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No. RW/NHVI-67(10)/85 *Dated the 16th October, 1985*

To,

All Chief Engineers of States/Union Territories dealing with roads.

Subject : Recycling of bituminous surfacing — Introduction of the technique of

In many developed countries in the West the technique of pavement recycling is now being adopted on an increasing scale specially in view of the all round need for economising on construction cost in highways and also for conservation of scarce resources. The world-over shortage in production and availability of petroleum products in the seventies underlined the need for such an effort.

Recycling is re-utilising the aggregate and binder in the existing bituminous pavement requiring fresh renewal or rehabilitation courses. This is achieved by milling the existing bituminous pavement wholly or partially and relaying it to the desired thickness after mixing the reclaimed material with suitable quantities of new aggregate and binder, if necessary.

Now that we have in India a substantial length of road pavement laid with high-quality bituminous surfacing of considerable age and many more road stretches are being laid with the same type it has been considered appropriate that we should also start introducing in our country the technique of recycling on a limited scale in order to familiarise ourselves with the different aspects of the technique and to gain adequate experience in actual laying in the field.

2. Broadly speaking recycling is done in two ways :

(a) In-place recycling; and

(b) Recycling through central paving plant.

In both the above-said methods recycling can be done by various combinations of cold/hot milling and cold/hot mix. Tentative specifications for recycling bituminous surfacing have been prepared and are enclosed herewith along with a note. The onus of the soundness of the recycled pavement will of course rest with the Contractor and a suitable clause may be added in the contract for this purpose.

3. It is suggested to select at least one suitable introductory section where recycling can be carried out and forward the details of the section to the Ministry for final consideration.

While selecting, it may please be ensured that the existing pavement does not need strengthening at least upto the expected life of the relaid wearing course. This is with an idea that for the present the recycling may be confined to bituminous wearing courses like asphaltic concrete, semi-dense carpet (over bituminous base course) only which because of ageing or for other reasons (like loss of the profile etc.) require to be renewed. With time, experience and availability of appropriate equipment the technique can be extended to other bituminous pavement courses.

4. It is further requested that your considered views on the subject of recycling including its tentative specifications and its applicability to the existing road systems in your State, with special reference to the National Highways may please be forwarded to the Ministry.

An early action in the matter will be very much appreciated.

BRIEF NOTE ON RECYCLING OF BITUMINOUS SURFACINGS

Over the past decade, there had been some effort among Engineers to recycle existing road pavement requiring renewal or rehabilitation in a bid to re-utilise the materials already locked in it. The Petroleum crisis in the seventies focussed serious attention on the subject among engineers in the developed countries, specially in Europe and in the North-American Continent. Through their efforts over the years a number of suitable equipment and design procedures have been evolved and it can be said that recycling has 'come to age' there.

2. The main advantages of recycling can be briefly summarised as under :

(i) Saving in consumption of fresh good quality aggregate and binder;

(ii) Saving in energy — Less requirement of fresh aggregate and binder means saving in energy in their production and haulage.

(iii) Correction to profile and rejuvenation of surfacing without increase in level of the road surface. Many minor yet vexatious problems like adjustment of kerb, manhole height, inlet level adjustment for services and pipe lines etc. as encountered especially on urban roads are avoided in this method.

(iv) Prevention of damage to the environment caused by opening of new quarries etc. due to reduced demand of aggregate to an extent.

(v) Saving in cost.

It has been reported that savings upto 30% or so in cost can be achieved by resorting to recycling.

3. Since we have in our country :

(a) large areas where good quality aggregate is either scarce and/or involve costly haulage and

(b) numerous pavement stretches which because of loss in profile or other reasons require rehabilitation it has been felt that the technology of recycling will be quite appropriate for application in certain situations where the existing pavement is adequate and does not need any strengthening but either the wearing course is showing signs of distress needing renewal or the pavement has lost its shape and needs profile correction; the existing pavement is showing signs of distress and strengthening courses cannot be directly overlaid on it etc.

4. Generally speaking, recycling can be of the following types :

(a) In-place recycling and

(b) Recycling through central paving plant

In both the above cases recycling can be done by various combinations of cold/hot milling and cold/hot mix.

5. In countries where recycling work has been carried out on a substantial scale certain design procedures have been evolved to facilitate recycling mix design and to determine the type and quantities of fresh materials (aggregate and binder) required for use in the mix. Briefly the process requires assessment of the grading and quantity of the aggregates available from the existing pavement and the penetration/viscosity of the binder in the same and also the penetration/viscosity and the quantity of the fresh binder and grading and quantity of fresh aggregate to be used so that the resultant mix conforms to the specifications of the final required surfacing course. After the requirement of fresh binder and aggregate has been determined, the same are mixed with the reclaimed milled materials and a hot or cold mix is produced in an appropriate mixing plant. In case of hot mix the plants selected should be capable of introducing and processing the reclaimed and fresh materials at different temperatures. The specifications for the final mix are to be guided by the standard specifications for the type of surfacing to be produced. The Standard Specifications for the relevant mix will also hold good for laying, rolling etc. of the mix.

