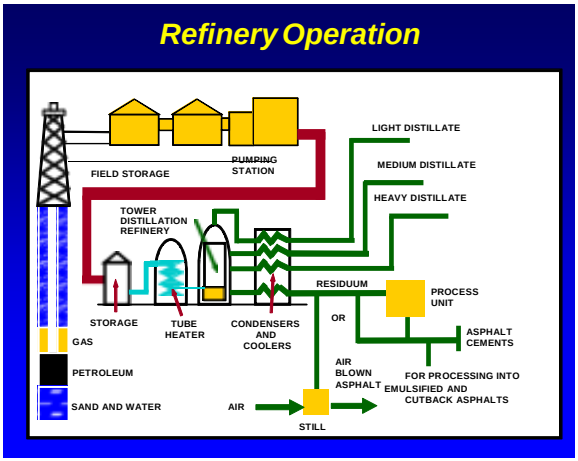
BITUMEN HANDBOOK

BITT POLYTECHNIC

DEPARTMENT OF CIVIL ENGINEERING

CONTENTS

1. INTRODUCTION



Bitumen is manufactured from crude oil. Bitumen is obtained as the last residue in fractional distillation of crude petroleum. Crude petroleum is a mixture of hydrocarbons of different molecular weights. In the petroleum refineries the individual components like LPG, naphtha, Kerosene, Diesel etc. are separated through the process of fractional distillation. The heaviest material obtained from the fractional distillation process is further treated and blended to make different grades of paving grade bitumen.

The actual bitumen output can be controlled not only by selecting the appropriate crude but also by adopting varying processes in the refinery. The choice of process would depend on the availability of suitable crude, demand of the end products and total commercial viability of the complete refining process.

Definition: Bitumen is defined as “A viscous liquid, or a solid, consisting essentially of hydrocarbons and their derivatives, which is soluble in tri-chloro-ethyelene and is substantially nonvolatile and softens gradually when heated. It is black or brown in colour & posseses waterproofing and adhesive properties. It is obtained by refinery processes from petroleum, and is also found as a natural deposit or as a component of naturally occurring asphalt, in which it is associated with mineral matte.

2. TYPES OF BUTUMEN

Bitumen or bituminous binder available in India is mainly of the following types:

2.1 Penetration Grade

2.1.1 Bitumen 80/100: The characteristics of this grade confirm to that of S 90 grade of IS-73-1992. This is the softest of all grades available in India. This is suitable for low volume roads and is still widely used in the country.

2.1.2 Bitumen 60/70: This grade is harder than 80/100 and can withstand higher traffic loads. The characteristics of this grade confirm to that of S 65 grade of IS-73-1992. It is presently used mainly in construction of National Highways & State Highways.

2.1.3 Bitumen 30/40: This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS-73-1992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country.

2.2 Industrial grade bitumen.

Industrial grade bitumen is also known as **blown** bitumen. This is obtained by blowing air into hot bitumen at high temperatures (normally beyond 180 ^{0}C). Blowing hot air into bitumen at high temperatures results in structural changes in bitumen. Esters are formed in this process and these esters link up two different molecules and higher molecular weight material increases drastically. **In the process the asphaltene content is increased which in turn results in higher softening points and very low penetration number.** Industrial grade bitumen is used in industrial applications and in water proofing, tarfelting etc.

2.3 Cutback

Cutback is a free flowing liquid at normal temperatures and is obtained by **fluxing bitumen with suitable solvents.** The **viscosity of bitumen is reduced** substantially by adding kerosene or any other solvent. **Cutback has been used in tack coat applications**.

2. TYPES OF BUTUMEN

2.4 Bitumen Emulsion

Bitumen emulsion is a free flowing liquid at ambient temperatures. Bitumen emulsion is a stable dispersion of fine globules of bitumen in continuous water phase. Dispersion is obtained by processing bitumen and water under controlled conditions through a colloidal mill together with selected additives. The use of proper quality emulsifiers is essential to ensure that the emulsion has stability over time and also that it breaks and sets when applied on aggregates/road surface. It is chocolate brown free flowing liquid at room temperature. Bitumen Emulsions can be of two types cationic & anionic. Anionic bitumen emulsions are generally not used in road construction as generally siliceous aggregate is used in road construction. Anionic bitumen emulsions do not give good performance with siliceous whereas cationic bitumen emulsions give good performance with these aggregates. **Therefore, cationic bitumen emulsions are far more popular than anionic bitumen emulsions.**

2.5 Modified Bitumen

Modified Bitumen are bitumen with additives. These additives help in further enhancing the properties of bituminous pavements. Pavements constructed with Modified Bitumen last longer which automatically translates into reduced overlays. Pavements constructed with Modified Bitumens can be economical if the overall lifecycle cost of the pavement is taken into consideration.

2.6. Viscosity grade Bitumen:

The new method of grading the product has now rested on the viscosity of the Bitumen (at 60^0C and 135 ^{0}C). The new grades have thus evolved with nomenclature:

Grades	Minimum of Absolute viscosity, Poise@ 60^0C	Approximate penetration grade
VG 10	**800**	**80-100**
VG 20	**1600**	**------**
VG 30	**2400**	**60-70**
VG 40	**3200**	**30-40/40-50**

3. INTRODUCTION TO VISCOSITY GRADE

Paving grade bitumen is the bitumen obtained from refineries and conforms to IS 73. Recently, the third revision of Indian Standards for Paving Bitumen Specifications

IS 73:2006 has been released by Bureau of Indian Standards. Three grades of Bitumen confirming to IS 73: 1992 are manufactured in India. In this third revision grading of Bitumen is changed from penetration grade to viscosity grade. To improve the quality of Bitumen, BIS revised IS-73-1992 Specifications based on viscosity grade (viscosity @ 60 deg. C) in July 2006. As per the Specifications, there are four grades VG-10, VG-20, VG-30 & VG-40.

With the current revision several key issues are addressed, like:

- **Performance** at high temperatures by adopting a viscosity-graded bitumen specification (based on viscocity at 60 ºC), in place of the current penetration-graded specification (based on penetration at 25 ºC)
- **Issues** relating to compaction, which the tender asphalt mixtures create as push and shove under the roller wheels, have also addressed by having a requirement of minimum viscosity at 135ºC, it will be helpful in minimizing the tender mix problems in the field.
- **Adoption** of viscosity-graded paving bitumen specifications will also reduce the number of total tests to 7

Without compromising the quality of bitumen and also no new tests are required in implementing this specification.

Viscosity grades Bitumen are categorized according to Viscosity (degree of fluidity) grading. The higher the grade, the stiffer the Bitumen. In Viscosity Grade, Viscosity tests are conducted at 60 deg. C and 135 deg. C, which represents the temperature of road surface during summer and mixing temperature respectively. The penetration at 25 deg. C, which is annual average pavement temperature, has been also retained in Specifications.

4. PROPERTIES OF BITUMEN

4.1. Bitumen –A Visco-Elastic Material

The properties of Bitumen can be defined in terms analogous to the Modulus of Elasticity of solid materials.

