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GUIDELINES FOR SELECTION, OPERATION AND MAINTENANCE OF BITUMINOUS HOT MIX PLANT

(FIRST REVISION)

INDIAN ROADS CONGRESS

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INTRODUCTION

There has been significant advancement in hot mix plant technology over the last two decades. This has prompted the revision of the document titled "Guidelines For Selection, Operation and Maintenance of Bituminous Hot Mix Plants" (IRC:90-1985) to update the same. With continued emphasis on mechanisation in road construction it is necessary to familiarize the consultants, contractors, concessionaires, planning and construction engineers with the technology aspects of hot mix plants and enable them to select the appropriate type of hot mix plant, operate the plant in an optimum manner with minimum downtime. It is hoped that this document will serve its intended purpose. The changes in the design of hot mix plants at various spell of time have been described in detail.

Scope

The Guidelines cover the following aspects :

a) Background

b) Purpose of Hot Mix Plant

c) Classification of hot mix plants, their salient, advantages and limitations.

d) Information to be furnished by the purchaser, while making an enquiry with the manufacturer

e) Information to be supplied by the manufacturer to the purchaser

f) Sample procedure for calculation or usages charges of Hot Mix Plant

g) Operation of Hot Mix Plant

h) Maintenance and upkeep of Hot Mix Plant

i) Major factors affecting the performance of Hot Mix Plant

j) Effect of moisture content, dust, altitude on output

k) Parmeters for the Selection of Hot Mix Plant

l) Calibration of Hot Mix Plant

The Secretary General IRC and the Convenor of the Mechanisation Committee (G-4), took a decision to revise the document and make it more contemporary and relevant. Thus, the task of revision of document was assigned to Shri R.K. Saxena, SE (Mech.) (Retd.), MORT&H. The document was revised with great painstaking efforts. The document was then scrutinized by Shri S.N. Das, Convenor, Mechanisation Committee (G-4) & CE (Mech), MORT&H along with the officers of the Mechanical Wing of MORT&H and various important aspects were included in the document. The draft document was then circulated to the Members of the Mechanisation Committee and tabled for discussion on 25.03.2010.

The Mechanisation Committee (personnel given below) in its meeting held on 25.03.2010 finalized the Guidelines and recommended its submission to the General Specifications and Standards Committee (GSS) for their consideration.

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Verma, Maj. V.C.	....	Co-Convenor
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Ex-Officio Member

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Secretary General, IRC
(R.P. Indoria)

The revised Guidelines were approved by the General Specifications and Standards Committee (GSS) in its meeting held on 24.04.2010 and the Executive Committee in its meeting held on 10.05.2010 and authorized the Secretary General, IRC to place the same before Council. The document was approved by the IRC Council in its 191st meeting held on 22.05.2010 at Munnar (Kerala). The Convenor, Mechanisation Committee (G-4) & CE (Mech.) MORT&H was requested by DG (RD) & SS to incorporate the comments offered by the Council members. The document after incorporation of comments was approved by the Convenor, GSS Committee for printing.

1 BACKGROUND

The hot mix plant technology came into existence around 1870, in which the basic requirement for preparation of hot mix that is drying, screening, proportioning and mixing were combined. These plants were crude and remained in that shape upto the end of 1900. By 1900, the plants were improved by including aggregates bins, cold elevators, rotary dryers, hot elevators, bitumen tanks and mixing platforms which consisted of an aggregate measuring box, bitumen bucket, and pug mill mounted at sufficient height to allow horse drawn carts pass underneath. The hot mix plants up to 125 tonne per hour capacity were available by 1930. There was considerable improvement in the design of hot mix plant during 1930 to 1940, when the conveyor belts, better quality of gates, feeders in cold feeder system, large size of dryers, cyclone type dust collectors, spring less scales and pyrometer recording system were inducted. These plants were continuous as well as batch type.

In early 1950, higher capacity of plants with automatic burner control, automatic proportioning and cycling function came into use. The hot mix plant continuous type 15/20 tonne per hour capacity were imported and inducted in India during 1963 under International Development Agency project. During 1970's the most significant development took place by emerging surge and storage bins; computerized control system and improvement in noise and dust control system in hot mix plant, considering health and safety aspect of operating staff. These plants were based on continuous production process, were simpler in design and more portable. The hot mix plants 20/30 tonne per hour capacity were indigenously developed in India during mid 70's and a good fleet worked successfully upto 90's. During late 1970 and early 1980's, there was sharp increase in petroleum price. Thus, further development took place in the design of hot mix plant making it more fuel efficient, reusing milled bituminous pavement known as "Reclaimed Bituminous Pavement" (RBP) to preserve the natural resources of aggregates and keep the environment free from pollutants. In Europe, USA and other parts of the world, asphalt is used as binder. Therefore, the pavement to be laid is known as asphalt pavement and reused milled asphalt pavement as "Reclaimed Asphalt Pavement" (RAP). In India bitumen is used as binder. Therefore, these terminologies are known as bituminous pavement and Reclaimed Bituminous Pavement" (RBP). Since, heating, drying and mixing took place in the same drum, these plants became popular with the name "Drum Mix Plant".

By the end of year 2000, further development took place in the design of hot mix plant for efficient utilization of heat produced in dryer drum and use of reclaimed bituminous pavement. This technology was known as double barrel technology. In this technology, the concentric chambers of same drum are used to heat the virgin aggregates and mix the same with molten bitumen, filler and reclaimed bituminous pavement.

Effort has been made in these Guidelines to get the highway engineers acquainted with different type of hot mix plants available in international market. It will facilitate selection of the hot mix plant in the region for preparation of hot mix depending upon the quantum of work, availability of aggregates, fuel efficiency and use of reclaimed bituminous pavement.

2 PURPOSE

The purpose of hot mix plant is:

a) To blend different sizes of aggregates in specified proportion.

b) To dry the aggregates (reduce moisture content to below 0.5 percent) and heat them to the specified temperature.

c) To heat the bitumen uniformly at specified temperature.

d) To feed controlled quantity of bitumen and filler in the specified proportion.

e) To mix the aggregates with bitumen and filler thoroughly and uniformly to produce homogenous mix at the specified temperature

f) To run in a safe, environment-friendly and reliable manner to carry out the above tasks accurately and consistently.

3 CLASSIFICATION

The plant is classified based on its capacity, type of flow of aggregates and hot gases in dryer drum, methodology adopted for preparation of hot mix.

3.1 Capacity of Hot Mix Plant

As per IS 3066-1965 and IS 5890-2004, the capacity of hot mix plant is given in tonne per hour and is specified in the following manner for two different values of the moisture content in the aggregates :

a) Output of plant at 6 percent moisture content in aggregates .

b) Output of plant at 2 percent moisture content in aggregates.

The hot mix plant 40/60 tonne per hour capacity specifies that the output of plant shall be 40 tonne per hour at 6 percent moisture content present in aggregates and 60 tonne per hour at 2 percent moisture content present in aggregates.

3.2 Methodology Adopted for Preparation of Hot Mix

Hot mix is prepared in hot mix plant either on continuous operation basis or in batch.

According to preparation of hot mix, hot mix plants are divided into two categories.

a) Continuous type

b) Batch type

3.2.1 *Hot mix plant (continuous type)*

In continuous type of plant, aggregates, fines and bitumen are continuously inducted into pugmill/drum mix in desired proportion and hot mix discharged without interruption.

3.2.2 *Hot mix plant (batch type)*

In batch type plant, hot bitumen is added with the batch of hot aggregates and filler (if necessary) at desired temperature in desired proportion in mixing unit. The mix prepared in batch is transferred either into silo for its storage or directly fed into tipper for transportation. This process of batch transfer continues one after the other. The batch type hot mix plant is classified based on capacity, type of flow of aggregates and hot gases, screening system adopted for grading the aggregates , quantity of hot mix prepared per batch and number of batches prepared per hour.

The batch type hot mix plants upto 400 tonne per hour capacity are available internationally.

Flow of material (aggregates, bitumen and fines) is similar for various designs of hot mix plants except the method of screening, proportioning and mixing.

Plant capacity is specified in number of batches produced per hour. Normally, one batch is prepared within 45 to 60 seconds.

3.3 Direction of Flow of Aggregates and Hot Gases

The direction of flow of aggregates and hot gases in dryer drum specify the type of flow in the plant. It may be of two types.

a) *Counter flow type*: In this type of plant, virgin aggregates enter the end from where exhaust gases are discharged. The aggregates and hot gases flow in opposite direction inside the dryer drum, which increases efficiency of heat transfer process, lowers exit gas temperature, reduces the plant emission and fuel consumption.

b) *Parallel flow type*: In this type of plant, aggregates and hot gases flow in same direction inside the dryer drum. This type of drum mixer has certain limitations, which are given below:

1) The thermal efficiency of plant is on lower side due to low heat transfer inside the drum mixer. As a result, fuel consumption is on the higher side.
2) The stack temperature is high, as most of the drying process of aggregates takes place near the burner zone.
3) High blast of air from burner carries the dust from dry aggregates through the exhaust, resulting in environmental hazards.

3.3.1 *Counter flow type dryer-mixer*

Three different types of dryer-mixers under this category are described below:

a) Counter Flow Drum Mix Coater **(Fig. 1)**

In this type of dryer-mixer, the virgin aggregates flow opposite to the hot gases in the dryer and enter the coater. The reclaimed bituminous pavement may also enter into the coater or mixing section along with the virgin aggregates in super heated condition, which in turn heats the reclaimed material.

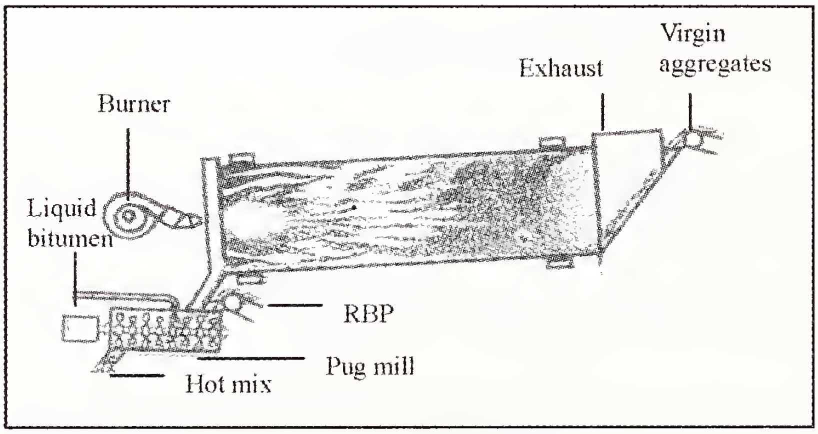


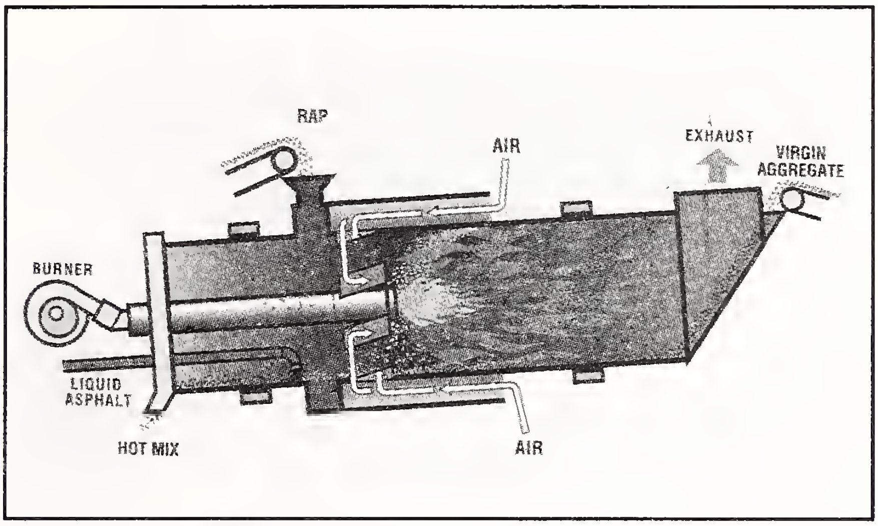
Fig. 1 Counter Flow Drum Mix Coater

The disadvantage of this type of drum mixer is that the hot virgin aggregates, liquid bitumen and reclaimed bituminous pavement are injected at approximately the same time in the coater, thus the mixing time is short in the coater.

In case higher percentage of reclaimed bituminous pavement is used, the short mixing time produces less homogeneous mixture.

b) Counter Flow Drum Mixer with Embedded Burner **(Fig. 2)**

In this type of mixer, the burner is in inserted position inside the drum. The reclaimed bituminous pavement is injected down stream of the burner, where it mixes with virgin aggregates and liquid bitumen. The disadvantage of this plant is that mixing time is short and to maintain the burner is cumbersome process, since its key components are not accessible. Thus, this type of drum mixer could not become popular.



COUNTERFLOW DRUM MIXER WITH EMBEDDED BURNER AND AIR - COOLED SHEEL

Fig. 2 Counter Flow Drum Mixer with Embedded Burner

c) Double Barrel Drum Mixer **(Fig. 3)**

In this type of mixer, the transfer of heat from virgin aggregates to reclaimed bituminous pavement is very effective due to sufficient mixing time. Thus, the mix produced is homogenous.

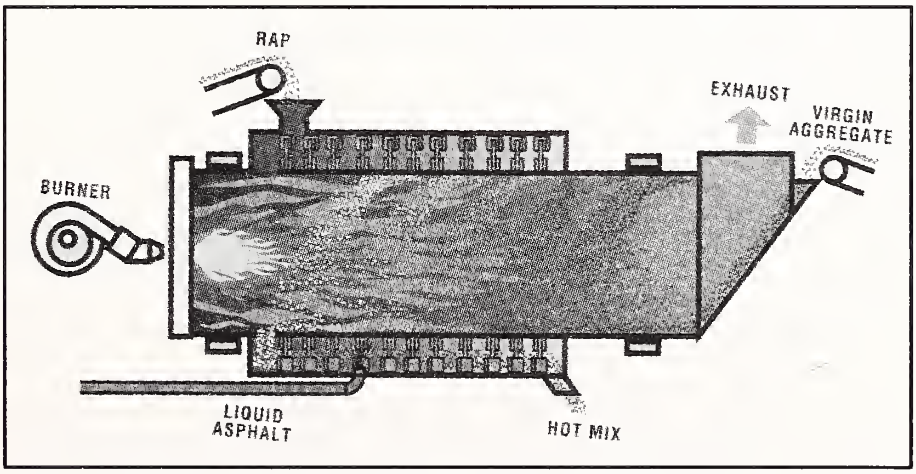


Fig. 3 Double Barrel Drum Mixer

3.3.2 *Parallel flow type drum mixer*

Three different type of mixers under this category are shown below.

a) Parallel Flow Plain Drum Mixer **(Fig. 4)**

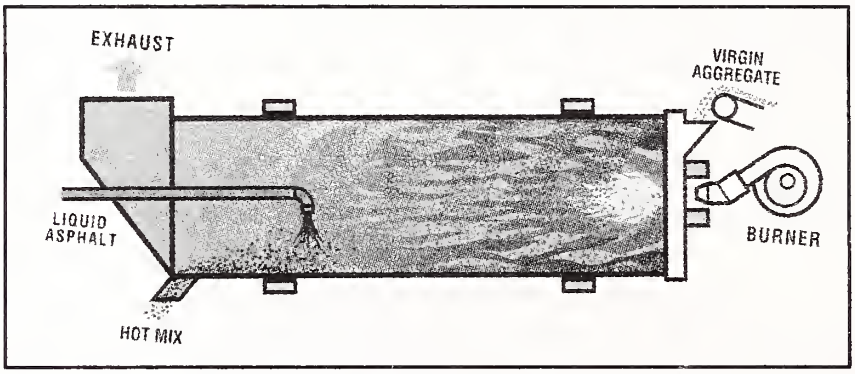


Fig. 4 Parallel Flow Plain Drum Mixer

It is a common type of parallel flow drum mixer and is being widely used in different road projects in India, since its induction in late eighties.

b) Drum Mixer with Centre Inlet for RBP **(Fig. 5)**

This type of drum mixer was developed in 1970's due to increase in crude oil prices. It has resulted in the use of reclaimed bituminous pavement. It is similar in design to plain drum mixer except a hole in the shell of drum to induct Reclaimed Bituminous Pavement (RBP). This plant is suitable for use of reclaimed bituminous pavement up to 30 percent.

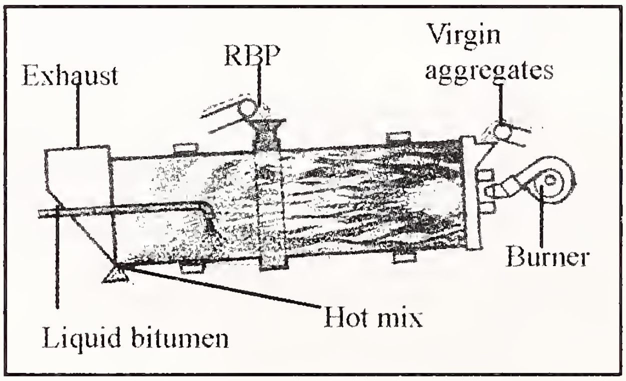


Fig. 5 Parallel Flow Drum Mixer with Centre Inlet for RBP

c) Drum Mixer with Coater **(Fig. 6)**

It is a parallel flow type drum mixer, in which hot gases and aggregates move in same direction and reclaimed bituminous pavement is added in cooler zone and mixed with liquid bitumen in a mixer or coater located at the discharge end of the drum. It gives more time for mixing reclaimed bituminous pavement with virgin aggregates and liquid bitumen. It produces good quality of homogenous mix using reclaimed bituminous pavement.

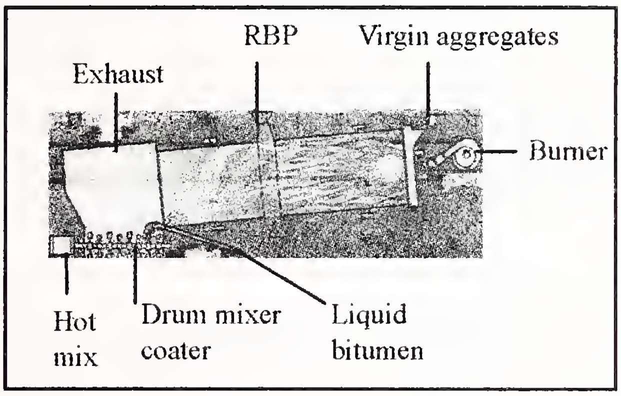


Fig. 6 Parallel Flow Type Drum Mixer with Coater

In this type of drum mixer approximately 70 percent of reclaimed material is heated by virgin aggregates and 30 percent by hot gases.

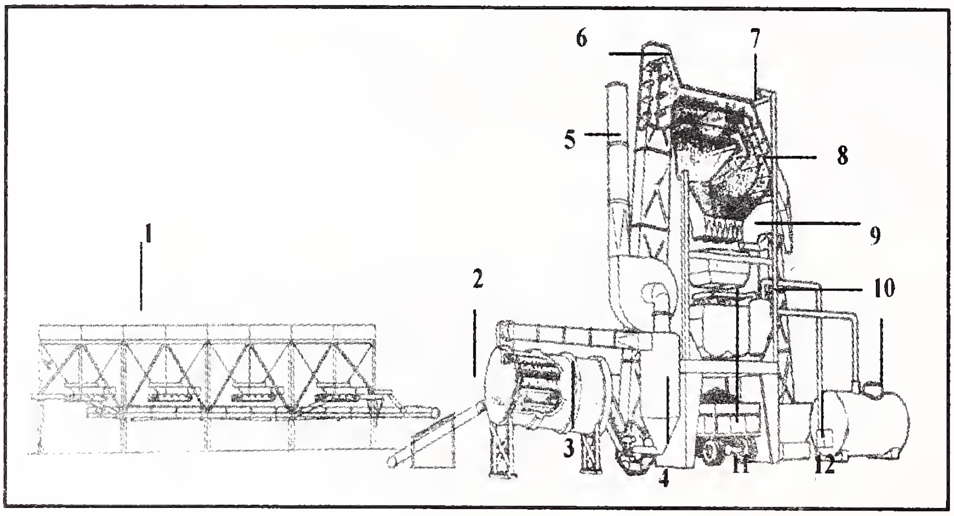
3.4 Mobility of Hot Mix Plant

The hot mix plant whether batch type or continuous type may be categorized based on two factors. a) Stationary type and b) Mobile type. Stationary type plants are more rigid and normally used in construction of flexible pavement, where quantum of work is more and frequently available to keep the plant engaged. In case quantum of work is small and plant needs frequent shifting, mobile type of plant is preferred. Major units of mobile type drum mix plant are fitted with pneumatic tyres, which make it convenient to tow it from one place to another. Mobile batch type hot mix plant does not require a crane of bigger capacity for its commissioning and dismantling. Nowadays a third category of hot mix plant known as self-erecting or portable type is also in use. In this case, the plants have an integrated foundation on which it can be erected.

