CHAPTER 2
TAMPING MACHINE AND DYNAMIC TRACK STABILIZER

201 General - Purpose of tamping and stabilization of track (ballast bed) is to produce well compacted sleeper supports in order to improve the load distribution across sleepers, restore track to correct geometry and have long lasting retentivity of packing. Tamping machines are used for correcting the track geometry and tamp the ballast while Dynamic Track Stabilizer (DTS) is used for better anchoring of the track skeleton in the ballast bed to improve the durability of track geometry under running traffic.

202 Tamping machine - Tamping machine measures the existing track parameters and lifts it to enable correction of the cross level and alignment, to achieve target or pre-determined parameter values, with an aim to improve the track geometry. It simultaneously packs the ballast under sleeper(s), using tamping tools fitted on tamping unit, to provide well compacted ballast bed.

(1) Functions - The main functions of tamping machines are-
   (a) Correction of alignment,
   (b) Correction of longitudinal and cross levels,
   (c) Tamping of ballast under the sleepers.

Some of the tamping machines have additional fitments for track ballast stabilization also.

(2) General Layout - General layout and important units of a tamping machine (09-32 CSM) are shown below-

![Diagram of tamping machine](image)

Fig. 2.1

203 Important assemblies of tamping machines

(1) Engine - Diesel engine is the main source of power. The engine converts chemical energy of fuel into mechanical energy, part of which is used directly
and remaining further converted into different forms of power for the working of machine.

(a) Mechanical power through gear boxes - A part of mechanical power generated is used, by means of hydrodynamic gearboxes (in most of the machines), for movement of tamping machine. Remaining mechanical power is converted to other forms as mentioned below.

(b) Hydraulic power through hydraulic pump - Hydraulic power is generated by means of hydraulic pump driven by mechanical power. It provides power for operations during working through various hydraulic motors and cylinders.

(c) Pneumatic power through compressor - Pneumatic power is generated by means of compressor driven by mechanical power. It is used for brakes and locking/unlocking system of assemblies, up and down movements of feelers, operation of bogies for datum selection, horn operation and chord tension etc.

(d) Electrical power through alternator and batteries - Electrical power is generated through alternator, or sourced from batteries. It is used to provide electrical power for sensing devices, feedback of corrected parameters, signals to hydraulic units, like directional valves, proportional valve and servo valve for operations.

(2) Tamping units - Two or more independent tamping units are provided in tamping machine (one or more for each rail depending on the make and model of the tamper). These are mounted on the machine frame by means of vertical guiding columns. In some of the machines, the tamping units are fitted to the satellite frame.

The tamping units on Indian Railways have the capability for tamping one/two/three sleepers at a time depending upon type and model of the tamping machine. The tools are arranged in pairs and each of the two sides of sleeper is tamped by four such pairs, four numbers on either side of each rail. The units are held on horizontal guide columns in order to slide sideways, which allow their manual/automatic centering over the rails in curves. The tools are vibrated by piston rods pivoted on eccentric shaft driven by hydraulic motors.

A typical layout of tamping unit and its different components are shown as Fig 2.2

The lifting and lowering of tamping units is achieved by means of a hydraulic tamping units lifting/ lowering cylinder. The insertion depth of tamping tools and squeezing pressure can be varied for different types of sleepers. In case of simultaneous tamping of double/triple sleepers, the opening width of tamping tools can be changed pneumatically by changing the clapper piece to suit the sleeper opening and by pneumatic operation of clapper cylinders for joint sleepers.
(3) **Tamping Tool** - The size & shape of the blade of tamping tool has a bearing on the quality of compaction (tamping) of ballast. The size of tamping tools differs, depending on model/make of tamping machine. Tamping tool with carbide shield called Tungsten Carbide Tamping Tool (TCTT) are now being used for improving the performance of tools. The positions of tamping tools (TCTT) for various machines with important dimensions are depicted at Annexure 2.1.

(4) **Lifting and Lining unit** - The lifting and lining unit is positioned in front of the tamping units. Lifting is carried out using one lifting cylinder with the help of roller clamps/hook on each side.

The lining operation starts simultaneously with the lifting operation. As soon as the target values are reached, lining and lifting operations are automatically stopped.

(5) **Satellite unit** - Continuous sleeper tamping machines have tamping & lifting cum lining unit, provided on the separate unit called satellite unit. Satellite unit is placed on an independent under-frame, which is mounted on wheels.
It can move independent of the main frame, capable of cyclic movement from sleeper to sleeper.

6. **Trolleys** - These are wheels mounted units provided with sensing feelers used for measurement and correction of the track parameters. Four trolleys are used in tamping machine, which are- front trolley, lining trolley, height transducer trolley, measuring trolley and rear trolley.

7. **Brake system** - Following types of braking system are provided on tamping machines:
   - **Direct brake** - It is applied only on machine during transit.
   - **Indirect brake** - This brake is used for application on machine and coupled camping coach/wagon while running. This brake system is provided in machines with KE valve. KE valve is available in all new tamping machines. It works with single piping system.
   - **Emergency brake** - This brake is applied on machine during transit alone or coupled with camping coach/wagon only when KE valve is in ‘ON’ position. It is applied through indirect brake system.
   - **Safety brake** - This brake is applied automatically by switching off hydrodynamic transmission gear (ZF Gear in Plasser machines). Normally this should not be used for service brake application.
   - **Parking brake** - This is hand operated mechanical brake, applied when machine is stabled.

204 Types of tamping machines

1. **Tampers without Satellite unit** - The tamping unit and the lifting cum lining unit are mounted on the main frame of the machine itself. The machine moves and stops at every sleeper for lining, levelling and tamping. One to two sleepers can be tamped simultaneously in one operation. Following machines fall in this category.

   a. **Duomatic (Plain Track Tamper)** - It is a Plain track tamper and with 32 tamping tools to pack two sleepers at a time. These machines are also referred as Work Site Tampers (WST) for purpose of nomenclature. The names of the models of Duomatic tamping machines presently in use on Indian Railways; and the name of manufacturer, are given below-
      - 08-32 Duomatic (Plasser India).
      - 08-32C Duomatic (Plasser India).
      - 08-32 WST with flat car (Metex–JSC Moscow, Russia).
      - VPR-02M without flat car (Kalugaputmash, Russia).

The important features/dimensions of these machines are given at Annexure 2.2.
(b) **UNIMAT (Points and Crossing Tamper)** - This is primarily a points and crossing tamping machine. Tamping unit of this machine is designed in a manner to allow independent operation of individual tamping tool. This helps in tamping of almost all the sleepers in points and crossings. Tamping tool(s), which infringes any track component, can be tilted individually or in pairs and rest of the tools tamp the sleepers. Tamping unit in most of these machines can be rotated to align with the sleepers, which are laid at an angle e.g. Fan Shaped Layout design. Advanced models of UNIMAT have the arrangement for lifting of third rail and more advanced have the provision for both; lifting as well as packing under the third rail. Various models of UNIMAT machines presently in use on Indian Railways with the name of the manufacturers are as under-

(i)  **08-275 UNIMAT (Plasser India).**  
(ii) **08-275-3S UNIMAT (Plasser India)** with arrangement only for lifting of third rail.  
(iii) **08-475-4S UNIMAT (Plasser India)** with arrangement for lifting and packing under the third rail.

The important features/dimensions of these machines are given at Annexure 2.3

(c) **Multi-Purpose Tamper (Plain and Points and Crossing Tamper)** - This machine is designed for spot attention on plain track as well as point and crossing. These may have a flat platform at rear end with crane facility for loading, unloading and transportation of P.way materials. Various models of Multi-Purpose Tampers, presently in use on Indian Railways are as given below-

(i) **UNIMAT Compact (MPT) (Plasser India),**  
(ii) **UNIMAT Compact Split Head (MFI) (Plasser India).**

The important features/dimensions of these machines are given at Annexure 2.4

(2) **Tampers with Satellite Unit** - These machines are provided with a satellite unit, which moves independent of the main machine in working mode. Components required for tamping, aligning and levelling of track are provided on this satellite unit. While the main machine moves at a uniform speed continuously, the satellite unit moves and stops at every sleeper (sleeper set) for lining, levelling and tamping. These machines do twist correction also. Different models of these types of machines can tamp two/three sleepers in one operation. The machines falling in this category are-

(a) **09-32 CSM (Plain Track Tampers)** - It is a Plain track tamper designed for lining, levelling, twist correction and tamping of sleepers. It has
tamping unit with 32 tamping tools to tamp two sleepers at a time. Single chord lining and double chord parallel levelling systems are used. The important features/dimensions of this machine are given at Annexure 2.5

(b) Tamping Express (09-3X) (Plain Track Tampers) - It is a plain track tamper designed for lining, levelling, twist correction and tamping of sleepers. It has 48 tamping tools to tamp three sleepers at a time. Single chord lining and double chord parallel levelling systems are used. The important features/dimensions of these machines are given at Annexure 2.6

205 Tamping Mechanism - The tamping units work according to the asynchronous constant pressure tamping principle. The tamping tools penetrate the ballast and perform a closing movement with sinusoidal vibrations, as shown in Fig 2.3.

![Fig. 2.3](image)

The tamping tools continue to move, pressing the ballast till desired force is reached and thus each of the tools applies the same force on the ballast. Since each of the tools continue to move for different durations and presses the ballast till the desired pressure is reached, the process is known as asynchronous constant pressure tamping operation. Components of tamping unit are shown in Fig 2.3.

