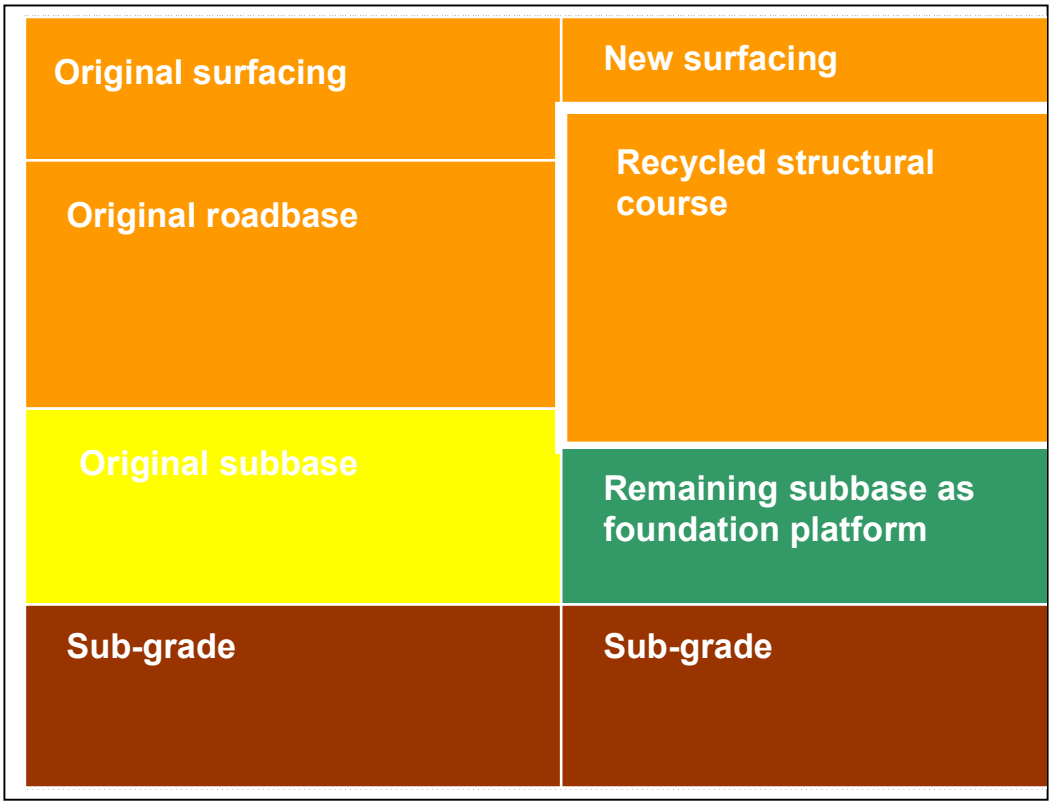


2. ADVANTAGES

Cold in-place recycling	Conventional (with reconstruction)
▪ Conservation of natural resources ▪ Energy savings (20-60%) ▪ Minimizes traffic disruption and time delays ▪ Wide range of distresses can be rectified ▪ Significant cost savings ▪ Less Manpower ▪ Minimum material stockpile	▪ Bigger Number of Manpower ▪ Longer Time to complete

Pavement thickness design

Original pavement **Recycled pavement**



3. MATERIAL AND PRODUCTION

Specification parameter for cold in place recycling with cement.

No.	Parameter	Requirements
1.	Compressive strength	2 - 5 N/mm2
2.	Cement Content	Optimum Value 2 ï 6 %
3.	Gradation	As specified below
B.S. Sieve Size		**JKR/SPJ/2008**
50.0 mm		100
37.5 mm		85 ï 100
20.0 mm		60 ï 100
10.0 mm		40 ï 90
5.0 mm		30 ï 75
2.36 mm		20 ï 60
425.0 micro meter		10 ï 45
75.0 micro meter		2 - 20

Materials

Using ordinary Portland cement for stabilizing agent.

Additional material (for widening and topping up): shall be crushed rock, which is hard, durable, clean, and essentially free from clay and other deleterious material.

