IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

HIGHWAY PROJECT

Guide Name .

Mr Chitranjan kumar
Assistant professor Head,
Department of Civil Engineering
Department of Civil Engineering,
Lingaya's Vidyapeeth.
Lingaya's Vidyapeeth, Faridabad

ABSTRACT

This report is based on the work of **"HIGHWAY PROJECT"**. This report contains the details of the execution work which I have seen during my training period. The contents of this report are theoretical as well as practical as per my site experience. I did my training from PWD department.

Public works department (PWD), under the ministry of public works department, is the pioneer in construction area of Punjab. It play a pivotal role in the in implementation of government construction projects.

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CHAPTER-1

1. INTRODUCTION:-

Roads are considered as the lifeline of any country. Some of the important roles of roads in India's economy are:

1. Connection to villages.
2. Communication in hilly terrain.

3. Carriers of freight and passengers complementing the railways

4. Helps agricultural development

5. Administrative convenience, etc.

Engineers have been always with open mind to adopt any material available to them for its use for the construction purposes. It is logical to see that the purpose of highway construction is to provide a firm and even surface for the carriageway or the pavement which could stand the stress caused due to number of load applications.

Types of Highway construction:

(i) Earth road and gravel roads.

(ii) Soil stabilized roads.

(iii) Water bound macadam (WBM) road.

(iv) Bituminous or black-top roads

(v) Cement concrete roads

1.1 Types of Pavements:-

From the point of view of structural performance, pavements can be classified as:

Flexible Rigid

Semi-rigid Composite

Flexible pavements are so named because the total pavement structure defects, or exes, under loading. A flexible pavement structure is typically composed of several layers of materials. Each layer receives loads from the above layer, spreads them out, and passes on these loads to the next layer below. Thus the stresses will be reduced, which are maximum at the top layer and minimum on the top of sub grade. In order to take maximum advantage of this property, layers are usually arranged in the order of descending load bearing capacity with the highest load bearing capacity material (and most expensive) on the top and the lowest load bearing capacity material (and least expensive) on the bottom.

A Rigid pavement derives its capacity to withstand loads from the flexural strength or beam strength, permitting the slab to bridge over minor irregularities in the sub grade, sub-base or base

upon which it rests. A Semi-rigid pavement represents an intermediate state between the flexible and the rigid pavement. It has much lower flexural strength compared to concrete slabs. A Composite pavement is one which comprises of multiple, structurally significant layers of different-sometimes heterogeneous-composition.

1.2 Design of Flexible Pavements:-

In the design of flexible pavements, it has yet not been possible to have a rational design method wherein design process and service behaviour of the pavement can be expressed or predicted theoretically by mathematical laws.

Flexible pavement design methods are accordingly either empirical or semi-empirical. In these methods, the knowledge and experience gained on the behaviour of the pavements in the past are usefully utilized.

There are some various methods used to design of flexible pavement:

Group Index Method

California Bearing Ratio Method

California R Value or Stabil meter method Tri axial test method

McLeod method Bur mister method

The design method, the GI, CBR, Stabil meter and McLeod methods are empirical methods. The Tri axial test method is a theoretical method using empirical modifications as suggested by Kansas State highway Department and therefore may be considered as a semi-empirical method. Bur mister method is a theoretical approach using elastic two-layer theory.

1.3 Traffic and Loading:-

There are three different approaches for considering vehicular and traffic characteristics, which affects pavement design.

1.3.1 Fixed traffic:-

Thickness of pavement is governed by single load and number of load repetitions is not considered. The heaviest wheel load anticipated is used for design purpose. This is an old method and is rarely used today for pavement design.

1.3.2 Fixed vehicle:-

In the fixed vehicle procedure, the thickness is governed by the number of repetitions of a Standard axle load. If the axle loads is not a standard one, then it must be converted to an equivalent axle load by number of repetitions of given axle load and its equivalent axle load factor.

1.3.3 Variable traffic and vehicle:-

In this approach, both traffic and vehicle are considered individually, so there is no need to assign an equivalent factor for each axle load. The loads can be divided into a number of groups and the stresses, strains, and deflections under each load group can be determined separately; and used for design purposes. The traffic and loading factors to be considered include axle loads, load repetitions, and tyre contact area.

CHAPTER 2

2. Material used:-

2.1 Cement:-

The natural cement is obtained by burning and crushing the stones containing clay, carbonate of lime and some amount of carbonate of magnesia. The clay content in such stones is about 20 to 40 percent. The natural cement is brown in colour and its best variety is known as the Roman Cement. The natural cement resembles very closely eminent hydraulic lime. It sets very quickly after addition of water. It is not so strong as artificial cement and hence it has limited use in practice. The artificial cement is obtained by burning at a very high temperature a mixture of calcareous and argillaceous materials. The mixture of ingredients should be intimate and they should be in correct proportion. The calcined product is known as clinker. A small quantity of gypsum is added to the clinker and it is then pulverized into very fine powder which is known as the cement.

2.1.1Properties of cement:-

Following are the important properties of good cement which primarily depend upon its chemical composition, thoroughness of burning and fineness of grinding:

It gives strength to the masonry. It is an excellent binding material. It is easily workable.

It offers good resistance to the moisture. It possesses a good plasticity.

It stiffens or hardness early.

2.1.2 Harmful constituents of cement:-

The presence of the following two oxides adversely affects the quality of cement:

Alkali oxides K_2O and Na_2O Magnesium oxide MgO

If the amount of alkali oxides exceeds 1 percent, it leads to the failure of concrete made from that cement. Similarly, if the content of the magnesium oxide exceeds 5 %, it causes cracks after mortar or concrete hardens. It is due to the fact that magnesium oxide, burned at a temperature of about 1500°C, slakes very slowly, when mixed with water.

Sources and brand- J K Laxmi cement and Birla cement Brand from Ratlam.

2.2 Aggregate:-

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads. To put it another way, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

The American Society for Testing and Materials publishes an exhaustive listing of specifications for various construction aggregate products, which, by their individual design, are suitable for specific construction purposes. These products include specific types of coarse and fine aggregate designed for such uses as additives to asphalt and concrete mixes, as well as other construction uses. State transportation departments further refine aggregate material specifications in order to tailor aggregate use to the needs and available supply in their particular locations.

2.3 Sand:-

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable,

depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica(silicon dioxide, or SiO_2), usually in the form of quartz.

As the term is used by geologists, sand particles range in diameter from 0.0625mm (or 1⁄16 mm, or 62.5 μm) to 2 mm. An individual particle in this range size is termed a sand grain. The next larger size class above sand is gravel, with particles ranging from 2 mm up to 64 mm (see particle size for standards in use). The next smaller size class in geology is silt: particles smaller than 0.0625 mm down to 0.004 mm in diameter. The size specification between sand and gravel has remained constant for more than a century, but particle diameters as small as 0.02 mm were considered sand under the Albert Atterberg standard in use during the early 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the minimum sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).