4 SALIENT FEATURES OF BATCH TYPE HOT MIX PLANT

4.1 Components of Hot Mix Plant (Batch Type)

The essential components of hot mix plant (batch type) are given in **Fig. 7**. In addition, Secondary pollution control device (Bag House Filter) and Hot mix surge silo are optional components of batch type hot mix plant. The brief details of the components are given below:



1- Cold Bin Feeder, 2- Cold Elevator/Cold Feed Conveyor, 3- Dryer Drum, 4- Primary Pollution Control Device, 5- Exhaust Stack, 6- Hot Elevator, 7- Screening Unit, 8- Hot Bins, 9- Weigh Box, 10- Bitumen Unit, 11- Mixing Unit (Pugmill), 12- Mineral Filler (Dust Collection System), 13- Control Panel (Not shown)

Fig. 7 Different Components of Hot Mix Plant (Batch Type)

4.1.1 *Cold bin feeder*

a) It contains minimum 4 Nos. bins with separators between them, to avoid inter mixing of aggregates being loaded in different bins.

b) The bin walls and bin gates are so designed as to prevent arching and ensure smooth flow of aggregates.

c) Bin gates have a graded scale to control the amount of gate-opening.

d) The capacity of all four bins is sufficient to run the plant for minimum 30 minutes.

e) The first bin containing fines is provided with a bin vibrator **(Fig. 8)** to avoid sticking of fines with the bin wall.

f) Variable speed motor (DC/AC) is provided below each bin, to control the speed of conveyor belt, to vary aggregates proportion.

g) One gathering conveyor is provided to collect aggregates of different sizes from the conveyors fitted under each bin.

h) Properly designed and calibrated bin gate are provided for smooth flow of aggregates.

i) Single deck vibratory screen is provided at discharge end of gathering conveyor to remove over size aggregates.

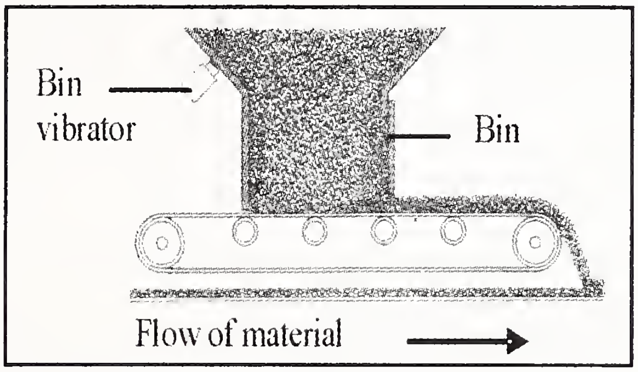


Fig. 8 Position of Bin Vibrator in 1st Bin

4.1.2 *Cold elevator or cold feed conveyor*

It feeds the aggregates received from gathering conveyor to dryer drum. The conveyor used is known as slinger conveyor.

4.1.3 *Dryer drum*

It plays a vital role in the performance of hot mix plant. It is revolving cylindrical drum normally ranging between 1.5 to 3.0 m in diameter and 6 to 12 m in length depending upon the capacity of plant. The drum is in inclined position and its length to diameter ratio is 4 to 6. It includes burner and blower fan, which provides primary air for combustion of fuel and an exhaust fan to create a draft through the dryer. The drum is fitted with longitudinal trough or channels called flights mounted with bolts and nuts. The flights lift the aggregates and drop it in veils through the burner flame and hot gases. The dwell time (retention time for aggregates in dryer drum) will depend on the slope of the dryer drum, its revolutions per minute, diameter, length, number of flights and their arrangement, and efficiency of burner. The balance between fuel and air supply should be maintained for complete combustion and efficient dryer operation. Imbalance between draft air and blower air velocities can cause a back pressure within the drum, which should be maintained.

Normally, dryers are designed to heat and dry the aggregates at 4 to 6 percent moisture content for maximum efficiency. If moisture content present in aggregates increases, the feeding of aggregates into dryer drum is reduced, resulting in drop in hourly production capacity of plant.

The temperature of the aggregates controls the temperature of mix. The layer of bitumen put on each particle of aggregates during mixing achieves the aggregates temperature instantaneously. The aggregates heated at high temperature can harden the bitumen during mixing while underheated aggregates cannot get a proper coating of bitumen. Therefore, aggregates should be heated uniformly at appropriate temperature to achieve homogenous mix. The temperature of aggregates should be measured with pyrometers/ thermocouple or other suitable device by putting them at appropriate location.

4.1.3.1 Burner and fuel

The burner used in hot mix plant is based on gas or fuel oil or a combination of them. In India, light diesel oil or furnace oil is used as fuel, hence burner should be suitable for such application. Burner should have a blower of adequate capacity to ensure efficient fuel atomization with low noise, auto ignition and flame failure detection device. The important components and the function of an efficient burner are as under:

a) Strainer	-	It removes contaminants in fuel oil and avoids trouble during operation
b) Flow Meter	-	It registers total volume of fuel oil burnt by the burner
c) Solenoid Valve	-	It opens or closes the fuel suction line based on the signal received from burner control panel.
d) Fuel Feed Pump	-	It feeds the fuel supply.
e) Relief Valve	-	It maintains the fuel pressure being fed to nozzle unit.
f) Control Valve	-	It regulates the return oil pressure from nozzle unit, thus adjusting the quantity of fuel oil atomized at the nozzle.
g) Blower	-	It supplies air for combustion including excess air.
h) Air Damper	-	It regulates the volume of air being supplied to burner in proportion with fuel oil and is fitted at the outlet of blower. The damper closes when intensity of flame is low and opens while it is high.
i) Blower and Fuel Pump Motor	-	These are low voltage, fully enclosed, fan cooled, squirrel cage induction motors to drive blower and fuel feed pump.
j) Control Motor	-	It is used to control opening of air damper and fuel return line valve through automatic temperature controller or manual switch.

k) Ignition Transformer and Electrodes	-	It transmits more than 15,000 V emitting electric spark in electrode gap to ignite fuel mist.
l) Flame Detector	-	The photo sensor detects the glare of oil flame and connects/ breaks relay contacts.
m) Automatic Temperature Indicator Controller	-	It is a microprocessor based digital indicating controller, which operates based on the signals received from a thermocouple or other sensing device fitted to measure aggregates temperature. The output signal is transmitted to control motor which adjusts air damper and fuel supply.
n) Pre-Heater	-	Heats the furnace oil to a temperature of 100-110°C to reduce its viscosity for efficient atomization/ combustion.

All controls, relays, indicators, switches, timers, pilot lamps, wiring for automatic or manual control of dryer burner are located in control panel.

The fuel oil tank should be located close to the burner and bottom of tank should be at same elevation as burner. The pipeline between burner and fuel tank should be clean, of adequate diameter with minimum bends to reduce suction resistance.

The viscosity of furnace oil is more specially during cold weather. Therefore, pre- heater of suitable capacity is provided to keep uninterrupted supply of fuel into burner.

4.1.4 *Primary pollution control device*

It is the primary dust collection system **(Fig. 9)** of hot mix plant. Its function is to remove undesirable amount of dust coming from the exhaust. It is cyclonic in shape, in which dust is collected and removed/ added to dry aggregates, if required. It consists of cyclonic separators and works on the principle of centrifugal separation. It is fitted at the rear of dryer drum. The flue gases leaving the dryer drum pass through these separators. Single cylinder cyclone basically consists of a large diameter cylindrical shell having a conical base. Dust laden gas enters this shell tangentially, which gives it spinning motion and makes it to travel upto bottom of cylinder. After reaching the bottom, it spirals up and is sucked out (vacuum created by exhaust fan) through coaxial cylinder fitted at the top. The larger size dust particles are thrown out towards the wall of the cylinder due to spinning motion of gas. These particles slide down and are collected in a hopper. These are removed through auger screw and sent to mixing zone, if desired. Multiple units of cones having longer length of cyclones, smoothness of inner wall are the main factors responsible for higher efficiency of cyclone. These are capable of removing 60 to 90 percent of dust from the dryer exhaust. Hot Mix Plant Emission and their Control are given in **Annex-C.**

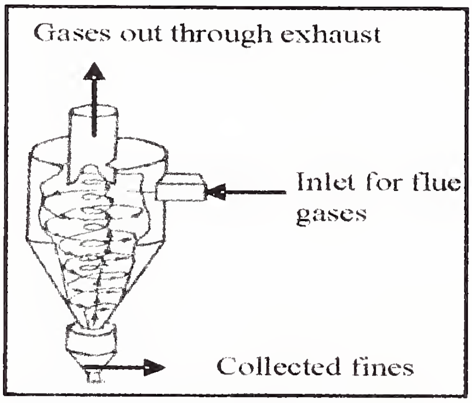


Fig. 9 Primary Dust Collector

4.1.4.1 Exhaust stack

The exhaust gases are eliminated through the plant exhaust stack. These gases further pass through the secondary pollution control device, that is bag house filter for further filtration.

4.1.5 *Hot elevator*

The aggregates after heating and drying are carried by a hot elevator (bucket conveyor system) to the gradation unit. A stone box is provided at the edge of hot elevator discharge chute, which lowers and smoothens the flow speed of aggregates falling on screen sieves. However, in case of tower model where the dryer is at the top, there is no need for any hot elevator.

4.1.6 *Screening unit*

The primary gradation of aggregates is done in cold bin feeder system. The secondary gradation of aggregates, in hot condition, is carried out in screening unit. Thus it is known as second gradation control unit of hot mix plant batch type. The screening of hot aggregates is essential in batch type hot mix plants to feed appropriate quantity of graded hot aggregates in each batch. Normally, two designs of plants have been adopted to separate different size of aggregates.

a) Through multi-deck vibratory screening

b) Through rotary screening

4.1.6.1 Hot mix plant (batch type) fitted with multi-deck vibratory screen **(Fig. 10)**

The screening in multi deck vibrating screen is done through reciprocating motion. In multi-deck vibratory screening, the aggregates after heating are taken through hot elevator to vibrating screen for second gradation **(Fig. 11 and 12)**.

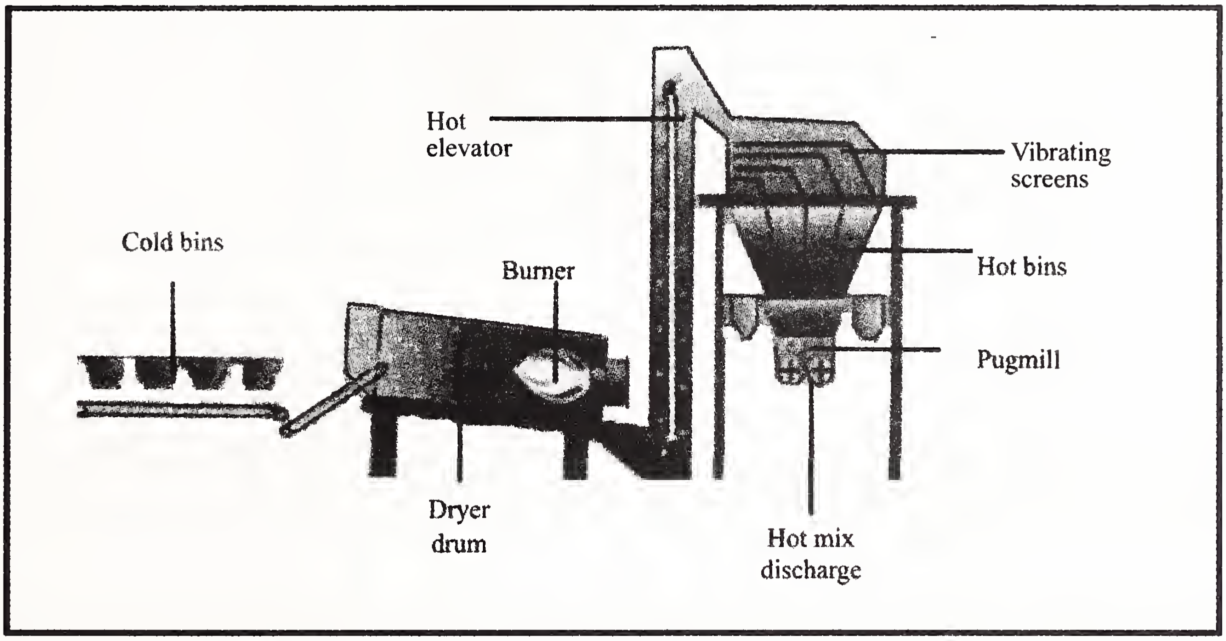


Fig. 10 Hot Mix Plant (Batch Type) fitted with Multi Deck Vibratory Screen

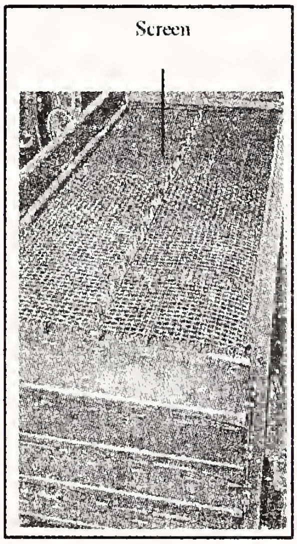


Fig.11 Different sizes of Screens in Sequence one over another

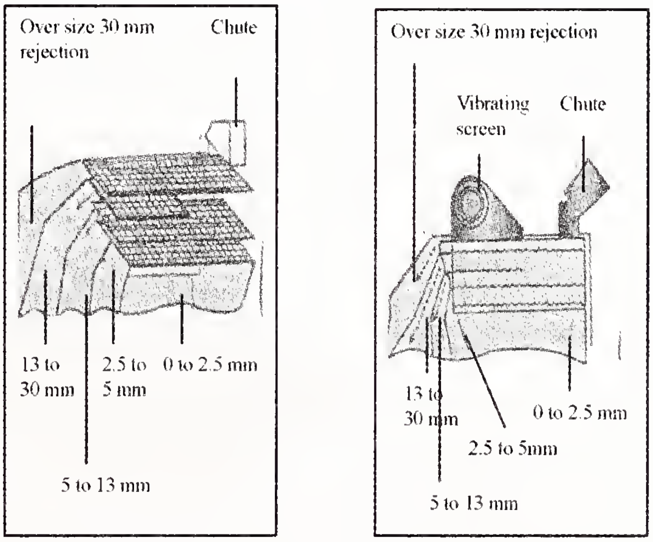


Fig.12 Screening the Aggregates to Achieve Specified Sizes through Reciprocating Motion

The hot aggregates received through hot elevator pass over a series of vibrating screens of different sizes, which separates them into specific sizes and deposits into hot bins.

4.1.6.2 Hot mix plant (batch type) fitted with rotary screen **(Fig. 13)**

In rotary screening, cold aggregates are taken into screening drum, where screening and heating takes place simultaneously. In both cases, graded material is collected in hot bins.

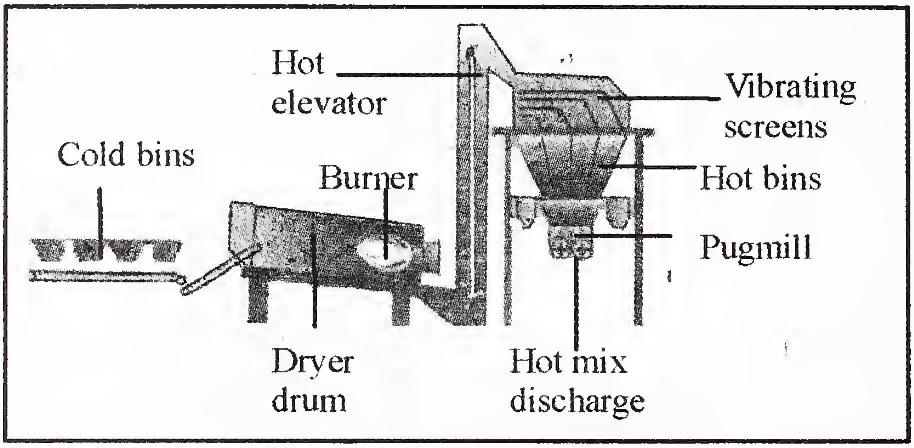


Fig. 13 Hot Mix Plant (Batch Type) Fitted with Rotary Screen

The heat losses in screening and dryer drum are lesser, thus thermal efficiency of hot mix plant (batch type) fitted with rotary motion is higher. Besides, the maintenance of this type of plant is also less.

In rotary screening unit, cold aggregates received from cold bin feeder are fed into drum, in which drying and screening of aggregates takes place in same drum via counter flow process **(Fig. 14).** The drum is inclined and mounted on two tire rings. The shovel flights are fitted to the internal surface along the drum length to move the aggregates and form an efficient drying curtain. Four sections of screens with screw flight plates on outer surface sieve the various sized aggregates and deposit heated aggregates into different compartments of hot bins. The over sized aggregates are removed for disposal. The vacuum drum pressure device fitted to control the rotary actuator at exhaust fan regulates the air flow.

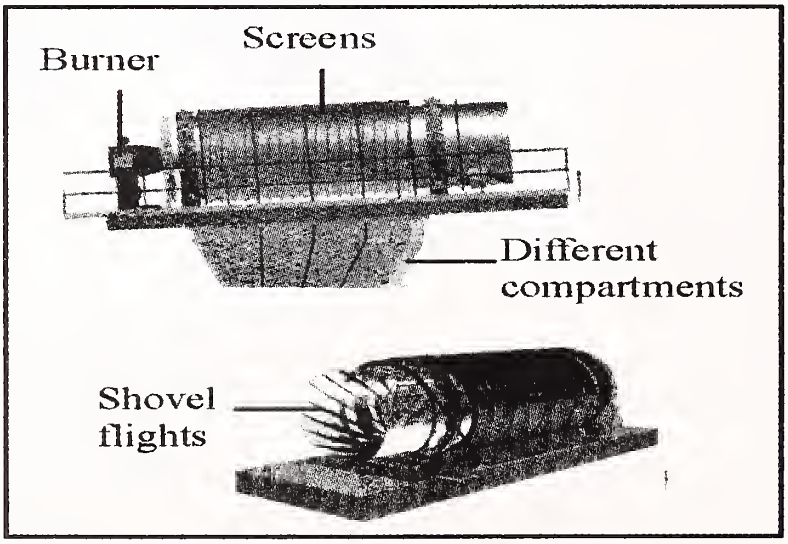


Fig. 14 Screening of Aggregates through Rotary Motion

4.1.6.3 Hot screens

For multi-deck vibratory screening unit, the screen provided at the top is a scalping screen, which rejects and carries off oversized aggregates. It is followed by two intermediate sized screens decreasing in size from top to bottom and last is fine screen. For rotary screening unit, the screen configuration along the direction of aggregates flow is reverse to that of multi-deck vibratory screening unit. That is, the first screen is the fines screen, whereas the last screen is the scalping or oversized rejection screen.

The function of the screens is to separate the aggregates into specific sizes. The screens must be clean, robust and their capacity matching with the capacity of dryer drum and pugmill. Induction of finer aggregates into a bin intended to contain next larger size fraction is called carry over. The carry over affects the mix design formula. Carry over more than the prescribed limit can add the fines present in aggregates in total mix, thus increasing the surface area to be covered with bitumen. To prevent excessive carryover, screens should be checked daily for cleanliness.

4.1.7 *Hot bins*

These are used to store the heated and screened aggregates of various sizes temporarily **(Fig. 15).** Each bin is an individual compartment or a segment at large compartment with division by partitions which are minimum 4 Nos. The capacity of each hot bin should be sufficient enough to hold the aggregates of each size and avoid their intermingling, when the plant is operating at full capacity. Normally, the capacity of all hot bins should be of about ten batches production.