All tamping tools, therefore, apply the same amount of pressure to the ballast being tamped; thus there is equilibrium of forces between the individual tool pairs and the specific surface pressure of all tools. During tamping of ballast, resistance gets built up in front of each pair of tools. The movement of the tool is completely
independent, according to the resistance encountered from the ballast. Once the resistance reaches the pre-selected value (hydraulic pressure in the squeezing cylinder), the corresponding tool pair stops squeezing automatically, however other tool pair(s) continue to squeeze till the resistance for those also becomes equal to preselected pressure. Individual tools may have different closing movements as shown in Fig 2.4.

![Fig. 2.4](image)

### 206 Tamping parameters

1. **Squeezing pressure** - Squeezing force per unit effective area of squeezing piston is called squeezing pressure. The force at face of tamping tool for consolidation of ballast will correspond to this squeezing force.

   For tamping units, presently available with Indian Railways, the squeezing pressure for different track structure is as below:

<table>
<thead>
<tr>
<th>Type of Track and Sleeper</th>
<th>Squeezing Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Track (CST9)</td>
<td>90-100 Kg/cm²</td>
</tr>
<tr>
<td>Plain track (ST&amp; wooden)</td>
<td>100-110 Kg/cm²</td>
</tr>
<tr>
<td>Plain track (PSC)</td>
<td>110-120 Kg/cm²</td>
</tr>
<tr>
<td>P &amp; C (ST/Wooden)</td>
<td>110-115 Kg/cm²</td>
</tr>
<tr>
<td>P &amp; C (PSC)</td>
<td>125-135 Kg/cm²</td>
</tr>
</tbody>
</table>

   The squeezing pressure should be kept on higher side of the stipulated range for caked ballast, however for deep screening sites and newly laid tracks with unconsolidated ballast bed, it could be on lower end of the range.

2. **Tamping depth** - For effective tamping of the ballast below the sleeper bottom, under the rail seat, the gap between top edge of the tamping tool blade and bottom edge of sleeper in closed position of the tamping tool should be adjusted depending upon the type of rail and sleeper. The desirable gap between top edge of the tamping tool blade and bottom edge of sleeper for different types of sleepers will be as under:
To obtain the correct depth of tamping tool during packing of sleepers, the initial (Zero) position of tamping tool is set as shown in Fig 2.5.

![Fig. 2.5](image)

**Fig. 2.5**

Tamping tool depth is calculated as:

\[
\text{Tamping tool depth} = \text{Sleeper depth at the rail seat location} + \text{Rail height} + \text{rubber pad thickness}
\]

**Example 2.1:**

For a track with 60 Kg rail and sleepers, the tamping depth will be

\[
= 172 \text{ mm (rail height)} + 210 \text{ mm (sleeper depth)} + 6 \text{ mm (thickness of rubber pad to drawing no. RDSO T-3711)}
\]

\[
= 388 \text{ mm (Fig 2.6)}
\]

![Fig. 2.6](image)

**Fig. 2.6**

(3) **Tamping Tool Vibration, Amplitude & Frequency** - The tamping tools are vibrated by piston rods pivoted on eccentric shaft driven by hydraulic motors with following parameters:

<table>
<thead>
<tr>
<th>Type of Sleeper</th>
<th>Desirable gap between top edge of the tamping tool blade and bottom edge of sleeper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat bottom sleeper</td>
<td>15-20 mm</td>
</tr>
<tr>
<td>Metal sleeper</td>
<td>22-25 mm</td>
</tr>
</tbody>
</table>

**Table 2.2**
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of revolution of vibration shaft</td>
<td>2000 to 2100 RPM (approx.)</td>
</tr>
<tr>
<td>Vibration frequency of tamping tool</td>
<td>33 to 35Hz. (approx.)</td>
</tr>
<tr>
<td>Amplitude of oscillation</td>
<td>3-5 mm</td>
</tr>
</tbody>
</table>

These values may vary depending on design/model/make of tamping machine. Technical manual of the machine may be referred for details of all such parameters.

4) **Vibration pressure** - The vibration pressure of tamping tool is so adjusted that vibration does not slow down or stop even while penetrating the ballast. The vibration pressure varies from machine-to-machine and ranges from 150 to 210 Kg/cm².

5) **Tamping cycle & squeezing time** - A complete tamping cycle involves lowering of tamping unit to the desired depth, squeezing of ballast (till all tool pairs reach pre-defined squeezing pressure), holding of tamping tools in that position, releasing and lifting of tamping unit & travelling of tamping unit to the next sleeper location. Time taken in squeezing the ballast with preset pressure is called the squeezing time.

Normal setting of machine is such that lifting and lining of track starts when the tamping unit is lowered by about 100 mm from its zero position. Squeezing action commences about 30 mm before the tool reaches the target depth. Squeezing...
circuit is cut-off as the preset squeezing time is completed. The tamping unit is then lifted in succession. Lifting and lining circuit is cut-off when tamping unit, while in lifting operation, is 100 mm before the Zero position. For maintenance packing, squeezing time of 0.8 second to 1.2 second should normally be adequate. Higher value of the above range of squeezing time is required for track with caked up ballast.

(6) **Tamping tool surface area** - Surface area of tamping tools blade of different machines is given in Annexure 2.1. Tools with more than 20% wear of the original surface area should not be used. The worn out tools are to be reconditioned/replaced.

### 207 Optional equipment

The use of optional equipment like Laser Beam System, Geometry Value Assessment (GVA), and ALC etc. simplifies working and reduces error-proneness associated with manual system of data collection and feeding. These systems are briefly described below-

(1) **Laser beam system** - A pair of photocells mounted on tamping machine receives a fanned-out laser beam from laser emitter. In case of unbalanced laser input received by photocells, a corresponding differential signal activates an electric motor, to move the whole receiver assembly along with front end of the chord to the centre of the laser beam. Thus, front tower end of chord is shifted laterally by the amount of error to enable design lining and levelling. Working of Laser Beam system is explained in Annexure 2.7.

(2) **Geometry Value Assessment (GVA)** - It is a small computer, which eliminates the feeding of adjustment values from tables and marking on sleepers. The locations of main points of curve i.e. starting of transition, transition length, radius, super elevation data etc. are fed into the computer.

The use of GVA eliminates the necessity of attention by operator for feeding values and thus avoids possible mistakes in calculations and/or feeding, which result in better progress with improved quality.

(3) **Automatic Guiding Computer (ALC) System** - It is advanced system, which automatically calculates the values of various track parameters, to be fed into machine on the basis of target track geometry. It has the capability to measure and record existing track parameters during a measuring run, in advance of working, and also allows flexibility to choose the desired track geometry. It also saves the operator from entering various parameters to be fed, as it does automatic feeding of parameters. The detailed working of this system is explained in Annexure 2.8. ALC’s are being provided with fault finding diagnostic software also.

(4) **Data Recording Processor (DRP) System** - It is a system for recording track parameters during working operation, at the working speed of the machine. It records the parameter of tamped track, like unevenness, alignment, cross-level, twist. The measuring sensors are so mounted that tamped track parameters are recorded in the working direction of the machine. It has a
system to predefined the limits of individual parameters and it is possible to evaluate and classify the measurement results. The parameters can also be displayed graphically along with calculated standard deviations of different parameters in small lengths (say 200 meter section). Apart from the track parameters, it can also be designed to record the machine working parameters like squeezing time, squeezing pressure and squeezing depth.

(5) **Computerized Measuring System (CMS)** - This is an on board computer used for displaying track parameters measured i.e. super elevation, versine and Longitudinal level etc. It also displays the nominal value fed by the operator. It also displays lifting and lining values fed manually, through Laser system and through ALC separately. It is used for digital calibration of lining and levelling system (For calibration of systems controlled by servo valve) & diagnosis of signals for proper working of these units.

(6) **Computerized Working System (CWS)** - This computer receives the various machine working parameter (controlled by proportional valve) from its circuit some of which are listed below and displays it on monitor-

(a) **Driving**: RPM of engine, work drive speed, run drive speed etc.

(b) **Tamping**: tamping depth, tamping position, speed of up and down of tamping unit, squeezing pressure, squeezing time etc.

(c) **Satellite drive** (if provided): satellite speed etc.

(d) **Automatic positioning**: Sleeper distance setting during automatic working.

It is also used for setting of the above parameters i.e. tamping parameter like tamping depth, squeezing time, squeezing pressure, satellite forward and reverse speeds etc.

208 **Lining system** - Lining system is for measuring and correction of track alignment. Single chord lining system is used in all tampers working on Indian Railways. The chord stretched between front and rear trolley is used for measuring alignment of track by means of measuring transducers. The track is, then slewed by lifting-cum-lining unit to the target alignment.

For the purpose of lining -

- Machine measures alignment of only one pre-selected reference rail and rectifies that rail i.e. reference rail.

- The alignment of other rail, being fixed with the sleeper, automatically gets rectified except for correcting the gauge defect.

- Versine on curved track depends on radius of curves, chord length for measurement and location of measurement.

(1) **Reference Rail** - The reference rail for carrying out attentions to alignment should be selected as given below-
(a) On curved track – outer rail (however, if outer rail is highly worn out, inner rail should be taken as reference rail).

(b) On straight track on single, double and middle line in multiple line section – Any of the two rails of the track being tamped, which is less disturbed.

(2) Lining method - Tamping machines follow two methods of alignment correction; 3-point & 4-point. Some of the latest machines have provision for only 3-point lining method.

(a) 4-Point Lining method - The selected reference rail is measured at four points on the curve taking two measurements for versines. These values are then compared to correct the geometry. This method reduces existing error significantly to improve the track alignment.

(b) 3-Point Lining method - The selected reference rail is measured using 3-points and the lining is performed until the measurement at middle measuring point reaches the target versine value. This method restores the geometry to almost perfect provided correct measurements are fed.

