

UNIT V RUNWAY DESIGN

Various design factors :

1. Design wheel load
2. Strength characteristics of materials used in pavements
3. sub grade supporting capacity

1. Design wheel load : the part of the **load** of a vehicle that is carried by a single **wheel** and transmitted by it to a road surface or a track.

But to carry large loads multiple axles are provided. Since the design of flexible pavements is by layered theory, only the wheels on one side needed to be considered. ... Standard axle load: It is a single axle load with dual wheel carrying 80 KN load and the design of pavement is based on the standard axle load.

2. Strength characteristics of materials used in pavements : the strength and deformation properties of Florida base course materials have been evaluated in laboratory experiments. The project involved the development of laboratory test techniques, the evaluation of base course materials according to these techniques, and the review of present state laboratory procedures in light of the new tests. The conclusions will be used to examine and revise present Florida base course specifications where necessary

3. subgrade supporting capacity : The overall strength and performance of a pavement is dependent not only upon its design (including both mix design and structural design) but also on the load-bearing capacity of the sub grade soil. ... Increasing sub grade support by alternative means. Sub grade elevation. Prime coats for HMA pavements.

Flexible pavements design methods :

1. Burmister method of pavement design
2. CBR method of pavement design
3. McLeod Design Method for flexible pavements
4. Group Index Method of Flexible Pavement Design

1. Burmister method of pavement design

Burmister introduced a semi empirical method for the design of flexible pavements. In this method, he considered pavement as number of layers. And some assumptions are considered which are as follows:

- The material in each layer is homogeneous
- The material is isotropic
- The material is elastic in nature
- Contact between the layers is continuous
- Unloaded top layer is free from normal and shearing stresses
- The surface layer is infinite in length (horizontal direction) and finite in depth (vertical)

- direction).
- The underlying layers are infinite in both directions
Burmister given the deformation equations for both flexible and rigid pavements by considering the poisons ratio of soil and pavement material to 0.5

For flexible pavements

$$\Delta = 1.5 \frac{paF_2}{E_s}$$

For rigid pavements

$$\Delta = 1.18 \frac{paF_2}{E_s}$$

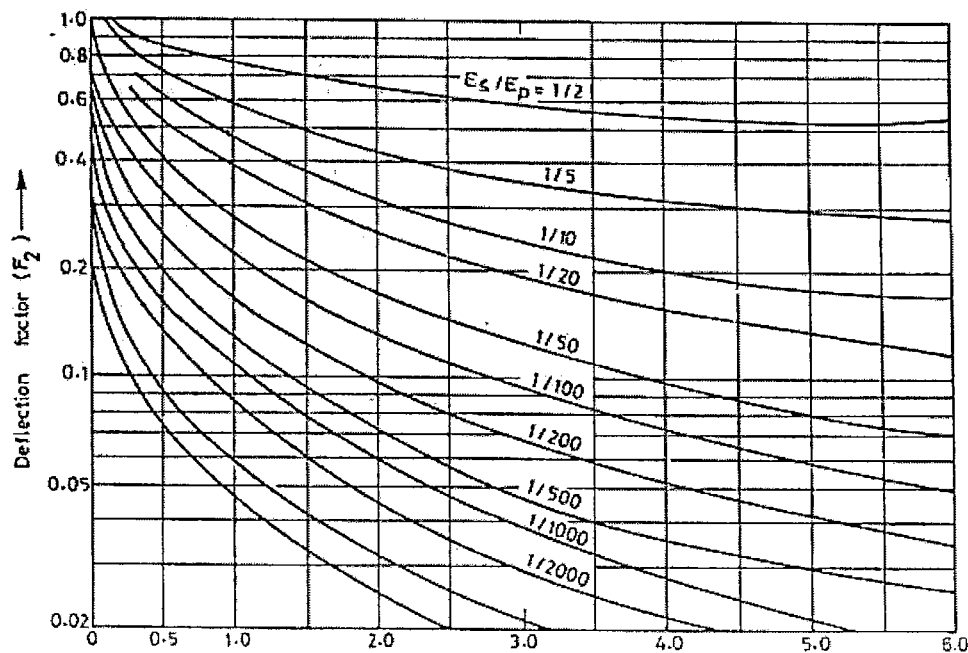
Where, p = uniform pressure

a = radius of plates

F_2 = deflection factor

E_s = modulus of the subgrade soil.

Deflection factor is dependent of ratio of modulus of subgrade soil to the modulus of pavement material. So, from the below graph we can select the value of deflection factor corresponding to the ratio of base layer thickness to the radius of load that is h/a .



Procedure of Flexible Pavement Design by Burmister's Method

In the Burmister's design process, firstly conduct plate bearing test on the soil. The diameter of plate used is 30cm. now determine the modulus of subgrade soil. In the next step, determine the deflection factor from the below formula

$$F_2 = \frac{\Delta.E_s}{1.18 p a}$$

After obtaining the deflection factor from above formula, now select the value of ratio of modulus of subgrade soil to the modulus of pavement material (E_s/E_p) for the given value of (h/a ratio from the graph.

Now for the design load (P) and tire pressure (p) determine the contact radius (a) from the below formula.

$$a = \sqrt{\frac{P}{\pi p}}$$

And again, find the new value of deflection factor F2 for the design deflection value

$$F_2 = \frac{\Delta.E_s}{1.18 p a}$$

Where $\Delta = 0.25\text{cm}$ or 0.5cm .

For the obtained values of new deflection factor and E_s/E_p ratio, select the appropriate h/a ratio from the above graph. And finally, by substituting contact radius (a) in h/a ratio we can get the value of base layer thickness (h).

CBR method of pavement design :

Flexible pavement design by CBR method is used to determine the total thickness of pavement. Generally there are two methods to design the pavement from CBR (California bearing ratio) value.