Each bin should be equipped with an overflow pipe to prevent the excess amount of aggregates from backing up into other bins. The overflow pipes should be set to stop overfilling of the bins. Overflow vents should be checked frequently to ensure that they are flowing. If a bin overfills, the screen above it rides on the aggregates, resulting in heavy carryover and the possibility of damage to the screen. Each compartment is equipped with pneumatically actuated two stage discharge gates controlled by the computer system. It is fitted with a maximum level indicator wired remotely to control the quantity of aggregates in bins and warn the operator when bins are full. Hot bins should not be allowed to run empty/ starving also. Any shortage or excess of aggregates in the hot bins should be regularized, by adjusting the aggregates supply from respective bin of cold bin feeder. Any leakage at the bottom of hot bins should be immediately repaired to avoid improper mix gradation.

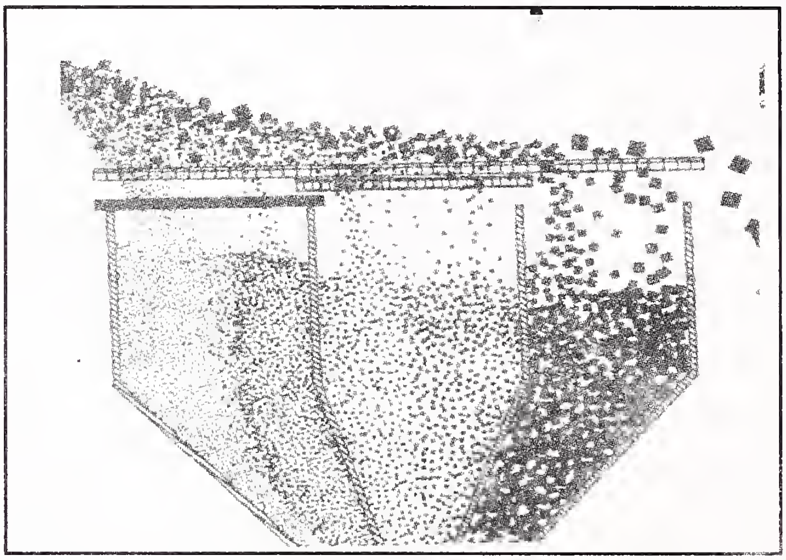


Fig. 15 Segregation of Aggregates in each Hot Bin

4.1.7.1 Hot bin levelling indicator

It detects the quantity of aggregates stored in hot bins and indicates when it falls below a certain level **(Fig. 16).** The indicators may be operated either electronically or mechanically. Presently, electronic indicators mounted on the side of the bins are used. Aggregates inside the bin apply pressure on the walls of the bin, which controls the operation of diaphragm and indicator. In case aggregates drop to a predetermined level, it is displayed through indicating lamps/warning sign in control panel.

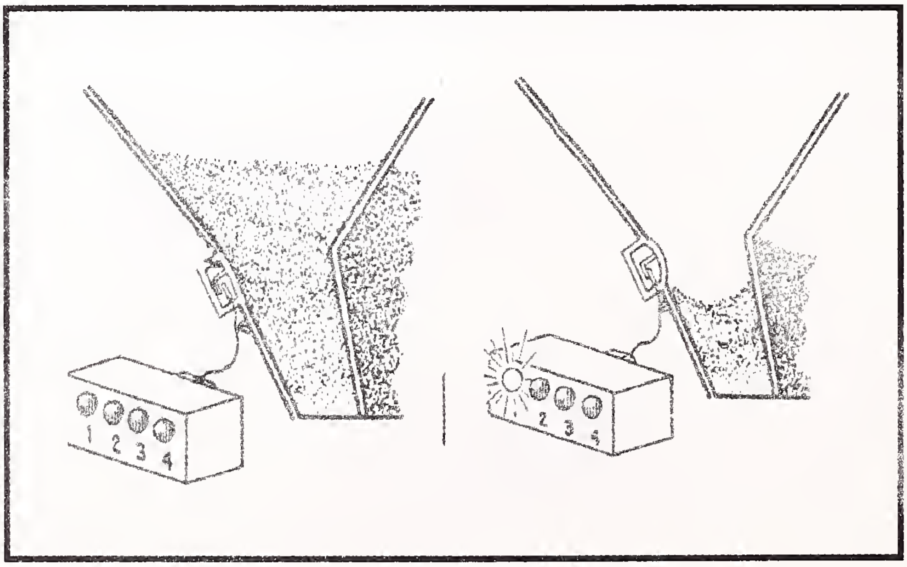


Fig. 16 Hot Bin Levelling Indicator

4.1.7.2 Aggregates temperature measurement device

The temperature of aggregates is measured by providing thermocouple in first hot bin, which contains fines.

4.1.7.3 Bin sampling device

This device **(Fig. 17)** is provided in the plant to take sample of hot aggregates from bins and to check their segregation. It diverts the flow of aggregates from feeders or gates under hot bins into sample containers. It is essential that sampling device be located such, as to collect representative samples of material in bins. It is seen from the flow of material over the screen in the plant that fine particles fall to one side of each bin and coarse particles to other side. Therefore, the position of sampling device in stream of material discharged from a bin determines whether the sample contains a fine portion, a coarse portion or an accurate proportion of material in bin. It assists in calibrating the grading of aggregates.

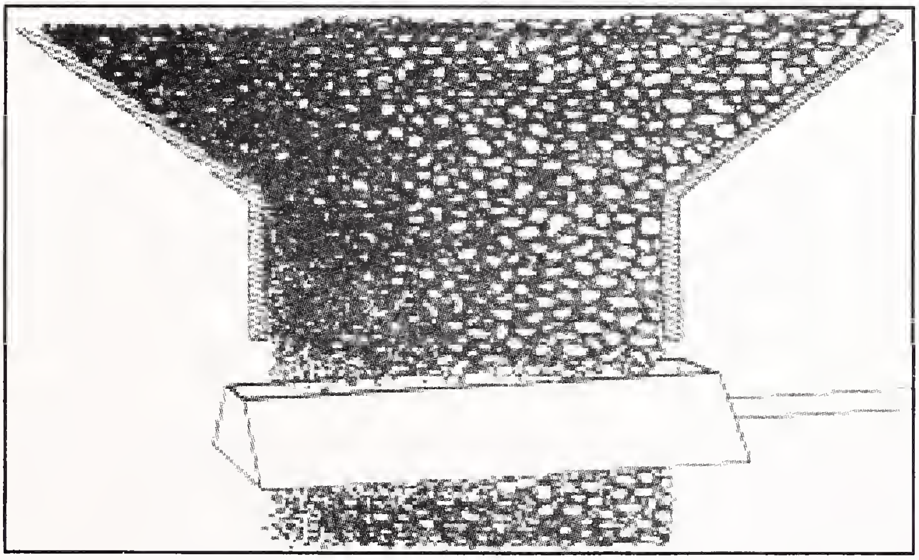


Fig. 17 Bin Sampling Device

4.1.8 *Weigh hopper*

The aggregates are withdrawn from hot bins in desired quantity through load cell and accumulated in weigh hopper. The sequence of collection of aggregates in weigh hopper is coarse aggregates first, intermediate sized aggregates next and fine aggregates in the last. This sequence is designed to place the fine fractions at the top of weigh hopper, so that they cannot leak out through the gate at the bottom of weigh hopper. This system allows the most efficient utilization of available volume in weigh hopper. Aggregates, thus collected in weigh hopper are transferred into pugmill where these are blended with desired quantity of bitumen. The sequence of operations is shown in **Fig. 18.**

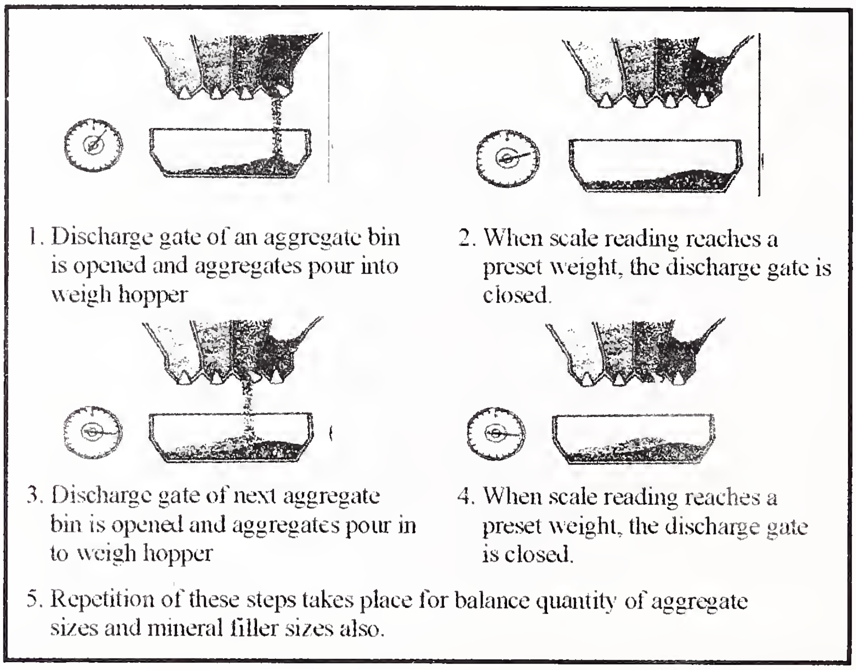


Fig. 18 Sequence of Operations used to Measure Aggregates and Mineral Filler in Weigh Box

4.1.8.1 Weighing equipment

It is used to weigh aggregates, filler and bitumen separately to achieve specified mix formula. Earlier, the weight of different constituents was being measured with spring balance system. Now, this system has been replaced with load cell which is lighter, more reliable, easy to calibrate and low in maintenance cost. The weight of each weigh hopper is measured through transducer, which sends electrical signal by a load cell. Load cell is installed at weigh hoppers with ball rod-ends, rubber vibration dampers and insulators. Following precautions are observed in this connection:

a) Lead wire of load cell may be tied 30 cm away from load cell.

b) Severe shock or excessive load more than 1.5 times the rated capacity should not be applied on load cell which may cause damage to it. Normally, load cell is designed to bear 20 to 30 percent of rated load when respective weigh hopper is full of rated load.

4.1.9 *Bitumen unit*

The unit mainly consists of bitumen tank, heating system, bitumen pump and delivery pipe.

4.1.9.1 Bitumen weigh bucket

Bitumen is weighed separately in weigh bucket **(Fig. 19)** before being inducted into pugmill. When the weight of bitumen reaches a pre-determined level in the bucket, a valve in delivery line closes it, which prevents its excess entry into bucket. The bitumen is then pumped into pugmill through spray bar.

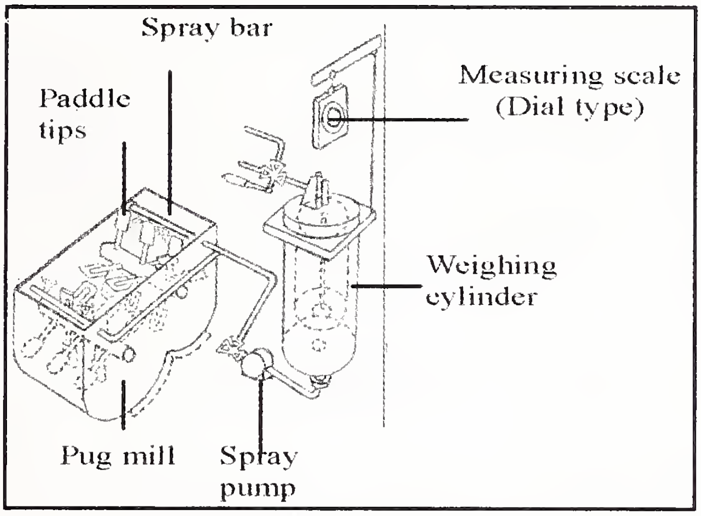


Fig. 19 System to Measure and Deliver desired Quantity of Bitumen in Pugmill

4.1.9.2 Bitumen tank

It is an insulated tank, of adequate capacity (minimum one day storage) meeting to the requirement of plant capacity. Minimum 2 Nos. bitumen tanks each of 45,000 litre capacity should be provided for smooth running of 165 tonne per hour capacity hot mix plant. Dial indicator type thermometer is provided outside the tank to indicate the temperature of bitumen.

The heating system of bitumen should be efficient, having good fluidity of bitumen for its easy pumping and spraying to get uniform coating on aggregates. The source used for heating may be through direct heating, thermic oil heating or electric heating. The viscosity of bitumen decreases with increase in temperature. Therefore, bitumen heating will depend on its grade. The heating temperature of modified bitumen is kept approximately 10°C above ordinary bitumen temperature. The heating may be done in any of the following ways:

a) Direct heating system

In this system , flue tube along with burner is provided in bitumen tank. Burner operated with light diesel oil/ furnace oil heats the bitumen around flue tube.

Thermic oil heating system **(Fig. 20)**

In this system, hot oil received from hot oil heater is circulated through the coils in bitumen tank, bitumen pump, spray pump, delivery pipe, bitumen weighing tank, spray bar and pugmill; to keep the bitumen supply uniform and maintain the temperature. It is provided with independent automatic control panel including oil temperature indicating controller, low level switch, low circulation pressure switch, over temperature cut off thermostat, burner control relays, burner operating circuits etc. Indicating type thermometer to show the temperature of thermic oil and bitumen should be provided at appropriate location for its visibility. It heats the bitumen and keeps bitumen tank, piping and weighing hopper at constant temperature. Its operation is pollution free.

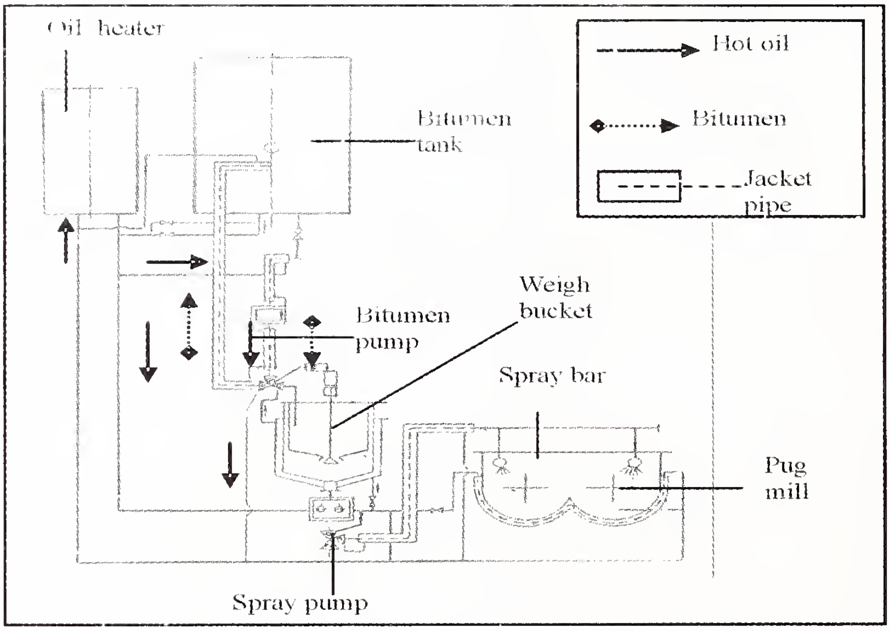


Fig. 20 Heating of Bitumen through Thermic Oil System

4.1.10 *Mixing unit (pugmill)*

It is the chamber in which bitumen and aggregates are mixed thoroughly to achieve homogenous mix. A lined mixing chamber with two horizontal shafts containing several paddle arms and paddle tips are mounted. The paddle tips can be adjusted and replaced easily. Paddles arms and tips are made of wear resistant high nickel hardened cast alloy steel for longer service life and low maintenance cost. It has hot oil jacketing system to avoid drop in mix temperature. The paddles must be set such that there are no dead areas in the pugmill. The dead area is a place where material can accumulate out of reach of paddles and cannot be mixed thoroughly. Dead areas can be avoided by assuring that clearance between paddle tip and the liner is less than half the maximum aggregates size. The quantity of material to be fed in pugmill is very important to achieve the homogenous mix **(Fig. 21)**. If material level is too high, the upper most material tends to float above the paddles and does not mix thoroughly. Conversely, too little material in pug mill results in raking of tip paddles through the material without actually mixing it.

Therefore, to achieve the maximum operating efficiency , the paddle tips should be barely visible at the surface of material during mixing.

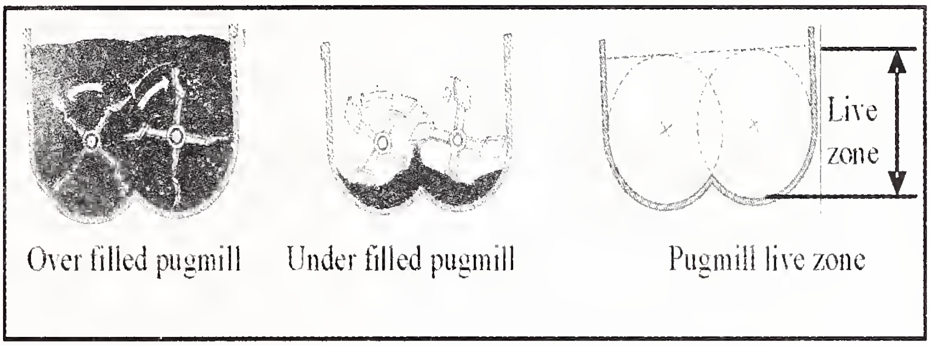


Fig. 21 Effect of Feed Material in Pug Mill

4.1.10.1 Mixing cycle

It is the cycle during which bitumen, aggregates and mineral filler are blended in pugmill of hot mix plant.

4.1.10.2 Batch mixing time

It is the time between opening of weigh hopper gate and closing of pugmill discharge gate. During this period, the aggregates and bitumen are properly mixed and homogenous mixture of thoroughly cooked particles achieved. The batch mixing time should be minimum and such that homogenous mixture of evenly distributed and uniformly coated aggregates particles is achieved. The sequence of operations in Pugmill is shown in **Fig. 22**. The improvement in design and techniques result in lowering the mixing time and achieve the mix as per specification. Longer mixing time will adversely affect quality of mix, due to exposure of thin bitumen film to high aggregates temperature in the presence of air, thus causing oxidation of bitumen. It will also result in drop in the capacity of plant. Thus, the production cost will increase.

Normally, batch mixing time of the plant begins with 30 second mix cycle. The optimum mixing time will depend upon type of aggregates, design of mix, presence of moisture in aggregates, viscosity of bitumen, shape and size of pugmill; shape, size number of paddle tips and their arrangement, peripheral speed of paddle tips, type and quantity of bitumen flow, method adopted for adding aggregates and their sequence, size of pugmill v/s batch size, condition of pugmill, operator's efficiency.

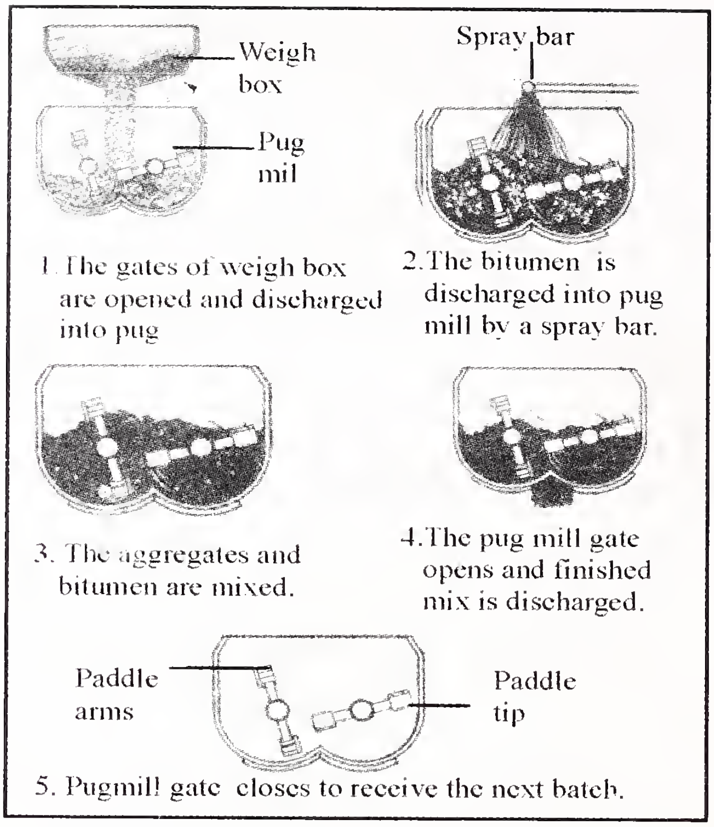


Fig. 22 Sequence of Operations in Pugmill

In batch type plant, mixing is a continuous process. Therefore, a hopper of smaller capacity for temporary holding is provided at the discharge end of the mixer to store the material until it can be delivered in a hauling truck.

