Guidelines on Composite Pavement- Design and Evaluation of Composite Pavements

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Abstract:- Pavement design is the process of selecting a practical and economical combination of materials of known strength and adequate thicknesses to support the anticipated traffic under expected environmental conditions.Pavements are layered structures of varying thicknesses and characteristics, resting on subgrade soil. They are designed for the purpose of carrying vehicular traffic. Depending on the load distribution characteristics and flexural stiffness of the pavement layers, pavements are mainly divided into (1) flexible pavements (IRC: 37, IRC: 81), (2) rigid pavements (IRC:58, IRC:15, IRC:76, IRC:SP62) and (3) Composite Pavements (IRCSP:60). The other types of pavements which are also in use are Paver Block Pavements (IRCSP:63), Steel Fibre Reinforced concrete pavements (IRC:SP:46) roller compacted Concrete pavement (IRC :SP68), Stone Set Pavement, continuously reinforced concrete pavements (IRC 101), Brick on Edge Pavements, gravel roads etc.The classical definition of pavement types is rather arbitrary, being based upon the above general pavement characteristics. The essential difference between the main two system types i.e rigid and flexible is the manner in which they distribute the load to the subgrade soils.

Keywords: Composite, flexible and rigid pavement,

I. INRODUCTION

In a true flexible system, the pavement lacks the inherent structural stiffness to resist the bending action of the applied load. Therefore, it merely distributes stresses to the subgrade and relies on the shearing resistance of the soils for its performance. As a consequence, the thickness design of a flexible pavement is based upon the concept of limiting the stress applied to the subgrade so that, under the worst environmental conditions/soaked conditions, the subgrade soils' strength is not exceeded.

Generally, a flexible pavement is composed of a series of layers of granular//bituminous bound bases/ stabilized/ and/or asphalt concrete materials, resting on compacted subgrade soil. The higher strength materials for carrying the traffic loads are the base and sub-base layers of the structure. The thickness of the asphaltic wearing surface may be relatively thin, such as with an asphalt surface treatment, in which case the granular materials provide the bulk of the pavement's load transfer capacity.

As a flexible pavement achieves higher stiffness, it acquires a greater ability to resist the bending action of the load and consequently approaches the limiting condition of the rigid pavement definition. In fact, an asphalt concrete pavement with high stiffness could essentially behave as a rigid slab and exhibit distress (failure) manifestations similar to those of a concrete pavement. In this case, limiting horizontal strain at the bottom of the asphalt concrete layer is considered.

In a rigid pavement system, the pavement layer(s) is composed of materials of high rigidity and high module of elasticity which distribute a low level of stress over a wide area of the subgrade soil. Consequently, the major factor considered in the thickness design of rigid pavements is the structural strength of the pavement layer(s); i.e. – flexural strength or modulus of rupture of the concrete itself.

Rigid pavements are classified into jointed plain, jointed plain-doweled, jointed reinforced-doweled, continuously reinforced, and pre-stressed. A jointed plain concrete pavement is an un-reinforced pavement structure with joints at certain designated intervals to compensate for expansion and contraction forces and thermally induced stresses. In contrast, the jointed reinforced concrete pavement is a jointed pavement which contains reinforcing steel (0.1-0.2%) to resist the temperature induced stresses and keep the cracks formed as a result of contraction, in a tight formation. Continuously reinforced concrete pavements, on the other hand, have been designed with sufficient reinforcement (0.5-0.6%) to eliminate the need for joints.

Pre-stressed concrete pavements are concrete pavements which have been pre-stressed and post tensioned like bridge girders to develop adequate internal stresses to resist traffic loadings.

Generally in a true sense, a composite pavement is defined as a pavement which is constructed with a rigid pavement as the lower layer and a flexible pavement surfacing or wearing course on the top or vice versa. The flexible (asphalt concrete) surface is designed to provide special functions such as frictional resistance, wear resistance, better traffic delineation, thermal insulation, and protection against adverse environmental effects.

II. SCOPE

The proposed guidelines describe the design and evaluation of existing pavements and design of flexible overlay over the rigid pavements or composite pavements. The Guidelines IRC:SP76 already covers the design of rigid overlay i.e white topping over flexible pavements.