Tentative Specifications for Recycling of Bituminous Surfacing (partial depth reclamation) — Applicable to Wearing Course.

1. Descriptions

The work shall consist of reclaiming bituminous wearing course materials and reutilising the same after processing and modification by adding fresh aggregate and bituminous binder, with or without softening agent. The processing and modification can be either in-place or in a central paving plant. The fresh mix shall conform to the requirements of this specifications and shall be laid in conformity with the lines, grade and cross-sections shown on the approved drawings or as directed by the Engineer-in-charge.

2. Scope

2.1 The reclamation of the existing bituminous wearing course shall be resorted to where the pavement surface has either cracked due to fatigue or ageing, rutted or contain fat patches and/or the road profile needs correction to improve riding quality.

2.2 The reclamation of the existing bituminous wearing course may be for its full depth or partial depth depending on the site requirement. The site requirement may be assessed visually and from the cores taken.

2.3 The reclamation of the existing bituminous wearing course shall be done only where it has a minimum thickness of 20 mm over a bituminous base course of minimum 50 mm thickness.

2.4 The process of reclamation of wearing course essentially presumes that the underlying pavement courses have not suffered any distress and have adequate strength for the operating loads during the life span of the re-laid wearing course.

2.5 The wearing course finally provided shall be of the same type as that reclaimed, especially so in partial depth reclamation.

2.6 The wearing course shall not be laid in more than 50 mm thickness in a single layer.

3. Materials

3.1 Fresh Binder

The grade of the fresh binder to be used for the hituminous mix shall be as directed by the Engineer-in-charge and shall conform to the relevant Indian Standard.

The softening agent, if used, shall be got approved from the Engineer-In-charge.

3.2 Aggregates

3.2.1 Fresh aggreggates

The fresh aggregates to be added shall consist of crushed stone, crushed gravel (shingle) or other stones. They should be cleaned, strong, durable, dry and free of disintegerated pieces, organic or other deleterious matter and adherent coating. As regards the physical requirements of coarse aggregates, fine aggregates etc. the requirements set forth in the clauses of the specifications for roads and bridges (MOST, RW) for the relevant bituminous wearing course shall hold good. Their quantitative requirement and gradation shall be as per the requirement of design mix.

3.2.2 Reclaimed bituminous wearing course materials

Reclaimed hituminous wearing course materials comprising of aggregates and binder from the existing bituminous wearing course shall be used after being tested and in a manner and in quantities as directed by the Engineer-in-charge.

3.3 Reclaiming Bituminous Wearing Course to full/partial Depth

3.3.1 Preparation of surface

Prior to milling, the existing pavement surface shall be cleaned off all dust, dirt and other extraneous materials.

3.3.2 Description

The existing bituminous wearing course will be reclaimed to full or partial depth, as directed by the Engineer-in-charge. The milled material for use in recycled bituminous course shall be handled in accordance with the requirements indicated in the following paragraphs unless specified otherwise.

3.3.3 Construction operation

3.3.3.1 Reclaiming equipment

Equipment for full or partial removal of existing bituminous wearing course shall be of adequate capacity and design for hot/cold milling work. It shall be capable of accurate depth of cut, profile and cross-slopes. Automatic grade and slope control facility should be available.

The cutting head shall be capable of milling any specified proportion of the total bituminous wearing course in one or more passes.

In the case of hot milling process adequate arrangement scale be there to ensure that direct heat is not applied to the pavement.

Where recycling is to be done with central paving plant the milled material shall be directly deposited in the hauling equipment from the milling machine or loaded from the windrow of milled material where approved by the Engineer-in-charge and shall be hauled directly to the stockpile or the central paving plant.

All loose materials or fines resulting from the milling operations shall be removed from the milled surface and collected in the hauling equipment for reuse.

3.3.3.2 Reclaiming operation

Existing bituminous wearing course shall be removed to the specified depth and to lines and grades as shown in the approved drawing for the work or as directed by the Engineer-in-charge.

The work of milling shall not be left in partial width of the pavement associated with the movement of traffic in one particular direction at the end of the working day.

The milled and the unmilled surfaces shall have junction with smooth transition with the longitudinal grade not steeper than 1 in 40.

Milling operation is to be coordinated with the paving operation so that large length of milled surface do not remain unpaved for long. When reclaiming is to be done in short or intermittent stretches, as in the case of a repair work, repaving should preferably be carried out the same day.

Care is to be taken to carry out milling operation without tearing or breaking the underlying or adjacent pavement.

