Manual on Construction Equipment for Rural Roads

May, 2016

National Rural Roads Development Agency
Ministry of Rural Development
Government of India

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Foreword

National Rural Roads Development Agency (NRRDA) has in effective collaboration with States been executing one of the largest rural road infrastructure development programme in the world under Pradhan Mantri Gram Sadak Yojana (PMGSY). Gained from the experience of constructing about 4,70,000 Kms. roads during last 15 years, unique systems, procedure and Standards have evolved across the country and have been applied in the rural roads sector with very satisfactory results.

Time bound and Good Quality construction has been the Centrality of the Programme since its inception in year 2000 with focus on construction of well engineered roads and bridges. Dedicated Specifications for Rural Roads and Standard Data Book (SDB) for rate analysis were developed in collaboration with Indian Roads Congress (IRC) and prescribed under PMGSY. These specifications envisage the construction and maintenance of roads through use of intermediate technology i.e. deployment of appropriate mix of manual labour and equipments. This in turn requires adequate knowledge about the availability of appropriate equipments in the market and their production capacity, operation, maintenance cost etc.

Selection of appropriate technology and equipments is critical to rural road construction. For each construction activity, there is an optimal combination of equipment and labour, for maximizing the output, depending on the nature and content of the work. The technical staff of the contractor as well as field engineers, need to know which tools/ equipments to use and how effectively to combine them with manual labour to maximize the desired quality of output. Therefore, a need was felt to develop a Manual which would be helpful in selecting the right equipments for construction work. The NRRDA, constituted a Committee of Experts under the chairmanship of the Director General (Road Development) & Special Secretary to the Ministry of Road Transport & Highways (MoRTH) to prepare a Manual on Construction Equipment for Rural Roads.

The Committee took into account the current and emerging practices in use of machines in Rural Roads. The present document has been developed based on the inputs form the professionals, practicing engineers, contractors and the equipment manufacturers. The draft document has been peer reviewed and discussed at a workshop held in August 2015 in Bangalore where besides the NRRDA, the road agencies from the states of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana participated. The workshop also had the benefit of participants from equipment suppliers and manufacturers and other relevant stakeholders. A number of useful suggestions and comments were received. The Manual has accordingly been updated.

The Manual broadly covers the key features of various types of machines and equipment relevant for rural roads. This would be of help particularly to contractors in remote areas who may not otherwise be aware of the performance capability of different construction equipments in meeting the requirements of the specifications in an economical manner.

I would like to place on record my deep gratitude to Chairman, Shri S. N. Das for ably guiding the Committee. Special thanks are due to Shri R. K. Saxena, retired Superintending Engineer (Mechanical) of MoRTH who undertook to prepare the base document with inputs from the members of the Committee. I would also like to acknowledge the valuable suggestions made by the members of the Committee, the iCEMA and its Office Bearers and my own colleagues S/Shri I. K. Pateriya, Uttam Kumar and Chaman Lal, Directors and Shri Rakesh Kumar, Assistant Director, during the course of preparing this Manual. I hope that this Manual will be found useful by the States in their effort to promote judicious use of appropriate machinery in rural road construction and maintenance.

Document of this nature cannot remain static with continuous upgradation of technology and construction practices. Feedback and suggestions to keep the document updated are welcome from the users of this Manual.

(Rajesh Bhushan)
Joint Secretary, MoRD &
Director General, NRRDA

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1. INTRODUCTION

1.1 Rural roads are now being constructed as well engineered roads as per standards laid down by the Indian Roads Congress. Under the PMGSY Programme, the National Rural Roads Development Agency, an arm of the Ministry of Rural Development has developed a series of documents and procedures for construction of rural roads. These documents include Specifications for Rural Roads and Quality Assurance Handbook.

1.2 The focus is on quality and speed of construction. The specifications require the deployment of plant and equipment for construction and maintenance of rural roads. It is essential that the equipment of appropriate type as per requirement should be deployed. The planning and execution of works require adequate knowledge about the type, capacity, selection, operation, maintenance of equipment and their usage charges. This would help in preparation of realistic estimates and overcoming the problems in timely completion of project and achievement of the specified quality. Several works on rural roads are in remote areas and the local contractors may not be aware of various types of equipments which can give satisfactory performance meeting to specifications in economical manner.

1.3 This Manual on Construction Equipment for Rural Roads has been prepared by the NRRDA for assisting the road agencies and the contractors in construction and maintenance of works on rural roads. Needless to emphasise that the use of proper equipment helps in achieving the prescribed specifications in a cost effective manner. It may be added that most of the plant and equipment required for rural roads are available in our country.

1.4 The aggregates play an important role in ensuring the quality of construction. Majority of rural roads have bituminous pavements. The cost of bituminous component is quite high in total construction cost. Accordingly, specific attention has been paid to cover the crushing plant and bituminous equipments like hot mix plant, paver finisher, bitumen pressure distributor, cold mix plant; precautions to be observed during construction of bituminous layers. This will help the planning, executing and inspection engineers to become familiar with these equipments.

1.5 The capacity, dimensions of the plants/ equipments given in the Manual are indicative and may vary somewhat based on their make, model, change in design and prevailing site conditions.

Guidelines for Selection of Plant and Equipment for Different Operations in Rural Roads

2. Guidelines for Selection of Plant and Equipment for Different Operations in Rural Roads

2.1 The construction activity for specific operation can be carried out by deploying different types of plants/ equipments. Anyhow, care should be taken in their selection considering that appropriate type of plant / equipments capable of achieving desired specifications based on site conditions are deployed on job in most economical manner. The following factors should be considered while selecting the plants and equipments.

(i) Location of work

(ii) Type of work

(iii) Quantum of work involved

(iv) Completion time period

(v) Distance of borrow area

(vi) Methodology adopted for doing the work

(vii) Availability of space for

(a) Commissioning of plants

(b) Parking the equipments

(viii) Adequate space for free movement of vehicles

(ix) Plants and equipments to be of repute make and proven design having all essential technical parameters to carry out the work meeting to specifications

(x) The plants and equipments maintained at all times in a manner with minimum down time

(xi) Capacity and quantity of allied equipments to be matching to the capacity of main plant and considering the lead time

(xii) Appropriate equipment for specific job

(xiii) Capable of achieving end result

2.2 Normally, the quantum of work and cost of construction package of rural roads is small. Therefore, the prime criteria for selection of the equipments for deployment on these works is that their cost, operation and maintenance should be minimum, without compromising on the quality.

2.3 Similar type of equipment after completing one activity should be transferred immediately to another activity for its better and economical use.

2.4 It should also be ensured that the equipments are of adequate capacity and their quantity assessed on realistic requirement of project. The surplus equipments will result in unnecessary investment on their basic cost, operation and maintenance charges.

2.5 The suggested plants and equipments meeting to the requirement of different clauses of Specifications for Rural Roads are given in Annex-I.

3. PLANT AND EQUIPMENT

3.1 The plant consists of different units in which processing of product takes place in multi-stages and end product achieved finally.

3.2 The equipment is used to perform the activity in single / multi stage.

3.3 There are different types of plants and equipments that can be used in rural road construction. These are:

- Earthwork Equipment
- Compaction Equipment
- Equipment used for Granular Sub-base, Bases and surfacing work
- Water Bound Macadam Equipment
- Wet Mix Macadam Equipment
- Bituminous Equipment
- Cement Concrete Equipment
- Allied Equipment
- Crushing and Screening Plant
- Bridge Construction Equipment
- Mobile Maintenance Unit

Earth Work Equipment

4. Earth Work Equipment

4.1 Earlier road construction, particularly earth work used to be considered as labour oriented job. The tremendous development in road sector in terms of volume and specifications, scarcity of labour and improvement in construction methodology have resulted in large scale mechanisation in this sector. In India, during the period 1960's to 1980's, motorized scrapers and towed scrapers with bull dozers as pushers were being used to cart earth from the borrow area to the earth filling area and motor grader for grading the earth surface. These machines filled with earth, being voluminous, were serving as compaction equipment also. The induction of self propelled single drum vibratory road roller / tandem vibratory roller as compaction equipment and tippers for transportation have changed the whole scenario in carrying out earth work.

4.2 Basically, the earth work equipments have been classified into two categories. (i) Track machines (ii) Wheeled machines**.**

4.2.1 Track machines: These are mounted on pair of crawler track, which provides better traction with lower ground pressure, hence more suitable for hilly and rough terrain. These are more versatile also. Their speed is low and cannot be used for long distance movement on its own power; since track damages the road surface and its repair cost is high.

4.2.2 Wheeled machines: These are mounted on pneumatic tyres, can travel faster and cover long distance on its own power. Its ground pressure is more, traction is less which results into slippage; hence not suitable on soft ground.

4.3 There are several types of equipments available for earth work. These are described in this chapter. Selection may be based on site conditions, quantum of work and completion time.

4.4 It would be preferred to carry out earth work with tractor based equipment in rural road works, since tractor is commonly used equipment in rural areas and is cost effective in operation and maintenance. Different types of attachments like front end loader, backhoe loader, dozing, radial loading, dozing and grading, grading can be fitted on the tractor. The attachment on tractor should be fitted based on its make, model, capacity and recommendations of the manufacturer.

The cost of soil stabilizer is high, therefore rotavator/ disc harrow/ tiller fitted at the rear of tractor has been proposed for granular sub-base, base spreading purpose and soil stabilization to improve sub-grade/ sub-base. It can be selected as per width requirement. It is less expensive and running is also economical.

4.5 Tractor fitted with Attachments

Tractor is the main source for transportation in rural areas and in agricultural fields. Thus, the attachments fitted on it shall be quite useful in rural road application due to its easy availability and their use in economical manner. Presently, different types of attachments are available to carry out specific construction activities. The capacity,

make, and model of tractor should be confirmed from the supplier of attachment before its procurement, to ensure that the tractor matches to the requirement of attachment. Some of the attachments provided on the tractor are multipurpose, which makes it more versatile and useful. The brief details of the tractor fitted with such attachments are given below.

4.5.1 Tractor fitted with Front End Loader Attachment (Fig. 4.1)

Fig. 4.1 Tractor fitted with Front End Loader Attachment

It is a low cost equipment used to lift and transport the soil/ aggregate for short distance and load it in to tipper or bins of wet mix plant or hot mix plant. The front end loader attachment is fitted with the tractor and can be detached within 20 minutes by a single person, if required.

The tractor used for fitment of this attachment should be of minimum 55 horse power. The bucket can be easily detached without application of spanner. It is provided with single lever joy stick arrangement and bucket level indicator for easy operation. Normally, the size of bucket is 0.6 cum with loading capacity 900 kg, dumping height 2.7 metre at 45º angle which can be extended up to 3.0 metre, depending on the model of the tractor. The output of this equipment is 48 cum per hour considering 90% efficiency and 40 seconds operation cycle.

4.5.2 Tractor fitted with Dozing Attachment (Fig 4.2)

Fig. 4.2 Tractor fitted with Dozing Attachment

It is also a low cost equipment in which dozing attachment can be fitted or detached easily. It is fitted on 60 to 70 hp tractor. The length of the blade is 2400 mm, height 900 mm and blade cutting capacity 120 mm. Blade, if damaged, can be replaced easily and economically. Dozing attachment can be fitted with single or double cylinder to control dozing action.

Direction control valve with relief valve is provided in the system. This prevents over loading of hydraulic system and reduces the maintenance cost.

4.5.3 Tractor fitted with Loader and Backhoe Attachment (Fig 4.3)

In road construction activity, the digging and loading activities are normally performed simultaneously. The tractor fitted with loader and backhoe attachment is very useful to perform these activities.

Fig. 4.3 Tractor fitted with Loader and Back Hoe Attachment

The fitment of this attachment depends on the capacity of the tractor, which should be 60 hp and above. The back hoe attachment can be used for loading tractor trailers as well as tippers. The specifications normally followed for this equipment are as under.

(i) Loader portion:

(a) The bucket capacity is 0.6 cum (900 kg)

(b) Lift height is 3.6 metre with dumping height 3.0 metre

(ii) Backhoe portion:

(a) The bucket capacity is 0.21 / 0.23 cum

(b) The bucket can be used for maximum digging depth up to 3.5 metre

(c) The bucket can be used with maximum load up to 3.2 metre height

(d) It can apply tear force of 5700 kg

(e) The boom can rotate up to 180° angle

4.5.4 Tractor fitted with Radial Loading Attachment (Fig 4.4)

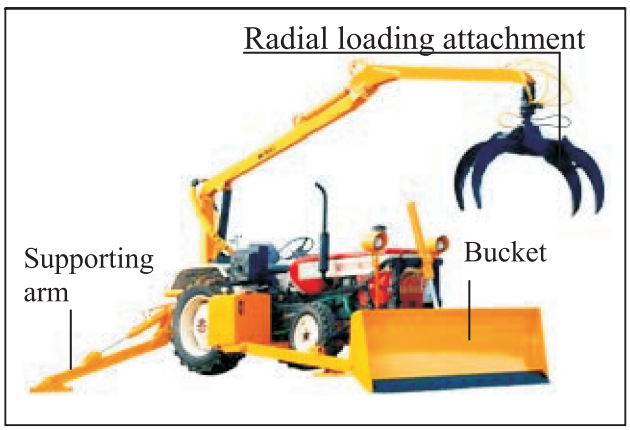


Fig. 4.4 Tractor fitted with Radial Loading Attachment

It is an attachment fitted with tractor of 60 hp and above. It has got the supporting arm in the back. The radial loading attachment can be used for loading/ shifting the cement bags, steel and cement hume pipes.

4.5.5 Tractor fitted with Dozing and Backhoe Attachment (Fig 4.5)

Fig. 4.5 Tractor fitted with Dozing and Backhoe Attachment

In road construction, the digging and dozing activities are sometimes required simultaneously. The tractor fitted with dozer and backhoe attachment is very useful for these activities. The backhoe attachment can normally be used for digging up to 3.5 metre depth. The backhoe attachments above 3.5 metre depth are also available for fitment of higher capacity tractor above 60 hp. The capacity of backhoe bucket is 0.23 cum and can lift it with full load up to 3.5 metre. The hydraulic pump should be of adequate capacity to operate these attachments. The length of dozer blade is 2400 mm and height 900 mm.

4.5.6 Tractor fitted with Grading Attachment (Fig 4.6, 4.7, 4.8)

Fig. 4.6 Tractor fitted with Grading Attachment

There are different types of grading attachments fitted on the tractor, based on the grading capacity and their width. The attachments shown in Figures 4.6, 4.7 and 4.8 are indigenously developed. These are useful and low cost equipment that can be used for grading purpose in rural roads. They can be fitted on the tractor having steering power attachment.

The tractors with 55 hp and above are suitable for fitment of these attachments. The width of grader blade is between 2.1 and 2.8 metre.

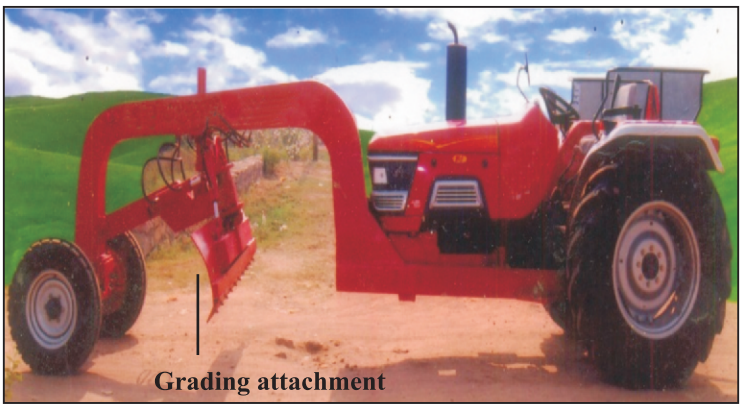


Fig. 4.7 & 4.8 Tractor fitted with Grading Attachment

4.5.7 Tractor fitted with Dozing and Grading Attachment (Fig 4.9)

Fig. 4.9 Tractor fitted with Dozing and Grading Attachment

This equipment comprises of dozing and grading attachments. The front dozing attachment is used to scatter the bulk material and grading attachment to smoothen the surface, make it flat and provide slope as per requirement.

These attachments are fitted on four wheel drive tractor of 75 hp capacity.

The main components of the attachments are

(i) Frame

(ii) Hydraulic jack for front dozer

(iii) Front dozer

(iv) Front axle

(v) Draw bar

(vi) Centre blade

(vii) Hydraulic jack for vertical movement

(viii) Control valve

The front dozer can move in vertical direction and centre blade in horizontal, vertical and diagonally. The circular drive provides the facility for movement of centre blade at different angles. The provision to offset the centre blade enables it for side cutting of road.

The tractor with four wheel drive and bigger tyres has several advantages in this equipment. (i) It has more traction effort (ii) It has less slippage (iii) Heavy duty front and rear axle makes it easier to work in rough terrain (iv) It has got higher ground clearance (v) It has wide range of speed which makes its running economical (vi) It has proper load distribution (vii) The dozing and grading operations can be done simultaneously, if required, (separate levers for operation)

The sizes of main components of this equipment are as under:

(i) Overall length: 6800 mm

(ii) Length of blade: 2130 mm

(iii) Length of front dozer: 1830 mm

(iv) Camber cutting height: 600 mm

(v) Width of front dozer: 600 mm

(vi) Height of blade from bottom: 480 mm

4.5.8 Rotavator

This attachment shown in Fig.4.10 and fitted at the rear of tractor is known as rotary tiller also.

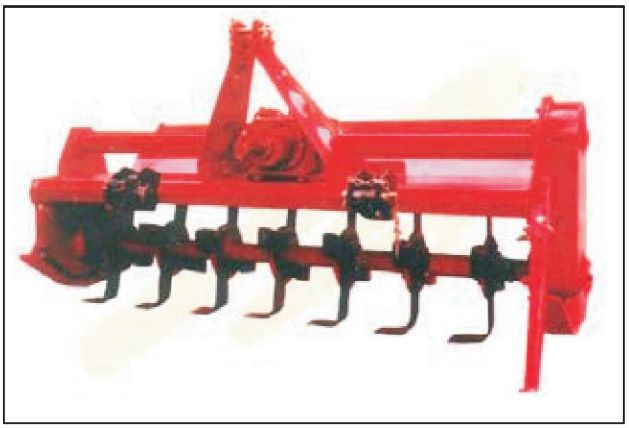


Fig. 4.10 Rotavator

It has three point linkage and can be fitted to the power take off (PTO) shaft of tractor. The design may vary depending on size and type of blades. It can be fitted on tractor ranging 30 to 75 hp. The width of rotavator is 1.0 to 2.4 metre and can be selected based on the requirement. The speed of rotor is 220 to 540 RPM. It is regulated by means of skids. The blades may very upto 42 in number.

The depth of tillage is up to 15 cm, which is controlled by side arms. Gear drive/ side chain drive shown in Fig.4.11 and 4.12 is provided for movement of tillers.

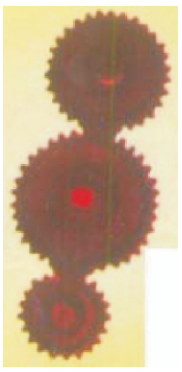


Fig. 4.11 Gear type

Fig. 4.12 Chain type drive

Heavy duty rotavator attached with tractor above 45 horse power may be used for lime stabilization purpose, i.e. for pulverizing and mixing the soil with additive and soil to the specified degree to full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material.

4.5.9 Disc Harrow (Fig 4.13)

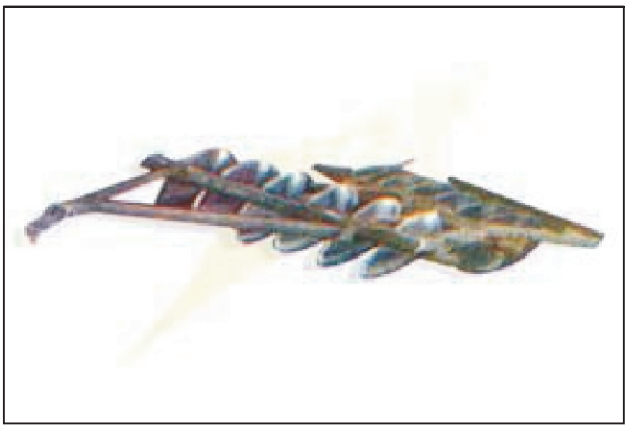


Fig. 4.13 Disc Harrow

It is versatile and has good manoeuverability. It is designed to fit on all types of tractors with rear hook or drawbar arrangements. Its discs are in concave shape which enables their penetration in earth by combination of weight and design. It is of two types (i) Trailing type (ii) Hydraulic mounted type.

4.5.10 Cultivator (Fig4.14)

Fig. 4.14 Cultivator

It can be fitted on all types of tractors. The frame of cultivator is made of mild steel. The heavy duty spring loaded tines mounted on sturdy steel frame provide excellent trash clearance with deeper penetration. Constant tine vibration shatter the sub soil to let it mix with additives. Normally 9 to 17 tines are provided as per requirement.

4.6 Backhoe Loader

Fig. 4.15 Backhoe Loader

The Backhoe loader (see Fig 4.15) functionally comprises of two components (i) Loader bucket (ii) Backhoe bucket. It is mounted on pneumatic tyres and is the most popular equipment used in road construction industry due to its multipurpose application like excavation, rock breaking, loading earth / aggregates into tippers, feeding the aggregate into bin feeder of wet mix plant and hot mix plant. It can be shifted from one place to another, easily on its own power depending on lead. Different capacities of Excavator cum loader are available and selection can be done based on requirement of bucket capacity, loading / digging depth, soil condition, project completion time, economy and use in future projects. Salient features of Backhoe loaders of different capacities are given in Table 4.1.

Table 4.1 Salient Features in respect of Backhoe loaders of different capacities

S.No	Particulars	Capacities of Backhoe loaders		
(i)	Engine capacity	50 hp	76 hp	92 hp
(ii)	Loader bucket capacity	0.60 cum	1.10 cum	1.20 cum
(iii)	Backhoe bucket capacity	0.18 cum	0.24 cum	0.32 cum
(iv)	Maximum digging depth	3.02 metre	4.77 metre	5.31 metre
(v)	Maximum working height for backhoe	3.88 metre	5.97 metre	6.25 metre
(vi)	Backhoe bucket rotation	182°	185°	185°
(vii)	Loader pay load	800 kg	1800 kg	1800 kg

S.No	Particulars	Capacities of Backhoe loaders		
(viii)	Wheel base	1.99 metre	2.17 metre	2.34 metre
(ix)	Minimum ground clearance	0.33 metre	0.36 metre	0.28 metre
(x)	Transmission – synchromesh with torque convertor	4 speed (4.55 to 28 km /hr)	4 speed (6.1 to 40 km/hr)	4 speed (7.26 to 40 km/hr
(xi)	Drive	Two wheel	Two wheel	Four wheel
(xii)	Power steering with working pressure	1810 psi	1750 psi	1750 psi
(xiii)	Travel speed	28 km/hr	40 km/hr	40 km/hr
(xiv)	Tyre size – Front Rear	7.5x16 14.9x24	9x16 16.9x28	12.5x18 16.9x28
(xv)	Weight	4530 kg	7460 kg	8470 kg

Larger size front tyres give better resistance and more traction during loading.

Four wheel drive backhoe loader is preferred due to its (i) Higher traction on all four wheels giving mobility even on slush and sand, enabling the machine to overcome gradients easily (ii) Availability of maximum speed enables quick and easy mobility of machine from one site to another (iii) Heavy duty loader arm for better lifting capacity.

The rock breaker can be fitted on Backhoe loader 76 hp and above, for demolition of structures, rock and existing road surface, if required.

The backhoe loader 50 hp capacity can be fitted with dozing attachment at extra cost, which gives additional advantage.

4.7 Wheeled Loader:

Wheel Loader (see Fig 4.16) is mounted on pneumatic tyres and is commonly used equipment in road construction industry due to its multipurpose application like loading earth / aggregates into tippers, feeding the aggregate into bin feeder of wet mix plant and hot mix plant. It can be shifted from one place to another easily on its own power depending on lead.

Fig. 4.16 Wheeled Loader

Loaders of different capacities are available and selection can be done based on requirement of their loading and bucket capacity, project completion time, economy and use in future projects. The loader with engine capacity of 76 hp, bucket capacity 1.1 cum, lower turning radius, higher traction force, adequate design of loader arm and chassis for longer life and provision of IP-69 electrics for better

reliability may be preferred for rural road application.

4.8 Tracked Excavator:

Tracked machines (see Fig 4.17) are more versatile, mounted on a pair of crawler tracks which provides stability with better traction, higher gradeability and low ground pressure. Its speed is quite low and movement on its power for long distance is uneconomical, since track repair is expensive.

Fig. 4.17 Tracked Excavator

The Tracked Excavator (i) 8 tonne capacity with engine 76 hp, bucket capacity 0.24 cum and 0.32 cum (ii) 12 tonne capacity with engine 80 hp, bucket capacity 0.65 cum can be used for rural road application especially in hilly terrain and rocky area.

4.9 Track Dozer

Fig. 4.18 Track Dozer

The track dozer is used in hilly/ rough terrain having steep slope and involving more quantity of earth work and time as constraint. Small capacity track dozer shown in Figure 4.18 fitted with 100 hp engine, operating weight 8500 kg, blade width 2.8 metre and blade capacity 2.0 cum can be deployed in rural roads/ hilly terrain.

Compaction Equipments

5. Compaction Equipments

The compaction in road construction/maintenance can be achieved by rolling. It increases material's load spreading capability and its durability by reducing air voids content and thereby ingress of water and air. The selection of roller to achieve the desired specifications for the job and its operator's skills are important factors to achieve proper compaction. The type and quantity of work involved to carry out earth work, bituminous work as per requirement i.e. thick lift, thin lift, their production will determine the type of roller viz static, vibratory, pneumatic type or their combination and their numbers needed.

Rolling is a process of densification and in case density resistant to ultimate traffic load is not imparted to the mat at construction stage, the material will deform under traffic and result in formation of channel or ruts on the surface, which may be accompanied by sideways displacement of materials.

Soil compaction is a mechanical process to orient particles as close as possible, thereby confining the water and removing air voids. The soil in a fill should have maximum density and be capable of supporting the remaining portion of roadway yet to be placed on the fill.

The compaction of mix material is influenced by the type of aggregates, its size, shape (degree of flakiness and elongation), grading, binder content, viscosity of binder and temperature of mix during compaction. This operation should be carefully implemented at site. Any defect observed during construction activity can be rectified at compaction stage only, since it is the last activity of construction.

The brief details of different types of rollers for their use in different types of works along with precautionary measures to be taken are given in this chapter.

5.1 Static Three Wheel Roller (Fig 5.1)

It is a conventional roller being used for compaction since decades. It is in the range of 80 to 100 kN weight. The weight of the Roller is fixed 80 kN; which can be increased up to 100 kN as per requirement, based on site conditions by induction of sand/ gravel/ water in front and rear rolls.

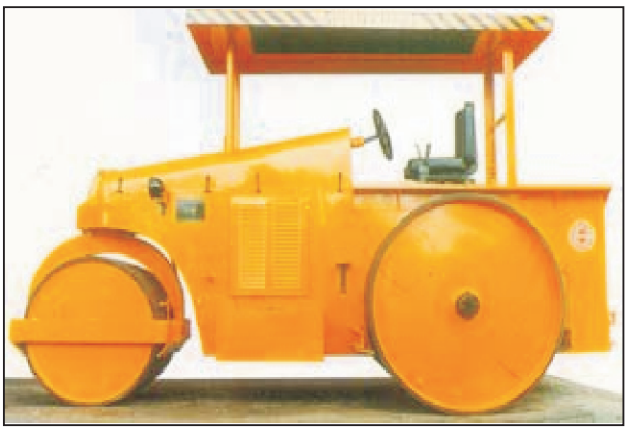


Fig. 5.1 Static Three Wheel Roller

Normally, the rolling width is 1810 mm, front roll width 950 mm, rear roll width 535 mm with over lap of rolls 100 mm. The static linear load is the deciding factor for compaction The minimum static linear load on front and rear roll wheels is 28 kg/cm and 48 kg/cm respectively. The speed of roller is in the range 1.5 to 9.0 km/hr and can be used for compacted layer thickness up to 100 mm.