209 4 Point Lining method

(1) Lining principle - This method can be used for correcting alignment of only the curved track. In this method track is measured at 4 references point and versines measurements of two intermediate points are compared (using geometrical versine ratio relation) to control the lining. The principle followed is that, in a circular curve, versines measured at two pre-decided locations on a chord of given length will have a fixed ratio, depending on the position of measuring points. This versine ratio is constant and is independent of the radius of the circular curve. The four points in machines are as below-

![Diagram of 4 Point Lining method](image)

*Fig. 2.8*

Here A is the rear trolley location, B is the location of measuring trolley (where versine is measured), C is lining trolley (where also versine is measured and correction is done), and D is the front trolley location.
Trolleys at A, B, C and D are pneumatically pressed against the outer rail (reference rail selected for alignment). A wire forming the chord is stretched between A and D representing the ‘base Line’. The transmitting potentiometers (transducers), which are fixed to the measuring trolley B and lining trolley C are connected to this wire by means of forks and the wire drives for measurement of versines. The geometrical property used in this method is explained below-

From the above figure,

**Theoretical Versine** \( H_1 = \frac{AC \cdot CD}{2R} \)

**Theoretical Versine** \( H_2 = \frac{AB \cdot BD}{2R} \)

**Versine Ratio** \( i = \frac{H_1}{H_2} = \frac{AC \cdot CD}{AB \cdot BD} \) *(is independent of radius of the curve)*

\( H_1 = i \cdot H_2 \)

Machine does the curve correction by slewing point C, until Versine \( H_1 \) is in the correct ratio to \( H_2 \) \((H_1 = i \cdot H_2)\). The Versine Ratio ‘\( i \)’ is the property of machine and depends on respective distance between the trolleys. The value of ‘\( i \)’ for various machines are listed in **Annexure 2.9**

In a four point lining system, location of A is taken as first reference point for subsequent corrections. It is, therefore, important to choose initial point, on the track with correct geometry, as pre-existing error at the initial point will get transmitted to track location being corrected. All subsequent corrections will also have accumulated errors.

Points A & B of the machine always remain on the corrected track (corrected w.r.t previous positions). Point D always remains on the portion of track, which is yet to be corrected. Lining correction is done at point C. The machine system feeds \( H_2 \) in system, where it is multiplied with constant \( i \), to give \( H_1 \). This value \((H_1)\) is then fed in difference amplifier and error, if any, is indicated on the galvanometer. The alignment is corrected at C by lining
units so that $H_1$ becomes equal to $H_2i$ or the ratio $H_1/H_2 = i$ is maintained and galvanometer indicates zero reading.

In the machine having satellite units, the constant value ‘$i$’ may vary due to relative movement of position C. To overcome this problem a compensation system is provided to automatically adjust for measuring locations.

(2) **Application of 4-Point Lining Method** - 4-point lining method can be used in following situations-

(a) When theoretical track geometry is either not known or not required to be known, track is aligned according to geometrical properties of existing curve.

(b) When, due to the location of track defects, the track slewing values are expected to be so large that they cannot be implemented without additional measures, and it is decided to smoothen the curve and rather than bringing it to the targeted/design profile.

Lining can also be carried out according to reference points or previously set slewing values, as explained below-

210 **Corrections to be applied in 4 Point Lining method** - The curve to be corrected as explained above has to be further compensated for following errors-

- The error due to front trolley being on disturbed track,
- At variable curvature where front trolley and rear trolley are on curve of different radii and the ratio of $H_1/H_2$ equal to ‘$i$’ does not remain true, like transitions portion of the curve or while exiting and entering from one curve to another.

(1) **Correction ($F_D$) in 4 Point Lining due to Front trolley on Disturbed track**

![Diagram](image)

**Fig. 2.10**

In figure 2.10, curve marked 1 shows the targeted alignment, 2 shows existing position of track (disturbed) being attended and 3 is corrected alignment with front trolley on disturbed track.
Points A and B in figure 2.10 are on the previously aligned track, point D is the front end of the chord i.e. front trolley is on the disturbed track with an error $F_D$, resulting in incorrect measurement of versine $H_2$. Point C is slewed until $H_1$ is in the correct ratio to incorrectly measured $H_2$. Depending on the distances of the measuring points (which are fixed for a given machine), an error remains at lining Point C, as shown in the figure, which is also called left over error or residual error ‘$F_R$’.

Left over error $F_R = \frac{F_D}{n_{4pt}}$

Error reducing ratio $n_{4pt} = \frac{AD \cdot BD}{AC \cdot BC}$

Value $n_{4pt}$ depends on trolley distances and its value for various machines are given in **Annexure 2.9**.

A Correction equal to $F_D$ in the direction opposite to it needs to be fed in front tower to eliminate this left over error, to apply $F_R$ at lining trolley.

The $F_D$ value has to be computed from the readings taken during field survey to be done prior to tamping. Either of the two methods may be adopted for the field survey.

- Measurement of versine on reference rail of the track (which is generally termed as disturbed track) and calculating slews by suitable software for realignment of curves, for deciding target curve which will be termed as desired curve.
- Survey with respect to fixed references like reference post, OHE masts etc. This is to bring the track on targeted alignment which is termed as design lining.

**(2) Versine Compensation (V) in 4 Point Lining at location with changing curvature**

For simple curves with transition at either end, the corrections are applied at following sections of the curves:

- For entry of machine from straight to transition and existing from transition to straight.
- Machine working in transition.
- For entry of machine from transition to circular curve and existing from circular to transition curve.

When machine enters from straight to (leading) transition with front trolley on transition and rear trolley on straight, the measurement of $H_2$ and $H_1$ are as shown below:
The correct versine at C will be $H_{2,i} + V$, where V is the versine compensation required to bring track to target position. In the above curve, this compensation will be towards outside of the curve. The value of compensation increases as transition curve is parabolic of third degree and will become maximum ($V_m$) when entire machine is on transition curve and will then remain constant.

When the machine enters from leading transition to circular curve, the compensation reduces from $V_m$ and will eventually become zero when the entire machine enters the circular curve. Similarly, when the machine enters from curve to trailing transition and from trailing transition to straight, the versine compensation is applied in opposite direction as shown below:

**Fig. 2.12**

*Note: Versine correction is applied at trolley C but is to be fed by operator in front cabin and therefore to be written for front trolley D location i.e CD distance ahead of where it is applied. The above graph has been made accordingly.*
Here \( R \) is the radius of circular curve, \( L_1 \) and \( L_2 \) are the transition length at either end, \( L_0 \) is the chord length of machine, and \( V_{m1} \) and \( V_{m2} \) are maximum versine compensations at the two ends.

The value of \( V_m \) depends on 3 factors i.e. position of different trolleys of the tamping machine, length of transition and radius of circular curve and worked out by formula:

\[
V_m = \text{Machine Constant} / L \cdot R
\]

**Machine Constant** = \((AC, CD, BC)/6\) (\(AC, CD, BC\) are shown in Fig 2.8)

Variation of \( V \) is not linear from zero to maximum value \((V_m)\). The value of \( V_m \) for different lengths of transitions and radii of curves along with corresponding values of \( V \) at intermediate locations are given in machine manufacturer’s instruction manual.

A sample distribution for \( V \) in the chord length of \( L_0 \) as given manufacturer’s instruction manual is given in Annexure 2.10 for guidance.

In machines with ALC, radius of curve and transition length can be fed into ALC, and feeding of \( V \) value is done by ALC itself.

Example-2.2 below explains the method of calculating \( V \) and \( V_m \) value.

**Example 2.2:**

To attend a curve of radius \( R=583 \) m with transition length 70 m by DUOMATIC 08-32C using 4 Point method.

For DUOMATIC 08-32C from Annexure 2.9

\( AB=5.0 \) m, \( BC=5.3 \) m, \( CD=9.35 \) m, \( AC=10.3 \) m, \( BD=14.65 \) m and \( AD=19.65 \) m.

Machine constant= \((10.3\times9.35\times5.3)/6=85.06,\)

Hence \( V_m=85.06/70\times583=0.002 \) m i.e. 2.0 mm

From Annexure 2.10

\( V \) value from straight to transition-

<table>
<thead>
<tr>
<th>Distance from ST and CT (Meter)</th>
<th>0 to 8 m</th>
<th>9 to 13 m</th>
<th>14 to 19.7m</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V ) in mm</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance from TC and TS (Meter)</th>
<th>0 to 8 m</th>
<th>9 to 13 m</th>
<th>14 to 19.7m</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V ) in mm</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

\( ST, CT, TC \) and \( TS \) stands for straight to transition, curve to transition, transition to curve and transition to straight respectively.
For remaining portion of transition length \( V = V_m \) should be fed. Direction of feeding will be as shown in Fig 2.12.

