

**RECOMMENDED PRACTICE FOR
PLANTS, TOOLS AND EQUIPMENT REQUIRED
FOR CONSTRUCTION AND MAINTENANCE OF
CONCRETE ROADS**

(First Revision)

(The Official amendments to this document would be published by
the IRC in its periodical, 'Indian Highways' which shall be
considered as effective and as part of the code/guidelines/manual,
etc. from the date specified therein)



**INDIAN ROADS CONGRESS
2015**

RECOMMENDED PRACTICE FOR PLANTS, TOOLS AND EQUIPMENT REQUIRED FOR CONSTRUCTION AND MAINTENANCE OF CONCRETE ROADS

(First Revision)

Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

June, 2015

Price : ₹400/-
(Plus Packing & Postage)

First Published	:	September, 1972
Reprinted	:	March, 1986
Reprinted	:	November, 2002 (Incorporate Amendments)
Reprinted	:	January, 2007
Reprinted	:	July, 2011
First Revision	:	June, 2015

(All Rights Reserved. No part of this publication shall be reproduced, translated or transmitted in any form or by any means without the permission of the Indian Roads Congress)

Printed by India Offset Press, Delhi-110 064

1000 Copies

Contents

	Page No.
Personnel of the Highways Specifications and Standards Committee	(i - ii)
1. Introduction	1
2. Scope	3
3. Classification of Plants, Tools and Equipment and Definitions	4
4. Plants, Tools and Equipment for different Layers:	6
4.1 Subgrade and Granular Sub Base (GSB)	6
a) Aggregate production	6
b) Transportation	8
c) Spreading	10
d) Mixing	10
e) Watering Devices	13
f) Compaction Equipment	13
4.2 Dry Lean Concrete (DLC)	18
a) Concrete Production	18
b) Concrete Transportation	24
c) Concrete Laying	24
d) Compaction, Curing and Finishing	26
4.3 Pavement Quality Concrete (PQC)	27
a) Concrete Production	27
b) Concrete Transportation	27
c) Spreading	28
d) Laying	29
e) Compaction of PQC	33
f) Finishing and Curing	35
g) Joint Cutting and Edging	39
5. Outline Specifications of Various Plants, Tools, and Equipment	44
6. Flow Charts	47
7. Selection of Plant, Equipment and Tools	51
8. Annexure	53-57

**PERSONNEL OF THE HIGHWAYS SPECIFICATIONS
AND STANDARDS COMMITTEE
(As on 12th January, 2015)**

1.	Das, S.N. (Convenor)	Director General (Road Development) & Special Secretary to Govt. of India, Ministry of Road Transport & Highways, New Delhi.
2.	(Co-Convenor)	Addl. Director General, Ministry of Road Transport & Highways, New Delhi
3.	Prasad, Vishnu Shankar (Member-Secretary)	Chief Engineer (R) S, R&T, Ministry of Road Transport & Highways, New Delhi
Members		
4.	Basu, S.B.	Chief Engineer (Retd.), MORTH, New Delhi
5.	Bongirwar, P.L.	Advisor, L & T, Mumbai
6.	Bose, Dr. Sunil	Head, FPC Divn. CRRI (Retd.), Faridabad
7.	Duhsaka, Vanlal	Chief Engineer, PWD (Highways), Aizwal (Mizoram)
8.	Gangopadhyay, Dr. S.	Director, Central Road Research Institute, New Delhi
9.	Gupta, D.P.	DG (RD) & AS (Retd.), MORTH, New Delhi
10.	Jain, R.K.	Chief Engineer (Retd.), Haryana PWD, Sonipat
11.	Jain, N.S.	Chief Engineer (Retd.), MORTH, New Delhi
12.	Jain, Dr. S.S.	Professor & Coordinator, Centre of Transportation Engg., Dept. of Civil Engg., IIT Roorkee, Roorkee
13.	Kadiyali, Dr. L.R.	Chief Executive, L.R. Kadiyali & Associates, New Delhi
14.	Kumar, Ashok	Chief Engineer (Retd.), MORTH, New Delhi
15.	Kurian, Jose	Chief Engineer, DTTDC Ltd., New Delhi
16.	Kumar, Mahesh	Engineer-in-Chief, Haryana PWD, Chandigarh
17.	Kumar, Satander	Ex-Scientist, CRRI, New Delhi
18.	Lal, Chaman	Director (Project-III), NRRDA (Ministry of Rural Development), New Delhi
19.	Manchanda, R.K.	Consultant, Intercontinental Consultants and Technocrats Pvt. Ltd., New Delhi
20.	Marwah, S.K.	Addl. Director General, (Retd.), MORTH, New Delhi
21.	Pandey, R.K.	Chief Engineer (Planning), MORTH, New Delhi

22.	Pateriya, Dr. I.K.	Director (Tech.), NRRDA, (Ministry of Rural Development), New Delhi
23.	Pradhan, B.C.	Chief Engineer (NH), PWD, Bhubaneswar
24.	Prasad, D.N.	Chief Engineer (NH), RCD, Patna
25.	Rao, P.J.	Consulting Engineer, Faridabad
26.	Raju, Dr. G.V.S.	Engineer-in-Chief (R&B), Rural Roads, Director Research and Consultancy, Hyderabad (Shri B.B. Lal), ADGBR, HQ DGBR, New Delhi
27.	Representative of BRO	Professor, Deptt. of Transport Planning, School of Planning & Architecture, New Delhi
28.	Sarkar, Dr. P.K.	CEO (Highways), GMR Highways Limited, Bangalore
29.	Sharma, Arun Kumar	Member (Technical), NHAI, New Delhi
30.	Sharma, M.P.	DG (RD) & AS (Retd.), MORTH, New Delhi
31.	Sharma, S.C.	DG (RD) & SS (Retd.), MORTH, New Delhi
32.	Sinha, A.V.	Member (Projects), NHAI, New Delhi
33.	Singh, B.N.	DG (RD) & SS (Retd.), MORTH, New Delhi
34.	Singh, Nirmal Jit	Chief Engineer & Addl. Secretary (Panchayat) Roads & Building Dept., Gandhinagar
35.	Vasava, S.B.	Addl. Director General (Retd.), DGBR, New Delhi
36.	Yadav, Dr. V.K.	(Shri Kaushik Basu), MORTH, New Delhi
37.	The Chief Engineer (Mech.)	

Corresponding Members

1.	Bhattacharya, C.C.	DG (RD) & AS (Retd.), MORTH, New Delhi
2.	Das, Dr. Animesh	Professor, IIT, Kanpur
3.	Justo, Dr. C.E.G.	Emeritus Fellow, Bangalore
4.	Momin, S.S.	Former Secretary, PWD Maharashtra, Mumbai
5.	Pandey, Dr. B.B.	Advisor, IIT Kharagpur, Kharagpur

Ex-Officio Members

1.	President, Indian Roads Congress	(Bhowmik, Sunil), Engineer-in-Chief, PWD (R&B), Govt. of Tripura
2.	Honorary Treasurer, Indian Roads Congress	(Das, S.N.), Director General (Road Development), & Special Secretary to Govt. of India, Ministry of Road Transport & Highways
3.	Secretary General, Indian Roads Congress	(Nahar, Sajjan Singh)

RECOMMENDED PRACTICE FOR PLANTS, TOOLS AND EQUIPMENT REQUIRED FOR CONSTRUCTION AND MAINTENANCE OF CONCRETE ROADS

1 INTRODUCTION

1.1 The road infrastructure has witnessed increasing mechanization (use of plants and equipment) over time for reasons of speedy construction with quality. Appropriate technology with use of minimal and light equipment is being adopted for construction and upgradation of rural roads whereas intensive use of equipment is being insisted for higher category of roads such as State Highways and National Highways.

1.2 Larger equipment like automatic concrete batching plants are assembled/manufactured commercially in our country, and for this standard specification viz IRC:SP:96-2012, IS 4925 exists to ensure their quality. Commercially available equipment currently being used for concrete roads are floaters, finishers, needle vibrators and screed vibrators etc. Sometimes, these have also fabricated by the field engineers. Large size fixed form and slipform pavers are being used in India for heavy traffic roads. Fixed forms pavers are being manufactured in India. However, slipform pavers complete with automatic dowel bar inserter and tie bar inserter are not being manufactured in India at present.

1.3 This document would help the field engineers in properly executing concrete paving jobs. This document also provides basis for the fabrication of such tools and equipment keeping in view the performance requirements, by way of sketches, and description of the essential features. For plants fabricated commercially, reference has been drawn to the relevant standards.

1.4 This recommended practice is closely allied to IRC:15-2011 (Standard Specifications and Code of Practice for Construction of Concrete Roads) and should be used in conjunction with that standard. This draft document discussed in the meeting of HSS Committee held on 09.08.2014 and it was decided to have this draft considered by the Mechanization Committee (G-4) also.

1.5 Accordingly, H-3 Committee had joint meeting with G-4 Committee on 30.9.2014 and suggestions of G-4 Committee were discussed. Subsequently, a core group meeting of the Members comprising Shri R.K. Jain, Shri Satander Kumar, Shri K.C. Sharma, Shri N.K. Nayek, Shri U.C. Joshi, Shri Jitendra Kumar, Shri Arvind Nagri and Shri Sanjay Bajaj drawn from both the Committees was held on 20.10.2014 and the document was revised. The revised document has also been considered and approved by the Mechanization Committee under the Convenor ship of Shri S.N. Das, DG (RD), MoRT&H. The H-3 Committee also approved the revised document in its meeting held on 14.11.2014 for placing before the Highways Specifications and Standards Committee (HSS).

The composition of the H-3 Committee is as given below:

Jain, R.K.	-----	Convenor
Kumar, Satander	-----	Co-Convenor
Kumar, Raman	-----	Member-Secretary

Members

Bongirwar, P.L.	Prasad, Bageshwar
Ganju, Col. V.K.	Sachdeva, Dr. S.N.
Gautam, Ashutosh	Seehra, Dr. S.S.
Gupta, K.K.	Sengupta, J.B.
Jain, L.K.	Sharma, Late R.N.
Joseph, Isaac V.	Singla, B.S.
Kadiyali, Dr. L.R.	Sitaramanjaneyulu, K.
Krishna, Prabhat	Tipnis, Col. Manoj
Kumar, Ashok	Venkatesha, M.C.
Kurian, Jose	Rep. of CMA (Avtar, Ram)
Maiti, Dr. S.C.	Rep. of E-in-C Branch
Pandey, Dr. B.B.	

Corresponding Members

De, D.C.	Nakra, Brig. Vinod
Justo, Dr. C.E.G.	Reddi, S.A.
Madan, Rajesh	Thombare, Vishal

Ex-Officio Members

President, Indian Roads Congress	(Bhowmik, Sunil), Engineer-in-Chief, PWD (R&B), Govt. of Tripura
Honorary Treasurer, Indian Roads Congress	(Das, S.N.), Director General, (Road Development) & Special Secretary to Govt. of India, Ministry of Road Transport & Highways
Secretary General, Indian Roads Congress	Nahar, S.S.

The composition of the G-4 Committee is as given below:

Das, S.N.	-----	Convenor
Verma, Maj. V.C.	-----	Co-Convenor
Basu, Kaushik	-----	Member-Secretary

Members

Bajaj, Sanjay	Raj, Hans
Balasubramanian, V.	Ramanath, K.

Gupta, Ajay	Ray, P.R.
Gupta, Dr. A.A.	Saxena, R.B.
Jain, Kapil Kumar	Saxena, R.K.
Kalita, N.K.	Sharma, K.C.
Kumar, Satander	Singh, Ajay Kumar
Kumar, Sudhir	Singla, B.S.
Kumar, V.G. Sakthi	Tiwari, Dr. Devesh
Matharu, Gurdeep Singh	Rep. of BIS
Patwardhan, S.V.	

Corresponding Members

Bampat, D.K.	Sachdev, V.K.
Dalela, Saurabh	Sehgal, H.K.

Ex-Officio Members

President, Indian Roads Congress	(Bhowmik, Sunil), Engineer-in-Chief, PWD (R&B), Govt. of Tripura
Honorary Treasurer, Indian Roads Congress	(Das, S.N.), Director General, (Road Development) & Special Secretary to Govt. of India, Ministry of Road Transport & Highways
Secretary General, Indian Roads Congress	(Nahar, Sajjan Singh)

The HSS Committee approved the draft revision in its meeting held on 12th January, 2015. The Executive Committee in its meeting held on 18th January, 2015 approved the draft revision for placing it before the Council. The Council in its 204th meeting held at Bhubaneswar, Odisha on 19th January, 2015 approved the draft revision of IRC:43 “Recommended Practice for Plants, Tools and Equipment Required for Construction and Maintenance of Concrete Roads” (First Revision) for publishing.

1.6 The technology of construction equipment is continuously getting developed and new sophisticated equipment are getting introduced in the market. The operating and maintenance cost of these equipment works out to 10-15% of completed items and as the use/adoption is necessary to get quality product, the actual use of these equipment is recommended.

2 SCOPE

The document describes most of the equipment which are being used presently. However there are no prohibition/restrictions to use equipment which can serve the purpose in a better manner. The operating and maintenance cost of these equipment is not likely to exceed 15% of completed cost and hence usage of these equipment is desirable.

The document deals with a current list and specification introductory of plants, tools, and equipment required for fully mechanized concrete pavement construction, semi-mechanized including labour intensive and overlays (white topping) as practiced in this country.

The list is described according to different phases of work, starting from subgrade, sub base, laying and compaction to the sealing of joints. Brief of the specification and pictorial views of some the tools and machines used for construction, quality control and maintenance of rigid pavement is also described.

3 CLASSIFICATION OF PLANTS, TOOLS AND EQUIPMENT

3.1.1 Based on processes for construction of layers for concrete pavement

The Plants, Tools and equipment have been categorized for construction of Sub grade/Sub base, Subbase Dry lean Concrete and pavement quality concrete and the same is mentioned in **Table 1**.

Table 1

Name of Layer	Classification of Plants, Tools and Equipment
Subgrade/Subbase	Transportation
	Spreading
	Mixing
	Watering
	Compaction
Subbase Dry lean Concrete	Concrete Production
	Transportation
	Laying
	Compaction
	Finishing
Pavement Quality Concrete	Concrete Production
	Transportation
	Spreading
	Laying
	Compaction
	Finishing and Curing
	Joint Cutting & Edging
	Sealing the joints

Detailed list of Plants, tools and Equipment of above category is mentioned in **Table 2**.