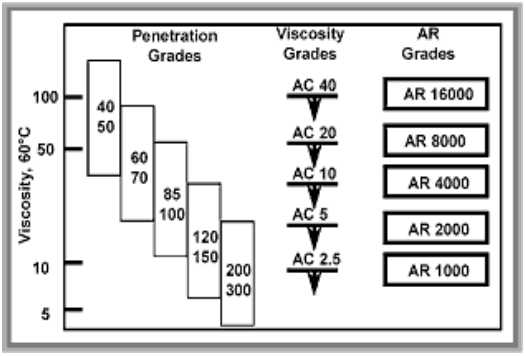
In case of solids, Modulus of Elasticity E is defined by Hooke's law Bitumen is a Visco-elastic material. At high temperatures it behaves like a liquid & hence liquid flow properties like Viscosity are exhibited. However, at low temperatures bitumen behaves like a solid and hence solid properties like stress & strain become relevant. Similarly, for shorter loading time bitumen behaves like a solid whereas for longer loading times bitumen behaves like a liquid.

The properties that bitumen exhibits in the intermediate temperature range and loading time are of great relevance as this range is very long and bitumen is handled in this temperature range most of the times.

Due to the visco-elastic nature of bitumen, there is always a phase lag in stress & strain in case of repetitive loadings. For purely elastic material the phase lag is 0^0 and for purely viscous material the phase lag is 90^0. In case of bitumen since it is neither a liquid nor a solid at most temperatures hence the phase lag is always between 0^0 to 90^0.

The above theory is extremely useful in studying fatigue characteristics, properties of creep & also tensile strength of bitumen.

4.2 Adhesion Properties of Bitumen



Bitumen has excellent adhesive qualities provided the conditions are favourable. However in presence of water the adhesion does create some problems. Most of the aggregates used in road construction possess a weak negative charge on the surface. The bitumen aggregate bond is because of a weak dispersion force. Water is highly polar and hence it gets strongly attached to the aggregate displacing the bituminous coating.

The factors influencing aggregate bitumen adhesion are plenty and some of the factors influencing this property are as below:

4.2.1 External: Rainfall, Humidity, Water pH, Presence of salts, Temperature, Temperature cycle, Traffic, Design, Workmanship, Drainage

4.2.2 Aggregate: Mineralogy, Surface texture, Porosity, Dirt, Durability, Surface area, Absorption, Moisture content, Shape, Weathering

4.2.3 Bitumen: Rheology, Constitution

4.2.4 Mix: Void content, Permeability, Bitumen content, Bitumen film thickness, Filler type, Aggregate grading, Mix type.

The above list is only indicative and not exhaustive.

5. ADVANTAGES OF VISCOSITY GRADE

1. **Based on the fundamental Engineering Properties:** VG system is based on fundamental engineering parameter i.e. actual performance on road and not on the empirical properties.

2. **Takes care of low as well high temperature:** Viscosity is measured at 60º C and 135ºC which takes care of both low and high temperature susceptibility of the Bitumen, which is not possible with Penetration value at 25ºC. Hence, road contractors can have better understanding of Bitumen performance in the field.

3. Any two same Viscosity Grade Bitumen would give similar rutting performance in hot summer unlike Penetration Grade.

4. **Greater Mix in ease design:** Greater ease of handling to customers as Viscosity value at two different temperature is available, which would enable users to measure accurate mixing and compaction temperature. Minimum specified Kinematic Viscosity Value at 135ºC helps to minimize the potential of tender mixes during construction.

5. **Less no. of tests save time and cost:** IS-73-2006 has only 7 tests to evaluate a sample compared to 14 tests in Penetration Grade system. This reduces time and cost of testing without sacrificing the quality.

6. **Longer Durability:** The pavement made from VG Bitumen will have better performance, because Viscosity value at 135ºC gives sufficient idea about mixing and compaction temperature and as a result pavement life is improved.

7. **Takes higher Traffic:** Penetration test was developed in the era of significantly lower pavement loading. In the past, truck weights were less than 30 tons with tyre pressure of 75 PSI. Today truck weight has increased to 35 tons a with tyre pressure of 125 PSI and increased traffic with extreme weather conditions. Therefore, to cope up with these changes shift from PEN Grade to VG Grade is required.

5. ADVANTAGES OF VISCOSITY GRADE

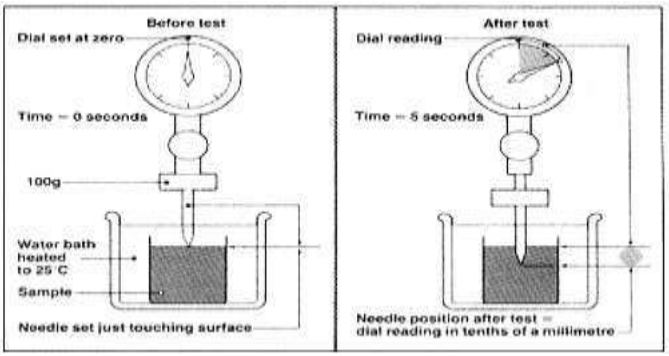
INDIAN BITUMEN SPECIFICATIONS AS PER IS 73:2006							
S.No.	**Characteristic**	**Unit**	**VG 10**	**VG 20**	**VG 30**	**VG 40**	**Test Method**
I)	Absolute viscosity at 60^{O}C, min	Poises	800	1600	2400	3200	IS 1206(Part 2) : 1978
II)	Kinematic viscosity at 135^{O}C, min	cst	250	300	350	400	IS 1206(Part 3) : 1978
III)	Flash Point, Cleveland open cup, min.	^{O}C	220	220	220	220	IS 1209 : 1978
IV)	Matter soluble in trichloroethylene, min.	% wt	99	99	99	99	IS 1216 : 1978
V)	Penetration at 25 ^{O}C, 100 gm, 5 sec.	1/10 mm	80 to 100	60 to 80	50 to 70	40 to 60	IS 1203 : 1978
VI)	Softening Point, min	^{O}C	40	45	47	50	IS 1205 : 1978
VII)	Tests on residue from thin film oven test / RTFOT						
	a) Viscosity ratio at 60 ^{O}C, max		4	4	4	4	IS 1206(Part 2) : 1978
	b) Ductility at 25^{O}C after thin film oven test, min	cm	75	50	40	25	IS 1208 : 1978

6. TESTS FOR VG GRADE BITUMEN

There are many bitumen properties which can be tested. All these tests replicate the actual field conditions in different ways. Different types of standard tests conducted on it are briefly described below:

6.1 Viscosity Based System

The actual tests conducted are as follows:

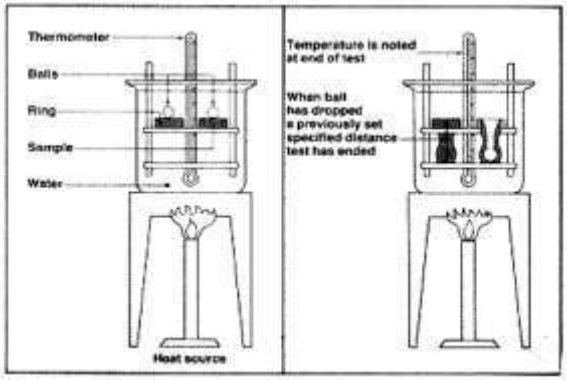


6.1.1 Viscosity Test

Viscosity at 135^{O}C is a fair indicator of the ability of bitumen to coat the aggregates properly. In order to get best coating the viscosity has to be optimum. Too viscous bitumen would result in inadequate and non-uniform coating of the aggregates. Very low viscosity would again result in inadequate coating as the bitumen will tend to bleed. Therefore viscosity at 135^{O}C is a true reflection of the quality of bond that is likely to be formed with the aggregate. Various testing equipments like Capillary Viscometer, Cup Viscometer, Tar Viscometer, etc. can be used for testing the viscosity.

