Production of Paving Grade Bitumen

Blending facility – unmodified bitumen

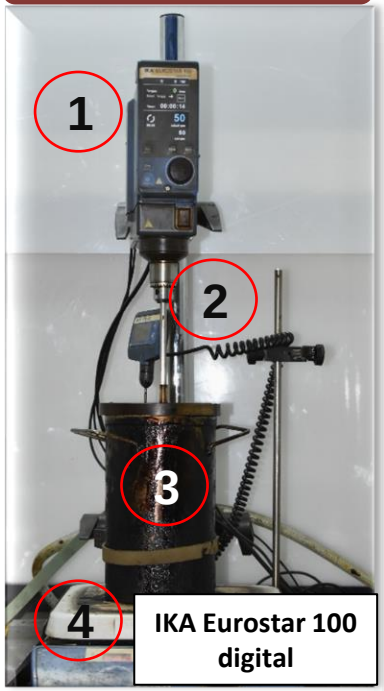
Working Principle

- The blending facility includes (1) overhead stirrer IKA Eurostar 100 digital control, (2) anchor stirrer, (3) blend container, and (4) heating plate to control the temperature.
- The blending scheme is designed based on blend type, blend components, duration of blending and temperature during blending.
- The blend components are residues obtained from auxiliary units (**P**ropane **D**e**A**sphalting, **F**luid **C**atalytic **C**racking) in a refinery.
- A quantity of approx. 1000 g of unmodified binders can be produced in a single batch.

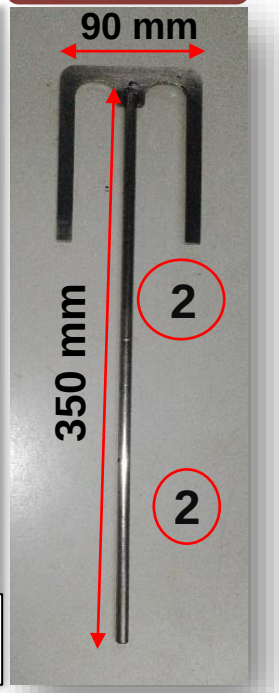
Application

- Production of paving grade bitumen complying with IS 73, 2018 specifications.

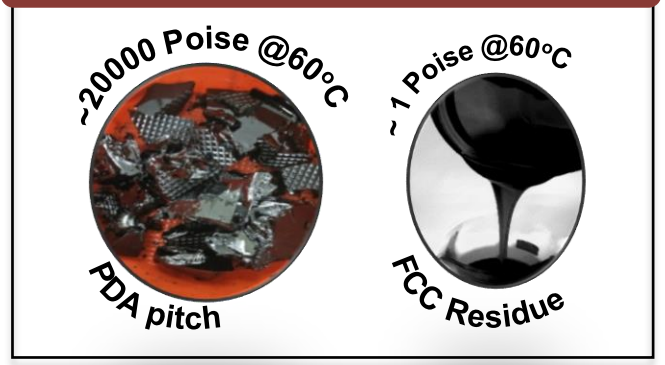
Blending



Anchor



Blend components



Chakkoth, U., Krishna, K. R., Ramkumar, M., Hussain, S. A., Rao, P. V. C., Choudary, N. V., Sriganesh, G., & Krishnan, J. M. (2020). Component blending for bitumen production for Indian refineries. *Sādhanā*, *45* (1), 1-16.

Blending facility – modified bitumen

Working Principle

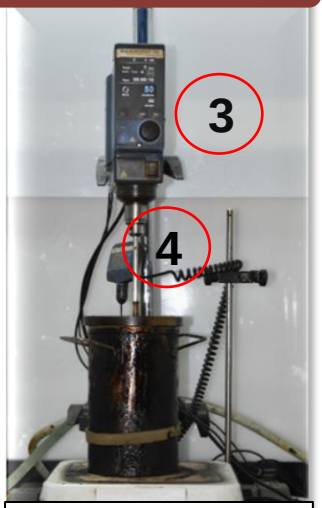
- The production of polymer modified bitumen is carried out in two stages. First, the dispersing tool is used to shred and disperse the polymers in the base binder and it is carried out using an 1) overhead stirrer IKA T50 digital, and 2) dispersing tool.
- Further, the blending is carried out using 3) IKA Eurostar 100 digital control overhead stirrer, and a 4) dissolver stirrer. The choice of shear rates are based on base binder, polymer additives/modifiers, and temperature during blending.
- A quantity of approx. 1000 g of bituminous binders can be produced in a single batch.

Application

- Production of paving grade bitumen complying with IS 15462, 2019 specifications.
- Rheological characterization of modified bitumen.