Note: These values are to be written on sleepers to be fed in versine potentiometer in front cabin when front trolley is above that location

The general principle followed in deciding the direction of feeding (toggle switch) versine compensation is as below:

If machine is entering:

- From large radius (straight has infinite radius) to low radius -towards outside
- From Low radius to large radius -towards inside

Versine compensation and its direction in different curve layout are as below:

(a) Curve with Transition

(i) Straight to Transition to Curve to Transition to Straight

![Diagram](image)

**Fig. 2.13**

![Diagram](image)

**Fig. 2.14**
(ii) **Compound Curve**
- \( R_1 > R_2 \) \( V_0 = V_2 - V_1 \)

Fig. 2.15

- \( R_1 < R_2 \) \( V_0 = V_1 - V_2 \)

Fig. 2.16

(iii) **Reverse Curve**

Fig. 2.17

Note: The chord length shown in above figures is machine chord length.
(b) **Curve without Transition** - For curves without transition, the correction values applied is called F. The versine correction F, when machine is entering from straight into a circular curve is zero at the tangent point SC (Straight Curve Junction) and as the front trolley moves into the circular curve, the value of F gradually increases till it attains a max value F\(_m\). It then gradually reduces, till it becomes zero when the rear trolley reaches at the tangent point CS (Curve Straight Junction). The value of F\(_m\) can be calculated as given below-

\[
Fm = \frac{Constant \ (C_f)}{R} \quad \text{(fig 2.11)}
\]

\[
C_f = \frac{AC.CD.BC}{2(AD + BC)}
\]

F will increase to F\(_m\) at a distance X from SC and from CS where X is equal to

\[
X = \frac{AD.BD}{(AC + BC)}
\]

The variation of F is not linear. F depends on the position of trolleys and radius of curve. Its value for different curves for a particular machine is given in machine manufacturer’s instruction manual. A sample of F values with reference to radius of circular curve for a particular machine, as supplied by manufacturer is shown in **Annexure 2.11**. The method of feeding F value for different curve configurations are given below:

(i) **STRAIGHT –CURVE-STRAIGHT**

(ii) **COMPOUND CURVE**

- **CURVE 1 TO CURVE 2** (R\(_1\) > R\(_2\)) \(Fm_0 = Fm_2 - Fm_1\) (Fm\(_1\) and Fm\(_2\) are corrections as given by machine manufacturer for curve 1 and 2 respectively)
Modes of Tamping using 4-Point Lining Method (Only for curves) - The modes of tamping by 4-Point lining method for correcting the curve are

(1) **4-point Smoothening or Compensation Mode** - In this mode, tamping is done on the basis of existing (theoretical/average) track geometry without conducting alignment survey. However, the beginning and end of transitions and radius of circular curve are needed to calculate versine. Compensation value V, for maximum it is called Vm value (for curve with transition). Or F value, for maximum compensation called Fm value (in case
of curve without transition). The value of Vm depends upon transition length and radius and Fm value depends upon radius of curve and depending upon machine constant. The machine constant. In this method existing curve is smoothened, however it is not brought to any targeted profile.

In machines with ALC, radius of curve and both transition length can be fed into ALC, calculation and feeding of Vm value/ Fm value done and feeding of V value is done by ALC itself.

(2) **4- Point Design Lining** – Here field survey of curve to be attended is done in advance to ascertain the error (F_D) from targeted profile (which can be design or desired alignment) at different locations. In addition to correction Vm and V or Fm and F as applicable for design or desired curve (R and L is taken for this curve for all calculations), correction F_D is also applied. The curve here is smoothened and also brought to near targeted profile.

In machines with ALC, radius of curve and transition length can be fed into ALC, and input of V and Vm or F and Fm value is done by ALC itself. Front offset values can also be fed through ALC by making a data file. These values can be fed for any chosen interval (say every 10 m – lower value of 3 to 5 m is desirable) and the ALC interpolates the values for every tamping location in between accordingly. F_D values can be written on sleepers also and fed by operator in slew potentiometer.

**Annexure 2.12** gives an example showing stepwise procedure, to be followed for 4-point Lining.

**212 3 Point Lining Method**

(1) **Lining Principle** - 3- point lining method can be used for straight as well as curved track. The track is measured using three points B, C and D and aligned according to pre-specified theoretical versine at point C. The chord at measuring position B is fixed by the fork and the potentiometer is switched off. The ordinate at C only is measured on chord BD and compared with pre-set (or fed) ordinate value. Any difference detected will activate the lining control to effect the necessary correction.

![Fig. 2.22](image-url)
The measuring chord is fixed between Points B and D. Geometrically

$$H_1 = \frac{BC \cdot CD}{2R}$$

Theoretical value

$$H_1 = \frac{BC \cdot CD}{2R} = \frac{\text{System constant}}{R}$$

The theoretical versine of $H_1$ at point C is dependent on chord length for a given machine and curvature. Alignment correction is done until the theoretical versine $H_1$ is achieved.

(2) Application of 3-point lining method - The 3-point method is mainly used if-

(a) The track is to be lined according to specified radii or versines. For straight track this versine is taken as zero.

(b) The lining system is used in conjunction with a sighting device and remote control or a Laser.

213 Corrections to be applied in 3-point lining method

In above figure, Point B is on the already aligned track (target alignment) behind the machine. The front end of the chord, point D is on the existing (disturbed) track and is having lining error $F_D$. Point C is aligned until $H_1$ corresponds with the specified theoretical versine. Due to wrong position of trolley D, the residual error $F_R = F_D / n_{3pt}$, remains, which needs to be corrected. This error, if not corrected, will also result in wrong positioning of trolley B for next position of tamping as machine moves forward and therefore the error at correcting position C further accumulates/increases as machine moves forward.

$$n_{3pt} = \frac{BD}{BC}$$

$n_{3pt}$ value for available tamping machines is listed in Annexure 2.9

The $F_D$ value has to be computed from the readings taken during field survey to be done prior to taking up tamping. Any of the three methods may be adopted for the field survey.

Fig. 2.23

$F_R = F_D / n_{3pt}$

$H_1 = \frac{BC \cdot CD}{2R}$

$F_D$

$F_R$

$R_3 - R_1$

TARGETED ALIGNMENT

EXISTING ALIGNMENT

CORRECTED ALIGNMENT

$H_1$

$F_D$

$F_R$

$BD/BC$

$BC \cdot CD$
• Survey with respect to fixed references to get slews which is $F_D$ required to bring the track to original design location w.r.t which references were provided.

• Measurement of versine on reference rail of the existing track and calculating slews using software for realignment of curves to get desired curve. The slew value becomes $F_d$.

• Recording alignment by taking measuring run using ALC and on deciding targeted alignment, the versines to be achieved are calculated by ALC duly considering displaced location of front trolley ($F_D$). $F_d$ is automatically taken while tamping using ALC and are not to be fed separately.

The correction $F_D$ would be accordingly applied for tamping without using ALC as shown below.

![Diagram showing the alignment process](image)

*Fig. 2.24*

**Note:** These values are to be written on sleepers to be fed in slew potentiometer in front cabin when front trolley is above that location.

### 214 Determination of target versine values for the 3-point lining method

Target versines are achieved at C but are fed in versine potentiometer in front cabin. Thus, the versine values to be achieved at trolley C is fed CD distance ahead at front trolley D position. Machine manufacturer has accordingly given the versine diagram to be fed at front trolley position and is discussed below. Following nomenclatures are used for target versines-

- **H** = Target versine of circular curve.
- **Hx, Hy, Hz, Hw** = Target versines for parabolic transitions. (In Plasser India Machines, these parameters are shown as $H_a, H_b, H_c, H_d$. $H_v$ is the rate of increase/decrease of versine in transition.

The target versines for different portions of curve are calculated as shown below:
Section X, Y, Z and W equal to machine chord length (BD) for 3point lining.
The versine of circular curve is:-

\[ H = \frac{\text{System constant value}}{R} \]

**SECTION X** - The versine Hx for section X is calculated by dividing the prepared operation constant value “Cxz” for X and Z portion by the product “R* L1”. L1 is the length of transition at entry.

\[ Hx = \frac{\text{Operation constant value for X & Z (Cxz)}}{R \times L1} = \frac{C_{xz}}{R \times L1} \]

**BETWEEN SECTION X and Y** - After section X till TC (end of the transition) the versines are increased by adding of one “Hv” per meter

\[ Hv = \frac{\text{System constant value}}{R \times L1} = \frac{H}{L1} \]

**SECTION Y** - Hy for the section ‘Y’ are calculated as

\[ Hy = H – Hw \]

Where Hw is further defined below

**SECTION Z** - Hz for the section ‘Z’ is

\[ Hz = H – Hx \]

Where Hx is further defined below

and L2 is transition length at exit
**BETWEEN SECTION Z and W** - After section “Z” till “TS” the versine are decreased by subtracting of the “Hv” per meter, where Hv=H/L2

**SECTION W** - The Versine “Hw” is obtained from formula

\[
Hw = \text{Operational constant value for } Y \text{ and } W \ (Cyw) / R.L^2 = \frac{C_{yw}}{R.L^2}
\]

The operational constant Cxz and Cyw are given in manufacturers manual and can also be calculated for different machines.

An example with calculations of various versines is given below:

**Example 2.3.**

Method of attending curve of Radius 583 m and transition length 70 m at both end by 09-32 CSM using 3-Point lining system.