III. PAVEMENT COMPONENTS

There are mainly following two types of pavements systems in India:

1 A flexible pavement

Which is usually comprised of a sub-base (of CBR about 20%) and/or granular/bituminous/stabilized base course (of CBR 80-100%) and a bituminous surface course(s) (of modulus of elasticity 500 - 6000 MPa ref IRC:37).

2 A rigid pavement

usually consists of a subbase course(s) and a hydraulic cement concrete (of modulus of elasticity 30000 MPa) slab.

Both systems are placed over the subgrade of the road-bed. The **road-bed**, which is the lowest part of the pavements' structure, is defined as the graded portion of the road, between the top and side slopes, prepared as the foundation for the pavement structure and shoulder. The top surface of the roadbed is called the **subgrade** and can be mechanically or chemically stabilized to improve its load carrying capacity.

Subgrade

The upper surface of the roadbed, called the subgrade, is shaped to conform to the Typical Section and supports both the pavement structure and shoulders. The subgrade (300 mm thick in case of low traffic roads and 500-600 mm thick in case of heavy traffic roads) is the foundation of the pavement structure, and is responsible for providing a variety of performance requirements, such as, uniform support, and resistance to both traffic forces and environmentally-induced stresses. Some times subgrade is provided over embankments as per IRC:36. CBR of the subgrade generally varies from 2-30%, however maximum design CBR considered is 10% as per IRC: 37. This is normally fopr conventional construction other than stabilized layers.

Sub-base

The next layer of higher specified quality is the sub-base. It is formed by the layer or layers of selected material of specified thickness placed on the subgrade to support a base course. In the case of a rigid pavement, the sub-base is directly under the concrete slab. The use of a sub-base course is probably the most economical solution in the construction of a pavement over poor quality soils, where a thicker pavement structure is required. Sub base is also considered as structural component of both bituminous and rigid pavement. In case of rigid pavement dry lean concrete is also considered as sub base. In addition to its major function of contributing as a structural member, it has other secondary functions such as:

- i) Providing permanent uniform and stable support to the overlying pavement structure.
- ii) Preventing intrusion of fine-grained soils into the base course or an open Graded drainage layer.
- iii) Minimizing the damaging effects of frost action in special cases where the frost penetration is excessive.
- iv) Acting as a drainage layer (in some cases) by preventing the accumulation of free water within the pavement system when permeability is more than 20 m / day.
- v) Preventing the pumping of fine-grained soil through joints, cracks, and discontinuities under the action of wheel loads and adverse environmental conditions.
- vi) Providing a working platform for construction equipment/construction vehicles.

An open graded drainage or filter layer sub base or base course is the newest addition to both flexible and rigid pavement structures to provide for rapid drainage of the pavement. This layer, non-stabilized or stabilized with asphalt or lime, fly ash cement or other chemicals or admixtures or stabilizer accrditated by IRC, are generally used on high traffic roads and is strongly recommended for all rigid pavements. Pavement edge drains, with outlets and end-walls, are required with all drainage layers. The ends of drainage layers shall not be covered with impermeable soil or other similar materials.

Base Course

The layer(s) of specified or selected material of designated thickness place on a sub-base placed over a subgrade to support a surface course is called the base course. Its material is of higher quality than that of the sub-base or subgrade courses. The base course is an integral part of the flexible pavement system, and is primarily constructed as a structural component. Depending on the structural application and design requirements, the base course might be treated with suitable stabilizing admixtures, such as cement, asphalt cement, lime, fly ash, or chemicals or other IRC accriditated stabilizer, in order to obtain sufficient stability, cohesion, and strength to provide added resistance to loading, or may be untreated if less traffic resistance is required. Materials that might otherwise be unsuitable for use as an untreated base course or granular base course can often provide satisfactory performance when treated with an adequate admixture such as those cited above.

Flexible Pavement Surface Course

Designed as an important member of the flexible pavement structure, the surface course is the uppermost layer(s) and not only provides resistance to the applied load, but also resists the abrasive forces of traffic and the disintegrating effects of climate, reduces the amount of water entering into the pavement, provides both skid resistance and a smooth and uniform riding surface for the traveling public.