5.2 Vibratory Tandem Roller (Fig 5.2)

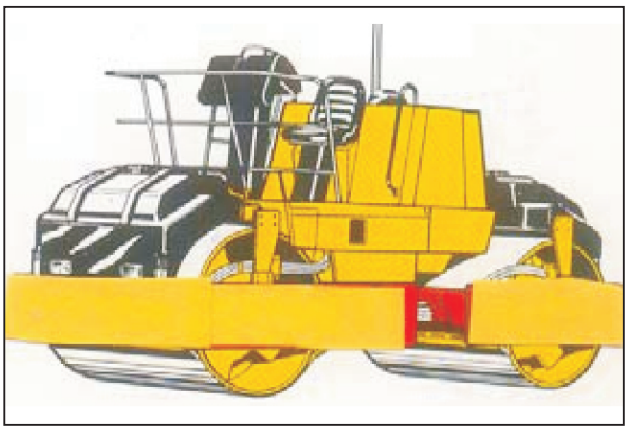


Fig. 5.2 Vibratory Tandem Roller

It consists of two rolls, which get the vibration motion through hydraulic system. The Vibratory Tandem Rollers in the range 80 to 100 kN and 60 to 80 kN weight are used for compaction on different specified works. It is clarified that the weight of Vibratory Tandem Roller remains fixed. It is used for compaction on stabilized sub base, base and bituminous work. The combination of static pressure and dynamic force in vibratory roller effects better compaction. (Fig 5.3) Vibratory tandem roller of similar weight as of static weight roller gives better compaction.

The frequency of vibratory tandem roller is in the range 33 to 50 Hertz and amplitude in the range 0.3 to 0.8 mm. (Refer IS 5500 Part 1: 2004)

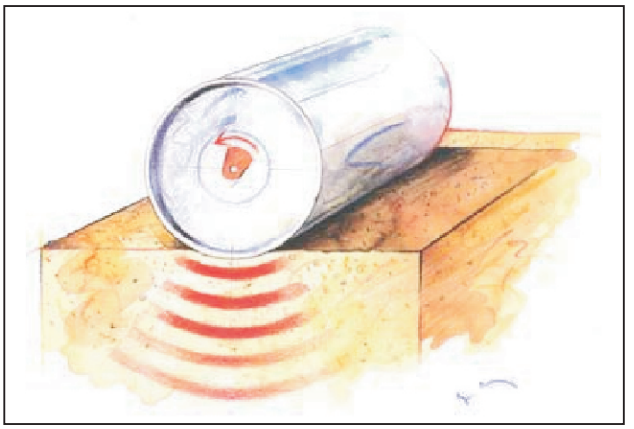


Fig. 5.3 Effect of Static Pressure and Dynamic Force during Vibration

This roller can be used in static as well as dynamic mode depending on the requirement of specifications. While using in static mode, static linear load may be calculated as under:

$$\text{Static linear load} = \frac{\text{Static weight of roller}}{\text{Rolling width}} \text{ N/mm}$$

It can be used for compacted layer thickness up to 200 mm.

5.3 Mini Vibratory Tandem Roller (Fig 5.4)

It consists of two rolls, which get the vibration motion through hydraulic system. The Mini Vibratory Tandem Rollers approx. 3 tonne weight can be used for compaction on road shoulders, trenches and the areas which cannot be accessed by 8 tonne tandem roller. It can be used for compaction of earth work as well as bituminous work. It being of small capacity, roller is provided with single amplitude normally 0.6 mm and frequency 55/67 Hertz. The general specifications of this roller are as under.

(i) Engine : Suitable hp

(ii) Operating weight: 3000 to 3500 kg

(iii) Drum width: 1250 mm

(iv) Drum thickness: 13.5 mm

Fig. 5.4 Mini Vibratory Tandem Roller

(v) Wheel base: 2030 mm

(vi) Ground clearance: 593 mm

(vii) Linear load: 13.2 kg/cm

(viii) Total applied force: 12600 kg

(ix) Working speed: 5 km per hour

(x) Inner turning radius: 2325 mm

(xi) Gradeability: 30%

5.4 Self Propelled Single Drum Vibratory Roller (Fig 5.5)

It is known as soil compactor also. It has got one steel drum in front and two pneumatic tyres in rear. The shape of pad foot in pneumatic tyre provides lesser contact area. Thus, more static linear load and higher amplitude on steel drum gives better compaction on earthen embankment.

Fig. 5.5 Self Propelled Single Drum Vibratory Roller

Normally, the rollers in the range 80 to 100 kN weight are used in embankment and soil compaction work. The static weight of Soil Compactor remains fixed. The steel drum vibrates during vibration mode. The frequency of vibration is in the range 25 to 50 Hertz and amplitude 0.8 to 2.0 mm. (Refer IS 5500 Part 1 : 2004)

5.5 Double Drum Walk Behind Roller (Fig 5.6)

It is fitted with vibrating mechanism in the frame. It generates sufficient vibrating energy to both the drums. It is available in the range 400 to 1000 kg. The light weight rollers are also available. It is driven by diesel engine. It is fitted with hydrostatic drive for easy movement by operator, who can adjust its speed and direction.

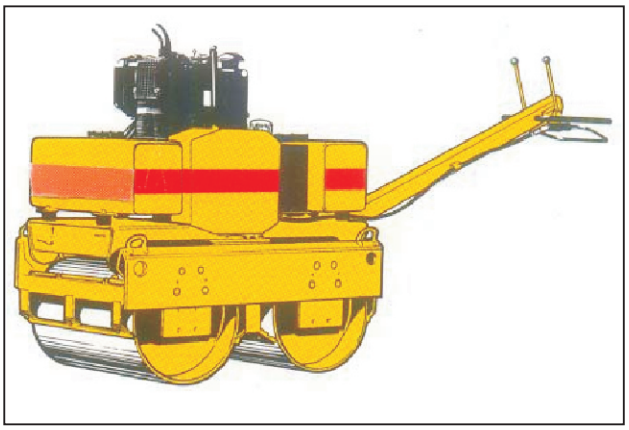


Fig. 5.6 Double Drum Walk Behind Roller

The frequency of these rollers is up to 63 Hertz and amplitude 0.5 mm. It is used for compaction in areas, which are not within the approach of static three wheel roller and vibratory tandem roller, for example, the edges of foundations, bridge abutments and specifically for pot hole repairs.

5.6 Single Drum Walk Behind Roller (Fig 5.7)

Fig. 5.7 Single Drum Walk Behind Roller

It comprises of single drum and fitted with vibrating mechanism in the frame. It generates sufficient vibrating energy on the drum. Its weight is 180 kg and working width 560 mm. The prime mover used is petrol engine or electric motor. It is used for compaction in areas, which are not within the approach of static three wheel roller and vibratory tandem roller, for example, the edges of foundations, bridge abutments and specifically for pot hole repairs.

5.7 Vibratory Plate Compactor (Fig 5.8)

Fig. 5.8 Vibratory Plate Compactor

The weight of plate compactor ranges from 60 to 1000 kg. The compaction effort depends upon its weight. It can be operated with diesel/ petrol. The vibrations propel the plate compactor forward or backward. Its frequency is in the range 40 to 100 Hertz and amplitude between 1 to 3 mm. It is the principle of vibratory plate compactor that more the weight, higher the amplitude and lower the frequency. These are divided into two categories.

(i) Heavy plate compactor (ii) Light plate compactor (i) Heavy Plate Compactor: It is in the range 400 to 1000 kg and operates at large amplitude. It is suitable for compaction on cohesive soils.

(ii) Light Plate Compactor: It is in the range 60 to 400 kg. It operates at high frequency and low amplitude. It is suitable for compaction of thin layers of sand, gravel and bituminous surface.

5.8 Rammer (Fig 5.9)

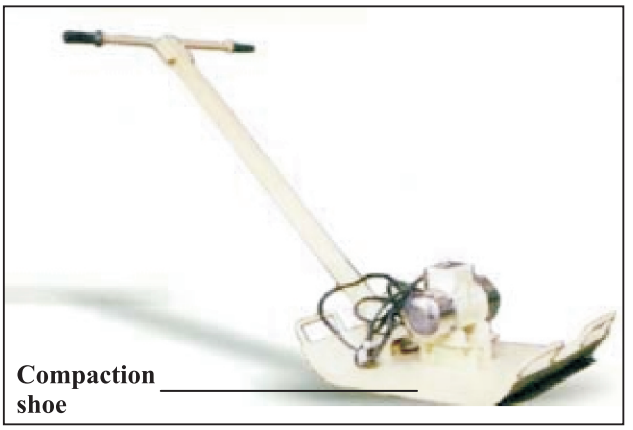


Fig. 5.9 Rammer

It is a common equipment for use in compaction of earth. It is driven with electrical motor/ petrol engine 5 hp. The length and width of compaction shoe is approx. 700 mm x 500 mm. The travel speed is 10 metre per minute. Normally, the weight of the rammer is 150 kg and can be used for compaction thickness upto 20 cm.

5.9 Vibratory Tamper (Fig 5.10)

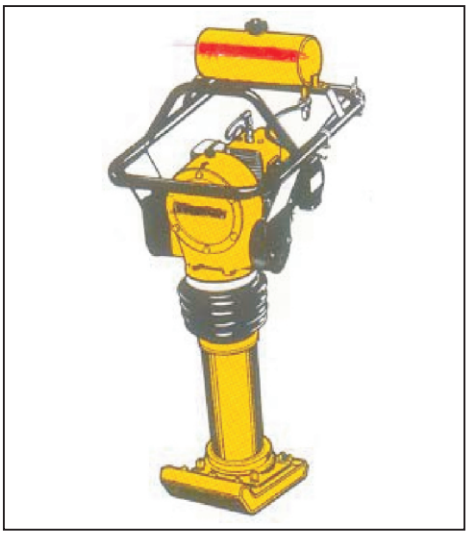


Fig. 5.10 Vibratory Tamper

It is a common equipment used for compaction purpose. It is driven by petrol and operating mass is in the range 60 to 85 kg. Its frequency is approximately 12 Hertz and amplitude 5 to 8 mm. The force exerted per blow is 13 to 22 kN. The length of bottom plate is 330 mm and width in the range 230 to 330 mm, The dimension may vary based on the design of manufacturer. It is used for compaction on sand, gravel, clay, sub-base and base.

Advantages of Vibratory Compaction

(i) The process of vibrations sets the particles in motion and rearranges them in densest space.

(ii) It achieves higher density and better depth effect than static compaction.

(iii) Through vibratory compaction, desired compaction is achieved in lesser number of passes than static compaction.

(iv) It is more efficient and economical than heavy static equipment used for similar jobs.

5.10 Pneumatic Tyre Roller (Fig 5.11)

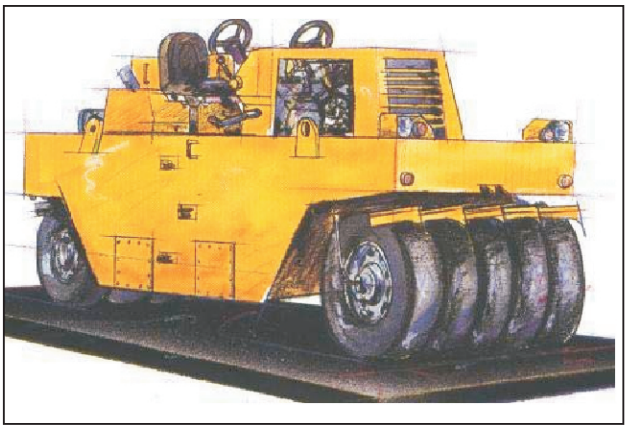


Fig. 5.11 Pneumatic Tyre Roller

It comes under the category of static roller. The kneading action of pneumatic roller on bituminous pavement reduces its permeability and makes the surface more smooth. It is being used in intermediate rolling on bituminous work. Self propelled pneumatic tyre rollers have been designed with specific features to lock the surface particles together and create a surface seal for smooth riding quality. Its salient features are as under:

(i) It is mounted on two axles, front axle having three to four tyres and rear axle four to five tyres.

(ii) The standard tyres are used. These tyres can be used at different pressures ranging 0.3 to 0.9 MPa depending on tyre ply rating. Pressure exerted by radial tyre is more than diagonal tyre, thus the chances of leaving tyre marks on bituminous surface are reduced.

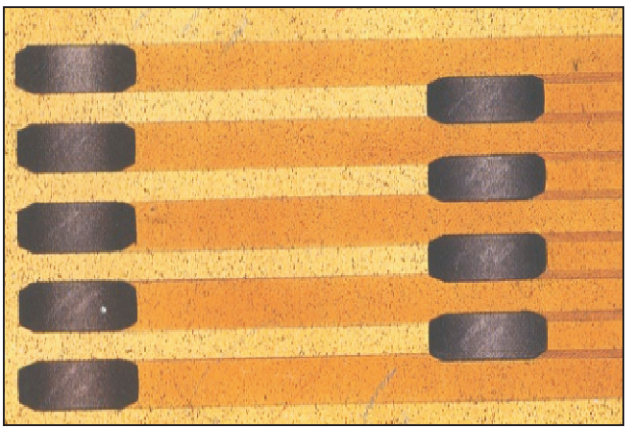


Fig 5.12 Front and Rear Tyres Over Lapping Gap

(iii) It is provided with hydrostatic drive for easy operation at desired speed. The travel and working speed of roller is in the range of 0-23 and 0-13 km/hour. However, to achieve quality in work, working speed of roller should be restricted to 6 km/hr.

(iv) There is some gap between the tyres provided in the front and rear tyres. This gap is filled with the movement of tyres. The front and rear tyres overlap 30 to 50 mm at normal pressure (Fig 5.12).

(v) The operating weight of pneumatic tyre roller can be increased by adding ballast on it, which may be in the form of scrap iron bar, sand or water.

Load on each wheel/ tyre

$$= \frac{\text{Total operating weight of pneumatic tyre roller + Ballast}}{\text{Number of wheels}}$$

- Maximum load capacity on each wheel is 3000 kg. The roller should be capable of exerting a minimum load of 1200 kg on each wheel.

Precautions:

The following precautions should be observed in operation of pneumatic tyre roller to achieve quality in work.

(i) It should be equipped with smooth tyres of equal size, ply in good running condition and inflated to nearly equal pressure with variation not exceeding 0.034 MPa on pneumatic tyres such as to get uniform pressure during rolling.

(ii) Desired ground contact pressure may be adjusted on roller with the ballast.

(iii) All wheels should roll true without wobble or creep.

(iv) In pneumatic tyre roller, rear wheels are drive wheels, they should be facing towards the paver finisher during paving and compaction.

(v) Each pass of the pneumatic tyre roller should over lap the preceding pass by at least one half the width of the roller.

(vi) Roller speed not to exceed 6 km/hr.

(vii) During rolling, pneumatic tyre should be kept moist and not wet to avoid picking up the mix material by moving tyres.

(viii) Intermediate rolling to be continued until all mix material has been compacted thoroughly.

(ix) Rolling operation should commence at outside edge of the surface and progress towards centre of the road.

(x) It should be ensured that during all subsequent passes, required density is achieved, before mix temperature drops to 85ºC.

(xi) It should not be allowed to stand on a finished paved surface before it has thoroughly cooled, otherwise it shall leave permanent depressions on mat surface.

Equipments Required for Granular Sub-base, Base and Surfacing Work

6. Equipment required for Granular Sub-base, Base & Surfacing work

The brief details of equipments required for laying and compacting granular material / natural gravel on sub-base, base and surfacing prepared sub-grade, lime treated soil for improving sub-grade / sub-base and cement stabilized sub-base, base are given below.

6.1 Tractor Towed Water Tanker

Tractor towed water tanker of 5000 litre capacity mounted on single axle fitted with proper water sprinkler system can be used for sprinkling of water. (Refer Allied Equipments Item No. 11.6)

6.2 Tractor Trolley fitted with Tipping Attachment

Tractor trolley fitted with hydraulic tipping attachment towed with tractor can be used for transportation of sub-base / base material and spread it uniformly and evenly in one or more layers. (Refer Allied Equipments Item No.11.5)

6.3 Tractor fitted with Grading Attachment

The sub-base material laid on prepared sub-grade shall be spread and graded with tractor fitted with grading attachment. (Refer Earth Work Equipments Item No.4.5.6)

6.4 Tractor fitted with Rotavator / Disc Harrow / Cultivator

If sub-base material consists of combination of materials, the mixing of pulverized soil with lime / cement, can be carried out with the tractor fitted with rotavator / disc harrow / cultivator. (Refer Earth Work Equipments Item No. 4.5.8, 4.5.9, 4.5.10)

6.5 Static Three Wheel Roller

The rolling of gravel / soil- aggregate sub-base, base and surface course shall be carried out with static three wheel roller in the range of 80 to 100 kN weight, if thickness of compacted layer does not exceed 100 mm. (Refer Compaction Equipments Item No. 5.1)

6.6 Vibratory Tandem Roller

The rolling of gravel / soil- aggregate sub-base, base and surface course shall be carried out with vibratory tandem roller 80 to 100 kN weight for a compacted single layer upto 200 mm. (Refer Compaction Equipments Item No. 5.2)

Water Bound Macadam Equipments

7. Water Bound Macadam Equipments

The following equipments can be used for water bound macadam works.

7.1 Tipper fitted with Chip Spreading Attachment

The coarse aggregates shall be spread uniformly and evenly in one or more layers such that the thickness of each compacted layer is not more than 100 mm for grading 1 and 75 mm for grading 2 and 3. The tipper fitted with chip spreader attachment can be used for this purpose. (Refer Bituminous Equipments Item No. 9.8)

7.2 Tractor Trolley fitted with Tipping Attachment:

Tractor trolley fitted with hydraulic tipping attachment towed with tractor can be used for spreading the coarse aggregates uniformly and evenly in one or more layers. The trolley having proper opening to be adjustable with rack and pinion arrangement at tail gate is suitable for this work. (Refer Allied Equipments Item No. 11.5)

7.3 Tractor Towed Mechanical Broom

The brooming shall be done with tractor towed mechanical broom. (Refer Allied Equipments Item No. 11.2)

7.4 Static Three Wheel Roller

The static three wheel roller in the range of 80 to 100 kN weight can be used for compaction purpose to achieve compacted layer thickness upto 100 mm thickness. (Refer Compaction Equipments Item No. 5.1)

7.5 Vibratory Tandem Roller

The vibratory tandem roller 80 to 100 kN weight can be used for compaction purpose to achieve compacted layer thickness upto 100 mm thickness. (Refer Compaction Equipments Item No. 5.2)

7.6 Tractor Towed Water Tanker

Tractor towed water tanker of 5000 litre capacity mounted on single axle fitted with proper water sprinkler system can be used for sprinkling of water. (Refer Allied Equipments Item No. 11.6)

Wet Mix Macadam Equipments

8. Wet Mix Macadam Equipment

The wet mix macadam base should be prepared thoroughly meeting to the specifications. The base should have adequate strength before laying of bituminous layer. The wet mix plant for preparation of mix should be of repute make, proven design and selected carefully to achieve the specified results. The brief details of wet mix plant with their capacity for use in rural roads are given in this chapter.

8.1 Wet Mix Plant

The purpose of Wet Mix Plant (Fig 8.1) is to prepare the wet mix macadam base material comprising of crushed, graded aggregate and granular material premixed with water in desired proportion.

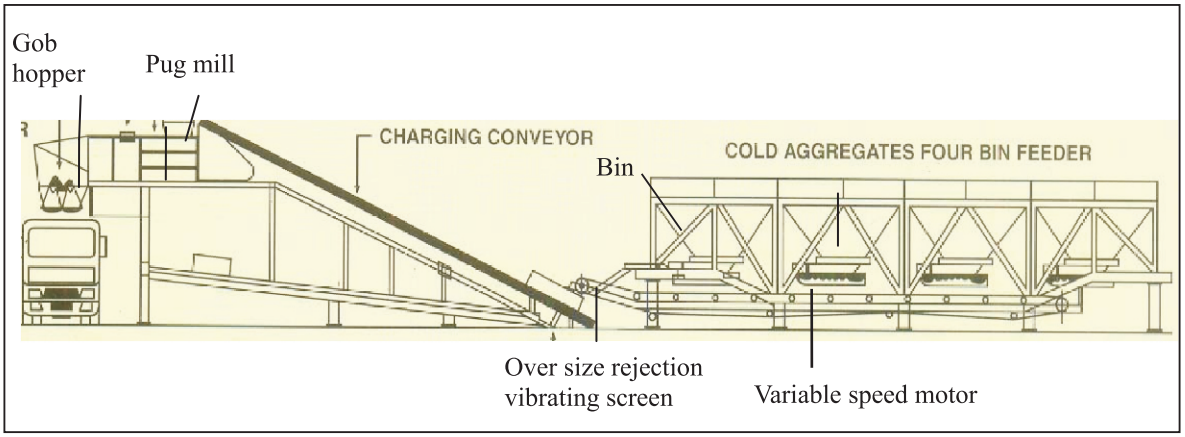


Fig. 8.1 Different Components of Wet Mix Plant

The Wet mix plant of 60 tonnes per hour (TPH) capacity is adequate for doing wet mix work for rural roads / hill roads. The essential components of Wet mix plant are as under:

(i) The plant should be fitted with minimum 4 no. bins of adequate capacity. Normally, the storage capacity of all the bins should be 30 cum. The width of the bin should be such that the loader can feed the aggregate into bin without intermixing. One bin vibrator is fitted in the first bin containing fines. The purpose of this bin vibrator is to prevent sticking of the fines to the walls of bin.

(ii) AC/DC variable speed motor is fitted under each bin to control the flow of material coming under each bin.

(iii) Aggregate over size rejection vibrating screen is provided between gathering and slinger conveyor to reject the over size material. It helps in preparing the wet mix as per specification and reducing the wear and tear of pug mill.

(iv) The charging conveyor (slinger conveyor) carries the material to pug mill.

(v) Water tank of minimum 10,000 litre capacity, self priming pump, control valve and spray bar with water flow meter is provided to add desired quantity of water in pug mill.

(vi) Hydraulically operated gob hopper is provided to collect and release the mix material instantaneously to avoid segregation.

(vii) The control panel is provided to control all the activities of plant in sequential manner and their precise process control i.e. operation of various drives, control the proportion of different sizes of aggregates/material. Following information is provided in control panel:

(a) Aggregate weight in tonnes/hr

(b) Total cumulative weight of aggregate in tonnes

(c) Water flow in litres per minute

(d) Total cumulative water used in litres

(viii) Safety devices like guards, railing, protection devices are provided.

(ix) The capacity of electrical motors fitted on different units of WMM Plant 60 TPH capacity is as under:

(a) Four bin feeder - 6 hp (Each of 1.5 hp) (b) Bin vibrator - 0.5 hp (c) Over size aggregate rejection screen - 0.5 hp (d) Pug mill drive - 15 hp (e) Water pump - 2 hp (f) Gob hopper - 3 hp (g) Charging conveyor - 5 hp (h) Slinger conveyor - 5 hp (i) Blower – 2 hp (j) Control panel – 5 hp

Power Requirement for Wet Mix Plant

The DG set 62.5 kVA is adequate to run the Wet mix plant of 60 TPH capacity.

8.2 Mobile Concrete Batching and Mixing Plant

In case the requirement of wet mix is less, it can be prepared in mobile concrete batching and mixing plant with weigh batcher. (Refer Cement Concrete Equipments Item No. 10.3)

Bituminous Equipments

9. Bituminous Equipment

The cost of preparation of bituminous mix and its laying is higher as compared to other activities of road construction. The bituminous equipments to be used for preparation of mix and their laying should be of repute make, proven design and selected carefully to achieve the specified results. The brief details of hot mix plant, bitumen pressure distributor, bitumen/ emulsion sprayer, paver finisher along with their capacity for use in rural roads are given in this chapter. Important tips for use of compaction equipments for bituminous and other works have also been included in this chapter. This would be helpful in achieving the quality of mat surface.

9.1 Bitumen Pressure Distributor

The purpose of Bitumen pressure distributor is to spray thin, uniform and accurately measured quantity of binder under pressure. The rate of spray of binder should be kept uniform. This is achieved by driving the pressure distributor at uniform speed. It is used for tack coating and also for prime coat purpose. The suggestive details of various components of bitumen pressure distributor are as under:

(i) Fully insulated tank of 50 mm thickness.

(ii) Positive displacement bitumen pump of 350 to 450 litre per minute capacity.

(iii) Air compressor 3 hp capacity with working pressure 10 kg/cm^2.

(iv) Driving unit capable of being operated with 25 hp diesel engine.

(v) Bitumen spraying pressure in the range 0 to 6 kg/cm^2.

(vi) Dial indicating type thermometer to measure 0^o C-300^o C to be provided in the tank.

(vii) Spray bar 2.4 metre width with extension up to 4.2 metre.

(viii) The nozzle distance to be 225 mm.

(ix) The spray bar movement is controlled pneumatically.

(x) The rate of application of bitumen is in the range 0.3 to 1.0 kg/ cm^2.

(xi) The rate of flow is controlled by a metering device. The calibration chart is provided for this purpose and supplied along with the machine.

(xii) The spray bar cleaning is done by air pressure/ diesel.

The bitumen pressure distributor is classified into two categories:

(i) Self Propelled Bitumen Pressure Distributor

(ii) Tractor Towed Bitumen Pressure Distributor

9.1.1 Self Propelled Bitumen Pressure Distributor (Fig 9.1)

Fig. 9.1 Self Propelled Bitumen Pressure Distributor

It consists of truck chassis of adequate capacity and dimensions suitable for mounting the bitumen tank with all accessories. The bitumen tank in the range 3000 to 4000 litre capacity mounted on truck chassis is sufficient for application in rural roads. The operation of spray bar is done from platform cabin provided at the rear of chassis.

9.1.2 Tractor Towed Bitumen Pressure Distributor (Fig 9.2)

Fig. 9.2 Spray Bar in Operation in
Tractor Towed Bitumen Pressure Distributor

The bitumen tank of 1500 to 2000 litre capacity along with all accessories mounted on chassis and towed with tractors is sufficient for application in rural roads.

9.2 Bitumen Sprayer (Fig 9.3, 9.4)

The function of bitumen sprayer is to spray the bitumen uniformly for tack coat or prime coat purpose, and application in pot hole/ patch repair and other small bituminous works. It can be towed with tractor or road roller. It is provided with accurate spray control system and available in 500/ 1000/ 1200/ 1500/ 2000 litre

capacity tank mounted on four wheel chassis. Pneumatic wheels are preferred due to their frequent movement during operation. It is fitted with diesel engine for operation of burner and bitumen pump.

Normally, 6.5 hp diesel engine is fitted with 500/1000 litre capacity tank. The bitumen pump is positive displacement internal gear type for continuous flow of bitumen. It is provided with turn table type tow bar for smooth movement of sprayer chassis. It has a spray bar hose up to 10 metre length fitted with hand spray attachment for uniform spray of bitumen.

Fig. 9.3 Towed Bitumen Sprayer

Fig. 9.4 Bitumen Sprayer Mounted on Pneumatic Tyres

9.3 Bitumen Emulsion Sprayer (Fig 9.5)

The function of bitumen emulsion sprayer is to spray the bitumen emulsion uniformly for tack coat or prime coat purpose, and application in pot hole/ patch repair. It can be towed with tractor.

It is provided with accurate spray control system and available in 800 to 2000 litre capacity tank mounted on four wheel chassis and pneumatic tyres. It is provided with turn table type tow bar for smooth movement of sprayer chassis. It has a spray bar hose of suitable length fitted with hand spray attachment for uniform spray of bitumen emulsion.

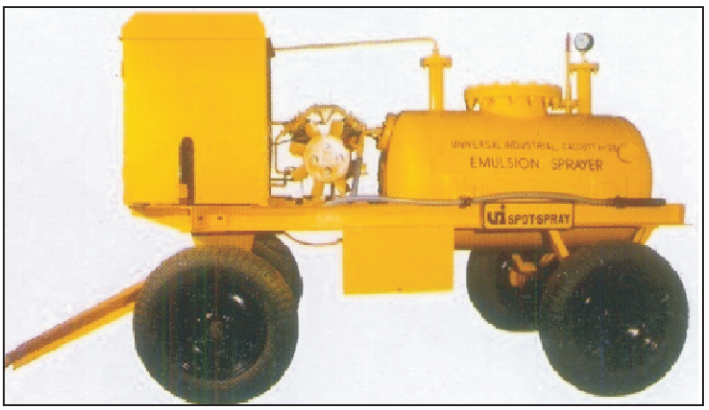


Fig. 9.5 Bitumen Emulsion Sprayer

9.4 Hot Mix Plant

The hot mix plants have been designed to prepare the hot mix of desired specifications comprising of aggregate, bitumen and filler. The guidelines for selection, operation and maintenance of bituminous hot mix plant have been published by the Indian Roads Congress [IRC: 90-2010]. The hot mix plants are of two types. (i) Hot mix plant (Batch type) (ii) Hot mix plant (Continuous type).

9.4.1 Hot Mix Plant (Batch Type): In this type of plant, hot bitumen is added with the batch of hot aggregates and filler (if necessary) at desired temperature in desired proportion in the mixing unit. The mix prepared in batch is directly fed into the tipper for transportation to work site. This process of batch transfer continues one after the other. The capacity of batch type hot mix plant starts from 135/165 tonne per hour. The requirement of hot mix material is much less in rural road which does not match to the capacity of hot mix plant (batch type) being of higher capacity. Its initial cost is high, requires more space for commissioning, running and operational cost is also higher, hence not recommended for rural road application.