For 09-32 CSM (from Annexure-2.9)

\[
AB=6 \text{ m}, \ BC=4.7 \text{ m}, \ CD=10.05 \text{ m}, \ AC=10.7 \text{ m}, \ BD=14.75 \text{ m}, \ AD=20.75 \text{ m}
\]

Here \( H = \frac{BC \cdot CD}{2R} = \frac{23617}{40.5} = 40.5 \text{ mm} \)

\( Hv= 40.5/L = 0.578 \text{ mm/m} \)

**Versine for sections X, Y, Z and W**

<table>
<thead>
<tr>
<th>Distance from ST, TC, CT &amp; TS (in m)</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>14.75</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION X AND Z</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. L</td>
<td>40810 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant for sections X &amp; Z (Cxz)</td>
<td>0</td>
<td>425</td>
<td>3399</td>
<td>11417</td>
<td>27191</td>
<td>53107</td>
<td>90534</td>
<td>135455</td>
<td>153120</td>
</tr>
<tr>
<td>( H_x = \frac{C_{xz}}{R.L} )</td>
<td>0</td>
<td>0.01</td>
<td>0.08</td>
<td>0.3</td>
<td>0.6</td>
<td>1.3</td>
<td>2.2</td>
<td>3.3</td>
<td>3.7</td>
</tr>
<tr>
<td>( H_z = H - H_x )</td>
<td>40.5</td>
<td>40.5</td>
<td>40.4</td>
<td>40.2</td>
<td>39.9</td>
<td>39.2</td>
<td>38.3</td>
<td>37.2</td>
<td>36.8</td>
</tr>
<tr>
<td><strong>SECTION Y AND W</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant for sections Y &amp; W (Cyw)</td>
<td>195238</td>
<td>148428</td>
<td>104167</td>
<td>65004</td>
<td>33489</td>
<td>12170</td>
<td>2362</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>( H_w = \frac{C_{yw}}{R.L} )</td>
<td>4.8</td>
<td>3.63</td>
<td>2.55</td>
<td>1.6</td>
<td>0.8</td>
<td>0.3</td>
<td>0.06</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( H_y = H - H_w )</td>
<td>35.7</td>
<td>36.9</td>
<td>37.9</td>
<td>38.9</td>
<td>39.7</td>
<td>40.2</td>
<td>39.9</td>
<td>40.5</td>
<td>40.5</td>
</tr>
</tbody>
</table>
Here the operational constant value $C_{xz}$ and $C_{yz}$ are given by manufacturers after every 2 m, therefore the calculation of versine is for two meters interval. This may be calculated for alternate sleepers.

For portion between $X$ and $Y$ in transition, the versine at end of section $X$ is increased at the rate of $Hv$ per meter for the length of (transition length – chord length) where at the end it should be equal to versine at starting of section $Y$.

<table>
<thead>
<tr>
<th>Distance from end ST</th>
<th>14.75</th>
<th>24.74</th>
<th>34.75</th>
<th>44.75</th>
<th>55.75</th>
<th>65.75</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from end of $X(x)$</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>55.25</td>
</tr>
<tr>
<td>$H_{xy}=3.7+x.Hv$</td>
<td>3.7</td>
<td>9.5</td>
<td>15.3</td>
<td>21.0</td>
<td>26.8</td>
<td>32.6</td>
<td>35.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance from end CT</th>
<th>14.75</th>
<th>24.74</th>
<th>34.75</th>
<th>44.75</th>
<th>55.75</th>
<th>65.75</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from end of $Z(z)$</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>55.25</td>
</tr>
<tr>
<td>$H_{zw}=36.8-z.Hv$</td>
<td>36.8</td>
<td>31.02</td>
<td>25.24</td>
<td>19.46</td>
<td>13.68</td>
<td>7.9</td>
<td>4.86</td>
</tr>
</tbody>
</table>

For portion between section $Z$ and $W$, the versine at end of section $Z$ is reduced at the rate of $Hv$ per meter for the length of (transition – chord length), where at the end it should be equal to versine at starting of section $W$.

The calculation has been shown at 10 m intervals, which for practical purpose is calculated at every sleeper on interpolated accordingly.

Note: These values are to be written on sleepers to be fed in versine potentiometer in front cabin when front trolley is above that location.

(2) Curve without Transition.

![Diagram](image-url)
The versine $H$ for the circular curve is obtained from formula

$$H = \frac{\text{System constant value}}{R}$$

The operational constant $F_x$ and $F_w$ are given by machine manufacturers in their manufacturers manual.

**215 Mode of Tamping using 3-Point Lining Method** - The modes of tamping by 3-Point lining method for correcting curve are

1. **3- Point Elementary Mode Lining** – In this mode, tamping is done on the basis of existing track geometry (theoretical/average) without conducting field survey for calculating shift ($F_D$) of curve and tamping is done using calculated versines $H$, $H_x$, $H_y$, $H_z$ and $H_w$ or $H_F x$ and $H_F w$ as applicable on the basis of theoretical or average track geometry (Preferably) as ascertained based on versine measurement for feeding into the machine manually.

   In the machines with ALC, the track geometry parameters i.e. radius of curve, transition detail can be fed and the versine $H$, $H_x$, $H_y$ etc. are calculated by ALC and fed to the machine.

   In this mode of lining, since front offset is not fed, curve is not brought to the any desired or designed location. Error is reduced but curve is not smoothened as front trolley error is reflected at correcting trolley position C.

2. **3- Point Design Mode Lining** – In this mode, tamping is done to achieve targetted (desired/designed) track geometry. However, in addition, field survey of track to be attended is carried out in advance to ascertain the error ($F_D$) of existing track at different locations from desired or designed alignment. Here, calculated versines i.e. $H$, $H_x$, $H_y$, $H_z$ and $H_w$ or $H_F x$ and $H_F w$ as applicable, on the basis of designed/desired track geometry and correction $F_D$ for achieving this desired/designed alignment is fed into the machine manually.
In the machines with ALC, the targeted track geometry parameters i.e. radius of curve, transition detail etc. and FD required for target profile is fed (by creating a separate computer data file) and targeted versines H, Hx, Hy etc. are calculated by ALC and fed to the machine. FD can alternatively also be fed through front potentiometer (front cabin).

The track is brought to the designed or desired target geometry and location based on target curve taken for calculating versine values and FD.

(3) **Measuring Run (with ALC) Lining Modes** - In machines with ALC, measuring run for recording of the curve and correction to curve is done using 3-point mode. The targeted (desired) curve parameters (SE) including transition details etc. are decided based on recorded data and fed into ALC. The target versine at each location i.e. H, Hx, Hy etc. are calculated by ALC itself (after taking into account FD at different locations) using desired target geometry and the measured curve data to correct curve accordingly.

**Annexure 2.12** gives an example giving step wise procedure, to be followed for 3-point Lining.

### 216 Comparison between 3 Point and 4 Point Lining System:

3 Point lining method can be used for both straight and curve while 4 Point lining method should be used only for curves. The comparison of two methods is given below:

(1) **3-Point Lining elementary mode /4-point Lining Smoothening Mode**

<table>
<thead>
<tr>
<th>S.No</th>
<th>3 Point Lining in elementary Mode</th>
<th>4 Point Lining in Smoothening/Compensation Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Versine of desired curve i.e. H, Hx, Hy, Hz and Hy etc. are calculated based on theoretical geometry of existing curve and chord length of machine. The calculated versine value is fed through versine potentiometer.</td>
<td>For circular portion of curve, machine measures versine at measuring trolley (H₂) and versine at lining trolley (H₁) is corrected on the basis of versine ratio. In transition, versine correction (Vm etc) are calculated based on theoretical/average geometry of existing curve and chord length of machine and is applied through versine potentiometer.</td>
</tr>
<tr>
<td>B</td>
<td>Since FD is not considered, residual error is $F_D/n_{3pt}$. Depending on chord length, the value of $n_{3pt}$ for machines working on Indian Railways is between 3 to 3.5. The residual error is thus $F_D/3$ to $F_D/3.5$ i.e. 33% approx.</td>
<td>Residual error here is $F_D/n_{4pt}$. The value of $n_{4pt}$ is in between 6 to 7.5. The residual error is thus $F_D/6$ to $F_D/7.5$ i.e. 13 to 16% approx.</td>
</tr>
</tbody>
</table>
Note:

(i) The residual error in 4-Point lining in smoothening mode is less as compared to that in 3-Point lining in elementary mode. When curve is not measured in advance, the curve achieved based on the theoretical/average geometry may not be to the acceptable alignment.

(ii) In 4- point method, left over error at any station could influence the track alignment at next station. However, it is still desirable to use this method for smoothening of curve, as it reduces the station-to-station versine variation.

(2) 3-Point Lining /4-point Lining in Design Mode

<table>
<thead>
<tr>
<th>S.No.</th>
<th>3 Point Lining in Design Mode</th>
<th>4 Point Lining in Design Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Versine of target curve i.e. H, Hx, Hy, Hz and Hv etc. are calculated based on desired or designed curve geometry and chord length of machine. The calculated versine value is fed through versine potentiometer. In addition slew values (F0) are fed in the front tower in slew potentiometer.</td>
<td>For achieving targeted desired or designed curve geometry, machine measures versine at measuring trolley (H2) and versine at lining trolley (H1) is corrected on the basis of versine ratio. In transition, versine (Vm etc) correction calculated for targeted geometry is applied in addition by feeding these values through versine potentiometer. In addition to above slew values (F0) are fed in the front tower in slew potentiometer.</td>
</tr>
</tbody>
</table>
| B     | In machines with ALC,  
(i) The target geometry (design/desired) may be fed directly in ALC along with F0 to get that targeted alignment.  
(ii) Measuring run data can be used for deciding the desired curve alignment ALC considers correction F0, calculated on the basis of measured run curve profile and targeted curve profile and is not to be fed separately. | In machines with ALC,  
The target track geometry may be fed directly and Vm correction is applied automatically based on radius and transition details. |
<p>| C     | Used with LASER system | Not applicable. |</p>
<table>
<thead>
<tr>
<th>D</th>
<th>The curve can be brought to the designed or desired target geometry and location.</th>
<th>The curve here can be smoothened and brought to near designed alignment or desired alignment</th>
</tr>
</thead>
</table>

**Note:**

(i) *If the track is desired to be brought to the known position and geometry (designed alignment) using fixed references for $F_D$, 3-point lining in design mode should be followed (refer para 213 & 215(2)).*

(ii) *In absence of fixed references, it is advisable to use measuring run mode of tamping for achieving desired alignment (refer para 215(3)).*

(iii) *In absence of fixed references and when measuring run is not feasible, desired geometry based on ROC calculation and corresponding $F_D$ be used with or without ALC. (refer para 213 & 215(2)).*

(iv) *4-Point design mode should normally be used only when it is intended to smoothen the curve and bring it close to desired alignment.*

217 **Levelling of Track** - Fixed type parallel chord levelling system is provided on all tamping machines. Longitudinal level of both rails and cross-level is corrected.