The pavement surface must be able to provide sufficient stability to resist the effects of traffic load, maintain its durability during periods of service, resist rutting and fatigue distress, and remain impervious to the effects of water. When several layers are employed as the surface course, the layer placed immediately atop the base course is commonly referred to as an intermediate (binder) course.

Rigid Pavement Slab

The uppermost layer of a rigid pavement is the concrete slab which is most commonly composed of hydraulic cement concrete. This layer requires adequate strength and durability to resist the actions of traffic; it also must be able to provide adequate bending resistance for distribution of load, and have adequate skid characteristics to resist the abrasive forces of traffic. Reinforcement, such as temperature steel, dowel bars, load transfer devices, and tie bars, are provided to resist load induced stresses as well as frictional, shrinkage, and thermally induced stresses.

AXLE LOADS

The most important factor in the structural design of composite pavements is the interaction between traffic and the different types of layers, specifically, the influence of vehicle type, traffic volume, and traffic-induced stresses upon the pavement. The primary factors that influence traffic-induced stresses are listed below:

- (1) Axle spacing.
- (2) Tire spacing (single tire vs. dual tires).
- (3) Load per axle or tire.
- (4) Tire pressure.
- (5) Number of load repetitions

During their service lives, pavement structures are exposed to various types of vehicles, with differing load configurations and magnitudes. The two most common load configurations are defined as follows:

Single Axle Load

The total load transmitted by all wheels whose centers may be included between two parallel transverse vertical planes, extending across the full width of the vehicle.

Tandem Axle Load

The total load transmitted to the road by two or more consecutive axles whose centers may be included between parallel transverse vertical planes, extending the full width of the vehicle.

Legal Axle Load

The legal maximum single axle load is 102 kN and the legal maximum tandem axle load is 150 kN. The determination of allowable axle loads is influenced by the load as per the width of tire, tire pressure, gross weight, and axle spacing.

TYRE PRESSURE

The stress applied to the pavement surface (known as contact pressure) is considered, for all practical purposes, to be equal to the tyre pressure.

IV. LOAD EQUIVALENCY

The traffic equivalency factor is a numerical factor that expresses the relationship of road damage, for a given serviceability level (the current ability of the pavement to serve high-speed, high-volume automobile and truck traffic), of a given axle load to the damage of another. This factor expresses the damaging effects of an axle load in terms of equivalent numbers of repetitions of 81.6 kN single axle loads or 14.968 KN of tandem axles. The equivalent single axle loads (ESAL's) is used in the design procedure of flexible over lay over rigid pavements.

An equivalent single wheel load (ESWL) is defined as the wheel load of a single tire that will cause an equal magnitude of stress, strain, deflection, or distress at a given location within a specified pavement system, compared to that caused by multiple wheel loads or loads of differing magnitude.

V. TESTING AND EVALUATION OF EXISTING PAVEMENTS

6.1 Pavement Evaluation

Before designing composite pavements, evaluation of existing pavement is necessary. The evaluation consists of the collection and use of pavement condition data for the purpose of pavement maintenance, resurfacing, restoration, rehabilitation, and reconstruction. Typical pavement condition data should include roughness, deflection testing and analysis, skid testing, and visual rating. In addition, coring and destructive testing may be beneficial to decide the serviceability rating of existing pavement.

6.1.1 Functional Evaluation :

Three meter Straight edge, Moving pro-filographs or laser devises; are often used to measure the depth of irregularities in the road surface indicating the longitudinal profile or rut depth for pavement management and possible pavement quality assurance programs in the future. Recently Heavy Simulator Vehicles has been procured by CRRI and the same could also be used as to measure the life of existing pavement and further design can be carried for the future required period or life.

Standards related to profile measurement and data analysis have been developed by ASTM under ASTM E 950 and ASTM E 1364. The indigenous response type fifth wheel bump integrator (BI) which measures suspension deflections (originally developed by TRRL in the UK) towed over the road surface (preferably in the wheel path) at a steady speed of 32+/-1 km/hour has to date been generally used in this country to evaluate the roughness in terms of mm/km. A brief description of the above equipment and procedures for calibration are given in the IRC publication "Guidelines for Surface Evenness of Highway Pavements", IRC: SP: 16-2004.