Viscosity at 60^{O}C is a very good indicator of the resistance of bitumen to melting/flowing on the road. It is considered to be replacement test for Softening Point test. Some specifications have replaced softening point test with Viscosity at 60^{O}C. However, at many places both the tests are carried out as both the tests are empirical and have their own limitations.

6.1.2 Softening Point

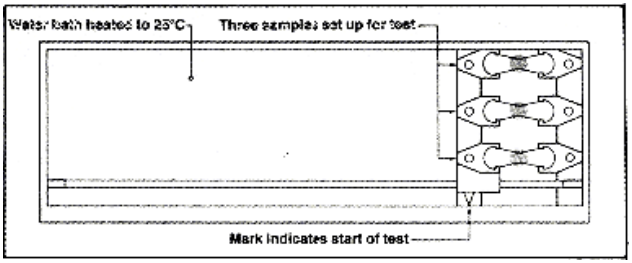


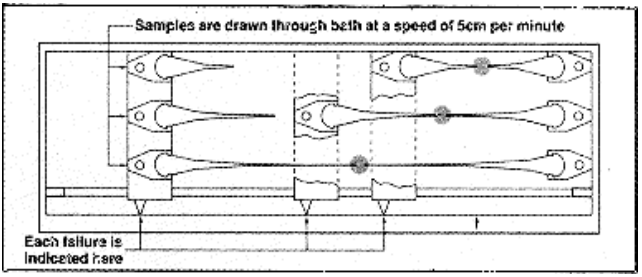
As mentioned earlier bitumen does not have a distinct melting point. It gradually softens when heated. As there is no distinct melting point therefore the softening point test has been developed to arbitrarily indicate the transition temperature. The softening point is also an empirical test and denotes the temperature at which bitumen would behave more like a liquid and less like a solid under standard conditions of heating and loading.

In this test a standard Ring and Ball Apparatus is used. The sample is taken in a standard mould and standard weights (in the form of steel balls) are placed on it. The system is then heated in a water bath at a standard rate. The temperature at which the bitumen coated steel ball touches the bottom of the beaker is called the Softening Point temperature.

Softening Point test is a very important test as it is a fair indicator of melting properties of bitumen. Bitumens with lower softening point tend to melt on the road in summer and start flowing under the impact of temperature and traffic. Subsequently when the bitumen cools down at night the road surface loses its original shape and becomes wavy. This mode of failure of roads due to bitumen is referred to as failure by rutting. Therefore it can be concluded that bitumens with higher softening point melt at higher temperatures and have better rutting resistance.

6.1.3 Ductility Test





The Ductility test is again an empirical test which measures the cohesive strength of bitumen. In this test a standard size bitumen sample is maintained at a constant temperature. The sample is pulled at a constant rate at constant temperature. The length at which the sample breaks is called the ductility of the sample. One unique feature of ductility test is that the test temperature at times varies from country to country and also from grade to grade.

Ductility test is an indicator of the cohesive strength of bitumen which in turn is a very loose indicator of the fatigue strength of the material. Material with higher ductility is more likely to withstand repeated cycles of loading and unloading in a better way. However some of the countries have completely discarded this test as the relationship between the fatigue strength and ductility appears to be very hazy. Moreover, testing of Thin Film Oven Test residue for change in penetration, softening point, viscosity, etc. is considered to be a much better indicator of the fatigue resistant properties.

6.1.4 Penetration Index or Penetration Ratio

The penetration of the same sample of bitumen can be measured at different temperatures and a temperature vs penetration graph can be plotted on a log log graph sheet. The graph is a straight line and the slope of this straight line is called the penetration index. Penetration index can also be calculated with the help of the following formula:

Penetration index is a fair indicator of the ability of bitumen to resist repeated variations in the temperature of the pavement. Penetration ratio is a simplified version of the Penetration Indext. It is very similar to penetration index but in this case the sample is tested with 100 gm weight on the needle at $25^{O}C$ and 200gm weight on the needle at $4^{O}C$. While deriving the values of Penetration Index and Penetration Ratio the assumption is that the properties of bitumen vary in a linear manner over the entire range of temperature (in service as well during application. However, this assumption may not be entirely true in case of certain bitumen or modified bitumens.

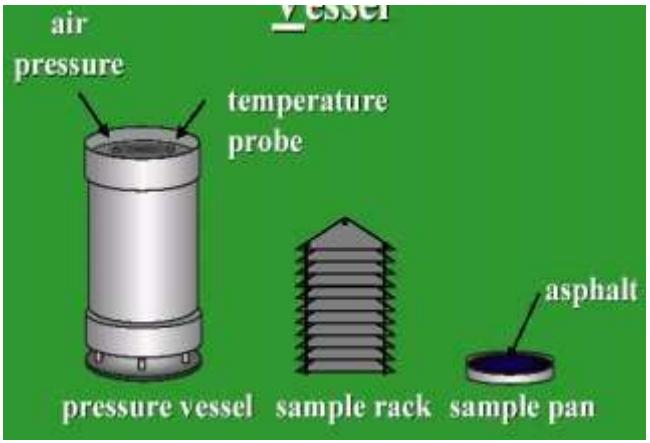
6.1.5 Matter Soluble in Organic Solvents

This test measures the presence of inorganic impurities in bitumen. Solvents like trichloroethylene, carbon disulphide, carbon tetrachloride, toluene, etc. are used for this purpose. In this test bitumen is dissolved in the solvent (trichloroehylene, carbon disulphide, carbon tetrachloride or toluene) and the material insoluble in the solvent is filtered out. It is then repeatedly washed with the solvent to remove all soluble matter. The insoluble matter that is finally left behind is weighed and the percentage calculated. The choice of solvent has been a matter of debate and discussion in the scientific community. Some of these solvents are considered to be toxic and hazardous. The laboratories and test method specification making bodies prefer not to use these toxic solvents and have switched over to less toxic or non-toxic solvents.

6.1.6 Flash Point

The flash point test like the flash point test of any other petroleum product tests the flammability of bitumen.

6.1.7 Rotating Thin Film Oven Test (RTFOT)



Once the bitumen is found to be meeting the viscosity criterion the next step of aging the sample in the laboratory is undertaken. The conventional TFOT test is replaced by Rotating Thin Film Oven Test. In the Rotating Thin Film Oven Test small bottles, like medicine bottles, are coated with bitumen on the inner side and the bottles are fixed in the oven on a shelf in horizontal position. A jet of air is periodically blown into each bottle to speed up the oxidation process. Therefore this test is faster test and can cause aging equivalent to two years (after laying) within 135 minutes.