9.4.2 Hot Mix Plant (Continuous Type): In this type of plant, aggregates, fines and bitumen are continuously inducted into pug mill / drum mix in desired proportion and hot mix discharged without interruption. Hot mix plant (Continous type) popularly known as Drum mix plant is covered under this category. It has been adopted widely due to its (a) Portability (b) Economy in basic cost (c) Lower fuel consumption (d) Reduced man power and maintenance cost (e) Trouble free operation (f) Ability to produce large quantity of mix relatively at low temperature. This type of plant being in lower capacity range, simple in design and small space requirement for its commissioning is ideal for application on bituminous work in rural road construction.

The brief details of Drum mix plant are as under:

9.4.3 Capacity of Hot Mix Plant

As per IS 3066 : 1965 and IS 5890 : 2004, the capacity of hot mix plant is specified in tonne per hour based on the presence of moisture content in the aggregates:

(i) Output of plant at 6% moisture content in aggregates.

(ii) Output of plant at 2% moisture content in aggregates.

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

9.4.4 Parallel Flow Type Drum Mix Plant (Fig 9.6)

This is a conventional type of plant, which was inducted during late 1980's in India and is commonly

used in different road projects in the country. In drum mix plant, aggregates gradation is controlled at the cold feed end. Aggregates heating, drying and bitumen mixing is done in the same drum. In parallel flow type drum mix plant, the aggregates and hot gases flow in the same direction inside the same drum.

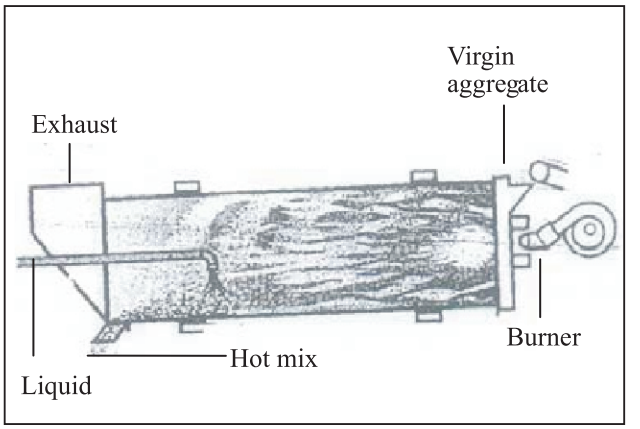
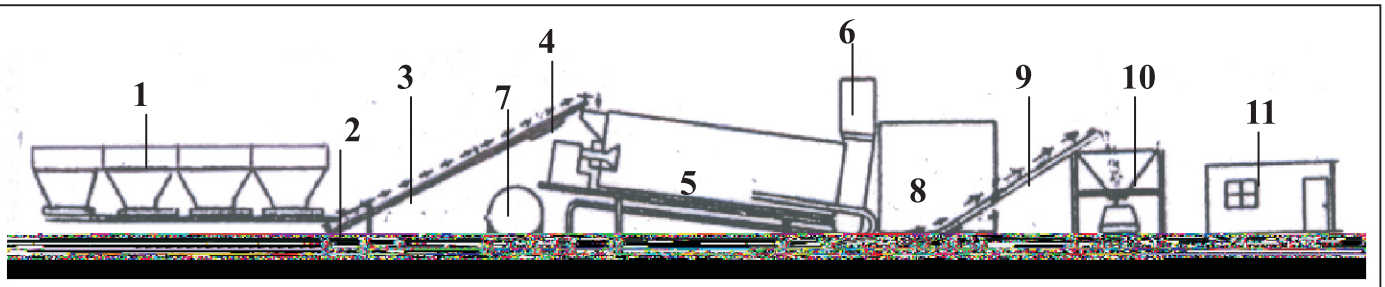


Fig. 9.6 Parallel Flow Type Drum Mix Plant

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

All the essential components of drum mix plant are shown in Fig 9.7. It also includes mineral filler system. The secondary pollution control device is an optional component of plant.



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. 9.7 Essential Components of Drum Mix Plant (Parallel Flow Type)

(i) Cold Bin Feeder **(Fig 9.8)**

(a) It contains minimum 4 no. 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. Bin gates have a graded scale to control the amount of gate opening.

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

(d) The first bin containing fines is provided with vibrator to prevent sticking of fines with the wall of bin.

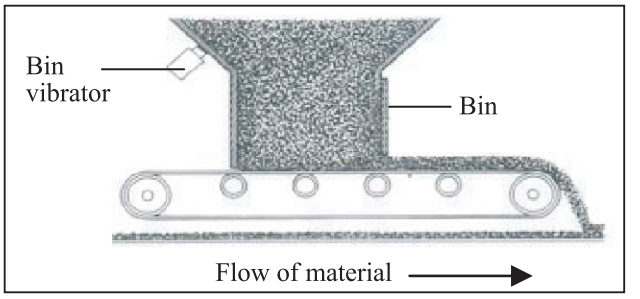


Fig. 9.8 Position of Bin Vibrator

(e) Variable speed motor is provided below each bin, to control the speed of conveyor belt to vary aggregates proportion, as desired.

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

(g) Properly designed and calibrated bin gates are provided for smooth flow of aggregates.

(ii) Aggregate Over Size Rejection Screen

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

(iii) 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.

(iv) Automatic Weighing System

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

***(v) Dryer cum Mixing Drum* (Fig 9.9)**

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

Its main functions are:

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

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

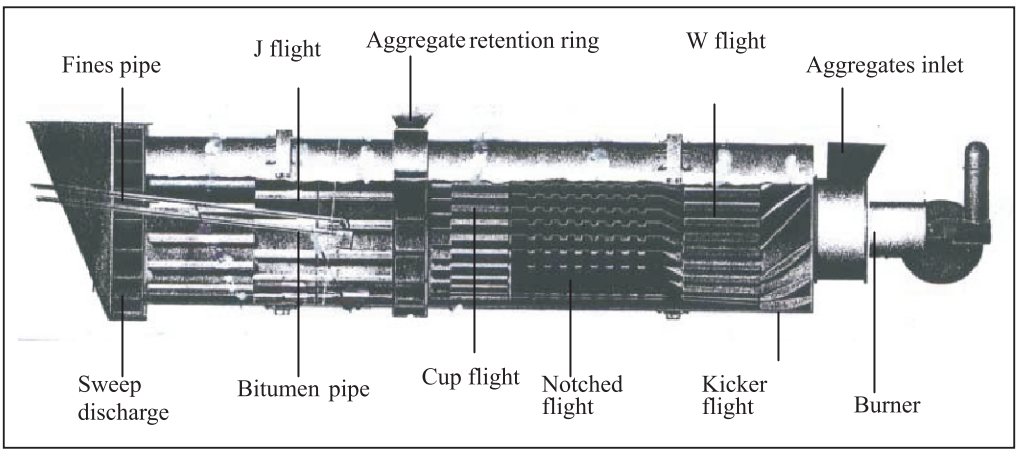


Fig. 9.9 Components of Dryer Cum Mixing Drum

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 shown in Fig.9.9 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 retention 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 depend on the output of the plant.

(c) The rate of drying the aggregates depends 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) The speed of drum should be in the range of 10 to 12 revolutions per minute and slope not to exceed 9 cm/metre.

(d) Burner (Fig 9.10)

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

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

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

(4) It should have auto flame failure detection system to prevent 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.

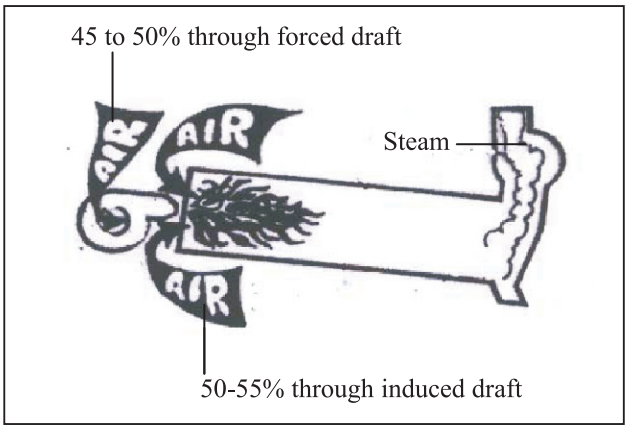


Fig. 9.10 Burner Used in Dryer Cum Mixing Drum

(7) Excess air, approximately 25%, 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 (Fig. 9.11)

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

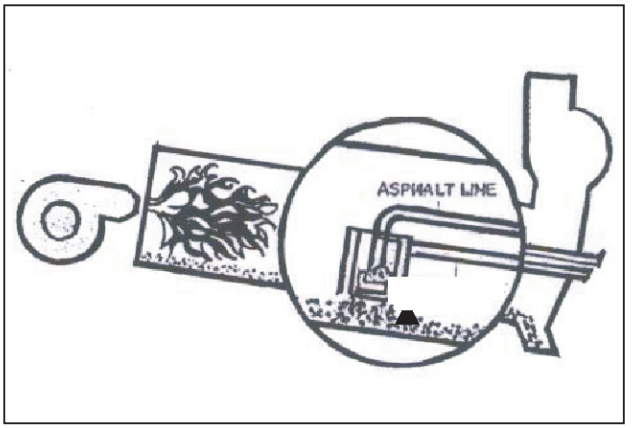


Fig. 9.11 Bitumen Fines Receiver

(vi) Exhaust Control System

Its main function is to induce air into 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 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.

(vii) 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 No. bitumen tanks should be provided along with the plant. The bitumen tank of 20 tonne capacity is adequate to run 40/60 tonne per hour capacity plant. 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 system 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 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 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 of two ways :

(1) Direct heating:

An insulated tank approximately 125 litre capacity containing hot oil with independent burner in flue tube is mounted on the chassis of bitumen tank. Air and fuel from existing bitumen heating system are used for heating hot oil. Hot oil in the range of 150ºC -180ºC 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.

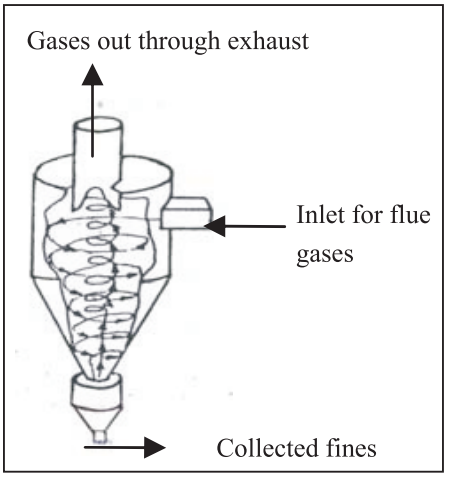


Fig. 9.12 Primary Dust Collector

(viii) ***Primary Pollution Control Device (Dust Collection System*** **Fig 9.12)** : It is the primary dust collection system 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 up to 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 to the wall of the cylinder due to spinning motion of gas. These particles slide down and get 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 % of dust

(ix) ***Hot Mix Conveyor***

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

(x) ***Gob Hopper***

Gob hopper collects the hot mix materials 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 been completely filled with mix material and the same is being transferred into tipper, to avoid segregation. Scrapper blade is provided in gob hopper to prevent sticking of fines on conveyor belt and achieve the desired mix formula.

(xi) ***Control Cabin***

The control panel consists of an air conditioned cabin to prevent 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 the control panel.

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

(a) Plant load (set as percentage 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 per hour:

(1) Quantity of aggregates

(2) Quantity of bitumen

(3) Quantity of mineral filler

(d) Total quantity of materials flow during specified period

(1) Aggregates in MT (metric tonne)

(2) Bitumen in kilogram

(3) Mineral filler in kilogram

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

(e) Temperature of Bitumen

(1) Aggregates

(2) Hot mix

In drum mix plant, there is no system of measuring the temperature of aggregates. Therefore, exhaust temperature is measured by putting thermocouple in exhaust chimney, which indicates temperature of exhaust 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 assessed 12ºC less than the exhaust gas temperature.

(xii) ***Mineral Filler System***

The rock dust, hydrated lime or cement are used as mineral filler and stored in a separate chamber to protect it from dampness to avoid its chocking/ hardening from moisture. The system consists of a screw feeder which carries filler from filler bin to weigh hopper 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 and sluggish. 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.

(xiii) ***Hot Mix Surge Silo*** **(Fig 9.13)**

The hot mix received from hot mix plant can be loaded directly into tipper. Alternatively, same can be transferred into surge silo 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. The combination of hot oil circulation and thermo/ ceramic wool is capable of maintaining hot mix temperature upto 16 hours approximately depending upon ambient temperature, quantity of bituminous mix and its temperature, hot oil temperature and its flow.

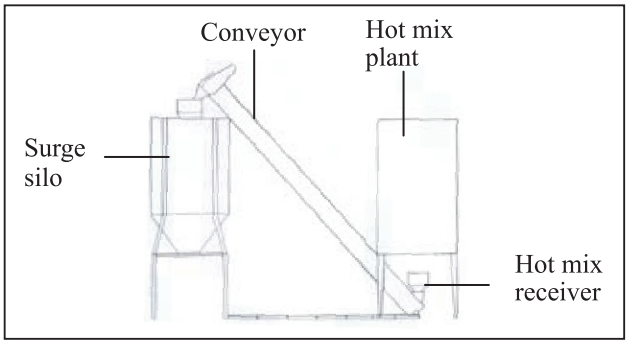


Fig. 9.13 Transfer of Hot Mix in to Surge Silo

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. For rural road works, there is no necessity of surge silo and the mix material can be loaded directly from gob hopper into tippers.

9.4.6 Secondary Pollution Control Device

In drum mix plant, wet scrubber type unit is used as secondary pollution control device, in which gases pass through the inlet and dust particles 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 :

(1) Open spray tower type

(2) Venturi type

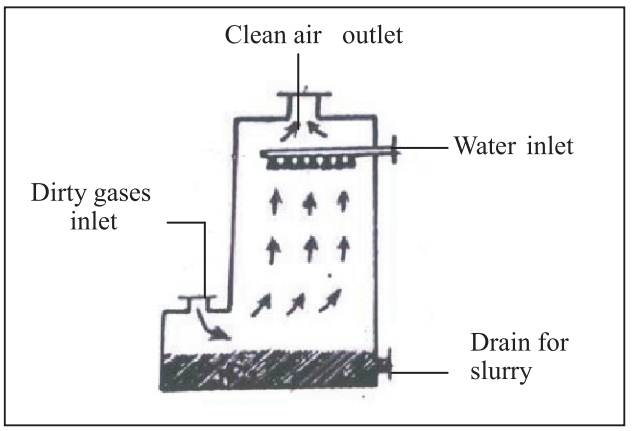


Fig. 9.14 Open Spray Tower Type Pollution Control Device

(1) *Open spray tower type* (Fig 9.14)

In open spray tower type, 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.

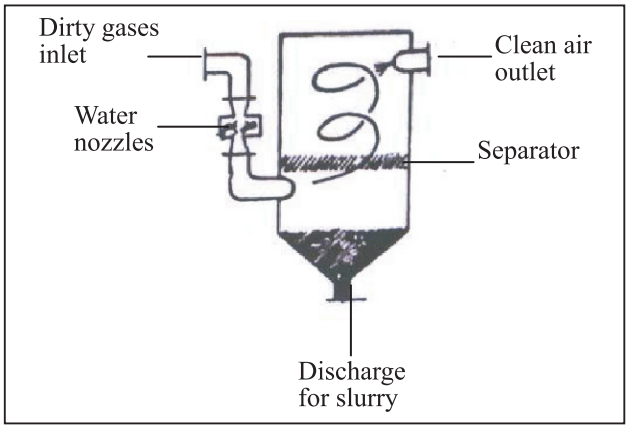


Fig. 9.15 Venturi Type Pollution Control Device

2) *Venturi type* (Fig 9.15)

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 atomizes 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.

The efficiency of venture type wet scrubber is higher than open spray tower type. The pollution control norms for the hot mix plant shall be applicable as per state government rules, where the hot mix plant is commissioned.

9.4.7 Power Requirement for Drum Mix Plant

Drum mix plant is fitted with electric motors for operation of different units. Drum mix plant of 40/60 tonne per hour capacity is ideal for rural road works. Total power requirement for different units of this capacity plant is approximately 105 horse power. The suggestive capacities of motors fitted on different units in 40/60 TPH plant are given below.

(i) Auxillary conveyor (4no) - 8 hp

(ii) Gathering conveyor (1no) - 5 hp

(iii) Vibratory screed (1no) - 3 hp

(iv) Slinger conveyor (1no) - 5 hp

(v) Thermo drum main drive (1no) - 20 hp

(vi) Exhauster (1no) - 20 hp

(vii) Dust control discharge screw (1no) - 1.5 hp

(viii) Load out conveyor (1no) - 5 hp

(ix) Hydraulic power pack (1no) - 5 hp

(x) Bitumen pump (1no) - 5 hp

(xi) Twin lobe air compressor (1no) - 10 hp

(xii) Mineral filler discharge screw (1no) - 1hp

(xiii) Burner air blower (1no) - 10 hp

(xiv) Burner fuel pump (1no) - 1hp

(xv) Fuel transfer pump (1no) - 1hp

(xvi) Hot oil circulating pump (1no) - 1 hp

(xvii) Control Panel (1no) - 5 hp

The DG set 82.5 KVA is adequate to run the drum mix plant 40/60 tph capacity

9.4.8 Use of Waste Plastic in Bituminous Wearing Courses:

The provision for use of waste plastic in bituminous wearing course (25 mm Semi-Dense Bituminous Concrete, Mix Seal Surfacing and 20 mm Open Graded Premix Carpet) exists (Refer: Specifications for Rural Roads Clause 512). The following steps shall be taken for its use.

(i) The waste plastic to be used shall be meeting the requirement of Clause 512.2.4 and 512.5.2 of MoRD Specifications and conform to the size passing through 2.36 mm sieve and retained on 600 micron sieve.

(ii) The quantity of waste plastic shall be 6 to 8 % of the weight of the bitumen.

(iii) The requisite quantity of waste plastic is injected with a pipe under compressed air in the drum mix plant through a pipe at 2/3 rd length of drum which shall be at the start of mixing zone. In batch type plant, it may be inducted through an opening over the pug mill.

(iv) The waste plastic initially coats the heated aggregate.

(v) In the next stage, the waste plastic coated aggregate is mixed with hot bitumen for 15 seconds. The temperature of the binder shall conform to the temperature of the grade of binder and type of mix.

(vi) The mix received can be transported by tipper for laying.

(vii) The temperature of mix at the time of laying shall be 110º C to 120º C.

9.5 Mini Hot Mix Plant

These plants have been designed for doing the works of premix carpet, semi dense bituminous carpet, patch work. The capacity of these plants is in the range 6/10 TPH and 10/16 TPH. These plants are either static type or mobile type.

9.5.1 Features of Mini Hot Mix Plant

The Mini hot mix plant (Fig 9.16) comprises of different units, the details of which are given below:

(i) Four bin feeder

(ii) Cold elevator

(iii) Dryer

(iv) Heating unit

(v) Dust collection system

(vi) Four deck vibrating screen

(vii) Weigh batcher

(viii) Mixing unit

(ix) Bitumen unit

(x) Skip hoist for lifting hot mix and unloading to tipper

(xi) Power unit for operation of different units

Fig. 9.16 Mini Hot Mix Plant (Static Type)

Static type plant is also portable type, which can be installed at one location and shifted to another location after completion of work.

Fig. 9.17 Mini Hot Mix Plant (Mobile Type)

Mobile type plant (Fig 9.17) is fully portable, mounted on pneumatic tyres, which can be shifted conveniently by towing different units with tractor/ tipper.

9.5.2 Mobile Mini Hot Mix Plant (Fig 9.18)

Fig. 9.18 Mobile Mini Hot Mix Plant

These types of plants (Fig 9.18) are available in the range 4/6 TPH capacity and fitted with mechanical telescopic jacks. These are designed to discharge the hot mix directly to mini tipper/ light commercial vehicle. These are suitable for carrying out patch work/ premix carpet work. It can be towed with tractor/ mini tipper.

9.5.3 Mobile Spot Mix Plant (Fig 9.19)

As the name implies, this mobile type hot mix plant (Fig 9.19) is suitable for preparation of hot mix instantaneously at the spot and use the mix for pot hole repair/ patch repair. The capacity of this plant is 3/5 TPH. It is mounted on two axles, fitted with pneumatic tyres. It is highly mobile and can be transported with tractor/ mini truck. In case distance is short, roller can also be used for shifting.

Fig. 9.19 Mobile Spot Mix Plant

9.6 Paver finisher: (Fig 9.20)

Paver finisher (Fig 9.20) is used to lay wet mix macadam and bituminous layer. The main functions of Paver finisher are (i) To lay and spread the mix to attain specified surface quality and correct the grade to meet the road design specification for safe and comfortable ride (ii) To achieve specified camber and super elevation in normal reach (iii) To achieve required thickness, uniform degree of compaction, homogenous quality of mix during laying and uniform bearing capacity over the entire surface. The Guidelines for selection, operation and maintenance of Paver finishers have been published by the Indian Roads Congress [IRC:SP:86-2010].

The Mechanical Paver finisher mounted on wheels having single bogie axle wheel in front and single drive axle in rear is suitable for rural road application. The bogie wheels are made of steel with molded rubber and drive wheels with pneumatic tyres of adequate capacity having good traction effort. Following are the features of Mechanical Wheeled Paver finisher:

Fig. 9.20 Mechanical Paver Finisher

(i) The paving speed is 0-25 metre/minute.

(ii) Travel speed is 0-16 km/hour.

(iii) The width of screed decides its paving width, which is 2.5 metre with mechanical extension up to 4.5 metre.

(iv) It can be used to lay the mix in the range 10 to 200 mm thickness.

(v) It can lay aggregate mixes such as wet mix macadam and bitumen mixes such as bituminous macadam, semi-dense bituminous concrete, bituminous concrete etc.

(vi) Its out put is 100 tonnes per hour.

9.6.1 Components of Paver finisher and their functions

The Paver finisher consists of two units:

(i) Tractor unit (ii) Screed unit

(i) Tractor Unit

It is the front part of the Paver finisher, on which prime mover, conveyors, augers, hydraulic system, operator's cabin and driving system are mounted. The primary function of the tractor is to propel the tipper, to convey and distribute the paving material through the auger and tow the screed.

(ii) Screed Unit (Fig 9.21)

It plays an important role in laying the mix material. The primary function of the tractor unit of Paver finisher is to convey and distribute paving material on ground in front of entire width of screed. The screed will pass over the head of the material deposited in front of screed. For smooth paving, the head of material should be maintained as constant as possible. The head of material affecting the height of screed is shown in Fig 9.21.

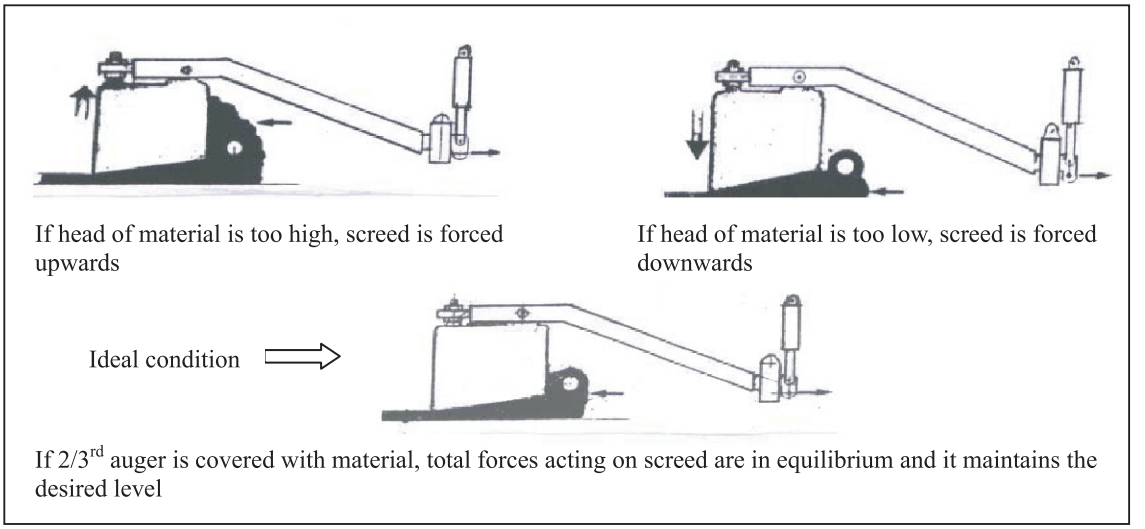


Fig. 9.21 Head of Material Affecting the Height of Screed

Tamping Unit (Fig 9.22)

Tamping bar comprising of steel bars with chamfered edges is provided along the length of the screed, which provides pre-compaction to the mix being paved. The tamper bars move up and down vertically with an amplitude 3 to 5 mm at a frequency ranging from 0 to 2,000 strokes per minute. The screed plate with hydraulically operated vibration system frequency ranging 0 to 3,700 vibrations per minute is provided to smoothen out the tamper edge marks on pre-compacted mat.

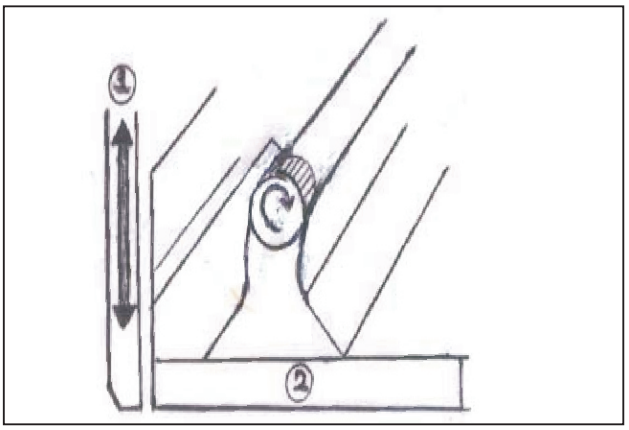


Fig. 9.22 Tamping Unit Combined with Vibrating Screed

Mechanical Paver finisher is equipped with heating system comprising of diesel/ oil fired burners, to pre-heat the screed plate and tamper bar to desired temperature, with diesel/ oil fired burners. The screed plate and tamper bar are heated at initial stage before starting the paving of bituminous mixes, which prevents the picking up of bitumen or its sticking. Afterwards, the screed plate and tamper bar are heated by the transfer of heat of bituminous mixes.

9.6.2 Adjustment of Screed Plate for Normal Crossfall / Superelevation (Fig 9.23, 9.24)

The screed plate can be adjusted at the centre through its (i) leading (ii) trailing edge. Leading edge of screed plate should be provided with slightly more crown, to ensure better flow of material to trailing edge. Adjustment of screed plate is done while paving and set at that point, where best surface texture of mat behind Paver is achieved

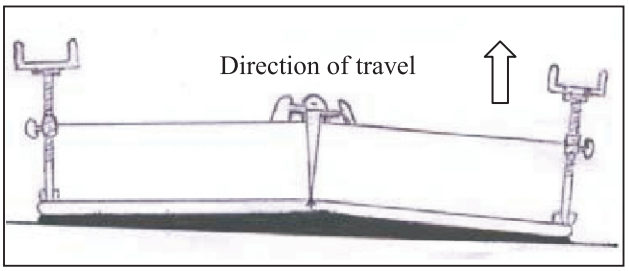


Fig. 9.23 Screed Plate Adjustment in Positive Crown Position

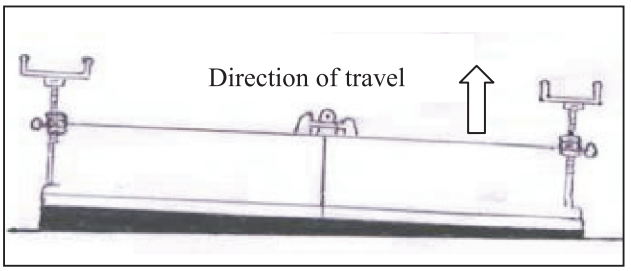


Fig. 9.24 Screed Plate Adjustment in Super Elevation Crown Position

Normal crossfall or superelevation can be provided in the profile by adjusting both halves of screeds to same required slope. Crown can be adjusted on the screed from -10 mm to +50 mm.

9.6.3 Precautions to be observed to maintain Mat Quality during Paving

The basic purpose of bitumen paving is to lay smooth mat surface for better riding quality. Following precautions should be observed during paving operation to maintain the mat quality.

(i) Continuous operation of Paver: The Paver should be allowed to work continuously. It should not be allowed to wait for the tippers for unloading of the mix during laying. In case the Paver stops; every time the forces acting upon the screed are severely disturbed resulting in the screed to settle down in fresh mat and leave a mark. During restarting the Paver, the material force against the screed will increase, causing the screed to rise. It takes approximately 3 to 4 tow arm lengths for the screed to restabilise at the previous planned angle with a resultant bump. Thus, the Paver speed should match the rate of material delivery to allow continuous operation of Paver and eliminate its stopping and restarting.