The roughness of a pavement is commonly reported in terms of an unevenness index as measured by the bump integrator. The maximum permissible roughness values (expressed in "mm/km") recommended by IRC: SP: 16-2004 for the roads with different types of surfaces are given in Table 1

(Ref. IRC. 51 : 10-2004)							
Wearing	Condition of Road Surface**						
Surface Type	Good		Average		Poor		
	BI mm/km	IRI m/km	BI mm/km	IRI m/km	BI	IRI m/km	
					mm/km		
Bituminous	< 2000	2.8	2000 - 3000	2.8 - 4.0	> 3000	> 4.0	
Concrete (BC)							
Cement	< 2200	3.0	2200 - 3000	3.0 - 4.0	> 3000	> 4.0	
Concrete (CC)							

 Table 1 Recommended Roughness Values for Roads in India*

 (Ref: IRC: SP: 16-2004)

* It is possible to design and construct composite pavements with roughness level lower than above or for higher design traffic with the use of modern equipment and construction practices supported with adequate logistics commensurate with the capacity of paver etc.

** Good –	serviceability rating 1 and 2
Average -	serviceability rating 3
Poor -	serviceability rating 4 and 5

Two methods of reporting the roughness are commonly followed. One is based on the bump integrator (BI) in mm/km as described above and the other is based on the International Roughness Index (IRI) in m/km. Table 2 gives the conversion values between BI and IRI.

IRI (m/km)	1.0	1.2	1.4	2.0	2.5	3.0	4.0
BI (mm/km)	630	770	920	1370	1760	2160	3000

Note: BI in mm/km = $630 \text{ x} (\text{IRI in m/km})^{1.12}$

a) **Roughness Surveys** – This is to be done as per IRC: SP: 16-2004. Research has established that pavements constructed initially with low roughness level have relatively longer life. There are three methods to assess roughness of the surface as suggested below:

(i) Sand Patch Method: As per IRC:15-2002, the value should be between 0.65 mm to 1.25 mm. in case of brush texturing,

(ii) Digital Vernier-callipers: minimum texture depth 2.5 mm in case of tynes.

(ii) **Measurement by British Pendulum Test:** The value of Skid Resistance Number (BPN) as per Transport Research Laboratory (TRL, Road Note No. 27), the value should be between 45 - 55 BPN (as per British Pendulum Test) in normal conditions. (Refer IRC:SP83 or ASTM D 303 -1983 for more details about the British Pendulum Test).

(iii) As per Mu – Meter: The acceptable values for Skid Number 36 to 31 at different traffic (vehicle) speeds from 50 kmph to 110 kmph.

(iii) **Faulting Surveys** – The faulting of joint/crack is normally measured with a millimeter scale. However, advance equipment like Georgia Faultmeter if, available may also used for measuring joint/crack faulting.

(iv) Core Testing – The guidelines refers to standardized testing procedures by the Bureau of Indian Standards (BIS) and IRC: 76. Core samples may be used for strength testing, and modulus of elasticity testing. Petro graphic as well as durability (materials related distress) testing may also be carried with the core samples.

b) Slab Curvature Measurement – In case of rigid pavements, curling/warping may be determined using the dipstick or by measuring slab deformation (deflections) at slab corners and at other locations using LVDTs or dial gauges. Such testing may be needed in some cases to determine, if premature failure conditions (cracking, etc) are due to excessive slab curling and warping.

c) Steel Corrosion Testing – The guidelines address procedures to identify the state and rate of corrosion of the reinforcing bars at wide cracks and longitudinal joints in Continuously Reinforced Concrete Pavements (CRCP) and Jointed Reinforced Concrete Pavements (JRCP) over time, these measurements provide an indication of the extent of corrosion damage and required type of overlay.

Structural Evaluation

The structural performance of the existing pavement refers to its ability to carry future traffic. There are a number of means of assessing structural capacity by measuring deflection and curvature of the pavement under heavy axle load.

Deflection based non-destructive testing methods such as FWD (very light weight/ light weight or heavy weight) are generally preferred as destructive testing is cumbersome, time consuming and costly.