(1) **Datum Rail and Cant Rail** – For correcting longitudinal profile, one of the rails is selected as datum (base) rail and other as a cant rail. Machine corrects datum rail and maintains cross-level on cant rail (other rail in case of straight track) with reference to datum rail. Datum (base) Rail should be selected as under:

- On curves- inner-rail.
- On straight track in double line-less disturbed rail, which is generally non-cess rail.
- On straight track in single line and straight middle track in multiple lines section- higher/less disturbed rail.

(2) **Selector Switch** – In tampers supplied by Plasser India, Cant Selector Switch is provided to select cant rail, which is kept opposite to the datum rail (base rail). In Russian Tamper, datum Selector Switch is provided for selecting datum Rail.

218 **Levelling and Lifting System**

(1) **Equipment** – It consists of two chord wires one for each rail, stretched tightly from Front tower (F) to Rear tower (R). Tamping machines rectify level defects in track by lifting it with reference to these levelling chords. Height transducers are mounted on middle feeler rods (M), which rest on track in between lifting unit and tamping unit. Both rails are controlled separately. Pendulums are provided between left and right feeler rods to keep both chords parallel and also measure cross level.
(2) Working – Height transducers provided on middle feeler rod measures the gap between its zero level and chord wire. Datum rail is lifted to eliminate this gap and other rail (cant rail) is lifted to bring specified cant between two rails, which is kept zero in straight track and equal to super elevation value on curved track.

(3) Reduction Ratio – In levelling process, front tower always remains on unlevelled track and rear tower on levelled track. Because of level defects at front tower location, the front end of the chord goes out of its correct position equal to level offset at that point. Due to incorrect position of the front end of chord proportional level errors remain after levelling.

Thus, the levelled track at M is having

\[ \text{Level error} = LF \cdot \frac{a}{a+b} = \frac{LF (Y)}{r} \]

Where,

- LF = Level offset (Y) at front tower
- \( r \) (reduction ratio) = \( \frac{a+b}{a} \)

(4) Reduction Ratio of Various Machines – Various machines have different reduction ratio (c/a) for lifting. Values for some of the important machines are:

<table>
<thead>
<tr>
<th>Bogie Distance (m)</th>
<th>08-275 UNIMAT</th>
<th>08-275-3S UNIMAT</th>
<th>09-32 CSM</th>
<th>UNIMAT Compact(MPT)</th>
<th>T-Express (09-3X)</th>
<th>08-32C Duomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM(a)</td>
<td>3.32</td>
<td>4.85</td>
<td>3.90</td>
<td>5.10</td>
<td>4.56</td>
<td>5.3</td>
</tr>
<tr>
<td>MF(b)</td>
<td>8.89</td>
<td>10.73</td>
<td>8.90</td>
<td>9.05</td>
<td>10.67</td>
<td>9.35</td>
</tr>
<tr>
<td>RF(a+b)</td>
<td>12.21</td>
<td>15.58</td>
<td>12.80</td>
<td>14.15</td>
<td>15.23</td>
<td>14.65</td>
</tr>
<tr>
<td>Reduction Ratio (r)</td>
<td>3.678</td>
<td>3.212</td>
<td>3.232</td>
<td>2.775</td>
<td>3.333</td>
<td>2.764</td>
</tr>
</tbody>
</table>
Mode of Working for Levelling - Tamping machine corrects the levelling error in following two modes.

1) **Smoothening or Compensation Levelling Mode** - In this mode, long level defect of track is not surveyed and general lift over the datum rail based on short wave defects is generally fixed (fed through potentiometer in front cabin) and the longitudinal level of track is smoothened accordingly. Longitudinal level is not completely corrected and thus some residual error \((F_R)\) remains.

![Fig. 2.30](image)

Only short wave defects, within the base of the machine can be smoothened. Super elevation in curve & correction value \(X\) & \(K\) (discussed at para 222(2) & (3)) are fed in addition. In the machines with ALC, the general lift and curve detail (design or desired as decided for alignment correction) may be fed through ALC in advance and the ALC will automatically adjust cant value fed and distribute SE in transition length.

In machines with CMS, the general lift, ramp in and ramp out is displayed on its screen.

2) **Design or Precision Levelling Mode** – In this mode instead of general lift, the lift value \((Y)\) for achieving target level based on field survey are fed through general lift potentiometer over the datum rail to rectify 100% error. All long wave and short-wave defects can be completely removed. Super elevation in curve & correction value \(X\) and \(K\) are fed in addition.

![Fig. 2.31](image)

In the machines with ALC, the target lifting value can be fed through ALC by preparing a data file or by writing them on sleepers. While working on curve, the radius, super elevation and transition length of targeted
desired/design curve can be fed in advance and the ALC will automatically adjust cant value fed and distribute SE in transition length.

*Note: Lift values at every location are to be written on sleeper to be fed in general lift potentiometer in front cabin when front tower is above that location.*

(3) **Measuring Run (ALC) Levelling Mode (for level on machine chord length)**

In machines with ALC, measuring run recording of the tangent track and curve can be done. The level of track is measured on levelling chord and is smoothened by eliminating different peaks and dips. However, long wave defect is not eliminated. In curves, after deciding targeted level and SE in circular portion the cant is distributed along the transition. In case additional lift of track is required, the minimum and maximum lift limits can be changed in ALC and track will be smoothened accordingly.

**220 General Lift** - It is the amount of lift, given to cover all undulations, for datum rail. The other rail is then lifted to maintain cross-level/super-elevation as required with reference to corrected datum rail.

(1) **Deciding General Lift** – The lifting of the track is decided based on the magnitude of the dips/peaks in the track. The target level for the datum should be such that it is always higher than the largest of dips, as ascertained by P.Way supervisor in advance, duly increased by a value of at least 10 mm at high points to achieve a uniform top surface of rail.

Therefore, the amount of lift, to be applied to datum rail, will be the algebraic difference of higher and lower point of Datum rail + 10 mm. Dips and peaks are decided on preliminary survey of Datum rail in chord equal to machine chord length (15 m) approximately for eliminating short wave defects. However, for straight track where datum is lower than other rail, it should be more than maximum cross level difference.

![Diagram](Fig. 2.32)

**Fig. 2.32**

(2) **Quantum of General Lift** – However, while fixing the target level, for datum rail, care should be taken to make sure that total lift value does not exceed 50 mm at any point on Datum rail. If more than 50 mm lift is required, it should be undertaken by in two passes of tamping machine. If lifting required is more than 30 mm but less than 50 mm, double insertion in the
same pass tamping should be done, minimum lift at any location should be 20 mm for effective tamping.

(3) **General Lift on Curves** – For Curves, when the existing super-elevation (SE) is less than equilibrium SE, general lift will be equal to track irregularities over the datum rail (inner rail + 10 mm) and when the existing SE is more than equilibrium SE, general lift will be the track irregularities in the datum rail plus max difference between existing and equilibrium SE

### 221 Ramp in Ramp out

(1) **Value of Ramp** – While giving the general lift, ramp in of 1 in 1000 and also while closing the work ramp out of 1 in 1000 should be given to the track for smooth transition.

![Fig. 2.33](image)

(2) **Method of Ramping** – Method of ramp in and ramp out and closing and opening of two successive blocks.

![Fig. 2.34](image)

(3) **Feeding of Ramp Values** – The principle of feeding lift for front tower (ramp in) is shown below:
As this machine is ahead to next position and suppose a lift of \( Y \) has been given to the front cabin. Total actual lift at lifting point (M) can be written

\[
T = X + \frac{Y - X}{r}
\]

In other words if \( T \) is the lift required at any position, the \( Y \) value at front tower would be

\[
Y = (T - X) \cdot r + X
\]

An example for ramp in and ramp out calculations is attached as Annexure-2.13

In machines with ALC, general lift value and ramp gradient is fed through it directly. In machines with CMS, general lift, and ramp gradient is displayed on screen.

222 Input of the Lifting and Cant Values - In machines like CSM, Tamping Express and UNIMAT-4S, the cross level is entered in the working cabin at location M. In other tampers it is fed in front tower (F).

The adjustment of the track lifting value (general lift/target height) is fed at the front reference (front cabin) point F manually or automatically. Proportional value is transmitted to electronic control and measuring transducer mounted on the middle feeler rod (M), which measures existing longitudinal level. Lifting of track is done till the difference becomes zero.

(1) Method of Feeding of Cant in Curves – In machines designed for feeding cross level through front cabin i.e. at F, following steps are to be followed:
(a) Total cant value should be distributed throughout the transition length in such a way that it is zero at ST & TS and maximum at TC & CT.

(b) Select higher rail as a cant rail.

(c) Do not feed super elevation when front F reaches at ST. Start increasing SE value from zero when M reaches ST. At this F is distance “b” (distance between M and F) away from ST.

(d) Cross level (XL) feeding at F, from there is increased at a uniform rate so that by the time R reaches ST, the desired value of SE at the position of M is achieved. Cross level (XL) feeding at F is accordingly adjusted and will normally be at rate more than the cant gradient.

(e) XL value from there and is increased at a uniform rate i.e. at cant gradient till M reaches TC and full SE is achieved there. The value of XL fed at F would be more than SE at this position as is seen above.