7. AGING OF BITUMEN

Bitumen, like any organic matter, is affected by factors like presence of oxygen, ultraviolet rays and changes in temperature. These factors are responsible for hardening of bitumen. Hardening results in decrease in penetration increase in softening point and increase in penetration index (PI). For increased life of bituminous pavement it is essential that excessive hardness does not take place. Hardening of bitumen takes under the influence of external factors in the following ways:

7.1 **Oxidative hardening**: When bitumen is exposed to atmosphere for a prolonged period the oxygen starts reacting with the bitumen constituents and higher molecular weight molecules are formed. Larger molecules results in lesser flexibility and hence increased hardness. The degree of hardness is dependent on factors like ambient temperature, exposure time & thickness of bitumen film. It is observed that for 10 ^{0}C increase in temperature above 100 ^{0}C the oxidation rate doubles.

7.2 **Hardening due to loss of volatiles:** Over a period of time the volatile components in bitumen evaporate. The rate of evaporation is dependent on temperature only. The volatiles in bitumen are relatively very low and hence hardening due to loss of volatiles is relatively small.

7.3 **Physical hardening:** At ambient temperatures bitumen molecules slowly reorient themselves. This result in physical hardening. This process is an extremely slow process and hence actual hardening due to the above factor is very low.

7.4 **Exudative hardening:** Educative hardening takes place due to the movement of oily components out of bitumen over a period of time. The rate of hardening due to this process is dependent on the type of bitumen and also on the porosity of the aggregate.

7.5 **Hardening of bitumen during storage**: Hardening of bitumen during storage can be easily minimised by taking a few simple precautions. Bitumen is stored in above ground tanks at high temperatures and high temperature and presence of oxygen are the two primary factors responsible for hardening of bitumen. Hence it is very important that bitumen be

handled at the lowest possible temperature, consistent with efficient use. Also the storage tanks should have low surface to volume ratio so as to minimize the exposed surface area.. Lower exposed surface area would mean lower oxidation rate.

While designing the tanks it should be ensured that the recirculation pipelines always enter the tank below the bitumen surface. This will reduce splashing during recirculation. When the recirculation line enters the tank above the product surface all the three factors which promote oxidation viz. high temperature, access to oxygen and high exposed surface to volume ratio, are present. Therefore bitumen quality deteriorates very fast.

If handled properly the hardening in tanks can be insignificant as the product is stored for shorter durations. If bitumen is to be stored for long durations (4 to 5 days) then the temperature should be reduced to 20 ^{0}C to 25 ^{0}C above softening point.

In case where bitumen is to be reheated to increase the temperature adequate precautions have to be exercised. Bitumen should not be heated continuously in the beginning. Continuous heating can result in very high localized temperatures in area close to the heating source.

7.6 **Hardening of bitumen during mixing & transportation of mix:** During with a thin film of bitumen the size of which may vary from 5 microns to bituminous macadam is approximately 10, 000 sqm. Therefore again the conditions are very favorable for oxidation and hardening. It is generally observed that bitumen hardens by one grade during mixing and laying. The above factor is taken into consideration while selecting the right grade of bitumen.

7.7 **Hardening of bitumen on road:** Some hardening of bitumen can take place on the road also due to oxidation. The level of oxidation is purely dependent on the access to oxygen. If the pavement is well graded and well compacted the hardening is nominal as the void content will be low.

Pressure Aging Vessel (PAV)

The RTFOT produces bitumen which is as aged as bitumen in a two year old road. However the bitumen on the road continues to age and tests need to be developed this aging also. The Pressure Aging Vessel (PAV) is used to age the sample further. The Pressure Aging Vessel consists of a stack of small trays. Bitumen sample is filled into these stacks and is further aged under high pressure. RTFOT + PAV aged sample is considered to be equivalent to bitumen in a 7 year old road.

8.1 Rutting Properties (Complex Modulus)

The complex modulus of the bitumen sample is an indicator of the ability of bitumen to resist deformation at high temperature and prevent subsequent rutting. The test is carried out separately on unaged sample on RTFOT aged sample. The testing is done on a Dynamic Shear Rheometer. In this the bitumen sample is placed between two plates and the upper plate is oscillated. The torque required for oscillation is directly converted into complex modulus digitally. The testing is done at the maximum pavement temperature and not at a standard temperature as in case of Penetration / Viscosity tests.

8.2 Fatigue Properties

The fatigue properties are also measured in the Dynamic Shear Rheometer. The sample is tested at temperature equal to average of maximum and minimum temperature of the grade + $4^{O}C$. This testing is done on a sample which is RTFOT + PAV aged.

8.3 Low Temperature Properties

The low temperature properties are measured using the Bending Beam Rheometer. The testing is done on RTFOT + PAV aged sample. As achieving extremely low temperatures in the laboratory can be a difficult task, the testing is done at minimum temperature + 10^{O}C. The sample in the form of a beam is taken in the Bending Beam Rheometer and is tested for deflection. The deflection values are directly translated with the help of a transducer into the Creep Stiffness value. In case of Modified Bitumen this test is replaced by the Direct Tensile Test

8.4 Bond failure by Displacement:

This type of bond failure takes place when water is introduced in bituminous mix. Water displaces the bitumen particles due to its strong polar nature and hence the bond failure takes place.

8.5 Bond failure by detachment:

This type of bond failure is slightly different from displacement failure. This type of failure takes place due to improper handling of the aggregate at the time of mixing. Due to the hydrophilic nature of most of the aggregates they are coated with a thin invisible layer of water. The aggregate needs to be heated to break this water layer. If the aggregate is not properly heated or dust content in the aggregate is high, bitumen will not be able to coat the aggregate properly. Bitumen will form a thin coat over the water layer without proper bonding and will detach very easily.

8.6 Film rupture:

Film rupture takes place when the aggregates are not properly coated with bitumen. At the sharp edges where the bitumen layer is thin water will penetrate the film and reach the aggregate and displace bitumen completely. This process can be very fast and is the single largest reason for road damage.

8.7 Blistering & pitting:

During summers due to the pavement temperature is high and hence bitumen viscosity is reduced. If this is preceded or succeeded by rainfall bitumen particles migrate to the water droplets and form a thin film over them and form blisters. Whenever the temperature goes up again the water evaporates leaving a pit with exposed aggregate surfaces.

8.8 Hydraulic scouring:

During monsoon water penetrates the voids in the pavement. Due to compression & tension cycle induced by the vehicular movement water and bitumen particles continuously rub against each other resulting in hydraulic scouring.

8.9 Pore pressure:

In poorly compacted mixes the void content is high and in monsoon the voids near the surface can get completely filled up with water. Since the material is poorly compacted movement of traffic compacts the surface making the surface impermeable and pore water pressure is exerted. With subsequent traffic movement water penetrates deep into the surface and erodes the bitumen aggregate bond.