If reclaimed material is to be processed in the plant, the reclaimed bitumen pavement material is placed in a separate cold bin and transferred to the pug mill through a charging conveyor. The reclaimed material is added in desired proportion to the aggregates that has been superheated in dryer drum. The heat transfer and mixing of two materials is done as they move through the pug mill.

4.1.11 *Mineral filler/dust control system*

The mineral filler such as rock dust, hydrated lime or cement are used for the purpose and stored in a separate chamber to protect it from dampness and to avoid its choking/ hardening from moistures. The system consists of (a) a screw feeder which carries filler from filler tank of adequate capacity (b) a screw feeder to carry dust collected from bag filter and merge both of them into a common chute known as filler stock bin. Transportation of filler from filler bin to weigh hopper is conducted either pneumatically or mechanically. In pneumatic system, mineral filler is sent under air stream and handled as a fluid. It is more accurate control system which eliminates the chances of plugging. The mechanical system consists of a receiving hopper, screw conveyor, dust tight elevator to charge an elevated silo with a vane feeder to meter the fines into the plant. The rotary valve is installed at the outlet of the filler bin, wherein rotary plates equipped within the rotor rotate and transfer the filler through the flapper gate, which is driven by air cylinder installed at lower part of the rotor. It opens/closes as per the requirement of filler into weigh hopper.

4.1.12 *Control panel*

In batch type plant, aggregates and bitumen are mixed in batch, which is controlled by opening and closing of weigh hopper, discharge gate, bitumen valve, pugmill discharge gate with preset automatically controlled timing device. Automatic proportioning and cycling control work together through preset interlocking devices. Automatic dryer control regulates the temperature of aggregates discharged from dryer automatically within a preset range. The control panel for batching console contains switches, circuits for automatic batching including preset controls for weigh batch, interlock controls, tolerance controls and limit switches.

The control panel consists of an air conditioned cabin to avoid the effect of heat, dust and vibration; which can cause malfunctions in the system. It incorporates all controllers, indicators including bin leveler, relays, switches, timers, pilot lamps, wiring for operation of all components. The function of complete plant including operation of different electric motors is controlled from control panel.

In addition to above, following controls of plant are exercised and the information displayed in control panel:

a) Plant load (set as percent of plant capacity)

b) Composition of different materials:
   1) Plant load
   2) Moisture content
   3) Aggregates bins
   4) Bitumen
   5) Mineral filler

c) Running weight of materials:
   1) Quantity of aggregates in tonne per batch
   2) Quantity of bitumen in kilogram per batch
   3) Quantity of mineral filler in kilogram per batch

d) Total quantity of materials flow during specific period
   1) Aggregates in tonne

2) Bitumen in kilogram

3) Mineral filler in kilogram

4) Total production of mix (1+2+3) in tonne

e) Temperature of

1) Bitumen

2) Aggregates

3) Hot mix

4.1.13 *Secondary pollution control device (bag house filter)*

It consists of a large metal housing containing hundreds of inverted, tabular, synthetic, heat resistant fabric filters. The function of a bag house filter **(Fig. 23)** is like a vacuum cleaner. The housing is divided into two chambers.

a) Dirty gas chamber

b) Clean gas chamber.

Dust laden flue gas enters the dirty gas chamber and subsequently to filter bags through open mouth. This gas is sucked out of the filter bags by the effect of suction pressure created by a vacuum pump. As the gas comes out of the filter bags, it gets filtered and dust is left behind on the inner walls of filter bags . Shaker arrangement (mechanical shaker or reverse air flow system) is provided to shake a portion of bags at a time, to clean them of dirt particles. The dust shaken out of the bags drops into a hopper at the bottom and is taken out/sent back to mixing chamber for its reuse, if desired. It is a highly efficient filter arrangement capable to separate large size particles up to 1 micron size with 99 percent efficiency. These filters are very expensive and should be used with great care for their optimum utilization and higher efficiency.

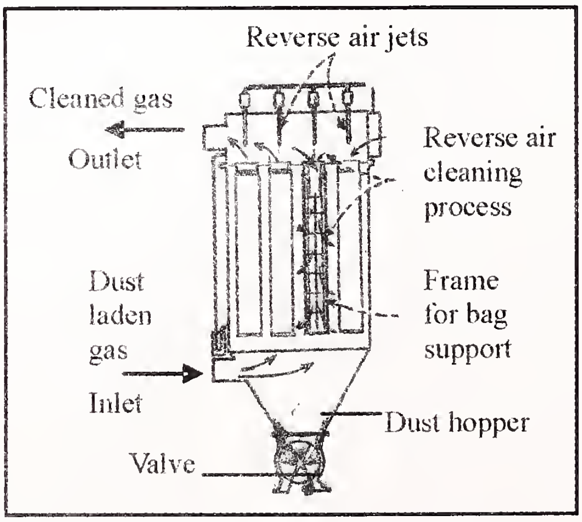


Fig. 23 Function of Bag House Filter

4.1.14 *Hot mix surge silo*

The hot mix received from hot mix plant can be loaded directly into tipper. Alternatively, same can be transferred into surge silo **(Fig. 24)** and stored temporarily till its controlled loading in tippers. It is a cylindrical shell with dual chamber, duly insulated with thermo/ ceramic wool and can maintain hot mix temperature upto 3 hours approximately. A combination of hot oil circulation and thermo/ceramic wool is capable to maintain hot mix temperature upto 16 hours approximately depending upon ambient temperature, quantity of bituminous mix and its temperature, hot oil temperature and its flow. Surge silos are normally available in the range of 50 to 200 tonne capacity. A weighing system may be connected to the holding bin of the silo, to monitor the amount of hot mix material being loaded in each tipper, which is controlled/ indicated in control panel.

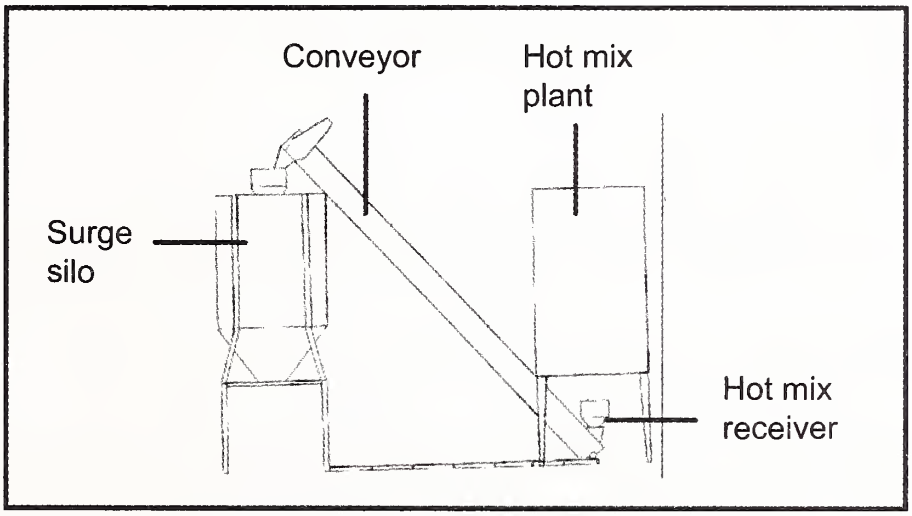


Fig. 24 Transfer of Hot Mix into Surge Silo

4.2 Selection of Site for Hot Mix Plant (Batch Type)

Following points should be considered before commissioning the hot mix plant (batch type) for its better efficiency:

a) The site should be at appropriate distance to ensure proper laying temperature.

b) The site should have sufficient space for stocking the aggregates for minimum 5 days consumption, parking of vehicles/ equipments, shed for their repair, storage of spares/fuel, staff residential sheds and other factors. Normally, 135/165 tonne per hour capacity plant shall require minimum 10,000 m^2 area.

c) Ground should be leveled and soil should have good bearing capacity to construct the foundation.

d) Site should be neat and clean for free entry and exit of tippers at plant site.

e) The environmental effects that is noise, vibration, dust, water pollution; should be considered in depth to prevent any harm to the residents or farm location.

f) Proper water drainage should be provided for smooth functioning of plant.

4.3 Advantages of Hot Mix Plant (Batch Type)

The plant is fitted with secondary gradation control unit, thus the aggregates received in pugmill are well graded. The aggregates and bitumen are measured in desired quantity per batch and mixed in pugmill. Thus, homogenous mix is received in desired proportion.

4.4 Limitations of Hot Mix Plant (Batch Type)

a) The cost of the plant is high.

b) The plant needs more space for commissioning.

c) Smaller capacity plants, less than 90 tonne per hour are not available in the market, their operation being uneconomical and not feasible.

4.5 Requirement of DG Set for Hot Mix Plant (Batch Type)

Hot mix plants are commissioned in remote area, to keep the environment pollution free. Power is not frequently available in remote areas, besides minimum fixed per kilowatt charges are also to be paid on monthly basis to Electricity Board and cabling, commissioning has also to be borne by consumer. The working period of plant is also limited. Thus, it is a costly and time consuming factor. The diesel generating set should be commissioned for economical and uninterrupted power supply to hot mix plants. Normally 500 kVA diesel generating set is required for operation of 135/165 tonne per hour capacity plant.

5 DRUM MIX PLANT

5.1 Brief

The drum mix plant was adopted in India during late 1980's, for laying bituminous mix. In drum mix plant, aggregates gradation is controlled at cold feed end and aggregates heating, drying and bitumen mixing are done in same drum. It has been adopted widely due to its a) Portability b) Higher efficiency c) Economy in basic cost d) Lower fuel consumption e) Reduction in man power and maintenance cost f) Trouble free operation g) Ability to produce large quantity of mix at relatively low temperature and h) environmental friendly.

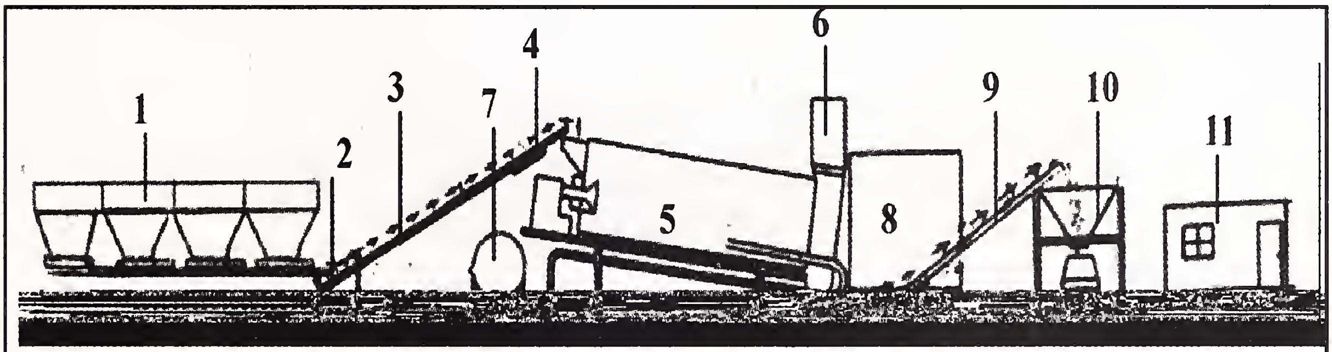
The drum mix plant may be either Parallel flow type or Counter flow type. In Parallel flow type drum mix plant, aggregates and hot gases flow in same direction inside the same drum. This is conventional type of plant and is used in India.

In Counter flow type drum mix plant, the aggregates and hot gases flow in opposite direction within the same drum. These may be of two types:

1) Drying and mixing of aggregates and bitumen takes place in same drum.
2) Drying of aggregates takes place in first drum and afterwards the dried aggregates are transferred to another drum where mixing of aggregates and bitumen takes place. This is known as dual drum plant also. A few such type of plants are in operation in India.

5.2 Components of Conventional Drum Mix Plant (Parallel Flow Type)

All the major components of drum mix plant (Parallel Flow Type) are shown in **Fig.25.** In addition to these, it includes mineral filler system. The hot mix surge silo and



1-Cold Bin Feeder (Minimum Bins-4 No.), 2-Aggregate Over size Rejection Screen, 3-Cold Feed Conveyor, 4-Automatic Weighing System, 5-Dryer cum Mixing Drum, 6-Exhaust Control System, 7-Bitumen Unit, 8-Pollution Control Device (Primary Dust Collector), 9-Hot Mix Conveyor, 10-Gob Hopper, 11-Control Cabin

Fig. 25 Major Components of Drum Mix Plant (Parallel Flow Type)

secondary pollution control device are the optional components of the plant. The brief details of the components are given below:

5.2.1 *Cold bin feeder*

The brief details have already been furnished in Para **4.1.1.**

5.2.2 *Aggregates over size rejection screen*

The brief details have already been furnished in Para **4.1.1.**

5.2.3 *Cold feed conveyor*

It is known as slinger conveyor also. The brief details have already been furnished in Para **4.1.2.**

5.2.4 *Automatic weighing system*

Load cell is provided at the center of slinger conveyor to measure the quantity of material being fed in the drum.

5.2.5 *Dryer cum mixing drum* **(Fig. 26)**

It is a rotary shell made of heat resistance steel 10 to 12 mm thick, supported on rings and rollers. Its main function is:

a) To remove moisture from aggregates by heating it at appropriate temperature.

b) To blend aggregates and bitumen in desired proportion to achieve homogenous mix within 140°C to 160°C.

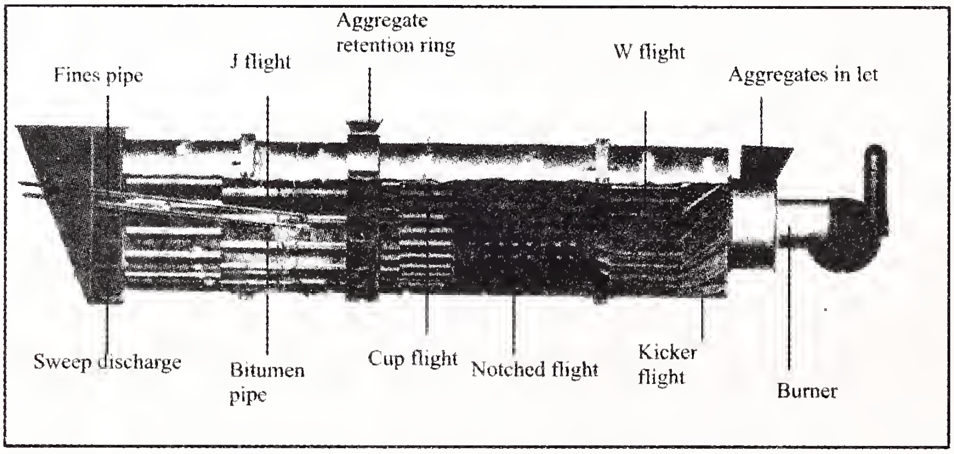


Fig. 26 Components of Dryer cum Mixing Drum

5.2.5.1 *Design aspects*

a) Dryer cum mixing drum is divided into two zones:

1) Combustion zone: The heating and drying of aggregates take place in this zone.

2) Mixing zone: The mixing of aggregates, filler and bitumen takes place in this zone.

b) The drum is provided with replaceable different shapes of flights, which perform following functions:

1) Kicker flight - It pushes the aggregates inside the drum

2) W flight - It eliminates showering of aggregates directly into flame

3) Notched flight - It allows the aggregates to fall scattered, so that all particles are heated uniformly.

4) Cup flight - It forms a veil of aggregates so that flame does not reach in mixing zone.

5) Aggregates rotation ring - It collects the aggregates received in combustion zone and moves it to mixing zone.

6) J.flight - It blends the aggregates , bitumen and filler/fines.

Quantity and arrangement of flights depends on the output of the plant.

c) Rate of drying the aggregates depend upon the moisture content present in it. The dwell time in dryer cum mixing drum, can control the drying of aggregates and achieve homogenous mix. It depends on following factors:

1) Length to diameter ratio of drum should be in the range of 4 to 6.

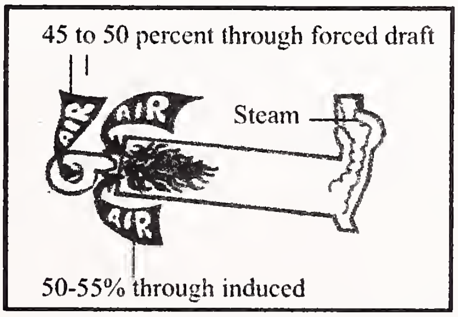
2) For drum mix plants up to 90 tonne per hour capacity; speed of drum should be in the range of 10 to 12 revolutions per minute and slope of drum not to exceed 9 cm/metre.

d) Burner

1) The fuel used in the burner in drum mix plant is light diesel oil/ furnace oil. Preheater is essential for use of furnace oil.

2) Burner used in dryer cum mixing drum **(Fig. 27)** is based on forced and induced draft principle, in which approximately 55 percent air by exhaust fan and 45 percent by air blower is inducted in drum for complete combustion of fuel.

3) The flame should be shorter, more intense and highly radiatory.



Fig, 27 Burner used in Dryer cum Mixing Drum

4) It should have auto flame failure detection system to avoid coating of aggregates with fuel. Photocell is used for detection of flame.

5) It should have auto ignition system to avoid explosion.

6) There should be no dribbling from nozzle tip when burner is in shut down position.

7) Excess air, approximately 25 percent should be supplied for complete combustion of fuel.

e) Bitumen line

1) Liquid bitumen is not sprayed into drum. It is pumped to a point with such pressure, from where it discharges by gravity into drum.

2) It should be close to flights so that same may not be picked up with gas stream.

3) It should be more inside the drum but within mixing zone due to longer dwell time for better mixing.

f) Bitumen fines receiver

The dust received from dust collector or filler received from mineral filler system is inducted in desired proportion in mixing zone of drum through bitumen fines receiver, **(Fig. 28)** which prevents the fines from becoming rear borne.

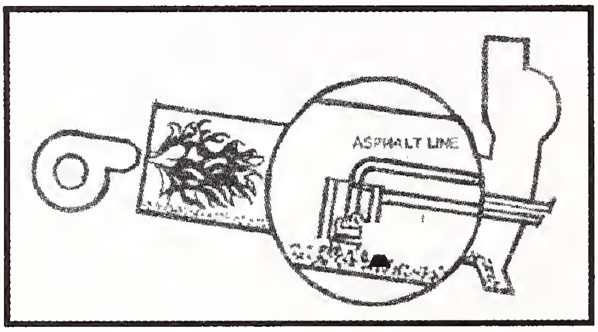


Fig. 28 Bitumen Fines Receiver

5.2.6 *Exhaust control system*

Its main function is to induce air in dryer cum mixing drum for complete combustion, to remove evaporated moisture in aggregates and products of combustion. It consists of:

a) *Exhaust fan:* It is of centrifugal type and adequate capacity. In case it is not of adequate capacity, the steam shall not be pulled out of drum and complete combustion will not take place resulting in higher fuel consumption and coating of aggregates with fuel. It should be fitted with 20 horse power motor for 40/60 tonne per hour and 25 horse power with 60/90 tonne per hour capacity plant to achieve optimum efficiency.

b) *Exhaust damper:* It is provided at burner end to control automatic draft, based upon vacuum pressure measured inside the dryer.

5.2.7 *Bitumen unit*

The bitumen unit mainly consists of:

a) Bitumen tank

It is insulated, of adequate capacity (minimum one day storage) meeting to the requirement of plant capacity. Minimum 2 Nos. bitumen tanks should be provided along with the plant. Total 20 and 25 tonne capacity bitumen tanks are adequate to run 40/60 and 60/90 tonne per hour capacity plants respectively. It consists of a tank fitted with burner in flue tube. The fuel used in burner is light diesel oil/furnace oil. Dial indicator type thermometer is provided outside the tank to indicate bitumen temperature. The burner should have thermostatic firing control for automatic control of bitumen temperature within the specified range.

b) Bitumen pump

It is a positive displacement pump driven by variable speed motor to induct bitumen in mixing zone of drum. The system ensures bitumen delivery in desired proportion to dry weight of aggregates. In case modified bitumen is being used in plant, provision for 1) one no. additional positive displacement pump just below flue tube 2) adequate number of agitators in bitumen tank, should be made for its proper circulation , mixing and maintaining uniform temperature. It may be ensured that Guidelines for use of modified bitumen are strictly followed to maintain the quality of mix.

c) Hot oil System

It consists of hot oil tank, hot oil pump and bitumen line jacketing. It is used to maintain uniform temperature of bitumen and avoids its clogging in bitumen line. The system may be used either as duct heating or indirect heating as described here:

1) Direct heating:

An insulated tank approximately 125 litre capacity containing hot oil with independent burner in flue tube is mounted on the chasis of bitumen tank. Air and fuel from existing bitumen heating system are used for heating hot oil. Hot oil in the range of 150°C-180°C is circulated through bitumen pump and bitumen line jacketing with an independent pump.