They are

1. CBR method recommended by California state of highways
2. CBR method recommended by IRC

CBR method recommended by California state of highways:

Data required for flexible pavement design:

- a. CBR value of soil subgrade
- b. CBR value of sub base course
- c. CBR value of base course
- d. Wheel load in KG or KN

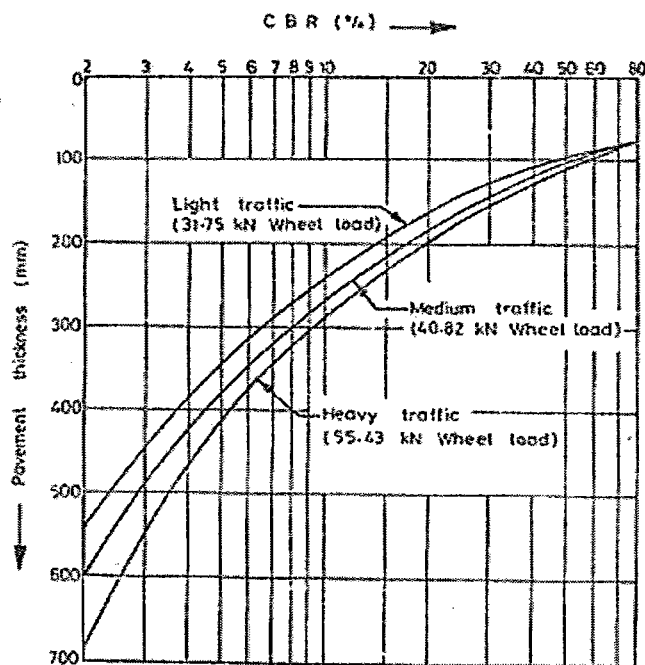
Wheel load is classified into three groups based on traffic conditions.

- Light traffic(3175 KG)

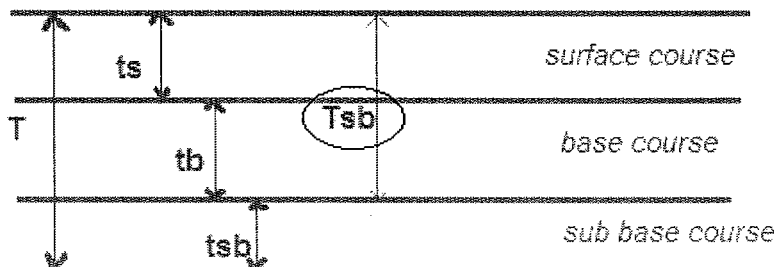
- Medium traffic(4082 KG)
- Heavy traffic (5443 KG)

Flexible Pavement Design Procedure:

Calculation of total thickness (T): From the below chart for given CBR value of soil subgrade and Wheel load value select appropriate thick curve value of “combined thickness of surface, base and sub-base line” which will give the total thickness of pavement.

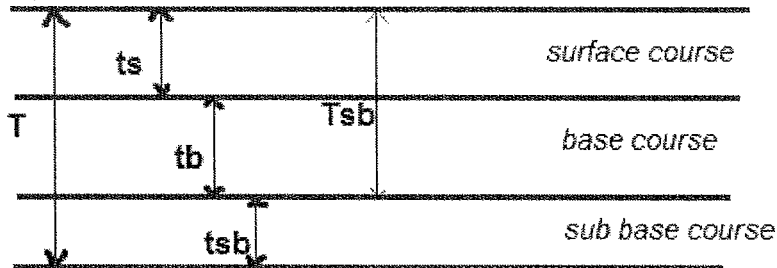


Calculation of sub base course thickness (t_{sb}): By using the above chart, for give CBR value of sub base course material and for wheel load read the thickness of pavement which is above the soil sub base. It is denoted as (Tsb). Which is highlighted by circle in the below fig. but here we have to find t_{sb} . Therefore, thickness of sub base course $t_{sb} = T - Tsb$



Calculation of base course thickness (t_b): Similar to the above procedure, from the CBR value of base course and wheel load read the value of thickness of pavement which is above the base

course (t_s). From this we can find out the value of t_b , $t_b = T_{sb} - t_s$
 Therefore all the values of pavement are known and cross section



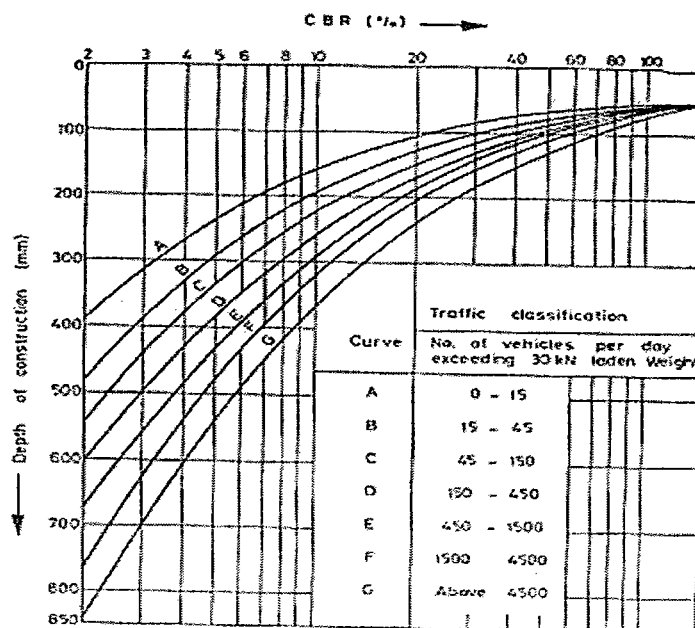
CBR method recommended by IRC (Indian road congress): In this method, the chart contains several curves (A, B, C, D, E, F, and G) which represents the different levels of traffic intensities. Based on this we will find out the layers thicknesses.

Data required for design:

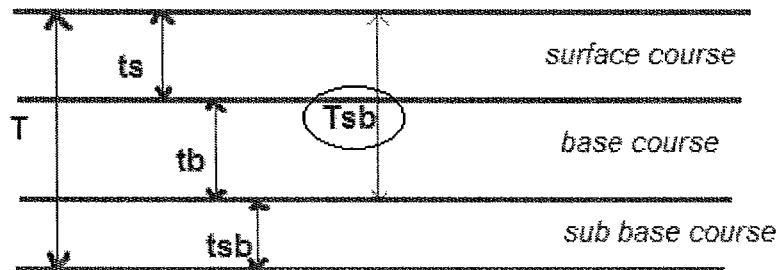
- CBR value of soil subgrade
- CBR value of sub base course
- CBR value of base course
- Traffic intensity

Flexible Pavement Design Procedure:

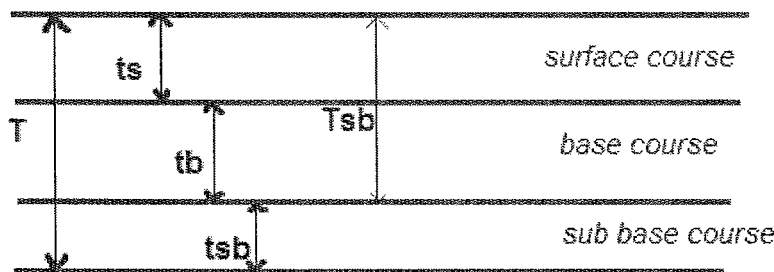
Calculation of total thickness (T): In this step, firstly for the given value of traffic intensity select appropriate curve from classification table which is shown in the below chart. Now, from the given CBR value of subgrade soil read the total thickness (T) with respect to selected curve.