2.4 Bitumen:-

Bitumen is a black, oily, viscous material that is a naturally-occurring organic by product of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar, incense, and decorative application on pots, buildings, or human skin. The material was also useful in waterproofing canoes and other water transport, and in the mummification process toward the end of the New Kingdom of ancient Egypt. It is also flammable. And, thanks to recent scholarship, this gooey stuff is also identifiable to source.

POINTS TO CONSIDER:-

The producer of bituminous mixtures, in purchasing a specified bitumen binder will expect that binder to possess the properties he has specified.

The producer will expect the binder to be delivered at the time he has specified, not before, holding tanks may not be empty and cleaned, and not after, he may have run out of that particular binder and had to cease production causing "knock on" problems.

The producer will expect binders to be delivered at agreed temperatures that do not cause handling or storage problems.

The producer should be able to store bitumen in the manner recommended by the supplier and in accordance with various appropriate British Standards specifications.

The producer should incorporate the purchased binder into bituminous mixtures, regarding amount, type and mixing temperature, as specified in a British Standard specification or Published Document, as set down in the design of a proprietary material, or as an agreed design/specification supplied by the Engineer.

The production plant will use a "recipe" to manufacture any bituminous mixture whether a "specified" mixture or a proprietary material, even if the material is to be assessed on a performance basis. There is no other way to produce large amounts of a uniform material, you need a "recipe" in the control room of the mixing plant to know what to mix together to obtain the material you want.

The producer will have manufactured the material in accordance with the order placed at the plant by the laying contractor or engineer in charge of the work.

The producer cannot be held responsible if the material ordered is not suitable for the situation in which it is being used, he will produce and supply the material ordered.

CHAPTER 3

3. Construction methodology and general specifications 3.1 Construction of Bituminous Roads:-

Bituminous pavements are in common use in India and abroad. Flexible pavements could be strengthened in stages by constructing bituminous pavement layers one after another in a certain period of time unlike the cement concrete pavement construction. The problem associated with the construction of bituminous pavements is control of the proper viscosity of the bituminous-aggregate mixtures during mixing and compaction operations. Bituminous constructions are also adopted for base and binder courses of pavements on heavy-traffic roads.

3.2 Types of Bituminous Constructions:-

The followings construction techniques are in use:

Interface treatments like prime coat and tack coat Surface dressing and seal coat

Ground or penetration type constructions-

- Penetration Macadam
- Built-up Spray Grout

Premix which may be any one of the following: ○ Bituminous bound macadam

- Carpet
- Bituminous Concrete
- Sheet Asphalt or Rolled Asphalt ○ Mastic Asphalt

3.3 Methods of Construction:-

Premix types of Bituminous Constructions are generally carried out in the field using appropriate plants. There are two types of Mixing Plant and Travelling Plant. The canter mixing plant consists of units for batching different materials, separate heating units for mixed aggregates and bitumen and a mixing unit of large capacity. The aggregates, filler and bitumen are transported to the site of the mixing plant which is stationed at a suitable location and the bituminous mix is again transported from the plant to the construction site. Generally there is very good control on the quality of the mix obtained from the central mixing plant. The travelling Plant is a smaller unit and can be shifted from time to time the road side as the bituminous construction progresses. In hot mix constructions the heated aggregates are mixed with heated bitumen in a central or travelling plant. In cold mix method, the aggregates at atmospheric temperature are mixed with bituminous material of low viscosity in cold or after slight heating.

3.3.1 Bituminous Construction procedures:-

In this Article, the material requirements, plant and equipment and construction process Employed for the following types of bituminous constructions have been presented:

Surface Dressing

Grouted or Penetration Macadam Built-up Spray Grout

Bitumen Bound Macadam Bitumen Carpet

3.3.2 Construction Procedure for Bituminous Concrete:-

The bituminous concrete is the highest quality of construction in the group of black top surfaces. Being of high cost specifications, the bituminous mixes are properly designed to satisfy the design requirements of the stability and durability. The mixture contains dense grading of coarse aggregate, fine aggregate and mineral filler coated with bitumen binder. The mix is prepared in hot-mix plant. The thickness of the bituminous concrete layer depends upon the traffic and quality of base course. The mix is prepared in a hot-mix plant. The thickness of the bituminous concrete layer depends upon the traffic and quality of base course.

3.4 Specifications of materials:-

(a) Binder: Bitumen of grade 30/40, 60/70, or 80/100 may be chosen depending upon the climatic condition of the locality.

Aggregate and filler: The coarse aggregate should fulfil the following requirements:

Aggregate impact value, maximum percent	:	30
Los Angles abrasion value, max percent	:	40
Flakiness Index, max percent	:	25
Stripping at 40°C after 24 hours, max percent	:	25
Soundness:		
Loss with sodium sulphate in 5 cycles, max. Percent	:	12
Loss with magnesium sulphate in 5 cycles, max. Percent	:	18

(c) Bituminous concrete mix:

Marshall Stability Test-number of blows to be applied on either side of specimen:50

Marshall Stability value, Minimum kg	:	340
Marshall Flow value, 0.25 mm units	:	8 to 16
Voids in mix, Percent	:	3 to 5
Voids filled with bitumen, Percent	:	75 to 85

CHAPTER 4

4. Plant and Equipment

For construction work of the bituminous concrete, a hot mix plant is used, In order to achieve to high quality in construction mechanized construction equipment should be used. A mechanical finisher may be used if available. The finisher is designed to produce a uniform level riding surface and to correct automatically small irregularities in the pavement surface. It consists of a receiving hopper, arrangements for spreading the mix to a desired uniform thickness and a tamper. This equipment is considered to be important in the construction of bituminous concrete pavements.

4.1 Construction Steps of Bituminous Pavements:-

Preparation of the existing base course layer: The existing surface is prepared by removing the pot holes or ruts if any. The irregularities are filled in with premix chippings at least a week before laying surface course.

Application of Tack Coat: It is Desirable to lay AC layer over a bituminous base or binder course. A tack coat of bitumen is applied at 6.0 to 7.5 kg per

$10m^2$ area, this quantity may be increased to 7.5 to 10 kg for non-bituminous base.

Preparation and Placing of Premix: The premix prepared in a hot mix plant of a required capacity with the desired quality control. The bitumen may be heated up to 150 - 177°C and the aggregate temperature should not differ by over 14°C from the binder temperature.

Rolling: A mix after it is placed on the base course, is thoroughly compacted by rolling at a speed not more than 5 km per hour. The initial or break down rolling is done by 8 to 12 tonnes roller and the intermediate rolling is done with a fixed wheel pneumatic roller of 15 to 30 tonnes having a tyre pressure

of 7 kg per $cm^{2.}$

Quality Control of Bituminous Concrete Construction: Periodical checks are made at site to ensure the quality of the resulting pavement mixture and the pavement surface for (a) aggregate grading (b) temperature of aggregate (c) grade of bitumen (d) temperatures of paving mix during mixing and compaction. At least one sample for every 100 tonnes of paving mix discharged by the hot mix plant is collected and tested for above requirements. The Variation in Thickness allowed is 6 mm per 4.5 m length of the construction.

Finished Surface: The AC surface should be checked by a 3.0 m straight edge. The longitudinal undulation should not exceed 8.0 mm and the number of undulations higher than 6.0 mm should not exceed 10 in a length of 300 m. The cross profile should not have undulations exceeding 4.0 mm.