3.1.2 Based on degree of Mechanization: Based on Mechanization, the Plant, Tools and Equipment are classified into the following two categories.

- i) Fully Mechanized
- ii) Semi Mechanized

Adoption of fully mechanized construction shall be used for large size projects. For major projects such as for major city roads, State Highways, National Highways, Expressways, fully mechanized construction is usually adopted. For smaller works, Semi Mechanized Plants, equipment and tools may be used for smaller works or for Rural Roads. The list of Plants, Tools and Equipment falling under Fully Mechanized or Semi Mechanized is given in **Table 2**.

Table 2

Sr. No	Process	Layers	Fully Mechanized	Semi Mechanized
1.	Transportation	Sub-grade & Sub-base	Dumper/Tipper Truck	Wheel Barrows
		DLC	Dumper/Tipper Truck	Wheel Barrows
		PQC	Transit Mixer/Tipper Truck	Wheel Barrows
2.	Soil stabilization	Sub-grade/ Sub-base	Soil Stabilizer	Rotavator/Disc Harrow
3.	Concrete production	DLC	Stationary and Mobile Concrete Batching & Mixing Plant	
				Concrete Mixer, Volumetric batcher
		PQC	Stationary and Mobile Concrete Batching & Mixing Plant	
				Concrete Mixer, Volumetric Batcher
4.	Laying	Sub-grade/ Sub-base	Motor Grader	
		DLC	Paver Finisher with Sensor	
		PQC	Spreader Slipform Paver	Fixed form paver Modular Screed
5.	Compaction	Sub-grade/ Sub-base	Static Road Roller (80-100) Pneumatic Tyred Roller Vibratory Road Roller (80-100kN) Sheepsfoot Road Roller Tamping foot Road Roller	Walk Behind Roller Plate Compactor
		DLC	Single/Double Drum Vibratory Road Roller (8-10 Ton)	Screeed, Needle or plate vibrators Plate Compactor
		PQC	Concrete Vibrators	Hand Tamper board,
6.	Finishing & Curing	DLC	Scribbler, Liquid curing compound sprayer, Hessian cloth, Gunny bags,	Floater, Scribbler, Liquid curing compound sprayer, Hessian cloth, Gunny bags, Long handled broom and tine, Canvas belt cloth, Wooden or steel bridges
		PQC	Texturing & Curing Machine	

4 PLANTS, TOOLS AND EQUIPMENT FOR DIFFERENT LAYERS

4.1 Subgrade and Granular Sub Base (GSB)

4.1.1 Aggregate Production

4.1.1.1 Crushers

A crusher is a machine designed to reduce large size rocks into smaller size rocks, gravel, or rock dust

Types of Crushers: The broad types of crushers and their advantages are as under:

A) Primary Crushers : Jaw and Gyratory Types :

In the first stage of crushing, usually the jaws, gyratory types of crushers are used.

Jaw and gyratory crushers are both capable of handling hard and abrasive rocks and selection is based upon the capacity and maximum lump size. Use of impactor is generally restricted to less abrasive rocks e.g. limestone.

Generally, for the same capital investment, the jaw crusher will be able to accept the largest boulder size. For capacities less than 1000 tonnes per hour, any of the two types could be selected while for a capacity much higher than 1000 tonnes per hour, the choice would normally fall on a Gyratory type crusher.

a) **Jaw Crusher :** The jaw crusher compresses the rock between fixed dimensions of feed opening jaw to create braking action. Maximum dimension of feed opening (gape) and the product size is determined by the width of discharge aperture when the jaw has retreated fully (open side setting). The moving jaw may be actuated by one of the two principal mechanisms - 'single toggle' and 'double toggle'. In the double toggle system, very powerful compressive forces are created without any abrasive motion; therefore, it is most applicable to the crushing of very strong, abrasive rocks but is more complex, heavy and expensive than a single toggle.

Jaw Crusher is suitable for all hard rocks, generally used for aggregate production.

b) **Gyratory Crusher :** It consists of a lined inverted conical crushing chamber within which gyrates an upright conical crushing member, the shaft and cone are protected by a liner.

The main advantage of a gyratory crusher is the much greater unit capacity for any given 'gape' or maximum lump size assuming that this capacity can be fully utilized to justify greater cost.

Gyratory crushers are sometimes employed at the secondary stage, (where cone crushers are more common) as they can accept larger lump sizes.

B) Secondary and Tertiary Types:

- a) **Cone Crushers :** Even though the jaw and gyratory types of crushers may be adapted to secondary and tertiary crushing, it is because of the greater capacity of the cone crusher that cone crushers are very commonly used for secondary and tertiary crushing.

The Cone Crusher is a development of the gyratory crusher. It consists of a gyratory upright conical crushing member. The main difference from gyratory type is that the crushing chamber is also in the form of an upright, truncated cone and the gyrating cone (45° angle) is supported entirely from beneath by the eccentric bush assembly. Also, the eccentric shaft rotates very much more rapidly (more than 200 rpm) than that of gyratory crusher. Thus, there is an improved energy utilization and improvement in the shape of aggregate. In order to ensure good cubical shape, low reduction ratios have to be used and also the crushing chamber should always be full of material, known as 'choke feed'.

The secondary cone crusher has as steeply inclined (sometimes stepped) crushing chamber formed by concave and a flatter, less steeply inclined conical crushing member.

The tertiary, short-head-cone- chamber has both crushing chamber and cone steeply inclined to promote the gravitational flow of more finely sized material.

- b) **Impactors :** In a lined chamber, a rotor fitted either with swing hammers (located by pins) or blow bars of alloy steel (located by mechanized or hydraulic clamps) revolves on a horizontal axis. The hammers or blow bars provide impact to the rock resulting in energy efficient crushing and producing cubical shaped aggregates.

Advantages are high reduction ratio, low capital and operating cost, ease of installation and low head room requirement and good product shape. Product size can be varied within limits by changing rotor speed and the clearances between rotor and liners. A serious limitation is abrasive wear. Abrasive wear requires costly replacement of hammers or blow bars and above all, results in loss of operating time. Therefore, use of impactors is restricted to crushing on non-abrasive rocks e.g. non-siliceous limestones and dolomites.

Impactors are not suitable for rocks having more than 5 percent free silica.

Swing hammer type impactors are generally used for the production of the finer sizes of aggregates but impact becomes ineffective at a particle size less than 3 mm.

A vertical shaft impactor comprises a horizontal table or rotor that revolves about the vertical axis of the drive shaft. The crushed rock fed into the centre of the rotor is ejected at high speeds and breaks by impact upon the hardened alloy anvils surrounding the rotor and by inter-particulate collision.

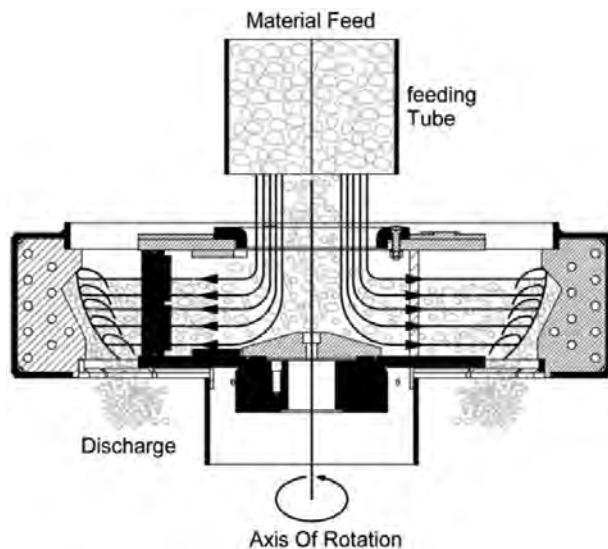


Fig. 1 Section of Vertical Shaft Impactor

The advantages are (i) cubical product shape and (ii) overcoming the problem of wear while crushing abrasive rocks.

- c) **Rolls Crushers** : Essentially, a rolls crusher comprises two contra rotating crushing rolls.

The use was common before the development of cone crushers. They suffer from the following two disadvantages:

- low-capacity
- wear of the roll surface when crushing abrasive rock

Rolls crusher may still find application within small capacity operations in confined spaces where simple construction and low headroom requirement are advantages or for processing very soft rocks (lime, high purity lime stones). In the modern versions the rolls are provided with hardened alloy steel teeth. Rock is broken by a combination of compression, tension and shear.

4.1.2 Transportation

4.1.2.1 Dumper/tipper truck

A dumper/tipper is a van or truck with a load area that can be mechanically raised up at an angle to allow the load (usually sand, gravel, etc) to be “tipped” out on to the ground behind the vehicle, thus saving it being unloaded manually.



Photo 1 Tipper Truck/Dumper

4.1.2.2 Loader

A loader is a machine that has a front-mounted square wide bucket connected to the end of two booms (arms) to scoop up loose material from the ground, such as dirt, sand or gravel, and move it from one place to another without pushing the material across the ground.



Photo 2 Wheel Loader

4.1.2.3 Wheel Barrows

Used for transporting the material for a very small distance.



Photo 3.1 Manually Operated Wheel Barrow



Photo 3.2 Electric Wheel Barrow

4.1.3 Spreading

Motor Grader

Graders are used to spread fill and finely trim the sub grade. They consist of a blade which can rotate in a circular arc about a sub horizontal axis and which is supported beneath a longitudinal frame joining the front steering wheels and the rear drive wheels to achieve specific slope and grade.

The front wheels are generally articulated whilst the rear wheels are set in tandem beneath the motor and control units. The blade is used to trim and redistribute soil and therefore graders usually operate in the forward direction.



Photo 4 Motor Grader

4.1.4 Mixing

4.1.4.1 In-situ soil stabilizer

A soil stabilizer is a construction vehicle with a powered metal drum that has rows of mixing blades or paddles. It blends soil, a binder agent (usually Portland cement or lime) and water together with paddles in the mixing chamber.

To Stabilize or modify soil/granular material with cement, lime or Fly ash or chemical stabilizers or combination of any admixture/binder, use of In situ stabilization/Pulverization equipment which are self-propelled equipment on four wheels with independent power to these wheels as they work in marshy areas and would require higher torque to overcome resistance. The equipment should be equipped with suitable hydraulic flow distributer to avoid slippage of wheels.

1. The self-propelled equipment should have inbuilt engine of suitable capacity preferably with belt drive system to drive the Milling/Pulverizing Drum.
2. In case, belt drive system is used, it should have automatic belt tensioner system.
3. The drum drive system would be equipped with suitable system to vary the drum speeds
4. The stabilization equipment should have provision of automatic water addition system.
5. The equipment should have provision of automatic depth control system and should be able to adjust to working depth.
6. The equipment should have provision of automatic controlled housing of mixing chamber for prevention of components of mix to escape from mixing chambers. The drum housing/Casing would also be hydraulic controlled.



Photo 5.1 Soil stabilizer in Operation



Photo 5.2

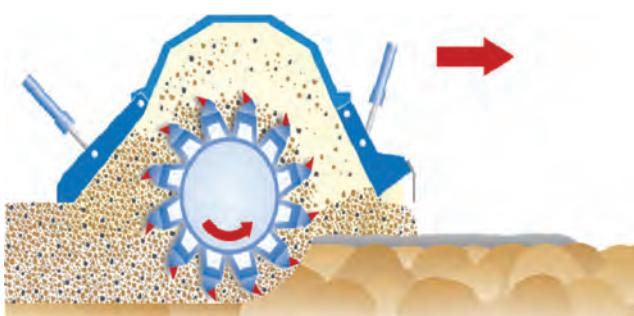


Photo 5.3 Mechanism



Photo 5.4 Soil Stabilizer



Photo 5.5 Soil Stabilizer in Action

4.1.4.2 Rotavator

A type of machine with rotating blades that breaks up soil for mixing the soil with additives.



Photo 6.1 Blades of a Rotavator



Photo 6.2 Small Sized Rotavator

4.1.4.3 Disc harrow

Disc harrow are used for pulverisation, and mixing of soil/aggregates and stabilizers.

It consists of many iron or steel discs which have slight concavity and are arranged into sections. The discs are also offset so that they are not parallel with the overall direction of the implement. This is so they slice the ground they cut over a little bit to optimize the result. The concavity of the discs as well as their being offset causes them to loosen and pick up the soil they cut.

Modern disc harrows are tractor-driven and are raised hydraulically.



Photo 7 A Typical Disc Harrow

4.1.5 Watering Devices

- i) Water Tankers/Lorries: Water tanker shall have provision of hose of adequate length.



Photo 8 Water Tanker

- ii) Bhisties/Water carriers
- iii) Water Cans
- iv) Water sprinkler

4.1.6 Compaction Equipment

Static three wheeled roller, Self propelled single drum vibratory roller, Tandem vibratory roller, pneumatic tyred roller, sheepsfoots roller etc may be used for compaction of subgrade.

As per the general practice in India, for lower subbase, if the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80-100 kN weight may be used. For a compacted single layer upto 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80-100 kN static weight capable of achieving required compaction.

In some countries, compaction in single lift of 300 mm using heavy vibratory or pneumatic tyred rollers are allowed.

Details of various kind of compaction equipments used are as under.

4.1.6.1 Static road roller

Static Road rollers are most suitable for compacting gravels, sand and crushed rock where some crushing action is required. Generally Static rollers of 80-100 kN capacity are used for compaction of soils.



Photo 9.1 Three Wheeled Static Roller



Photo 9.2 Mini Road Roller

4.1.6.2 Sheepsfoot roller

For compacting heavy clays and silty clays, sheepsfoot rollers are found to be very effective.



Photo 10 Sheepsfoot Vibratory roller

4.1.6.3 Padfoot/tamping roller

They can compact clay materials from 30 cm to 40 cm thickness. Tandem pad foot rollers are used for compaction with higher speed and for large sized works. These rollers are best suitable for compacting cohesive soils.



Photo 11 Padfoot/Tamping Roller

4.1.6.4 Pneumatic tyred road roller

Pneumatic tyred roller is use on small to medium size compaction jobs, primarily on granular materials.



Photo 12 Pneumatic Tyred Roller

4.1.6.5 Vibratory roller

High amplitude and low frequency setting is used for compaction of a thick layer whereas low amplitude and high frequency setting is used for the compaction of thin layer. Vibratory rollers compact intelligently when system controls automatically changes the different compaction

parameters of the roller viz., amplitude, frequency based on measurement to achieve the target density.