Calculation of sub base course thickness (t_{sb}): By using the above chart, for give CBR value of sub base course material and for traffic intensity value read the thickness of pavement which is above the soil sub base. It is denoted as (T_{sb}). Which is highlighted by circle in the below fig. but here we have to find t_{sb} . Therefore, thickness of sub base course $t_{sb} = T - T_{sb}$



Calculation of base course thickness (t_b): Repeat the above procedure again, from the CBR value of base course and from traffic intensity value read the value of thickness of pavement which is above the base course (t_s). From this we can find out the value of t_b , $t_b = T_{sb} - t_s$. Therefore all the values of pavement are known and cross section of pavement is as follows.



3. McLeod Design Method for flexible pavements

The McLeod method is based on two basic principles:

1. The application rate of a given aggregate should be determined such that the resulting seal coat will be one-stone thick. This amount of aggregate will remain constant, regardless of the binder type or pavement condition.
2. The voids in the aggregate layer need to be 70 percent filled with asphalt for good performance on pavements with moderate levels of traffic.

Design Procedure Components

Median Particle Size. The Median Particle Size (M) is determined from the aggregate gradation chart. It is the theoretical sieve size through which 50 percent of the material **Flakiness Index.** The flakiness index (FI) is a measure of the percent, by weight, of flat particles. It is determined by testing a sample of the aggregate particles for their ability to fit through a slotted plate (TxDOT Test Method Tex-224-F).

Average Least Dimension. The Average Least Dimension, or ALD (H), is determined from the Median Particle Size and the Flakiness Index. It is a reduction of the Median Particle Size after accounting for flat particles. It represents the expected seal coat thickness in the wheel paths where traffic forces the aggregate particles to lie on their flattest side. The ALD is calculated as follows:

$$H = \frac{M}{1.139285 + (0.011506)FI}$$

Equation 4-6.

where:

- H = Average Least Dimension, inches
- M = Median Particle Size, inches
- FI = Flakiness Index, percent.

Loose Unit Weight of the Cover Aggregate. The dry loose unit weight (W) is determined according to TxDOT Test Method Tex-404-A and is needed to calculate the voids in the aggregate in a loose condition. The loose unit weight is used to calculate the air voids expected between the stones after initial rolling. It depends on the gradation, shape, and specific gravity of the aggregate.

Voids in the Loose Aggregate. The voids in the loose aggregate (V) approximate the voids present when the stones are dropped from the spreader onto the pavement. Generally, this value will be near 50 percent for one size of aggregate, less for graded aggregate. After initial rolling, the voids are assumed to be reduced to 30 percent and will reach a low of about 20 percent after sufficient traffic has oriented the stones on their flattest side. However, if there is very little traffic, the voids will remain 30 percent, and the seal will require more binder to ensure good aggregate retention. The following equation is used to calculate the voids in the loose aggregate:

$$V = 1 - W/62.4G$$

Equation 4-7.

where:

- V = Voids in the loose aggregate, in percent expressed as a decimal
- W = Loose unit weight of the cover aggregate, lbs/ft³
- G = Bulk specific gravity of the aggregate (Tex-403-A for natural aggregates and Tex-433-A for lightweight aggregates).

Aggregate Absorption. Most aggregates absorb some of the binder applied to the roadway. The design procedure should be able to correct for this condition to ensure enough binder will remain on the pavement surface. McLeod suggests an absorption correction factor, A, of 0.02 gal/SY if the aggregate absorption is around 2 percent (as determined from Tex-403-A). In the

Minnesota Seal Coat Handbook, it is recommended that a correction factor of 2 percent be used if the absorption is 1.5 percent or higher.

Traffic Volume. The traffic volume, in terms of vehicles per day, plays a role in determining the amount of asphalt binder needed to sufficiently embed the aggregate. Typically, the higher the traffic volume, the lower the binder application rate. At first glance, this may not seem correct. However, remember that traffic forces the aggregate particles to lie on their flattest side. If a roadway had no traffic, the particles would be lying in the same orientation as when they were first rolled during construction. As a result, they would stand taller and need more asphalt binder to achieve the ultimate 70 percent embedment. With enough traffic, the aggregate particles will be laying as flat as possible causing the seal coat to be as thin as possible. If this is not taken into account, the wheel paths will likely bleed. The McLeod procedure uses Table 4-3 to estimate the required embedment, based on the number of vehicles per day on the roadway.

Traffic Factor*				
Traffic – Vehicles per day				
Under 100	100 to 500	500 to 1000	1000 to 2000	Over 2000
0.85	0.75	0.70	0.65	0.60
* The percentage, expressed as a decimal, of the ultimate 20 percent void space in the aggregate to be filled with asphalt.				

Traffic Whip-Off. The McLeod method also recognizes that some of the aggregate will get thrown to the side of the roadway by passing vehicles as the seal coat is curing. This loss is related to the speed and number of vehicles on the new seal coat. To account for this, a traffic whip-off factor (E) is included in the aggregate design equation. A reasonable value is to assume 5 percent for low volume, residential type traffic and 10 percent for higher speed roadways Existing Pavement Condition. The condition of the existing pavement plays a major role in the amount of binder required to obtain proper embedment. A new smooth pavement with low air voids will not absorb much of the binder applied to it. Conversely, a dry, porous and pocked pavement surface can absorb much of the applied binder. Failure to recognize when to increase or decrease binder application rate to account for the pavement condition can lead to excessive stone loss or bleeding. The McLeod method uses the descriptions and factors in Table 4-5 to add or reduce the amount of binder to apply in the field.

Table 4-5. Surface Correction Factor, S.