(ii) Constant speed of Paver: The Paver should move continuously, uninterrupted to produce smooth, seamless pavement. An abrupt change in paving speed causes an immediate disturbance in the balance of forces acting upon the screed. Sometimes it is not possible to maintain constant forward speed of Paver. In such cases the interruptions should be minimised and change in paving speed carried out gradually to achieve smoother finished mat.

(iii) Exchange of tipper: The exchange of tipper should be carried out as smoothly as possible to avoid disturbing the smooth, uninterrupted forward motion of the Paver. The following precautions should be taken in this connection:-

(a) The mix delivery tipper should be stopped close but not too short of the Paver. The Paver should be allowed to pick up tipper for shifting of mix during running.

(b) Never allow tipper to bump the Paver.

(c) The applying and holding the brakes of tippers excessively while dumping their load may cause the paver to slow down which in turn will cause the screed to rise. The tipper driver should apply only light pressure on the brakes just sufficient to maintain contact with the paver.

(d) Avoid tippers pulling away prior to completely dumping all material in the hopper.

(iv) Constant head of material: The head of material should be maintained across the entire width of screed and the material should cover approximately 2/3rd auger screw as shown in Figure 9.21. If the head of material is too high, the resistance to forward travel increases and the screed starts to rise resulting in the formation of ridge in the mat and excessive wear on augers. In case the head of material is too low, the screed will settle because there is not enough material to support it.

(v) Mix design specifications:

(a) Maximum aggregate size, ratio of aggregate, fines and bitumen should be selected carefully.

(b) Segregation: It is a material deficiency caused by separation of larger size aggregates from the bulk of paving material.

(c) Mix temperature: The temperature of the mix should be uniform while dumping it from the tipper to hopper of Paver, for which following precautions should be observed.

(d) All tippers should take the shortest and most practical route to the Paver.

(e) Ensure all tippers take the same route to the Paver. All tippers arrive in the same order, in which they were loaded at hot mix plant.

(f) No bunching of tippers should occur at the Paver. The "lay down rate" should match the material delivery rate.

(vi) Screed compaction: The Paver must be maintained in sound mechanical condition to deliver a smooth mat.

(vii) Quality of base being paved: In case there are undulations in the base being paved, the affected stretch should be paved in multiple lifts (two or three layers), to increase the averaging effect of screed.

(viii) The loading of bituminous mix should be done such that segregation does not take place. The tipper should not be allowed to remain at one

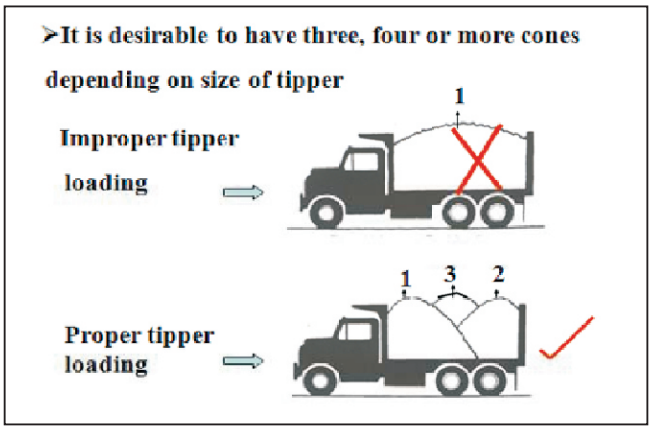


Fig. 9.25 Sequence for Proper Loading of Hot Mix in Tipper

location. Initially, loading of mix should take place adjacent to driver cabin, afterwards nearer to tail board end. The walls of cabin and tail board will restrict the segregation of material. The final layer shall be put above both the cones as shown in Figure 9.25.

(ix) During cold weather or long hauling distance, the tipper should be covered with tarpaulin and mix prepared at maximum allowable temperature, to avoid drop in mix temperature.

(x) Under normal conditions, 40 km is considered as reasonable lead, which may depend on several factors like type of mix, mix temperature, restrictions in movement of tipper from plant site to laying site, ambient temperature etc.

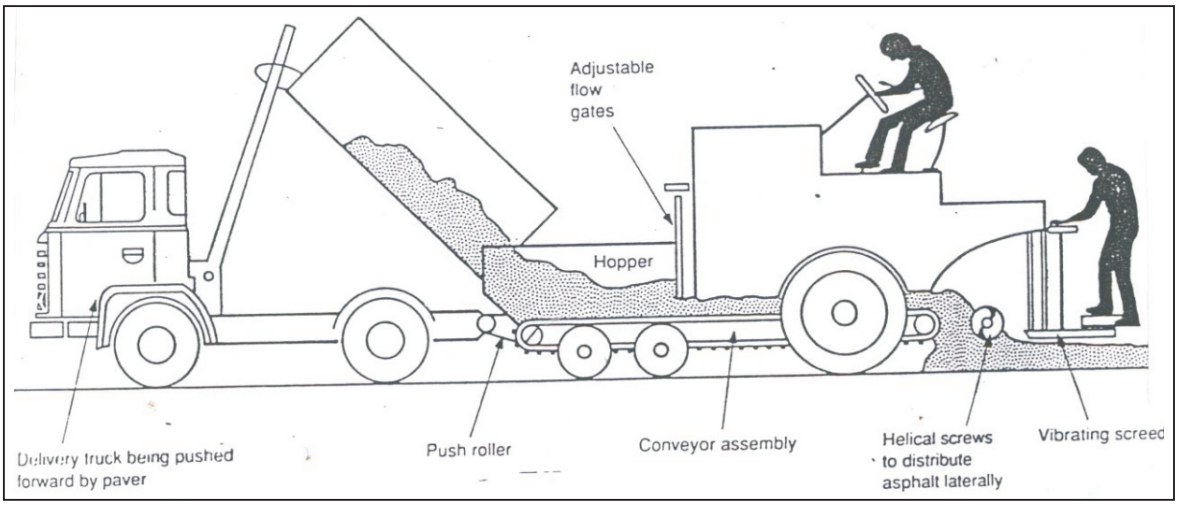


Fig. 9.26 Feeding of Mix Material from Tipper to Paver Finisher and its Laying

9.7 Mini Mechanical Paver Finisher (Fig 9.27)

This is a very useful equipment for laying bituminous mix on narrow roads and shoulders of roads. It is capable of laying mix minimum 1.5 metre width. The weight of the paver is approximately 4 tonne and can be easily transported on mini truck. The paver is fitted with hydraulically operated vibratory screed for smooth laying and better compaction. The other features of the equipment generally observed are:

Fig. 9.27 Mini Mechanical Paver Finisher

(i) Capacity of equipment: 35 TPH (maximum)

(ii) Paving thickness: 150 mm (maximum)

(iii) Hopper capacity: 2 tonne

(iv) Travel speed; 18 km per hour

(v) Working speed: 1.5 to 16 metre per hour

(vi) Basic width of screed: 1.5 metre

(vii) Extension of screed: 2.75 metre

9.8 Chip Spreader Attachment

The purpose of Chip spreader (Fig 9.28) is to spread the chips uniformly on the tack coat during surface dressing. Chip spreader is a costly equipment and should be used if enough quantity of work is available in nearby stretches. Chip spreader attachment fitted with tipper is ideal for surface dressing work in rural road application. The attachment is bolted in place of the tail gate of a normal tipper. Following are the features of tipper fitted with chip spreader attachment.

(i) The rate of spread of chips depends upon the gravity and speed of tipper acting independently.

(ii) The feed roller spreads the chips uniformly and accurately.

(iii) The variations in road speed of tipper produces corresponding variations in the rate of discharge of the chips.

(iv) The hopper is provided with augers to distribute the aggregates to full width of box.

Fig. 9.28 Chip Spreader Attachment Fitted with Tipper

(v) The capacity of hopper is 1.0 to 1.5 cum.

(vi) The chips in the hopper is replenished from the raised body of tipper.

(vii) It is propelled in reverse direction for spreading chips on bituminous layer.

(viii) The chips upto 20 mm size and 2.5 metre width can be laid.

(ix) The maximum working angle is 40º.

(x) Cut off door levers and guides are provided to control the flow of aggregates.

9.9 Application of Cold Mix

The provision for application of bitumen emulsion exists in Premix carpet and surface dressing. The aggregates for their application should be coated uniformly with bitumen emulsion. The equipment to be used may be (i) Cold Mix Plant (ii) CC Mixer with weigh batcher; depending on their requirement.

9.9.1 Cold Mix Plant: (Fig 9.29):

It is of higher capacity and can be used for Premix carpet work for mixing of 13.2 mm and 11.2 mm sizes of chips with bitumen emulsion. Initially, 13.2 mm chips mixed with bitumen emulsion and afterwards 11.2 mm chips can be laid. This plant is of higher capacity and for rural roads 10 tonne plant is adequate. The different components of plant are as under.

(i) Single bin of minimum capacity 2.8 cum (5 tonne) fitted with conveyor and operated with variable speed motor

- Bin should be able to operate for minimum 30 minutes.

(ii) Load cell

(iii) Charging conveyor

(iv) Pug mill

(v) Emulsion tank fitted with stirrer and variable speed motor;

- To avoid settling of water, stirrer should be used so that emulsion mixes with water uniformly. The variable speed motor controls the flow of bitumen emulsion.

(vi) Control panel

- It can control desired flow of bitumen emulsion and aggregate

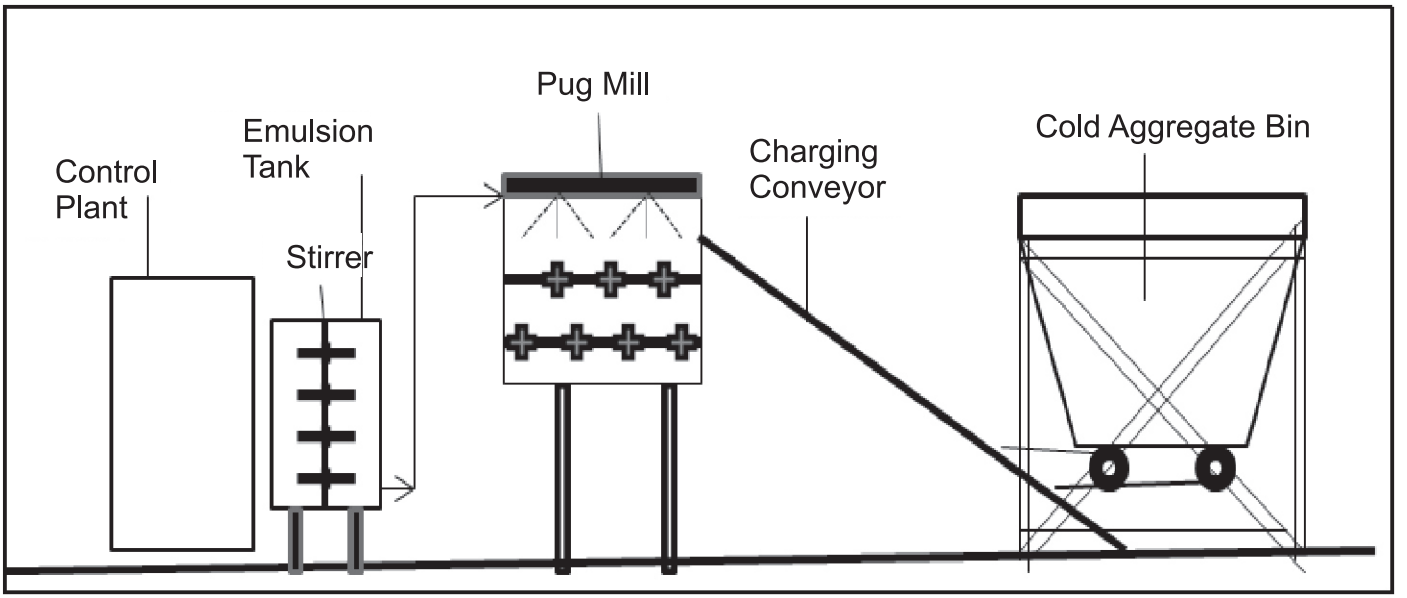


Fig. 9.29 Different Components of Cold Mix Plant

Cold mix plant 10 tonne capacity is capable of laying 275 sq metre road length per hour with 20 mm thickness and is adequate for rural road work.

The cold mix can be loaded in tractor trolley fitted tipping attachment / tipper and transported to laying site.

9.9.2 CC Mixer with weigh batcher

It can be used for preparation of cold mix provided the quantity requirement is not much. The normal concrete mixer with weigh batcher 10/7 cu ft can produce 0.19 cum mix per batch. The stirrer should be provided in the drum from which the bitumen emulsion is being transferred in weigh batcher. The time taken to prepare one batch is 8 minutes (loading-3 minutes, mixing-2 minutes, unloading-3 minutes). Ideally, 6 cycles per hour can be completed assuming 10 minutes each cycle; therefore 1.14 cum (57 sqm of 20 mm thickness) per hour mix can be prepared. It can prepare and lay 80 metre road length of 5.5 metre width per day or about one km of single lane in 9 working days.

9.10 Essential tips for use of compaction equipments on bituminous and other works:

(i) In portions having unidirectional cross fall / super-elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly overlapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least one metre away from any preceding stop

(ii) In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre, parallel to the centre line of the road uniformly overlapping each of the preceding tracks by at least one third width until the entire surface has been rolled.

(iii) Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/ or removed and made good.

(iv) The purpose of bituminous compaction is to reduce air voids in the mix for increase of stability, durability of roads under specified traffic conditions and increase bituminous mix density, to achieve road evenness as per specification.

(v) The vibration sets the particles in motion and rearranges them to keep low void space and high density.

(vi) Hot mix will tend to creep or shove side ways if there is no confined edge such as curb, gutter, adjacent mat etc. In such case, first pass of roller to be kept 30 cm away from edge. It will act as confined edge for rest of mat.

(vii) In vibration compaction, higher density is achieved with lesser number of passes than static compaction.

(viii) The principle of vibration compaction is that density should be achieved from bottom towards top and vibration should be applied accordingly during compaction.

(ix) The following frequency and amplitude should be followed during different application in vibration mode.

S.No	Application	Frequency (in Hertz)	Amplitude (in mm)
(i)	Embankment of sub-grade soils	25-30	1.5-2.0
(ii)	Granular, stabilized base and sub base	25-50	0.8-2.0
(iii)	Bituminous surface	33-50	0.3-0.8

(x) During compaction the speed of roller should be kept constant, not exceeding 5 km per hour.

(xi) The rolling should be carried out in three consecutive phases during compaction of bituminous layer.

(a) Initial / Break down Rolling

(b) Intermediate Rolling

(c) Finish Rolling

Initial / Break down Rolling: In Initial / Breakdown rolling, the roller should be very close to the Paver, so that the mix can be compacted at higher temperature with less compaction effort. In Initial / Break down rolling Static Three Wheel Roller or Tandem Vibratory Roller may be used as shown in Fig 9.30. The driven wheels (larger wheels) of static three wheel roller should be facing towards screed plate of paver finisher.

It puts higher initial force on mix material; which removes the air voids, brings mix particles close and helps in retaining heat. The tandem roller should be used in static mode to have initial uniform compaction. Two passes are usually sufficient in break down rolling.

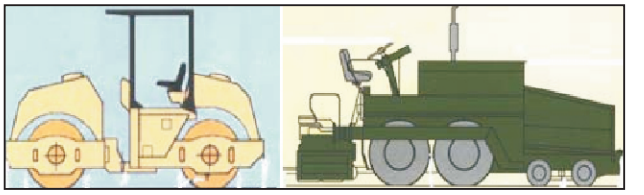


Fig. 9.30 Roller and Paver Finisher during Break Down Rolling

- Rolling of 30 cm un-compacted mat may be done in subsequent passes.

- During rolling on longitudinal/transverse joint, the roller drum should be on hot adjacent mat and overlap cold mat by 15 cm. The vibrator to be made operational, which shall pinch the material into joint.

- Intermediate Rolling: It should follow break down rolling as close as possible and continue till mat density has been achieved. The Intermediate Rolling should be carried out with Tandem Vibratory Roller 6 to 8 tonne. The first pass should be in static mode or with low amplitude; so that the mix material sticking to rolls is not damaged. Next passes are to be done with high amplitude till it shows the tendency of bouncing. The subsequent passes are to be done with low amplitude and final in static mode.

- Finish Rolling: It starts when desired compaction has been achieved. Its purpose is to remove roller marks or other blemishes left from previous rolling. The Tandem Roller 6 to 8 tonne in static mode should be used for this work.

(xii) Requirement of number of passes for compaction on bituminous work:

It depends on (a) Compaction properties of mix (b) Specified degree of compaction (c) Static linear load (d) Vibration characteristic. Normally 4 to 6 passes are required for compaction with Tandem Vibratory Roller 6 to 8 tonne.

(xiii) Minimum two number rollers should be in operation during bituminous compaction.

(xiv) The wheels of roller should be clean, water nozzle clear for spray.

(xv) Roller should keep moving continuously when on hot mix. It should never be allowed to stand on mat being compacted or even a newly compacted surface.

(xvi) If it becomes absolute by necessary to park the roller on mat, it should be parked at oblique (45° to center line) angle so that subsequent rolling operations will remove any depression resulting from parked roller.

(xvii) Any roller, especially a vibrating one should not be left parked on an un-compacted bituminous surface.

(xviii) Roller wheels should be kept moist and not wet, to avoid picking up the mix material.

Too much water will cool down the bituminous surface and create steam which is harmful.

(xix) The steady and uniform speed to be followed for better performance of compaction.

(xx) Never vibrate the roller while it is in stationary stage. If vibration continues in stationary stage or while changing direction, each vibrating wheel will leave an indentation in pavement at stopping point.

(xxi) Travel direction to be reversed as smooth as possible to eliminate creation of deformations due to braking force on bitumen.

(xxii) If it is necessary to stop the roller for fuel or any other reason, it should be kept on firm pavement to avoid the formation of groove under its stationary weight.

(xxiii) To reverse the direction of roller; slow braking should be applied until it comes to a halt before reversing.

(xxiv) The change in direction of roller should be effected gradually.

(xxv) Sharp turns along the curve may tear mat surface during compaction. It can be avoided by rolling in two or more directions (See Fig 9.31).

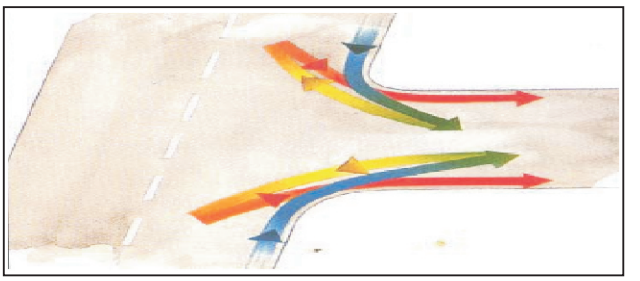


Fig. 9.31 Compaction at Curves

(xxvi) Rolling of longitudinal joint be done immediately behind Paver with driven rolls nearest the Paver.

(xxvii) For Edge Rolling:

(a) Shoulders to be leveled equal in thickness to expected compacted mat thickness before its laying, to avoid edge distortion.

(b) Rolling to commence at edge and progress towards center and upper side longitudinally.

(c) In super elevation and unidirectional cambered portion, compaction should progress from lower to upper edge and parallel to center line.

(d) Rolling should take place in longitudinal direction except in case of transverse joints.

(xxviii) Minimum laying and rolling temperature of mix should be 115ºC and 80ºC respectively.

(xxix) Before putting the machine on work, ensure that:

(a) Fuel tank is filled so that stoppages of the machine are avoided during compaction.

(b) Engine and hydraulic oil level is maintained.

(c) Machine is greased.

(xxx) Jerky starts, sudden braking should not be made while rolling.

(xxxi) Change of lane should be done only on already compacted surface.

(xxxii) After rolling, mat surface should be inspected for patches of loose material, broken edges.

(xxxiii) The materials mixed with dirt or other deficiencies should be removed or replaced with fresh hot mix, re-compacted to merge with surrounding area in density and surfaces evenness.

Cement Concrete Equipments

10. Cement Concrete Equipments

The cement concrete equipments are used in construction of cement concrete roads, minor bridges, culverts and other reinforced structures in rural road works. In case the requirement of concrete mix is less, it can be prepared at site in concrete mixer with weigh batcher and laid with wheel barrow. If the quantity of concrete mix requirement is more, it can be prepared in concrete batching and mixing plant of adequate capacity as per requirement. Special attention may be paid to the quality of sand being supplied. The same may be checked and screened in sand screeming machine before their use. The bar bending and bar cutting machines may be provided at site to speed up the reinforcement work.

The equipment for loading of aggregates, cement and feeding of water in desired proportion and preparation of concrete mix and its transportation exists in same machine, which have been developed indigenously and known as self loading mobile concrete mixer. The details of this equipment along with other cement concrete equipments like transit mixer, concrete pump, concrete vacuum dewatering pump, concrete joint cutter, power trowel, concrete vibrator, kerb laying machine are described in this chapter.

10.1 Stationary Concrete Batching and Mixing Plant

These plants are used to prepare homogenous concrete mix. Normally, they are available in the range 15, 20 and 30 cum per hour capacity suitable for rural road application based on the quantum of work and completion time. These are of two types

(i) Stationary Concrete Batching and Mixing Plant with boom scraper

(ii) Stationary Concrete Batching and Mixing Plant with storage bins

10.1.1 Stationary Concrete Batching and Mixing Plant with boom scraper (Fig 10.1)

It has got a reversible drum, in which aggregate, cement, admixture and water are added in desired proportion. Steel wall partition is used to stock different size of aggregates separately. It consists of following components:

(a) Boom scraper: It collects aggregate in the bin and loads it into skip hoist. The boom length is normally 10 to 15 metre.

(b) Pneumatic control gates.

(c) Cement screw conveyor: It transfers the cement from silo to the drum.

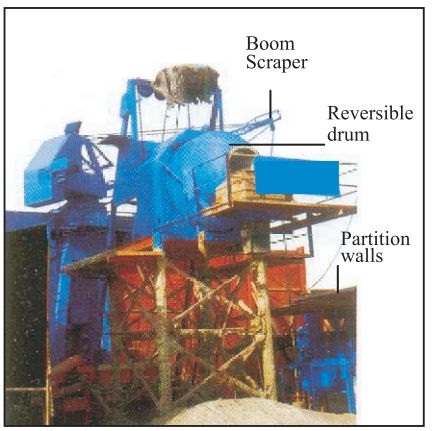


Fig. 10.1 Stationary Concrete Batching and Mixing Plant with Boom Scraper

(d) Load cell: It measures the quantity of different sizes of aggregates being fed to the skip hoist.

(e) Skip hoist: The aggregates in measured quantity fed to the skip hoist transfers it to reversible drum. The capacity of scraper bucket is 300 litre.

(f) Water dozing arrangement: Water in desired proportion is added in reversible drum.

All the activities are computerized controlled.

10.1.2 Stationary Concrete Batching and Mixing Plant with Storage Bin (Fig 10.2)

All the components of this type of plant are similar to boom scraper type plant, except lifting the aggregate through boom.

In this type of plant, aggregate is stored in storage bins - 4no. Each bin contains different size of aggregates, which are weighed and transferred in desired proportion through conveyor belt into skip hoist. The skip feeds these aggregates into the reversible drum. The plant is mounted on steel structure and mix material can be transferred into tipper directly. The brief details of components are given in para 10.1.1 above.

Fig. 10.2 Stationary Concrete Batching and Mixing Plant with Storage Bin

10.2 Mobile Concrete Batching Plant (Pan Type) (Fig 10.3)

It is available in 15, 20 and 30 cum per hour capacity. The salient features of this plant are as under:

(i) The aggregate, cement and water in desired proportion are collected in a pan, where these are mixed.

(ii) It is compact in design and can be transported easily, even by towing system also.

(iii) The loading of aggregate and sand can be done with the help of wheel loader, conveyor.

(iv) It contains microprocessor based control panel with integrated computerised batch controller which accommodates eight different types of mix recipes.

(v) It is provided with three nos. load cells below pan mixer for weighing of aggregates/ sand/water/ cement.

(vi) Separate silo with screw conveyor system and admixture attachment can be fitted with plant as optional.

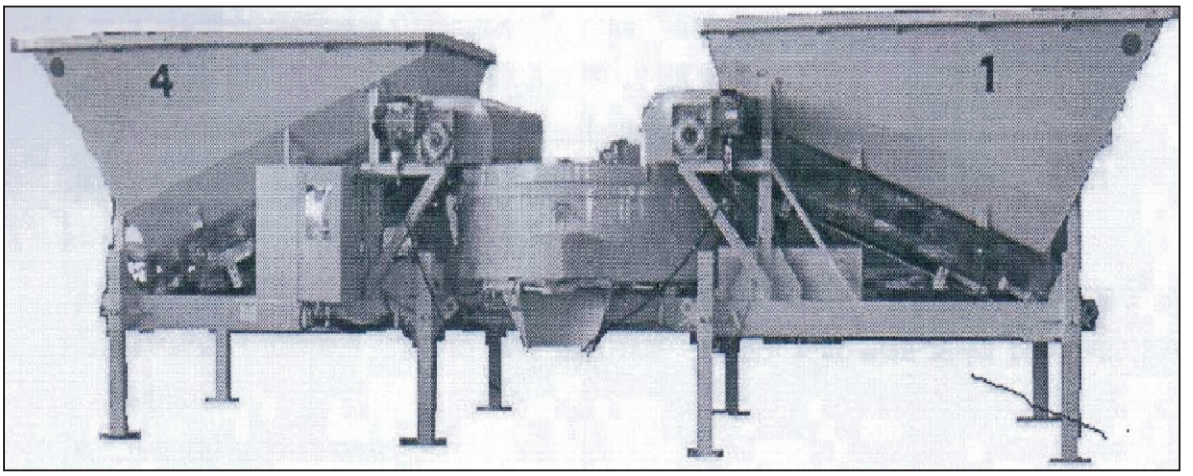


Fig: 10.3 Mobile Concrete Batching Plant (pan Type)

(vii) The complete plant can be transported on 11 metre trailor and commissioned within a week time.

10.3 Mobile Concrete Batching and Mixing Plant (Fig 10.4)

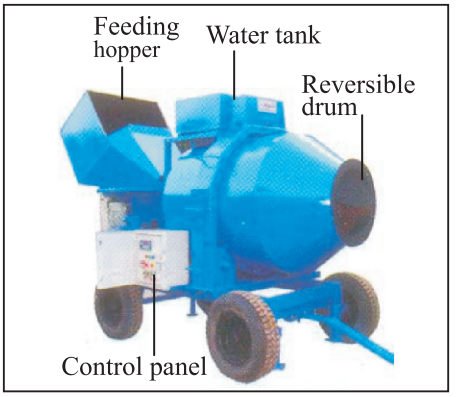


Fig. 10.4 Mobile Batching and Mixing Plant

It is a common equipment popularly known as CC Mixer, used for mixing the aggregate, cement and water since induction of cement in construction field. Earlier, these mixers were simple in design and of 10/7 cft capacity with 6 hp prime movers; afterwards there have been sufficient improvement in their design. The batch capacity 10 cft indicates it in unmixed and 7cft in mixed condition.

These are of two types.

(i) Aggregate feeding through rope system

(ii) Aggregate feeding through hydraulic system.

These days, hydraulic feeding system is preferred as it causes less physical fatigue to the operator. The hydraulic tipping hopper capacity is 1,000 to 1,500 kg. The drum for mixing purpose is reversible type. The capacity per batch is 0.4 to 0.6 m^3. It is provided with water flow meter and load cell weighing system with digital display to measure the quantity of aggregates. All controls of plant are operated from one single point. The plant may be operated with diesel engine/ electrical motor of 12 to 16 hp capacity.

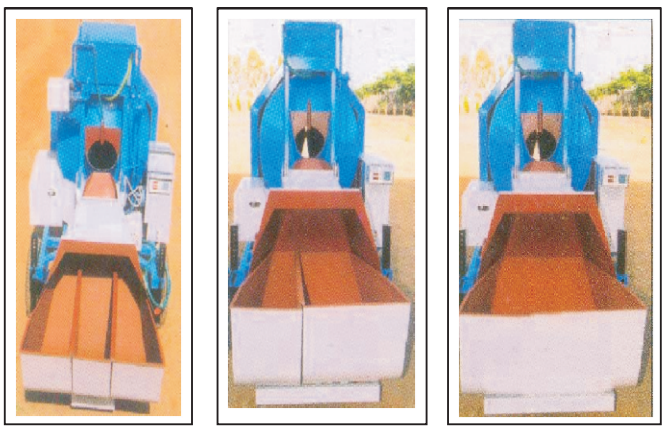
10.3.1 Weigh Batcher (Fig 10.5)

It is provided to measure the weight of aggregates being fed to concrete mixing plant. It is of three types depending upon the number of bins.