Photo 13 Vibratory Roller

4.1.6.6 Walk behind roller

Walk-behind rollers can be single drum or tandem models. Both types are self-propelled and can work in reverse travel direction and are controlled by cable or road linkages. The mobility of walk-behind rollers improves compaction power when compared to plates and tampers. They are used for soil, granular and asphalt compaction and for small area repair and pothole work. Walk-behind vibratory single drum rollers have a weight range between 160 to 460 kg, high frequencies of 70 to 77 Hz and amplitudes from 0.4 to 0.5 mm. Twin drum walk-behind rollers have two drums of identical size with a relatively small diameter. Each drum has its own eccentric shaft. Both drums are driven, are connected by a rigid frame and are steered by pulling or pushing the guide bar. Double drum models may also feature hydraulic controls, which lessens steering effort.



Photo 14 Typical Walk Behind Roller for Compaction of Narrow Area

4.1.6.7 Vibratory plate compactor

Vibratory Plate Compactor operates on low amplitude and high frequency, designed to compact granular soils. Smaller versions are manually guided and therefore suitable for compacting small or awkwardly shaped areas. Light plate compactors (<400 kg) work on high frequencies and comparatively low amplitude are suitable for compacting thin layers of sand and gravel. Heavy vibratory plate compactors (> 400 kg) are applicable for semi-cohesive soils and on large amplitudes.



Photo 15 Vibratory Plate Compactor

4.1.6.8 Rammers

Rammers are the light compacting equipment used for small areas, which provide impact load. Rammers delivers high force and used for cohesive and semi-cohesive soils.



Photo 16.1 Manual rammer



Photo 16.2 Gasoline Driven Rammer

For detailed information, following may be referred.

- i) IRC:SP:97-2013 "Guidelines on Compaction Equipment for Road Works"
- ii) IRC:SP:25-1984 "Gopi and his Road Roller-Guidelines on Maintenance of Road Rollers",
- iii) IS: 5500 (Part1)- Vibratory Roller General Requirements Part 1: Self Propelled Tandem Drum (Second Revision),
- iv) IS: 5500 (Part 2)- Vibratory Roller General Requirements Part 1: Self Propelled Single Drum (Third Revision).

4.2 Dry Lean Concrete (DLC)

The details of plant, equipment and tools required for construction of sub bases i.e. Dry Lean Concrete (DLC) or lean cement concrete are given as under:

4.2.1 Concrete Production

The following plant, equipment and tools shall be used for concrete production for DLC.

4.2.1.1 Concrete batching and mixing plant

A plant is an assembly of mechanical and electronic equipment, in which raw material is processed and undergoes through various processes to produce the desired output. Plants for production of concrete are classified into two types:

- A) Batch type
 - B) Continuous type
- A) **Batch Type :** Batch types plants are further classified into two categories:
- a) Central Mix Plant
 - b) Mobile or Portable Plants
 - a) Central Mix Plant

Central Mix Plant mixes the ingredients internally before being loaded into the truck. Small plant may have an output as low as 12 m³/hr, medium plants may have an output in the range of 30 to 100 cum/hr and larger plants may have an output of more than 100 cum/hr. Plants of more than 300 cum/hr are available in India.

The plant shall consist of all arrangements for:

- i) Receiving all ingredients of concrete, viz fine and coarse aggregates from storage bins, cement from silos and water form tank:
- ii) Weighing each ingredient for each batch of the mix: For concrete batching plant of capacity below 20 cum/hr, the aggregates, sand, and cement may be weighed one after the other cumulatively in the same weigh batcher whereas for concrete batching plants more than 20 cum/hr capacity, individual batchers are provided

for each ingredients. Water and admixtures measurement is preferred by weight. However, for plants upto 30 cum/hr capacity, water and admixture may be measured by volume. The batching plant shall have facility for injecting at least two admixtures in the mixing pan.

- iii) Mixing these ingredients thoroughly to form a concrete of required specification.

The concrete is said to be adequately mixed if the samples taken from different portions of a batch will have essentially the same unit weight, air content, slump and coarse-aggregate content within permissible limits.

The mixing action of concrete involves two operations:

- i) A general blending of different particle sizes of the ingredients to be uniformly distributed throughout the concrete mass.
- ii) A vigorous rubbing action of cement paste on to the surface of the inert aggregate particles.

Controls: The annunciations like operating conditions; fault indications etc. can be very easily displayed on the computer screen with the help of software SCADA ((Supervisory Control and Data Acquisition). This software makes the data storage and printout very flexible and easy. The live weight of the ingredient in the weigh hoppers are continuously upgraded on the computer along with the operating status of equipments. SCADA based system with GPRS technology provides the real-time batch data to the client server.



Photo 17.1 Central Mix Type Plant

b) **Mobile or Portable Plant**

A portable facility will generally be built onto truck trailers having the framework carrying batchers, mixers, conveyor and control equipment to facilitate transportation on public roads from site to site.



Photo 17.2 Mobile Concrete Batch and Mixing Plant

4.2.1.1.1 Quality of mix

- a) The properties of mixers which affect the homogeneity of mix are as under:
 - i) Workability of the fresh concrete as defined by the slump.
 - ii) Density of concrete
 - iii) Air content
 - iv) Compressive strength
 - v) Operation close to rated capacity; unless leads to non-uniform mixing and un-economical
- b) Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible sound or other suitable warning device each time the lock is pressed.

Quality of Batcher: The quality of batcher depends upon type of batcher used (manual, semi-automatic or automatic), calibration of batchers, etc. The batcher should be calibrated at suitable interval not exceeding 1 month. For details of calibration, IS 4926 may be referred.

4.2.1.1.2 Mixing energy

Mixing energy is defined as product of average power consumption during the mixing cycle and duration of mixing cycle. For reasons of economics, mixing energy should be kept low but the quality of concrete should be considered first. Mixing energy is used for monitoring workability during mixing.

4.2.1.1.3 Mixer efficiency

Mixing efficiency of the mixture is its ability to mix the ingredients to obtain a concrete having uniformity within the prescribed limits. The uniformity of mixed concrete shall be evaluated by finding the % variation in quantity (weight in water) of cement , fine aggregate and coarse aggregate in a freshly mixed batch of aggregate. Efficiency and quality of concrete mixer depends largely on:

- i) Duration of mixing,
- ii) Speed of mixing drum,
- iii) Timely supply of water
- iv) Proper cleaning of mixing blades and of inner surface of the drum.

4.2.1.1.4 Maintenance

- i) The plant must be kept clean and in good mechanical condition to do a good job of mixing.
- ii) Accumulation of hardened concrete in the drum and mixing blades will reduce the efficiency of the mixture.
- iii) Badly worn out mixture blades need to be replaced periodically.
- iv) Remove the old dried concrete built up around the blades.

4.2.1.1.5 Environmental issues

- i) Keep the cement in completely enclosed silos.
- ii) Keep the mixing equipment, stockpiles and silos away from the property line.
- iii) Add cartridge or bag filters to the silos, so the air that is pushed out when they are filled does not carry dust with them.
- iv) Enclose the cement conveyor belts, so that dust does not blow away as the cement is moved to the silos or mixing drum.
- v) Use filters called bag houses where the concrete is mixed and where it is dropped into the trucks. Like large vacuum cleaners, these filters suck the dust out of the air before it can blow away.
- vi) Spray water on the haulage road and stock piles.

4.2.1.1.6 For detailed information following documents may be referred

- i) IS-4925:2004: Concrete Batching and Mixing Plant – Specification

- ii) IS-4926: 2003 Ready Mix Concrete – Code of Practice
- iii) IRC:SP:96-2012 “Guidelines for Selection, Operation and Maintenance of Concrete Batching and Mixing Plants”
- iv) IS-12119:1987 General requirements for Pan mixers for concrete
- v) IS-1791 : 1985 General requirement for Batch Type Concrete Mixers
- vi) IS-4634:1991 : Methods for testing performance of Batch Type Concrete Mixer

4.2.1.2 Concrete mixer

Free fall mixers are used for smaller works. Following are free fall mixers:

- i) **Tilting Mixers**
- ii) **Non-Tilting Mixers**
- iii) **Reversible Mixers**
- i) **Tilting Mixers:** Free fall mixing suits concretes that are not too stiff, usually with a slump up to 50 mm is commonly used on construction sites.

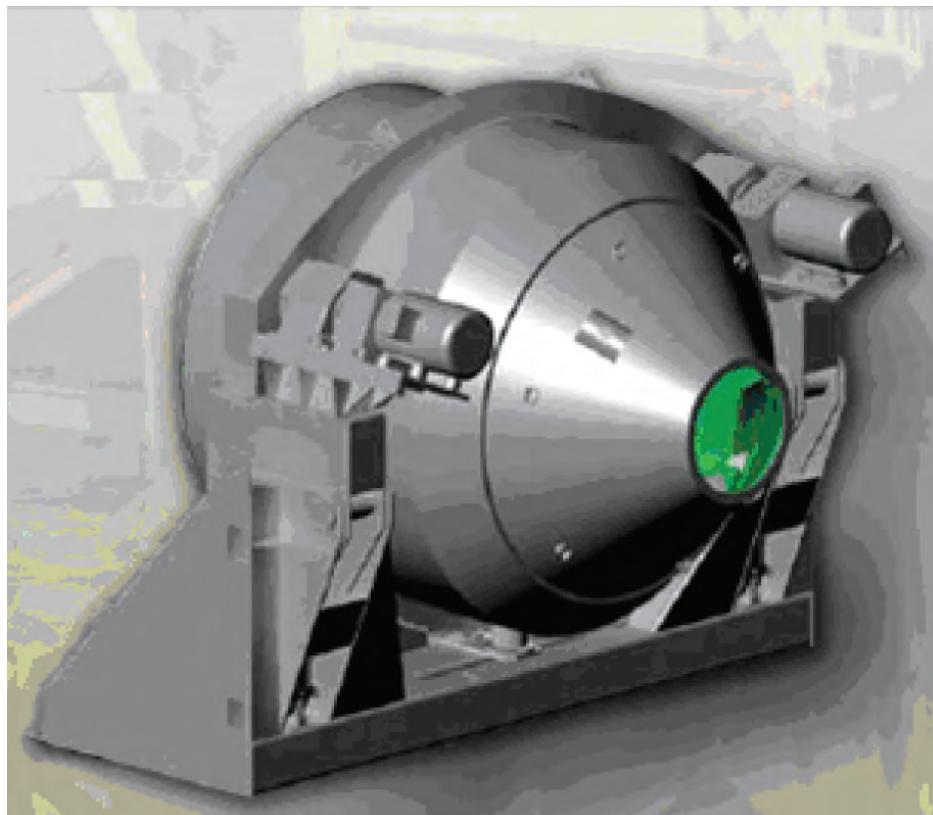


Photo 18.1 Tilting Mixer

- ii) **Non-Tilting Mixers :** A non-tilting drum mixer is one in which the axis of the mixer is always horizontal, and discharge takes place by inserting a chute into the drum or by reversing the direction of rotation of drum.



Photo 18.2 Non-Tilting Mixer

- iii) **Reversible Mixers:** The reversible drum mixer is similar to the non -tilting (described below) except that the same opening is used to add the constituents and to discharge the aggregate. The drum on a reversible mixer has one horizontal axis around which it rotates. In mixing position, the drum rotates in one direction; while for discharging, the rotation is reversed.

4.2.1.3 Volumetric batcher

Volume batching is not permitted for any regular work of concrete. However for very specific work for example for laying a slab for full depth repair or for any specific work where volume batching is permitted for aggregates, the aggregate measuring boxes should consist of deep, narrow, wooden boxes fixed with handles on either side for carriage. Some typical boxes of different capacities are given in Figure below. Typical dimensions of different boxes are given in **Table 1**. It should be ensured that the sides and bottoms of the measuring boxes retain their shape during use and do not bulge when loaded. If needed, wooden stiffening battens should be used at the sides or bottoms to ensure this. Alternatively, iron boxes may be used.

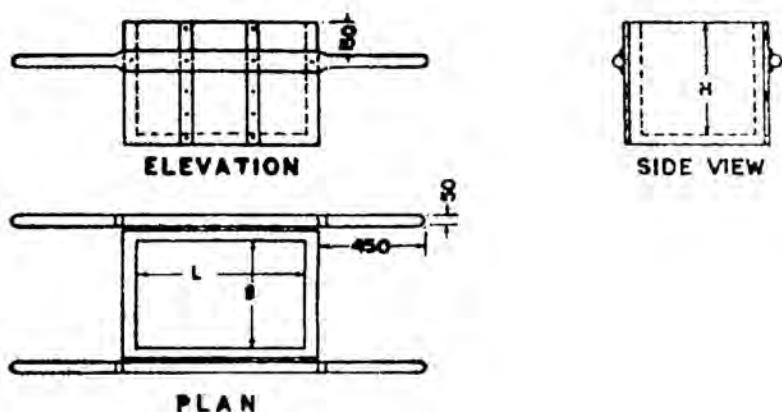


Fig. 2 Volumetric Batcher

4.2.1.4 Water and admixture measures

For the purpose of correct gauging of the mixing water and admixtures, water measuring can of capacity 6 to 15 liter may be used. Where concrete mixes are fitted with water measures, it is preferable to use them in case of semi mechanized construction method. Alternatively, empty five-liter, two-liter and one-liter tins may be used as water measures. In the last case it should be ensured that the tins are not bent or deformed and they deliver correct volume of water to the nearest 0.05 liter. The tins should be provided with suitable handles.

4.2.1.5 Water pumps

Water pumps, if required for pumping water for concrete mixing and curing operations, may be of centrifugal type conforming to IS:1520, or any other suitable pump of approved quality and make.

4.2.2 *Concrete Transportation*

Segregation tends to occur during filling and discharging of concrete handling equipment unless concrete is discharged vertically. When discharge is at an angle the larger aggregate particles are thrown to the far side of the container or forms and the mortar is concentrated on the near side.

Transportation of the mix includes determination of haul distance, routes, time to transport, types of conveyance; such as trucks, type of trucks, tippers, and conveyor belts, etc., ambient conditions, and production rates. Normally tipping trucks are used to transport the DLC mix to the paving site.

During transportation following requirements should be fulfilled:

- a) No segregation or separation of materials in the concrete.
- b) Concrete delivered at the point of placing should be uniform and have proper consistency.