Existing Pavement Texture	Correction, S
Black, flushed asphalt surface	- 0.01 to - 0.06
Smooth, nonporous surface	0.00
Slightly porous, oxidized surface	+ 0.03
Slightly pocked, porous, oxidized surface	+ 0.06
Badly pocked, porous, oxidized surface	+ 0.09

McLeod Seal Coat Design Equations

The following equations are used to determine the aggregate and binder application rates. While the results may need adjustment in the field, especially the binder application rate, they have been shown to provide a close approximation of the correct material quantities.

Aggregate Design Equation. The aggregate application rate is determined from the following equation:

$$C = 46.8 (1 - 0.4V)HGE$$

Equation 4-8.

where:

- C = Aggregate application rate, lbs/SY
- V = Voids in the loose aggregate, in percent expressed as a decimal (Eq. 7)
- H = Average least dimension, inches
- G = Bulk specific gravity of the aggregate
- E = Wastage factor for traffic whip-off (Table 4-4).

Binder Design Equation .The binder application rate is determined as follows:

$$B = \frac{2.244HTV + S + A}{R}$$

Equation 4-9.

where:

- B = Binder application rate, gal/SY
- H = Average least dimension, inches
- T = Traffic Correction Factor (based on vehicles per day, Table 4-3)
- V = Voids in loose aggregate, percent expressed as decimal (Eq. 7)
- S = Surface condition factor, gal/SY (based on existing surface, Table 4-5)
- A = Aggregate absorption factor, gal/SY
- R = Percent residual asphalt in the emulsion expressed as a decimal. Check with supplier to determine percent residual asphalt content of emulsion. For asphalt cement, R = 1.

Design of Flexible Pavement by Group Index Method :

Determination of Group Index Value of Soil Subgrade Group Index is a number assigned to the soil based on its physical properties like particle size, Liquid limit and plastic limit. It varies from a value of 0 to 20, lower the value higher is the quality of the sub-grade and greater the value, poor is the sub-grade. By sieve analysis test we can determine Group index value of soil subgrade from below equation

$$GI = 0.2a + 0.005 ac + 0.01bd$$

Where,

a= percentage of soil passing 0.074 mm sieve in excess of 35 per cent, not exceeding 75.

b= percentage of soil passing 0.074 mm sieve in excess of 15 per cent, not exceeding 55.

c= Liquid limit in per cent in excess of 40.

d= Plasticity index in excess of 10.

4. Group Index Method of Flexible Pavement Design

Data Required for Flexible Pavement Design

1. Group index of soil subgrade

Group index value range of different soils is given below

- For good soil – 0 to 1
- For fair soil – 2 to 4
- For poor soil – 5 to 9
- For very poor soil – 10 to 20

2. Traffic volume It is the measure of Annual average daily traffic, peak-hour traffic. It is denominated by commercial vehicles/day or CVPD.

It is classified in three categories. Based on number of vehicles per day.

If no. of vehicles per days is

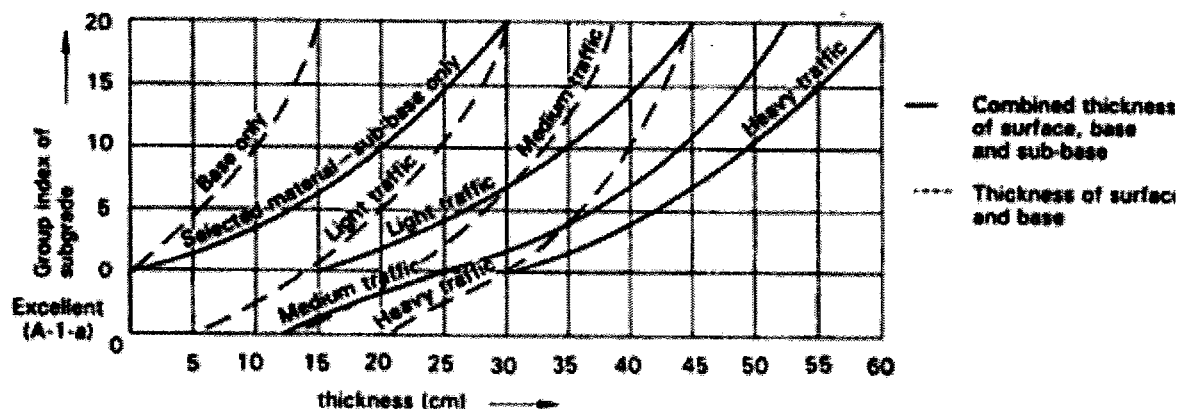
- <50 – light traffic
- 50-300 – medium traffic
- >300 – Heavy traffic

Flexible Pavement Design Procedure:

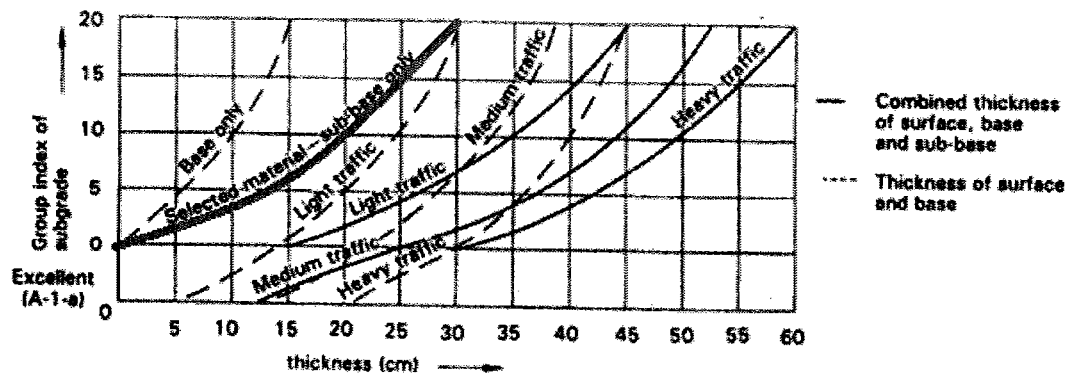
Before going to design the pavement we must know the structure of flexible pavement

Calculation total thickness (T):

From the below chart for given group index of soil subgrade and traffic volume value select appropriate thick curve value of “combined thickness of surface, base and sub-base line” which will give the total thickness of pavement.