Blending

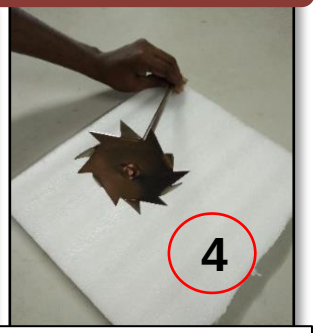
IKA T50 digital ULTRA TURRAX



IKA Eurostar 100 digital

Stirrer types

Dispersing tool



Dissolver

Production of Bituminous Emulsion

Colloid mill – bituminous emulsion

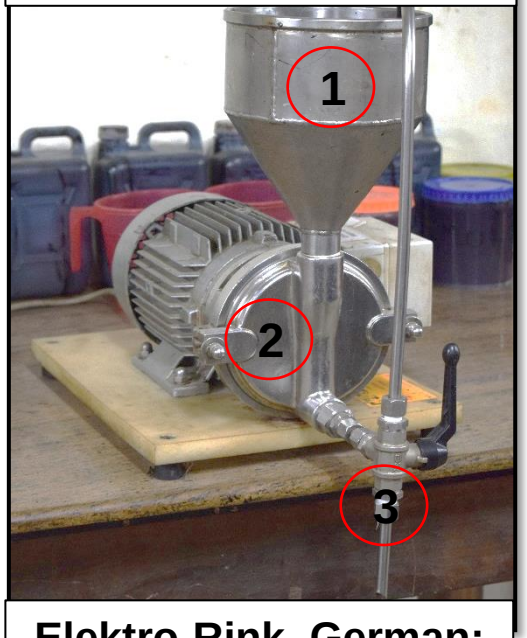
Working Principle

- The colloidal mill consists of 1) hopper, 2) stator-rotor and 3) outlet.
- The colloid mill works on the rotor stator principle with a narrow gap.
- The bitumen is dispersed in the soap solution by the shearing action of rotor which runs at 3000 rpm.
- A quantity of 1000 g of emulsion can be produced in a single batch.

Application

- Different types of emulsion can be prepared using unmodified bitumen, such as:
  - Cationic and anionic
  - Slow-setting (SS), medium setting (MS) and rapid setting (RS)

Courtesy: Ingevity®



Elektro-Rink, German: Colloid Mill

Emulsion samples

Production of Foamed Bitumen

Foaming Equipment

Working Principle

- Foaming equipment (WLB 10 S) consists of a bitumen tank with temperature control, measuring water gauge, expansion chamber, and a spaying nozzle.
- Water and air are injected into hot bitumen (>160°C) in a expansion chamber.
- The foaming action results in expansion of the binder into several orders of magnitude.

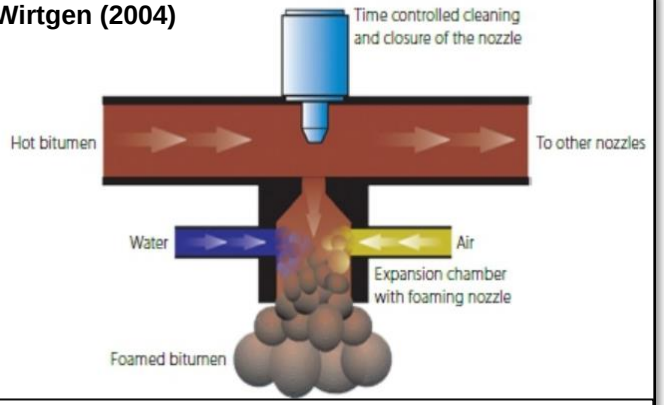
Application

- Rheological characterization of foamed bitumen.
- Production of cold and warm bituminous mixtures.

Courtesy: Wirtgen Group®

Wirtgen, German:
Foaming equipment: WLB 10 S

Wirtgen (2004)



Foamed bitumen production

Wirtgen, F. (2004). *Cold Recycling Manual.* Wirtgen GmbH: Windhagen, Germany.

Specification Compliance Testing

IS 73, 2018 – Unmodified Bitumen
IS 15462, 2019 – Modified Bitumen
ASTM D6373, 2021 – Performance Grading

Penetrometer

Working Principle (ASTM D5, 2020)

- The equipment consists of semi automated moving head and standard needle holder.
- Standard needle is allowed to vertically penetrate the bitumen sample under specific conditions of loading, time, and temperature.
- The depth of penetration is measured in units of 0.1 mm.