There is a limitation on using the concrete mix after adding the water within a stipulated time, the mix shall not normally be carried beyond 30 km of lead on a maintained road nor requiring more than 60 minutes of travel time. The elapsed time between addition of water for preparation of mix and completion of rolling should not be more than 1.5 hours. During transportation the material should be covered with tarpaulin or additives should be added to maintain the mix in required condition.

4.2.2.1 Wheel barrows

Wheel barrows (with single or two wheels) when used to transport concrete over short distances from the mixer to the point of placement should conform to IS : 2431 and IS : 4184 respectively.

4.2.3 *Concrete Laying*

4.2.3.1 Paver finisher with electronic sensor

For detailed information, IRC:SP:96 “Guidelines for Selection, Operation and Maintenance of Paver Finishers” and IS:7251-1974 Specification for Concrete Finishers may be referred.



Photo 19.1 Sensor Paver



Photo 19.2 Laying Operation

4.2.3.2 Kerb laying paver

The kerb laying machine is an equipment for casting/laying continuous concrete kerbs, channel and other concrete formation of different dimensions to close tolerances, used in road construction through an extrusion process.



Photo 20 Kerb Laying Paver

4.2.4 *Compaction*

Double drum smooth wheeled vibratory rollers of minimum 80 to 100 kN static weight are suitable for compaction of dry lean concrete. For smaller works, plate compactors may be used. Details of various rollers mentioned under para 4.1.6 may be referred.



Photo 21 Double Drum Vibratory Road Roller

For detailed information, following may be referred :

- i) IRC:SP:97-2013 “Guidelines on Compaction Equipment for Road Works”
- ii) IRC:SP:25-1984 “Gopi and his Road Roller Guidelines on Maintenance of Road Rollers”
- iii) IS: 5500 (Part1)- Vibratory Roller General Requirements Part 1: Self Propelled Tandem Drum (Second Revision),
- iv) IS:5500 (Part 2)- Vibratory Roller General Requirements Part 1: Self Propelled Single Drum (Third Revision)

4.2.5 *Curing Compound Sprayer*

Curing compound sprayer consists of an assembly of tank for storing curing compound and a hose which can be mounted on a frame that enables an easy movement of the equipment. It may also be provided with a pump that helps in generating the required rate and pressure. Pressure settings can also be adjusted in some equipment.



Photo 22 Barrel Mounted Sprayer

4.2.6 Watering Devices

Equipment mentioned under para 4.1.5 may be referred.

4.2.7 Finishing Equipment

Scrabbler

Scrabbler is an ideal machine for floor surface preparation. These units are used widely to level and to provide non-slip surfaces and in the removal of coatings. Scrabbler uses air as a tool to exert pressure on a surface. It is used for the following purposes:

- Scabbling down high spots or leveling uneven joints
- Removing delaminated concrete surface materials
- Removing spalled or deteriorated concrete



Photo 23 Scrabbler

4.3 Pavement Quality Concrete

The Plant, Equipment and Tools used for Pavement Quality Concrete are as under:

4.3.1 Concrete Production

All the equipment used for production of concrete for DLC shall also be used for production of concrete for PQC. Normally, Concrete Batching and Mixing Plant is used. The equipment mentioned under para 4.2.1 for production of concrete may be referred.

4.3.2 Transportation

Transit mixer (for paving by fixed form), tipping trucks, wheel barrows etc. are used for transportation of concrete mix.

Non-agitator truck: These are used when haul distance is small.

Agitator trucks : The truck bed contains a large barrel or drum that is used to continuously roll or agitate the concrete mixture keeping it from solidifying before use.

Transit mixer : These trucks are used to mix the ingredients while the truck is on the move. A transit mixer is used to perform following three functions:

- a) It can mix coarse aggregates, fine aggregates, cement and water for production of concrete while it is moving or stationary.
- b) It can prevent segregation of already mixed concrete during transit by agitation, as a result of slow revolution of the drum.
- c) It can completely mix the shrink concrete (that is concrete partially mixed in central batching and mixing plant) while it is moving or stationary.



Photo 24 Transit Mixer

For detailed information IS:5892-2004 Concrete Transit Mixer – Specification (First Revision) may be referred.

The condition of the road should also be taken into account for travel time. Re-tampering the mixed material by adding water or by other means should not be permitted. To minimize segregation, re-handling of the mix should be minimized. Also, when placing the mix on grade, minimum drop heights should be used and paving to be done from lower to higher grade.

4.3.3 Spreading

Placer/Spreader

It places a metered supply of concrete mix in front of the paver using a series of conveyor belts, augers, plows and strike off devices. Using a placer/spreader allows the contractor to receive material from transport vehicles and place a uniform amount of concrete mix in front of the entire paver width, while minimizing segregation.

The spreader receives the concrete from the hauling units and places it in rough form in its proper location on the roadbed to the depth of the mat reinforcement. Reinforcement mats are placed immediately behind the spreader.

The subbase must be thoroughly moistened ahead of the spreader to prevent rapid loss of water from the concrete. Care must be taken to see that the correct quantity of concrete is placed; too much will overload the following paver, and too little will result in having necessarily to halt the paving while additional material is being added. The interval between the spreader and paver is important; the distance should be kept as short as possible because the concrete will set in about 20 minutes.

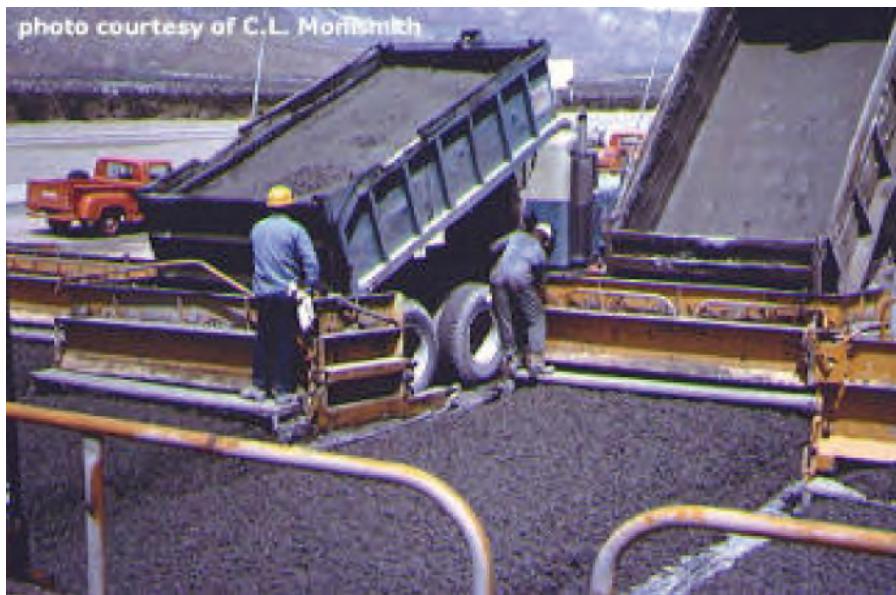


Photo 25 Concrete Spreader

References : IS:7242-1974 : Specification for Concrete Spreaders may be referred

4.3.4 *Laying*

There are two basic methods of placing and finishing concrete pavements: fixed form paving and slip-form paving.

Stationary forms are used in fixed form paving. The forms are built to the line and grade of the finished pavement, and the paving equipment rides on the forms.

4.3.4.1 *Slip form paving*

Slipform paving is defined as a process used to consolidate, form into geometric shape and surface finish a PCC mass by pulling the forms continuously through and surrounding the plastic concrete mass. Slipform paving is most appropriate for larger jobs that require high production rates. Slip-form paving usually uses string lines for line and grade. The paving units are equipped with sensors that run along the string lines. Slip form pavers can pave to grade, spread the concrete over the subgrade, vibrate, tamp, strike off, and shape the concrete to the desired thickness and surface configuration. Concrete is contained by short side-forms built into the paving equipment. Components of the slip form paver are as under:

- i) Distributor (augur or plough) and regulating bar
- ii) Vibrators
- iii) Finisher with conforming plate and slip forms
- iv) Dowel Bar Inserter (DBI) and Tie Bar Inserter (TBI)
- v) Twin oscillating beams
- vi) Auto float for finishing the surface
- vii) Texturing and curing compound spraying unit.



Photo 26 Slipform Paver

The paver usually performs screeding, consolidation and initial finishing. Some pavers are equipped to place reinforcing steel (if needed), dowel bars and tie rods as well. Slip-form pavers use their own weight to mould the plastic concrete into the correct shape.

Consolidation

After screeding, the paver consolidates the fresh PCC using a series of vibrators. Typically, the most effective vibrator position is after the strike-off mechanism and at the final slab elevation. Most pavers use fully adjustable vibrator spacing to account for different conditions and mix types, while still providing adequate influence zone overlap.

Initial Finishing

Initial finishing is accomplished by extruding the PCC mass through a moving form made up of the base course (bottom), the side forms (vertical edges of the paver) and the confirming plate (flat paver pieces mounted behind the vibrator). Extruding PCC through the resulting rectangular shape provides the final slab dimensions and also serves to imbed larger aggregate particles below the surface, which results in a smooth finish. Some pavers are also equipped with a hydraulic tamper bar (sometimes called a “jitterbug”), located just behind the vibrators. By moving up and down, the tamper bar is thought to:

- 1) Assist in consolidation and finishing by tamping large aggregate particles below the slab surface.
- 2) Keep the large aggregate moving in an area where it may have tendencies to stop or stick.
- 3) Keep the material moving around the vibrators so as not to collect and cause flow problems.

Placing of dowel/tie bars at their pre-designed locations are also done by slip form pavers.

Advantages of slip form paving:

- **Uses low-slump PCC.** Low-slump PCC of the order 25 ± 10 mm is necessary so that the fresh PCC is able to hold its shape once the slipform paver has

passed. Low slump PCC can be made with less water and usually has higher compression and flexural strengths than comparable high slump mixes.

- **High productivity.** Large jobs generally require high production rates.
- **Smooth riding surface.** Automation and computer control allows pavers to produce very smooth riding surfaces

PCC placement, consolidation, finishing and curing is typically done in Slipform paving. Most often, these steps are accomplished by three pieces of equipment: the placer/spreader (used for rough placement), the concrete paver (used for final placement, consolidation and initial finishing), and the texturing and curing machine. These machines usually travel together in series down the length of the project.

4.3.4.2 Fixed form paving

Despite the speed and ease of Slipform paving, there are still many applications where fixed form paving is more practical and cost-effective. These include streets, intersections, local roads, and complicated short-run or variable-width pavements.

The formwork should consist of mild steel channels for straight lengths and wooden sections reinforced with mild steel angles for curved portions. Manufactured sections are also available for formwork as given in IRC:15. The details of mild steel stakes for fixing mild steel channel and wooden formwork are given in **Fig. 29**.



Photo 27 Fixed form Concrete Paver

Particular advantages of fixed form paving are:

- Tight tolerances and side clearances. Existing curbs or other features can be used as forms.
- Custom geometry. Forms can be placed in just about any pavement geometry, which allows for multiple changes in pavement width, smooth curves, blockouts and other abnormalities.

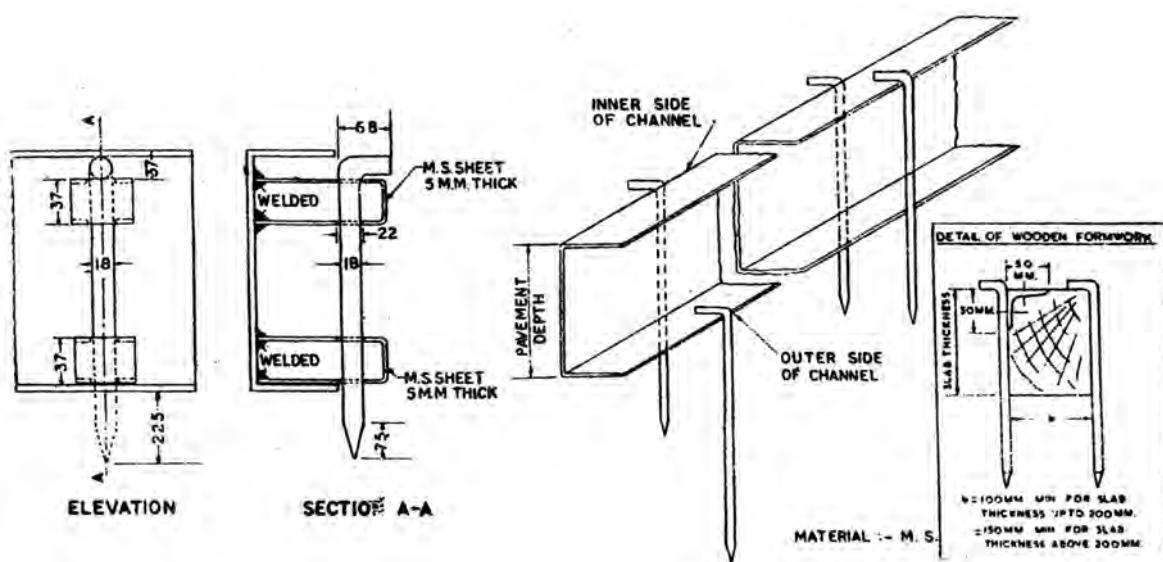
- Better construction staging. Forms can be placed such that staged construction can be used to maintain traffic flow or intersection use.
- Less expensive equipment and mobilization. Forms and equipment are less expensive than slipform paving equipment. If paving operations are small enough, this cost savings can more than offset the higher production rates of slipform paving.



Photo 28

4.3.4.2.1 Formwork and Iron stakes

The formwork should consist of mild steel channels for straight lengths and wooden sections reinforced with mild steel angles for curved portions. Manufactured sections are also available in the market and may be used if they meet the construction requirements. The general requirements for formwork as given in IRC:15 should be compiled with. The details of mild steel stakes for fixing mild steel channel and wooden formwork are given in **Fig. 3**.



Note : All Dimensions are in mm

Fig. 3 Details of Side-Shuttering/Fixed-Form Prepared with MS Channel and Steel Pins

4.3.5 Compaction of PQC

Concrete vibrators are not used only to consolidate the concrete for maximum density, but they also internally blend the different lifts of concrete together into a single solid mass with few to no air pockets and no lift lines on the finished exposed surface. After deciding whether to use internal or external vibration, following shall be considered in making an appropriate choice:

- i) Frequency,
- ii) Amplitude,
- iii) Power and
- iv) Size.