As already indicated in para 3.3.3.1 all milled materials and fines remaining in the resultant milled surface shall be swept clean and materials deposited in the hauling truck. This cleaning operation shall follow the milling train immediately and not more than 100 metres behind.

Any deficiency in the milled surface occurring as a result of milling operation shall be promptly repaired. The milled surface may be opened to traffic at the end of the working day, when permitted by the Engineer-in-charge, after inspecting the surface for any traffic hazard and removing the same and carrying out any repairs, if necessary.

Contamination of the reclaimed hituminous wearing course material with granular or other deleterious materials shall be avoided.

3.3.3.3 Materials

The reclaimed bituminous wearing course material shall conform to the following gradation.

Sieve designation	*Per cent by weight passing the sieve*
100 mm	100
80 mm	99-100
40 mm	95-100

When the milled materials do not conform to the above gradation further crushing has to be done till the specified grading is obtained.

3.3.3.4 Stockpiling of milled materials

Unless otherwise directed the stockpile site shall be approved by the Engineer-in-charge. Within the site, the stockpile base shall be fixed preferably on the highest ground ensuring surface drainage away from the base.

The stockpile base shall be prepared with brick/stone/lean concrete and shall be of adequate dimensions to accommodate the maximum expected volume of milled material required to be handled in a given time.

The milled material shall be arranged in a stockpile by a conveyor belt. No equipment shall be permitted to work on the stockpile and every care should be taken, not to compact or displace the stored material any further. The free fall height of the conveyor belt to the stockpile should be minimum and not more than 2 metre at any time. The total height of the stockpile should not at any time be more than 2.5 metre.

3.3.4 Mix Design

The final mix shall conform to the grading, binder content, and quality requirements of the relevant wearing course to be laid. The specification of the end product shall be as per the relevant clause of specification for the wearing course (asphaltic concrete or semi-dense carpet as the case may be).

The procedure to be followed for the same is briefly outlined below :

(a) Obtain representative samples from the wearing course to be recycled in the form of cores. At least two cores (about 150 mm dia.) may be taken from the existing surface on a random basis for every 2,000 sqm. area of pavement. This requirement could be increased in case of appreciable variation. The decision of the Engineer-in-charge will be binding. Separate samples should be collected for each lane of repaving. If the bitumen percentage or the aggregate grading or density varies appreciably from one lane to another, separate design of mix may be prepared for each lane. The depth of core sample should be at least equal to the proposed depth of reclamation.

(b) Carry out the following laboratory tests on the extracted aggregates and binder of the wearing course to be reclaimed. Extraction can be done with any standard solvent used for the purpose :

(i) Gradation, specific gravity and AIV test of the reclaimed aggregate;

(ii) Penetration and viscosity of the reclaimed binder;

(iii) Repeat penetration and viscosity test for the reclaimed binder after mixing it with different percentage of fresh bituminous binder of a suitable grade to result in the final required grade in the mixed binder;

(iv) Mix trial percentage of fresh aggregates and reclaimed aggregates with the blended binder;

(v) Carry out Marshall's stability test on the mixed material to see if it conforms to the design requirement;

(vi) Finally arrive at a design mix formula.

3.3.5 Equipment

3.3.5.1 For the central paving plant suitable hot mix plants of adequate capacity and capable of hot mixing reclaimed material and fresh aggregates and binder shall be used. The plant shall contain facility for heating the reclaimed materials without damage to the old binder and without undue pollution of the environment. Arrangement for indirect heating of reclaimed material shall be ensured.

The plant may either be of continuous drum type or of batch type with necessary modification, having coordinated set of essential units such as dryer for heating, device for grading and batching (in any specified reclaimed/fresh material ratio) — feeding by weight with required quantities of aggregate, a binder heating and control unit for metering out the correct quantity of aggregate and heated binder together with a paddle mixer for intimate mixing of the binder and aggregates.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the minerals aggregates are coated uniformly.

The mix shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and be covered over in transit, if so directed by the Engineer-in-charge.

Mix transported from the hot mix plant to the site shall be spread by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix true to specified grade, lines and cross-sections. The paver should preferably have an arrangement for autograde and camber control.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the central-line of the road. Longitudinal joints shall be offset by atleast 150 mm from those in the binter cderse. All joints shall be offset by atleast 150 mm from those in the binter course. All joints shall be cut vertical to the full thickness to the previously laid mix and the surface painted with hot bitumen before placing fresh material.

In case of hot process. the main joint with the existing surface shall also be preheated before laying the mix so that it is thoroughly jointed. The material left on the joints after repaving shall be simultaneously cleaned and levelled.