Petrotest, Germany: Penetrometer

Application

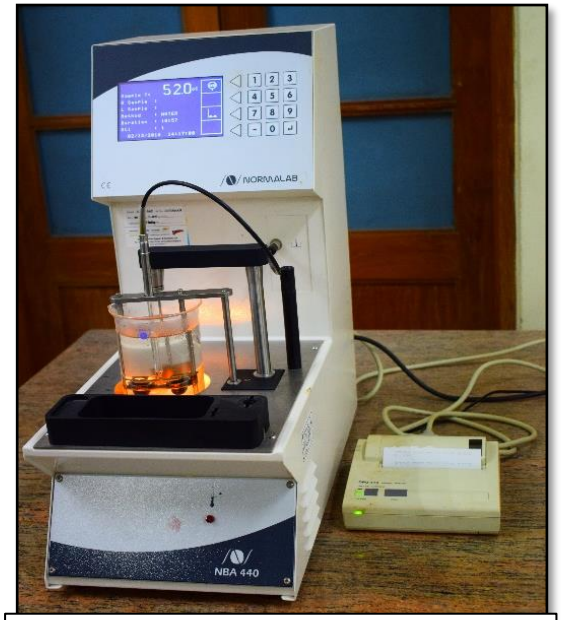
- To measure penetration of bituminous binders.
- Specification compliance testing for paving bitumen as per IS 73, 2018 (unmodified) and IS 15462, 2019 (modified).

Experimental set-up

Ring and Ball Apparatus

Working Principle (ASTM D36, 2020)

- The apparatus consists of shouldered brass rings, balls, ball centering guide, ring holder and assembly, bath, thermometer.
- Bituminous binders are cast in brass rings, and heated at a controlled rate in a liquid (water/glycerin) bath. Each brass ring supports a steel ball of 3.5 g weight.
- The softening point is reported as the mean of the temperatures at which the bitumen sample ‘softens’ to allow each steel ball, to fall a distance of 25 mm.



Normalab, France: Ring and Ball Apparatus

Application

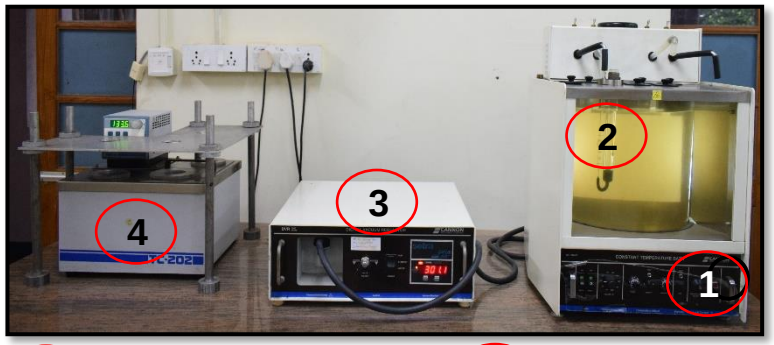
- To measure the softening point of bituminous binders.
- Specification compliance testing for paving bitumen as per IS 73, 2018 (unmodified) and IS 15462, 2019 (modified).

Bitumen samples: Rings and balls

Viscometer

Working Principle (ASTM D2171, 2018)

- The measurement set up consists of (1) Cannon temperature controlled oil bath, (2) calibrated capillary type Cannon viscometer, (3) Cannon DVR1000 digital vacuum regulator, (4) Brookfield TC-202 sample conditioning oil bath.
- The time required by a fixed volume of binder to flow through a calibrated capillary tube is measured.
- Viscosity is computed by multiplying the measured time with a calibration factor.



1 Oil bath: Testing

2 Viscometer

3 Digital vacuum regulator

4 Oil bath: Conditioning

Application

- Capillary type viscometers are used to determine the absolute (60°C) and kinematic viscosity (135°C) of bituminous binders.
- Specification compliance testing for paving bitumen as per IS 73, 2018.

60 °C	135 °C

Cannon Instrument company, USA: Viscometer

Rotational Viscometer

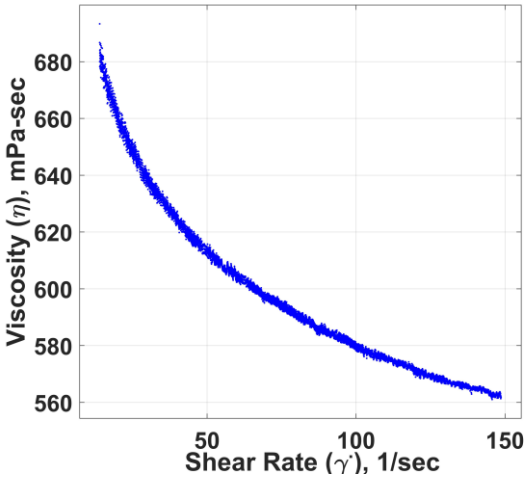
Working Principle (ASTM D4402, 2015)