Since concrete contains particles of varying sizes, the most satisfactory compaction would be obtained by using vibrators with different speeds of vibration.

The various types of vibrators used are described below:

i) Internal or Immersion or Needle Vibrators

This is the most commonly used vibrator. It essentially consists of a steel tube (with one end closed and rounded) having an eccentric vibrating element inside it. This steel tube called poker is connected to an electric motor or a diesel engine through a flexible tube.

The vibrators run by 110 V, 200 Hz Generator and operate at speeds ranging from 8000 to 12000 vpm (vibrations per minute). The diameter of the poker vibrators is in the range of 20-80 mm. The diameter of influence is 900 mm and the pokers are placed at a spacing of 360 – 500 mm to ensure proper compaction of the concrete in the compaction chamber. The amplitude of vibration is in the range of 0.4-0.8 mm. For proper uniform compaction across the slab, it is essential to have same frequency of all the vibrators. The idea of compaction is to remove the air voids. IS:2505-1980 General requirements for Concrete Vibrators Immersion type, IS:3558-1983 Code of Practice for use of immersion vibrators for consolidating concrete may be referred.



Photo 29 Poker Vibrator

ii) **External or Shutter Vibrators**

These vibrators are clamped rigidly to the formwork at the pre-determined points so that the form and concrete are vibrated. They consume more power for a given compaction effect than internal vibrators.

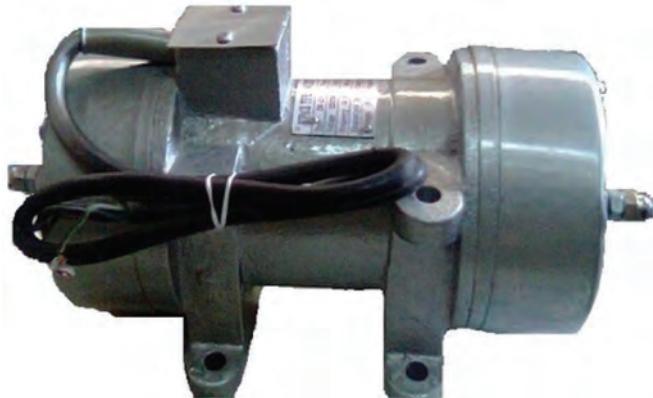


Photo 30 Shutter Vibrator

These vibrators can compact upto 450 mm from the face but have to be moved from one place to another as concreting progresses. The external vibrators are more often used for pre-casting of thin in-situ sections of such shape and thickness as cannot be compacted by internal vibrators. For detailed information, IS:4656-1968 – Form Vibrators for Cement Concrete may be referred.

Very stiff mixes respond better to high amplitude and lower frequency. The high frequency use tends to give a better surface appearance.

iii) **Surface or Screed Vibrators**

These are placed directly on the concrete mass. These best are suited for compaction of shallow elements and should not be used when the depth of concrete to be vibrated is more than 150 mm. Very dry mixes can be most effectively compacted with surface vibrators. The surface vibrators commonly used are pan vibrators and vibrating screeds. For detailed information IS: 2506-1964 Screed Board Vibrators may be referred.



Photo 31 Surface Vibrator

Frequency and Amplitude- Frequency and amplitude under no load (Operation in air) shall be tested in accordance with IS:6923-1973; Method of Test for and shall be as given below:

Hand Tamper Board : The hand tamper, used in lieu of screed board vibrator for compacting concrete for minor jobs, or as an emergency stop-gap arrangement in case of breakdown of the screed board vibrators, should consist of a hard wood beam of rectangular section of sufficient weight to ensure adequate compaction and should be fixed securely with sturdy handles to withstand the tamping action. A typical dimensioned sketch is included in **Fig. 4.**

The lower face of the tamper board should conform to the desired profile of the pavement cross-section, and be fitted with a mild steel shoe of appropriate width, as in the case of screed board (IS : 2506) to prevent wear.

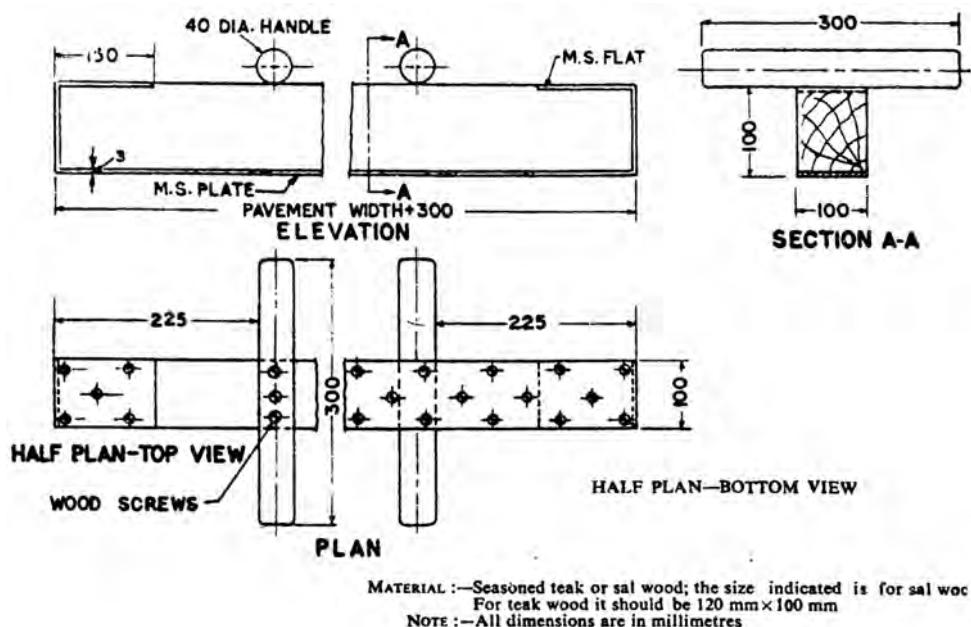


Fig. 4 Wooden Hand Tamper

4.3.6 *Finishing and Curing*

The equipment used for Finishing of PQC pavement and Curing are as under:

4.3.6.1 *Texturing and curing machine*

The texturing and curing machine follows the paver and is used to impart macro texture and apply a curing membrane over the pavement. Sometimes the paver is equipped with a tining/texturing machine, while a separate machine is used for applying the curing membrane.

Curing is done once finishing of an area is complete and the original wet sheen has nearly disappeared. On tined pavements, curing is usually specified to occur in two passes, one forward and one in reverse, to ensure both sides of the texture ridges are coated with curing membrane.

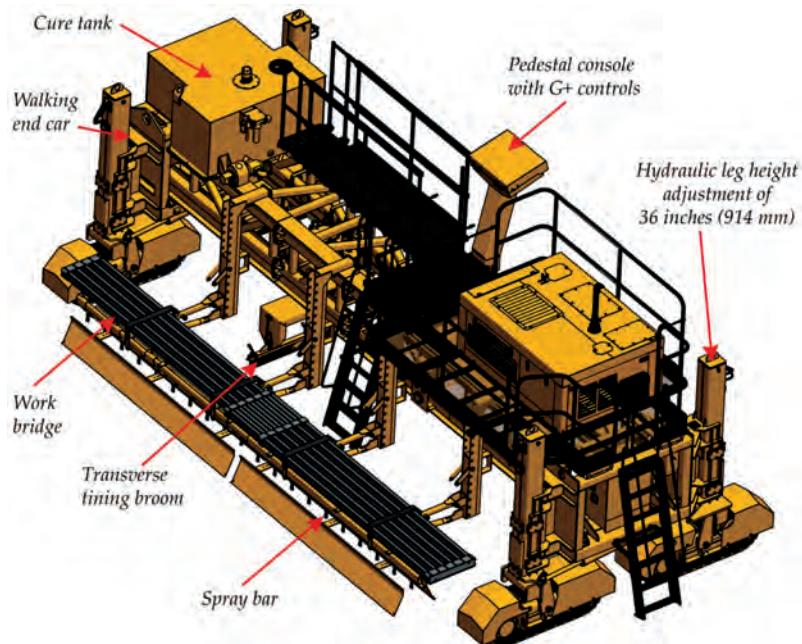
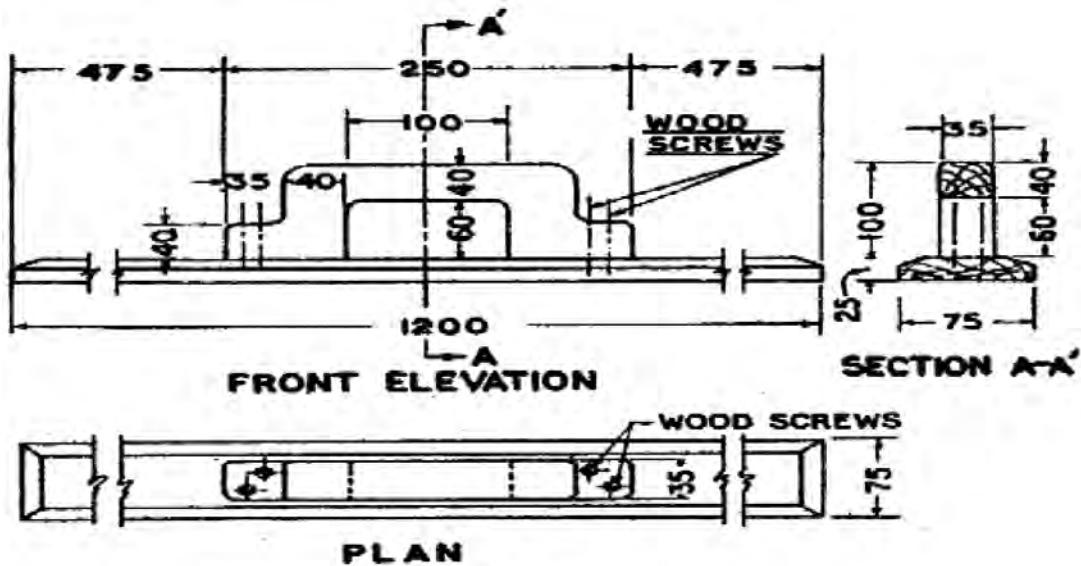


Fig. 5 Texture and Curing Machine

4.3.6.2 Floater

The float used for smoothing the compacted concrete, should be made of hard wood board of dimensions shown in **Fig. 6**, planned to true surface and fixed with a suitable handle as illustrated. Currently floaters or finishers are also being used in semi mechanised construction as shown in **Photo 32**, not only for finishing even these are being used to make the surface abrasion resistant using some commercial hardener while floating or finishing. These are generally known as mechanical/power floater and trowel for finishing of fresh PQC.



MATERIAL :—Seasoned teak or sal wood
NOTE :—All dimensions are in millimetres

Fig. 6 Float



Photo 32.1 Power Floater

Bull Float : The bull float is a flat, long-handled tool used to flatten minor ridges and holes, as well as embed aggregate particles further into the concrete, bringing the smoother “cream” consistency concrete to the surface for better finishing.



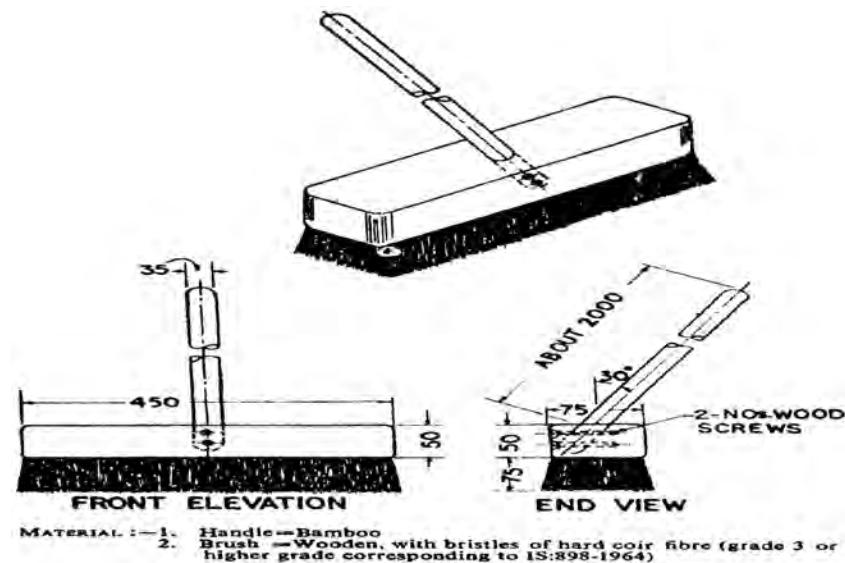
Photo 32.2



Photo 32.3

4.3.6.3 Long - Handled Broom and Tine

The long handled coir, Nylonbroom for giving broom marks across the pavement surface in longitudinal or transverse direction to make it skid resistance should conform to the requirements given in **Fig. 7**. The fibers should meet the requirement of IS:189 and be of Grade 3 or higher than this specification. The bottom should be replaced when the bristles wear down to a length of about 40 mm. For Tining in Semi Mechanized method, tining Brush (steel/aluminum) as shown in **Fig. 33** is also used for 3 mm width and 3 - 4 mm depth for making the road skid resistant.



Notes : All Dimensions are in Millimeters

Fig. 7 Broom and Tine

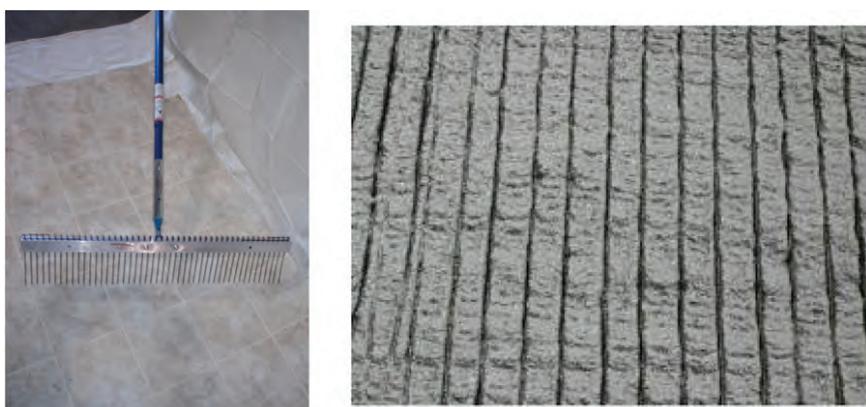


Photo 33 Typical Tine Finished Groover and Finished Concrete Surface

4.3.6.4 Wooden or steel bridges

Wooden bridges, used for straddling (spanning across the nascent slabs without touching it) the slabs to enable the masons to carry out surface finishing operations on the compacted concrete, or to enable placement of concrete in case of reinforced concrete pavements without disturbing the reinforcement mesh, should conform to the dimensions shown in

Fig. 8. for a limiting slab width of 4 m. For finishing operations alone, a lighter bridge (limiting full slab smaller width) may be adopted as shown in **Fig. 8**. For larger slab width, suitable design should be prepared for each case. **Photo 35** shows steel bridge which may be used both in semi mechanized and mechanized construction.