9. MODIFIED BITUMEN

9.1 Advantages of Modified Bitumen:

a. Lower susceptibility to temperature variations.
b. Higher resistance to deformation/wear and tear.
c. Better adhesion between aggregates and binder.
d. Increase in fatigue life.
e. Resistance in reflective cracking.
f. Better age resistance properties.

9.2 Types of Modified Bitumen:

A variety of additives are used for modification of Bitumen. The degree of modification depends on type of Modifier, its dose and nature of Bitumen. The most commonly used Modifiers are:

9.2.1 Synthetic Polymers

9.2.1.1 Synthetic Polymers - Plastomeric Thermoplastics

1. Low Density Polyethylene(LDPE)
2. Ethylene Vinyl Acetate (EVA)
3. Ethylene Butyl Acetate (EBA)
4. Ethylene Ter Polymer (ETP)

9.2.1.2 Synthetic Polymers - Elastomeric Thermoplastics

1. Styrene Isoprene Styrene (SIS)
2. Styrene Butadiene Styrene Block Copolymer

9.2.2 Natural Rubber

1. Latex Powder
2. Rubber Powder

9.2.3 Crumb Rubber

1. Crumb Rubber without additives
2. Crumb Rubber with additives

9.3 Cost Benefit Analysis:

Since other components of the cost of construction remains same except for the binder, the overall increase in the cost of construction is approx. 15-25%. However, the field trials have proved that frequency of overlaying can be minimized and the maintenance cost can be reduced to about 22-30% excluding the cost of interest, safety and comfort to the road user.

ABRADED ROAD (UNMODIFIED)

CRACKED ROAD (UNMODIFIED)

POTHOLE (UNMODIFIED)

MODIFIED (CRMB) SECTIO

APPENDIX-I : ROAD METALS AND MATERIALS

ABRASION : The abrasion test measures the abrasion or wear and tear resistance of the aggregate. The test is performed in the Los Angeles drum which is charged with a given weight of aggregate meeting one of the sieve grading. The drum containing the charge and the abrasion steel balls is rotated for 500 revolutions after which the material is screened through a No.12 sieve. The percentage passing is the wear percentage.

AROMATICS: About 40 to 65 % of bitumen weight is due to aromatics. This is a dark brown viscous liquid consisting of non polar carbon chains. They have high dissolving ability and act as dispersion medium for asphaltenes. Increase in aromatic content results in reduced shear strength.

ASPHALTENES: Asphaltenes are highly polar and complex aromatic hydrocarbons of high molecular weight. Asphaltene content largely affects the rheological (flow

BLEEDING - The exudation of bituminous material on a roadway surface after construction.

BLINDING - A covering of stone chips, sand or other suitable material applied to a road surface after an application of asphalt.

BORROW - All material used in making embankments which does not come from necessary excavation.

BRACCIA - Braccia is a deposit containing a large proportion of coarse angular rock fragments.

BRICK - A building and paving material made from moist fire clay, semi-fire clay, or shale or clayey-silt-sand, or combinations thereof, cut or moulded into blocks and hardened by burning.

CALCINED GYPSUM - Gypsum partially dehydrated by means of heat.

CALIFORNIA BEARING RATIO : The strength of the sub grade and unbound granular material is measured in the California Bearing Ratio test. In this test a circular piston 1932 sqmm in area is driven into the material at a specific rate.

The load acting on the piston is recorded and that corresponding to a penetration of 2.5mm is determined. The ratio of that load to 1360 kg (The value obtained from a standard crushed stone sample) expressed as percentage is the CBR value of this material.

CARPET - The term is applied to the wearing surface topping or top course of a bituminous surface laid in two or more coats.

CHIPS - Small angular fragments of stone containing no dust.

CHOKE - To fill up the voids.

CINDER - Slag particularly from iron blast furnaces or the accumulation of clinkers, ashes and cinders resulting from burning coal.

CLAY - A type of soil which contain colloidal scale-like particles which are the cause of plasticity. Plasticity and dry strength are affected by shape and mineral composition of the particles.

COHESION - The force that binds the particles of any material together.

CORRUGATIONS - Ripples, waves or unfirm undulations which are liable to appear in all types of road surfaces.

COURSE - One or more layers of road metal spread and compacted separately for the formation of the road or pavement. Courses are often referred to in the order of their laying, as first course, second course, third course, etc.

CROWN - The higher part of the curved surface of the road. Often used to designate the difference in elevation of the highest point of a roadway and the edge of the traveled way. Also the highest point on a cross-section, within the traveled way, usually at the centre.

CRUSHED GRAVEL - Crushed gravel is considered suitable for use in bituminous mixtures if at least 95% of the particles have one fractured face due to crushing.

CRUSHED ROCK - Crushed rock is obtained by mechanically crushing quarry stone, gravel or talus.

APPENDIX-I : ROAD METALS AND MATERIALS

CRUSHER RUN - Stones obtained directly from crushers containing all fractures of the stone from maximum size to crusher dust.

DENSITY: Density is the unit weight of a given bituminous mix. This gives an indication of the bitumen content in designed mix and helps to establish the basis for controlling/ determination of compaction during construction. Density of specimens obtained from pavements determines the effectiveness of rolling.

DETOUR - A route the traffic follows in going around a closed portion of road, a temporary diversion or route.

DIATOMACEOUS EARTH - Diatomaceous earth is composed essentially of siliceous skeletons of diatoms (extremely minute unicelled organisms). It is composed mainly of silica, white or light gray in colour and is extremely porous.

DISINTEGRATED GRANITE - It is a granite which has been subjected to natural weathering conditions to the extent that some of the minerals have been altered; e.g., feldspar to kaolin, mica to chlorite, which alterations are accompanied by considerable loss of mechanical strength in the rock structure.

DRY SIEVE ANALYSIS: This test determines the material retained on each sieve size as the material, thoroughly dried, is passed over a set of sieves of standard selected sizes of square openings. The sieves are held together in a frame so that the sieve with the largest opening is on top and those of smaller openings successfully follow one below other.

DUCTILITY : Ductility is an indication of the extension or stetchability of bitumen under standard conditions. A small briquette of bitumen of a given dimension at a standard test condition is pulled in an apparatus at a standard rate of speed until the thread of bitumen breaks. The length of the pull measured in centimetres is designated as ductility of the bitumen sample under test.

EFFECTIVE SPECIFIC GRAVITY : This determined the degree to which the water permeable voids in an aggregate are permeable to asphalt binder. As bitumen is more viscous than water it will coat these voids to a lesser extent.

APPENDIX-I : ROAD METALS AND MATERIALS

FAT - Containing an excess of bituminous material. A fat asphalt mixture is one in which the asphalt cement is in excess and the excess is clearly apparent.

FLASH POINT: Flash point is the minimum temperature at which bitumen gives an instantaneous flash in the presence of an external open flame.

FOAM - The condition of hot asphalt cement caused by rain or water getting into the hot bitumen and causing excessive building up of small steam bubbles.

FORMATION LEVEL - The surface of the excavated or made up ground on which a road is constructed.

FOUNDATION - Denotes that portion of a road structure lying on the formation level.

FRIABLE - Easily broken up.