Compaction requirements

Either as a percentage of maximum dry density or bulk relative density

- Usually between 95-100 % of Job Standard Mix for natural gravels
- Usually between 97-100 % of Job Standard Mix for mixture of crushed aggregates and RAP
- Usually between 98-100% of Job Standard Mix for RAP

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Requirements before recycling commences

- Determination of in-situ moisture contents
  - 1 week in advance

Loose Sampling:

Determination of Maximum Dry Density (MDD) Mg/m3

Determination of Optimum Moisture Contents (OMC) %

- Daily production plans
  - Sketch of overall length, width, showing parallel cuts and overlaps
  - Sequence and length of each cut
  - Estimated time required for cutting, mixing & compaction
  - Location of samples taken for moisture determination
  - Proposed water addition for each cut & transition line
  - Amount & type of stabilizing agent(s)
  - Proposed control testing program

- Referencing of horizontal alignment by means of pegs (or poles)

- Preparation of the surface
  - Clean of all vegetation and other foreign matter
  - Removal of standing water
  - Remarking proposed longitudinal cut lines

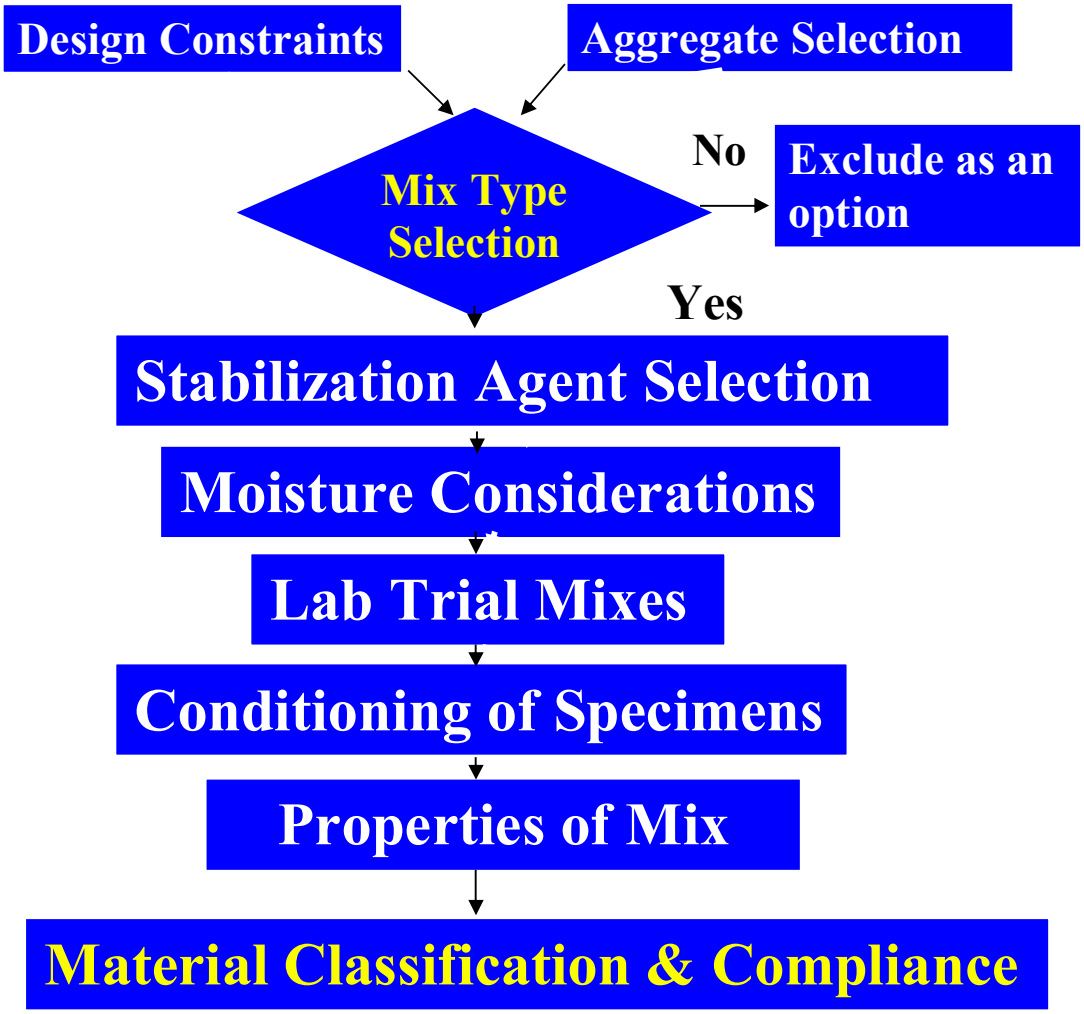
Pre-milling, where required

Trial sections

- Minimum 150 m length
- Demonstrate capability of equipment & processes
- Determine effect on the grading by varying forward speed & rate of rotation of the milling drum
- Establish the application rates of the stabilizing agent(s)
- Verify the optimum compaction moisture content and determine the sequence and manner of rolling necessary to achieve minimum compaction requirements

4. MIX DESIGN OF COLD IN PLACE RECYCLE

MIX DESIGN FLOW CHART



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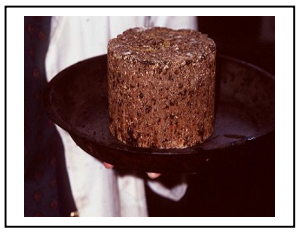
Aspects addressed

Characteristics of material

- Engineering properties (UCS, ITS, strain-at-break, etc.)
- Mechanical properties (stiffness, shear strength)
- Durability



Behavior under loading

- Change in above properties with loading

Mix design

- Linkages with field behavior and performance

Structural design

- Construction

Determination of Application Rate and Amount of Cement to be used.