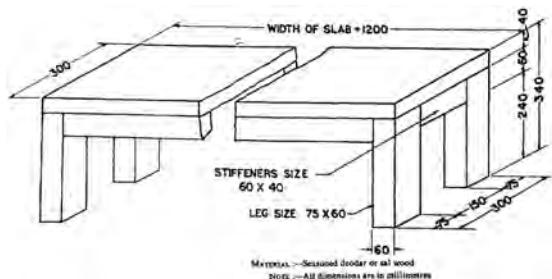


Fig. 8.1 Wooden Bridge

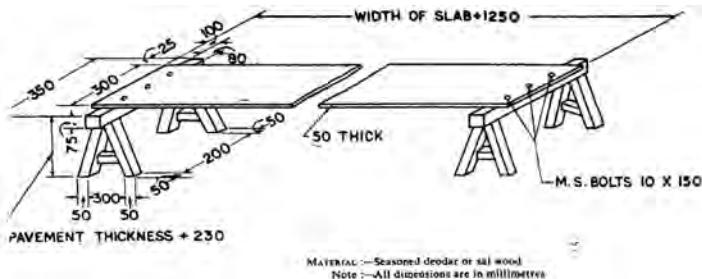


Fig. 8.2 Wooden Bridge



Photo 34 Steel Bridge

4.3.6.5 Curing compound sprayer

The sprayer mentioned under para 4.2.5 may be referred.

4.3.7 Joint Cutting & Edging

4.3.7.1 Diamond cutter

Rotating disc diamond cutter of travelling type should have appropriate arrangement for lowering raising the blade to any desired level. It should also have suitable guides for enabling a straight cut to be made along the desired line. The diamond cutter having water-feeding arrangement may be of any approved standard make. **Photo 36.1 and 36.2** show pictorial views of Joint Cutter for cutting contraction and longitudinal or construction joint (post construction).



Photo 35.1 Joint Cutter



Photo 35.2 Joint Cutting with Small Size Hand Held Joint Cutter

4.3.7.2 Jack hammer

A jack hammer is a pneumatic or electro-mechanical tool that combines a hammer directly with a chisel. Hand-held jack hammers are typically powered by compressed air, but some use electric motors. Larger jack hammers, such as rig mounted hammers used on construction machinery, are usually hydraulically powered. They are usually used to break up rock, pavement, and concrete.

Only energy involved in making a jack hammer pound up and down is supplied from an air hose. The hose, which has to be made of especially thick plastic, carries high-pressure air (typically 10 times higher pressure than the air around us) from a separate air-compressor unit powered by a diesel engine. Piledriver smashes down on the drill bit over 25 times each second, so the drill pounds up and down in the ground around 1500 times a minute.

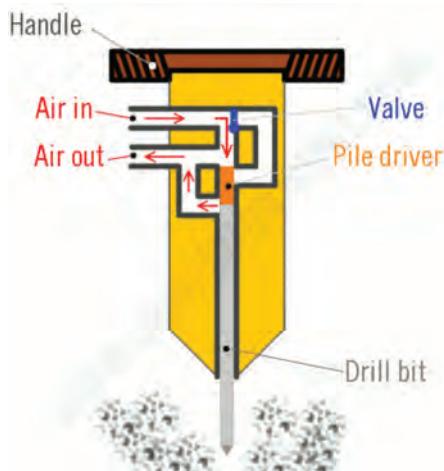


Fig. 9 Jack Hammer



Photo 36 Jack Hammer at Site

4.3.7.3 Air compressor

An air compressor is a device that converts power (usually from an electric motor, a diesel engine or a gasoline engine) into kinetic energy by compressing and pressurizing air, which, on

command, can be released in quick bursts. There are numerous methods of air compression, divided into either positive-displacement or negative-displacement types.

Air compressors are used for various purposes in road construction like cleaning of road surfaces, providing necessary pressure for jack hammers.



Photo 37 Air Compressor

4.3.7.4 Edging tools

The single-edging tool used for rounding the transverse edges at expansion joints and the longitudinal edges should conform to requirements. The double edge tool, used for the rounding transverse edges at dummy contraction joints to ensure same level on either side of the joint should conform to Figure shown.

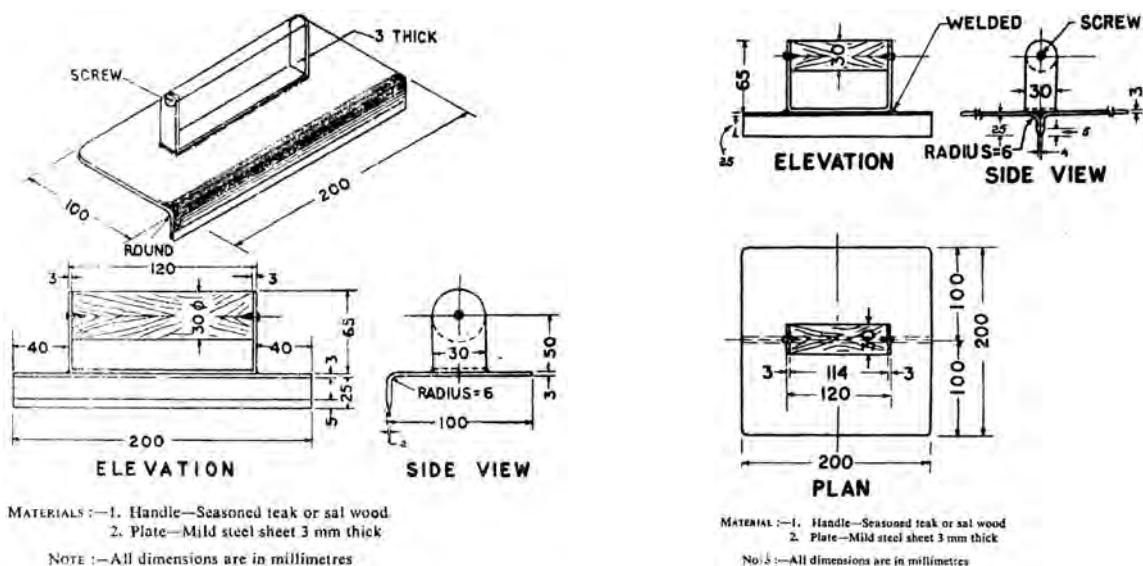


Fig. 10

Edge Preparation



Photo 38

4.3.7.5 Sealing with Sealants

4.3.7.5.1 When sealants are applied an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with the recommendation of the manufacturer. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint grove to be sealed is below 7°C.

4.3.7.5.2 If hot applied sealant is used, it shall be heated and applied (after using raker) from melter and pourer as shown in **Fig. 11, 12 and 13**. Hot sealants shall be rubberized bitumen type. For large road projects sealant shall be applied with extruder having flexible hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature, as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturer's recommendations and reheated materials shall not be used.

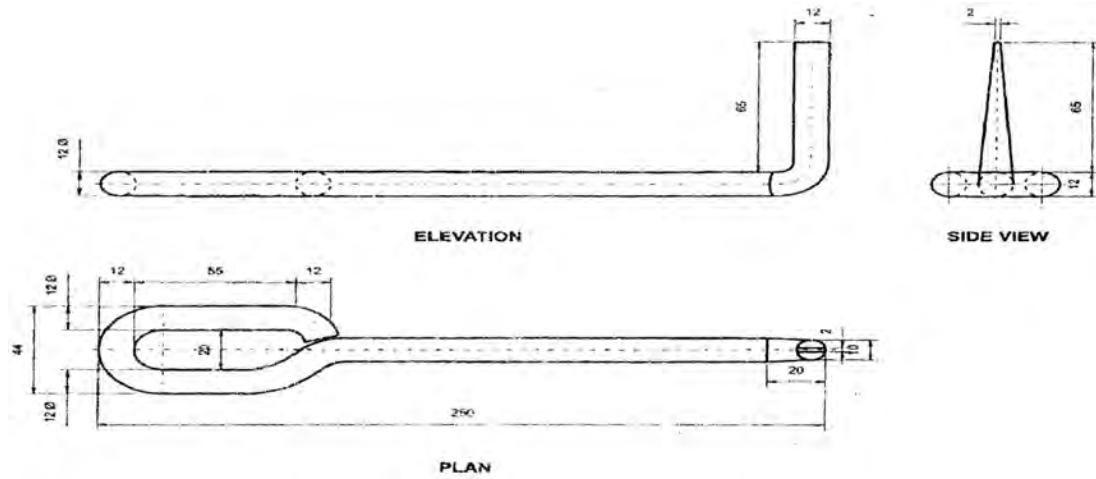


Fig. 11 Details of Raker

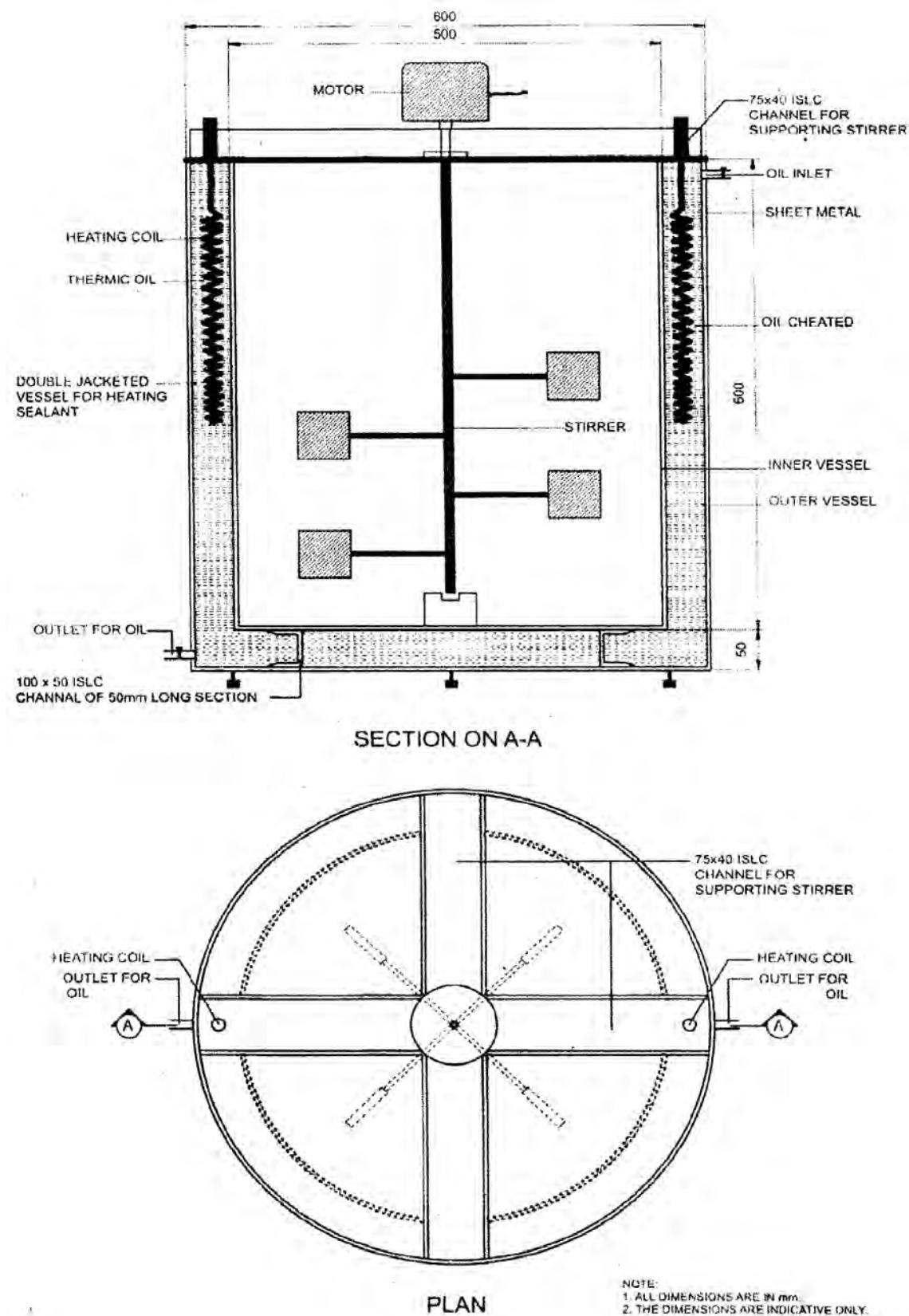


Fig. 12 Schematic View of a Sealant Melter

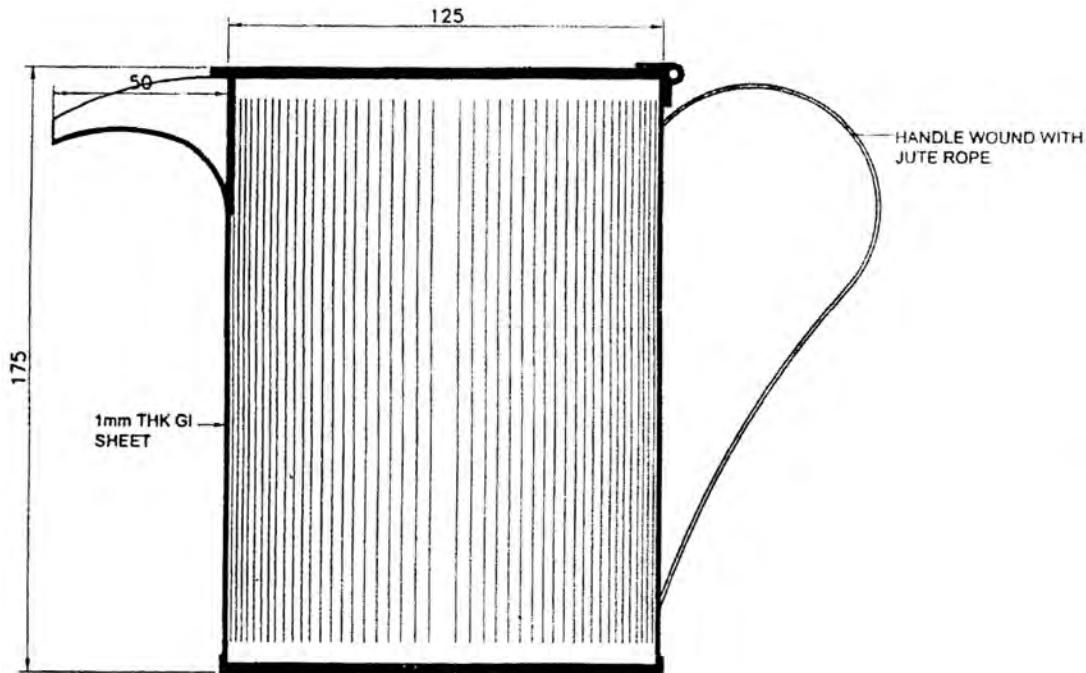


Fig. 13 A Pouring Cattle for Hot Poured Sealant

5 OUTLINE SPECIFICATIONS OF VARIOUS PLANTS, TOOLS, AND EQUIPMENT

5.1 Aggregate Production

5.1.1 Stone Crushers

5.1.1.1 Primary crushers

- i) Lump sizes higher than 1 m and capacities upto 1500 tonnes per hour can be achieved
- ii) Reduction ratio possible in Jaw Crusher is usually in the range 4:1 to 6:1.
- iii) Reduction ratio possible in Gyratory Crusher is usually in the range of 4:0 to 6:1 and frequency of gyrating action is between 100 and 200 cycles/minutes and the 'movement' or 'throw' between 20 and 55 mm.
- iv) For Impactors, reduction ratios of 20:1 are possible in a single stage; for double rotor impactors, the reduction ratio may be as high as 40:1.