4.2 Construction items executed during training:-

Road Alignment – Design of Super Elevation And Camber, Trace Cut and Layout (Box Culvert),

Tests (CBR, Impact, In-Situ Density),

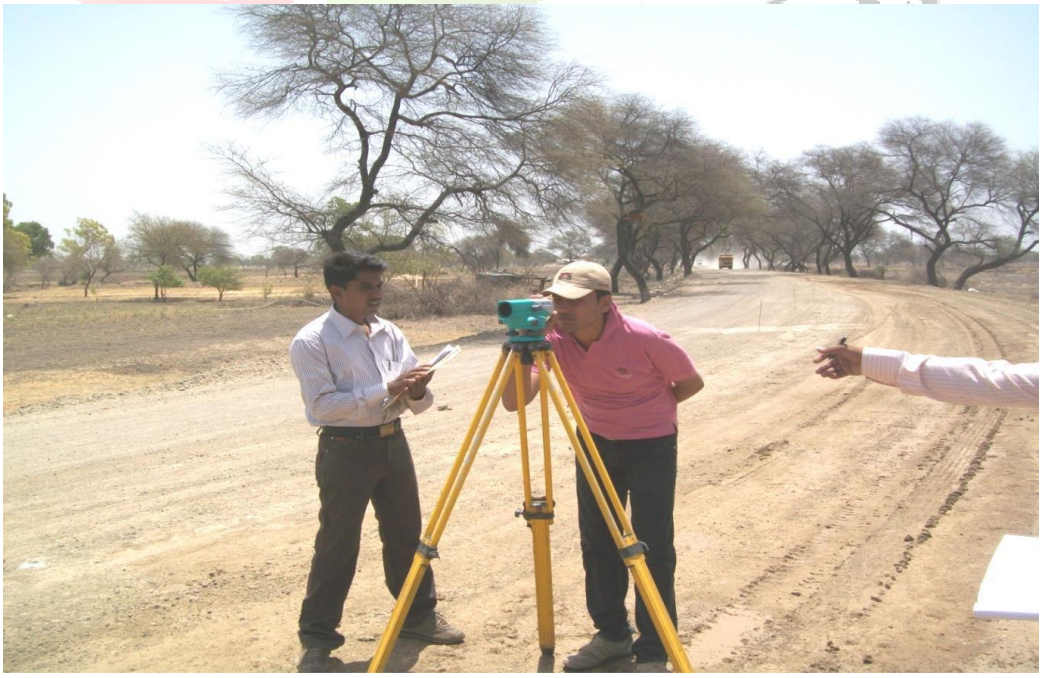
Earthwork (Embankment, Preparation of Subgrade, Soil Compaction).

4.2.1 Super Elevation:-

In order to counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge, thus providing a transverse slope throughout the length of the horizontal curve. This transverse inclination to the pavement surface is known as super elevation or cant or banking. The super elevation 'e' is expressed as the ratio of the height of outer edge with respect to the horizontal width.

4.2.2 Super Elevation Design:-

To super elevate the pavement up to the maximum limit so as to counteract the centrifugal force fully, neglecting the lateral friction is safer for fact moving vehicles. But for slow moving vehicles this may quite inconvenient. As a compromise and from practical consideration it is suggested that the super elevation should be provided to fully counteract the centrifugal force due to 75 percent of the design period, by neglecting lateral friction developed) and limiting the maximum super elevation to 0.07 (except on hill roads, not bound where the maximum allowable value is 0.1).



Figure[1]-Checking Level of Super Elevation

4.2.3 Steps for Super elevation Design:-

Various steps in the design of super elevation in practice may be summarized as given below:

The super elevation for 75 percent of design speed (v m/sec or V kmph) is calculated neglecting the friction

- $e = (0.75v)^2/gR$ or $(0.75V)^2/127R$

If the calculated value of 'e' is less than 7 % or 0.07 the value so obtained is provided. If the value of 'e' as per above equation, exceeds 0.07 than provide the maximum super elevation equal to 0.07 and proceed with steps (iii) or (iv).

Check the coefficient of friction developed for the maximum value of e = 0.07 is at the full value of design speed,

- $F = (v^2/gR - 0.07)$
- If the value of f thus calculated is less than 0.15, the super elevation of 0.07 is safe for design speed. If not, calculate the restricted speed as given in step-4.

As an alternative to step-3, the allowable speed (v_a m/sec or V_a kmph) at the curve is calculated by considering the design coefficient of lateral friction and the maximum super elevation, i.e.,

$e + f = 0.07 + 0$

$= 0.22 = v_a^2/gR$

- Calculate safe allowable speed,

$v_a = (0.22gR)^{0.5}$ m/sec

- Or $v_a = (27.94R)^{0.5}$ kmph

4.3 Camber:-

Camber is the slope provided to the road surface in transverse direction to drain off the rain water from the road surface. Drainage and quick disposal of water from the pavement surface by providing cross slope is considered important because of following surface:

To prevent the entry of surface water into the subgrade soil through pavement, the stability, surface condition and the life of the pavement get adversely affected if the water enters in the subgrade and the soil gets soaked.

To prevent the entry of water into the bituminous pavement layers, as continued contact with water causes stripping of bitumen from the aggregates and results in deterioration of the pavement layer.

To remove the rain water from the pavement surface as quickly as possible and to allow the pavement to get dry soon after the rain; the skid resistance of the pavement gets considered

decreased under wet condition, rendering it slippery and unsafe for vehicle operation at high speeds.

The required camber of pavement depends on:
The type of pavement surface, The amount on rainfall

A flat camber of 1.7 to 2% is sufficient on relatively impervious pavement surface like cement concrete or bituminous concrete. Too steep cross slope is not desirable because of the following reasons:

Transverse tilt of vehicle causes uncomfortable side thrust and a drag on the steering of automobiles. Also the thrust on the wheels along the pavement edges is more causing unequal wear of the tyres as well as road surface.

Discomfort causing throw of vehicle when crossing the crown during overtaking operations.

Problem of toppling over of highly laden bullock carts and trucks. Formation of cross ruts due to rapid flow of water.

Tendency of most of the vehicles to travel along the centre line.

4.4 Culvert:-

Wherever streams have to cross the roadway, facility for cross drainage is to be provided. Also often the water from the side drain is taken across by these cross drain in order to divert the water away from the road, to a water course or valley. The cross drainage concreting in box culvert at sites structure is commonly in use are culverts and small bridges. When a small stream crosses a road with a linear waterway less than about six meter, the cross drainage structure provided is called culvert; for higher values of linear waterways, the structure is called a bridge.

The common types of culverts in use are:

Slab Culvert Box Culvert Arch Culvert Pipe Culvert

Box Culvert of square or rectangular shapes is made of RCC. RCC box

Culvert is ideal for in-situ constructions for openings of size up to 5 m.

Figure[2]-concreting in box covert at sites

They can be constructed in square boxes or multiple boxes or rectangular boxes, depending upon site conditions.