(i) Single bin

(ii) Double bin

(iii) Three bin



Three Bin Two Bin Single Bin

Fig.10.5 Different Types of Bins Fitted with Load Cell to Measure Different Size of Aggregates

The type of bin is selected based on the proportion of different sizes of aggregates to be mixed. The load cell is fitted on bin, which indicates the quantity of aggregates in kg. Normally two bins are sufficient for rural road works. The load and its connected accessories should be cleaned daily after completion of work and it should be disconnected, while welding is being done in the plant for its longer life.

10.4 Double Beam Screed Board Vibrator (Fig 10.6)

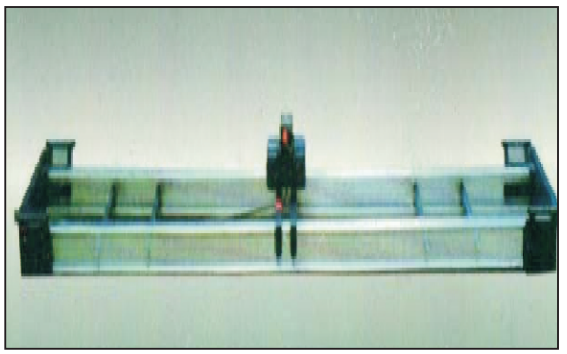


Fig. 10.6 Double Beam Screed Board Vibrator

It is self travelling type screed, fitted with 2 HP electric motor. It is guided along the form work and pulled by two operators at both ends. It is normally available in 4.2 metre length and 1 to 8 metre width depending on the requirement.

10.5 Top Mat Spreader (Fig 10.7)

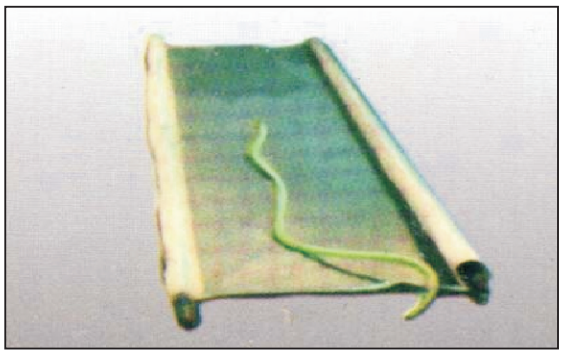


Fig: 10.7 Top Mat Spreader

It is used to spread the mix material. It is fitted with two side handles and available in desired sizes. The maximum available size is 7 metre x 5 metre.

10.6 Bottom Mat (Sieve Mat) (Fig 10.8)

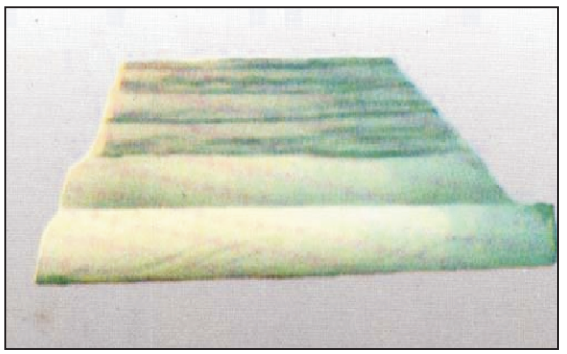


Fig: 10.8 Bottom Mat (Sieve Mat)

It is put after mix material has been spread. It prevents escape of concrete particles during operation of concrete vacuum dewatering pump. It is available in desired sizes with maximum size7 metre x 5 metre.

10.7 Concrete Vacuum Dewatering Pump (Fig 10.9)

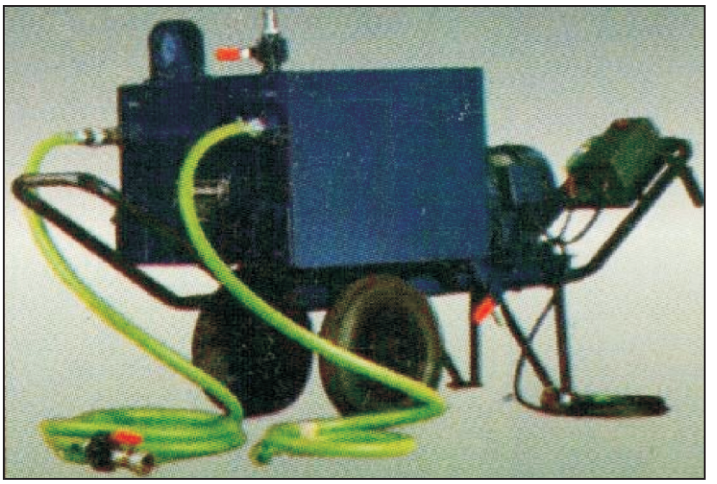


Fig. 10.9 Concrete Vacuum Dewatering Pump

It is used for removal of excess water from concrete slab after compaction, leveling and gives faster floor finish. It is fitted with electric motor 5 to 7.5 HP. Its pump capacity is 110 cum per hour. It has following advantages.

(i) It achieves higher compressive strength.

(ii) It reduces shrinkage and permeability.

(iii) The surface obtained is durable / abrasion resistance.

(iv) The speed of construction increases resulting in economy in time, labour and shuttering material.

10.8 Concrete Pump (Fig 10.10)

Fig: 10.10 Concrete Pump

It is an important equipment for transfer of mass concreting at a pressure of 60 bar up to a distance of 300 metre. In case there is space restriction for movement of transit mixers, it can be used successfully with pipe line. It comprises of diesel engine / electric motor of adequate capacity, concrete pump mounted on heavy duty chassis fitted with two pneumatic tyres for easy move ability @ 25 km per hour.

Normally, 30, 45 and 60 cum per hour capacity pumps are used depending on requirement of concrete. The concrete delivery pipe line is of 100 to 150 mm diameter with maximum aggregate size flow 40 mm. For small works, 15 cum per hour capacity pump with 95 bar maximum concrete pressure with 60 HP diesel engine/electric motor, concrete delivery pipe line 75-100 mm diameter for flow of 20 mm maximum aggregate size are also available.

10.9 Concrete Vibrator (Fig 10.11)

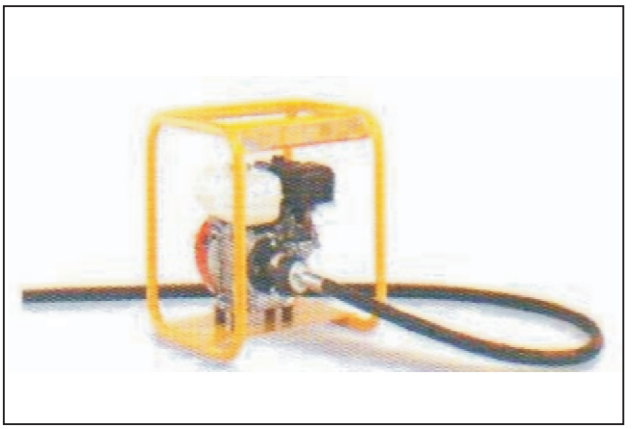


Fig. 10.11 Concrete Vibrator

The purpose of vibrators is to produce vibrations which when transmitted to plastic concrete make it to flow and effect compaction. The air bubbles are forced out of concrete due to vibrations. The needle vibrator is known as immersion or poker vibrator also.

It has a power unit and long flexible tube at the end of which a vibrating head is attached. Whenever compaction is to be done, the vibrating head is inserted into the concrete. The needle vibrator for compaction of mass concrete has 25, 40 or 60 mm diameter needle with 4 to 6 metre long flexible shaft and powered by prime mover, which may be Electrical motor 2 to 3 hp or Petrol / kerosene engine.

10.10 Disc Float / Power Float (Fig 10.12)

Fig. 10.12 Disc Float / Power Float

This equipment is fitted with circular disc and 3 HP electric motor. It is used to remove the surface undulations to achieve surface finish.

10.11 Power Trowel (Fig 10.13)

It is fitted with 4 nos. adjustable blades and 3 HP electric motor. It is used to achieve surface finish after compaction

Fig. 10.13 Power Trowel

10.12 Ride on Trowel (Fig 10.14)

Fig. 10.14 Ride on Trowel

This equipment is used for finishing of the concrete surfaces. Its productivity is very high and it can cover large areas within a short span of time. It is fitted with 20 HP petrol engine, weight 250 kg, blade speed 140 RPM, working width 1800 mm with spray arrangement.

10.13 Bitumen/ Concrete Joint Cutter (Fig 10.15)

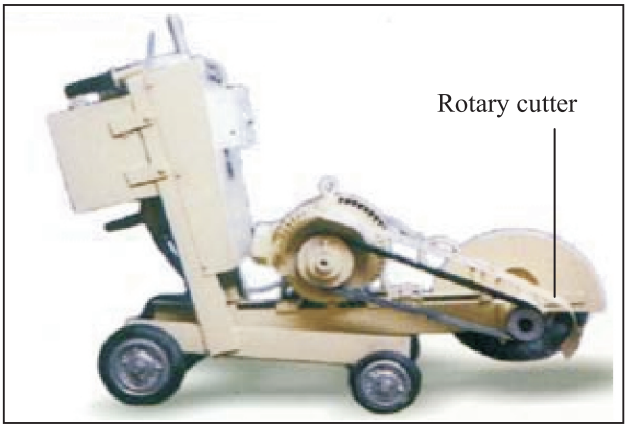


Fig. 10.15 Bitumen / Concrete Joint Cutter

It is used to cut the bitumen/ concrete joint. It is driven with electric motor/ diesel engine. One water tank of approx. 50 litre capacity is provided for spray of water on circular cutter, used to cut the bitumen/ concrete joint. It is mounted on four number moulded rubber wheels for its easy transportation and application.

Normally, two types of machines, based on their capacity, are used for bitumen/ concrete joint cutting. The machine with (i) 8 HP & 3600 RPM electric motor, cutting speed 15 metre per hour, weighing approx. 130 kg can be used for cutting depth 100 mm and (ii) 10 HP & 3600 RPM electric motor, cutting speed 20 metre per hour, weighing approx. 150 kg can be used for cutting depth 150 mm.

10.14 Bar Cutting and Bar Bending Machines

The reinforcement steel is used in construction of cement concrete road and bridge works. The TMT steel bars are received in long length and in different sizes. Normal range is 8mm to 36mm diameter. These are to be cut and bent as per requirement meeting to bar bending schedule. Since the requirement is huge, considering the time factor and make it available for reinforcement purpose, these have to be cut and bent at fast speed and this work can be carried out in Bar cutting and Bar bending machines.

10.14.1 Bar Cutting Machine (Fig 10.16)

Fig.: 10.16 Bar Cutting Machine

The bar is inducted in the machine which is cut under pressure with the blade. Multiple number of TMT bars ranging 8 to 36 mm diameter normally being used can be cut in this machine, which is provided with 4 to 6 HP electric motor. The weight of machine is from 400 to 750 kg depending on capacity of machine. It has got dual operation system by hand and foot pedal.

10.14.2 Bar Bending Machine (Fig 10.17)

Fig: 10.17 Bar Bending Machine

It is used for bending the TMT bars. It is easy to operate by hand and foot also. Multiple number of TMT bars ranging 8 to 36 mm diameter normally being used can be bent in the machine, which is provided with 4 to 7.5 HP electric motor. The weight of machine is 400 to 750 kg depending on capacity of machine.

10.15 Sand Screening Machine

The purpose of sand screening machine is to remove the sludge and over size particles from the sand. The

machine should be rugged in construction, capable of giving efficient performance with low maintenance cost and trouble free operation. These machines are of two types based on their design.

(i) Rotary sand screening machine

(ii) Vibratory sand screening machine

10.15.1 Rotary Sand Screening Machine (Fig 10.18)

Fig. 10.18 Rotary Sand Screening Machine

It has got a cylinder of 600 mm diameter x 1500 mm in length, in which the sand is transferred through hopper. The cylinder is in taper stage, due to which the sand passes from one end to another. The capacity of this machine is 4 cum per hour. The electric motor of 2 hp single phase/ 4 hp is used for rotating the drum. The GI mesh of 5 mm x 5 mm size is used, which can be replaced as per requirement. The size of the machine is 2000 mm (L) x 700 mm (W) x 1200 mm (H) with approximate weight 125 kg.

10.15.2 Vibratory Sand Screening Machine (Fig 10.19)

Fig. 10.19 Vibratoy Sand Screening Machine

It works on eccentric vibration system in which the sieve vibrates at 1440 vibrations per minute. The capacity of machine is 6 cum per hour. It is fitted with one hp single phase electric motor. The size of the machine is 1350 mm (L) x 1150 mm (W) x 1190 mm (H). It is fitted with screen size 750 mm x 150 mm, which can be replaced as per requirement. The mesh of 5 mm x 5 mm size is fitted on screen.

10.16 Self Loading Mobile Concrete Mixer (Fig 10.20)

Fig: 10.20 Self Loading Mobile Concrete Mixer

This equipment is very useful in rural road application in which different sizes of aggregates/ cement can be loaded in mixing drum, water added in desired quantity and mixing done, the concrete transported to laying site and unloaded at desired location. It can be used successfully and small works i.e. for semi mechanized concrete road construction system.

This equipment is available in 1cum, 2 cum and 4 cum concrete output in one batch. Normally, the equipment with 2 cum and 4 cum concrete output is preferred due to its higher output and economy, the details of which are given in Table 10.1. It is operated by single person at minimum turning radius, due to which it can be used in narrow and restricted job area. The adequate power makes it operational at sufficient gradeability.

Table 10.1 Particulars of Mobile Concrete Mixer

S.No	Description	4 Cum Mixer	2 Cum Mixer
(i)	Diesel engine capacity	110 hp	54 hp
(ii)	Chassis - High tensile steel fabricated box type	yes	yes
(iii)	Four wheel drive with hydro static transmission	yes	yes
(iv)	Vehicle speed	0 to 30 kmph	0 to 20 kmph
(v)	Loading bucket operated through hydraulic cylinder. Single joystick provided to control loading and unloading bucket operation	yes	yes
(vi)	Electronic weigh batching system provided to weigh different sizes of aggregates and their batching	Eight sizes	Eight sizes
(vii)	On board water tank with electronic metering system provided to feed in mix.	370 litre	370 litre

S.No	Description	4 Cum Mixer	2 Cum Mixer
(viii)	Self priming pump 230 lpm provided to draw water from external source and to feed to water tank or directly to mixer drum.	yes	yes
(ix)	Volume of hydrostatic drum	5.3 cum	2.8 cum
(x)	Speed of drum	0 to 22 RPM	0 to 18 RPM
(xi)	Hydraulic steering provided to move vehicle with minimum turning radius	yes	yes
(xii)	Capable to work in tough terrain with gradeability	yes	yes
(xiii)	Electro hydraulic switches provided to control travel lever for change of gears, drum rotation, loading arm lift	yes	yes
(xiv)	Gross vehicle weight / Net vehicle weight	16500/7400 kg	9600/4800 kg
(xv)	Output per hour	12 to 14 cum	6 to 8 cum

The Self loading mobile concrete mixer 1 cum may also be used for preparation of concrete mix and its unloading at desired location, which shall depend on quantum of work to be carried out and its completion period.

10.17 Transit Mixer (Fig 10.21)

Fig: 10.21 Transit Mixer

The purpose of transit mixer is to fill the concrete mix, transport it from concrete batching plant to concrete laying site in homogenous form and unload at that location. It should be ensured during concrete transportation that neither the concrete segregation nor setting takes place. Normally, the transit mixer with nominal volume 6 cum, gross vehicle weight 25 tonne with slave engine or PTO driven arrangement is used for rotation of mixer up to 12 RPM. It is provided with water tanker 450 litre capacity.

10.18 Mini Dumper (Fig 10.22)

Fig. 10.22 Mini Dumper

It can be used for transport of mix concrete received from small capacity concrete batching plants / concrete mixer with weigh batcher to exact location where it is required for laying purpose. It can also be used for towing and handling various jobs at site It is available in 1 tonne and 2 tonne capacity. It can go easily in narrow spaces, where the approach of transit mixer / tractor trolley is difficult. It has got 4 x 4 wheel drive, front end hydraulic tipping arrangement with discharge height of 600 mm, enabling the driver to unload the material at desired location.

10.19 Schematic Diagram Showing Operation of Different Equipments in Cement Concrete Work (Fig 10.23)

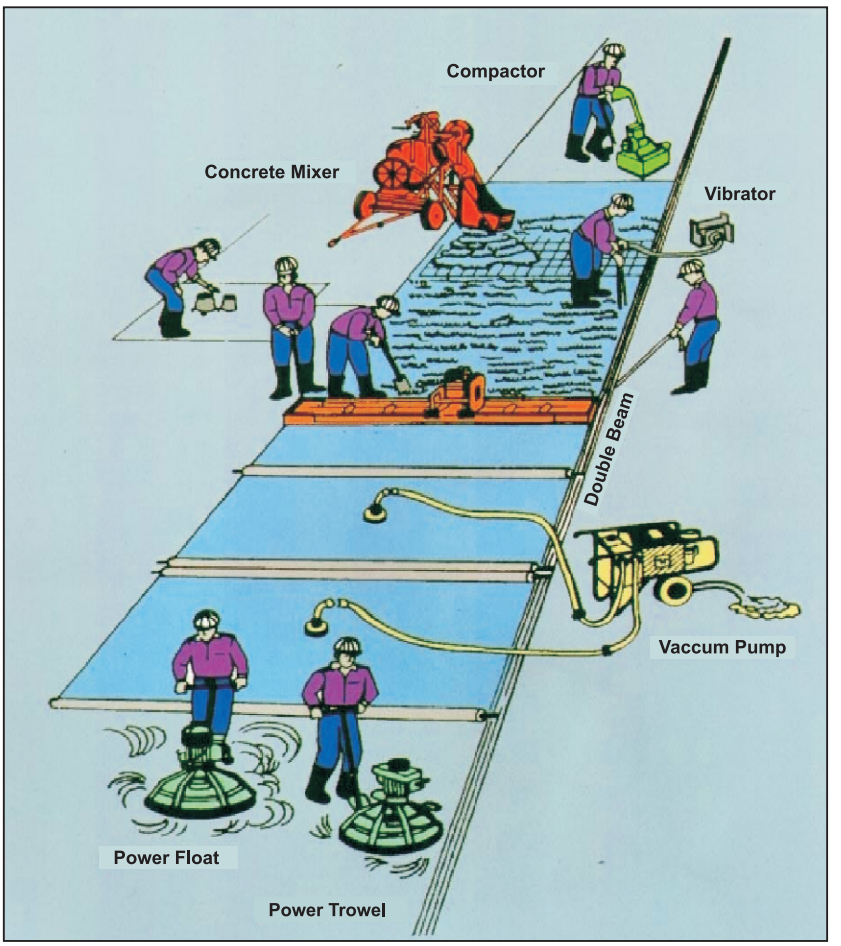


Fig: 10.23 Schematic Diagram Showing Operation of Different Equipments in Cement Concrete Work

Different Operations:

(i) Compaction of base

(ii) Preparation of concrete mix

(iii) Spreading of concrete mix

(iv) Leveling of mix

(v) Dewatering

(vi) Removal of undulations

(vii) Finishing of surface after compaction

10.20 Kerb Laying Machine (Fig 10.24)

Fig. 10.24 Kerb Laying Machine

It works on the principle of extrusion in which the force developed due to ramming action mechanism is used to lay kerb even with zero slump concrete. It is mounted on pneumatic wheels and can lay kerb up to 450 mm x 450 mm. The moulds can be fitted with bolts as per requirement meeting to the specifications with maximum height of 400 mm. It should have mould profile change facility quickly. It is fitted with 16 hp petrol engine having electronic ignition system, automatic sensors to control steering and height, which follows reference line. The ready mix concrete received from transit mixer is fed directly into it. It can lay kerb in single pass operation with operating speed of 100 metre per hour. The other features of machine are as under:

(i) Weight of machine: 900 kg (approx)

(ii) Steering / height control: Auto/ manual

(iii) Turning radius: 2.4 metre

(iv) Accuracy: ± 3 to 5 mm

Allied Equipments

11. Allied Equipment

The crushing and screening of aggregate, earth work, wet mix, bituminous and cement concrete work to carry out road construction involves main equipments for carrying out these works. In addition to this, allied equipments are needed to assist the main equipments. The capacity and requirement of these equipments should match with the main equipment. Some of the equipments like lighting tower, road marking machine have also been covered for their likely use in future. The brief details of the equipments along with their capacity required for rural roads are given in this chapter.

11.1 Tipping Truck (Fig 11.1 and 11.2)

It is basically a truck fitted with heavy duty, abrasion resistant smooth steel body which avoids sticking of material in bottom and sides of body. Tipping truck is a common equipment used for transportation of earth, aggregate, wet mix, bituminous material etc. The loading of material into tipper is done by loader / excavator or directly from wet mix/ hot mix plant. The unloading of material can be done at site/ into paver finisher. It is fitted with a hydraulic ram which enables to unload the material. The hydraulic pump is operated from the engine of tipping truck. The tippers used in road construction are of two types based on their capacity.

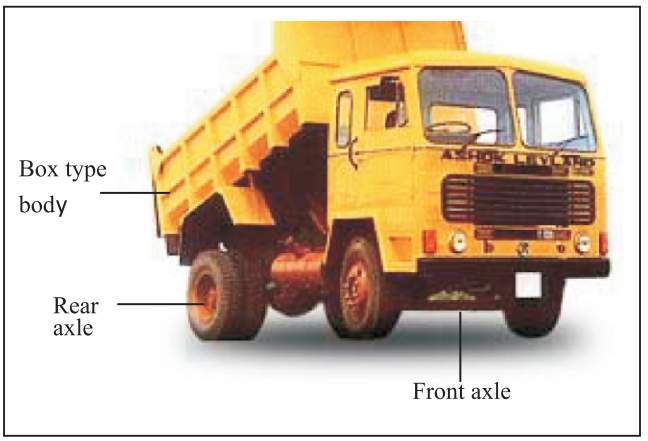


Fig. 11.1 Tipping Truck on Single Axle

(i) Tipping truck on double axle: The capacity of this tipper is 6 to 8 cum and engine is of 110 hp. The maximum permissible gross vehicle weight is 16.2 tonne. It is used for low volume work. Its operational cost is more.

(ii) Tipping truck on tandem axle: The capacity of this tipper is 14 cum. The maximum permissible gross vehicle weight is 25 tonne. It is preferred due to its lower operational cost and coverage of more quantity of material in single trip.

The tipping trucks are further classified based on their body construction. These are of two types

(i) Scoop type (ii) Box type

Fig. 11.2 Tipping Truck on Tandem Axle

Scoop type has tapered portion at the rear, while box type is fitted with tail gate at the rear.

11.2 Tractor Towed Mechanical Broom (Fig 11.3, 11.4)

The mechanical broom is towed with the tractor. The sweeping takes place in front direction. The brooms may be of two types.

(i) Mechanical broom with horizontal axis brush

(ii) Vertical broom with vertical axis brush

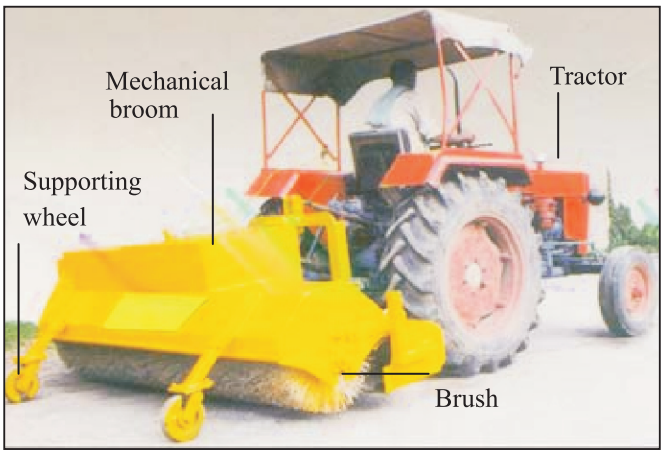


Fig. 11.3 Tractor Towed Mechanical Broom With Horizontal Axis Brush

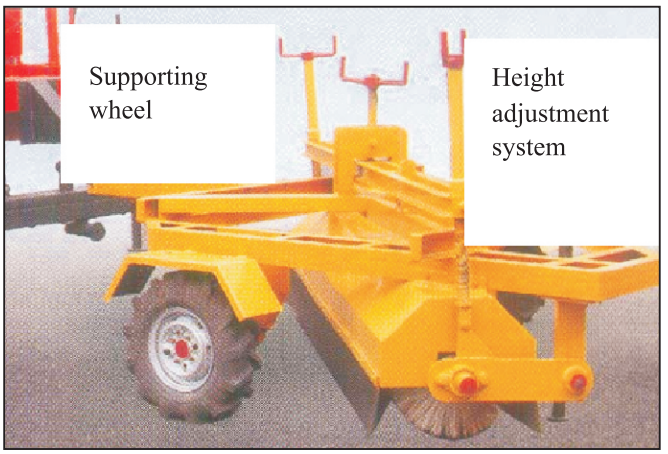


Fig.11.4 Tractor Towed Mechanical Broom With Vertical Axis Brush

The broom is driven by power take off end of tractor, supported with two wheels and fitted with hydraulic lift arrangement. Sweeping takes place in front direction. The sweeping collection arrangement is provided in the machine. The sweeping width is normally 2100 mm.

The brush in horizontal axis covers more contact area, thus same is mostly used in road construction activity.

11.3 Air Compressor (Fig 11.5)

The Air compressor fitted with diesel engine 38 hp, coupled with compressor unit, covered with canopy, mounted on chassis, towed with tractor or vehicle; can be used independently for operation of pneumatic jack hammer, pneumatic rock breaker, demolition tools.

Fig. 11.5 Air Compressor

The two stage air intake filter prevents dust and dirt particles from entering the compressor and engine. The direct drive from prime mover makes its use economical with better performance. The basic requirements of this unit are as under.

(i) Maximum working pressure: 8.5 kg/cm²

(ii) Normal working pressure: 6.5 kg/cm²

(iii) Free air delivery at 6.5 kg/cm² and working pressure 1480 rpm: 140 cfm

This Air compressor can be used for operation of one jack hammer.

Jack Hammer: It is used for demolition of reinforced structures / to drill in rocks for blasting purpose. It comprises of rock drill with drill rod / buster, lubricator, air grinder and hose pipe.

11.4 Tractor fitted with Air Compressor Unit (Fig 11.6, 11.7)

Fig. 11.6 Tractor Fitted with Air Compressor Unit

It is a useful equipment for use in rural roads specifically for demolition of structures, cutting of hard rock and cleaning of road surface before tack coating. The compressor unit can be fitted on tractor 45 hp and above. The compressor can be used for operation of jack hammer, breaker and pneumatic tools.

The compressor unit mounted on trolley and driven and towed by tractor can also be used for this purpose.

It is fitted with two long cylinders interconnected to each other which contains compressed air received from compressor. The compressor input pulley derives power through V belt fitted on tractor engine power shaft. The basic requirements of this unit are as under.

(i) Maximum working pressure: 8.5 kg/cm²

(ii) Normal working pressure: 6.5 kg/cm²

(iii) Free air delivery at 6.5 kg/cm² and working pressure 1400 rpm: 134 cfm

This Air compressor can be used for operation of one jack hammer.

Fig. 11.7 Air Compressor Unit Mounted on Trolley

11.5 Tractor Towed Trolley (Fig 11.8, 11.9)

It is useful, conveniently available and economical mode for transportation of earth, cement, aggregate, steel and other construction materials in road construction. It is mounted on single/ double axle fitted with hydraulic tipping arrangement capable of taking 12 tonne load.

Fig. 11.8 Single Axle Trolley Fitted with Hydraulic Tipping Arrangement

Fig. 11.9 Double Axle Trolley Fitted with Hydraulic Tipping Arrangement

The normal dimensions of both types of trolley are 3350 mm (length) x 1950 mm (width) x 600 mm (height). The side walls of trolley is 3 mm and floor platform 5 mm thick. The rear drop down door system gives flexibility for loading and unloading of material.

Single axle trolley is available to take load of 8 and 10 tonne and double axle of 10 and 12 tonne.

11.6 Tractor Towed Water Tanker (Fig 11.10)

It is commonly used in road construction activity. The water tanker of 5000 litre capacity, sheet thickness 4 mm is mounted on sturdy chassis. Normally, its length is 3050 mm, width 1400 mm, height 1170 mm and weight 1350 kg. It can be towed with tractor of 45 hp capacity. It should be fitted with proper sprinkler system for uniform water sprinkling.

Fig. 11.10 Tractor Towed Water Tanker

11.7 Diesel Generating Set (Fig 11.11, 11.12)

It is used as prime mover mainly for running Jaw Crusher, Wet mix plant, Hot mix plant. The DG set should be silent, compact, light weight and environment friendly certified by Central Pollution Control Board for emissions and noise compliance. These are of two types.

(i) Skid type

(ii) Trolley mounted, portable type

Fig. 11.11 Diesel Generating Set (Skid Type)

In skid type DG Set, engine and alternator are mounted on steel frame, which can be commissioned on concrete structure. This type of DG set is required when the application is for longer period at particular location.