GRADED STONE OR METAL - It is a stone metal that has been segregated into sizes suitable for use under various construction specifications. The maximum size rock in any one gradation is usually 6 to 8 cm max. & 2 to 4 cm min.

GRANITE - Granites are crystalline even graded rocks consisting essentially of feldspar and quartz with smaller amounts of mica and other ferro- magnesian minerals.

GRAVEL - Gravel consists of bulky mineral grains larger than about 5 mm diameter. Pieces larger than 5mm are called stones and pieces larger than 25 cms are called boulders.

GREEDY - Applied to an aggregate or surface which will absorb a large quantity of bituminous binding material.

GRIT - Applied to small sized stone used for binding road surfaces which have received a bituminous dressing.

GROUTING - To fill the joints and voids in smaller masonry or in courses of road metal with grout, such as asphalt.

APPENDIX-I : ROAD METALS AND MATERIALS

GYPSUM - Hydrous calcium sulphate, contains 32.5 % lime, 46.6 % sulphur trioxide and 20.9% water. Some varieties are alabaster, gypsite, satin spar & selenite.

HAND PITCHED - Applied to large stones, boulders or bricks placed by hand or a road to form a foundation or bottom course.

HARD CORE CLINKER - Broken brick, rubble, etc., placed in a road structure to form a foundation or bottom course.

HOGGING - Fine sand, earthy gravel, moorum, laterite, limestone dust, crusher dust and other suitable fine material that forms the slurry grout in water bound macadem surfaces.

HOT LAID MIXTURES OR HOT MIX ASPHALT - Plant mixes of bitumen and aggregates which must be spread and compacted while in a heated condition. They are prepared directly with bituminous cements and lose their workability when cooled to atmospheric temperatures.

HYDRATED LIME - A dry powder obtained by treating quicklime with enough water to satisfy its chemical affinity under the condition of its hydration. It consists essentially of calcium hydroxide or a mixture of calcium hydroxide and magnesium oxide and magnesium hydroxide.

KANKAR - Kankar is much the same as moorum but with much higher degree of calcification. “Lime Kankar” is usually found in beds upto a depth of three metres, which when removed breaks up into high percentage of very hard nodules of limestone like pieces containing a matrix of sand & silt.

Lake Asphalt: Asphalt deposits are found in the form of surface of deposits at a few places in the world. However there is the single lake of approximately 100 acres which is the single largest deposit of asphalt in the world. The lake is about 90m deep and is estimated to contain from 10 to 15 million tonnes of asphalt. This material cannot be used directly on the road as it is very hard and therefore it is blended with softer grades of bitumen to get the right results.

APPENDIX-I : ROAD METALS AND MATERIALS

LATERITE - A name derived from the Latin word for brick earth and applied to the red residual soils or surface products that have originated in site from the atmospheric weathering of rocks. Especially found in the tropics. In many cases laterite is disintegrated granite which has become restablised by oxidation of contained minerals within the original stone such as iron, aluminum, etc. Laterite is quite often red in colour and extensively used in road construction in India.

LEAN - Containing a deficiency of bituminous material or conversely containing excess of aggregate.

LEVELING COURSE - A course placed for the purpose of shaping old surfaces to proper cross section to receive a subsequent surface course.

LIMESTONE - Any natural rock of sedimentary origin composed principally of calcium carbonate or of calcium and magnesium carbonates in either its original chemical of fragmental or crystallised form.

MARSHALL TEST : The Marshall test consists of the manufacture of cylindrical specimens 102 mm in diametre & 64 mm high by using a standard compaction hammer and a cylindrical mould. The specimens are tested for their resistance to deformation at 60^0C at a constant rate of 50mm/min.in a testing rig. The top and bottom of the specimen remain unconfined. The maximum load before failure is called Marshall Stability and the amount of deformation of the specimen before failure is known as Marshall Flow. The ratio of stability to flow is called Marshall Quotient and is an indicator of the materials resistance to permanent deformation.

MASONRY - Masonry in its widest sense, includes all construction of stone or similar material, in which the separate pieces are either placed together with or without cementing material to join them; or encased in a matrix of firmly cementing material. In usual practice, the word “Masonry” is qualified by some proper term to more particularly describe the masonry under consideration, such as, stone, concrete, brick, wet, dry, coarsed, uncoarsed, ashler etc.

MOORUM - Moorum though often used in road construction is quite soft (softer than brick) and breaks down quite easily. It consists of silt and sand which have become partially stablised by calcification and other means due to filtering action of the original deposit on ground water. Moorum is also formed from disintegrated rocks and the two most common varieties are the yellow and the red moorum; it is reddish if the base is laterite and yellowish if the base is trap. Moorum is found in most parts of India and is especially prevalent in the Deccan.

number & increases the softening point and hence harder grades of bitumen can be obtained by increasing asphaltene content. Asphaltene constitute 5 to 15 % of bitumen by weight.

ORGANIC MATTER - Organic matter consists either of partly decomposed vegetation as in peats or of finely divided vegetable matter as in organic silts and organic clays.

PALLIATIVE - A short lived dust layer. Applied to water, oils and other preparations with which roads are treated to temporarily lay dust.

PEA GRAVEL - Clean gravel, the particles of which equal the size of peas.

PEAT SOIL - Soil composed predominantly of organic material, considerably decomposed but slightly fibrous with easily recognizable plant remains.

PENETRATION : Penetration determines the relative hardness or consistency of bitumen by measuring the distance that a standard needle will penetrate vertically into a sample of bitumen at 25^{O}C under a load of 100 grams applied for 5 seconds.

PERMEABILITY - The degree to which any material permits the injection of water.

PIT STONE - Pit stone is usually gravel dug from pits or conglomerate quarry faces. Most pit stones vary from rounded to subrounded.

PORTLAND CEMENT - Portland cement is a product obtained by finely pulverizing clinker produced by calcining incipient fusion an intimate and properly

proportioned mixture of agrillaceous and calcareous materials with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

QUARRY STONE - Quarry stone is stone that has been mined by blasting or otherwise from solid rock at quarry site. Usually all faces of such stones are fractured.

QUARTZITE - A metamorphosed quartz sandstone, formed by deposition of secondary silica between the original grains, so that the rock is more firmly cemented and less porous than before and tends to break across the grains.

QUICK LIME - A calcined material, the major part of which is calcium oxide or calcium oxide in natural association with lesser amount of magnesium oxide, capable of slaking with water.

RESINS: Resins are dark brown in colour, are solid or semi-solid and are highly polar in nature. The polar nature of resins imparts strong adhesive properties to bitumen. Normally, resin accounts for 10 to 20 % of bitumen by weight. Increase in Resin content hardens the bitumen, reduces penetration index and increases shear strength & viscosity.

ROAD METAL OR AGGREGATES - Hard granular materials of many types and sizes used in road construction, i.e., sand, gravel, crushed gravel, crushed rock, slag, cinder, moorum, kankar, laterite, portland cement clay, limestone dust, diatomaceous earth, mineral fillers, etc.