The advantage lies in the elimination of the stout abutment sections which are unavoidable in slab construction. Standard designs can eliminate the process of designing for individual's needs. With box culvert, it may be necessary to provide a downstream and an upstream curtain wall to prevent scour at erodible beds. We supervise to labour at site for proper vibration to reduce air voids and arrangement of proper reinforcement for concreting in Culvert. Drawings (Plan, Section, etc.) of box culvert-1 are shown in figure. There were twenty one culverts in which six are box culvert and fifteen Hume pipe culverts in whole length of the road.

4.5 Earth Work:-

4.5.1 Embankment:-

When it is required to raise the grade line of highways above the existing ground level it becomes necessary to construct embankments. The grade line may be raised due to any of the following reasons:

To prevent damage to pavement due to surface water and capillary water. To keep the subgrade above the high ground water table.

To maintain the design standard of the highway with respect to the vertical alignment

The design elements in highways embankments are:

Height

Fill material Settlement

Stability of foundation, and Stability of slopes

4.5.2 Height:-

It is depends on the desired grade line of the highway and the soil profile or topography. It is also governed by stability of foundation, particularly when the foundation soil is weak.

4.5.3 Fill Material:-

Granular soil is generally preferred as highway embankment material. Organic soils, particularly peat are unsuitable. The best of the soils available locally is often selected with a view to keep the lead and lift as low as possible. At times light-weight fill material like cinder may be used to reduce the weight when foundation soil weak.

4.5.4 Settlement:-

The settlement may settle after the completion of construction either due to consolidation and settlement of the foundation or due to settlement of the fill or due to both. If the embankment foundation consists of compressible soil with high moisture content, the consolidation can occur due to increase in the load. Whatever be the type of settlement, it is desirable that the settlement is almost complete before the construction of pavement.

4.6 Stability of Soil:-

When the embankment foundation consists of weak soil just beneath or at a certain depth below in the form of a weak stratum, it is essential to consider the stability of the foundation against a failure. This is all more essential in the case of high embankments.

4.7 Stability of slopes:-

The embankment slopes should be stable enough to eliminate the possibility of a failure under adverse moisture and other conditions. Hence the stability of the slope should be checked or the

slope should be designed providing minimum factor of safety of 1.5. Often much flatter slopes are preferred in highway embankments due to aesthetic and other reasons.

4.8 Construction of embankments:-

The embankment may be constructed either by rolling in relatively thin layers or by hydraulic fills. The former is called rolled-earth method and is preferred in highway embankments. Each layer is compacted by rolling to a satisfactory degree or to a desired density before the next layer is placed. Compaction is carried out at optimum moisture density before the next layer is placed. Compaction is carried out an optimum moisture content so as to take advantages of maximum dry density using a specified compacting effort and equipment. The thickness of the layers may vary between 10 to 30 cm depending on various factors such as soils types, equipment, specifications etc. The practice of dumping the earth without compacting properly and allowing the fill to get consolidated under weather during few subsequent seasons should be avoided as the settlement will continue for a very long period. If the pavement is constructed before the settlement of the fill is almost complete, the pavement is likely to become uneven and also fail later-on.

4.9 Preparation of Sub grade:-

The preparation of subgrade includes all operations before the pavement structure could be laid over it and compacted. Thus the preparation of subgrade would include site clearance, grading (embankment or cut section) and compaction. The subgrade may be situated on embankment or excavation or at the existing ground surface. In all the cases, site should be cleared off and the top soil consisting of grass, roots rubbish and other organic matter are to be removed. Next, the grading operation is started so as to bring the vertical profile of the subgrade to designed grade and camber. Bull dozers, scrapers and blade graders are useful equipment to speed up this work. It is most essential to compact the top of subgrade, upto a depth of about adequately before placing the pavement layer.

4.10 Soil Compaction:-

By compaction of soil, the particles are mechanically contained to be packed more closely, by expelling part of the air voids. Compaction increases the density and stability, reduces settlement and lowers the adverse effects of moisture. Hence proper compaction of fills, subgrade, sub-base and base course are considered essential for proper highway construction. The various factors influencing soil compaction include the moisture content, amount and type of compaction, soil type and stone content. It is well known fact that there is an optimum moisture content (OMC) for a soil which would give maximum dry

density for a particular type and amount of compaction. Hence it is always desirable to compact the soil at the OMC after deciding the compacting equipment.

Figures[3]- Compacting By Vibrator Roller at Site.

CHAPTER 5

5. Compacting Equipment:-

Roller

smooth Wheeled Roller Pneumatic Tyred Roller Sheep foot Roller

Watering Rammers Vibrators

5.1 Field Control for Compaction:-

For adequate quality control in construction, it is essential to have proper. The two field control in compaction field control tests needed is:

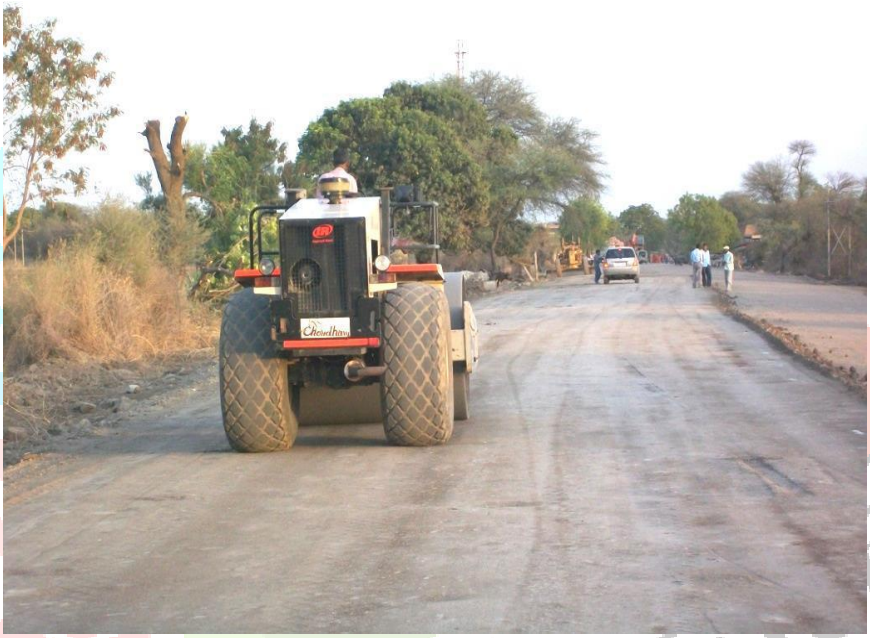
Measurement of moisture content.

Measurement of dry density

The moisture content of the soil may be found before compaction by any one of the rapid methods suitable at the site. If the moisture is controlled at the OMC, then the next control needed

may be suited at the site. If the moisture is controlled at the OMC, then the next control needed is the dry density, the desired value of which may be achieved by increasing the number of passes for the selected equipment and the thickness of each layer. Dry density may be found by any suitable method.

Replacement method is considered quite satisfactory. A certain percentage (say 100 or 95 %) of the standard density is generally aimed at in the field compaction. Thus by fields checks it is possible to control the construction to achieve adequate compaction However, statistical quality control methods should be followed for the compaction in construction of high embankment.