There are cases when pavement in long continuous stretch is badly damaged and distressed. In all such cases, it may be considered desirable that pavement in such condition be opened up and each layer is tested to identify the exact cause of failure/distress. The Falling Weight Deflectometer (FWD) is a very quick and accurate method for assessing residual life of the pavement, and also for composite pavement design. The FWD (in case of light weight or heavy weight) is attached to a 4 wheeled vehicle, and results recorded directly on to computer disc, for later analyses.

This testing is an important part of any pavement evaluation plan. Key aspects are addressed such as the time of testing for pavements, especially in case of cracks in the pavements for testing for load transfer efficiency (LTE) across the crack and void detection.

The analysis is based on a mechanistic approach and designed to provide the following:

1. Determine in place resilient module of pavement layers and subgrade, k-value (modulus of subgrade reaction as per IRC:15)

- 2. Compare strength of segments
- 3. Evaluate load transfer efficiency across joints in concrete pavement
- 4. Compute predicted structural life
- 5. Design thickness for rehabilitation options
- 6. Compute life cycle costs
- 7. Evaluate cost-effectiveness of design alternates
- 8. Determine optimum time and strategy for rehabilitation
- 9. Develop staging plan to meet budget
- 10. Develop priorities

VI. CONCEPT ON THE DESIGN OF COMPOSITE PAVEMENT CASE I FLEXIBLE OVER RIGID LAYER

This configuration consists of a flexible layer on top of a rigid surface layer (typically jointed plain concrete pavement or continuous reinforced concrete pavement) where the flexible layer is used to increase the performance of the rigid layer. (Flexible layers over lean concrete base or cement treated base are considered to be flexible pavements) The function of the flexible layer is to act as a thermal and moisture blanket to reduce the vertical temperature and moisture gradient within the rigid surface layer and decrease the deformation (curling and warping) of concrete slabs. In addition, the flexible layer acts as a wearing course to reduce wearing effect of wheel loads on the rigid surface layer.

Flexible over rigid composite pavements are found most often on older concrete pavements or over top of the deck slabs or approach slabs (in the bridge structures) that have had a flexible pavement overlay such as hot mix asphalt, open graded friction course, or rubberized asphalt concrete, placed over previously built jointed plain concrete pavement (JPCP) or continuously reinforced concrete pavement (CRCP). New or reconstructed flexible pavements over JPCP or CRCP typically have not been built in the past on State or national highways because they have been viewed as combining the disadvantages of rigid pavements (higher initial cost) and flexible pavements (more frequent maintenance).

Thin flexible layers (i.e. sacrificial wearing course) have sometimes been placed over JPCP or CRCP to improve ride quality or friction of the rigid layer considering rigid layer as structurally sufficient to take the future traffic load. Because ride quality and friction can also be improved by grooving or diamond grinding the existing rigid layer, performance evaluation of the proposed overlay shall be carried for a life-cycle cost analysis (LCCA) to determine if diamond grinding/grooving or a flexible sacrificial overlay is more cost effective before deciding which option to select.

In some cases such as matching the existing pavement structure when widening, adding truck lanes to an adjacent flexible pavement, or providing a new wearing surface to an old rigid surface layer that is still structurally sound, composite pavements may be the best option.

As per MORTH specification clause 2701, bituminous wearing course consists of bituminous concrete /bitumen mastic in wearing coat as per the relevant clauses of MORTH specification. In brief, bituminous wearing coat comprises the following:

- i) A layer of mastic asphalt, 6-8 mm thick after applying a prime coat over the top of the deck slab before the wearing coat is laid.
- ii) 50 -60 mm thick asphaltic concrete as wearing coat in two layers of equal thicknesses may be laid. In case of high rain fall intensity areas, the thickness of mastic asphalt may be increased to 12-15 mm.

Case II: Rigid Pavement over Existing Bituminous Pavement:

Minimum 200 mm thickness requirements for conventional white topping (WT) surface layers, and 100-200 mm thick for Thin white topping (TWT) over flexible pavement for moderate to heavy traffic roads and 50- 100 mm thick for Ultra Thin White Topping (UTWT) for very low traffic such as for foot path, car parking etc; pavements are designed according to the standards and procedures for rigid pavements as per IRC 58, IRCSP83 and as per IRC: SP76-2008.