5.1.1.2 Secondary and tertiary types

- i) Reduction ratio achieved in Cone Crusher varies from 4:1 to 8:1
- ii) The reduction ratio in Rolls Crusher is generally limited to 3:1

5.2 Concrete Production

5.2.1 Concrete Mixers

Mixing Time :

S. No.	Type of Mixer	Usage	Capacity of Mixer (L)	Minimum Mixing Time (in Second)
1	Non-tilting reversible drum type	Low workability, large size of aggregates, small works	375, 500, 750, 1000, 1500, 2000	40
2	Pan type	Larger size project and Pre-cast works	375, 500, 750, 1000, 15000, 2000, 3000	30
3	Single shaft/twin shaft/ compulsory type/pug mill type	Larger sized work	500, 750, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 4000, 5000, 6000	30

5.2.1.1 Batching tolerances

Ingredient	Batching Tolerances
Cement and other cementitious material	± 1%
Water	± 1%
Aggregates	± 2%
Admixtures	± 1

5.2.2 Volumetric Batcher

Dimensions of Boxes Suggested for Volumetric Measuring of Aggregates

All Dimensions are in mm

Thickness of planks are 25 mm in case of wood (Deodar or teak wood) or metal (2-3 mm)

S.No.	Volume in Cu m	Length in m (L)	Breadth in m (B)	Height in m (H)	Remarks
1	0.015	0.25	0.20	0.3	The sieves can be circular.
2	0.03	0.3	0.25	0.4	
3	0.0375	0.3	0.25	0.5	
4	0.06	0.4	0.3	0.5	
5	0.075	0.5	0.3	0.5	

5.3 Laying

5.3.1 Paver Finisher for DLC Layer

- i) Wheel drive - Normally, single drive axle is suitable up to 5 m width and double drive axle up to 8.5 m width
- ii) Range of paving speed

Speed	Wheeled Paver		Tracked Paver
	Mechanical	Hydrostatic	Hydrostatic
a) Paving speed	0-25 m/minute	0-40 m/minute	0-16 m/minute
b) Travel speed	0-16 km/hour	0-7.5 km/hour	0-3.6 km/hour

iii) Paving Thickness

The following paving thickness is normally possible for laying the mix.

- a) Mechanical Paver finisher : 10 mm to 200 mm.
- b) Hydrostatic Paver finisher : 10 mm to 350 mm.
- iv) The output of different types of Paver finisher is in the following range:
 - a) Mechanical Paver finisher Up to 100 tonnes per hour
 - b) Hydrostatic Paver finisher Up to 700 tonnes per hour
- v) The tamper bars move up and down vertically with an amplitude between 3 to 5 mm. They operate at a frequency between 0-2000 strokes per minute, which should be adjustable within this range.
- vi) Crown can be adjusted on the screed from -10 mm to + 50 mm.
- vii) Normally, the capacity of hopper is 20-30 tonnes

5.4 Compaction

5.4.1 Pneumatic Tyred Rollers

Passes	Job Characteristics	Maximum Depth of Layer (in mm)	Wheel Load Desired (in tons)
4 to 8	Compaction of loamy sand	300 mm	1.5 to 1.7
		500 mm	2.0 to 2.5
		700 mm	3.0 to 4.5
4 to 6	Compaction of bituminous material	80 mm	1.5
		130 mm	2.5
		200 mm	4.0
4-6	Compaction of concrete (DLC)	150 mm	6.0

5.4.2 Vibratory Rollers

As per IRC:97-2013

Application guidelines - vibratory rollers					
application	roller	static linear pressure kg/cm	amplitude mm	frequency Hz	rolling speed km/h
earthworks dams		≥ 30	≥ 1,5	28 - 35	1 - 2,5
granular bases subbases		≥ 10	≥ 0,4	28 - 60	2 - 4
asphalt base course		0,35 - 0,9	30 - 60	2 - 4	
asphalt wearing course		10 - 30	≤ 0,5	40 - 60	2 - 6

BAD1a-22/04

5.4.3 Vibrating Needle

As per IRC:97-2013 for needle vibrators

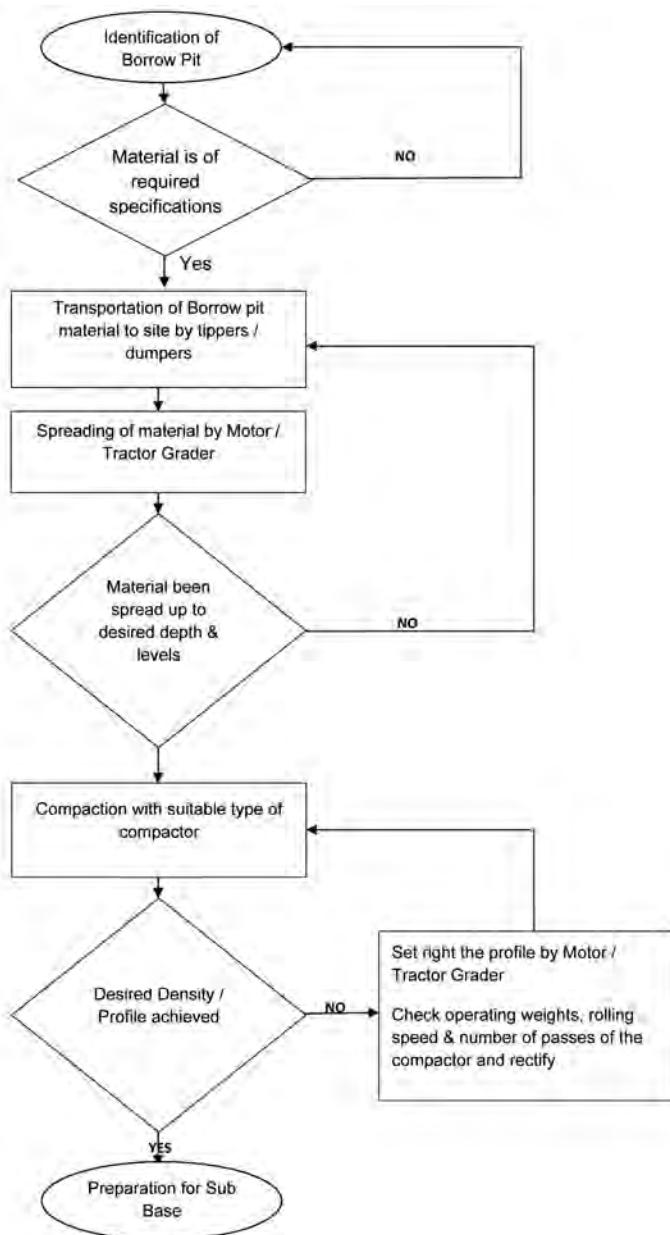
Diameter of Vibrating Needle (mm)	Frequency of Vibration (vpm)	Amplitude (mm)
20-80	8000-12000	0.4-0.8

5.4.4 Rammers

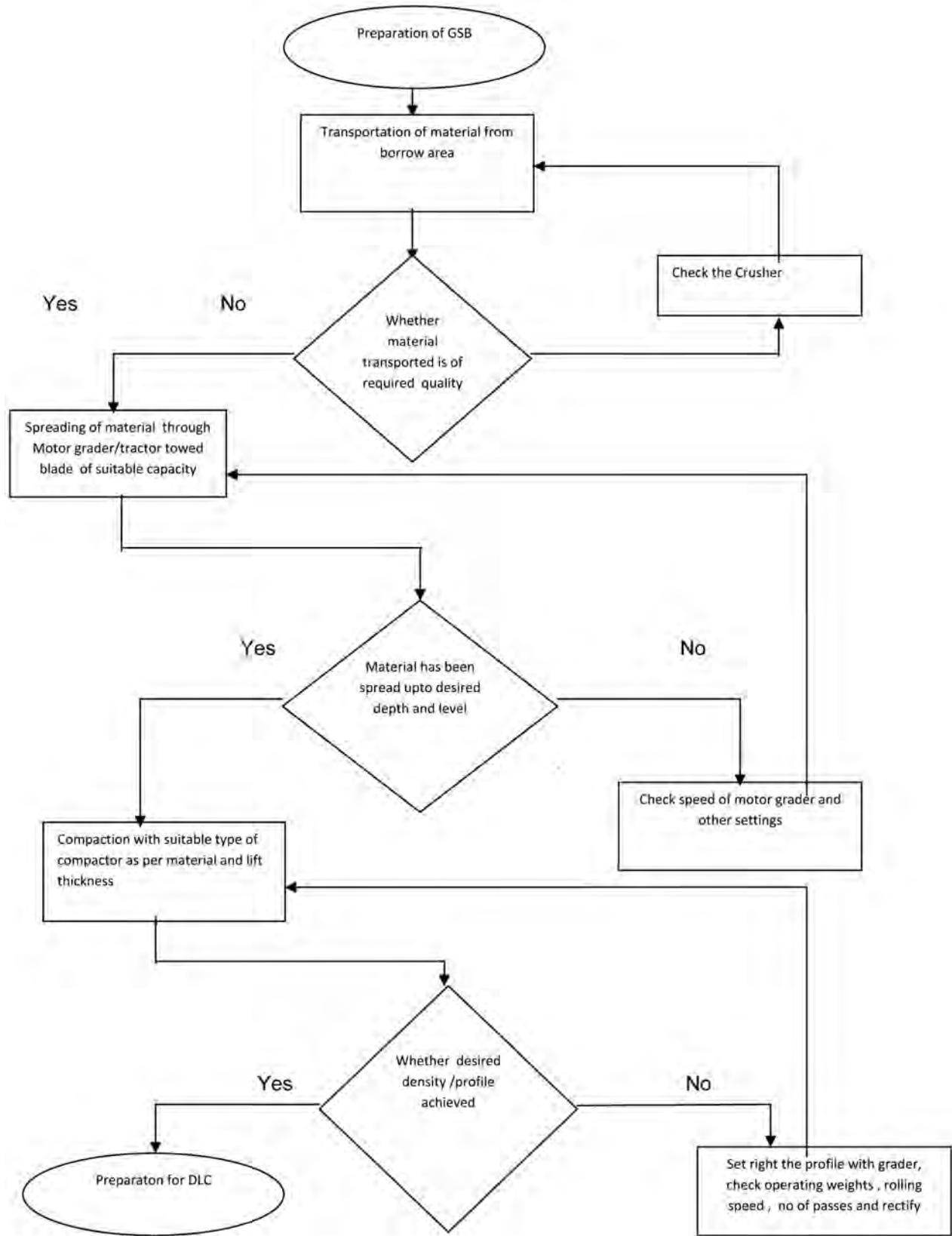
They operate in the frequency range of 500-750 blows per second.