(f) Value of XL feeding at F is now decreased at uniform rate from there to make it equal to SE in a distance of “a” (distance between R and M).

(g) XL fed in F equal to SE shall remain constant over the circular curve and beyond until M reaches at CT.

(h) At this point start reducing XL till R reaches CT i.e. in a distance of “a” and the value at M and F should be as required there.

(i) XL at F is further reduced at a uniform rate equal to cant gradient, till M reaches TS. The value of XL in F at this position would be negative.
Beyond this the negative XL at F is increased to Zero in a distance of “a” i.e. till R reaches TS.

In machines like CSM, Tamping Express and UNIMAT-4S, in which cross level is entered in the working cabin at location M, the actual cant value at M is entered and additional feed of cant through ±10 mm potentiometer may also be required to be fed in front tower. In latest model machines, provided with encoders, additional feeding through ±10 mm potentiometer is not required. In most of such machines, the ±10 mm potentiometer is not being provided at all.

If the galvanometer does not come to zero position (desired cant is not achieved), additional correction required to bring it to zero, is to be fed through ±5 mm potentiometer in working cabin at M.

(2) **Correction (K) in Cross-Level to be fed due to error created by Curvature** –

While working in curve, both the levelling chord shifts inside. Also the height transducer gets tilted thus causing extra lift equal to K beyond general lift or lift value Y fed. Therefore, to achieve the desired level of track the general lift/lift value, will have to be reduced by value called correction “K”.

(a) Correction value “K” is fed while working in curve and is equal to

\[ K = \frac{\text{Constant.SE}}{R} \]

(b) The correction value "K" depends on radius, super elevation and gauge of the track. The constant varies from machine to machine. The K value is deducted from the amount of general lift/lift to be given in the front tower. The K value distribution is given in below.

(c) Value of K correction, depending on curvature, gauge and super elevation, for any machine is supplied by manufacturer in the instruction manual. A sample is enclosed as **Annexure 2.14.**
(3) **Attention to Vertical Curve** – The levelling chord and track profile are not parallel when machine works in vertical curve. The requirement of lift is either more or less than that given by machine in case of summit and valley curve respectively. To account for the same, general lift/lift value is adjusted depending on type of curve. Accordingly, additional correction value “X” is applied to general lift/lift value as below.

**Fig. 2.38**

(a) **For Summit Curves** – X’ value starts from beginning of summit (AA) as shown in Fig 2.38. The value of ‘X’ gets added to the existing lifting value & reaches maximum when the complete levelling chord is on the vertical curve. The value ‘X’ reduces from end of summit (AE) and becomes zero at the point so that the complete levelling chord is out of vertical curve. L is levelling chord length.

(b) **For Valley (sag) Curves** – If the vertical curve is as below then ‘X’ value starts from beginning of valley (AA) as shown in Fig 2.39. The value of ‘X’ gets subtracted to the existing lifting value & reaches maximum when the complete levelling chord is on the vertical curve. The value ‘X’ reduces from end of valley (AE) and becomes zero at the point so that the complete levelling chord is out of vertical curve. L is levelling chord length.

**Fig. 2.39**
The value of X for different vertical curves are given by machine manufacturer, One sample is enclosed as Annexure 2.15.

223 Survey and Working of Tamping Machines in Design Mode - The Guidelines for survey of track (for getting $F_0$ and $Y$), and operation of tie tamping machines in Design mode is given in Annexure 2.16. The methods of operation including feeding of requisite data in various modes of tamping are given in Annexure-2.12.

224 Works required Before, During and After Tamping

(1) General - Activities/works to be done before, during, and after tamping are elaborated in following paragraphs. In addition to the above, areas needing special care in respect of various machines are also brought out.

(2) Preparatory Works for Introduction of Tamping Machines for Plain Track and Turnouts - Before undertaking through maintenance tamping of plain track and/or turnouts, advance planning and fulfillment of pre-requisite are necessary to ensure quality work and increased retentivity of tamping. Action as detailed hereunder shall be taken and a detailed project report prepared duly incorporating location specific needs, if any.

(a) A field survey should be carried out to

(i) Determine existing profile of track including availability of clean and total ballast cushion, to decide the extent of lift and assess ballast requirements.

(ii) Take census of hogged and battered joints, if any, which may require end cropping or reconditioning etc.

(iii) Take census of broken and damaged sleeper on plain track as well as in turnouts.

(iv) Make assessment of the extent of cess repairs required.

(b) A minimum clean ballast cushion of 150 mm below the bottom of the sleepers, at rail seat location, is recommended for quality output and retentivity of tamping by the tamping machines. For new line, doubling, gauge conversion etc. the total (clean) cushion before undertaking tamping by machine should be at least 250 mm (on main line) and 150 mm on loop lines/siding.

(c) Availability of adequate ballast should be ensured in shoulders and cribs to allow required lift as per proposed vertical profile as per the relevant provisions in the Indian Railways permanent Way Manual (with all correction slips) and Indian Railways Schedule of Dimensions (with all correction slips) and to maintain ballast profile as per IRPWM after tamping work.

(d) Track drainage should be improved and pumping locations should be attended. Rounded ballast in these locations should be replaced with
clean and angular ballast. For aforesaid objectives planning and execution of deep screening of ballast, if required, training out of ballast, and cess repair works should be done well in advance.

(e) All broken and damaged sleepers should be replaced including those in points and crossings.

(f) Necessary attention to hogged/battered joints is given, as required, by end cropping or reconditioning etc.

(g) Permanent reference pillars for alignment as discussed in Annexure 2.16 should be marked.

(h) In case of tamping on turnouts, sufficient length of approach track, taking into account the special track features on either side should also be planned for tamping. In case of the turnout leading to loop line, the turn in-curve shall also be tamped along with turnout.

(3) Pre-tamping Works - The following preparatory works shall be completed before undertaking tamping of track

(a) Another round of field survey should be carried out just before deployment of tamping machine to update the existing profile of track and rework proposed track profile as per guidelines detailed in Annexure 2.16. The time gap between this field survey and actual tamping machine working should be minimum.

(b) In case the permanent reference pillars have been installed and documented, the slew and lift data can be used directly.

(c) Alternatively the measuring run facility (ALC) of tamping machine, if available, should be used for surveying the existing track profile and determination of proposed track profile during the block itself just before commencing tamping operation.

(d) The beginning and the end of curve/transition curves should be written conspicuously on sleepers. In addition various parameters mentioned below (as shown in the sketch) should be written on every alternate/every third sleeper for use of the operator for feeding.

(i) For straight track–slew (F_D), lift (Y) values for designed longitudinal profile.

(ii) For horizontal curves–slew (F_D), versine compensation (V_m/F) values (in 4 point lining system) or versine (H, Hx, Hy, Hz, Hw ) values (in 3 point lining system) Super-elevation and lowering values (K correction), lift (Y) values for designed longitudinal profile.

(iii) For vertical curves–correction values for vertical curves (X correction).
(e) Ballast should be heaped up in the tamping zone to ensure effective packing. However, sleeper top should be visible to the operator and the ballast must not obstruct the working of lifting rollers.

(f) Necessary attention to all remaining hogged/battered joints, as required, is given.

(g) All cup joints, if any, should also be attended.

(h) Deficient fittings and fastenings should be made good and all fittings and fastenings like fish bolts, keys, cotters, loose-jaws, elastic rail clips etc. should be properly tightened. Worn out fittings and rubber pads should also be replaced.

(i) Sleepers should be squared, uniformly spaced and the gauge corrected.

(j) De-stressing of rails, adjustment of creep, expansion gaps in joints and SEJs etc., if necessary, shall be carried out.

(k) Guard-rails at the approach of girder bridges and on ballasted deck bridges shall be removed temporarily.

(l) All obstructions such as rail lubricators, signal rods & bonds, cable pipes, axle counter etc., which may obstruct the tamping tools should be removed temporarily. In case it is not possible to remove, these obstructions should be clearly marked and made known to the operator before the start of the work.

(m) Wooden distance blocks (pieces) on platform lines, wooden blocks and joggled fish plates etc. shall be removed temporarily ahead of tamping & J-clips therein shall be replaced with proper liners and ERCs.

(n) In electrified sections, the earth/structure /cross bonds should either be removed temporarily or properly adjusted for unobstructed tamping.
(o) Level crossing shall be opened and check-rail shall be removed temporarily ahead of tamping machine.

(p) Suitable speed restriction as per the policy guidelines issued by Railway shall be imposed, if existing Joggled fishplates are removed before packing. This speed restriction shall be relaxed only after re-fixing Joggled fishplates.

(q) For **turnouts**, following works should be done in addition

(i) Complete layout including spacing of sleepers as per relevant drawings shall be checked and corrected, if required.

(ii) The broken/battered or worn nose of the crossing should be either replaced or reconditioned, as necessary.

(iii) Ensure that all broken/damaged sleepers, if any, in crossing portion have been replaced.

(iv) High points on the turn out and approaches should be determined and general lift should be decided. General lift of minimum 10 mm must be given.

(v) A joint inspection by SSE/TM and SSE/P.way shall also be carried out to ensure that pre-requisite and preparatory work, to achieve high quality work by machine, are ensured.

(r) **Co-ordination with other Departments:**

(i) **Operating Department:** for planning and arrangement of sufficient line blocks to ensure optimum use of tamping machines.

(ii) **Electrical Department:** for availability of OHE staff, as required.

(iii) **S&T Department:** for availability of signal staff and making communication arrangements, as required.

(4) **Operations During Tamping** - The following points should be observed by the SSE/JE/TM and the SSE/JE/P.Way:

(a) The tamping machine should work in design mode only, except for initial round of tamping at worksite. DTS shall be deployed to work behind the tamping machine in the same block.