Fig. 11.12 Diesel Generating Set (Portable Type)

In portable type DG Set, engine and alternator are mounted on chassis of trolley which has got four wheels and can be conveniently shifted as per requirement. Thus, it is required in case of frequent shifting.

The DG set comprises of following general specifications

(i) General:

(a) Prime power rating in kVA / kW (b) Current in amps (c) No. of phases (d) Power factor

(ii) Engine:

(a) Make (b) Model (c) BHP (d) Cooling system (e) Aspiration system Natural / Turbo charged (f) No of cylinders (g) Revolutions per minute (h) Swept volume (i) Type of governor (j) Fuel tank capacity (k) Lube oil sump capacity (l) Fuel oil consumption in litre per hour @ 75% load (m) Lube oil consumption in litre per hour (n) Total coolant capacity (o) Starting system (p) Battery capacity in ampere-hours and volts

(iii) Alternator Specifications:

(a) Voltage (b) RPM (c) Frequency (d) Voltage regulation (maximum) (e) Class of insulation.

(iv) Control Panel:

(a) Key switch / Auto start (b) Bus bar of suitable capacity with in / out going terminals (c) Indicating lamps for 'Load on' and 'Set running' (d) Instrument fuses duly wired and ferruled (e) MCCB of suitable rating with over load and short circuit protections (f) Multifunction meter displaying Voltage, Current, Frequency, Water temperature, Oil pressure, kVA, kW.

(v) Protection Devices:

(a) Over speed shut down (b) Low lube oil pressure shut down (c) High engine water temperature shut down (d) Under speed shut down (e) Battery charging alternator fail warning (f) Fail to start shut down.

LED indicating lamps for fail to start, over speed, under speed, low oil pressure, high engine temperature and failure for battery charging alternator should be available.

11.8 Hydra Crane (Fig 11.13)

It is a useful equipment for loading / unloading hume pipes, steel, other construction materials; erection and commissioning of Jaw Crusher, Hot mix plant / Wet mix plant. Hydra crane 10/12 tonne is sufficient for rural road works. It has slotted boom to adjust different jib length and hydraulic system for its easy movement. Following are the features of hydra crane.

Fig. 11.13 Hydra Crane

(i) Rated capacity: (a) Maximum load lifting capacity at minimum reach (b) Load lifting capacity at boom tip at maximum reach (c) Maximum hook height

(ii) Engine of adequate capacity

(iii) Transmission: Heavy duty with forward and reverse speeds

(iv) Speed: Up to 25 km per hour

(v) Steering: Articulated power steering with minimum 6 metre turning radius

(vi) Boom: Hydraulically operated, box type with telescopic arrangement minimum in three parts

(vii) Hoist: Hydraulically operated winch capable to operate maximum load of crane

(viii) Hydraulic system: Hydraulic pump of adequate capacity with spool control valve and pressure relief valve for precise operation

(ix) Brake: Efficient braking system hydraulically/ pneumatically/ mechanically operated

(x) Tyres: Front- four no, Rear- two no; of adequate capacity and ply rating

(xi) Safety: (a) Over audio warning system (b) Safety brakes on hoist (c) Hose protection device (d) Cylinder guard protection device

11.9 Diesel Welding Set (Fig 11.14, 11.15)

It is an essential service equipment required for maintenance of Plant and Equipment.

Fig. 11.14 Diesel Welding Set (heavy Duty)

Fig. 11.15 Diesel Welding Set (light Duty)

It may be classified in to (i) Heavy duty portable welding set (ii) Light duty portable welding set. Heavy duty portable welding set (Fig. 11.14) is mounted on trailer and can be towed easily with a jeep/ tractor. Light duty portable welding set (Fig. 11.15) can be easily shifted manually. Following are the features of welding set.

(i) Prime-mover: Diesel engine of adequate capacity (ii) Type- Brushless (iii) Welding current range 10 to 400 Amps (iv) Maximum hand welding current @ 60% duty cycle 400 Amps (v) Maximum hand welding current @ 100% duty cycle 310 Amps (vi) Open circuit voltage 90 volts DC (vii) Meeting to CPCB norms (viii) Insulation type class H (ix) Capable to use 1.5 to 5.0 mm electrode (x) Rating - 10 & 5 kVA (xi) Voltage - 415 and 230 (xii) Phase three/ single.

Fig. 11.16 Lighting Tower

11.10 Lighting Tower (Fig 11.16)

The traffic volume on rural roads is low, thus the construction activity is carried out during day. Where necessary, provision for one number lighting tower can be made for work at night and during dark hours. The brief details of lighting tower are as under.

(i) Telescopic mast height- 9 metre

(ii) Light capacity- 4000 watt (4x1000 watt)

(iii) Type of bulb- Sodium vapour/ Metal halide

(iv) Diesel engine- 10 hp

(v) Alternator 220 volt, frequency 50 Hz, Out put wattage- 4.5 kW

(vi) Wind withstanding capacity- 50 kmph

11.11 Road Marking Machine (Fig 11.17, 11.18, 11.19)

Fig. 11.17 Truck Mounted Road Marking Machine

The road marking machine required for marking the road surface with paint is classified into three categories (i) Truck Mounted Road Marking Machine (ii) Self Propelled Road Marking Machine (iii) Operator Propelled Road Marking Machine.

(i) Truck Mounted Road Marking Machine (Fig. 11.17)

It is mounted on truck equipped with paint pumps. The smaller capacity machine is provided with two tanks of approximately 200 to 500 litre capacity each for yellow or white line marking. It can be provided with pressurized glass bead system for surface application. The hot oil application is also available to maintain paint temperature up to 80°C for its smooth application through water heat exchanger.

(ii) Self Propelled Road Marking Machine (Fig.11.18)

Fig. 11.18 Self Propelled Road Marking machine

It is a compact self propelled machine mounted on axles fitted with hydraulic drive. In case of emergency hydraulic drive can be disengaged and machine towed for longer distance. It is also provided with two glass bead containers. It can lay line width 10 to 100 cm and used up to 26° gradient.\

(iii) Operator Propelled Road Marking Machine (Fig. 11.19)

Operated Propelled Road Marking Machine (Fig 11.19) is suitable for application of thermo plastic paint and cold paint. The machine is provided with glass bead container, stainless steel drum in which glass beads are inducted and direct heating done with LPG

The swapping of material is done at spot. The mercury temperature gauge is provided to measure the temperature of paint. The machine is provided with 4 cm screed box with hook mechanism system which allows clean cut and sharp smooth strips at spot. The self wheel lock system on rear wheel allows perfect straight line marking. The LPG supply is done to the burners which are provided in the tank, screed box and hand torch. The paint spray gun can be used as hand spray gun also, if required.

Fig. 11.19 Operator Propelled Road Marking Machine

The whole machine is mounted on tubular chassis fitted with 3 rubber wheels (i) diameter 250mm 2 Nos (ii) Diameter 150mm 1 No which can be easily towed by single operator. The brief details of machine are as under:

(i) Glass bead container: capacity 10 kg fitted with rotor type spraying mechanism, which automatically activates with the turn of mechanism with glass beam flow adjustment.

(ii) Thermoplastic tank stainless steel tank capacity 100 kg.

(iii) Heating system: LPG supply to burners.

(iv) Screed box: Provided of 4 cm with option of 15cm, 20cm, 30cm and 50cm

(v) Dimension: 1200mm (L) x 600mm (W) x 900mm (H).

(vi) Weight: approx. 120 kg.

The quantity of road length for application of road marking is small in rural road in each stretch, therefore operator propelled road marking machine is preferred due its economical use.

Crushing and Screening Plant

12. Crushing and Screening Plant

It is a normal practice to procure aggregates for road construction from out source. In case adequate quantity, specified quality and grading of aggregates is not available and quarry is nearby; the crushing and screening plant may be commissioned. The jaw crusher can produce the aggregates meeting to rural road specifications. The Jaw crusher of 60 TPH capacity with screening unit having essential features is adequate and economical to produce the aggregates. In case, the requirement of aggregate is above 120 tonne per day and quarry is nearby, the mobile crushing plant 18 to 20 tonne per hour capacity mounted on chassis, towed with tractor is appropriate for use. Alternatively, if the requirement of aggregate is about 40 tonne per day and small quarries exist in the area; it would be preferred to deploy small capacity 4 to 6 tonne per hour capacity jaw crusher and granulator. It would be semi-mobile type mounted on rigid chassis, fitted with diesel engine/ electric motor. This machine will need smaller size of feed. A rotary screen mounted on crusher chassis shall be used for grading the material of different sizes.

The details of crushing and screening plant comprising of feeder system, jaw crusher, screening unit, conveyor system and guidelines to be followed for its operation and maintenance are included in this chapter.

12.1 Grizzly Feeder

The Grizzly Feeder is fitted prior to jaw crusher. The main function of grizzly feeder is extraction, scalping and feeding of metered material to jaw crusher. It is robust in construction and able to handle hard, abrasive materials and absorb impact. The heavy main frame constructed from steel bars/ rolled section and hard faced, reinforced with large beam supports feeder trough is able to withstand the substantial impact loads, encountered under the truck- dumper hoppers. The grizzly feeder is tapered towards lower end, to avoid the clogging of feed material. It is of two types.

(i) Stationary grizzly feeder

(ii) Vibrating grizzly feeder

(i) Stationary Grizzly Feeder

It is used for screening of coarse dry material. The slope should be from 35° to 40° for free movement of feed material. For better performance of grizzly, the bars/ rolled section should have minimum width at the top and maximum at the bottom as shown in Fig.12.1. It prevents wedging of oversized material as it travels down the grizzly.

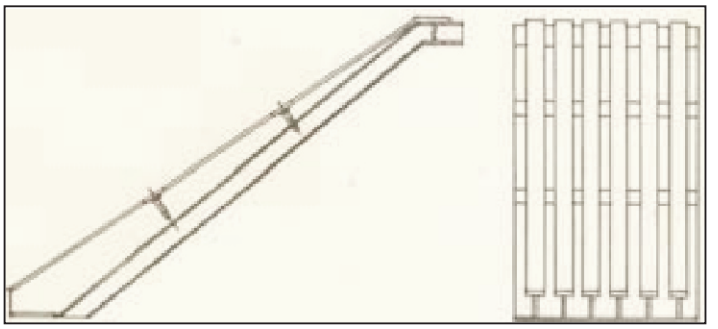


Fig. 12.1 Stationary Grizzly Feeder

(ii) Vibratory Grizzly Feeder

It is simple grizzly mounted on rotating eccentric shaft fitted on vibrators, which provide linear vibrating force to move large boulders as shown in Fig.12.2. This type of grizzly is normally used in crushing plants above 100 tonne per hour capacity to handle large volume, damp and sticky materials. Stepped grizzly is used in high capacity plants to save head room.

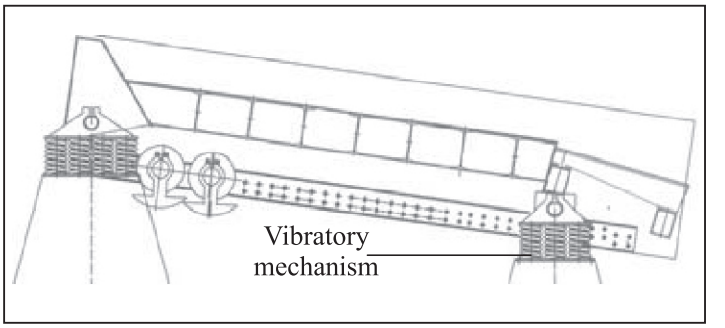


Fig. 12.2 Vibratory Grizzly Feeder

12.2 Jaw Crusher

It is the basic unit of all crushing plants. Jaw crusher having following essential features can produce good quality aggregates needed for rural roads.

(i) Selection of Jaw Crusher:

It depends upon:

a) Capacity of feed hopper which includes its width, volume and vibrating mechanism.

b) Size of jaw crusher

- It is specified in terms of intake width, intake depth, jaw setting (closed setting), production of aggregate, horse power (hp) of electric motor, number of strokes per minute and weight of machine.

- In case of portable plants, it is necessary to give consideration to length, width, height, axle weight and king pin weight for selection.

(ii) Function of Jaw Crusher:

Jaw crusher consists of two jaws. (a) Stationary jaw (b) Movable jaw. Both the jaws compress the rock within a fixed dimension of feed opening jaw. Material is received where two surfaces most diverge and compress until pieces are small enough to fall through the narrowest space known as neck. Moving jaw can be activated by single toggle mechanism or double toggle mechanism.

Single Toggle Mechanism: The cross section of single toggle jaw crusher mechanism is shown in Fig.12.3. In this mechanism, the swing jaw motion is elliptical downwards and towards stationary jaw, while crushing is upwards and backwards when allowing crushed

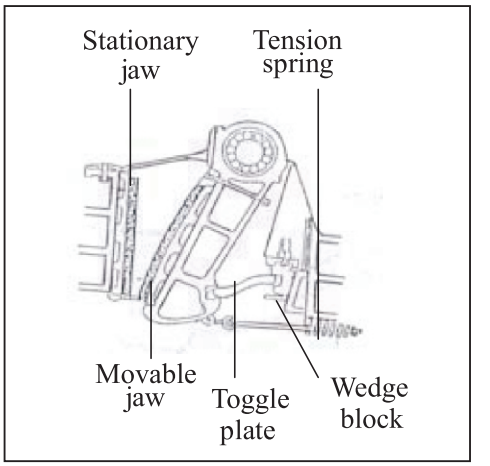


Fig. 12.3 Single Toggle Jaw Crusher

material to exit. The downward pushing action promotes a higher capacity force and consequently higher wear of jaw plates.

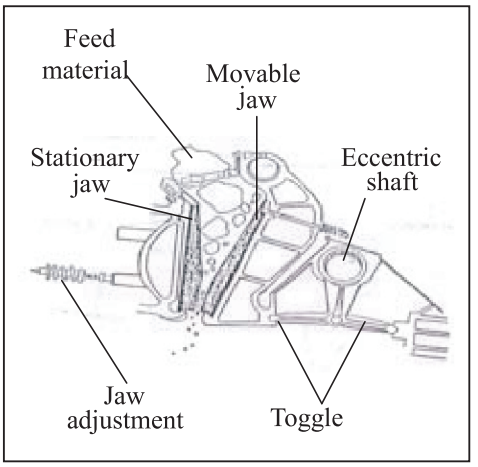


Fig. 12.4 Double Toggle Jaw Crusher

Double Toggle Mechanism: In double toggle jaw crusher shown in Fig.12.4, the centre of swing jaw is in line of crushing zone. It eliminates the vertical motion of jaw plate and results into its linear motion which creates very powerful compressive forces during crushing without any abrasive motion. Therefore, a) Wear of jaw plates is reduced. b) Maximum power is utilized for crushing.

12.2.1 Modern Jaw Crusher

Salient Features:

The demand for higher capacity crushing plants with modular design and additional features has increased substantially. Accordingly, there has been considerable improvement in the design of jaw crushers. The salient features of a modern jaw crusher are as under:

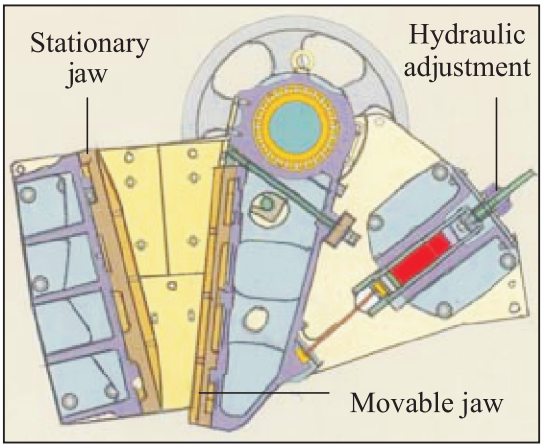


Fig. 12.5 Modern Jaw Crusher

a) The capacity of this crusher is higher.

b) It is robust in construction.

c) It is more reliable.

d) It has modular design with pin and bolt arrangement to reduce metal fatigue.

e) It has good crushing ratio.

f) It has hydraulic setting adjustment to control the level of material and most productive setting for different materials shown in Fig.12.5.

12.2.2 Operation of Jaw Crusher

Following points should be considered during operation of jaw crusher.

1) To reduce percentage of flaky material, serrated jaw plates as shown in Fig.12.6 should be used.

2) To obtain consistent quality of output, appropriate feeders should be installed to regulate the feed.

3) Avoid feeding bigger size pieces than the size recommended by the manufacturer.

4) The feed size should be restricted to 70-80% of crusher mouth opening.

5) The mixed material should be fed to get best crushing results.

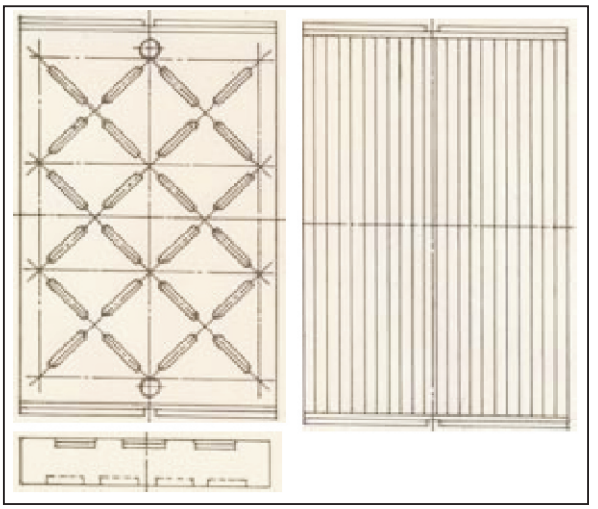


Fig. 12.6 Serrated Jaw Plates

6) The maximum crushing ratio should be restricted, within the range 4:1 to 7:1.

7) Choke feeding increases the quantity of fines in the product. Therefore, free crushing should be adopted which maintains optimum capacity of the plant with desired quality of product.

12.3 Screening Unit

The function of screening unit is to scalp, grade, recirculate the oversize material for further crushing and dewatering the aggregates. The screening unit is of two types (i) Stationary screens (ii) Mobile screens

(i) Stationary Screens:

These may be horizontal, single, double and triple in inclination to produce one, two or three sizes of products as shown in Fig.12.7.

Fig. 12.7 Stationary Screens

(ii) Mobile Screens:

These are mounted on wheels and can be moved by road as shown in Fig.12.8.

Fig. 12.8 Mobile Screens

12.4 Conveyor System

It is a material handling system to transfer material from one point to another. The conveyors are of different widths and lengths meeting to the requirement of plant. The conveyor system is of two types. (i) Stationary conveyors (ii) Mobile conveyors

(i) Stationary Conveyors:

These are normally used with stationary plants. These are available in truss frame form also, which are simple, compact, easy and quick to dismantle, transport and erect at desired location as shown in Fig.12.9.

(ii) Mobile Conveyors:

These are the links between Jaw Crusher and further processing stages. These follow the crushing unit as it moves along the quarry face, eliminating the use of costly dump trucks. These are shown in Fig.12.10.

Fig. 12.9 Stationary Conveyors

Fig. 12.10 Mobile Conveyors

12.5 Power Requirement for Crushing and Screening Plant

The DG Set 62.5 kVA is sufficient for running Jaw Crusher 60 TPH capacity along with screening unit and essential conveyor system .

12.6 Mobile Crushing Plant

This plant is in the range of 15 to 20 tonne per hour capacity, and comprises of jaw crusher/ granulator, rotary screen and conveyors for transfer of material. The prime mover used may be diesel engine or electric motor. It would be preferable to operate it with diesel generating set. The complete plant is mounted and aligned on

portable trolley fitted with pneumatic wheels. The total weight of the plant is about 6 to 7 tonnes and can be pulled by a tractor. It does not require any foundation and can be shifted easily, where working site changes frequently and boulders of appropriate sizes are easily available for feeding the plant. The mobile crushing and screening plant is shown in Fig. 12.11.

Fig. 12.11 Mobile Crushing Plant

The brief details of various components fitted on this unit are as under.

(i) Jaw crusher

It is double toggle type having production capacity 15 to 20 tonnes per hour depending on type of crushed material and requirement of crushed aggregate sizes.

- The crusher RPM is 375.

- The power required for its operation is 25 HP at 1440 RPM

(ii) Vibrating screen:

- The screen size is 25 cm x 8 cm with screening capacity 35 to 45 TPH.

- The power required is 5 HP at 1440 RPM.

(iii) Main hopper:

- It is made of structural steel with storage capacity 9 to 10 tonnes approximately.

(iv) Conveyors:

- The belt conveyors of different sizes meeting to their functions are provided in the plant.

12.6.1 Power Requirement:

The diesel generating set 62.5 kVA mounted on trolley is suitable for operation of mobile crushing plant 15 to 20 TPH capacity.

12.7 Important Tips for Operation, Maintenance and Safety of Crushing Plant

Following points should be taken care of in selection and for efficient and economical running of crushing plant:

(i) The boulders received from quarry should be stocked in adequate quantity close to the feed point of crushing plant.

(ii) The ground should be leveled.

(iii) The feed size of boulders to be inducted in jaw crusher and final grading to be achieved along with output should be intimated to the manufacturers before initiating procurement of crushing plant. This will enable the manufacturers to offer appropriate models and their combination. The combination of accessories is essential. Its inappropriate selection may adversely affect the production of crushing plant.

(iv) The cost of Jaw crusher 60 TPH along with allied equipments used for aggregate production may be approximately Rs. 100 lakh. In addition to this, other expenditure towards leasing of land, establishment, inventory of spares is also to be met out. Therefore, it should be operated in minimum two shifts at its optimum capacity. Insufficient running will result in higher cost of aggregates.

(v) The quarry with a short lead to crushing plant does not require a buffer stock pile. For long lead say 250 metre or more lead, a buffer stock pile has to be created near the jaw crusher. The additional equipment to re-handle the stock e.g loader, tipper etc, space for storage should be provided. The ramp should be adequately designed to cater to the requirement.

(vi) The maintenance schedule of crushing plant and allied equipments should be planned so that the production does not get hampered.

(vii) The over loading of equipment gives small time gain in production capacity of plant. It should be borne in mind that the prolonged over load operation reduces the life span of critical components. The repairs required due to over loading are much more expensive and time consuming. It disturbs the normal maintenance schedules and as a consequence, the plant is not available at the time of need. The gain due to over loading is only short term and misconceived, as such it should be avoided.

(viii) The performance of crushing plant is adversely affected by poor control and inadequate design of material feed system. As such, due care needs to be exercised in design and control of the feed system.

(ix) The crushing plant should be kept in operation, for minimum sixteen to eighteen hours per day. For this, it is essential to have trained technical personnel and efficient spare parts inventory management system. The non-availability of minor spare parts may lead to idling of plant for long time. It shall be

preferred to have a service support arrangement with the manufacturer / supplier on annual maintenance contract and on tonnage basis, while finalizing the purchase order. The annual maintenance contract will depend on material characteristics such as crushability, impact strength, abrasive index, brittleness, flakiness and graded material requirement. Alternatively, adequate inventory of fast moving spare parts may be kept in stock.

(x) The crushing plant is heavy duty equipment and comprises mostly of moving components. The site engineer should make a thorough examination of plant at the beginning of each shift. He should be familiar with plant features including mechanical condition of each component and ensure their running duly complying with the safety requirements.

(xi) The safety equipment like guards for drives, railings for platforms and walkways; should be properly maintained, to avoid accidents during inspection, operation and maintenance of plant.

Bridge Construction Equipments

13. Bridge Construction Equipments

The construction of bridges and culverts is a specialized job. In rural roads, the bridges and culverts would be of small span. For bridge construction activity; earth moving, cement concrete, allied equipments, and other specific equipments for bridge construction such as grab dredging crane and pile driving equipments shall be required. The details of other equipments have already been described in respective chapters. The grab dredging crane and pile driving equipment are covered in this chapter.

13.1 Grab Dredging Crane (Fig 13.1)

The most effective and economical way to handle large volume of bulk loose materials is by using a grab dredging crane. In bridge construction, huge quantity of such bulk materials in the form of clay, sand, stone pieces etc are to be removed for which grab dredging cranes are most suitable. It consists of tracked excavator fitted with single jib crane and provision of grab bucket operated with ropes for its holding and closing. The digging and material handling are in vertical line. The bucket has got teeth at its lower end, which bite in to the soft, loose or medium hard material as the bucket is raised.

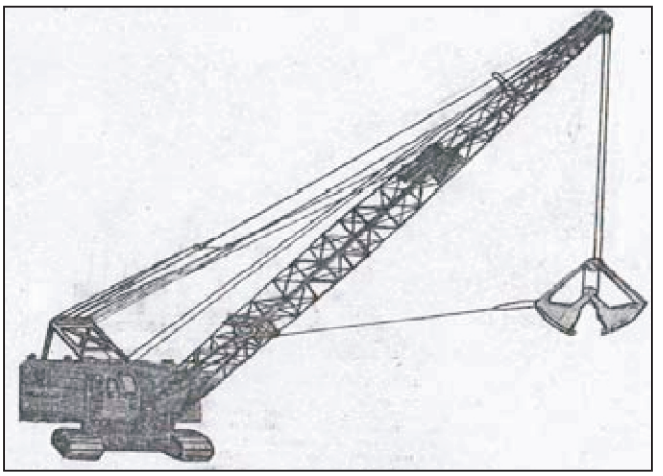


Fig. 13.1 Grab Dredging Crane with Grab Bucket

This method of excavation is most suitable to remove the material for sinking of wells in bridge construction, This equipment can also be used to load bin from stock pile of aggregates.

The size of grab dredging crane depends on the following factors.

(i) Length of track

(ii) Capacity of engine

(iii) Height and horizontal distance of jib

(iv) Load carrying capacity of grab bucket

- Normally 0.5 to 2.0 cum grab buckets are used with grab dredging crane.

13.2 Pile Driving Equipment (Fig 13.2)

The pile driving equipment is used to lift heavy weights, normally by means of pulleys and drop the weight on to the end of the pile. There has been tremendous improvement in the design of piles. Several methods have been devised to raise the weight and guide the pile. These are as under:

(i) Vertical Travel Lead System: The impact hammer is connected to the boom by a sliding connection which allows the lead to be elevated or lowered below grade.

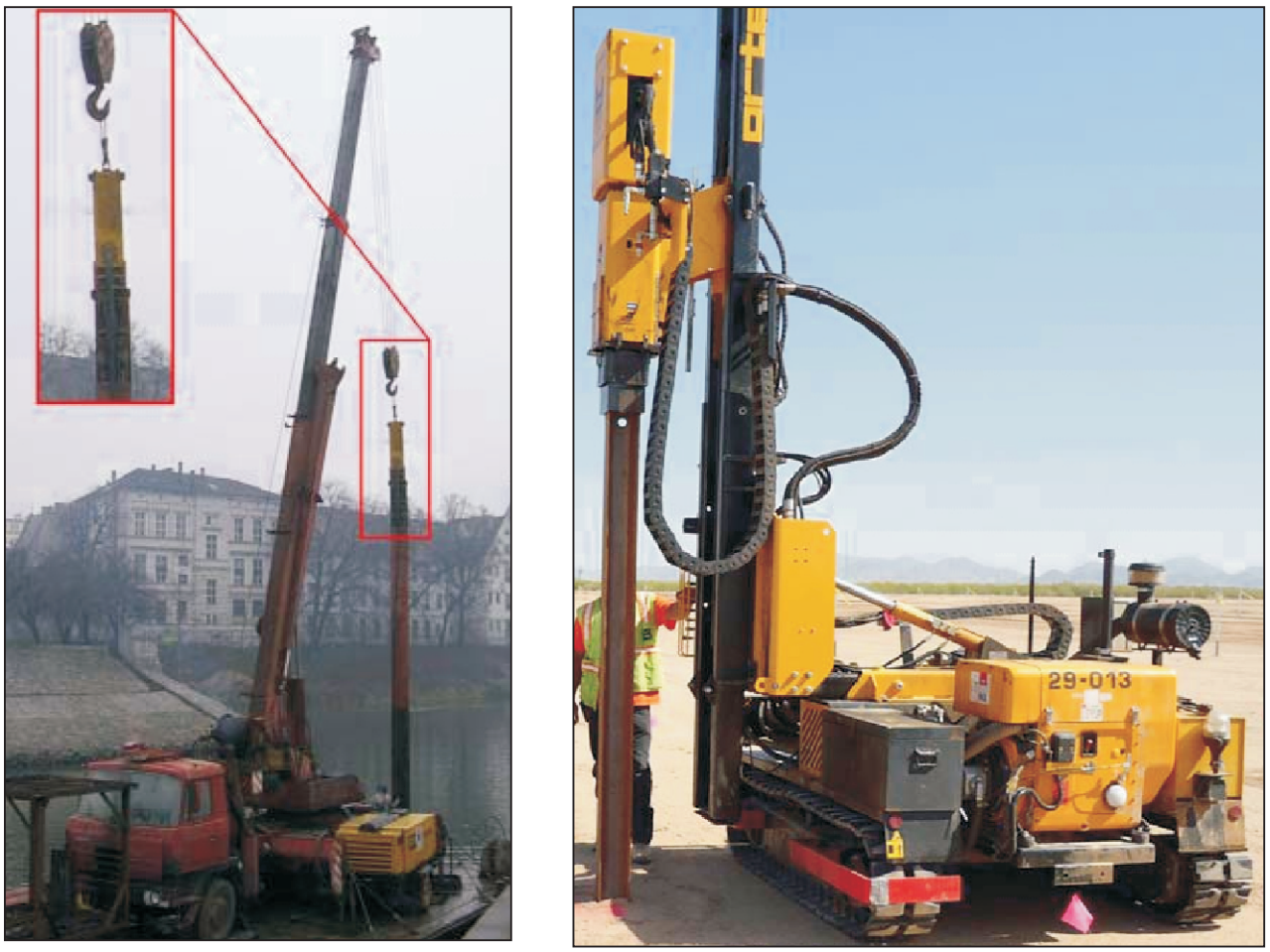


Fig. 13.2 Pile Driving Equipment in Operation

(ii) Diesel Hammer: It is a large two stroke diesel engine. The weight is the piston and the apparatus which connects to the top of pile which is the cylinder. The weight is raised by the cable supported at crane end. It draws air into the cylinder, now diesel is injected into the cylinder.