6. FLOW CHARTS

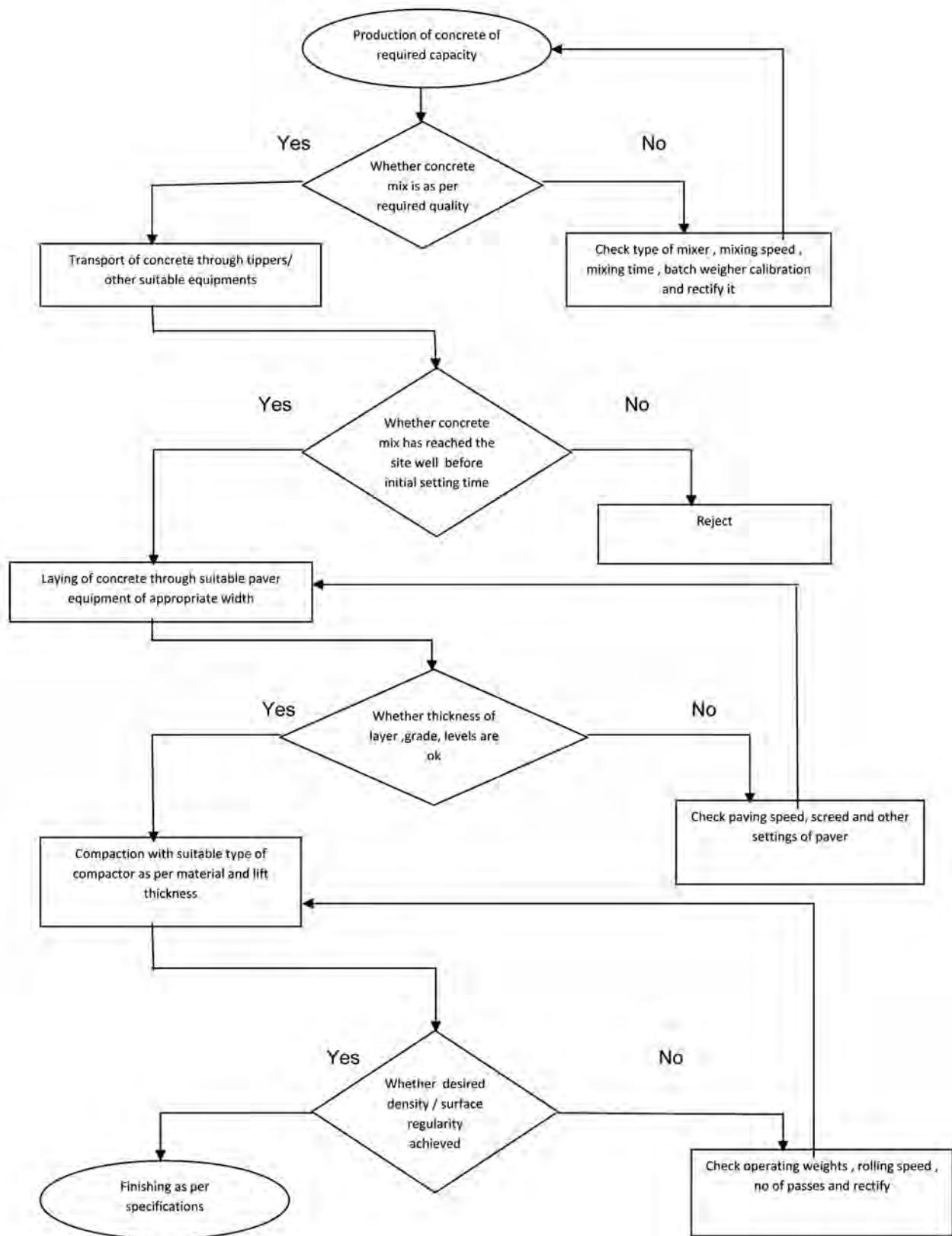
6.1 Flow Chart for Laying of Sub Grade Layer



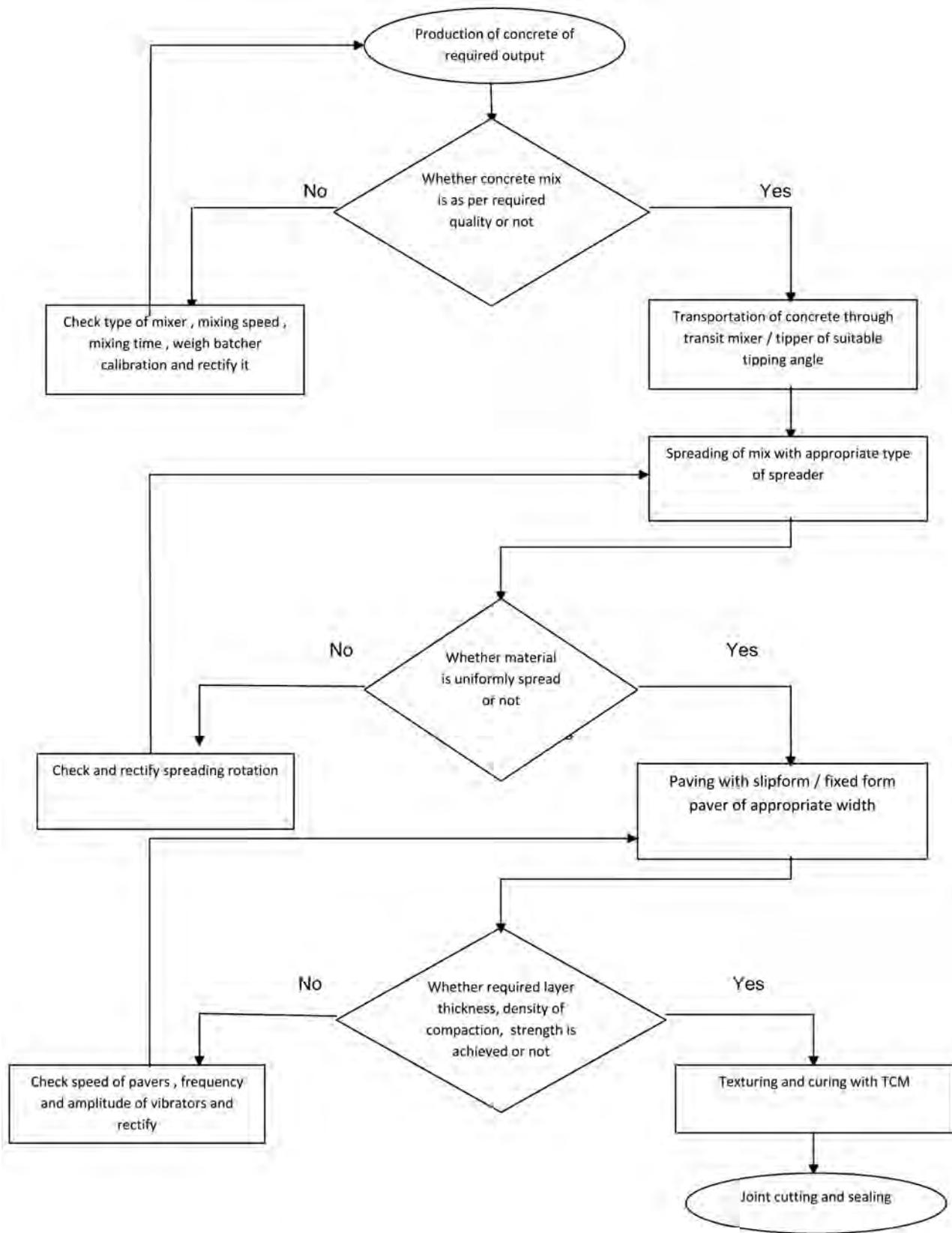
6.2 Flow Chart for Construction of Granular Sub Base



6.3 Flow Chart for Construction of Dry Lean Concrete



6.4 Flow Chart for Construction of Pavement Quality Concrete



7 SELECTION OF PLANT, EQUIPMENT AND TOOLS

7.1 Work Related Selection Criteria

These selection criteria of plant, equipment and tools are always associated with the following factors:⁹

- Type of works (Expressways/NH, SH, MDR, ODR, VR, Urban Road, Rural Roads etc.)
- The quantity of required concrete
- The concrete of required quality
- To purchase equipment costs
- Schedule of construction work
- Site conditions

7.2 Selection criteria related to plant, equipment and tools: while selecting the plants/equipment, tools for concrete construction

Item	Options Available	Criteria for Selection
Mechanization	Fully Mechanized/Semi Mechanized	<ul style="list-style-type: none"> ● Type of works – Expressways, NH Works, Urban Roads, Rural Roads etc ● Volume of Work ● Project Completion Time
Type of Plant/Equipment /Tools	Concrete Production Plant/Equipment	<ul style="list-style-type: none"> ● Required Concrete Volume ● Required concrete quality ● Project Completion time ● Level of Automation ● Mobility
	Central Concrete Batching and Mixing Plant/Mobile Concrete Batching and Mixing Plant	<ul style="list-style-type: none"> ● Site terrain ● Accessibility ● Water supply ● Transport Routes ● Availability of Working space ● Climate ● Capacity of plants
	Stone Crushing Plant	<ul style="list-style-type: none"> ● Size of lump ● Capacity of plant
	Concrete Mixers	<ul style="list-style-type: none"> ● Mobility ● Mixing Capacity ● Mixing Speed ● Mixing Method ● Discharge Method ● Concrete Properties (Maximum size of aggregates, slump etc.)

Item	Options Available	Criteria for Selection
	Transit Mixer/Agitators/ Dumpers/Wheel barrows	<ul style="list-style-type: none"> • Distance between place of production and job site • Transportation capacity • Type of route • Climate
	Needle Vibrators/External Vibraotrs/Surface Vibrators/ table Vibrators	<ul style="list-style-type: none"> • Depth of concrete to be compacted • Type of Mix
	Type of Rollers/Compactors	<ul style="list-style-type: none"> • Size of work • Lift thickness • Type of material to be compacted • Properties of material to be compacted
	Mechanical Paver Finisher/ Hydrostatic Sensor Paver	<ul style="list-style-type: none"> • Paving Width • Paving Thickness • Quantity of concrete to be paved viz. capacity of paver • Terrain (Hilly/Plain) • Type of Work (Expressways/NH, SH, MDR, ODR, VR, Urban Road, Rural Roads)
	Fixed Form/Slip Form	<ul style="list-style-type: none"> • Variable shapes
	Fully Automatic/Semi Automatic Batcher	<ul style="list-style-type: none"> • Required Production rate • Required standards of Batching performance

Annexure - I

A. Definitions

Machine : Machine is an assemblage of rigid bodies that transmit forces, motion and energy in a pre-determined manner.

Mechanism : Mechanism is defined as a combination of rigid or resistant bodies, formed and connected so that they move with definite relative motions with respect to one another.

Plant : A plant is an assembly of mechanical and electronic Equipment, in which raw material is processed and undergoes through various processes to produce the desired output. The plant may be stationary (located at a permanent location) or portable (moved from site to site).

Paver Finisher : A self-propelled construction equipment that forms and finishes concrete simultaneously.

Slipform paving : Slip form paving is defined as process used to consolidate, form into geometric shape finish a Plain Cement Concrete (PCC) mass by pulling the forms continuously through and surrounding plastic concrete mass.

Roller : A roller is a compactor used to compact soil, gravel, concrete or asphalt in the construction.

Tool : A device that aid in accomplishing a task.

IS: 6461-6 (1972) 'Glossary of terms relating to cement concrete, Part 6: Equipment, tools and Plant' may be referred for definitions of terms related to Plants, Tools and Equipment.

Annexure - II

Ancillary items for concrete works

Gunny bags, hessian cloth, crow bar, pick axe, shovel, spade, powrah, canvas belt cloth, digital vernier calliper, iron rake, scrapper, sand paper, pouring kettle, plywood planks, gun for placing polysulphide, graduated wedge, string line guide wires, stakes 3d model, thermometer, kerosene stove, cycle pump, coir brush or wire brush.

Annexure - III

C Typical Range of Specifications

Based on the data collected from the various top equipment & plant manufacturers, the typical range of the various specifications has been figured out and mentioned below in the table.

a) Equipments for the layer Subgrade/GSB

S. No.	Equipment	Specifications	Range
1	Grader	Max speed forward/rev	40.8/51.7 kmph
		Min speed forward/rev	34 .1/42.5 kmph
		Turning radius min/max	6.5 - 12.4 m
		Blade width min/max	3.1 - 7.3 m
		Blade arc radius	413 - 550 mm
		Blade pull min/max	5480 - 43518 kgs
		Maximum Blade Position Angle min/max	35 - 90 deg
		Mouldboard Side shift – right min/max	660 - 4902 mm
		Moldboard Sideshift – right	510 - 4528 mm
		Maximum lift above ground	400 - 634 mm
2	Tandem	Maximum depth of cut	400 - 790 mm
		GVW	12000 - 65840 kgs
		Operating weight min/max	7260/13180 kgs
		Max Working speed	7.4 kmph
		Drum width	1500 - 1680 mm
		Drum dia	1140 - 1219 mm
		Vibration frequency	41.7/30.8 - 48/58 hz
3	Compactor	Amplitude	0.61/0.42 - 1.01/.41 mm
		Centrifugal force	63/63 - 120/99 KN
		Operating weight min/max	2562 - 24910 kgs
		Max Working speed	9.2 kmph
		Drum width	1067 - 2220 mm
		Drum dia	787 - 1784 mm
		Vibration frequency	27 / 30 - 30/42 Hz
4	PTR	Amplitude	1.2/0.53 - 2.3/0.48 mm
		Centrifugal force	55.6 - 368/239 KN
		Operating weight min/max	28300 - 3470 kgs
		Max working width	2084 - 1276 mm
		Max Working speed	11.5 kmph

b) Equipments for the layer DLC/PQC

S. No.	Equipment	Specifications	Range
1	Concrete batching plant	Capacity Min/max	12 - 360 m ³ /hr
		Batch count	40 - 60 cycle per hour
		Mixer capacity	0.5 - 6 m ³
		Precision of aggregates	2%
		Precision of cement/flyash/water	1%
		Max agg size	80 mm
2	Mobile concrete batching plant	Capacity Min/max	18 - 140 m ³ /hr
		Batch count	40 - 60 cycle per hour
		Mixer capacity	0.5 - 6 m ³
		Cement weigh capacity	100 - 2500 kgs
		Aggregate weigh capacity	875 -6000 kgs
3	Paver	Working width min/max	1.1 - 13 m
		Layer thickness	10 mm - 400 mm
		Paving speed	18 mpm - 90.5 mpm
		Laydown rate	250 - 1100 tph
		Hopper capacity	5-14 tonnes
		Screed vibration/min	0-3000
		Tamping strokes (5 mm)/min	0-1600
		Gradient	10%
4	Slipform paver	Paving width	2.0 - 16 m
		Paving thickness	0.4 - 0.5 m
		Working speed	5 - 11 mpm
		DBI- dia/length	20 - 40 mm/500 - 600 mm
		Tie bar - dia/length	20 - 40 mm/400 - 1200 mm
5	Transit mixer	Capacity	2 - 10 m ³
		Drum speed max	0-14 rpm
		Water tank min/max	200 - 650 litres
		Drum angle min/max	12 -15 degrees
		Filling ratio min/max	50 - 59 %
6	Fixed form paver	Paving width min/max	2.74 / 15 m
		Paving speed	5 mpm
		Based on Apollo	Drive tube speed
			0-80 RPM
			Strike tube Speed
			0-400 RPM
			Rate
			450 sq m/hr
	Based on HEM	No of hydraulic vibrators & normal operating pressure	8-12/800-1300 psi

S. No.	Equipment	Specifications	Range
7	Texturing and curing machine (Based on wirtgen)	Working width min/max Working height	3.65 m - 18 m 0 - 0.5 m
	(Based on Power curbers)	Operating speed	0-30.5 mpm
		Transverse boom	1.52 - 3.05 m
8	Placer/spreader	Placing spreading width	3.66 m - 12.2 m
	Based on Gomaco spreader	Strike off	7.32 m
		Belt conveyor - width	1.52 m
		Belt conveyor - length	6.71 m
		Belt drive/speed	Hydrostatic/149.81 mpm
		Track speed	Upto 21.18 mpm
		Spreader Auger type/dia/speed	Split/508 mm/29.5 rpm