2) Indirect heating:

Hot oil tank is installed at the top of bitumen tank, from where hot oil passes by gravity into the pipe line passing through the bitumen tank. Hot oil gets heated by bitumen tank temperature and circulated in bitumen pump and bitumen line jacketing via independent pump. This practice is normally used to heat hot oil in drum mix plant.

5.2.8 *Primary pollution control device (dust collection system)*

The brief details have already been furnished in Para **4.1.4.**

5.2.9 *Hot mix conveyor*

The hot mix prepared in dryer cum mixing drum is taken to gob hopper through hot mix/load out conveyor.

5.2.10 *Gob hopper*

Gob hopper collects the hot mix material and transfers it to tipper through hydraulic arrangement. The blades of gob hopper should remain in closed position, while mix material is being fed into it. These should open when gob hopper has completely filled with mix material and the same is being transferred into tipper, to avoid segregation. Scrapper blade is provided in gob hopper to avoid sticking of fines on conveyor belt and achieve desired mix formula.

5.2.11 *Control cabin*

The brief details have been furnished in Para **4.1.12.**

In drum mix plant, there is no system to measure the temperature of aggregates. Therefore, exhaust temperature is measured by putting thermocouple in exhaust chimney, which indicates temperature in control panel. It may be ensured that complete fuel combustion takes place in dryer drum and temperature is stable for fifteen minutes before considering final exhaust gas temperature. Aggregates temperature is approximately 12°C less than the exhaust gas temperature.

5.2.12 *Mineral filler system*

The brief details have been furnished in Para **4.1.11.**

5.2.13 *Hot mix surge silo*

The brief details have been furnished in Para **4.1.14.**

5.2.14 *Secondary pollution control device*

It is of two types. a) Wet scrubber b) Bag house filter. Hot Mix Plant Emission and their Control are given in **Annex-C.**

a) Wet scrubber type unit

In this type of unit, gases pass through the inlet and dust particles are trapped by water shower/forced water spray, thus separating them from gas stream. It can separate dust particles upto 5 micron size and eliminate certain amount of gases also with varying efficiency. This system requires large quantity of water. The ponds of adequate capacity are made to collect the slurry, reclaim and reuse the water. The particles settled should be removed frequently preferably within 2 to 3 days for its better efficiency. These are of two types, the details of which are given below:

1) Open spray tower type **(Fig. 29)**

The dirty gases enter the chamber and pass through water spray under pressure. The dust particles in the form of slurry settle down and are removed from the bottom. The clean air passes out of the chamber.

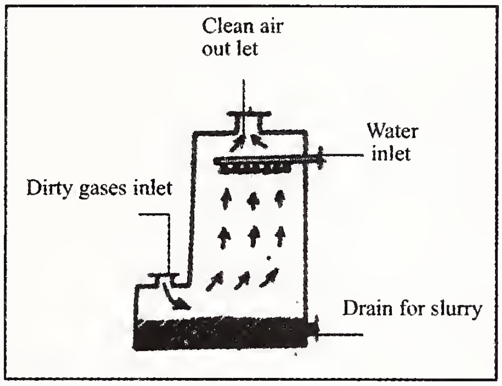


Fig. 29 Open Spray Tower Type Pollution Control Device

2) Venturi type **(Fig. 30)**

In venturi scrubber type, dust laden gases are made to pass through a venturi section which is constantly wetted through stream of water at high pressure. The flue gases pass through this venturi section and atomize the liquid resulting in deposition of dust particles with fine water droplets. In the complete process, clean air goes out and dust particles in the form of slurry are removed from the bottom of the cylinder.

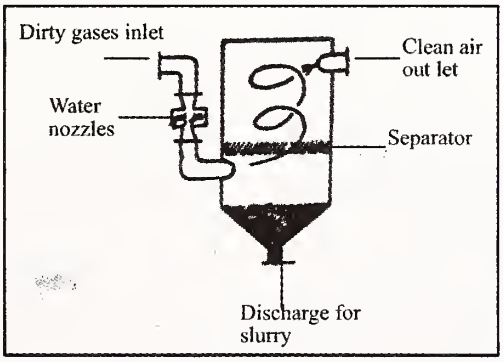


Fig. 30 Venturi Type Pollution Control Device

The efficiency of venturi type wet scrubber is higher than open spray tower type.

5.3 Advantages of Hot Mix Plant (Drum-Mix Type)

a) The cost of the plant is less.

b) The plant needs less space for commissioning and its transportation is also easy.

c) The plants are available in different capacities ranging from 40/60 to 400 tonne per hour.

d) The operation and maintenance cost of plant is less, as compared to other types of plants.

5.4 Limitations of Hot Mix Plant (Drum-Mix Type)

a) The plant does not have second gradation control unit i.e. only graded material could be used to achieve desired mix quality.

b) The plant does not have any system to measure aggregates temperature. Aggregates temperature is assessed by deducting 12°C from exhaust gas temperature.

c) The quality of hot mix prepared is not as homogenous as in case of batch type plant.

5.5 Power Requirement for Drum-Mix Plant

Drum mix plant is fitted with electric motors for operation of different units.

Normally, drum mix plants of 40/60 and 60/90 tonne per hour capacity are being used in India and total requirement of power for different units is approximately 105 and 130 horse power respectively, the details of which are given below:

Sl.No.	Details of unit	Horse power required	
		60/90 t.p.h	**40/60 t.p.h**
a)	Auxillary conveyors (4nos.)	8.00	8.00
b)	Gathering conveyor	5.00	5.00
c)	Vibratory screen for oversize rejection	3.00	3.00
d)	Slinger conveyor	5.00	5.00
e)	Dryer cum mixing drum	25.00	20.00
f)	Exhauster	25.00	20.00
g)	Dust collector conveyor screw	1.50	1.50
h)	Load out conveyor	7.50	5.00
i)	Hydraulic power pack	5.00	5.00
j)	Asphalt pump	5.00	5.00
k)	Air compressor for mineral filler	15.00	10.00
l)	Burner air blower	15.00	10.00
m)	Burner fuel pump	2.00	1.00
n)	Hot oil circulation pump	1.00	1.00
o)	others	7.00	5.50
	Total	130.00	105.00

All the motors are not in operation at full load continuously. The generating set 82.5 kVA and 110 kVA are adequate to run 40/60 and 60/90 tonne per hour capacity drum mix plant respectively.

5.6 Double Barrel Drum Mix Plant

In double barrel drum mix plant technology, the concentric chambers of same drum are used to heat and mix the virgin aggregates with liquid bitumen, filler material and reclaimed bituminous pavement (if required). The heat produced in dryer drum is utilized more effectively in following manner:

a) The inner shell of the dryer drum de-moisturises and heats the virgin aggregates upto required temperature and discharges it to outer shell.

b) The outer shell (annular portion) fitted with arms and tips is utilized to mix the hot and dried virgin aggregates with reclaimed bituminous pavement, filler material and liquid bitumen. It works as pugmill and produces homogenous mix with use of reclaimed bituminous pavement upto 50 percent.

5.6.1 *Sequence for preparation of hot mix*

a) The aggregates in desired proportion are fed from cold bin feeder to dryer drum (counter flow type) and shaken well with a vibratory flap arrangement at the entry of dryer drum, which loosens the dust particles sticking to the aggregates.

b) The dryer chamber consists of three sections fitted with different types of flights for efficient drying of aggregates and effective heat utilization. The arrangement of flights is shown in the **(Fig. 31)**. The function of different types of flights is also shown below:

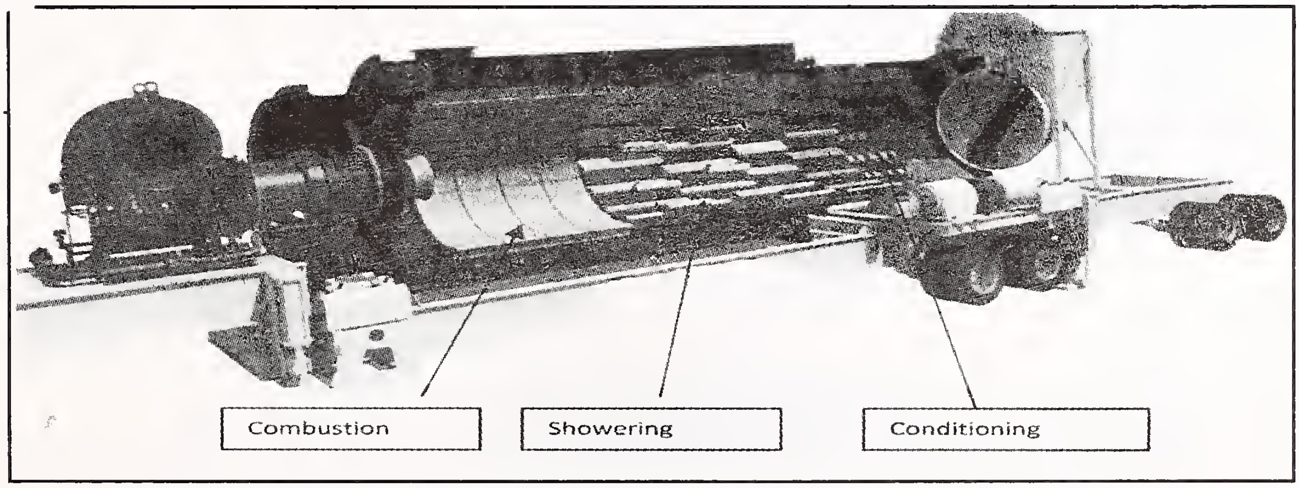
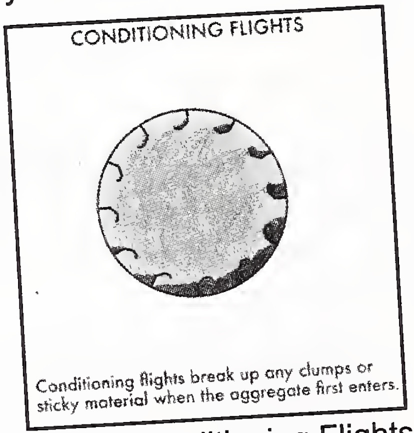


Fig. 31 Arrangement of Different Types of Flights in Double Barrel Plant

1) Conditioning flights: These are used to break up the lumps or sticky materials as the aggregates enter the dryer chamber **(Fig. 32)**.



Conditioning flights break up any clumps or sticky material when the aggregate first enters.

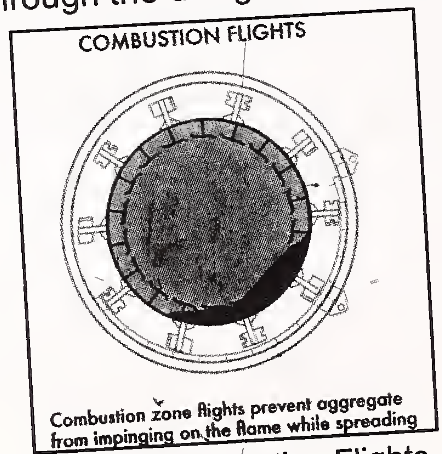
Fig. 32 Conditioning Flights

2) Showering flights: These are attached to the shell and arranged such as to lift the aggregates and ensure their exposure evenly for effective drying **(Fig. 33)**.

Showering flights make sure that the material is veiled evenly through the hot gas stream.

Fig. 33 Showering Flights

3) Combustion flights: These are in the combustion zone and prevent aggregates from impinging on the flame while spreading the material for maximum radiant heat transfer. After completing the drying operation, the dried aggregates come out of the inner drum through the designated outlet near the burner **(Fig. 34)**.



Combustion zone flights prevent aggregate from impinging on the flame while spreading

Fig. 34 Combustion Flights

c) The outer periphery of drying drum is fitted with paddles, arms and tips. It is less than overall length of dryer drum, covered with another stationary shell and does the function of a mixing chamber.

The drum rotates in inclined position. The aggregates, liquid bitumen, reclaimed bituminous pavement and other ingredients as per job mix formula present in mixing chamber **(Fig. 35)** are pushed upwards against gravity by the paddles/arms fitted at the outer periphery of the dryer drum. Due to slow material movement in mixing chamber, the mix gets sufficient time for proper mixing before the same is pushed to the final outlet (towards the upper end of mix chamber). It also utilizes the radiant heat of dryer chamber, which reduces the fuel consumption.

In this section, the hot superheated virgin aggregates which come out of the dryer chamber, mix with the reclaimed bituminous pavement (RBP) being externally fed to mixing chamber (close to the outlet of dried aggregates). The reclaimed bituminous pavement absorbs the heat from virgin aggregates and evaporates the moisture content present in it. Old bitumen present on reclaimed bituminous pavement melts and coats the virgin aggregates thinly as the aggregates cool to mixing temperature.

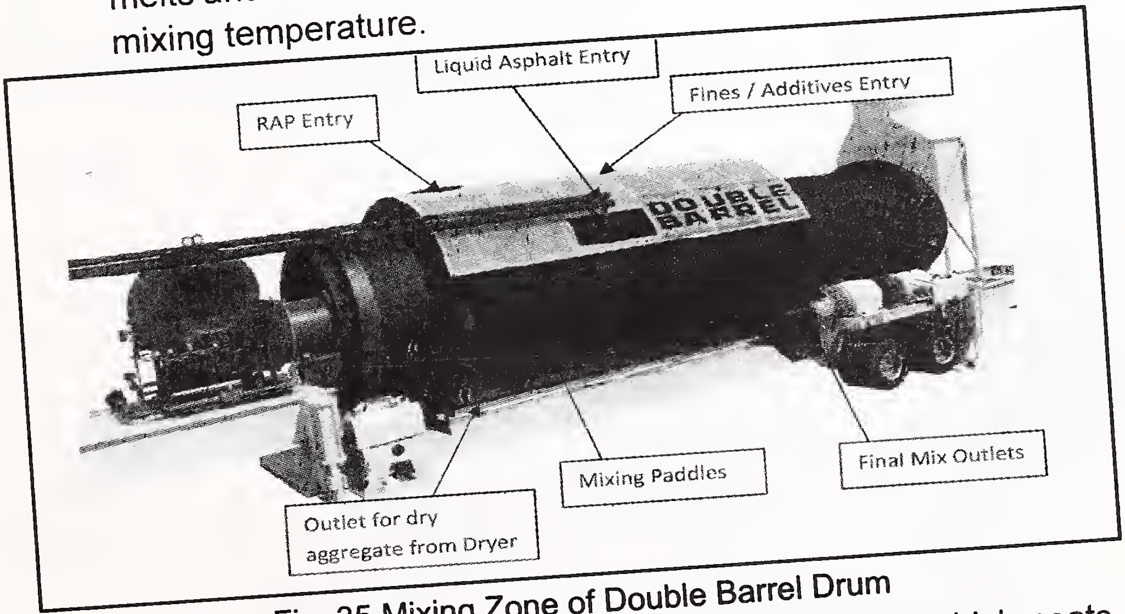


Fig. 35 Mixing Zone of Double Barrel Drum

d) The liquid bitumen is injected as per mix design, which coats both the virgin and old aggregates with a thick film of bitumen. The fines/ additives are added at a later stage, which gets embedded into thick bitumen film and mixing continues till hot mix exits in mixing chamber.

5.6.2 *Components of double barrel drum mix plant*

1) Cold bin feeder (minimum bins-4 nos.)

2) Cold feed conveyor
3) Double barrel drum
4) RBP feeder
5) Primary dust collector
6) Bitumen unit
7) Drag conveyor
8) Gob hopper
9) Control cabin
10) Mineral filler system
11) Secondary pollution control device (Bag house filter system)
12) Hot mix surge/storage silo

5.6.2.1 *Cold bin feeder*

The brief details have already been furnished in Para **4.1.1.**

5.6.2.2 *Cold feed conveyor*

It is known as slinger conveyor also. The brief details have already been furnished in Para **4.1.2**

5.6.2.3 *Double barrel drum*

A double barrel drum consists of two concentric chambers. The inner chamber acts as dryer drum and outer chamber as mixing drum. It is fitted in inclined position and rotates at slow speed through chain and sprocket mechanism. The drum shell is supported by two steel tyres which rest on four trunion rollers and two guide rollers. The process flow diagram is shown in **Fig. 36.**

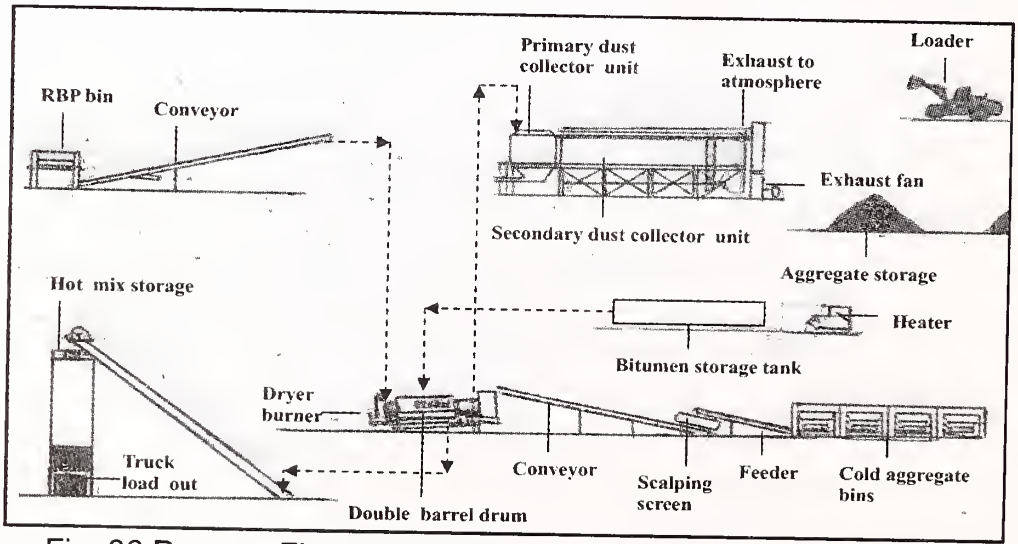


Fig. 36 Process Flow Diagram for Double Barrel Drum Mix Plant

The dryer drum is fitted with low noise and high efficiency burner at one end. The dryer chamber is fitted with flights of three different configurations to ensure proper demoisturising and heating of virgin aggregates upto required temperature. The heated aggregates travel by gravity assisted by rotational movement of the drum (towards the burner side) and finally come out of the dryer chamber to the mixing chamber. The annular portion of the dryer drum is fitted with mixing paddles/blades for churning the hot virgin aggregates with externally added reclaimed bituminous pavement, liquid bitumen and other additives for homogenous mixing as per job mix formula. The hot mix inside the mixing chamber are pushed against gravity by the mixing blades and finally come out of the mixing chamber as final product.

5.6.2.4 RBP feeder

It consists of bin and conveyor, which feeds the reclaimed bituminous pavement to double barrel drum. The reclaimed bituminous pavement feeding arrangement may comprise of an impact crusher and close loop screening arrangement as optional to ensure proper down sizing of milled reclaimed bituminous pavement.

5.6.2.5 Primary pollution control device (dust collection system)

The brief details have been given in Para **4.1.4.**

5.6.3 *Bitumen unit*

The unit mainly consists of bitumen tank, bitumen heating system, bitumen pump and delivery pipe. Bitumen pump fitted with variable speed motor is used to feed the liquid bitumen as per job mix formula through hot oil jacketed bitumen pipe line. In addition to this, other controls like tachometer, flow meter etc. are provided to ensure correct feeding of bitumen in mixing chamber.

5.6.4 *Drag conveyor*

The hot mix prepared is discharged from mixing chamber through drag slot conveyor to the surge bin or hot mix storage silo.