4% cement is to be used with water to give initial strength to recycled layer thus to exhilarate the setting time of stabilization. Cement application rate for 200 mm CIPR layer thick is calculated as below :

Volume of CIPR / m^2	-	0.2 m^3 (1m x 1m x 0.2m)
Weight / m^2	-	400 kg (Density 2000 kg / m^3)
4% cement by weight	-	16 kg / m^2
Area per 50 kilo / bag of cement (50kg / bag / 16kg / m^2) Length and Width / area	-	3.12 m^2 1.30 m length x 2.4 m width
Proposed length, width for 50 kilo (1 bag of OPC)	-	(1.30m length x 2.4m width) = 3.12 m^2

5. PLANT AND EQUIPMENT

Equipment and Machineries

The machineries and equipment to be used in the Cold in Place Recycling are complying with the Standard Specification for CIPR.

The minimum requirement of plant and machineries for the performance of a particular Cold in Place Recycle operation is listed in the following table.

Plant Item	Minimum requirement
Recycler Wirtgen WR 2000 	o Cold in place recycling. o 2.0 m max cutting and recycling width. o 500 mm max cut and recycling depth. o Built in micro processor to regulate application of water with respect to travel speed and mass of recycle material. o Built in metering system for pumping water at 200 lit/minutes. o Direct attachment to water tanker. o Self cleaning spray nozzles across width recycling.
Vibratory Roller 	o Compaction. o 12 ï 24 static mass. o Vibration frequency: 29 ï 35 Hz. o Vibration amplitude: 0.91 ï 1.66 m (large amplitude / low frequency for initial compaction, deep penetration of energy; Small amplitude / high frequency for the final compaction, shallow penetration of energy.

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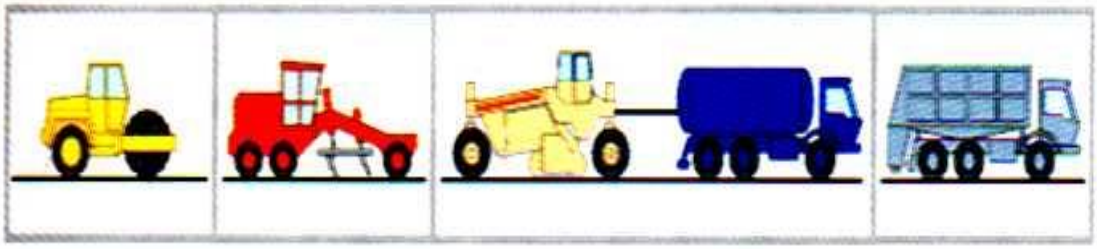
Plant Item	Minimum requirement
Motor Grader 	○ Surface grading. ○ Hydraulic control, constant-speed. ○ 100 kW engine power. ○ 3.66 m blade length, 610mm blade height.
Water Tanker 	○ Watering. ○ Min. 10,000 liter capacity tankers shall be used to as mobile water supply during recycling. ○ Spare water tanker of similar capacity shall be provided at site to ensure continuous daily watering supply.
Cement Spreader 	○ Placement of cement.

6. METHOD OF CONSTRUCTION COLD IN PLACE RECYLING (CIPR).

ILLUSTRATING THE CONSTRUCTION PROCESS OF CIPR

PROCESS RECYCLING & STABILISATION



DIRECTION OF WORK

a. Imported Material

Topping up need to be done to avoid lack material after recycling in order to get uniform level of finish surface, thus avoid irregularities in finish surface. Area that having depression or need to be topping up with important material (crusher run) due to thin existing road layer of Bituminous and road base shall be identify.

b. Cement Spreading

Area of cement shall be measure in order to get 4% by weight per square meter. Spreading of cement shall using cement spreader machine in order to control cement content during recycling.

Unloading of cement

Cement Spreading

Cement uniformly spread

c. Recycling Using WR2000 Recycler

Recycling process shall be carried using WR2000 Recycler and pushing the water tanker. The machine shall be inspect to ensure the proper recycling is carried out and set up the recycling train as been agreed in method statement. Hose that connect water tanker and recycler for water supply shall not have a bad leaking.

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Data provide:

Pulverisation

Result of calibration of water flow from recycler through nozzles. (This is to ensure water spray rate is as been in design).