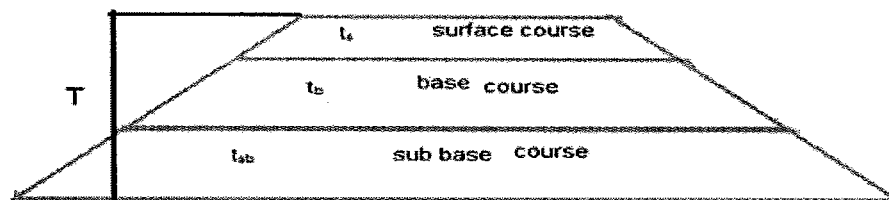
Calculation thickness of sub-base course (t_{sb}): From the below chart for given group index of soil subgrade select appropriate curve value of “thickness of sub base only” which will give the thickness of the sub-base course. The curve highlighted in below diagram



Calculation of thickness of base and surface course (t_b & t_s): Thickness of surface and base course = total thickness – sub-base thickness = $T - t_{sb}$. The combined value of thickness of base and surface course can be found out from above chart form dotted curve with the help of group index value and traffic volume. Or otherwise assume the thickness of surface course (t_s) = 5 cm. Then we can easily calculate the value of thickness of the base course,

$$T_b = T - t_{sb} - t_s$$

Cross section of flexible pavement:



The group index method is essentially an empirical method based on the physical properties of the subgrade soil and it does not consider the strength characteristics of soil and is therefore open to question regarding its reliability.

The pavement is designed as a flexible pavement upon a black cotton soil sub grade, the CBR method as per IRC 37-2001 is most appropriate method than available methods. The pavement is designed as a flexible method from which each method is designed on the basis of their design thickness from which each method has different cost analysis of a section, from which CBR as per IRC is most appropriate in terms of cost analysis.

Design Of Rigid Pavement

Data: Width of expansion joint gap=2.5cm

Maximum variation in temperature between summer and winter=13.10°C

Thermal coefficient of concrete=10*100°C

Allowable tensile stress in CC during curing=0.8Kg/cm²

Coefficient of friction=1.5

Unit weight of CC=2400kg/cm³

Design wheel load=5100Kg

Radius of contact area=15Cm

Modulus of reaction of sub base course=14.5Kg/cm³

Flexural strength of concrete =45Kg/cm²+

E value of concrete=3*10⁵Kg/cm²

Value =0.15Δ Design load transfer through dowel system=40%

Permissible flexural stress in dowel bar=1400Kg/cm²

Permissible shear stress in dowel bar=1000Kg/cm²

Permissible bearing stress in concrete =100Kg/cm²

Permissible tensile stress in steel=1400Kg/cm²

Permissible bond stress in deformed tie bars=24.6Kg/cm²

Present traffic intensity=4100

commercial vehicles/day (Data collected by traffic survey)

(Note: The data assumed based on IRC-58:2002) SLAB THICKNESS

Assume trial thickness of slab=20cm

Radius of relative stiffness, $Eh^3/I = \mu/12K(1 - 2\mu)^{1/4} = [3 \times 10^5 \times 20^3 / 12 \times 14.5(1 - 0.152)]^{1/4}$

$L = 61.28$ $L_x/I = 445/95.41 = 4.66$ $L_y/I = 350/95.41 = 3.66$ (according to I.R.C.Chart)

Adjustment for traffic intensity $A_d = P' (1+r)(n+30)$

Assuming growth rate =75 %

Number of year after the last count before new pavement is opened to traffic $n = 3$ $A_d = 4100 (1 + (7.5/100))(3+30) = 44592.6$ CV/day

So traffic intensity being in the range >4500, Fall in group and the adjustment factor =+2cm

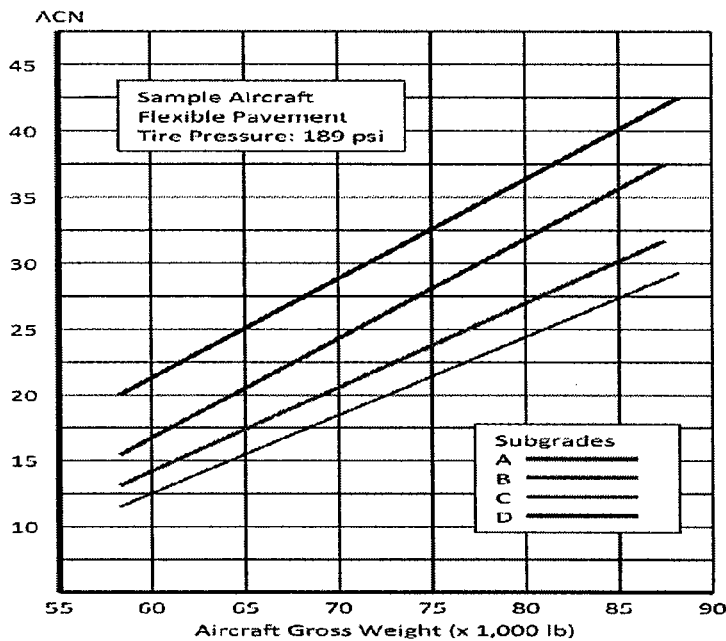
So revised design thickness of the slab =20+2 =22 cm

The pavement is designed as a rigid pavement, the method suggested by IRC is most suitable. It is observed that flexible pavements are more economical for lesser volume of traffic. The life of flexible pavement is near about 15 years whose initial cost is low needs a periodic maintenance after a certain period and maintenance costs very high. The life of rigid pavement is much more than the flexible pavement of about 40 years approx 2.5 times life of flexible pavement whose initial cost is much more then the flexible pavement but maintenance cost is very less.

LCN SYSTEM OF PAVEMENT DESIGN :

Load Classification Number LCN A number expressing the relative effect of an aircraft on a pavement or the bearing strength of a pavement. The original LCN classification system was developed in the UK in the late 1940s but in 1971 the method of calculating LCNs was altered and the LCN/LCG system introduced.

$$\text{Contact area} = \text{load} / \text{tire pressure}$$



system of classification of the supporting capacity of pavements, indicating their ability to support loads without cracking or becoming permanently deformed.

The number is obtained by making plate bearing tests on the pavement. Likewise, the equivalent single wheel load of any aircraft can be expressed in terms of LCN.