3.3.5.2 In the case of in-place processing the set of equipment shall consist of a remixer with a hopper for storage of fresh material, with conveyor belt of variable speed, bitumen storage tank with arrangement for heating and controlled pumping and a pug mill. The system must have arrangement to transport milled material directly to pug mill by conveyor belt or any other suitable device. Similarly it should be equipped with a transport device for feeding recycle mix directly into the hopper of the paver finisher.

3.3.6 **Rolling**

Immediately after the spreading of mix by paver, it shall be thoroughly compacted by rolling with a set of rollers moving at a speed not exceeding 5 km per hour. The initial or break-down rolling shall be with 8-12 tonne three wheel roller and the surface finished by final rolling with 8-10 tonne tandem rollers or suitable pneumatic rollers.

The wheels of roller shall be kept moist to prevent the mix from adhering to them but in no case shall fuel lubricating oil be used for this purpose. Rolling shall commence longitudinally from the edges and progress towards the centre except that on superelevated portions it shall progress from the lower to upper edge parallel to the centre-line of the pavement. The roller shall proceed on the fresh material with rear of fixed wheel leading so as to minimise the pushing of the mix and each pass of the roller uniformly overlap not less than one third of the track made in the preceding pass. Rolling shall be continued till the density achieved is at least 95% of that of the laboratory Marshall specimen and all roller marks are eliminated.

3.3.7 **Opening to traffic**

Traffic may be allowed immediately after completion of the final rolling when the mix has cooled down to the surrounding temperature.

3.3.8 **Surface finish and quality control of work**

The surface finish of construction shall conform to the requirements of Clause 901 of MOT Specification for Roads & Bridges.

Control on the quality of materials and works shall be exercised by the Engineer-in-charge in accordance with Clause 902 of MOT Specification for Roads & Bridges.

3.3.9 **Arrangements for traffic**

The provisions of Clause 105 of MOT Specification for Roads & Bridges shall apply as regards the flow of traffic during construction.

3.3.10 **Measurements for pavement**

For purposes of payment the work shall be measured as under: It shall be paid separately for each sub item. All incidental charges are supposed to be inclusive in the rate of the sub item.

3.3.10.1 **Recycling through central paving plant**

(i) The milled material shall be paid by weight. The rate shall be inclusive of cleaning of pavement surface, milling, loading and unloading in haulage trucks and sweeping of the milled surface. The transportation from site to the stockpile shall be paid in addition as per usual schedule rates;

(ii) Supply of fresh aggregate and bitumen at stockpile site; the measurement for this should be as per usual practice i.e. by volume in case of aggregate and by weight in case of binder;

(iii) Complete item of processing of bituminous mix and laying it at site including spreading by paver and rolling and haulage to site in tipper trucks etc. all complete will be paid by weight, measured while collecting in the haulage truck.

3.3.10.2 **In-place recycling**

(i) The milled material shall be paid by volume (m^3). The volume shall be ascertained through representative cores taken for this purpose prior to milling in place.

(ii) Complete item of processing of bituminous mix and laying at site including rolling will be paid by volume (m^3). The Volume shall be ascertained through representative cores taken for this purpose after the repaving operation.

(iii) The quantities of fresh aggregate and binder shall be arrived at from the design mix and measurements in (i) & (ii) and shall be paid by volume for fresh aggregate and by weight for fresh binder.

Terminology for Pavement Recycling Work

Pavement Recycling

The term pavement recycling implies reuse of the existing pavement materials after retrieving and processing the same with or without addition of fresh materials.

Bituminous Surfacing Recycling

A process wherein bituminous pavement materials are retrieved and processed either in a central paving plant or in-place in an appropriate plant to which fresh aggregate and binder may be added with or without a softening agent to meet the specifications required for the resultant mix and then paver laid.

Reclaimed Bituminous Pavement Materials

Existing pavement materials aggregates and binder, which have been retrieved for being utilised in recycling.

Fresh Aggregates

The additional aggregates other than those retrieved from the existing pavement and used in recycling in combination with reclaimed bituminous pavement aggregates.

Fresh Binder

The additional binder other than that retrieved from the existing pavement and used in recycling in combination with reclaimed bituminous pavement binder.

Partial Depth Reclamation

The reclamation of the existing pavement restricted to a limited depth of the bituminous course through milling.

Full Depth Reclamation

The reclamation of the existing pavement carried out in full depth of the bituminos course through appropriate mechanical equipmeqt.

Cold Milling

The process using equipment with hard-steel cutting teeth operated with a rotary which can gradually retrieve existing pavement in ambient temperature upto specified depths.

Hot Milling

Milling process carried out after softening the bituminous pavement by indirect heating.

Central Paving Plant

Arrangement for producing mixed materials of coarse and fine aggregates along with bituminous binder in a centrally set up plant with stockpiles of material. The mix is transported to work site in suitable haulage trucks and paver-laid.