Figures[4]- Compacting By Vibrator Roller at Site.

5.2 Importance of Soil Compaction:-

For highway engineers, a study of the compaction properties of soil is extremely important for the following reasons:

Soils which are compacted to a high density have greater strength and hence a pavement constructed on such sub grades requires lesser thickness.

Compaction of soils reduces the possibility of settlement of embankments during the life of pavement and slope of failure.Compacted sub grades are less susceptible to change in moisture content. This means that swelling and shrinkage of soils, accompanying moisture changes, can be reduced.

5.3 IRC/BIS Codes:-

IRC Design Guidelines

Some of the important points recommended by the IRC for the CBR method of design (IRC: 37-1970) are given below:

The CBR tests should be performed on remolded soils in the laboratory. In-Situ tests are not recommended for design purpose. The specimens should be prepared by static compaction wherever possible and otherwise by dynamic compaction. The standard test procedure should be strictly adhered to.

In new constructions the CBR test samples may be soaked in water for four days period before testing. However in areas with arid climate or when the annual rainfall is less than 50 cm and the water table is too deep to affect the subgrade adversely and when thick and impermeable bituminous surfacing is provided, it is not necessary to soak the soil specimen before carrying out CBR test.

The top 50 cm of subgrade should be compacted at least up to 95 to 100 percent of proctor density.

An expected of the traffic to be carried by the road pavements at the end of expected life should be made keeping in view the existing traffic and probable growth rate of traffic. Pavements of major roads should be designed at least for 10 years life period and the following formula may be used in such cases for estimating the design traffic.

$$A = P\,[1+r]^{(n+10)}$$

- Where A = number of heavy vehicles per day for design (laden weight >3 tones)

P = number of heavy vehicles per day at least count r = Annual rate of increase of heavy vehicles

n = Number of years between the last count and the year of completion of construction.

The value of P in the formula should be the seven day average of heavy vehicles found from 24-hour counts. If a reliable value of growth factor r is not available, a value of 7.5% may be assumed for roads in rural areas.

When sub-base course materials contain substantial proportion of aggregates of size above 20 mm, the CBR value of these materials would not be valid for the design of subsequent layers above them. Thin layers of wearing course such as surface dressing or open graded premixed carpet up to 2.5 cm thickness should not be counted towards the total thickness as they do not increase the structural capacity as the pavement.

5.4 Machinery, Equipment Used:-

Dumpers Grader

Excavators

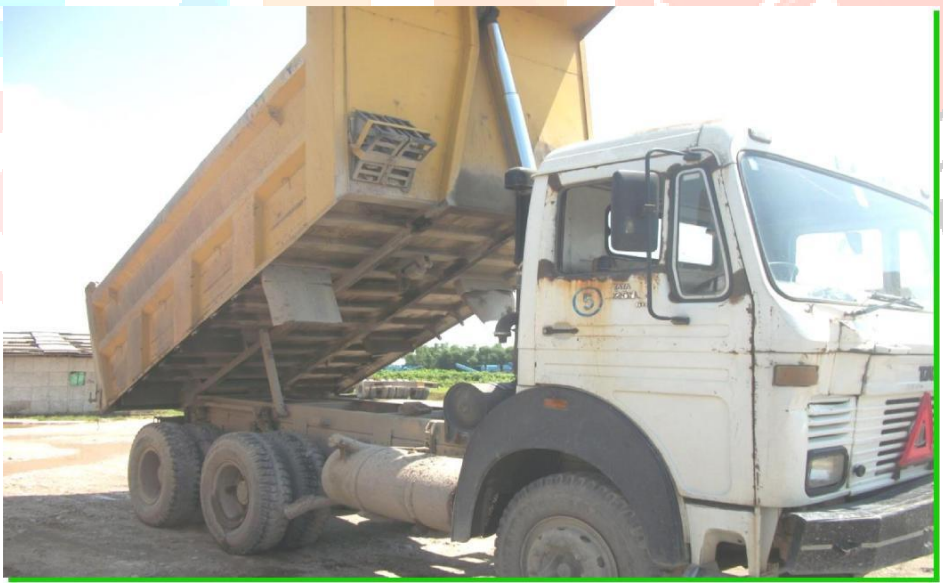
Vibrator Roller Needle Vibrator Plate Vibrator

Transit mixer / Cement Concrete Mixer Concrete Batching Plant

Auto Level for Survey Total Station Survey

5.4.1 Dumpers:-

A dumper is a vehicle designed for carrying bulk material, often on building sites. Dumpers are distinguished from dump trucks by configuration: a dumper is usually an open 4-wheeled vehicle with the load skip in front of the driver, while a dump truck has its cab in front of the load. The skip can tip to dump the load; this is where the name "dumper" comes from. They are normally diesel powered. A towing eye is fitted for secondary use as a site tractor. Dumpers with rubber tracks are used in special circumstances and are popular in some countries.



Figure[5] - Dumper

Early dumpers had a payload of about a ton and were 2-wheel drive, driving on the front axle and steered at the back wheels. The single cylinder diesel engine (sometimes made by Lister) was started by hand cranking. The steering wheel turned the back wheels, not front. Having neither electrics nor hydraulics there was not much to go wrong.

The skip was secured by a catch by the driver's feet. When the catch is released, the skip tips under the weight of its contents at pivot points below, and after being emptied is raised by hand. Modern dumpers have payloads of up to 10 tones and usually steer by articulating at the

middle of the chassis (pivot steering). They have multi-cylinder diesel engines, some turbocharged, electric start and hydraulics for tipping and steering and are more expensive to make and operate. An A-frame known as a ROPS (Roll-Over Protection) frame may be fitted over the seat to protect the driver if the dumper rolls over. Some dumpers have FOPS (Falling Object Protection) as well. Lifting skips are available for discharging above ground level. In the 1990s dumpers with swivel skips, which could be rotated to tip sideways, became popular, especially for working in narrow sites such as road works. Dumpers are the most common cause of accidents involving construction plant.

5.4.2 Grader:-

A grader, also commonly referred to as a road grader, a blade, a maintainer, or a motor grader, is a construction machine with a long blade used to create a flat surface. Typical models have three axles, with the engine and cab situated above the rear axles at one end of the vehicle and a third axle at the front end of the vehicle, with the blade in between. In certain countries, for example in Finland, almost every grader is equipped with a second blade that is placed in front of the front axle. Some construction personnel refer to the entire machine as "the blade."

In civil engineering, the grader's purpose is to "finish grade" (refine, set precisely) the "rough grading" performed by heavy equipment or engineering vehicles such as scrapers and bulldozers. Graders can produce inclined surfaces, to give cant (camber) to roads. In some countries they are used to produce drainage ditches with shallow V-shaped cross-sections on either side of highways. Graders are commonly used in the construction and maintenance of dirt roads and gravel roads. In the construction of paved roads they are used to prepare the base course to create a wide flat surface for the asphalt to be placed on. Graders are also used to set native soil foundation pads to finish grade prior to the construction of large buildings. In some locales such as Northern Europe, Canada, and places in the United States,

Graders are often used in municipal and residential snow removal. In scrubland and grassland areas of Australia and Africa, graders are often an essential piece of equipment on ranches, large farms, and plantations to make dirt tracks where the absence of rocks and trees means bulldozers are not required. Graders are also used for underground mining.