The mix design of the concrete shall be as per IRC:44. The minimum characteristic compressive strength of concrete in such case shall preferably be M 40.

VII. PRECAUTIONS REQUIRED FOR FLEXIBLE OVERLAY OVER RIGID PAVEMENT OR COMPOSITE PAVEMENTS

Flexible layers placed over rigid surface layers need to be engineered and use materials that will meet the following requirements:

Joints or cracks from the underlying rigid surface layer should not reflect through the flexible layer for the service life of the flexible layer.

The flexible layer should be engineered to provide an initial IRI of 1.0 m/km (63 in/mile) and maintain an IRI that is less 2.68 m/km throughout its service life.

A major factor in the effectiveness and service life of the flexible layer is the condition of the bond between the flexible and rigid layers. For a good bonding condition between flexible and rigid layer, the thickness of the flexible layer does not play an important role in its service life. Therefore, for practical purposes, if there is no thickness requirement from the structural/constructability point of view, the minimum thickness of the flexible layer should be based on material factors such as, gradation and aggregate structure, type of binder, etc as per MORTH Specification. The minimum flexible overlay thickness adopted shall as per clause 6.1.5.

VIII. DESIGN PROCEDURES

EMPIRICAL METHOD

Before deciding to construct a new composite pavement, a life cycle cost analysis (LCCA) should be completed to determine whether the composite pavement is more cost effective over the long term than flexible or rigid pavement alternatives.

At present, there is no comprehensive procedure to design a structural layer of flexible pavement over a rigid surface layer of JPCP or CRCP. When designing composite pavements using Jointed Plain Concrete Pavement (JPCP) or Continuously Reinforced Concrete Pavement (CRCP), the existing rigid layer with base and sub-base is designed as a rigid pavement using the procedures IRC:76. No reduction is made to the thickness of the rigid layer on account of the flexible overlay. The flexible pavement is treated as a sacrificial wearing course, and thus has no structural value.

When enough information is not available, the thickness requirement for placing a flexible pavement overlay over an old rigid pavement can be used as a conservative thickness for a new pavement. **Surface Course**:

General On resurfacing projects, the entire paved shoulder and traveled way shall be resurfaced. Not only does this help provide a smoother finished surface, it also benefits bicyclists and pedestrians when they are allowed to use the shoulder. The flexible surface (in case of Mix Seal Surface /Open Graded Pre Mix Carpet layer) is considered to have no structural value, but in case of asphaltic or bituminous concrete wearing course is considered as structural layer. In both the cases, reflective cracking and ride quality need to be considered.

Reflective cracking. If the flexible layer is placed over an existing (old) rigid pavement, the thickness is calculated based on the procedure outlined for rigid pavement rehabilitation, mainly for reflective crack retardation. The thickness depends on the design life of the flexible sacrificial wearing course, as well as mix gradation, type and percentage of the binder. For additional information on rehabilitation of rigid pavements refer to IRC: 76. However, a minimum thickness of 60 mm BM/DBM and 40 mm BC (after applying a prime coat or mastic layer of 6-8 mm thickness (clause 6.1.5) over the existing rigid pavement layer and prime coat over BM/DBM layer @ 600-800 gm/ sq m) is required In case of Heavy traffic roads such as national or state Highways

In case low traffic roads, a minimum thickness of 40 mm BM/DBM and 25 mm SDBC (after applying a prime coat over the existing rigid pavement layer and another coat over BM/DBM layer @ 600-800 gm/ sq m)) is required.

Ride Quality. When the smoothness of the existing roadway is 2.680 m/km or greater as measured by the International Ride Index (IRI), a minimum 75 mm flexible layer (60 mm asphalt concrete using polymer modified concrete) should be placed. The overall thickness can be a single material or a combination of open graded, dense/gap graded, or SAMI (Stress Absorbing Membrane Internal) material. It is advisable that the existing pavement will need to be repaired to assure the roadway smoothness will remain below 2.68 m/km throughout the life of the overlay or the designed serviceability rating.