- The equipment has a Couette type arrangement with viscometer head, apparatus-measuring geometries (spindles), temperature controlled thermal chamber, temperature controller and sample chamber.
- The torque required to rotate the measuring geometry immersed in the sample at a selected speed of rotation is measured and used to compute the shear stress. The shear rate is calculated from speed of rotation of spindle (angular velocity) using the Margules equation.
- The viscosity of the material is computed as the ratio of shear stress and shear rate. All the measurements are recorded at fixed time intervals using a software interface.

Brookfield, USA: Rotational Viscometer

Application

- Characterization of Newtonian and non – Newtonian (shear rate independent viscosity and stress overshoot) response of materials over a temperature range of 25 to 200°C
- Determination of mixing and compaction temperature of unmodified bitumen.



Ductilometer: Ductility Test

Working Principle (ASTM D113, 2017)

- The apparatus consists of briquet mold, water bath and testing machine.
- Bituminous binders are cast in a briquet mold, and are pulled apart at a speed of 5 cm/min., using the testing machine at a specified temperature.
- The distance to which the binders will elongate before breaking when two ends of a briquet specimen are pulled apart is the measure of ductility.

Application

- To measure of tensile properties of bituminous binders.
- Specification compliance testing for paving bitumen as per IS 73, 2018 (unmodified) and IS 15462, 2019 (modified).

Ductility mold

Ductilometer: Elastic Recovery Test

Working Principle (ASTM D6084, 2018)

- The apparatus consists of briquet mold, water bath and testing machine.
- Bituminous binders are cast in a briquet mold, and are pulled apart at a speed of 5 cm/min., elongated up to 10 cm deformation to form a thread. The thread is severed at the centre. The recovery of the thread after conditioning sample at test temperature is measured.
- The elastic recovery is expressed as the ratio of change in length of the severed thread to original length, in percentage.

Application

- To quantify the degree of modification and elastic characteristics of polymer modified bitumen.
- Specification compliance testing for paving bitumen as per IS 15462, 2019 (modified).

Elastic recovery mold

Dynamic Shear Rheometer (DSR)

Working Principle

- The equipment consists of different measurement geometries, temperature controller, loading device, and data acquisition system.
- The material response is measured in terms of deflection angle/torque for a given load/deformation to compute shear strain and shear stress respectively.
- The measurements can be carried out in both time and frequency domain over a wide range of temperature.

Anton Paar, Germany: DSR MCR 302

Application

- Characterization of the linear and non-linear viscoelastic response of materials.
- Rheological characterization of bituminous binders: Performance Grading (ASTM D6373, 2021), MSCR (ASTM D7405, 2020), LAS (AASHTO TP 101, 2014), oscillatory shear response (ASTM D7175, 2015).

Courtesy: Anton Paar, Germany. DSR MCR 702

Laboratory Simulation of Aging

Rolling Thin Film Oven

Working Principle (ASTM D2872, 2019)

- The equipment consists of a temperature controlled convection type oven, air flowmeter, circular metal carriage, temperature sensors and cylindrical glass bottles, cooling rack.
- Bituminous binder samples are heated and transferred to cylindrical glass bottles and placed in a rotating carriage within an oven set at 163°C temperature for a duration of 85 minutes.

Cox & Sons, USA:
Rolling thin film oven

Application

- To simulate the short term aging of binder during mixing and compaction.
- To quantify the effect of heat and air on bituminous binder films.
- Specification compliance testing for paving bitumen as per IS 73, 2018 (unmodified), IS 15462, 2019 (modified bitumen), and ASTM D6373, 2021 (performance grading).

Sample cooling rack

Thin Film Oven

Working Principle (ASTM D1754, 2020)

- The equipment consists of a (1) temperature controlled oven, rotating shelves, thermometer and (2) cylindrical steel pans to hold the bitumen samples.

- Bituminous binders are heated and transferred to steel pans of fixed dimensions and placed in a rotating shelf within an oven set at 163°C temperature for a duration of 5 hours.

Application

- To simulate the short term aging of binder during mixing and compaction.

- To quantify the effect of heat and air on bituminous binder films.

Courtesy: Total®

Matest®, Italy:
Thin film oven

Bitumen samples

Pressure Aging Vessel

Working Principle (ASTM D6521, 2019)

- The equipment consists of a pressure vessel, connected to devices for measuring, controlling and recording temperature and pressure.
- Bituminous binder is subjected to a pressure of 2.1 MPa at a temperature of 90/100/110°C for 20 hours.
- The choice of test temperature depends on the climatic conditions in the field.
- Samples are placed in degassing oven to remove entrapped air.