ROCK ASPHALT: In France, Switzerland & Italy naturally coated bituminous aggregate is found at a few places. The natural asphalt in these regions is found in rocky terrain consisting mainly of calcerous porous rocks like limestone and sandstone. Over the period of time the asphalt has seeped into the stones and hence naturally occurring stones coated & impregnated with asphalt are found in these areas.

SAND - Sand consists of mineral grains varying from about 5 mm to 0.05 mm in diameter.

SATURATES: Saturates are aliphatic hydrocarbons and are non polar in nature. They are white or straw in colour. Saturates account for 5 to 20% of the weight of bitumen. Increasing Saturates can make the bitumen softer.

SHOULDER - In highway use, that portion of the roadbed between the traveled way or pavement and the top of the ditch slope in cuts or top of embankment in fills.

SILT - Silt consists of natural mineral grains smaller than 0.05 mm which lack plasticity and have little or no dry strength.

SLAG - Fused or partially fused composed of silica in combination with lime or other bases, resulting in secondary products from the reduction of metallic ores.

SLAKED LIME - Slaked lime is calcium hydroxide, a compound formed by hydration of free lime.

SOFTENING POINT : Softening point is the temperature at which a standard quantity of bitumen will become fluid. It is usually tested by a ball/ring test method.

SOLUBILITY : The portion of bitumen which fully dissolves in carbon tetrachloride represents the actual binder material in the bitumen sample.

TALUS - Talus is naturally broken stone as is often found in slides and at the base of rocky heights. Talus rock, with some exceptions, has all faces fractured and is usually classified angular to subangular.

TAR: Tar is obtained during the process of destructive distillation of wood or coal. Tar was used in road construction in India till 1950s. Today due to better quality and availability Bitumen has completely replaced tar in the road construction industry.

THEORETICALLY GRADED STONE : Theoretically graded stone is obtained by uniformly mixing calculated percentages of known graded sizes to yield a combined gradation suited to the work proposed. Gradation limits are ordinarily specified in writing or are shown on a gradation chart, in either case the

allowable minimum and maximum amounts passing or retained on the various screens and sieves used are indicated.

THIN FILM OVEN TEST : This test indicates the amount of hardness that may be expected to occur in bitumen during plant mixing. The tendency to harden is measured as a percentage of penetration after and before the thin film oven test. 50grams of the sample is held in a standard size cup, rotated on a shelf inside a well ventilated oven maintained at $165^{O}C$ for 5 hours. Penetration is taken before and after the test.

TRAP ROCK - Trap rock includes the dark - coloured fine grained and dense igneous rocks composed essentially of the ferro magnesian minerals, basic feldspars, and little or no quartz. The ordinary commercial variety of trap is basalt, diabase or grabo. “Black Trap” refers mainly to the basalt rocks.

VISCOSITY : Viscosity of bitumen determines the flow characteristics of bitumen at a given temperature. It is taken in the Saybolt Furol seconds.

VOIDS : Determination of voids in a compact specimen of paving mixture is done by checking the specific gravity of aggregate and the specific gravity of bitumen used.

WASH SIEVE ANALYSIS : Where the aggregate contains extremely fine dust whichmay stick to the coarse aggregate particles, the particle size distribution is made by washing procedure.

APPENDIX-II

LIST OF FREQUENTLY USED CODES, SPECIFICATIONS & STANDARDS

Number Designation	Title
IRC: 14-1977	Recommended practices for 2 cm thick bitumen & tar carpets (third revision).
IRC: 16-1989	Tentative specification for priming of base course with bituminous primer.
IRC: 17-1965	Tentative specifications for single coat bituminous surface dressing.
IRC: 20-1966	Recommended practices for bituminous penetration macadam(full grout).
IRC: 23-1966	Tentative specifications for two coat bituminous surface dressing.
IRC: 27-1967	Tentative specification for bituminous macadam (base & binder course).
IRC: 29-1968	Tentative specification for 4 cm asphaltic concrete surface course.
IRC: 37-1984	Guidelines for design of flexible pavement(first revision)
IRC: 47-1972	Tentative specification for built-up spray grout.
IRC: 48-1972	Tentative specification for bituminous surface dressing using precoated aggregates.
IRC: 72-1978	Recommended practice for use & upkeep of equipment, tools and appliances for bituminous pavement construction.
IRC: 82-1982	Code of practice for maintenance of bituminous surface of highways.
IRC: 90-1985	Guidelines for selection, operation and maintenance of bituminous hot mix plant.

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LIST OF FREQUENTLY USED CODES, SPECIFICATIONS & STANDARDS

IRC: 94-1986	Specifications of dense bituminous macadam.
IRC:SP:11-1977	Handbook of quality control for construction of roads and runways (first revision).
IRC:SP:53-1999	Guidelines on use of polymer and rubber modified bitumen in road construction
IS: 73-1992	Paving bitumen – specifications
IS: 215-1961	Road tar
IS: 217-1988	Cutback bitumen
IS: 334-1982	Glossary of terms relating to bitumen & tar
IS: 454-1994	Cutback bitumen from waxy crude - specifications.
IS: 702-1988	Industrial bitumen
IS:1195-1968	Procedure for testing for hardness number of bitumen mastic.
IS:1201 to 1220-1978	Indian standard methods for testing tar and bituminous materials
IS:1398-1960	Packing paper, waterproof, bitumen laminated
IS:5317-1969	Specification for bitumen mastic for bridge decking and roads
IS:6241-1971	Method of test for determination of stripping value of road aggregates.
IS:8887-1978	Specification for bitumen emulsion for roads (cationic type)

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COMMONLY USED CONVERSION FACTORS

To Convert	To	Multiply by
Millimetres	Inches	0.03937
Centimetres	Inches	0.39370
Inches	Centimetres	2.54
Metres	Feet	3.28084
Feet	Metres	0.3048
Kilometres	Miles	0.62173
Miles	Kilometres	1.60934
Metres	Inches	39.37
Metres	Yards	1.09361
Yards	Metres	0.9144
Square Centimetres	Square Inches	0.15500
Square Inches	Square Centimetres	6.4516
Square Feet	Square Metre	0.092903
Square Metre	Square Feet	10.764
Square Metre	Square Yards	1.196
Square Yards	Square Metre	0.836126
Square Kilometres	Square Miles	0.38610
Square Miles	Square Kilometres	2.58998
Acres	Sqaure Metres	4046.85
Cubic Centimetres	Cubic Inches	0.061024
Cubic Inches	Cubic Centimetres	16.387
Cubic Feet	Cubic Metres	0.0283167
Cubic Metres	Cubic Feet	35.3148
Cubic Metres	Cubic Yards	1.30796
Cubic Yards	Cubic Metres	0.76455
Cubic Metres	Imperial Gallon	219.97
Cubic Metres	U.S.Gallon	264.17
Imperial Gallon	Litres	4.54596
U.S.Gallon	Litres	3.78533
Litres	Imperial Gallon	0.219975
Litres	U.S.Gallon	0.264178
Imperial Pints	Litres	0.56825
U.S. Pints	Litres	0.47317

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COMMONLY USED CONVERSION FACTORS