5.6.5 *Gob hopper*

The brief details have already been furnished in Para **5.2.10.**

5.6.6 *Control cabin*

The entire operation of plant being run on automatic mode is controlled from a centralized control room. The brief details have already been furnished in Para **4.1.12.**

5.6.7 *Mineral filler system*

The brief details have been furnished in Para **4.1.11.**

5.6.8 *Secondary pollution control device (bag house filter system)*

The brief details have been furnished in Paras **4.1.13** and **5.2.14.**

5.6.9 *Hot mix surge silo: The brief details have been furnished in Para* ***4.1.14.***

5.7 Advantages of Hot Mix Plant (Double Barrel Drum-Mix type)

Double barrel drum mix plant has got following advantages over other type of plants:

a) The size of similar capacity of double barrel drum mix plant is less than the hot mix plant (batch type) and its transportation is also easy and economical.

b) The plant being of counter flow type and having insulated mixing chamber optimizes energy utilization.

c) The fuel consumption for heating the aggregates is on lower side.

d) Infrared sensors fitted at mixing chamber sense and control the desired hot mix temperature and ensure even production.

e) The mixing takes place in pugmill, thus more homogenous mix evenly coated with uniform bitumen film thickness and negligible oxidation is achieved.

f) Higher percentage of reclaimed bituminous pavement upto 50 percent, can be used to produce consistently high quality of hot mix.

5.8 Limitation of Hot Mix Plant (Double Barrel Drum-Mix type)

The use of double barrel drum mix plant has following limitations:

a) Second gradation control unit is not provided in the plant, thus accurate grading is not assured.

b) Only graded material is to be used.

c) The cost of double barrel drum mix plant is high in the category of drum mix plant.

6 OPERATION OF HOT MIX PLANTS

6.1 Principles for Operation

The following principles govern the operation of modern hot mix plant:

a) The operation should be carefully planned, so that the final product is of a high quality.

b) The operation should be run by a competent manager, who with his supporting staff, are all fully conversant with the plant, its operation and maintenance.

c) The aim should be continuity in operation, avoid break-down and intermittent working.

d) The adequate stock of ingredients must be ensured.

6.2 General

The Guidelines given in plant manufacturer's operational manual should be strictly followed. The points given below should also be taken care of before starting, shutting down and running the plant.

a) The sample of aggregates, bitumen and mix material should be taken at regular intervals of time and tested.

b) The stock piles of aggregates should be checked regularly.

c) The operation of cold feeders (setting of cold feeders) should be checked twice daily and more frequently, if variation appears in the mix and got calibrated, if required.

d) The operation of the dryer should be checked regularly.

e) The hot screens, hot bins and dust collector should be checked daily for uninterrupted flow of aggregates.

f) The weigh hopper and bitumen bucket should be checked daily. The accuracy of all scales should be checked at least once a week.

g) The operation of mixer unit should be checked regularly.

h) In drum mix plant and double barrel drum mix plant, the bitumen pump should be checked for its accuracy and got calibrated, if required.

i) Carry out visual inspection of the mix, collect mix samples, do extraction test on mix and bitumen penetration daily or as required, to ensure compliance with specifications.

j) The records pertaining to quantity of aggregates, bitumen, mix being laid and their temperature, be maintained.

6.3 Precautions During Operation of Plant

The following precautions should be observed during various sequence of operations of the plant to achieve better performance and optimum utilization:

6.3.1 *Cold aggregate feeder*

a) Segregation of aggregates as well as intermixing should be prevented, while loading aggregates into bins.

b) Bins should contain the aggregates of correct size and kept loaded fully, to allow even flow through the feed gate in a particular set position. The approximate tonnage per hour for gate openings is provided in the form of calibration chart for each gate.

c) Arching of fine aggregates is prevented by placing a vibrator in the bin containing fines.

d) Moisture on fine aggregates should be avoided, so that clogging may not take place.

e) To avoid any damage of conveyor belt, by getting the aggregates stuck between gate and belt, the discharge gate openings of bins be kept 1.5 times the maximum feed size of aggregates. If required, grizzly may be kept over the bins to prevent large pieces of stone coming in the bins, which may clog the gate.

f) After completing the work for day, bins should be left with minimum material especially during rainy season. It will ensure less strain on belts and drives while starting four bin feeder next day and their longer life.

g) The material build up should be checked periodically to prevent rollers from turning and remove the same.

6.3.2 *Cold aggregate bucket elevator*

a) In order to reduce the feeding height of four bin feeder, a pit of approximately one meter depth should be dug, to place cold elevator mounting frame.

b) Ensure the buckets receive the material from gathering conveyor, eliminating digging, although the edges are hard faced to give long life.

c) Ensure aggregates are not accumulated in pit.

d) In case of rains during previous night, ensure the water logging in pit of cold elevator is removed.

e) Don't start the feeder, until the dryer burner has been incited.

6.3.3 *Dryer unit*

a) Before starting the dryer, ensure the feed box bottom door is opened, dust removed and cleaned.

b) Before starting the plant, the nozzle and burner should be cleaned with kerosene oil.

c) Don't allow the aggregates to flow through the dryer drum, when the vertical hot elevator bucket is not working.

d) Before starting the dryer drum, the aggregates should not be inside it; since a very high torque is required to start the dryer drum filled with aggregates.

e) If furnace oil is used in the burner, it should be pre-heated to bring down its viscosity, before passing it through burner. The furnace oil to be preheated between 100°C-110°C.

f) Before starting a new installation, ensure that combustion chamber of dryer drum and bitumen boiler are completely dry. Refractory lining of combustion chamber should be dried with low wood fire and not by oil firing.

g) Don't permit open fire around fuel oil tanks.

h) Always stand and hold torch at desired length, to prevent getting burnt in case burner puffs back.

i) While lighting burner, never allow excessive fuel to be sprayed into combustion chamber of drum.

j) Don't keep the burner lighted for a long time preferably more than five minutes, without aggregates inside the dryer drum, as the dryer drum may bulge. Operate the burner on low flame, when it is not loaded fully.

k) Shape of the flame is regulated by means of air swirling action. Maximum swirl will produce a short wide flame and minimum swirl a long cigar shaped flame.

l) If fuel pump delivery is irregular or negligible, prime the pump and see the pump does not suck air through joints on suction side.

m) Observe the exhaust smoke during operation. If it is found black, it means incomplete combustion of fuel and feeding of excess fuel. In case of white smoke, it shows the presence of moisture in fuel. Necessary action may be taken accordingly.

n) Ensure no holes are formed in the cyclone unit, which may add to excess dusty conditions at site.

o) The flow of material in dryer drum should be uniform. It should not be over loaded by passing more quantity of aggregates from four bin feeder to dryer drum. It should be checked by measuring hot aggregates temperature, to be maintained at about 180°C and moisture content not to exceed 0.5 percent.

p) The heat loss of aggregates from dryer to mixer and hot mix from mixer to laying site should be checked at regular intervals of time.

q) At the end of day, put off the dryer drum burner by stopping fuel oil supply and then the motor.

6.3.4 *Burner*

The burner fitted on dryer unit should be adjusted properly to maintain uniform and desired aggregates temperature. Shorter and longer flame length will heat the aggregates and dryer ends properly.

6.3.5 *Hot elevator*

a) Before starting the plant, the material at the foot of elevator should be removed through flap door.

b) Don't allow the aggregates to flow from dryer drum, when vertical bucket elevator is not working.

c) Hot elevator discharge chute is provided with liners and to be checked weekly to determine the extent of wear.

d) Hot aggregates from dryer drum should be delivered to vertical elevator only when the motor of elevator picks up the speed and runs at rated revolutions per minute.

e) Care should be taken to see that buckets receive the material directly with out digging.

6.3.6 *Gradation unit*

6.3.6.1 *Screening unit:*

a) The screen must be of adequate area, having correct size of openings and arranged in sequence.

b) The screen must be set at proper slope for smooth flow of aggregates.

c) The screen should not have holes. The clogging of screen will not allow the aggregates to pass through. Therefore, the screens must be inspected and cleaned frequently.

6.3.6.2 *Weighing hopper:*

a) Ensure that sufficient material is always stored in all four hopper bins.

b) The automatic leveling control device to maintain minimum level of aggregates in any bin stops the plant, if aggregate level drops to predetermined level; should be checked periodically. It may also be ensured that over flow from any bin should not occur. The cold feed should be controlled accordingly.

c) The sample of aggregates should be taken from each hot bin at regular intervals to check for proper grade.

d) The proper gate openings should be ensured, since the output and proportioning of aggregates depends upon the same.

6.3.6.3 *Proportioning the aggregates:*

a) Ensure that aggregate feeder gates are set as per calibration chart provided on each gate.

b) Gradation tests may be carried out on each sample, collected at regular intervals.

c) Check up the scales for zero error at no load every day.

d) The aggregates should be discharged from hot bins into weigh hoppers, starting with coarse and progressing down to the finest, in the batch plant.

e) The aggregates, filler and bitumen weighing scales should be calibrated correctly and checked periodically preferably once in two weeks.

6.3.7 *Mixer unit*

a) The pugmill does the job of proper mixing, if the tips of paddle arms are found clearly above the mix. An under filled pugmill does not allow the paddles to work properly. In an over filled pugmill, the material floats above the paddles and is not fully mixed.

b) The mixing should be done in shortest possible time, to produce uniform mix. If the mixing time is too short, the particles would not have a uniform coating of bitumen. If the time is too long, the bitumen coating will harden because of long exposure of bitumen to heat and air. An average time for dry mixing could be about

15 seconds followed by 30 to 45 seconds of mixing, after bitumen is added.

c) Over size aggregates entering the mixer, tend the mixer arms to bend. The clearance between the paddle tips and inside lining of mixer box should not be more than 2 cm.

d) Check aggregates hopper gates and bitumen feed valve to see that they close tightly and no leakage takes place into mixer after the feed is stopped.

e) Ensure sequence of feeding the material. Therefore, coarse aggregates first, followed with smaller sizes progressively in order of size.

f) See that the paddles and tips are set to ensure proper mixing action.

g) See that the lining and tips are not worn. The tips have a tendency to wear faster in macadam work compared to seal coat.

h) Check distribution of bitumen uniformly over entire width of mixer covering all parts.

i) Check the temperature of mix frequently, as soon as it is dumped into tippers. Ensure that the temperatures of aggregates and bitumen are within the specified range.

j) Check the mix temperature frequently for laying and rolling.

6.3.8 *Bitumen unit*

a) Ensure before filling the bitumen tank, it does not contain water. Even a small amount of water will cause hot bitumen to foam up several times its normal volume, resulting in its over flow.

b) Fill up the bitumen tank to its 80 percent capacity only, since the volume of bitumen increases while raising the temperature. The over flow of bitumen can be fire hazardous.

c) The boiler should be located nearest to the plant to ensure safety, reduce the strain on the bitumen pump and prevent the clogging of bitumen line. The lead pipes should be insulated against risk to the work man and maintain the bitumen temperature. It should always be at inclined position to enable the hot bitumen to run down to the bitumen boiler when not in use. The boiler should also be erected with slight downward inclination towards the hottest firing end. Cold bitumen under the flue tubes will then drain down the inclination towards the firing end and can be drained without choking.

d) The top lids of the bitumen tank should be kept closed, since the water, dust are the deterrents to good and clean bitumen. Clean the external sides of barrels, before charging to prevent foreign matter going into the boiler. The dust and fine particles settle down around the flue tubes, which results in poor heat transfer, local heating of flue tubes and cracks are produced in welding resulting in leakage, which can be fire hazardous.

e) In case excess fuel has been fed into flue tubes, shut off the fuel supply and allow air to blow off the fuel and again start the procedure for lighting the burner. It is always safe to start the blower first before turning on the fuel.

f) Bitumen must be maintained at specified temperature. Overheating may cause cracking and it may be difficult to pump.

g) Whenever there is a change in type of bitumen to be used, the bitumen tank should be drained and cleaned thoroughly with solvent before further use.

h) Certain solvents like diesel oil to be used for cleaning are highly inflammable and must be thoroughly drained before bitumen is circulated. If the traces of such solvents reach the mixer and come ir contact with the heated aggregates, risk of fire cannot be ruled out.

i) Bitumen tank burner may be lighted, only when the level of bitumen inside the tank is higher than the heating tubes.

j) Circulate the hot oil for about fifteen minutes to melt the bitumen sticking to the walls of the bitumen line.

k) While inducting hot oil into a cold line, open the valve very slowly, to allow piping and jackets heat up gradually. Rapid induction of hot oil into cold lines will result in uneven expansion of lines and may damage the connecting points in line.

l) The hot oil level should be checked regularly in the hot oil tank. If the level falls, check for any leakage in hot oil or jacketed bitumen pipe lines.

m) Ensure that the dust does not enter the meter relay box and dial head.

6.3.8.1 Bitumen pump

a) It is a rotary gear type of pump in which while working, suction develops on the kettle side and pressure on the delivery side of the pump.

b) The gear pump should be thoroughly drained at the end of each operating period. The failure to clean the pump results in solidifying the bitumen around the rotor and may break the gear teeth or driving shaft, when the power is applied. The only means of relieving the clogged rotor is by heating the pump, which is troublesome.

c) Never run the pump in dry state.

d) When "Weeping" becomes apparent at the bottom pump gland, tighten the gland nuts carefully, one flat at a time. If "Weeping" is allowed to persist, it soon becomes a leak and gland packing is to be replaced.

e) It should be made a practice to disengage the pump drive at the end of operation. Otherwise, if the plant is started next day, before the bitumen is sufficiently heated for circulation, the pump drive, if still engaged will place excessive strain on the driving shaft and might cause the shaft or rotors to break. The pump rotor should also be reversed for about four to five minutes, as soon as the plant is stopped, to empty the bitumen pipe lines. Always observe that the pump rotors are free by applying the V-belt drive gradually. Slipping of the belt over the pump driving pulley indicates that the rotors are clogged and need heating to relieve them. Never apply the drive quickly, as it may cause damage to the pump rotors or shaft.

   In case chain drive is being used, engage the clutch slowly and ensure that the pump gears are not clogged, which is indicated by excessive slipping of the clutch.

f) If the rate of flow of pump falls during operation, the cause may be slipping of clutch. In case it is not so, it would mean that pump rotors have worn out and need renewal.

g) It has been practically found in the field that clogged bitumen pump is relieved by heating the case, either by using a blow pump or igniting the oil soaked waste. These methods destroy the pump gland and should not be used.

h) Boiling water may also be poured continuously over the pump housing to relieve the clogged rotor.

i) When a new pump or pump with new rotor is fitted, the pump at times may fail to lift the bitumen. To overcome this, uncouple the pipe from delivery side and pour a small quantity of heated bitumen approximately ten litres and at same time reverse the pump rotor by means of hand wheel. Reconnect the pipe and start up. This difficulty would not occur, once the pump has been operating satisfactorily.

j) Bitumen to be used in the mix should be heated to ensure its fluidity, before the pump is started. The bitumen must be allowed to circulate for atleast fifteen minutes before the mixing commences, so as to keep the meter, spray bar warm and also relieve the solidified deposits throughout the circuit. A test cock in return line, close to the kettle is provided to ensure that bitumen has completely circulated.

7 ESSENTIAL ACTIVITIES WHILE STARTING, OPERATING AND SHUTTING DOWN PLANTS

7.1 Check List Before Starting the Plant

The following items covered in the check list should be verified by the operator and ticked before starting the plant. The date and time should be mentioned in the check list and kept as record:

a) Have you carried out daily maintenance schedule as per instructions.

b) Have you topped up all oil tanks and gear boxes with proper grade of oil and fuels.

c) Have you checked the oil level in the air cleaner and topped it up.

d) Have you checked the tension of "V" belts, flat belts and chains.

e) Have you checked all grease points.

f) Have you checked all guards and covers fitted in the plant complying the safety norms.

g) Have you heated the bitumen pipe line through hot oil system for uninterrupted supply of bitumen.

h) Have you cleared the accumulated stones before starting the bucket elevator.

i) Have you checked the conveyor belts for any damage or wear.

j) Have you checked the conveyor rollers for free turning.

k) Have you checked too much fuel is not sprayed into the combustion chamber of dryer.

l) Have you checked there is no water in the bitumen tank before pouring the bitumen in the tank.

7.2 Sequence of Operation for Starting and Shutting Down the Plant

The starting and shutting down the plant should be done in chronological order for its smooth running. The sequence for starting various components of plant is as under:

a) Exhaust fan

b) Dust cleaning system
c) Filler feeding system
d) Vibrating screen
e) Hot elevator
f) Dryer
g) Inclined belt
h) Collecting belt
i) Cold aggregate feeder
j) Burner
k) Mixing unit
l) Cold bin feeder

During shutting down the plant, the first component to be stopped is the input of aggregate system. The material trapped inside the drum should be then flushed out from the system in the sequence shown below:

a) Cold bin feeder
b) Collecting belt
c) Inclined belt
d) Burner
e) Hot elevator
f) Vibrating screen
g) Mixing unit
h) Drying drum
i) Cleaning system and filler system
j) Exhaust fan

The following points should also be considered, while starting and shutting down the plant:

a) After ten minutes before seizing the production of plant or two to three batches short of desired number of batches; the feeder unit should be stopped.
b) As soon the last portion of aggregates leaves the dryer, the burner should be shut off from the cock provided close to the burner, which

cuts off the fuel supply. Now shut off the dryer motor. When the final batch has been mixed and discharged, both ends of paddle shafts should be cleaned with light diesel oil or high speed diesel to ensure that they are free to rotate at the time of starting the plant next day.

c) The plant should not be stopped, in case the material is in transit. The plant may be stopped if dryer, elevator, screens, bins, mixer are empty.

d) Now, put off the bitumen tank burner by stopping the fuel supply. Stop the bitumen pump and reverse its drive immediately, either by hand wheel or reversing the motor rotation. Move the lever on pressure regulator (metering system only) to draining position. Fix the discharge of weigh/ spray system hopper in open position. The bitumen system must be drained thoroughly to ensure its easy operation the next day. All bitumen piping should have slope downwards to the kettles to assist drainage, and a tap fitted in the delivery line just after the pump, which may be left open over night to prevent the clogging of the pump. If cleaning solvents are used, these should be thoroughly drained off, before re-circulating the bitumen.

e) The fuel tank should be filled.

f) Defects, if any or unusual sound should be reported to the concerned engineer and got rectified.

g) Check and rectify any leakage, especially in bitumen and hot oil system.

h) Check all bolts, nuts for tightness and tension in the chain.

i) Inspect the blower of exhaust fan for balancing and play of bearings.

j) Weld the cracks in the sheets, if found.

k) Clean the plant, specially dust/aggregates collected underneath the belt/ chain conveyors and lubricate all points.

l) Keep the motors and exhaust pipes covered to avoid rain or dew entering inside.

7.3 Upkeep of the Plant During Idling

If the plant is left in open for more than six weeks, certain precautions should be observed, especially on mobile plants and in extreme climatic conditions, which are as under:

a) Isolate the mains supply to electrically driven plant to prevent unauthorized starting.

b) Cover the exposed starter panels.

c) Wrap all V-belts including pulleys with a strong, self-adhesive paper and lubricate exposed chain drives.

d) Grease all adjusting screws, dryer swiveling support rollers, motor slide rail adjusting screws, jacks to prevent rusting.

e) Protect the dryer burner nozzle.

f) Remove the pneumatic tyred wheels of a mobile plant and keep them safely. Protect the hubs of axles also.

g) If roller shutters are fitted on the mixer housing, lower and lock them up.

h) Close the windows of the control cabin and keep the doors locked.

i) Cover the top of the exhaust fan to prevent ingress of water.

j) Cover the inlet of the burner air blower.

k) If the door is fitted in the dryer feed end box, pin it in the closed position.

l) The plant may be painted, if required to prevent corrosion.

8 MAINTENANCE AND UPKEEP OF HOT MIX PLANT

Proper maintenance and upkeep of hot mix plant is required for its long life, control on frequent breakdowns, maintaining quality of output and controlling the operating cost.