Application

- To simulate the long term aging of binder occurred during the service life of the pavement.
- Specification compliance testing for paving bitumen as per ASTM D6373, 2021 (performance grading).

Prentex, USA:
Pressure Aging Vessel

Prentex, USA:
Degassing oven

Bituminous Emulsion Testing

IS 3117, 2004: Anionic type
IS 8887, 2018: Cationic type

Coagulation Test

Working Principle (IS 8887, 2018-Annex-D)

- The apparatus consists of glass boiling tube with cork, 600-micron sieve, and a thermostatically controlled water bath.
- The sample is poured into a boiling tube at 30°C and stirred, and stored at sub-zero temperature.
- The coagulation is quantified on the residue obtained by sieving the sample through 600-micron sieve.

EIE instruments, India: Coagulation Test Apparatus

Application

- To assess the coagulation tendency of emulsion where the ambient temperature is less than 15°C.
- Specification compliance testing for bitumen emulsion as per IS 3117, 2019 and IS 8887, 2018.

Storage Stability Test

Working Principle (IS 8887, 2018-Annex-D)

- The apparatus consists of measuring cylinder with two outlets.
- A quantity of 500 ml of emulsion is allowed to stand in a graduated cylinder for 24 hours and samples are collected from top and bottom outlets.
- The difference between the bitumen residue content collected at top and bottom outlets of measuring cylinder is a measure of the storage stability.

Storage stability cylinders

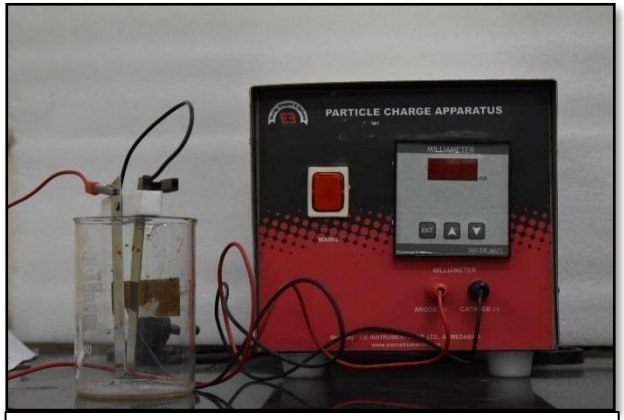
Application

- It quantifies the tendency of the bitumen globules to settle over period of time.
- Specification compliance testing for bitumen emulsion as per IS 3117, 2004 and IS 8887, 2018.

Particle Charge Test

Working Principle (IS 8887, 2018-Annex-E)

- The equipment consist of a positive and a negative electrode which are connected to a controlled direct-current source (8 mA).
- The electrodes are inserted into the emulsion, and with the passage of current an appreciable layer of bitumen is deposited on the oppositely charged electrode.



EIE instruments, India: Particle charge apparatus

Application

- Identification of the nature of emulsion whether cationic or anionic or non – ionic.
- Specification compliance testing for bitumen emulsion as per IS 3117, 2004 and IS 8887, 2018.

Coating Ability and Water Resistance Test

Working Principle (IS 8887, 2018-Annex-F)

- The equipment consist of mixing pan and blade, sieves and constant head water spraying apparatus.
-
- Aggregates coated with emulsion are sprayed using a constant head (775 mm) water sprayer.
- The coating ability is quantified visually in terms of the total aggregate surface area that is coated with bitumen after spraying.

EIE instruments, India: Constant Head Water Sprayer

Application

- This test determines the ability of an emulsion to coat an aggregate, to withstand mixing action while remain as a film on aggregate, and the resistance to washing action.
- Specification compliance testing for bitumen emulsion as per IS 3117, 2004 and IS 8887, 2018.

Saybolt Furol Viscometer

Working Principle (IS 3117, 2004)

- The equipment consists of oil tube, thermometer, receiving flask, timing device, and pipette.
- It is used to measure the viscosity of bituminous emulsion.
- The viscosity is measured as the time required for 60 ml of emulsion to flow through a calibrated orifice under controlled temperature.

HEICO, India:
Saybolt Furol viscometer

Application

- To determine the viscosity of bitumen emulsion
  - 25°C (slow setting emulsion) and
  - 50°C (medium and rapid setting emulsion)
- Specification compliance testing for bitumen emulsion as per IS 3117, 2004 and IS 8887, 2018.