Speed of recycler during recycling is as been in method statement. (Acceptance criteria shall be as low 5m/minute and up to 12m/minute).

Depth of recycling

(Depth checking at least 2 test per 50 m linear progress shall be carried out to ensure the depth is +/- 10mm of design depth). Records shall be kept in Joint Dipping Form.

In case of area that determined to be out of design (e.g. exceed water content, improper level after curing) after recycling, the area have to be excavate, spread cement and recycle it again.

d. Compaction of Recycled Asphalt Pavement

Compaction must be carried out in accordance as below:

Initial Compaction

Initial compaction shall be carried out immediately after recycling. This used a static compaction by roller. Roller moves at the back or recycler.

Final Compaction

Final compaction shall be carried out after grading works with proposed passes

2 passes static

2 passes vibrate with high amplitude

2 passes vibrate with low amplitude

2 passes static

e. Surface Grading (Surface level and Shape Control)

Grading works shall be commended after initial compaction and before final compaction using 6 tyre grader. Grading works shall comply with agreed percentage of camber of roads.

After grading works and compaction had finished, the finished level shall have uniform and well distributed of recycling material with no segregation.

f. Curing of Recycled Asphalt Pavement

Water shall be sprayed regularly to prevent the surface from dying out and for curing purpose, Alternatively, if early opening to traffic is required, a rapid setting bitumen emulsion curing membrane with a minimum spray rate of 0.6 litre/m^2, shall be applied immediately after finishing operations.

g. Opening to Traffic of Recycled Asphalt Pavement

Recycled asphalt layer can only be open to traffic minimum 3 hours after final compaction.

h. Overlaying with New Premix

New premix can only be open to traffic not less than 4 hours after commencement of rolling or restricted to minimum speed of 30 km/hr or less and sharp turning when opening in less than 4 hours

i. Road Marking

Road marking will be carried out after the completion of the pavement work.

j. Dust Control

In order to control dust after excavating for widening, cement spreading, recycling and other works involved during this process, a low quantity of water is spread onto surfaces to control dust. Workers need to be supplied with proper mask during works commenced.

7.0 TRAFFIC MANAGEMENT DURING CONSTRUCTION

Traffic Management and Safety

Ensure that traffic safely accommodated on the remaining width of road while work is underway, to provide enough and proper signage, cones and other safety equipment (safety vest and safety boot) to road users and workers during construction and signboard to inform road users that the road is under construction process with estimated time taken mentioned on it. It is also recommended to inform road users to take other alternative road for comfort riding.

Traffic Management Scheme

Refer to the Traffic Management Scheme as per Arahan Teknik (Jalan) 2C/85. Extra flagman is needed at the middle of closure length to accommodate traffic while using half lane road.

Personal Protective Equipment

Workers shall be supply with proper attire to carry out site works (e.g: safety footwear, mask, hand glove, and safety vest)

Machineries Parking During Working Time and At Night

Ensure that all machineries parked during working time and at night are in 1 place and in proper arrangement without disturbance to road users and the road itself. This is to ensure safety for road users during both times.

8.0 PERFORMANCE CONTROL

Quality Control

The Quality Control and Assurance shall follow the Project Quality Plan (PQP). All test and inspection shall be in accordance to the Project Specification and summarized in accordance to Inspection and Test Plan (ITP) of the PQP.

Material delivery inspection shall include;

a. Aggregate delivery ï supplier source, time, date and quantity delivered.
b. Aggregate gradation as specified in the ITP.
c. Water ï check source of water.

Quality checks on machine, equipment and plant shall be:

a. Use machineries inspection forms for approval from JKR / Client.
b. Check that all machineries, equipment and plant are clean and all parts are working.
c. Check for adequate machineries used from the List of Equipment/ machineries.

Daily inspection shall include:

a. Weather checks based on area weather changes.
b. Check moisture content.
c. Check cement spreading rate (kg/m^2)
e. Check on homogeneity of the recycled material and uniform placement of the CIPR mix at the back or the recycler.

Getting In-situ Moisture Content using Speedy Moisture Tester

f. Check on rolling speed, rolling overlap, number of passes.
g. Check on finished surface level tolerances and cross slope chambering.

9.0 CONCLUSION

Cold In Place Recycle method is practicable alternative to re strengthen the sub base of pavement using existing pavement material by in-situ breaking up using specialist plant by means of crusher, pulverizing or blended into gradation and re-compact to become a new pavement layer with stabilizer agent to obtain improved strength and material properties

We are also capable of achieving:

- Energy savings (20-60%)
- Wide range of distresses can be rectified
- Significant cost savings
- Less Manpower
- Minimum material stockpile