The schedules for maintenance of hot mix plants are prescribed by the manufacturers and given in their maintenance manuals. Sometimes the working conditions of particular site need frequent checking of specific items due to their premature failure. These items are added in the maintenance schedules as per requirement. The maintenance schedule forms daily, weekly, fortnightly, monthly, quarterly, half yearly should be got printed, the items checked as per format, signed by the maintenance staff and kept in records. The history sheet of plant should also be maintained properly and transferred along with the plant to assess the requirement of critical components at particular spell of time. It may be ensured during maintenance that recommended type and grade of oil, lubricants are used in the plant. The Do's and Don'ts for maintenance of hot mix plant are mentioned at **Annexure-G**. A brief of normal maintenance schedule is given below:

8.1 Maintenance Schedule

8.1.1 *Daily maintenance schedule*

a) Lubricate all parts as given in daily lubrication chart.

b) Check the gear box oil level atleast one hour after the shut down of plant, when the oil will settle down and indicate the correct level. If necessary top them up.

c) Top up all drip feed lubricators.

d) Tighten all bolts after completing day's operation, especially mixer arms, tips, liners, elevator buckets, dryer lifters, roller paths etc.

e) The following points should also be attended to during operation of the plant:

   i) Bitumen cocks are operated for production of every batch of mix material. These should be lubricated at an interval of every two hours. Other cocks need lubrication daily.

   ii) Check the bearings and ensure that over heating does not occur.

   iii) Turn on all chain drive drip feed lubricators.

   iv) Turn the key on the filter, in the burner fuel supply pipe line periodically during the day, to remove water and sediments.

   v) Open the tap of moisture separators of air receiver twice daily.

   vi) Check the gland of bitumen pump. Tighten if "Weeping" is evident.

   vii) Be alert for undue noises, which may be due to loose bolts.

   viii) Tighten the bucket bolts on hot elevator.

   ix) Recheck the angle of dryer drum under frame to ensure that no local sinkage has occurred.

1) Weekly Maintenance Schedule (Fifty to sixty hours):

In hot mix plants the trouble does not happen momentarily. It takes place slowly due to slackness of belts/chains, loose bearings and other factors. The plant has open gearing, open chain drives/flat belt/ V-belt drives, anti-friction metallic bearings due to its low revolutions drive. The grease used for gear lubrication becomes a grinding material, when it absorbs the dust and fine sand. These should be cleaned at least once a week and new grease applied.

a) Lubricate all components as instructed in weekly lubrication chart.

b) Clean the filters on suction side of the burner fuel and bitumen pump.

c) If filters are fitted on the blower, remove the element, wash it in paraffin, soak lightly in fresh oil and refit.

d) Check all V-belts and chain drives and do necessary adjustments accordingly.

e) Inspect feeder and conveyor belts for wear and tear and broken fasteners.

f) Check the belt scrapers on feed unit and in gob hopper. Ensure they are in good condition and effective. If necessary, replace them.

g) Check the conveyor belts; in case of holes or cuts, repair them immediately by lacing or vulcanizing.

h) Clean the cyclone of dust collection.

i) Periodic inspection of flue tube is essential to prevent a fire accident resulting out of punctured tube.

2) Monthly Maintenance Schedule (Two hundred to Two hundred fifty hours):

a) Clean the burner nozzles as per instructions.

b) Check all electrical wiring and cables for loss of insulation or corrosion and replace, if required.

c) Check the screen cloth, screen meshes and repair/ replace, if required.

d) Check the elevator pins, links and replace, if worn out.

e) Check the load cell and replace, if required.

3) Quarterly Maintenance Schedule (Eight hundred to One thousand hours):

a) Drain the oil of gear boxes, flush them and refill to correct level with recommended gear oil.

b) Inspect the dryer chain ring for worn out or broken pins. Remove the affected segments of the ring/pins and replace them.

c) Check the oil level in exhaust fan bearings and top up, if required.

d) Inspect the liner plates in dryer feed ring, discharge chute, elevator discharge chute and interior of paddle mixer and replace, if required.

e) Check the burner combustion chamber refractory for carbonization, clean it and repair, if required.

f) Clean electric contact and relays in control panel.

g) Do the calibration of load cell and weigh bucket.

4) Maintenance of Electric motors:

a) Isolate the mains supply to prevent unauthorized starting.

b) Cover all the exposed motor starter panels and controls, with tarpaulin or plastic sheet to prevent their damage during rains.

c) Always place the proper size of fuse, while replacing it. Never put a substitute of different size.

d) Do earthing of entire electric supply line properly.

e) Keep the motors and contacts always clean, by blowing away the dust.

f) Test check no-volt coils and over load protection devices for their proper function.

g) All the wiring should be placed under insulated cabling and properly covered trench.

8.2 Requirement of Tools and Plant for Maintenance

The hot mix plants are located in remote area, where repair facilities are not available. It is essential to have a small workshop for the repair and maintenance of hot mix plant and allied equipments for their upkeep and effective utilization. The following tools and plants should be available in the workshop at site.

a) Diesel welding set

b) Small electrical tools for drilling, grinding etc.

c) Pillar drill machine 25 mm capacity.

d) Gas welding set.

e) Chain pulley block (three tonne capacity).

f) Hydraulic jack of adequate capacity for erection of plant.

g) 25 mm Manila rope length 50 m, 100 mm wire rope about 70 m in length, Wire rope clamps, Packing timber like railway sleepers.

h) One set of hand tools such as spanner, screw drivers, hammers, chain spanners, screw spanner, chain and pipe wrench.

i) Grease guns, oil cans, trays.

j) General items of store like bolts, nuts, washers, pins, fasteners, fan belt, jitter, cotton waste and other fast moving items.

8.3 Requirement of Spare Parts and Lubricants for Repair and Maintenance

It is essential that adequate inventory of fast moving spare parts and recommended lubricants should be available for repair and maintenance of hot mix plant. The manufacturer's recommendations for fast moving spare parts may be followed. It would be appropriate to place the order for fast moving spare parts along with the plant, so that the work does not suffer during operation. Normally, the procurement of spare parts @ 10 percent cost of plant is adequate. The bulk purchase of spare parts and lubricants should not be carried out, which involves space, blockage of investment, chances of pilferage and fire hazard. In case the procurement is to be done through import, time factor for placement of purchase order, opening of letter of credit, shipping period, custom clearance, inland transportation should also be taken into consideration.

9 SAFETY ASPECTS AT HOT MIX PLANT SITE

The safety of equipments, operating and maintenance staff should be the prime criteria at hot mix plant site. Efforts should be made to make the plant site as accident free zone. In this connection, following precautions should be strictly followed:

9.1 Work Site

a) Create awareness regarding safety among staff.

b) There should be no slip-shot and short cuts.

c) Provide proper training to staff on safety.

d) Always employ a skilled and trained worker for the job.

e) Every worker should be medically fit for the job assigned.

f) Provide first-aid boxes with adequate supplies.

g) Keep fire fighting equipments in operational condition.

h) Ensure that workers wear helmets, safety belts, goggles, gloves and other items as necessary.

i) Use proper tools and tackles.

j) Ensure proper and clean platform/pathways for the work men to pass through.

k) Provide adequate illumination.

l) Provide guards and railings wherever necessary.

m) Blow siren before start of plant every time.

n) There should be an emergency switch located at a short distance from the plant, which will stop all plant operations in the event of an emergency.

o) A First Aid Box should always be available, in the control room.

p) Smoking should be prohibited near binder or fuel storage tanks.

9.2 Plant and Equipment

a) Keep the equipment in good running condition.

b) Never operate unsafe equipment.

c) Be familiar with all controls, gauges, instruments.

d) Look around before starting the plant and equipment.

e) Never leave the equipment unattended with its engine running.

f) Keep operator's platform clean and free from oil and grease.

g) Operate the equipment only from operator's seat/platform.

h) Never carry out servicing, adjustment and repairs, when the equipment is running.

i) Never permit unauthorized persons to handle the equipment.

j) The operator must have maximum unrestricted view of the operating area.

k) Avoid loose connections in electrical system.

l) Ensure that engine is switched off and immobilized against unauthorized use.

m) Don't leave the control, when the equipment is working.

n) Be careful in removing the radiator cap, after engine has been running.

o) Avoid leakage and over heating of bitumen.

p) Take precautions against backfire from burner.

q) Store fuel and lubricants away from plant.

r) Keep away from hot bitumen.

s) Be careful while attending to lighted burner.

t) Inspect all cables of plant periodically.

u) Shut down procedure:

   1) Put all the controls in neutral.

   2) Shut off the engine after allowing it to idle and gradually cooled down.

v) No open fire should be allowed around bitumen or fuel storage tanks.

9.3 Loading and Tansportation of Plant and Equipment

a) Load and unload the plant and equipment on the leveled ground.

b) Use the indicated lifting points, while lifting the plant and equipment with a crane.

c) Ensure correct loading and unloading procedure for different type of equipments.

d) Use ramp of adequate strength.

e) Block transport vehicle, so that it cannot move.

f) Tie and block the equipment securely for transport.

9.4 Maintenance of Plant and Equipment

a) Avoid fire hazards. Close fuel shut off valve.

b) Carry out repair and servicing in accordance with manufacturers' recommendations.

c) Before working on hydraulic system, make sure that hydraulic pressure is released.

d) While installing the electrical system, the supply battery must be disconnected.

e) Protect the eyes with safety glasses, while striking the metal parts and during welding.

f) Wear gloves, while handling bitumen, parts of sharp edges and during welding.

10 MAJOR FACTORS AFFECTING THE PERFORMANCE OF HOT MIX PLANT

The performance of hot mix plant depends on its design criteria, operational efficiency, maintenance and availability of allied machines. The following are the major factors which affect the performance of drum mix plant:

10.1 Presence of Moisture Content in Aggregates

The presence of moisture content in aggregates plays a vital role in preparation, production of hot mix and fuel consumption of hot mix plant.

If moisture content is very high say 8-10 percent, the aggregates shall not fall out of flights in a uniform veil, thus there shall not be uniform and adequate heating of aggregates. Thus, the increase in moisture content results in drop of production and increase in fuel consumption also.

The indicative relation between moisture content and output is given in **Annex-D**.

10.2 Dust Content in Mix

With increase in dust content in mix, output falls because there is more surface area to be coated by bitumen which requires greater mixing time. The indicative relation between dust content and output is given in **Annex-D**.

10.3 Altitude

The output of plant is derated approximately @ 3.5 percent every 300 m rise in elevation above sea level. The requirement of plant in specific area should be assessed based on this factor also. The variation of output with altitude is attached in the **Annex-D**.

10.4 Insulation of Drum

The output of plant can be increased by 2.5 percent and fuel consumption decreased by 4 percent by maintaining temperature difference between outer and inner shell of drum approximately 60°C. The drum shell should be insulated with glass wool or aluminium painted to avoid heat losses.

11 SUGGESTIONS

11.1 Following suggestions are made for selection of hot mix plant, its trouble free operation, efficient running and to achieve qualitative mix:

a) The hot mix plant should be of reputed make and proven design.

b) The capacity of plant should be selected based on availability of space for its commissioning, quantum of work and time period for its completion.

c) The Guidelines, instructions, maintenance schedules prescribed in manufacturers' manual should be strictly followed.

d) History sheets/log books should be maintained properly. It shall give an assessment for the requirement of spare parts needed for replacement at particular spell of time and their stocking for future use. It will reduce the inventory of spare parts in stock.

e) Fast moving spare parts should be kept in store at plant site to avoid idling of the plant.

f) Pyrometers/thermocouples are very sensitive instruments. These should be shielded from the heat of dryer drum, vibrations of the plant and got calibrated frequently; atleast once during the working period.

g) The vibrating screen cover should be opened regularly, checked for sieves wear and tensioning conditions and adjusted accordingly.

h) Control panel of hot mix plant should be got calibrated regularly to ensure accuracy of hot mix and output of plant.

i) In case of break down of plant, instructions given for trouble shooting in operational manual should be followed.

j) Genuine spares to be procured from plant manufacturer, to avoid break down and keep their interchangeability.

k) Skilled operators, technicians duly trained by plant manufacturer or otherwise, should be deployed for smooth operation / maintenance of plant.

l) Control Panel should have provision to store real time process data for reference and review.

m) High speed drives should be properly guarded, electrical wiring should have proper insulation and should be properly earthed and all relevant safety codes should be fully complied in design, erection and operation of the hot mix plant.

11.2 Information to be furnished by the purchaser is given at **Annex-A.**

11.3 Information to be supplied by the manufacturer to the purchaser is given at **Annex-B.**

11.4 The Parameters for the selection of Hot Mix Plant are given at **Annex-E.**

11.5 The Sample Calculation to ascertain the rate of usage charges of Hot Mix Plant is given at **Annex-F.**

11.6 The Sample Calculation for the output analysis of Hot Mix Plant is mentioned at **Annex-H.**

11.7. The Sample Calculation to work out requirement of Hot Mix Plant is mentioned at **Annex-I.** .

11.8 Some inputs regading calibration of Hot Mix Plants are given at **Annex-J.**

ANNEX-A
(Clause **11.2**)

INFORMATION TO BE FURNISHED BY THE PURCHASER WHILE MAKING AN ENQUIRY WITH THE MANUFACTURER

There are different types of Hot Mix Plants available with their salient features. It is suggested that following information in respect to Hot Mix Plant may be furnished by the manufacturer while making the purchase, so that appropriate type, make and model could be offered by the manufacturer.

1) **Site Conditions:**

a) Space available for commissioning the plant.

b) Altitude above mean sea level

c) Temperature and climate

d) Any other special conditions under which hot mix plant is to be used

2) **Type of Hot Mix Plant:**

Drum mix coater/Drum mix with embedded burner/Plain drum mixer/Drum mixer with centre inlet for RBP/Hot mix plant (Batch type)/Double barrel drum mix plant

3) **Type of flow:**

Counter flow/Parallel flow

4) **Methodology adopted for preparation of hot mix:**

Continuous type/Batch type

5) **Mobility of Hot Mix Plant:**

Stationary type/Mobile type

6) **Essential and optional units of Hot Mix Plant:**

The components shown below may be selected based on the type of requirement of plant.

a) Cold bin feeder (Minimum- 4 No.)

b) Aggregates over size rejection screen

c) Cold elevator/cold feed conveyor

d) Automatic weighing system
e) Dryer drum
κ) Dryer cum mixing drum
g) Primary pollution control device
h) Hot elevator
i) Screening unit
j) Hot bins
k) Weigh box
l) Bitumen unit
m) Mixing unit (Pugmill)
n) Mineral filler/ dust collection system
o) Control panel
p) Secondary pollution control device (Essential component as Bag house filter in batch type plant and optional as wet scrubber type in drum mix plant)
q) Hot mix surge silo (Optional component)

ANNEX-B
(Clause **11.3**)

INFORMATION TO BE SUPPLIED BY THE MANUFACTURER TO THE PURCHASER

The manufacturer should furnish the information to the purchaser as shown in **ANNEX-A**. In addition to that, following information should also be supplied to the purchaser to get him acquainted with the product and assist him in selection of plant.

1) Model and type of Hot mix plant offered

2) Brief description of the plant along with its units and their capacity

3) Specific features of the plant, if any

4) Type and No. of flights in Dryer/Dryer cum mixing drum

5) Capacity of electric motors fitted with different units of plant

6) Capacity of DG set required for operation of plant

7) Overall dimensions and weight of different units of the plant for transportation purpose

8) After sales-service, nearest to the commissioning site

9) Supply of spare parts catalogue, operation and maintenance manual assured

10) List of fast moving components assured

11) Details of similar model of plants supplied so far, year wise

12) Provision of training facilities

ANNEX-C
(Clause **4.1.4 & 5.2.14)**

TYPICAL HOT MIX PLANT EMISSIONS AND THEIR CONTROL

The pollution norms are fixed by the respective State Pollution Control Board which are binding on plants where they are in use. The following information are merely guiding factor.

Emission Factors for Particulate Matter (PM_{10}), CO, No_x, SO_2 and VOCs :

Process	Emission Factor (kg/tonne)[a]			
	CO	NO_x	SO_2	VOCs
Batch mix asphalt plants :-				
Natural gas-fired dryer	0.17	0.013	0.0025	0.0072
Oil-fired dryer	0.035	0.084	0.12	0.02
Drum asphalt plants[b] :-				
Natural gas-fired dryer	0.028	0.015	0.0017	0.022
Oil-fired dryer	0.0018	0.038	0.028	0.03

Process	Batch Mix Asphalt Plants	Drum Mix Asphalt Plants[b]
	PM10[a] (Kg/tonne)	PM10[a] (Kg/tonne)
Natural gas-fired dryer:		
Uncontrolled	2.2	2.2
Fabric filter	0.0098	0.0041
Oil-fired dryer:		
Uncontrolled	2.2	2.2
Fabric filter	0.03	0.015

Source: *USEPA document AP-42 (1995),[a] Factor units are kg of PM_{10} emitted per tonne of asphalt produced, includes both parallel and counter flow asphalt plants.*

Typical Hot Mix Asphalt Plant Emission Control Technologies : -

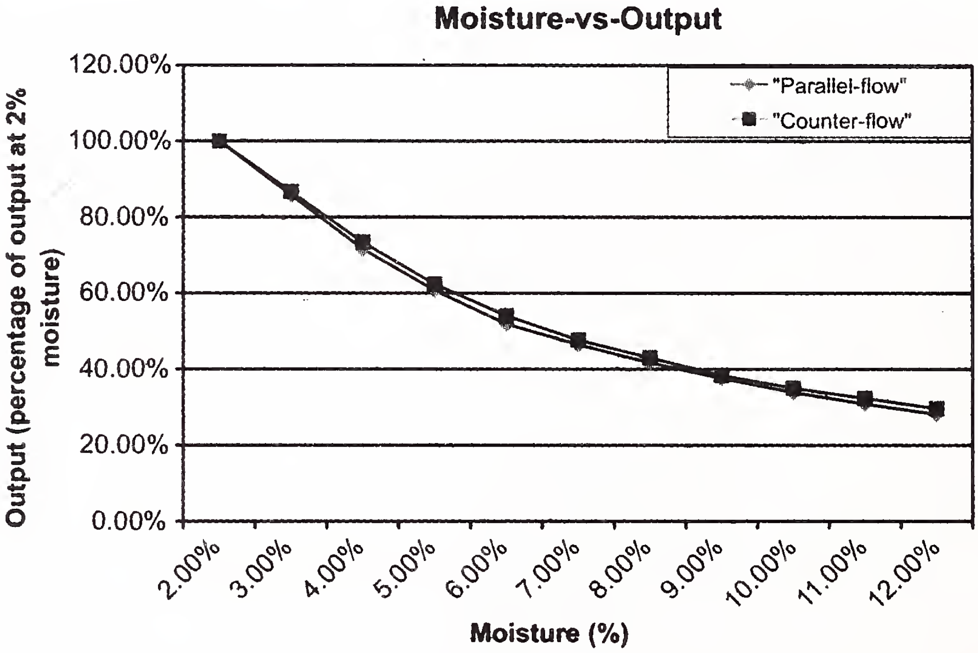
Emission Source	Pollutant	Control Technique	Typical Efficiency (%)
Process	PM_{10}	Cyclones	50 - 75
		Multiple cyclones	90
		Settling chamber	< 50
		Baghouse	99 – 99.7
		Venturi scrubber	90 – 99.5
	VOCs SO_2	Dryer and combustion process modifications	37 - 86
		Limestone	50
		Low sulfur fuel	80
Fugitive dust	PM_{10}	Paving maintenance	60 – 99
		Wetting & crusting agents	70 – 80
		Crushed reclaimed Asphalt Pavement Material	70

***Adapted from** : Gunke., Kathryn. O'C. 1992. Hot-Mix Asphalt Mixing Facilities. Buonicore, Anthony J., and Wayner T. Davis, Editors. Air Pollution Engineering Manual. Van Nostrand Reinhold, New York, NY, USA.*

ANNEX-D
(Clause **10.1, 10.2, 10.3)**

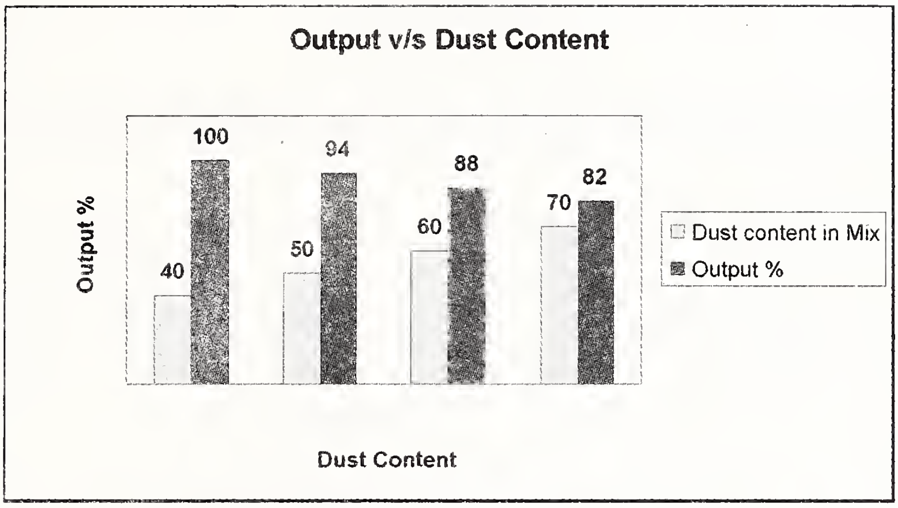
TYPICAL CHARTS OF HOT MIX PLANT OUTPUT VS DIFFERENT PARAMETERS

DEPENDENCY OF OUTPUT WITH SALIENT PARAMETERS



Moisture in aggregates (%)	Output (TPH)	
2.00%	100.00%	100.00%
3.00%	85.76%	86.67%
4.00%	71.53%	73.33%
5.00%	60.68%	62.33%
6.00%	51.86%	54.00%
7.00%	46.44%	47.67%
8.00%	41.69%	43.00%
9.00%	37.63%	38.33%
10.00%	33.90%	35.00%
11.00%	30.85%	32.33%
12.00%	28.14%	29.67%

Dust content	Output %
40 %	100
50 %	94
60 %	88
70 %	82



EFFECT OF ALTITUDE ON PRODUCTION OF MIX

Effect of altitude on the production of mix in a Hot Mix Plant on a 7′ diameter drum with 300^0 F (148.9°C) mix, 310^0 F (154.44°C) stack temperature and 5 percent moisture removed.