IX. M ATERIALS

- i) Water Bound Macadam: As per IRC: 19 and MORTH/MORD Specification.
- ii) Wet Mix Macadam: As per MORTH/MORD Specification
- iii) Tack Coat/Prime Coat: MORTH/MORD Specification
- iv) Bituminous Macadam: As per IRC: 100 and MORTH/MORD Specification
- v) Dense Bituminous Macadam: MORTH/MORD Specification
- vi) Asphaltic Concrete/Bituminous Concrete: MORTH/MORD Specification

X. TYPES AND CONSTRUCTION OF OVERLAY:

Types of overlays and reference of the construction methodology is given in Table 3.

Sl No	Type of Overlay	Reference				
1	Water Bound Macadam	IRC: 19 and MORTH/ MORD Specification				
2	Wet Mix Macadam	IRC: and MORTH/ MORD Specification				
3	Prime/Tack Coat	IRC: and MORTH/ MORD Specification				
4	Bituminous macadam	IRC: and MORTH/ MORD Specification				
5	Dense Bituminous macadam	IRC: and MORTH/ MORD Specification				
6	Bituminous/Asphaltic Concrete	IRC: and MORTH/ MORD Specification				

 Table 3 : Types of overlays and reference of the construction methodology

XI. STEPS OF CONSTRUCTION

(1) **Preliminary Cleaning:** Before constructing the overlay, the surface is cleaned off all caked mud, cow dung, bituminous/paint/diesel/petrol like substance or by-products etc using wire brush or suitable solvents.

(2) **Preparation of the Existing Pavement**. Existing pavement distresses should be repaired before overlaying the pavement. Cracks wider than 3 mm should be sealed asphalt mortar (a mixture of bitumen and sand i.e sand seal coat) devoid of coarse aggregates. Cracks of less than 3 mm shall be filled with hot bitumen or primer Spalls in rigid pavement should be repaired with epoxy resins mortar (1 part epoxy: 3 part coarse sand) as per IRC:SP:83.

It is preferable to break the slabs (into smaller pieces) which are rocking. Broken slabs or punch-outs shall be replaced and shall be full depth repair as per IRC:sp83. Loose flexible pavement if any should be removed and replaced with atleast M 35 grade concrete alongwith potholes and localized failures repaired. Ideally existing flexible wearing courses if any on rigid pavement shall be removed and, if needed, underlying pavement repaired prior to placing a new flexible wearing course. In some cases it may be more practical to overlay over the existing new layer.

- (3) Routing Cracks : Routing cracks before applying crack sealant has been found to be beneficial. The width of the routing should be 3 mm wider than the crack width. The depth should be equal to the width of the routing plus 3 mm. In order to alleviate the potential bump in the overlay from the crack sealant, leave the crack sealant 3 mm below grade to allow for expansion (i.e. recess fill).
- (4) **Prime Coat and Tack Coat :** Both prime coat and tack coat shall be applied on the top of each intermediate overlay layers except top layer. The minimum quantity of prime coat or tack shall be sprayed uniformly @ 0.85 kg/sq m before placement of overlay in all cases. As specified, sufficient curing time shall be given to the tack/prime coat to have proper adherence to the base layer.
- (5) **Chicken Mesh:** Chicken Mesh shall also be used over the applied tack/prime coat to minimize reflection cracking from the PQC to the top bituminous layer.

XII. PAVEMENT DESIGN METHODS

Individual Pavement Design Methods being adopted are given as under:

(a) Flexible Pavement Design (overlay or existing lower flexible pavements)

IRC : 37 and IRC: 81 methods determine the thickness of flexible pavement based on the thickness equivalencies of materials, soil support values, characteristic Benkelman beam deflection and million standard axle (msa) loads etc to design the pavement systems.

(b) Rigid Pavement Design (for existing pavement)

IRC 58 design is based on the program software to design rigid pavements and verifies the structural capability using IITRIGID methods. These programs are based upon traffic loadings, concrete elastic modulus, modified modulus of subgrade reaction (K), and working stress (f) of concrete.