Capacities range from a blade width of 2.50 to 7.30 m and engines from 93– 373 kW (125–500 hp).

Figure[6]- Grader

5.4.3 Excavators:-

Excavators are heavy equipment consisting of a boom, bucket and cab on a rotating platform (known as the "house"). The house sits atop an undercarriage with tracks or wheels. All movement and functions of the excavator are accomplished through the use of hydraulic fluid, be it with rams or motors. Their design is a natural progression from the steam shovel.

Excavators are used in many ways:

Digging of trenches, holes, foundations Material handling

Brush cutting with hydraulic attachments Forestry work

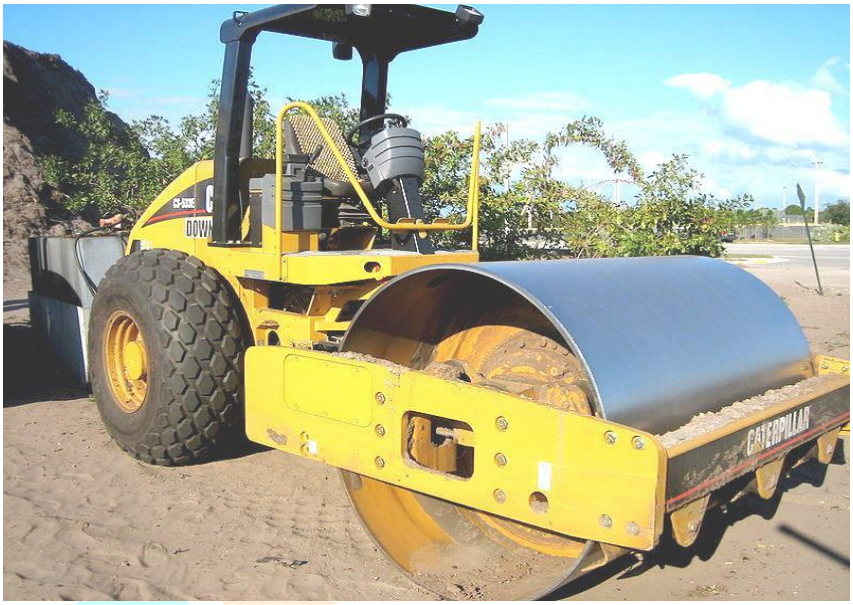
Demolition

General grading/landscaping

Heavy lift, e.g. lifting and placing of pipes

Mining, especially, but not only open-pit mining Driving piles, in conjunction with a Pile Driver.

➢ Figure[7]road roller



5.4.3.1 Configurations:-

Excavators come in a wide variety of sizes. The smaller ones are called mini or compact excavators. Caterpillar's smallest mini-excavator weighs 3549 lb (1610 kg) and has 19 hp; their largest Model weighs 187,360 lb (84,980 kg) and has 513 hp. The largest excavator available is the BucyrusRH400; it weighs in excess of 2,160,510 lb (980,000 kg), has 4500 hp and has a bucket size of about (52.0 m^3).Engines in excavators drive hydraulic pumps; there are usually 3 pumps: the two main pumps are for supplying oil at high pressure (up to 5000 psi) for the rams, slew motor, track motors, and accessories, and the third is a lower pressure (700 psi) pump for Pilot Control, this circuit used for the control of the spool valves, this allows for a reduced effort required when operating the controls. The two main sections of an excavator are the undercarriage and the house. The undercarriage includes the blade (if fitted), tracks, track frame, and final drives, which have a hydraulic motor and gearing providing the drive to the individual tracks, and the house includes the operator cab, counterweight, engine, fuel and hydraulic oil tanks. The house attaches to the undercarriage by way of a centre pin, allowing the machine to slew 360° unhindered. The main boom attaches to the house, and can be one of 3 different configurations:

Most are mono booms: these have no movement apart from straight up and down.

Some others have a knuckle boom which can also move left and right in line with the machine.

The other option is a hinge at the base of the boom allowing it to hydraulically pivot up to 180° independent to the house; however this is generally available only to compact excavators.

Attached to the end of the boom is the stick (or dipper arm). The stick provides the digging force needed to pull the bucket through the ground. The stick length is optional depending whether reach (longer stick) or break-out power (shorter stick) is required.

On the end of the stick is usually a bucket. A wide, large capacity (Mud) bucket with a straight cutting edge is used for clean-up and levelling or where the material to be dug is soft, and teeth are not required. A general purpose (GP) bucket is generally smaller, stronger, and has hardened side cutters and teeth used to break through hard ground and rocks. A general purpose bucket with no teeth is known as an "Eels" bucket. Buckets have numerous shapes and sizes for various applications. There are also many other attachments which are available to be attached to the excavator for boring, ripping, crushing, cutting, lifting, etc.

5.4.4 Vibrator Roller:-

A road roller (sometimes called a roller-compactor, or just roller) is a compactor type engineering vehicle used to compact soil, gravel, concrete, or asphalt in the construction of roads and foundations. In some parts of the world, road rollers are still known colloquially as steam rollers, regardless of their method of propulsion. This typically only applies to the largest examples (used for road-making).

Uses:-

Road rollers use the weight of the vehicle to compress the surface being rolled. Initial compaction of the substrate is done using a pneumatic-tired roller, with two rows (front and back) of pneumatic tyres. The flexibility of the tires, with a certain amount of vertical movement of the wheels, enables the roller to operate effectively on uneven ground. The finish is done using metal-drum rollers to ensure a smooth, even result.

5.4.5 Needle Vibrator:-

In all the vibrators, the internal vibrator is most commonly used. This is also called, “Needle Vibrator”, “Immersion Vibrator”, or “Poker Vibrator”. This essentially consists of a power unit, a flexible shaft and a needle. The power unit may be electrically driven or operated by petrol engine or air compressor. The vibrations are caused by eccentric weights attached to the shaft or the motor or to the rotor of a vibrating Element. Electromagnet, pulsating equipment is also available. The frequency of vibration varies up to 12,000 cycles of vibration per minute. The needle diameter varies from 20mm to 75 mm and its length varies from 25 cm to 90 cm. The bigger needle is used in the construction of mass

concrete dam. Sometimes, arrangements are available such that the needle can be replaced by a blade of approximately the same length. This blade facilitates vibration of members, where, due to the congested reinforcement, the needle would not go in, but this blade can effectively vibrate. They are probable and can be shifted from place to place very easily during concreting operation. They can also used in difficult positions and situations

5.4.5.1. Depth of Immersion of Vibrator:-

To be fully effective, the active part of the vibrator shall be completely immersed in the concrete. Its compacting action can be usually assisted by maintaining a head of concrete above the active part of the vibrator, the primary object of which is to press down upon and confine the concrete in the zone of influence of the vibrator. The vibrator head shall be dipped through the filling which is to be consolidated to a further depth of 10 to 20 cm in the lower layer which has already been consolidated so that there is a good combination of various layers and the grout in the lower layer is distributed in the new filling.