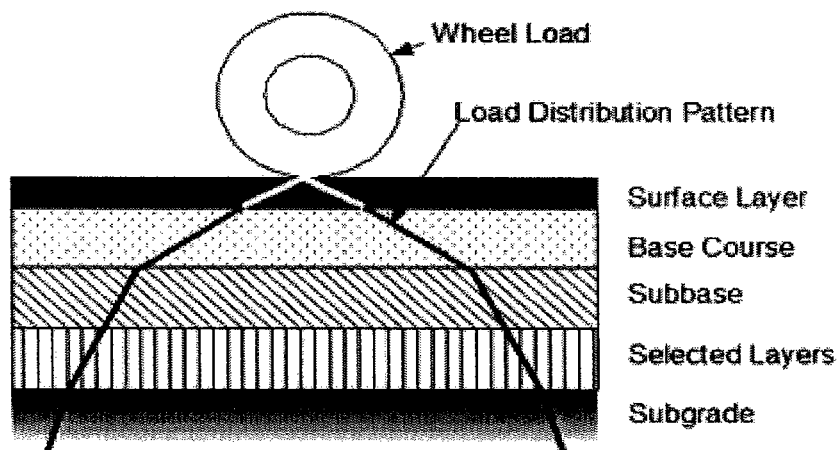
LCN is independent on the gear geometry, tire pressure, and the composition and thickness of the pavement. Thus, if the LCN of an airfield pavement is larger than the LCN of the aircraft, the aircraft can safely use the pavement. To express the capacity of pavement as a single number, the standard load classification was introduced (shown in the table).

Wheel loading		Tire pressure		LCN
(Lbs)	(kg)	(psi)	(kg/cm ²)	
10,000	4,500	75	5.27	10
20,000	9,100	80	5.62	20
30,000	13,600	85	5.98	30
40,000	18,600	90	6.33	40
50,000	22,700	95	6.68	50
60,000	27,200	100	7.03	60
70,000	31,800	105	7.38	70
80,000	36,300	110	7.74	80
90,000	40,800	115	8.09	90
1,00,000	45,400	120	8.44	100

Pavement failures:

Introduction

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The major Flexible pavement failures are fatigue cracking, rutting, and thermal cracking. The fatigue cracking of flexible pavement is due to horizontal tensile strain at the bottom of the asphaltic concrete. The failure criterion relates allowable number of load repetitions to tensile strain and this relation can be determined in the laboratory fatigue test on asphaltic concrete specimens. Rutting occurs only on flexible pavements as indicated by permanent deformation or rut depth along wheel load path. Two design methods have been used to control rutting: one to limit the vertical compressive strain on the top of sub-grade and other to limit rutting to a tolerable amount (12 mm normally). Thermal cracking includes both low temperature cracking and thermal fatigue cracking.



Failures may be:

Failure in sub grade

- Inadequate Stability
- excessive application of stresses
- plastic deformation

Failures in sub base or Base course

- Inadequate stability
- Loss of binding action
- Loss of bearing course materials
- Inadequate wearing course

Causes of Premature Failures

- Rutting due to high variation in ambient temperature
- Uncontrolled heavy axle loads
- Limitation of pavement design procedures to meet local environmental conditions

Common Flexible Pavement Failure/ Distresses

- ☐ Cracking
- ☐ Deformation
- ☐ Deterioration
- ☐ Mat problems
- ☐ Problems associated with seal coats

Category	Distress type
1. Cracking	Longitudinal, Fatigue, Transverse, reflective, block, edge
2. Deformation	Rutting, Corrugation, Shoving, depression, overlay bumps
3. Deterioration	Delamination, Potholes, Patching, raveling, stripping, Polished aggregate, Pumping
4. Mat Problems	Segregation, Checking, Bleeding
5. Seal coats	Rock loss, Segregation, bleeding/fat spots, Delamination

Types of Distresses/Failures and Definitions :

Longitudinal Cracking: Cracks that are approximately parallel to pavement centerline and are not in the wheel path. Longitudinal cracks are non-load associated cracks. Location within the lane (wheel path versus non-wheel path) is significant. Longitudinal cracks in the wheel path are normally rated as Alligator 'A' cracking

Fatigue Cracking: Cracks in asphalt layers that are caused by repeated traffic loadings. The cracks indicate fatigue failure of the asphalt layer. When cracking is characterized by interconnected cracks, the cracking pattern resembles that of an alligator's skin or chicken wire. Therefore, it is also referred to as alligator cracking

Transverse Cracking: Cracks that are predominately perpendicular to pavement centerline and are not located over Portland cement concrete joints. Thermal cracking is typically in this category

Reflection Cracking: Cracks in HMA overlay surfaces that occur over joints in concrete or over cracks in HMA pavements.

Block Cracking: Pattern of cracks that divides the pavement into approximately rectangular pieces. Rectangular blocks range in size from approximately 0.1 square yard to 12 square yards

Edge Cracking: Crescent-shaped cracks or fairly continuous cracks that intersect the pavement edge and are located within 2 feet of the pavement edge, adjacent to the unpaved shoulder. Includes longitudinal cracks outside of the wheel path and within 2 feet of the pavement edge.

Rutting: Longitudinal surface depression that develops in the wheel paths of flexible pavement under traffic. It may have associated transverse displacement.

Corrugation: Transverse undulations appear at regular intervals due to the unstable surface course caused by stop-and-go traffic

Shoving: A longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles, and is usually located on hills or curves, or at intersections. It also may have vertical displacement

Depression: Small, localized surface settlement that can cause a rough, even hazardous ride to motorists

Overlay Bumps: In newly overlaid pavements, bumps occur

Delaminating: Loss of a large area of pavement surface. Usually there is a clear separation of the pavement surface from the layer below. Slippage cracking may often occur as a result of poor bonding or adhesion between layers.

Pot holes: Bowl-shaped holes of various sizes in the pavement surface. Minimum plan dimension is 150 mm.

Patching: Portion of pavement surface, greater than 0.1 sq. meter, that has been removed and replaced or additional material applied to the pavement after original construction.

Raveling: Wearing away of the pavement surface in high-quality hot mix asphalt concrete that may be caused by the dislodging of aggregate particles and loss of asphalt binder.

Stripping: The loss of the adhesive bond between asphalt cement and aggregate, most often caused by the presence of water in asphalt concrete, which may result in raveling, loss of stability, and load carrying capacity of the HMA pavement or treated base

Polished aggregate: Surface binder worn away to expose coarse aggregate

Pumping: Seeping or ejection of water and fines from beneath the pavement through cracks.