		Factor	Production Rate TPH
ALTITUDE IN FEET ABOVE SEA LEVEL	0	1.00	267
	500	0.98	262
	1.000	0.96	257
	1,500	0.94	252
	2,000	0.92	247
	2,500	0.91	243
	3,000	0.89	238
	4,000	0.86	230
	5,000	0.83	222
	6,000	0.80	214
	7,000	0.77	205
	8,000	0.74	197
	9.000	0.71	191
	10,000	0.69	184

ANNEX-E
(Clause **11.6**)

CHECKLIST FOR SELECTION OF HOT MIX PLANT

SELECTION PARAMETERS FOR HOT MIX PLANT

Selection item	Options available	Selection Criteria
1) Capacity	3 TPH – 650 TPH	i) Volume of work ii) Completion time iii) Availability of site area iv) Quantity required to b produced per day
2) Type	a) Batch type/Continuous type	i) Purchase cost ii) Maintenance cost iii) Position of availability and after sales service iv) Gradation v) Use of RBP vi) Emission norms vii) Noise restriction viii) Variation of Mixes
	b) Static/Portable/Mobile	i) Size of the Plant ii) Volume of mix to be produced and the period thereof to meet local requirement iii) Cost of erection vis-à-vis transportation
	c) Conventional layout/ Tower type layout	i) Site area available ii) Ease of erection
	d) Parallel Flow/Counter Flow/Double Barrel	i) Purchase cost vis-à-vis fuel saving ii) Position of availability and after sales service iii) Use of RBP
3) Bitumen Tank	a) Plain tank/Specialized tank for modified bitumen	i) Requirement of using straight run or modified bitumen ii) Position of availability and after sales service
	b) Direct Heating/Hot Oil Heater	i) Ease of maintenance ii) Local fire safety/emission control norms
4) Pollution Control System	Multicyclone/Bag House Filter /Wet Scrubber	i) Need to use recuperated fines ii) Local emission control norms

ANNEX-F
(Clause **11.7)**

SAMPLE PROCEDURE FOR CALCULATION OF RATE OF USAGE CHARGES OF HOT MIX PLANT

Assumptions

a) Salvage value = 15 percent of the cost of equipment at site

b) Storage charges = 1 percent of total investment to be depreciated, spread over the economic life

c) Repair and maintenance charges per hour including replacement of tyres = 150 percent of total investment to be depreciated spread over the economic life

d) Over head charges @ 5 percent of the sum of wages per hour + Servicing charges (Manpower and material cost)

1. For Equipments Used Departmentally

1.1 Ownership charges

A)	Total investment at site of work (This includes A/T cost, sales tax, excise/custom and other duties, transport expenses consisting of freight by ocean or rail, insurance, loading/ unloading charges, erection and commissioning on receipt)	=	Rs. X (say)
B)	Deduct salvage value @ 15 percent of total investment	=	0.15X
C)	Total investment to be depreciated	=	0.85X
D)	Economic life of machine in hours	=	Y hours
E)	Depreciation per hour	=	Rs. 0.85 X/Y per hour
F)	Storage charges per hour (1 percent of "C" spread over the economic life)	=	0.01x Rs.0.85 X/ Y
	Total ownership charges	=	(E) + (F) --------I

1.2 Operation charges

G) Repair and maintenance charges per hour (including maintenance and replacement of tyres) is 150 percent of "C" spread over the economic life = 1.5x(C)/(D) -------- II

1.3 Overhead charges

5 percent of ownership and operation charges	=	0.05x (I+II) -------III
Ownership charges per hour	=	Rs
Operation charges per hour	=	Rs.
Overhead charges per hour	=	Rs.

1.4 Running charges

Operating staff/labour wages

	Designation	No.	Unit wage per month	Wages per month
i)	Operator			
ii)	Helper			
iii)	Cleaner			
iv)	Misc. Expenses			

Total wages required for Operating staff and labour per month = Sum of wages per month

H) Total wages required for Operating staff and labour per hour = Total wages required for Operating staff and labour per month/Hours per month

I) Servicing charges

Servicing charges includes man power cost

	Designation	No.	Unit wage per month	Wages per month
i)	Mechanic			
ii)	Cleaner			

Total wages required for servicing staff per month = Rs.

Total wages required for servicing staff per hour = Total wages required for servicing staff per month/Hours per month

J) Servicing charges (Material cost)

	Fuel/lubricant	Rate per litre	Consumption (In litre/kg) per month	Expenditure per month
i)	Fuel			
ii)	Lubricants			

iii) Grease

iv) Hydraulic oil

v) Gear oil

vi) Cotton waste

vii) Furnace oil (In case of hot mix plant)

Total expenditure per month = Rs

Total servicing charges (material cost) = Total expenditure per month/Total hours per month

K) Cost of lubricating oil, fuel consumed per hour

L) Total running charges per hour = H+I+J+K ---------------------------------------IV

Over head charges @ 5 percent of total = 0.05x(L) -----------------------------V

Hire charges = I+II+III+IV+V

2. For Equipments Given to Contractor and Outside Agencies

When the equipments are issued to contractors, interest and insurance charges @ 10 percent of the average investment per year will be calculated as under and added.

$$= \frac{A}{1500} \times \frac{60^*}{100} \times \frac{10}{100}$$

* on 5 years life

= Rs.

M) Interest and insurance charges per hour

Therefore the total charges in that case would be as follows:

Ownership charges (E+F+M)	=	I
Operational charges	=	II
Running charges	=	IV
Overhead charges @ 5 percent of total charges per hour (I+II+IV)	=	V
Hence hire charges per hour	=	I+II+IV+V

ANNEX–G
(Clause 8)

DO'S AND DON'TS FOR MAINTENANCE OF HOT MIX PLANTS

Do's:

- Maintain proper gap between Skirt rubber and Auxiliary belt
- Ensure belt center run position
- Gate opening of all bins should be as per requirement
- Greasing of bearing and oil checking in all gear boxes
- Rubber guard should be fitted properly and greasing of bearing.
- Slinger belt should be center run and greasing of bearing and oil checking in gear box.
- Load cell frame should be free during operation and locked when plant is not working
- Check the oil level in all gear boxes.
- Proper setting of thrust wheel of drum
- Greasing of all bearings.
- Ensure the trunion wheel adjustments.
- Tighten the nuts and adjustments bolts.
- Ensure proper adjustments/tighten of drum drive gear Motor chain .
- Ensure proper lubrication of drum drive chain.
- Pre-heat the Drum before feeding of aggregates
- Start burner with zero damper position
- Before starting burner, clean both the ignition electrode
- Observe the smoke of burner during operation to ensure that the burner operates properly.
- Ensure leakage free operation of pump and solenoid and pressure relief valve
- Ensure photocell working for auto mode of burner
- Start the exhauster with close position of exhauster
- Belt tightening of exhauster belt.
- Watch out for any black smoke at chimney outlet
- Monitor the differential pressure during operation.
- Monitor the smoke temperature while running.

- Ensure continuous operating of the cascading ring.
- Grease the vibrating screen daily before the start up of the plant
- Check all the cylinders before start up of the plant
- Clean the air filter and oil fiter daily.
- Check the Compressor pressure daily
- Ensure clean air inlet to the air compressor.
- Carry out maintenance at regular intervals
- Water earth pits regularly
- Follow safety rules.
- Maintain Generator, monitor Voltage and Frequency
- Keep the control room clean and remove all unwanted materials
- Keep panel power off while carrying out any welding work in the plant
- Keep all panels under shelter, water should not enter the panels.
- Remove all material from the plant before shut down
- Check the calibration at regular intervals. Also it is advised to undertake calibration of load cells for the measurement of flow rate of aggregates, bitumen and filler on regular intervals (say one month)
- Operate the bitumen transfer pump only after the bitumen temperature reaches beyond the 120°
- Check alignment/tighten at regular intervals
- Close the main valve at the fuel tank before servicing fuel pipeline; prepare and place suitable container or vat under pipe joint before loosening it.
- Disconnect the load cell, invertors and other electrical devices when the welding work is carried out in the plant.
- Stop the operation of the plant when you see the lighting near by or hear clap of thunder and also shut off the electrical lightning.
- Adjust all the vibrator weights to the same phase and the same mass.
- Do the checking of the Level of the Hot oil in hot oil tank

Don'ts:

- Do not operate Bin Vibrator when bin is empty
- Do not allow the level of bitumen in the Bitumen tank to fall below safety level
- Don't close bin gate when Plant is in operation:
- Don't operate Vibrating Screen in idle mode.

- Don't feed the higher size of Aggregates in Drum
- Don't stop the drum till it reaches the ambient temperature.
- Don't disturb the burner working pressure during operation
- Do not operate the Burner without operating exhauster and Drum
- Do not fully open the Damper gate while running.
- Do not operate Exhauster with Full open Exhaust Damper
- Don't touch the hot oil pipe line by hand directly
- Do not operate the plant without proper knowledge. This could be dangerous.
- Do not start Drum motor directly on load try to remove load or give momentum to drum before power is switched ON
- Do not start or stop the bigger motor frequently on load
- Never use wires instead of fuse links. Spare fuse links are provided in the panel
- Do not power the panel without proper earthing
- Do not run the plant at more than rated capacity
- Do not run without proper earthing
- Do not run the panel without proper supply power condition
- Do not touch the panel without wearing shoes
- Do not close the breaker on load without cover or arc chutes ;the flash may damage your eyes
- Do not try to carry out the maintenance with power ON
- Do not bypass safety of any equipment with power ON
- Do not use under size cables or motors .This can result in fire hazards.
- Never touch the metal parts of terminal with your finger
- Do not smoke in the vicinity of the HMP and certainly not within 5 meters of fuel tank and fuel pipe line

ANNEX-H
(Clause **11.6**)

SAMPLE CALCULATION FOR OUTPUT ANALYSIS OF A HOT MIX PLANT

Time period for completion of 1 Km (2 lane) Bituminous Pavement Construction by 60-90 TPH Drum Mix Plant

Sl.No.	Type of Pavement	Quantum of work involved in 2 lane (7.00 m) NH Road in cum	Quantity of aggregate in Tonnes/Km. assuming density 2.2
1)	75 mm BM	7 mx0.075 mx1x1000 m = 525 cum	= 525x2.2 = 1155 Tonnes
2)	25 mm SDBC	7 mx0.025 mx1x1000 m = 175 cum	= 175x2.2 = 385 Tonnes

3) Total tonnes of aggregates to be prepared in Hot Mix Plant: 1155+385 = 1540 Tonnes

4) Average output of Plant : 60-90 TPH Plant (Say) 75 TPH

5) Assume Plant working hours per day – 7.5 Hrs

6) Total Tonnage produced in a day 75x7.5 = 562.5 Tonnes

7) Time required for producing 1540 tonnes aggregates.

$$\frac{1540}{562.5} = 2.73 \text{ days} \qquad \text{(Say) 3 days}$$

ANNEX-I
(Clause **11.7**)

SAMPLE CALCULATION TO WORK OUT REQUIREMENT OF HOT MIX PLANT

Assumption

200 Km of 2 lane road (7.00 m width) to be strengthened with 50 mm BM and 25 mm SDBC in a year.

i) Quantity of aggregates for 50 mm BM for 200 Km = 7 m x 0.050 m x 200 x 1000 = 70,000 cum.

Assume density of aggregates : 2.2

Quantity of BM : 70,000 x 2.2 = 1,54,000 Tonnes.

ii) Quantity of aggregates for 25 mm SDBC for 200 Km. = 7 m x 0.025 x 200 x 1000 = 35,000 cum.

Assume density of aggregate : 2.2
Quantity of SDBC = 35,000 x 2.2 = 77,000 Tonnes

iii) Total quantity of aggregate to be prepared in Hot Mix Plant : 1,54,000 + 77,000 = 2,31,000 Tonnes

iv) Suppose the work will be executed with 60-90 TPH Drum Mix Plant, Average output = 75 TPH

v) Total working hours of Plant in 1 year : 1500 Hrs.(assuming 200 working days @ 7.5 working hours per day)

vi) No. of Plant required to produce mix 2,31,000 in a year

$$= \frac{2,31,000}{75 \times 1500} = 1.71 = 2 \text{ Plants}$$

ANNEX-J
(Clause **11.8**)

CALIBRATION OF HOT MIX PLANTS

Calibration is the process of adjusting the settings for known levels of accuracy. Every time a measurement is made or a process is performed, there is an actual result and an expected result. Because of random and variability with a definite pattern, the actual result usually differs from the expected result. Calibration is done to either identify/ rectify the non-random variability or account for it in such a way that the difference between the actual and expected results is negligible.

Calibration is done for the Cold bin feeders, Temperature measuring devices and load cells to measure the flow rate of aggregates and the Bitumen. The details of the procedure of calibration vary with the type of plant and the manufacturer.

Calibration, for example, of a load cell in a drum mix plant is undertaken for three to four control settings covering the production range anticipated for the material.

Calibration of the Load Cell

The load cell in a Drum Mix Plant is used to measure the flow rate of aggregates and the Bitumen. The calibration is initially done in the static mode and then in dynamic mode.

a) The default settings (factory settings) of the load cells are to be checked. If there is any change, there is a requirement to calibrate. The speed of the slinger conveyor is checked which is LN/60 where L is the length of the slinger conveyor and N is the RPM.

b) Thereafter the static calibration of the load cell (beneath the slinger conveyor) needs to be done with the help of a standard weight. Therefore theoretical value of the TPH is equal to Weight (Kg) x Speed of the slinger conveyor (m/sec) x (3600/1000) TPH

c) To undertake the dynamic calibration of the load cell the Slinger conveyor, gathering conveyor, load out conveyor and thermodrum have to be started. The gate opening of the cold bin feeder is set as per the manufacturer's recommendation. Only one feeder is kept in open position. Also a trolley or a truck with known tare weight is selected and is kept under the loadout conveyor.

The plant is allowed to run for a fixed time duration and the output is collected on the trolley/truck. The weight of the material is calculated after calculating the weight of the loaded truck. The actual TPH is calculated from the weight of the material output from a given feeder, time of output and percentage of this aggregate (from the job Mix formula).

This process is followed for at least three control settings. The Load cell constant (Actual TPH/Theoretical TPH) is then calculated.

Calibration of the Bitumen Flow Rate

The Plant is allowed to run at 100 percent load and 3 percent (say) of Bitumen . The arrangement to collect the discharge of bitumen pump in a vessel is made. The system is allowed to run for duration of 30 seconds. The actual weight of the output is calculated by subtracting the difference between the empty vessel and the vessel filled with bitumen. The theoretical weight of the output for a Plant with output of 45 Tons per Hour is (TPH*(1000/3600)*30*(3/100)). This process is repeated for at least three observations. If the actual weight is less than the theoretical weight then the speed of the pump is increased.

In the case of Batch Mix Plant the load cell is calibrated for Aggregates, Filler, and Bitumen. The details have to be followed as per the manufacturer's recommendations Manuals.

For the sake of illustration, Manufacturers prepare a calibration chart for each of the aggregates to be used in the hot mix.

An example of determining the control settings for each cold feed using the calibration chart is as follows:

1) Mix Design Criteria

Coarse Aggregate	20 percent (Cold Feed #1)
Intermediate Coarse Aggregate	40 percent (Cold Feed #2)
Fine Aggregate	30 percent (Cold Feed #3)
Filler	10 percent (Cold Feed #4)
Binder Content	5.0 percent

2) Flow Rate Per Cold Feed

Q = T B P

Q = Required Flow Rate per Bin (t/h)

T = Plant's Mix Production Rate (t/h)

B = Percent of Aggregates in Mix (as decimal)

P = Percent by Weight of Total Mix (as decimal)

Plant Production of 350 t/h

Q (Cold Feed #1) = 350 x .95 x .20 = 66.5 t/h

Q (Cold Feed #2) = 350 x .95 x .40 = 133 t/h

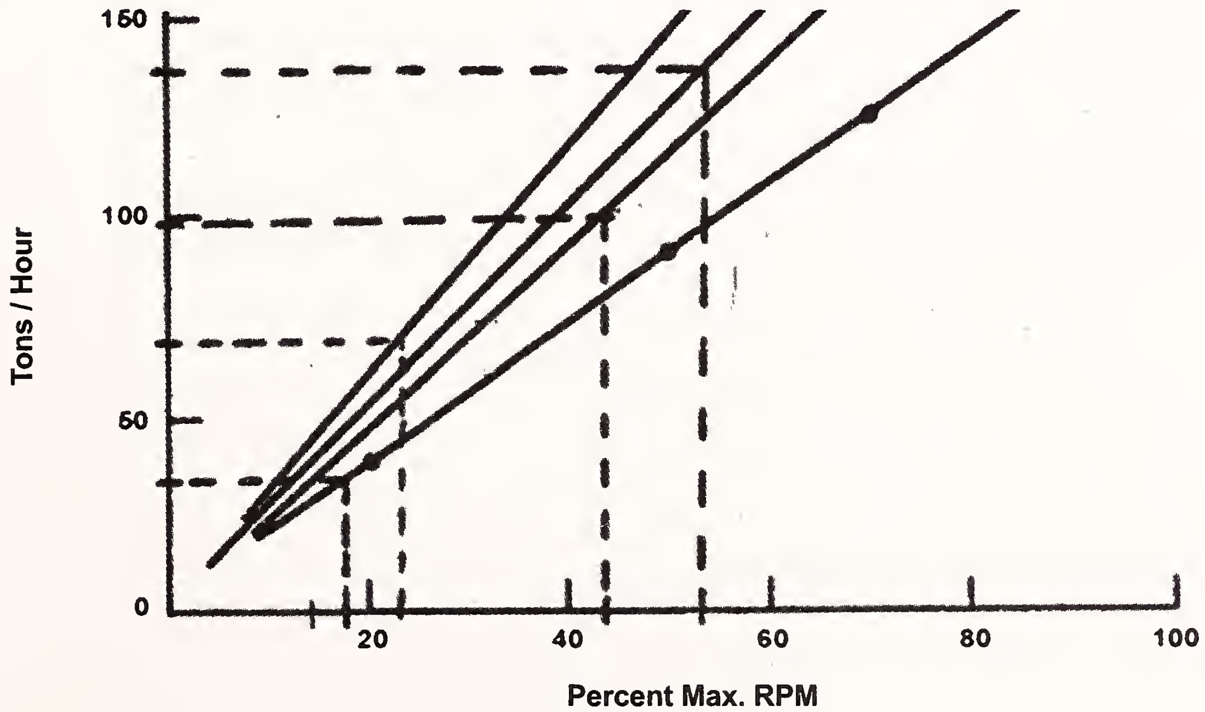
Q (Cold Feed #3) = 350 x .95 x .30 = 99.8 t/h

Q (Cold Feed #4) = 350 x .95 x .10 = 33.2 t/h

3) The calibration chart to determine the control settings for each cold feed is used by locating the production rate for each cold feed on the vertical scale, moving horizontally to the appropriate control line and then vertically down to locate the control setting. The approximate bin settings are:

Bin 1 = 23 percent
Bin 2 = 53 percent
Bin 3 = 43 percent
Bin 4 = 18 percent

By making these determinations, the discharge rate of each cold feed supplies a balanced flow of material. This balance is critical as it provides a uniform flow of material.



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