5.4.5.2. Precautions while using vibrator:-

Care shall be taken that the vibrating head does not come into contact with hard objects like hardened concrete, steel, wood, as otherwise the impact may damage the bearing.

The prime mover should as far as possible, be started only when head is raised or resting on soft support.

When the space for introduction is narrow, the vibrator should be switched on only after the vibrator head has been introduced into the concrete.

The vibrator may be used vertically, horizontally or at an angle depending upon the nature of the job but always needle vibrator used vertically.

5.4.6 Table Vibrator:-

This is the special case of formwork vibrator, where the vibrator is clamped to the table. Or table is mounted on springs which are vibrated transferring the variation to the table. They are commonly used for vibrating concrete cubes. Any article kept on the table gets vibrated. This is adopted mostly in the laboratories and in making small but precise prefabricated R.C.C. members.

5.4.7 Transit Mixer:-

Transit mixer is one of the most popular equipment for transporting concrete over a long distance particularly in ready mixed plant (RMP). There are two variations. In one, mixed concrete is transported to the site by keeping it agitated all along at a speed varying between 2 to 6 revolutions per minutes. In the other category, the concrete is batched at the central batching plant and mixing is done in the

truck mixer either in transit or immediately prior to discharging the concrete at site. The truck mixer the speed of rotating of drum is between 4-16 revolutions per minute.

Figure[8] - Placing of Concrete through Chute by Transit Mixer

With the development of twin fin process mixer, the transit mixers have become more efficient in mixing. In these mixers, in addition to the outer spirals, have two opposed inner spirals. The outer spirals convey the mix materials towards the bottom of the drum, while the opposed mixing spirals push the mix towards the feed opening. As per estimate the cost of transportation of concrete by transit mixer varies between Rs. 160 to 180 cubic meters.

Compressive strength test for Cement.

In-situ density from cores.

California bearing test for sub grade soil Impact test

Specific gravity and water test

CHPATER 6

6. Quantity Control:-

Bituminous road construction demands a very high degree of quality control.

The tests to be conducted at regular intervals are necessary and this are:

Concrete strength (7 days and 28 days cube) at the rate of 2 specimens for every 150 cum.

Compressive strength test for Cement. In-situ density from cores.

California bearing test for subgrade soil Impact test

Specific gravity and water tests

6.1 Tests:-

6.1.1 Concrete Compression Strength test:-

It is the most common test conducted on the hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. First take cube mould of the size 15 x 15 x 15 cm.

Largest nominal size of the aggregate does not exceed 20 mm, 10 cm size cubes may also be used as an alternative.

Now make mixture of concrete and fill it in the mould and compact it well so it's not causes neither segregation nor excessive laitance.

Now clean the top with towel for finished well and covered with a glass or metal plate to prevent evaporation.

Now place it in moist air of at least 90% relative humidity and at a temperature of 27° ± 2° C for 24 hours ± ½ hour

This test is carried out to determine the compressive strength of cement. Following procedure is adopted:

The mortar of cement and sand is prepared. The proportion is 1:3 which means that x gm of cement is mixed with 3x gm of sand.

The water is added to the mortar. The water cement ratio is kept as 0.4 which means that 0.4x gm of water is added to dry mortar.

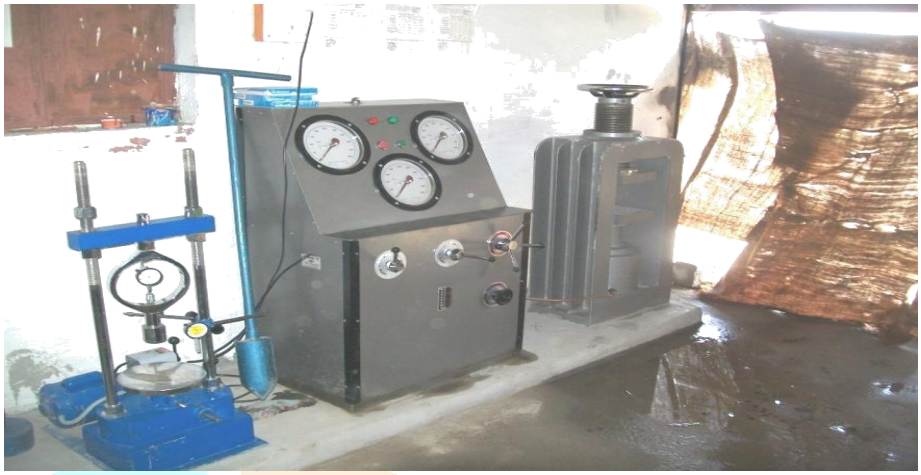
The mortar is placed in moulds. The test specimens are in the form of cubes with side as 70.6 mm or 76mm. the moulds are of metal and they are constructed in such a way that the specimens can be easily taken out without being damaged. For 70.6 mm and 76 mm cubes, the cement required is 185 gm and 235 gm respectively

The moulds are placed in a damp cabin for 24 hours.

The specimens are removed from the moulds and they are submerged in clean water for curing.

The cubes are tested in compression testing machine at the end of 3 days and 7 days. The testing of cubes is carried out on their three sides without packing. Thus three cubes are tested each time to find out the compressive strength at the end of 3 days and 7 days. The average value is then worked out. During the test,

the load is to be applied uniformly at the rate of 350 kg/cm^2 or 35 N/mm^2.
The compressive strength at the end of 3 days should not be less than 115 kg/cm^2 or 11.50 N/mm^2 and that at the end of 7days not be less than 175 kg/cm^2 or 17.50 N/mm^2.



Figure[9]– Compressive Strength Testing machine in Q/C La

6.1.2 In-Situ Density test:-

Object of In-situ density test is to determine the mass density of soils by two methods-

Core cutter method

Sand replacement method.

We use sand replacement method at site to determine density of subgrade of compacted soil at site

6.1.2.1 Sand Replacement method:–

Apparatus:-

Sand pouring cylinder, trowel or bent spoon, cylindrical calibrating container, metal tray with hole (30 cm square with 10 cm hole in the centre), sand (clean oven dried, passing 60 micron sieve), balance (accuracy of 1 gm and 0.01 gm), moisture content crucibles, oven desiccators, tongs, glass plate (about 45 cm square), metal tray (about 30 cm square), scraper tool, measuring jar (1000 cc).

Procedure:-

Calibration of Apparatus:-

Measure the internal volume of the calibrating container from the volume of the water required to fill the container.

Fill the pouring cylinder with sand within about 1.0 cm of the top and weight it.

Place the pouring cylinder concentrically on the top of calibrating container. Open the shutter to allow the sand to run out and fill the calibrating cylinder When there is no further movement of sand in pouring cylinder, close the

shutter.

Remove the pouring cylinder and weight it to the nearest gram

Place the pouring the cylinder on plane surface such as glass plate

Open the shutter and allow the sand to run out. When there is no movement of and in the cylinder close the shutter.