Segregation: Separation of coarse aggregate from fine aggregate as a result of mishandling of the mix at several points during mix production, hauling, and placing operations. Segregation leads to non-uniform surface texture and non-uniform density

Checking: Short transverse cracks, usually 1 to 3 inches in length and 1 to 3 inches apart, which occur in the surface of the HMA mat at some time during the compaction process. The cracks do not extend completely through the depth of the course, but are only about ½ inch deep

Bleeding/Flushing: Excess bituminous binder occurring on the pavement surface. May create a shiny, glass-like, reflective surface that may be tacky to the touch. Usually found in the wheel paths

Segregation: Separation of coarse aggregate from fine aggregate as a result of mishandling of the mix at several points during mix production and placing operations. Segregation leads to nonuniform surface texture

Bleeding/Fat Spots: Excess binder occurring on the surface treated pavements. May create a shiny, glass-like, reflective appearance. Fat spots are localized bleeding

Common Rigid Pavement Distresses

- **Spalling**
- **Faulting**
- **Cracking**
- **Longitudinal cracks**
- **Slab cracking**
- **Durability**
- **“D” cracking**
- **Polished Aggregates**
- **Pop-out**
- **Blow Ups**
- **Pumping and**
- **water bleeding**
- **Shrinkage**
- **Cracking**

Spalling at the Joint :

- Cracking, breaking or chipping of joint/crack edges. Usually occurs within about 0.6 m (2 ft.) of joint/crack edge.
- Loose debris on the pavement, roughness, generally an indicator of advanced joint/crack deterioration.
- Excessive stresses at the joint/crack caused by infiltration of incompressible materials and subsequent expansion (can also cause blowups).

Faulting :

- A difference in elevation across a joint or crack usually associated with undoweled JPCP.
- Usually the approach slab is higher than the leave slab due to pumping, the most common faulting mechanism.
- Faulting is noticeable when the average faulting in the pavement section reaches about 2.5 mm (0.1 inch).
- When the average faulting reaches 4 mm (0.15 in), diamond grinding or other rehabilitation measures should be considered.

Longitudinal Cracking :

- Longitudinal cracks not associated with corner breaks or blowups that extend across the entire slab.
- Typically, these cracks divide an individual slab into two to four pieces.
- Often referred to as “panel cracking”.

Corner Cracking :

- A crack that intersects the PCC slab joints near the corner. “Near the corner” is typically defined as within about 2 m (6 ft) or so.
- A corner break extends through the entire slab and is caused by high corner stresses.

- Severe corner stresses caused by load repetitions combined with a loss of support, poor load transfer across the joint, curling stresses and warping stresses.

Durability:

- Cracking Series of closely spaced, crescent-shaped cracks near a joint, corner or crack.
- It is caused by freeze-thaw expansion of the large aggregate within the PCC slab.
- Durability cracking is a general PCC distress and is not unique to pavement PCC.
- Some roughness leads to spalling and eventual slab disintegration.

Polished Aggregate :

- Areas of pavement (either PCC or HMA) where the portion of aggregate extending above the asphalt binder (in the case of HMA) or cement paste (in the case of PCC) is either very small or there are no rough or angular aggregate particles. Repeated traffic applications.
- Generally, as a pavement ages the protruding rough, angular particles become polished.
- This can occur quicker if the aggregate is susceptible to abrasion or subject to excessive studded wear and tear.

Popouts:

- Small pieces of PCC that break loose from the surface leaving small divots or pock marks.
- Pop outs range from 25 – 100 mm (1 – 4 inches) in diameter and from 25 – 50 mm (1 – 2 inches) deep.
- Pop outs usually occur as a result of poor aggregate durability.
- Poor durability can be a result of a number of items such as:
 - Poor aggregate freeze-thaw resistance.
 - Expansive aggregates
 - Alkali-aggregate reactions

Blow-ups

- A localized upward slab movement and shattering at a joint or crack.
- Usually occurs in spring or summer and is the result of insufficient room for slab expansion during hot weather.
- During cold periods (e.g., winter) PCC slabs contract leaving wider joint openings. If these openings become filled with incompressible material (such as rocks or soil), subsequent PCC slab expansion during hot periods (e.g., spring, summer) may cause high compressive stresses.
- If these stresses are great enough, the slabs may buckle and shatter to relieve the stresses.
- **Blowup can be accelerated by:**
 - Joint Spalling (reduces slab contact area and provides incompressible material to fill the joint/crack).

- D-Cracking (weakens the slab near the joint/crack area).
- Freeze-thaw damage (weakens the slab near the joint/crack area).

Pumping and Water Bleeding :

- Movement of material underneath the slab or ejection of material from underneath the slab as a result of water pressure.
- Water accumulated underneath a PCC slab will pressurize when the slab deflects under load.
- This pressurized water can do one of the following:
 - Move about under the slab.
 - Move from underneath one slab to underneath an adjacent slab.
 - This type of movement leads to faulting.
 - Move out from underneath the slab to the pavement surface.
 - This results in a slow removal of base, sub-base and/or sub grade material from underneath the slab resulting in decreased structural support.

Shrinkage Cracking :

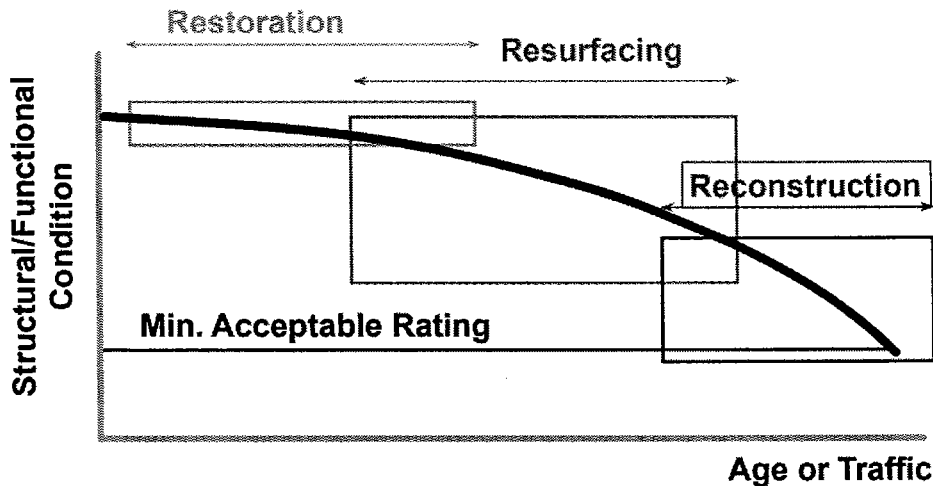
- Hairline cracks formed during PCC setting and curing that are not located at joints. Usually, they do not extend through the entire depth of the slab.
- Shrinkage cracks are considered a distress if they occur in an uncontrolled manner (e.g., at locations outside of contraction joints in JPCP or too close together in CRCP).
- Possible causes-
 - Contraction joints sawed too late.
 - Poor reinforcing steel design.
 - Improper curing technique.
 - High early strength PCC