The weight is dropped, using quick release; due to which the mixture gets ignited and transfers the energy of falling weight to the pile head. Now, the rising weight draws in fresh air and this cycle is repeated until stopped by pile crew.

(iii) Hydraulic Press: This equipment uses hydraulic rams to press the piles in to the ground. This system is used where noise and vibrations are sensitive issues for compliance.

(iv) Vibratory Pile Hammer: Vibratory pile hammers contain a system of counter- rotating eccentric weights powered by hydraulic motors and designed in such a way that horizontal vibrations are cancelled and vertical vibrations transmitted in to the pile. The pile driving machine is positioned over the pile by clamps / bolts. Vibratory hammers can either drive in or extract a pile. Hydraulic fluid is supplied to the driver by hydraulic pumps driven by diesel engine.

- The capacity of Pile driving equipment depends on (i) Weight of hammer (ii) The Height of hammer from which it shall be operative (iii) Number of blows per minute (iv) Horse power of prime mover (v) Hydraulic pressure

For Rural road application, it may be mentioned that the weight or power of hammer should be sufficient to ensure penetration of at least 5 mm per blow until rock has reached. It should be preferred to use heaviest hammer (Minimum 2.5 tonne) with limited stroke, so as not to damage the pile. Stroke of a single acting or drop hammer be limited to 1.2 metre.

Mobile Maintenance Unit

14. Mobile Maintenance Unit for Pot hole / Patch Repair Work in Rural Roads

The pot hole / patch repair work on roads can be done in two ways.

(i) Receiving hot mix from the hot mix plant (By using hot bitumen)

(ii) Repair the road by use of bitumen emulsion with aggregate at site.

The quantity of hot mix required in rural road is very small. The repair of pot hole/ patch repair from hot mix plant is not feasible and would be uneconomical, unless the same contractor has several road stretches in the area. It would be preferred that the repair of rural road may be carried out by use of bitumen emulsion with aggregate at site. One such unit has been proposed for maintenance of rural roads, the details of which are as under.

14.1. Methodology:

The following methodology would be adopted for repair of pot hole / patch work in rural road.

(i) Inspection of road and identify the affected area

(ii) Cleaning the road surface manually

(iii) Trimming the pot holes / patch work in rectangular shape

(iv) Cleaning the pot holes

(v) Apply tack coat with bitumen emulsion

(vi) Filling the aggregate into pot holes/ patch work

(vii) Spray bitumen emulsion on aggregate and fines

(viii) Compaction

14.2. Tools and Equipments Required:

14.2.1 Air compressor mounted on Tractor 45 HP (Fig. 14.1):

The brief details of Air compressor mounted on tractor 45 HP are given below.

(a) Maximum working pressure: 8.5 kg/cm^2

(b) Normal working pressure: 6.5 kg/cm²

(c) Normal and maximum operating speed on load: 1400 rpm

(d) Speed at power take off: 1400 rpm

(e) Free air delivery at 6.5 kg/cm² and working pressure 1400 rpm: 134 cfm

(f) Free air delivery 63.4 litre per second

(g) Power required for compressor shaft at full load: 42 hp

Fig. 14.1 Air Compressor Mounted on Tractor

(h) Air receiver capacity: 80 litre

(i) Net weight of air compressor unit with mounting: 650 kg

14.2.2 Tractor Trolley (Fig. 14.2)

The tractor trolley size 3350 mm (length) x 1950 mm (width) x 600 mm (height) fitted with tipping attachment and mounted on double axle capable to take 12 tonne load should be used. Care is required during fabrication that Air compressor end and front portion of trolley have minimum 60 cm gap between Air compressor end and front portion of trolley; so that Air compressor is not damaged during transportation.

Fig. 14.2 Tractor Trolley

14.2.3 Bitumen Emulsion Trolley

The bitumen emulsion trolley having bitumen emulsion tank of approximately 100 litre capacity is fitted with three rubber wheels (a) Diameter 250 mm two numbers in rear (b) 150 mm one number in front. The tank is fitted with spray arrangement. The trolley can be towed easily by a single person.

14.2.4 Double Drum Walk Behind Roller (Fig. 14.3)

The specifications of the roller are as under.

(a) Weight of roller : 450 to 550 kg

(b) Working width : 560 mm

(c) Operating speed (Front/ reverse): 25 metre per minute

(d) Walking speed : 1.6 km per hour

(e) Total applied force : 6 kg per cm

(f) Water tank arrangement provided

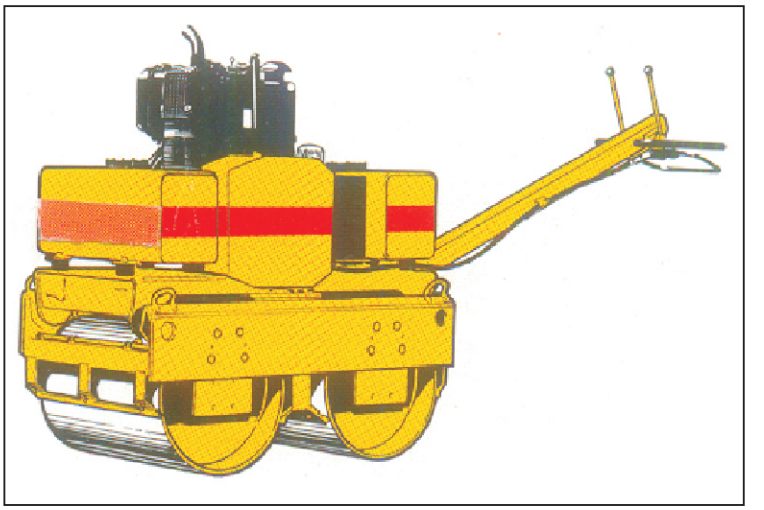


Fig. 14.3 Double Drum Walk behind Roller

14.2.5 Single Drum Walk Behind Roller (Fig. 14.4)

(a) Weight of roller : 180 kg

(b) Working width : 560 mm

(c) Actual load : 2.9 kg per cm

(d) Walking speed : 1.6 km per hour

Fig. 14.4 Single Drum Walk behind Roller

14.2.6 Mixing Pan

For mixing emulsion with aggregates, use of a mixing pan is recommended. The suggestive dimensions of the mixing pan are given in Figure 14.5. It may be made of 3mm steel.

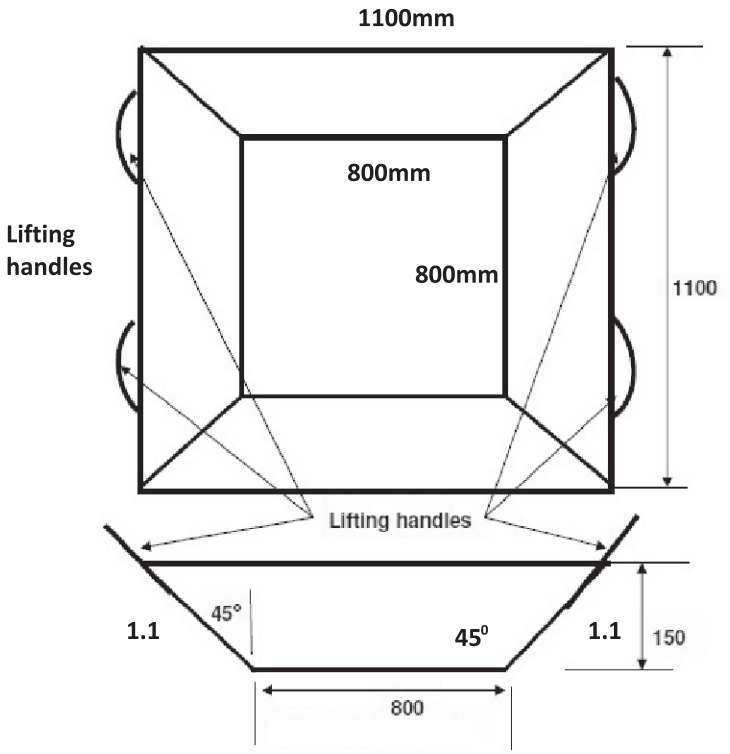


Figure 14.5 Mixing tray

While undertaking the operation of mixing the aggregates and the emulsion, the mixing pan should be free of any foreign matter. Further, it must be cleaned at the end of each day's operation.

14.2.7 Other tools

(a) Jack hammer
(b) Pneumatic hose
(c) Hand tools like pick, shovel, buster chisel, broom, brush etc

14.3 Sequence of Operation:

(i) Cleaning the road surface: The pot hole/ patch repair to be carried out should be properly checked, and road surface cleaned with the broom/ brush. The pot holes/ patches should be trimmed in rectangular shape with the jack hammer operated with air compressor. If required, the edges may be shaped with hand tools also. Now, the disintegrated material removed and pot hole/ patches cleaned by blowing air from air compressor.

(ii) Tack coating: Tack coating should be done with the bitumen emulsion. The trolley having bitumen emulsion tank fitted with spray arrangement is used for tack coating purpose.

(iii) Mixing of aggregates and emulsion and Spreading of Mix: The aggregate available in tractor trolley is brought to repair site in wheel barrow. The mixing pan is cleaned so that it is free of any foreign matter. The correct amount of aggregate and emulsion are mixed thoroughly in the pan. The pot hole/ patches in layers are then filled with the mix material such that it is spread uniformly. The layer is spread such that it is slightly above the road surface.

(iv) Compaction: The compaction shall be carried out with walk behind roller

Note :

- The trolley has got 4 cum space, out of which 1 cum may be used for stocking of walk behind roller, emulsion tank, emulsion trolley and other tools. and balance 3 cum may be used for stacking of aggregate.

- In case bitumen is required to be used, the bitumen boiler mounted on pneumatic tyres fitted with sprayer can be used in place of emulsion. However, it is prefuable to use bitumen emulsion, since its use is simple and safe also. It would be ensured that bitumen emulsion being used is of repute make and has not exhausted its life.

14.4 Approximate Cost of Unit

The indicative cost of the unit (prices January, 2015) is given below

S.No	Description	Cost in Rs. lakh
(i)	Tractor fitted with air compressor unit	8.0
(ii)	Tractor trolley double axle	1.5
(iii)	Emulsion tank with sprayer mounted on trolley	1.0
(iv)	(a)Double drum walk behind roller 550 kg weight	6.0
	(b) Single drum walk behind roller 180 kg weight	2.5
(v)	Jack hammer – 2 no	1.0
(vi)	Hand tools, hose pipe, mixing pan and other items	0.5
	Total	18 lakh*

* It would be preferred to procure both types double drum and single drum walk behind rollers in the unit, so that in case of operational problem compaction is not affected.

14.5 Utilisation of Unit:

Assumption: Width of road 5.5 metre, Area covered under maintenance 4%, Thickness of road crust 20 cm, Length of road 1000 metre

(i) Volume of road crust 1000 x 5.5 x 20/100 = 1100 cum

(ii) Volume of road to be repaired per km = 1100x4/100 = 44 cum

(iii) Number of trips to be carried out by tractor per day - 4

(iv) Volume of road that can be repaired per day 3 x 4 = 12 cum

(v) Repair of one km road can be done in 44/12 = 3.7 say 4 days

Documentation, Operation, Maintenance, Inspection, Safety and Shifting of Equipments

15. Documentation, Operation, Maintenance, Inspection, Safety, Training and Shifting of Equipments

The documentation of equipments is an essential part of equipment management. It helps us to plan the shifting of equipments from one project to another, assess their timely repairs, evaluate the performance of equipments and their disposal. The inventory register, log books and history sheet are essential documents and should be maintained. The equipment manufacturers guidelines for repair and maintenance of equipments should be followed and fast moving spare parts kept in stock to avoid their idling. Safety is an essential parameter and should be strictly followed in respect to work site, equipment repair and maintenance, inspection, loading and transportation. Any accident results in recurring loss of reputation of company, fear in the labour, wastage of man power due to its occurrence and financially also; thus all precautions should be taken to avoid such happenings. These aspects are covered in this chapter.

15.1 Documentation

It is an essential part of equipment management system. It assists in evaluation of the performance of equipment, utilization, forecast its repairs and maintenance, initiate timely procurement of spare parts, fuel / lubricant consumption, rate analysis and its timely disposal also. Proper maintenance and upkeep of equipments lead to their longer life, avoiding frequent breakdown, i.e. saving in unnecessary expenses for stoppage of work and replacement of components. Following precautions should be taken in this regard.

(i) The log book and history sheet of equipment should be maintained properly. It assists to forecast the repairs involved in plant / equipment and initiate timely procurement of spare parts for such repairs.

(ii) Follow the instructions given in the manufacturer's maintenance manual.

(iii) The schedule for routine maintenance i.e. weekly, monthly, quarterly, half yearly, yearly should be followed. In case schedules are prescribed on running / time period basis, whichever falls earlier should be followed. Periodical overhauling should be carried out based on manufacturer's guidelines. Regular maintenance helps in prolonging the life of the equipment and ensures better productivity.

(iv) Sufficient quantity of fast moving spare parts and recommended lubricants should be available in store. It may be ensured that dead inventory does not take place in stock.

(v) Necessary action for procurement of spare parts likely to be worn out in near future should be taken in advance, to avoid idling of equipment.

(vi) The tools required for day to day maintenance and on other specific jobs, should be made available at works site, as per manufacturer's recommendations.

15.2 Operation and maintenance of equipment

(i) Study and follow equipment's operation and maintenance manual instructions and carry out servicing and repairs as per manufacturer's recommendations.

(ii) Keep the equipment in good working condition

(iii) Never operate an unsafe equipment.

(iv) Operators should familiarise themselves with all controls, gauges, instruments, emergency stop switch etc. before its operation.

(v) Never leave the machine unattended with its engine running.

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

(vii) Look around before starting.

(viii) Never carry out servicing, repairs and adjustments, while the equipment is working.

(ix) Be sure that hydraulic pressure is released before working on hydraulic system.

(x) Periodical maintenance schedules should be followed.

(xi) During shut down of machine, put all controls to neutral position. Set the transmission lock, apply parking brakes and remove ignition keys.

(xii) Do not get under the machine unless it is shut off.

(xiii) Shut-off the engine after allowing it to idle, as per the recommendations of the manufacturer.

(xiv) Ensure use of PPE (personal protection equipment) and safety gadgets such as helmets, goggles, gloves etc.

(xv) Ensure use of proper tools and tackles at appropriate location.

(xvi) During maintenance, close fuel shut off valve and avoid fire accidents.

(xvii) Check the oil level in gear boxes and top up, if required.

(xviii) Adequate illumination should be available.

(xix) Never permit unauthorized persons to sit on equipment.

(xx) Do not leave the control when machine is working.

(xxi) Exercise care while removing the radiator cap, after the engine is running.

15.3 Inspection and testing

In case some defect has been observed and it affects the smooth operation of machine, it should be stopped immediately, got checked and defect rectified. Machine should be inspected in all respects by a trained person at regular intervals and got recorded in inspection sheet.

15.4 Safety Precautions

(i) Railing should be provided in all exposed areas to ensure that an operator cannot fall off.

(ii) Safety guards should be provided over the auger to stop any thing from falling down into the auger system.

(iii) The platforms should have good anti skid surface/ projection to avoid slippage.

(iv) Precaution should be taken for heating the screed of paver and firing the burner of hot mix plant to prevent the risk of explosion and injury to the crew.

(v) Closed cabin should not be used in equipments as they accumulate fumes from hot bitumen.

(vi) All controls must be within easy reach of operator and provide him with good all round visibility.

(vii) The operator's seat should be comfortable and easily adjustable to the height and physique of the operator.

(viii) A First Aid Box should always be available at site.

(ix) There should not be open fire around the bitumen or fuel storage tanks.

(x) All gears, pulleys, chains, belt sprockets, dangerous moving parts should be well guarded and protected.

(xi) Covered stairs and platform ladders should be provided to all parts of the operating plant.

(xii) All stairs and platforms should have handrails.

15.5 Disclaimer

The manual does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this Manual to establish appropriate safety practices prior to its use taking into cognizance the safety guidelines of the Manufacturer and Industry Standards.

15.6 Training and Skill Development

(i) Provide proper training to operators and maintenance staff before its operation.

(ii) Provide proper training on safety aspects in respect of each equipment.

(iii) Employ well trained, skilled, medically fit workers.

15.7 Tips for shifting the equipment

(i) Load and unload the equipment on leveled ground only.

(ii) Lift the equipment as per the recommendations of the manufacturer.

(iii) Use the indicated lifting points, while lifting the machine with a crane.

(iv) Be sure of the weight while lifting the machine.

(v) Use ramps of adequate strength.

(vi) Block the transport vehicle firmly during loading process, so that it cannot move.

(vii) Tie and block the equipment securely during transportation.

(viii) Avoid jerky swings and hoists or sudden brakes.

(ix) Park the equipment on firm and level ground whenever possible or at right angle to any slope.

(x) Use warning signals like cordoning, red light etc. when parking the equipment.

(xi) If the machine comes into contact with a charged electric line; either stay on the machine or jump off and never step off. Do not allow any person on the ground to touch the machine.

(xii) Keep blade or bucket low for better stability and visibility while travelling.

Factors Affecting the Output and Performance of Plant and Equipments

16. Factors Affecting the Output and Performance of Plant and Equipments

It is essential that output and performance of equipments to be deployed on work should be known on actual basis to plan their requirement. Each construction activity is correlated to another. In case the activity at initial stage gets delayed due to lesser output and slow performance of equipment; it has an adverse effect on future activities, ultimately, delay in completion of project. The climatic conditions during which the equipments are to be used should also be considered while assessing their requirement.

The normal output of machine in the field is assessed as 65% of manufacturer specified output after considering job factor and management factor. Thus, the planning in project should be carried out after considering all these aspects regarding output and performance of equipments.

16.1 It is necessary to know the actual output of plant and equipments in specific project to assess their requirement, which shall depend on field conditions and other factors.

16.2 The manufacturers of plant and equipments project their output based on ideal conditions, which are not available in the field. Therefore, the actual output of plant and equipment is less than projected.

16.3 The performance of plants and equipments is affected by two factors (i) Job factor (ii) Management factor

16.3.1 Job factor: It is connected with the existing physical conditions at site, which will affect the performance of equipment; the details of which are as under.

(i) Swelling and shrinkage factor for materials.

(ii) Rolling resistance being faced during transportation

(iii) Gradient during loading and travel, which may be favorable or unfavorable.

(iv) Tractive efficiency, which will determine the quantity of tractive force required to avoid slippage

(v) Reduction in engine horse power due to its use at higher altitude

(vi) Climatic and terrain conditions

(vii) Presence of moisture content in earth and aggregate

(viii) Type of soil during excavation

(ix) Depth of cut and angle of swing in use of dozing and grading equipment

(x) Life achieved by the equipment

(xi) Proper and timely maintenance of equipment

16.3.2 Management factor: This factor is connected with the management of equipments, the details of which are as under.

(i) Operator's efficiency: It depends on the skill and experience of the operator

(ii) Proper matching of plant and equipment during operation with respect to their production

- The machines should neither be idle nor surplus to the requirement during particular operation. For example in earth work, capacity and number of excavators, tippers and soil compactors should match considering the borrow area and quantum of earthwork.

(iii) Management of maintenance schedules: The maintenance schedule of equipments should be arranged such that production does not hamper.

(iv) Unavoidable delays in operation of equipments when their activities are interrelated. For example in wet mix macadam operation, the tipper remains idle while being loaded from wet mix plant and operates at low speed during transfer of wet mix material into wet mix paver.

(v) Adequate facilities for repair and maintenance and availability of spare parts.

(vi) Good relationship between management, project engineer and workers.

16.4 The job factor may vary between 80 to 90 % and management factor 70 to 80%. Thus, the average output would be 0.85x0.75=0.65.

16.5 In case some manufacturer specifies the output of equipment "A" cum per hour under ideal conditions. Its normal output would be 0.65 x A after considering job and management factor.

16.6 The average working season for the road construction equipments is 200 to 220 working days depending on climatic condition

16.7 The road construction equipments do not get continuous work. Therefore, their average utilization is considered 1500-1600 hours per year depending on the type of equipment.

Requirement of Plant and Equipment – Their Planning and Estimation

17. Requirement of Plant and Equipments - Their Planning and Estimation

It is essential to plan the activities of the work, on which the equipments are to be deployed. The requirement of plant and equipments on these activities should also be assessed in practical manner considering all parameters. The planning should be done sufficiently in advance, so that action for their procurement, hiring, transfer from other places and facilities for their setting up can be initiated.

17.1 Factors to be considered for planning

17.1.1 The survey for local factors and site conditions, which can affect the performance of plant and equipment should be carried out.

17.1.2 The items of works, which are to be carried out with the equipments should be clearly identified.

17.1.3 The general strategy to carry out different operations should be worked out.

17.1.4 The sequence of construction operations should be finalized.

17.1.5 The methodology to be adopted for different operations should be ensured.

17.1.6 The plant and equipment to be deployed for different operations to be identified

17.2 Estimation for the Requirement of Plant and Equipment

The requirement of plant and equipment can be assessed based on following factors.

(i) Availability of quantum of work

(ii) Time period provided for completion of work

(iii) Output of the equipment

17.2.1 Quantum of work

The quantum of work involved in each operation such as earth work, wet mix macadam, tack coat, bituminous macadam, premix carpet, compaction etc may be calculated. Due allowance for excess and wastage should be added. The sequence of operations along with their quantities should be prepared.

17.2.2 Time Period for Completion of Work

Normally, the time period for completion of the work is the duration between the date of commencement and date of completion of work. The following factors should be considered while calculating the time period for completion.

(i) The working period for road construction activity is limited due to climatic and other social factors like festivals, harvesting etc. The manual labor deployed in road construction activity is from villages. They wish to follow the social customs. The working period is in the range of 200 to 220 working days. The working period for regularly used machines like Road Roller, Tractor towed equipments, Backhoe loader, Concrete mixer with weigh batcher, Tippers etc may be considered 1600 hours.

(ii) While calculating time period, (a) time spell due to poor climatic conditions and social factors affecting the workers to proceed on leave during working period (b) time required for repair and periodical maintenance of equipments, shifting of plants and equipments like hot mix plant, wet mix plant, pavers, excavators, loaders, generating set, rollers etc and their commissioning; should be deducted from the time period provided for completion of work.

(iii) The bar chart for different activities in work should be prepared. In case one equipment is required in several activities, same may be transferred to another activity after its completion and requirement assessed accordingly.

17.2.3 Output of Equipment

There are different types, make and model of equipments available in the country, which have their own specific features, therefore practically it is not possible to forecast their exact output for various operations.

It is essential to have good knowledge by the Planning Engineers and Field Engineers about the plant and equipments to enable them to assess the requirement of correct type of plant and equipment for specific job. The various factors affecting the output of plant/equipment have been described in chapter 16.

The average output of different types of plant and equipments considered for rural road application is given in Annex-IV.

17.2.4 General

(i) The plant/equipments are divided into two categories. (i) Main equipment (ii) Allied equipments. The requirement of main plant/equipment should be assessed correctly. The requirement of allied equipments depends on main plant/equipment.

(ii) It should be ensured that allied equipments are utilized effectively and not kept idle. For example in bituminous macadam work; hot mix plant is the main equipment while loader, paver finisher, tippers, rollers, bitumen pressure distributor, mechanical broom are allied equipments. In such case loader, tipper, rollers can be used in other activity also. Therefore, while calculating the requirement of equipments, it may be ensured that allied equipments if deployed on particular activity, are shifted to another activity after completing that activity. The bar chart for requirement of equipments should be prepared activity wise in the project; which shall give the best assessment for their requirement in the project.

(iii) In case, there is not much cost difference and the performance of the plant/equipment of specific make already supplied is satisfactory, it should be preferred to have the plants/equipments of similar type, make and model, to reduce the spares inventory and minimize operation, repair and maintenance problems.