Weigh the pouring cylinder with remaining sand

6.1.3 Measurement of soil density:-

Clean and level the ground where the field density is required

Fill the pouring cylinder within about 1.0 cm of the top and weight it.

Place the metal tray with the central hole over the portion of soil to be tested. Excavate the soil approximately 10 cm dia and 15 cm deep with bent spoon.

The hole in the tray will guide the diameter of hole to be made in the soil collect the excavated soil in the metal tray weight to the nearest gram.

Determine the moisture content of the excavated soil.

Place the pouring cylinder over the hole so that base of the cylinder covers the hole concentrically.

Open the shutter and allow the sand to run out into the hole. When there is no movement of sand, the shutter is closed.

Remove the cylinder and weigh it.

Application:-

Density is used in calculating the stress in the soil due to its overburden pressure.

It's needed in estimating bearing capacity of soil foundation system, settlement of footings, earth pressures behind the retaining walls, dams, and embankments.

It is the density which controls the field compaction of soils. Permeability of soils depends upon its density.

Void ratio, porosity, and degree of saturation need the help of density of soils.

6.1.4 Impact Test for Aggregates:-

This test is designed to evaluate the resistance of an aggregate to sudden impact. Since vehicle loads cause impact, this test gives an indication of the performance of aggregates to resist crushing under impact. The test has been standard (IS: 2386 Part IV). The IRC specifications also indicate the minimum acceptable values as per this test.

The test consists of subjecting a specimen of aggregate (passing 12.5mm sieve and retained on 10 mm sieve) filled into a cylindrical mould 10.2 cm interval dia and 5 cm height.

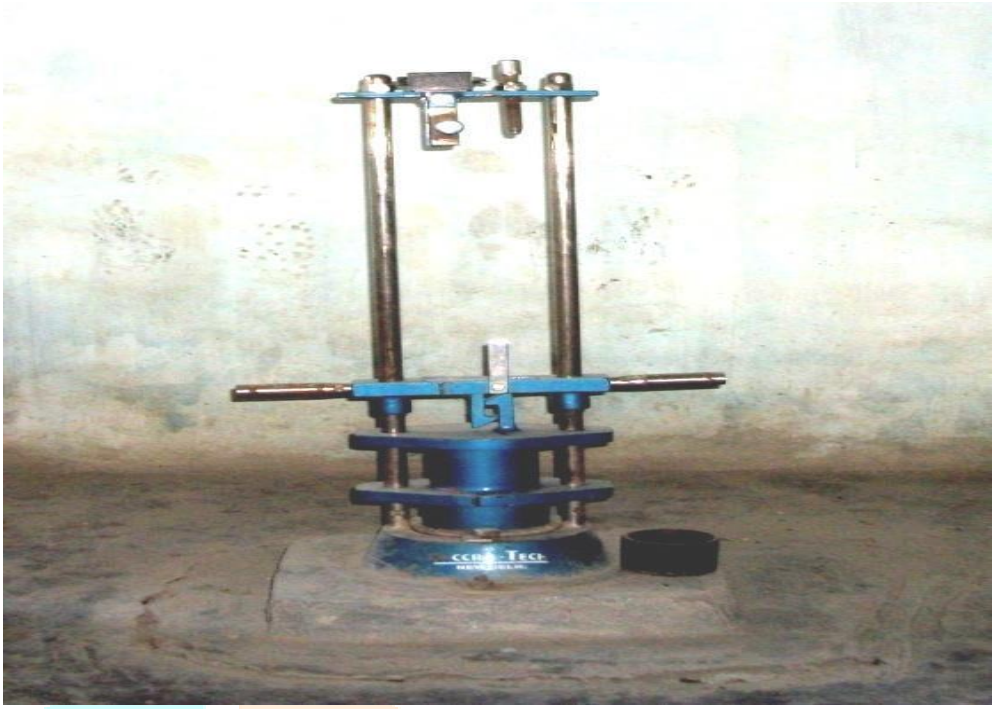
The impact is provided by dropping a hammer of weight 13.5- 14.0 kg through a height of 380mm.

Aggregate passing fully through 12.5 mm sieve and retained on 10 mm sieve are filled in the cylindrical measure in three layers, each layer being transferred to the cup of aggregate and tamped 25 times with the rod.

After subjecting the specimen to 15 blows through the hammer, the crushed aggregate is sieved on 2.36 mm sieve.

The weight of materials passing through this sieve expressed as a percentage of the total weight of the sample gives the aggregate impact value. The test is conducted in dry state as well as in wet state.

For low-grade aggregate, maximum of 50 percent wet aggregate impact value is allowed when used in sub-base. When used as base course, the limit is 40 percent. For surfacing courses, the limit is 30 percent.



Figure[10]-Impact Test machine for Aggregates

6.1.5 Specific gravity and water absorption tests:-

The specific gravity of an aggregate is considered to a measure of the quality or strength of the material. Stones having low specific gravity values are generally weaker than those having higher values. The specific gravity test also helps identifying the stone specimen. Stones having higher water absorption value based on crushing and hardness tests. About 2 kg of dry aggregate sample is placed in wire basket and immersed in water for 24 hours. The sample is weighed in water and the buoyant weight is found. The aggregate are then taken out weighed after drying the surface. Then the aggregate are dried in an oven for 24 hours at a temperature 100- 110°C, and then the dry weight is determined. The specific gravity is calculated by dividing the dry weight of aggregate by weight of equal volume of water. The water absorption is expressed as the percent water absorbed in terms of over dried weight of the aggregates. The specific gravity of rocks vary from 2.6 to 2.9. Rock specimens having more than 0.6 percent water absorption are considered unsatisfactory unless found acceptable based on strength tests. However slightly higher value of porosity may be acceptable for aggregate used in bituminous pavement construction, if the aggregate are found otherwise suitable.

CHAPTER 7

7. Suggestions for Improvement and Safety Measures at Site:-

All workmen should use safety helmets at work site, provided by the contractor. All workmen should wear reflective jackets, while working in traffic moving

zone.

Adequate precautions should be taken to prevent accidents from electric current while digging operation in underway.

Workers employed on bituminous works, stone crushers, concrete batching plant etc. should wear protective goggles, gloves, gumboots, ear plunges etc.

Those engaged in welding work should wear protective shine.

All scaffolds, ladders and other safety device should be maintained in a safe and sound condition.

All construction vehicles should have reverse horns.

Conclusions

Practical training is very advantageous for me. Theoretical as well as practical knowledge is essential to enter in any industry. Generally we read theories but keep practical knowledge is show implementation on this theoretical knowledge. So we were going for practical training to learn many. Things and our site engineer give best knowledge as he could give according their knowledge. He taught us many things such as how to control labour, right way of communication with labour so they give best result as they can give, how to take level of road alignment, necessity of BIS/IRC Codes in road construction. Demand of transportation, design of super elevation, etc.

REFRENCES

IRC: 58 - 2002, guidelines for the design of plain jointed rigid pavements for highways.

IRC: 15 - 2002, code of practice for construction of cement concrete roads.

IRC: 44 – 2008, guidelines for cement concrete mix design for pavements.