Design of Flexible Overlay Over Rigid or composite Pavements:

For design of composite pavements, there is no universally accepted and rational method of design to workout the thickness of flexible overlay over rigid pavements. However, different methods to rejuvenate and salvage the concrete slab at the early ages of its distressed life with limited cracks, both in numbers and size, are being tried throughout the world and are mainly confined to airfield pavements. Experimental test tracks of composite pavements were laid by CRRI in Hyderabad on NH -7 during 1970. A brief summary of design based on the present traffic conditions is given in Table4.

TABLE 4: Tentative Design Thickness of Bituminous Overlays over Rigid Pavements or existing composite

51	Thicknes	Minimum	Present	Wearing course hituminous	Wearing course
No	s of	Condition/s	traffic	Overlay	Overlay
	Existing	erviceshilit	inmes	o really	hituminous plus
1	Concrete	v* of			granular thickness
1	clah and	Evisting			Erandiar (nickness
1	sub basa	Concrete			
1	COURSe	Paraments			
1	course,	at par			
	mm	IRCSP:83			
1	50-150	≤ 4	0-10	25mm SDBC over 50 mm BM 0r	25 mm Asphaltic
1				60 mm Asphaltic concrete	concrete over
1					minimum 75 mm
L					WBM/ WMM
2	50-150	≤ 3	10-50	25 mm Asphaltic concrete over 65-	40 mm Asphaltic
1				O DS 100m Ambabia any amb	concrete over
1				Or 75-100m Asphaltic concrete	minimum 100 mm
_	20.120	< 3	20.120	10 mm tombolic commence and 25	WMM
2	50-150	20	50-150	40 mm Asphaltic concrete over /5	40-00 mm Asphaltic
1				Ambaltia Cananta	concrete over
1				Asphaltic Concrete	minimum 150 mm
1					WINDA
4	150-250	< 4	0-10	20mm Pre Mix Camet over 50 mm	20mm Premix Carnet
				BM 0r 40 mm Asphaltic concrete	over minimum 75
1					mm WBM/ WMM
5	150-250	< 4	10-50	25 mm Asphaltic concrete over 65	40 mm Asphaltic
1				mm BM/DBM Or 75-100m	concrete over 75 mm
1				Asphaltic concrete	WMM
6	150-250	< 3	50-150	40 mm Asphaltic Concrete over 50	40 mm Asphaltic
1				mm BM	concrete over
1				Or	minimum 75 mm
1				100 mm Asphaltic concrete	WBM/ WMM
7	More	< 4	0-10	20mm Pre Mix Carpet over 50 mm	20mm Premix Carpet
1	than 250	-		BM 0r 40 mm Asphaltic concrete	over minimum 75
1				_	mm WBM/ WMM
8	More	<u><</u> 4	10-50	25 mm Asphaltic concrete over 50	25 mm Asphaltic
1	than 250	_		mm BM/DBM	concrete over
1				Or 75-100m Asphaltic concrete	minimum 75 mm
1				-	WMM
9	More	≤ 3	50-150	40 mm Asphaltic Concrete over 50	40 mm Asphaltic
1	than 250	_		mm BM 0r 75 mm Asphaltic	concrete over
1				concrete	minimum 75 mm
					WBM/ WMM

- If defects in the concrete slabs are on higher sides, the existing conditions can be rectified as per IRCSP83 to bring the required serviceability rating, otherwise the existing concrete slab shall be scarified broken into pieces and may be used as drainage layer/sub base after proper gradation etc as per MORTH/MORD specification.
- When, serviceability of PQC slab is equal to or higher than 3, then in the case of bituminous overlays, chicken mesh/Stress Absorbing membrane at the top of the existing concrete slab after applying tack/prime coat is required to minimize reflection.

REFERENCES

- [1]. "Guidelines for Providing Improved Drainage Systems for VDOT Pavement Structures" is available as a guide for design and construction of a drainage layer system. USA
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- [3]. Pavement Design, Federal Highway Administration (FHWA) 1995
- [4]. IRC:37-200, Guidelines for the Design of Flexible Pavements,
- [5]. IRC:58, Guidelines for the Design of Plain Jointed Rigid Pavements for Highways,
- [6]. IRC:81-1997, Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique
- [7]. IRC:SP 17, Guidelines for the Overlay of Concrete Pavements