To Convert	To	Multiply by
Grains	Grams	0.0648
Grams	Grains	15.43
Ounces	Grams	28.3495
Grams	Pounds	0.002205
Kilograms	Pounds	2.2.462
Pounds	Kilogram	0.453592
British Tons	Metric Tons	1.01605
Metric Tons	British Tons	0.98421
U.S. Short Tons	Metric Tons	0.907185
Metric Tons	U.S. Short Tons	1.10231
Kilograms per sq. Centimetres	Pounds per sq. Inch	14.22
Pounds per sq. Inch	Kilogram per sq. Centimetres	0.0703
Pounds per sq. Foot	Kilogram per sq. Metres	4.882
Grams per Cubic centimetres	Pounds per cubic foot	62.4
Force de Cheval	Horse Power	1.0139
Horse Power	Force de Cheval	0.9863

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CUSTOMER CARE OFFICES

MARKETING HEADQUARTERS	
Hindustan Bhawan, 8, Shoorji Vallabhdas Marg, Ballard Estate, Mumbai - 400 001 • Phone : 022-2618031 • Fax : 022-2611802	**I & C Department,** R & C Building, 4th Floor, Sir J. J. Road, Byculla, Mumbai – 400 008. • Tel. – 022 23789000, • Fax – 022 – 2374 0227
REGIONAL OFFICES	
HPCL, **Ahmedabad** Direct Sales RO, Petroleum House, Behind Memnagar Fire Station, Navrangpura, Post Box – 4032, Ahmedabad – 380 009. • Tel Nos. : 2791 0257 / 2791 1672 / 2791 1082 (Ext : 213/225) • Fax No : 27911033 (DS), • STD Code : 079	HPCL, **Bhopal** Direct Sales RO, Gautam Nagar, Govindpura, Bhopal – 462 023 • Tel Nos. : 4270 737 / 2585 994 • Fax No : 4275 316 (DS) / 2789 904 (Ret) • STD Code : 0755
HPCL, **Mumbai** Direct Sales RO, WZTC, 3/4, Junction of SV Road & Turner Road, Bandra (West), Mumbai – 400 050 • Tel Nos. : 2640 2810, 2645 2161 / 71, 2643 7165 / 66 / 68 (Board Extn : 209/212) • Fax No. : 2641 0177 (DS) / 2644 1509 (Ret) • STD Code : 022	HPCL, **Nagpur** Direct Sales RO Oriental Building, S. V. Patel Marg, Post Box No. 8, Nagpur – 440 001. • Tel. Nos. : 2520 618 / 2520 617 • Fax No. : 2527 807/ 2548 411 • STC Code : 0712
HPCL, **Pune** Direct Sales RO, 3/C, Dr. Ambedkar Road, 3rd Floor, Next to Nehru Memorial Hall, Post Box No. 90, Pune – 411 001. Tel Nos. : 2621 3000, • Fax No. : 2621 3030 • STD Code : 020	HPCL, **Chandigarh** Direct Sales RO, Tel Bhawan, Plot No. 6 – A, Madhya Marg, Sector 19 – B, Chandigarh – 160 019 • Tel Nos. : 2780 042 / 2781 035 • Fax No. : 5046 511 (DS), 2548 443 (Ret) • STD Code : 0172

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HPCL, **Delhi** Direct Sales RO, 7th Floor, Core II, North Tower, SCOPE Minar, Laxmi Nagar, New Delhi 110 092 • Tel Nos. : 2240 8100 (DS Extns : 501 / 502, 503 – 507) • Fax No. : 2201 3965 / 2201 0616 • (STD Code : 011)	HPCL, **Jaipur** Direct Sales RO Tel Bhawan, Sahkar Marg, Jyoti Nagar Jaipur – 302 005 • Tel Nos. : 2740 154 / 2740 318 • Fax No. : 2740 319 (DS) / 2740 358 (Ret) • STD Code : 0141
HPCL, **Lucknow** Direct Sales RO, Plot No. 1, Nehru Enclave, Gomti Nagar, Lucknow – 226 010. • Tel. Nos. : 2308 123 / 2309 581 (Extn: 20, 21) • Fax No. : 2308 869 (DS) / 2309 178 (Ret) • STD Code : 0522	HPCL, **Bhubaneswar** Direct Sales RO, 5th Floor, Alok Bharati Bldg., Shaheed Nagar, Bhubaneswar – 751 007. • Tel Nos. : 2541 926 • Fax No. : 2546 676 / 2542 698 (DS), 2547 509 (Ret) • STD Code : 0674
HPCL, **Kolkata** Direct Sales RO, Industry House, 7th & 8th Floor, 10, Camac Street, Kolkata – 700 017 • Tel Nos. : 2282 9881 / 82 / 83 • Fax No. : 2282 7805 (DS), 2282 9885 (Ret) • STD Code : 033	HPCL, **Raipur** Direct Sales RO, Madina Manzil, 2nd Floor, Medical College Road, Raipur – 492001, Chhattisgarh • Tel. No. : 2532 541 / 3206 759 • Fax No. : 2535 443 • STD Code : 0771
HPCL, **Jamshedpur (Tatanagar**) Direct Sales RO, Station road, Burma Mines, Near Star Talkies, Tatanagar – 831 002, Jharkhand • Tel Nos. : 2345 455 / 2345 456 / 2345 457 • Fax No. : 2942 668, • STD Code : 0657	HPCL, **Visakh** Direct Sales RO, Petronilayam, Opp. AU 'IN' Gate, China Waltair, Visakhapatnam – 530 003. • Tel Nos. : 2566029 / 2564078 / 2563789 • Fax No. : 2563 745 / 2525 409 (DS) / 2564403 (Ret), • STD Code : 0891

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HPCL, **Bangalore** Direct Sales RO, 77, Old Madras Road, K. R. Puram Doorvaninagar PO, Bangalore – 560 016. • Tel Nos: 2853 0540 /431/433 (Ret) • Fax No: 2853 0550 (DS)/0548 (Ret) • STD Code : 080	HPCL, **Belgaum** Direct Sales RO, Rani Chenamma Nagar, Sambhaji Road, Belgaum – 590 006. • Tel Nos. : 2440 192 / 2440 550 • Fax Nos. : 2441 770 • STD Code : 0831
HPCL, **Chennai** Direct Sales RO, Petro Bhavan, No. 82, T. T. K. Road, Alwarpet, Chennai – 600 018. • Tel Nos. : 2498 8526 (Extn : 211 / 210 / 212) • Fax No. : 2498 8527 (DS) / 2841 4360 (Ret) • STD Code : 044	HPCL **Kochi** Direct Sales RO HPCL, Karshaka Road, Post Box No. : 2425 Kadavanthra P. O., Cochin, Kerala • Tel Nos. : 2314 543 / 2314 522 • Fax No. : 2314 427, • STD Code : 0484
HPCL, **Secunderabad** Direct Sales RO, 130/1, Sarojini Devi Street, Next to St. Patrick's School, Secunderabad – 500 003. • Tel Nos. : 2770 1844 / 3360 / 4203 / 2655 • Fax No. : 2770 4383 (DS) / 2770 0974 (Ret) • STD Code : 040	