BRIEF DETAILS OF FIGURES OF EQUIPMENT AND THEIR COMPONENTS

Fig. No	Item No.	Details of Equipment
Fig. 4.1	4.5.1	Tractor fitted with front end loader attachment
Fig. 4.2	4.5.2	Tractor fitted with dozing attachment
Fig. 4.3	4.5.3	Tractor fitted with loader and back hoe attachment
Fig. 4.4	4.5.4	Tractor fitted with radial loading attachment
Fig. 4.5	4.5.5	Tractor fitted with dozing and back hoe attachment
Fig. 4.6, 4.7, 4.8	4.5.6	Tractor fitted with grading attachment
Fig. 4.9	4.5.7	Tractor fitted with dozing and grading attachment
Fig. 4.10, 4.11, 4.12	4.5.8	Rotavator with its drives
Fig. 4.13	4.5.9	Disc harrow
Fig. 4.14	4.5.10	Cultivator
Fig. 4.15	4.6	Back hoe loader
Fig. 4.16	4.7	Wheeled loader
Fig. 4.17	4.8	Tracked excavator
Fig. 4.18	4.9	Track dozer
Fig. 5.1	5.1	Static three wheel roller
Fig. 5.2	5.2	Vibratory tandem roller
Fig. 5.3	5.2	Effect of static pressure and dynamic force during vibration
Fig. 5.4	5.3	Mini vibratory tandem roller
Fig. 5.5	5.4	Self propelled single drum vibratory roller
Fig. 5.6	5.5	Double drum walk behind roller
Fig. 5.7	5.6	Single drum walk behind roller
Fig. 5.8	5.7	Vibratory plate compactor
Fig. 5.9	5.8	Rammer
Fig. 5.10	5.9	Vibratory tamper
Fig. 5.11	5.10	Pneumatic tyre roller
Fig. 5.12	5.10	Front and rear tyres over lapping gap
Fig. 8.1	8.1	Different components of wet mix plant
Fig. 9.1	9.1.1	Self propelled bitumen pressure distributor
Fig. 9.2	9.1.2	Spray bar in operation in tractor towed bitumen pressure distributor

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Fig. 10.14	10.12	Ride on trowel
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Annexures

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Annex-I

Requirement of Equipments in Rural Roads meeting to Different Clauses of Specifications for Rural Roads (First Revision)

Page No	Specification Clause No.	Requirement of Equipments
6	105 -Construction Equipments	Proven efficiency, Operated and maintained, appropriate type meeting to job requirement, trial conducted, cannot be removed without approval of Engineer
15	114- Methodology and sequence of work	Submit construction methodology, mechanical equipments proposed for use, sequence of activities with schedule from start to end of project
24	202- Dismantling culverts, small bridges	Pneumatic tools operated with tractor towed compressor unit/ Air compressor
	301-Embankment	
31	301.3.4.1 (b) iii – Borrow pits	Dozer, Tractor fitted with dozing attachment, Tractor fitted with backhoe and loader attachment, Backhoe loader
35	301.5.8 – Embankment around structures, 301.7 – Earthwork for widening existing road embankment	Double / Single drum walk behind roller, Vibratory Plate compactor, Power Rammer
	302- Earthwork in cutting	
40	302.3.3 Excavation – General	Wheeled Excavator, Tractor fitted Excavator, Tractor fitted with loader and backhoe attachment, Backhoe loader
41	302.3.5 – Rock excavation	Pneumatic tools operated with tractor towed compressor unit / Air compressor, Rock breaker attached with wheeled / tracked excavator, Backhoe loader
43	302.3.12 - Backfilling	Double / Single drum walk behind roller, Vibratory plate compactor, Rammer
	305- Excavation for structures	
56	305.3.9 - Backfilling	Double / Single drum walk behind roller, Vibratory plate compactor, Power rammer, Mechanical Tamper
	306 – Fly ash Embankment	
58	306.3.6.1- Spreading	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight
59	306.3.6.3 - Compaction	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight

	400- Granular sub-base, bases and surfacing	
77	401.3.1 – Preparation of sub grade	Tandem vibratory roller 80 to 100 kN weight in static mode
77	401.3.2 – Spreading and compacting	Tractor fitted with motor grader attachment, Tractor towed rotavator/ disc harrow/ tiller, Self propelled water tanker / Tractor towed water tanker, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight
82	402.4.2 – Spreading and compacting	Tractor towed rotavator/ disc harrow/ tiller, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, self propelled water tanker/ Tractor towed water tanker
	403- Lime treated soil for improved subgrade / sub-base	
85	403.3.3 – Equipment for construction	Tractor towed rotavator/ disc harrow/ tiller
	403.3.4 – Mix-in-place method of construction	Tractor towed rotavator/ disc harrow/ tiller
	403.3.8 - Rolling	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight in static mode
	405- Water bound macadam sub-base/base/surfacing	
96	405.3.5 – Rolling 405.3.6 - Application of screenings	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Tipper / Tractor trolley fitted with grit spreading attachment
	406- Wet mix macadam base	
100	406.3.3 – Preparation of mix	Wet mix plant, Concrete mixer with weigh batcher (For small quantity), Pug mill or Pan type mixer, concrete batching plant
101	406.3.4 – Spreading of mix	Tractor towed motor grader, Mechanical Paver finisher fitted with vibratory and tamping arrangement
101	406.3.5 - Compaction	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Vibratory plate compactor, Rammer
	407- Shoulder construction	
103	407.4.1 – Construction operations	Mini vibratory tandem roller, Double drum walk behind roller
	409- Lime-flyash stabilized soil sub-base	
109	409.5.1 – Preparation of subgrade	Tractor towed water tanker, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight in static mode
109	409.5.3 – Mixing method	Concrete mixer with weigh batcher
109	409.5.4 – Spreading and moisture control	Tractor fitted with dozing attachment, Tractor towed water tanker fitted with sprinkler system, Tractor towed rotavator/ disc harrow/ tiller

110	409.5.5 Compaction	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight in static mode
	411- Crusher-run macadam base	
115	411.3.2 – Spreading, watering, mixing and compaction	Tractor fitted with grader attachment, Tractor towed water tanker fitted with sprinkler system, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Hauling vehicle with or without spreading device
	500- Bituminous surfacing courses	
	501- Preparation of surfaces	
123	501.2.1 – Preparing existing granular surface	Tractor towed mechanical broom, Tractor fitted with air compressor unit
123	501.2.3.1 – Filling pot hole and patch repair	Tractor fitted with Air compressor unit, Tractor towed mechanical broom, Hot mix plant / Cold mix plant, Mechanical sprayer, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Double / Single drum walk behind roller / Plate compactor/tamper/power rammer
124	501.2.3.2 – Crack sealing	Tractor towed mechanical broom, Emulsion tank fitted with flexible hose and spray bar or lance
	502 – Prime coat over granular base	
130	502.4.1- Equipment; 502.4.3 – Application of bituminous primer	Self propelled / tractor towed bitumen pressure distributor / Mechanical sprayer
	503 – Tack coat	
132	503.4.1- Equipment . 503.4.3 Application of tack coat	Self propelled / tractor towed bitumen pressure distributor / Mechanical sprayer
	504 – Bituminous Macadam	
136	504.3.3 – Tack coat	Self propelled / tractor towed bitumen pressure distributor
136	504.3.4 – Preparation and transportation of mix	Hot mix plant, Tipping truck
136	504.3.5 - Spreading	Mechanical Paver finisher
137	504.3.6 - Compaction	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Tandem vibratory roller 60 to 80 kN weight
	505 – Surface Dressing	
141	505.2.2 – Preparation of base	Mechanical broom / Tractor fitted with air compressor unit
141	505.2.3 – Application of binder	Bitumen emulsion sprayer
142	505.2.4 – Application of	Tipper fitted with chip spreading attachment/Tractor with

	stone chips	trolley fitted with tipping attachment and tail gate with proper opening; Self propelled machine with emulsion sprayer and chip spreader arrangament
	505.2.5 - Rolling	Pneumatic tyre roller, Tandem vibratory roller 6 to 8 tonne in static mode
	506 – Open Graded Premix Carpet	
144	506.1.3.4 – Preparation of premix	Hot mix plant / Mini hot mix plant 6/10 tph capacity; Tipper of adequate capacity
145	506.1.3.5 – Spreading and rolling	Tandem vibratory road roller 80 to 100 kN weight
147	506.2.4.5 – Preparation of premix	Cold mixing plant; Concrete mixer
147	506.2.4.6 – Spreading and rolling	Tandem vibratory road roller 80 to 100 kN weight in Static mode
	508 – Seal coat	
152	508.3.2 – Preparation of surface	Mechanical broom / Tractor fitted with air compressor unit
152	508.3.3 – Construction of type A seal coat	Self propelled/ tractor towed bitumen pressure distributor fitted with spray bar, Tipper fitted with chip spreading attachment / Tractor with trolley fitted with tipping attachment and tail gate with proper opening Tandem vibratory road roller 80 to 100 kN weight, Bitumen emulsion sprayer with spray attachment
152 153	508.3.4 - Construction of type B seal coat	Mini hot mix plant, Tandem vibratory road roller 80 to 100 kN weight; For Bitumen emulsion premixing to be done in cold mix plant / CC mixer with weigh batcher
	509 -25 mm Semi- Dense Bituminous Concrete	
159	509.5.1.1 – Cleaning of the surface	Mechanical broom / Tractor fitted with air compressor unit
159	509.5.2 – Tack coat	Self propelled / tractor towed bitumen pressure distributor
159	509.5.3 – Preparation and transportation of mix	Hot mix plant, Tipper
160	509.5.4.3 - Spreading	Mechanical Paver finisher
161	509.5.5 - Compaction	Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight, Tandem vibratory roller 60 to 80 kN weight
	512 – Bituminous wearing courses using waste plastic	
170	512.5.3 – Mixing of shredded plastic waste bitumen in hot mix plant,	Waste plastic injected with a pipe under compressed air in heating zone of drum mix plant

	aggregate and bitumen in hot mix plant	
	800 – Concrete for structures	
215	805 - Equipments	CC Mixer with weigh batcher (for bridges less than 60 metre), Concrete mixing and batching plant minimum 200 litre capacity, Concrete vibrator, Screed vibrator, Sand screening machine
217	807 –Transportation, placing and compaction	Mini dumper, Tipper / Tractor trolley with tipping attachment; Concrete vibrator, Screed vibrator
	1200 – Foundation and Substructure for Structures	
	1204 – Pile foundations	
293	1204.9.1, Pile driving equipment,	Pile driving equipment
	1205 – Well foundations	
303	1205.2 – Setting out and preparations for sinking	Crane with grab bucket capacity 0.5 to 2.0 cum, Submersible pump, Air compressor with pneumatic operation accessories, Concrete batching plant, transit mixer, Concrete pump, Concrete vibrator
	1500 – Cement concrete pavements	
	1501 – Plain cement concrete pavement	
410	1501.5 - Subgrade	Self propelled / Tractor towed water tanker fitted with sprinkler system, Static road roller 80/100 kN weight, Tandem vibratory roller 80 to 100 kN weight
415	1501.11.2 – Plant, equipment and tools	Concrete mixer with weigh batcher, screed vibrator, concrete vibrator, Concrete joint cutter
420	1501.15 – Compaction of concrete	Plate compactor, Screed vibrator, Concrete vibrator
422	1501.20 – Joint filling	Concrete joint cutter
	1502 – Roller compacted concrete pavement	
428	1502.4.2 – Batching and mixing	Concrete batching plant, Concrete mixer with weigh batcher (For small quantity)
429	1502.4.4 - Transportation	Mini dumper, Transit mixer, Tipper, Concrete pump
430	1502.4.5 – Placing of roller compacted concrete	Mechanical Paver finisher
430	1502.4.6 – Rolling and compacting	Tandem vibratory roller 80 to 100 kN weight, Self propelled single drum vibratory roller (Soil compactor)

Remark: Higher version of equipment suggested in different clauses may be accepted, provided it meets to the requirement of specific job and acceptable to project engineer.

Annex-II

Assessed Economic Life of Road Construction Equipments Years

S.No	Description	Assessed Economic Life (In Years)
	I. Bituminous Construction Equipments	
1.	Drum mix plant	15
2.	Mini hot mix plant	15
3.	Paver finisher (Mechanical)	15
4.	Bitumen pressure distributor (self driven)	15
5.	Bitumen pressure distributor (tractor towed)	12
6.	Bitumen boiler with sprayer	12
7.	*Bitumen emulsion sprayer	12
8.	*Tipper / tractor fitted with chip spreader attachment	12
	II. Earth Moving Equipments	
9.	Wheeled / Crawler dozer	15
10.	Excavator cum loader	15
11.	Front end loader	15
12.	Tractor	12
13.	*Tractor fitted with	
	(a) Front end loader attachment	12
	(b) Dozing attachment	12
	(c) Dozing and grading attachment	12
	(d) Loader and back hoe attachment	12
	(e) Radial attachment	12
	(f) Dozing and backhoe attachment	12
	(g) Grading attachment	12
	(h) Rotavator / Disc harrow / Cultivator	12
	III. Compaction Equipments	
14.	Static three wheel roller	18
15.	Vibratory tandem roller	15
16.	*Self propelled single drum vibratory roller	15
17.	Double drum walk behind roller	12
18.	Vibratory plate compactor	8
19.	Vibratory tamper	8
20.	Rammer	8
	IV Cement Concrete Equipments	
21.	Concrete batching and mixing plant	15
22.	Concrete mixer with weigh batcher	10
23.	*Concrete / Bitumen joint cutter	10
24.	Concrete pump	12
25.	Kerb laying machine	12

26.	Double beam screed board vibrator	8
27.	*Concrete vacuum dewatering pump	12
28.	Concrete vibrator	8
29.	Concrete transit mixer	15
30.	*Self Loading Mobile Concrete Mixer	12
31.	*Disc / Power float	12
32.	*Power trowel	12
33.	*Ride on trowel	12
34.	*Sand screening machine	12
	V. Allied Equipments	
35.	*Primary jaw crusher	15
36.	*Wet mix plant	15
37.	*Tractor towed hydraulic broom	12
38.	Diesel generating set	15
39.	*Hydra crane	15
40.	Diesel welding set	15
41.	Tipping truck (double axle / tandem axle)	15
42.	Mini dumper	8
43.	*Tractor fitted with jack hammer	12
44.	Tractor towed water tanker	12
45.	Air compressor	12
46.	*Bar cutting machine	12
47.	*Bar bending machine	12

Note:

1. The economic life of Road / Bridge construction equipments has been prescribed in MORTH letter no.RW-24011/5/93-RMP dated 30th December'1993. It was based on the type of equipments available during 1960's to 1990's
2. There has been lot of improvement in the design and technology of Road / Bridge construction equipments, thus their life and efficiency has increased. This criteria has been considered while assessing their life.
3. The availability of work in Road/ Bridge sector has also increased and the chances of Road / Bridge construction equipments remaining idle have reduced.
4. The life of some equipments marked with symbol* has not been prescribed by MORTH. Their life has been assessed based on similar type of equipments/and information gathered from site engineers / equipment manufacturers.

Annex-III

Assessed fuel consumption of Road Construction Equipments

S.No	Description	Fuel consumption (in litre per hour)
	I. Bituminous Construction Equipments	
1.	Drum mix plant 40/60 TPH	250
2.	Mini hot mix plant	4 litre per MT
3.	Paver finisher (Mechanical) for dual application WMM and Bituminous work	7
4.	Mini Paver finisher (Mechanical)	3
5.	Bitumen pressure distributor (self propelled) 4000 litre	Truck-3, Auxiliary Engine-3, Boiler-8, Total-14
6.	Bitumen pressure distributor (tractor towed)	Tractor-3. Auxiliary Engine-3, Boiler-8, Total-14
7.	Bitumen boiler 1000 litre with sprayer	Auxiliary Engine – 2, Burner – 5, Total -7
	II. Earth Moving Equipments	
8.	Crawler dozer 8.5	10 - 12
9.	Backhoe loader 0.18/0.6 cum bucket capacity (50 hp)	3.5
10.	Backhoe loader 0.24/1.1 cum bucket capacity (76 hp)	5
11.	Backhoe loader 0.32/1.2 cum bucket capacity (92 hp)	6
12.	Track Excavator 7 - 8 tonne (76 - 80 hp), bucket capacity 0.24 - 0.32 cum	7
13.	Track Excavator 12 - 14 tonne (80 - 100 hp) , bucket capacity 0.65 – 0.70 cum	9 – 11
14.	Front end loader 1.1 cum (76 hp)	5
15.	Tractor 55 hp	4
16.	*Tractor fitted with	
	(a) Front end loader attachment	4

	(b) Dozing attachment	4
	(c) Loader and backhoe attachment	4
	(d) Radial attachment	4
	(e) Dozing and backhoe attachment	4
	(f) Dozing and grading attachment	5 to 6
	(f) Grading attachment	4
	(g) Rotavator	4
	(h) Disc harrow	4
	(i) Cultivator	4
	III. Compaction Equipments	
17.	Static three wheel roller	3 to 4
18.	Vibratory tandem roller 8 to 10 tonne	8
19.	Mini vibratory tandem roller 3.0 to 3.5 tonne	5
20.	Self propelled single drum vibratory roller 10 to 12 tonne (Soil compactor)	9
21.	Pneumatic tyre roller	7
22.	(i) Double drum walk behind roller 550 kg (ii) Single drum walk behind roller 180 kg with petrol engine	2
	IV Cement Concrete Equipments	
23.	Kerb laying machine fitted with Petrol engine	2
24.	Concrete vibrator fitted with (i) Petrol engine 3 hp, 6 metre shaft and 60 / 40 / 25 mm needle (ii) Petrol engine 1.9 hp, 6 metre shaft and 60 / 40 / 25mm needle	1
25.	Concrete transit mixer 6 cum	4
26.	Self Loading Mobile Concrete Mixer (i) Capacity 4 cum (ii) Capacity 2 cum	 8

	V Allied Equipments	
27.	Tractor towed hydraulic broom	4
28.	(i) Diesel generating set 82.5 kVA	11
	(ii)Diesel generating set 62.5 kVA	9
	(iii) Diesel generating set 30 kVA	4
29.	*Tipper 6.4 cum fitted with chip spreader attachment	2.5
30.	*Tractor with trolley fitted with chip spreader attachment	4
31.	*Hydra crane 12 tonne with 11 metre boom	3.5
32.	Diesel welding set	1.5
33.	Tipping truck 14 cum (Tandemaxle)	3.5
34.	Tipping truck 6.4 cum (Single axle)	2.5
35.	Mini dumper	1.5
36.	Tractor 45 hp fitted with Air compressor unit	4
37.	Tractor towed water tanker	3
38.	Air compressor 40 hp	3

Note:

1. The fuel consumption shown above is based on normal working conditions.

2. The fuel consumption would depend on type, model of equipment, its maintenance, operating staff skill, ambient temperature, altitude, feeding, transfer of material and site conditions at which it is being used.

3. In Drum Mix Plant, fuel consumption is as under
   (a) For aggregate heating and mixing: 4 litre per tonne
   (b) For bitumen heating: 1 litre per tonne
   (c) Average output – 50 tonne per hour

   Total fuel consumption per hour = 5x50 = 250 litre per hour

4. Mini Hot Mix Plant: The fuel consumption shall depend on the type and capacity of plant. The fuel consumption is assessed 4 litre per MT.

Annex-IV

Assessed Output of Road Construction Equipments in Different Operations on Hourly Basis

S.No	Type of Equipment	Type of Operation	Assessed Output
1.	Self propelled bitumen pressure distributor	Tack coating	1750 sq metre per hour
2.	Dozer 8.5 tonne, blade 3.25 metre	Dozing / cutting	As per site conditions
3.	Drum mix plant 40/60 TPH	Preparation of hot mix for BM, SDBC, PC	50 metric tonne per hour
4.	Front end loader 1.0 cum bucket	(i) For earth / aggregate filling in tipper	40 cum per hour
		(ii) Feeding hot mix/ wet mix plant	15 cum (25 tonne) per hour
5.	Mechanical broom fitted with tractor	For cleaning the road	1650 sq metre per hour
6.	Excavator cum loader 1.0/0.24 cum	excavation	100 cum per hour
7.	Mechanical Paver finisher	Laying wet mix/ hot mix	80 tonne per hour
8.	Mini mechanical paver finisher	Laying hot mix	24 tonne per hour
9.	Concrete mixer 10/7 cft capacity with weigh batcher	Preparation of concrete mix	2 cum per hour
10.	Jaw crushing and screening plant 60 TPH	Preparation of aggregate	50 TPH (may vary depending on size of aggregate crushed)
11.	Self-propelled single drum vibratory rollet 80-100 kN weight (Soil compactor)	Compaction of earth work, sub-base	160 cum per hour
12. (i)	Static three wheel roller 80-100 kN weight	Earth work	70 cum per hour
(ii)		WMM	16 cum per hour
(iii)		Surface dressing	500 sqm per hour
(iv)		Pre-mix carpet 20 mm	250 sqm per hour
(v)		Seal coat 20 mm	500 sqm per hpur
(vi)		BM / 50/75	12 cum per hour
13. (i)	Vibratory tandem roller 80-100 kN weight	Earth work/ WMM	110 cum per hour
(ii)		BM	60 cum per hour
14.	Vibratory tandem roller 60-80 kN weight	Surface dressing	400 sqm per hour
15.	Wet mix plant 60 TPH	Preparation of wet mix	50 tonne per hour

16.	Tipper 6.4 cum fitted with chip	Surface dressing	1000 sqm per hour
	spreader attachment 2.5 metre width		
17.	Tractor trolley fitted with tail gate metering chip spreader arrangement 2.1 metre width	Surface dressing	500 sqm per hour
18.	Tractor with disc harrow/ cultivator 2 metre width	Pulverising of soil	800 cum per hour
19.	Tractor with rotavator 2 metre width	Scarifying / Mixing	42 cum per hour
20.	Tractor fitted with dozing attachment	Dozing / cutting	As per site condition
21.	Tractor fitted with grading attachment	Scarifying / leveling	As per site conditions
22.	Tractor fitted with loader and back hoe attachment 0.6 / 0.21 cum bucket digging depth 3500 mm	Excavation	25 cum per hour
		Loading	28 cum per hour
23.	Tractor fitted with loader attachment bucket capacity 0.6 cum	Loading	28 cum per hour
24.	Sand screening machine	Screening	5 cum per hour

Annex-V

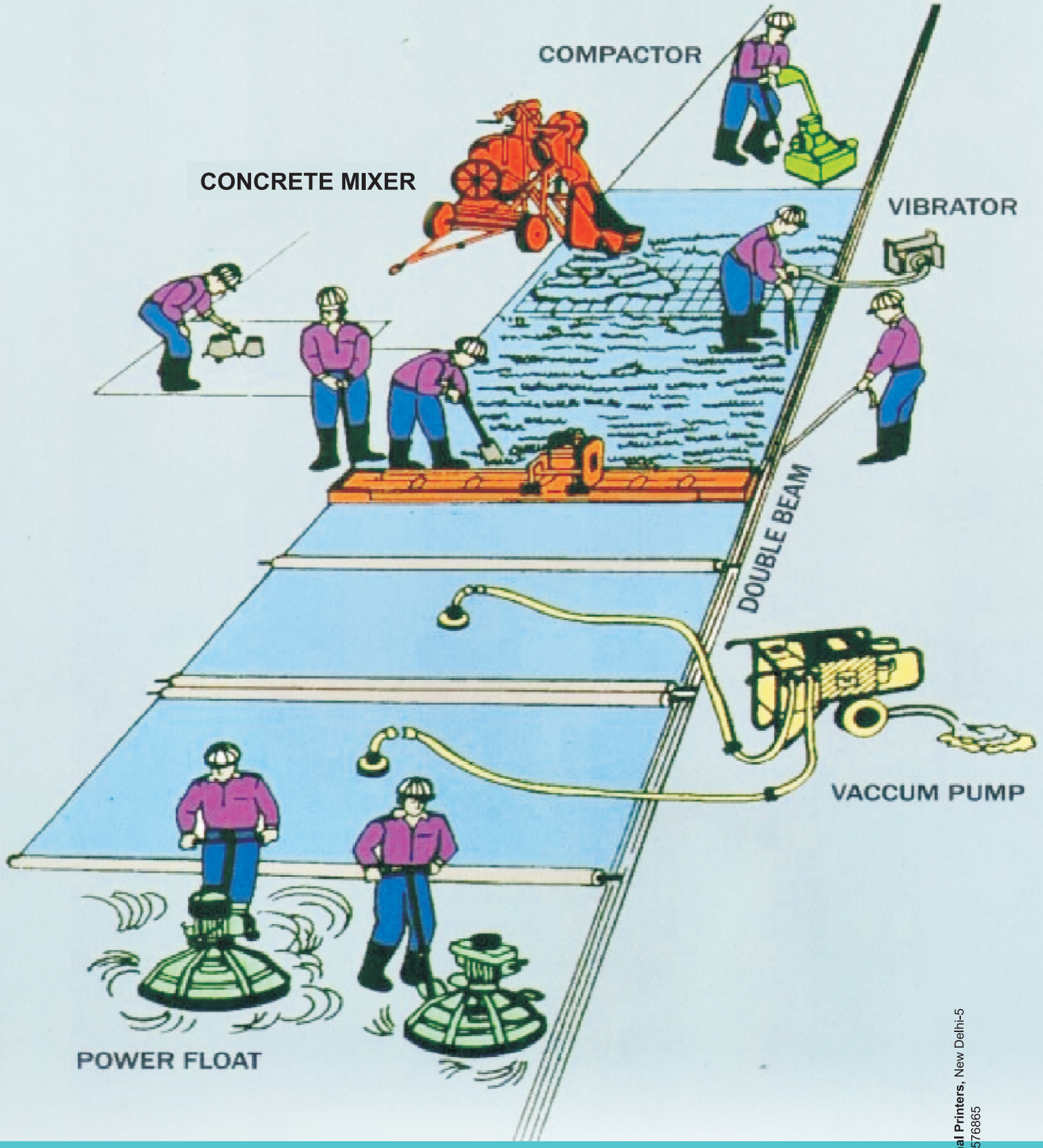
List of Manufacturers of Construction Equipments relevant for Rural Roads

S.No	Type of Equipment	Name of Manufacturer	Address	E.mail / Phone No.
1.	Self loading mobile concrete mixer	AJAX FLORI ENGG (I) Pvt Ltd.	No. 253/1, 11th Main, 3rd Phase, Peenya Industrial Area, Bangalore - 560058	info@ajax-flori.com 080-67200082/83
2.	Tractor fitted with front end loader, dozing loader and back hoe, radial, dozing and back hoe attachment, back hoe loader, wheeled loader	BULL MACHINES Pvt Ltd.	SF No. 5/1A, Trichy Road, Coimbatore -641 103	sales@bullmachine.com 0422-6586677/55; 09842287770
3.	Concrete Pump, Transit mixer concrete batching plant	SCHWING STETTER (INDIA) Pvt. Ltd.	F71-72, Sipcot Industrial Park, Irungattukottai, Sriperumpudur Taluk, Kancheepuram District, Tamilnadu – 602 105	schwing@vsnl.com; Chennai@schwingstetterindia .com
4.	Bar Bending, Bar cutting machines	(i) SKG Equipment Pvt. Ltd,	# 59, Gautam Complex, Sector-11, CBD Belapur, Navi Mumbai – 400 614	info@skgengg.com, 022-27562145/ 27578745
5.	-do-	(ii) SPARTAN ENGINEERING INDUSTRIES Pvt. Ltd.	Level1, 111, New Tejpal Industrial Estate, Andheri, Kurla Road, Sakinaka, Mumbai – 400 072	construction@spartanindia.com 022- 40550000
6.	-do-	(iii) SKG Equipment Pvt. Ltd.	# 59, Gautam Complex, Sector – 11, CBD Belapur, Navi Mumbai – 400 614	info@skgengg.com 022-27562145/ 27578745
7.	-do-, + Concrete batching plant, CC mixer with weigh batcher, Sand screening machine, Mini dumper	UNIVERSAL Construction Machinery	Universal House, Warje Naka, Pune - 411052	sales@uceindia.com 020- 25230777 020- 65008033
8.	Drum mix plant, Wet mix plant, Mechanical Paver finisher, Mechanical Broom, Self propelled bitumen pressure distributor, Bitumen boiler with sprayer, Bitumen emulsion tank with sprayer	Capius Roadtech Pvt. Ltd.	Plot No. # 4008, Phase IV, Road # R4, Near Nika Tube Cross Road, GIDC Vatva, Ahmedabad – 382 445	info@capious.com 079-25833436/ 25833597, 09428415753
9.	Concrete batching plant, Concrete mixer with weigh batcher, Concrete transit mixer, Concrete pump, Double drum walk	Jamshedji Construction Machinery co.	J-157, MIDC, Bhosari, Pune – 411 026	infi@jamshedji.com exportjamshedji@yahoo.com 020-27120682/ 27129332

	behind roller, Plate compactor, Rammer, Concrete vibrator, Ride on trowel, Disc power float, Power trowel, Concrete vacuum dewatering pump,			
10.	Drum mix plant, Wet mix plant, Mechanical Paver finisher, Mechanical Broom, Self propelled bitumen pressure distributor, Kerb laying machine	Ammann Apollo	Ammann Apollo House, Near Mithakhali Circle, Navrangpura, Ahmedabad – 380 009	Info.ain@ammann-group.com 079-26563730/ 66188888
11.	-do-, + Static three wheel roller	Speed Crafts Limited	'Layak Bhavan', Boring Canal Road, Patna – 800 001	info@speedcrafts.com, info@speedcrafts.net
12.	Tractor fitted with grading, dozing and grading, loading, dozing attachment	CNH Industrial,	Kishan Equipment, New holland Flat (India) Pvt. Ltd. Division, Plot No.3, Udyog Kendra, Greater Noida-201306	Janak.raj@cnhind.com 08373915379
13.	Tractor fitted with Air compressor, Compressor mounted on trolley and operated with tractor, Portable air compressor	Sri Balaji Workshop	449, Uthukuli Road, Kunnathur, Tirupur District – 638 103, Tamilnadu	info@balajicompressor.com 04294-263843/ 9842767001/ 9842730236 Info@vayvayaastra.com
		Vayuayaastra Syndicate	580, Uthukuli Road, Kunnathur, Tirupur District – 638 103, Tamilnadu	
14.	Backhoe loader, Tracked excavator, Wheeled loader, Tandem vibratory mini roller	JCB India Limited	23/7, Mathura Road, Ballabgarh -121 004, Haryana	08130636086/ 09891258369 puneet.vidyarthi@jcb.com
15.	Crushing and screening plant	Singh Crushers	Singh House, C-2, NICE, Satpur, Nashik -422 007	sales@singhcrushers.com 0253-2350101/ 2355501
16.	Tandem vibratory roller, Self propelled single drum vibratory roller, Pneumatic tyre roller	Atlascopco	Corporate Office, Sveanagar, Dapodi, Pune – 411 012	r.thirugnam@in.atlascopco.com cr.india@in.atlascopco.com
17.	Rotavator, Disc harrow, Rotavator	Bull Agro Implements	S F No.200/1B5, Karnanplayam (PO), Ravathur Plavu, Coimbatore -641 402	marketing@bullagro.com
18.	Concrete vibrator, Vacuum dewatering pump, Power trowel, Power floater, Double beam screed board vibrator, Top mat and filter (sieve mat), CC mixer, Double drum walk	Jamshedji Construction Machinery Co,	J-157, MIDC Bhosari, Pune – 411 026	Info2jamshedji.com, 020-27120682

	behind roller, Ride on trowel, Rammer, Plate compactor			
19.	Road marking machine	Krison Industries	S. Radha Krishna Road, Andheri West, Mumbai – 400 069	Prem@krisonroadmarking.com 022-26843813
		Vinayak Equipments	Plot 5-6, Rudra Industrial Estate, Vatva, Ahmedabad	viral@vinayakequipments.com
20.	Wet mix paver,Mini hot mix plant, Mini paver finisher, Bitumen boiler with sprayer, Bitumen emulsion tank with sprayer,	Universal Industrial (Kind attention: Mr Hazra)	1 /2, M .L. Mitra Road, 1st floor, Kolkata -700 017	spotmix@cal.vsnl.net.in 033-22876058, 033-22834693, 09830021574
21.	Chip spreader	S.P.Enterprise, Ahmedabad		08043258617
		Sidhartha Equipments, Mehsana		08049462786
		Apple Equipment, Mehsana		08048110477
22.	Tractor fitted with front grading attachment	Balvir Industries	Baradari Chowk Murar, Ralior Madhya Pradesh	0751-2368907 09329787713

Note:- The information indicated above is not exhaustive. There may be other manufacturers also.



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