Maintenance And Rehabilitation

- The combined effects of traffic loading and the environment will cause every pavement, no matter how well-designed/constructed to deteriorate over time. Maintenance and rehabilitation are what we use to slow down or reset this deterioration process.
 - Maintenance actions, such as crack sealing, joint sealing, fog seals and patching help slow the rate of deterioration by identifying and addressing specific pavement deficiencies that contribute to overall deterioration.
 - Rehabilitation is the act of repairing portions of an existing pavement to reset the deterioration process.
 - For instance, removing and replacing the wearing course in a pavement provides new wearing course material on which the deterioration process begins anew.
 - This Module discusses the maintenance options for HMA and PCC pavement.
- Rigid Pavement Distress is a serious issue all over the world,
- The distresses causes some serious problems at wide range.

- Prevention of rigid pavement distress is a challenge to the Engineers.
- Maintenance and Rehabilitation is to be properly done to prevent the distresses in rigid pavement.

Pavement maintenance :



- Pavement maintenance is treatment of road defects The first step in the maintenance process is collection of information about defects •
- Some defects are environment-related, like silting of drains, clogging of culverts & vegetation growth. These are treated under routine maintenance (say, twice a year).
- Traffic induced defects are assessed by manual and mechanical methods and treated according to the type and intensity of defect.

Pavement Defect: Cracking

Development If neglected, general or local destruction of pavement

Remedies

Surface cracking: local sealing or filling of cracks

Cracks in pavement structure: local sealing, filling of cracks and patching when cracking is severe

Treatment: Local Sealing

- Defects treated: Cracks & Final treatment for local repairs
- Material used

Cutback bitumen, coarse sand up to 5 mm, chippings 6 to 10 mm size for local repairs

Execution steps

- a) sweep area (surface must be clean & dry)
- b) mark out the area to be sealed, with chalk
- c) distribute binder (use water can) 1kg/m² ; do not overheat bitumen.
- d) distribute aggregate by scattering with shovel.. Whole area must be covered.

crack sealing •

Defects treated

Closely spaced cracks

• Materials used

Bituminous slurry

• Execution

a) Sweep the area (surface must be dry and clean)

b) mark out the area to be repaired, with a chalk

c) prepare bitumen slurry by mixing 6 liters of bitumen emulsion with 20 liters of coarse sand (< 5mm) –

d) Spread the slurry with squeegee in thin layer 5 mm thick) over marked area. Allow it to dry before allowing traffic

Airport drainage

An adequate drainage system for the removal of surface and subsurface water is vital for the safety of aircraft and for the long service life of the pavements. Improper drainage results in the formation of puddles on the pavement surface which can be hazardous to aircraft taking off and landing poor drainage can also results in the early deterioration of pavements.

Purpose of drainage

The functions of an airport drainage system are as follows;

- Intercepting and diversion of surface and ground water flow originating from lands adjacent to the airport.
- Removal of surface run off from the airport
- Removal of subsurface flow from the airport

Design storm for surface run off

Federal aviation administration recommends that for civil airports the drainage system be designed for a storm whose probability of occurrence is once in 5 years. The designs should, however be checked with a storm of lesser frequency (10 to 15 years). Drainage system for military airfields is based on a 2-years storm frequency. Rainfall intensity is expressed in inches per hour for various durations of a particular storm. The FAA adopts the following formula for the calculation of amount of run off.

$$Q = CIA$$

Q = Run off from the drainage basin (ft/sec)

C = ratio of runoff to rainfall (coefficient of runoff)

I = Rainfall intensity (inch /hour)

A = Drainage area in acres

For drainage basins consisting of several types of surfaces with different infiltration characteristics, the weighted run off coefficient should be computed as

$$C = \frac{A_1C_1 + A_2C_2 + A_3C_3}{A_1 + A_2 + A_3}$$

Having calculated the discharge to be handled, the pipes diameter is determined. Pipes used are of perforated metal, concrete on vitrified clay. Pipes are of usually 6" diameter with a minimum recommended slope of 0.15%. a minimum thickness of 6" of filter material should surround the drain and filter material must be many times more pervious than the protected soil. For cleaning and inspection, manholes and risers are often installed along the drains. The crops of engineers recommend that manhole be placed at intervals not more than 1000 ft with one riser midway between the manholes. Some time one combined drain is provided both for surface and subsurface drainage (combined system).

Surface drainage

Water from a discharge area is collected into the storm drain by means of inlets. The inlets structures consists of a concrete box, whose top is covered with a grating made of cast iron, cast steel or reinforced concrete a cover is designed to takes aircraft wheel loads. The inlets are spaced from 200 – 400 ft. Support locations of inlets depend on the configuration of the airport and on the grading plan.

Normally drains are placed near the edge of the runway pavement or at the toe of the slope of the graded area. The grades of the storm drain should be such as to maintain a minimum velocity of 2.5 ft/sec self cleaning velocity. The diameter of surface drains should not be less than 12". The design should be such that entire quantity of surface run off should be removed in 1 to 2 hours following the rain storm.

Ponding

If the airport area is subjected to high rainfall intensities and calculations gives very large diameter of drains required to remove water from the land area. So ponding of water is done to accumulate water for some time and then allow it to enter the drains, thus reducing size of drains. Water is collected in catch basin and carried away by storm sewer.

Sub surface drainage

Functions of subsurface drainage are to

Remove water from a base course

Remove water from the sub grade beneath a pavement and

Intercept, collect and remove water flowing from springs and previous strata.

Base drainage is usually required;

Where frost action occurs in the sub-grade beneath a pavement

Where the ground water is expected to rise to the level of base course.

Where the pavement is subjected to frequent inundation and the sub-grade is highly impervious and sub surface waters from adjacent areas are seeping towards the airport pavements.

Methods for draining sub-surface water : Base course are usually drained by installing sub-surface drains adjacent to and parallel to the edge of pavement. The pervious material in the trench should extend to the bottom of base course and center line of the drain pipe should be placed a minimum of 1 ft below the bottom of the base course. Sub grade is drained by pipes installed along the edge of the pavement and the center line of the drain should be placed at edge.