(b) The tamping (Squeezing) pressure should be adjusted according to the type of sleeper as sleeper as given in Para 206(1).

(c) The gap between top edge of the tamping blade and the bottom edge of the sleeper in closed position of the tamping tools should be adjusted depending upon the type of rail and sleepers. The gap for different types of sleepers should be as given in para 206 (2).

(d) During tamping the squeezing time should be kept as specified in Para 206 (5) Lower squeezing time should be chosen for ballast in un-
consolidated/partially consolidated conditions. Higher squeezing time may be required for track with caked up ballast.

(e) The machine should have full compliments of tamping tools. The tamping tools should not be loose or worn out. The wear on the tool blade should not be more than that specified in Para 206 (6).

(f) Care should be taken to ensure that tamping tools are inserted centrally between the sleepers into the ballast to avoid damage to sleepers. The number of insertions of the tamping tool per sleeper varies with the type of sleeper and the amount of track lift to be given as per Para 220(2). One additional insertion should be given for joint sleepers.

(g) For LWR/CWR track, the relevant provisions of LWR manual shall be adhered to.

(h) Ramp in and Ramp out to be provided as per Para 221.

(i) If work is to be done during night, sufficient lighting at work site should be ensured.

(j) Correct feeding of relevant values – $F_d$, $Y$, $V_m$, $F$, $H$, $K$, $X$ shall be ensured, while working in manual mode.

(k) During tamping, the parameters of tamped track should be checked immediately after tamping for cross level and alignment and necessary corrective action should be taken.

(l) For Turnouts

(i) Ensure that sufficient length (at least 50 m) of approach track, taking into account the special track features, on either side are also tamped in continuation.

(ii) For turnouts in quick succession, without sufficient length in between, adequate line block shall be planned to tamp adjacent turnouts together.

(iii) S&T connections and stretcher bars shall be removed.

(iv) While moving the machine over the switch after tamping on main line portion, either leading or first following stretcher bar is connected for safe movement of machine over switch.

(v) For tamping of turnouts, main line portion is to be tamped first. Sequence of tamping is given in Annexure 2.17.

(vi) In case of diamonds (with/without slips), direction of more traffic should be tamped first as shown in Annexure 2.17.

(vii) While tamping mainline portion, the additional lifting arrangement, provided in the machine (UNIMAT-3s), lifts the turnout side rail also. Therefore the lifted end of sleepers on turnout side should be adequately supported on wooden
wedges, or using non-infringing jacks under rails, till these sleepers are tamped by machine. In latest model (UNIMAT-4s), tamping of sleeper support under third rail can also be tamped.

(viii) In case of the turnouts leading to loop rail, the turn in-curve shall also be tamped in continuation.

(m) It should be ensured that S&T and electrical staff are associated during the work.

(5) Post Tamping Operations - The Section Engineer (P. Way) shall pay attention to the following items:

(a) Checking and tightening of loose fittings.

(b) Replacement of broken fittings.

(c) The ballast shall be dressed neatly as per IRPWM profile. Proper consolidation of ballast between the sleepers shall be done manually in case Tamping machine is not followed by DTS.

(d) Actual output of the work done, shall be compared with reference to rated output. Analysis and monitoring of ineffective time shall be done.

(e) Any unusual occurrences shall invariably be reported to M/C control & Engineering Control along with loss of working time, if any.

(f) Final track parameters on straight track as well as main line on turnouts should be recorded with the help of recorders provided in the tamping machine or by optional equipment like Data Recording Processor (DRP) or by separate run of track measuring trolleys etc. The machine should, after tamping, be able to achieve track geometry generally to category A standards, but in no case lower than category B limits specified in IRPWM.

(g) A copy of this record should be kept with the Section Engineer (P. Way).

(h) If the recorder is not available, then gauge and cross level at every 5th sleepers of tamped track should be recorded.

(i) In addition, the versines and super-elevation of curves shall also be recorded.

(j) While working in LWR territory, the provision of Manual of Instructions on Long Welded Rail (with all correction slips) should be followed.

(k) The fixtures like checkrails etc. removed during pre-tamping operation should be restored.

(l) Guard rails removed during preparatory work should be restored.

(m) Distance blocks on platform lines, joggle fishplates, OHE bonds, signaling rods/bonds & cables pipes shall be put in place and fittings shall be tightened.
Dynamic Track Stabilizer (DTS)

(1) General – During maintenance operations such as tamping, lifting, slewing, deep screening etc. the lateral resistance of track gets reduced which rebuilds gradually with passage of trains. This consolidation can also be achieved faster, uniformly and more effectively by means of a Dynamic Track Stabilizer.

(2) General Layout – The general layout of Dynamic Track Stabilizer are given below:

![Diagram of Dynamic Track Stabilizer]

Advantages of DTS - Consolidation by the DTS has the following major advantages:

(a) Elimination of initial differential settlements, which are caused by the impact of passing trains.

(b) The track geometry achieved by tamping machines is retained for a longer duration as consolidated structure of ballast bed is built up.

(c) Lateral track resistance increases resulting in enhanced safety against track buckling.

(d) Speed restrictions can be relaxed earlier.

(4) Brake System

Following types of braking system are provided on machine:

(i) Direct Brake - It is applied only on machine during transit.

(ii) Indirect Brake - This brake is used for application on machine and coupled camping coach/ wagon while running. This brake system is provided in machines with KE valve. KE valve is available in all new tamping machines. It works with single piping system.
(iii) **Emergency Brake**- This brake is applied on machine during transit alone or coupled with camping coach/wagon only when KE valve is in ‘on’ position. It is applied through indirect brake system.

(iv) **Safety Brake**- This brake is applied automatically by switching off hydrodynamic transmission gear (ZF Gear in Plasser machines). This should not be normally used as service braking system.

(v) **Parking Brake**- This is hand operated mechanical brake, applied when machine is stabled.

### 226 Working Principle of Dynamic Track Stabilizer

1. **Mechanism of DTS** – Heavy dynamic consolidating units are pressed firmly against both rails by hydraulic pressure. Flywheels produce a horizontal oscillations (some of machines use vertical oscillations also) directed laterally to the track, which together with a vertical load is transmitted onto the track and subsequently to the ballast bed. The dynamic effect of directional oscillation causes the sleepers to be "rubbed into' the ballast bed and produces a "flowing movement" of the ballast which get denser by filling of the voids.

   This compaction causes not only a controlled and uniform settlement of the track but also an enhanced friction between sleeper and compacted ballast bed, thus increasing lateral track resistance.

   The oscillation frequency is adjustable. The impact by the dynamic force and simultaneously applied static force are important aspects of functioning of DTS. Hydraulic cylinders attached between the machine frame and the consolidating units apply vertical static loads on both rails. The vertical load helps in maintaining firm contact between the consolidating units and the track for transmitting the oscillation. The vertical static pressure is also adjustable.

2. **Levelling System in DTS** – DTS is equipped with a levelling system, which prevents the longitudinal, and cross level values achieved after tamping from varying due to differential settlement of various segments of track during operation of DTS. The transducers of the longitudinal level and the cross level measuring system recognize the tendencies towards formation of faults of this kind and influence the load control with their measuring signal via the automatic governor, thus counteracting the tendency of propagation of the faults.

3. **Speed of Working of DTS** – The speed of working can be controlled by an adjustable hydrostatic drive. If the track geometry is corrected by several passes of the tamping machine, then a low speed of working of 0.5 kmph to 1.0 kmph is selected for first and second passes of the machine. For subsequent passes, higher working speed is selected.

4. **Stabilization Achieved by DTS**- It is possible to permit speed of 40 kmph on
freshly deep-screened tack, if ballast is adequate and Dynamic Track Stabilizer has been used behind the tamping machine.

227 **Modes of Working of Dynamic Track Stabilizer** - The machines are capable of working in following two modes

(1) **Maximum Settlement/Constant Pre Load Mode (i.e. Levelling system-OFF)** – In the this mode of working, the machine works to achieve higher consolidation through maximum pressure (vertical load) and thus larger settlement, however, the settlement achieved in this mode of working is usually irregular, though the consolidation level of ballast bed is high.

(2) **Controlled Settlement/Variable Pre Load Mode (i.e. Levelling system-ON)** – In this mode of working, the DTS machines are capable of settling the track in a controlled manner while maintaining the track geometry, both longitudinal and cross level. A settlement value is preselected (around 30% of lift during tamping) and the pressure (vertical load) in the long cylinders is controlled by levelling system. In some machines measuring and control system has been installed which can remove any residual fault in track geometry.

228 **Types of Dynamic Track Stabilizer** - There are three make of DTS machines in use over Indian railways

(1) **Types of DTS**
   (a) DTS 62N (Plasser India).
   (b) DTS VKL-404IN (BHEL, India).
   (c) DTS DSP-C8T (METEX -JSC, Moscow Russia).

(2) **Salient Features of Different DTS** – The important dimensions of the machines are given at Annexure 2.18. Salient features and technology used in different machines are given below:

<table>
<thead>
<tr>
<th>S.N.o.</th>
<th>Feature</th>
<th>Plasser’s DTS – DGS-62N</th>
<th>BHEL’s DTS – VKL-404IN</th>
<th>METEX’s DTS – DSP-C8T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bogie</td>
<td>One bogie is powered bogie for travel drive and both bogie serves as powered bogie for working drive</td>
<td>One bogie is driving and second is idle. The driving bogie is equipped with two traction motors.</td>
<td>One bogie is driving and second is idle during running. However, during working, both bogies are powered.</td>
</tr>
<tr>
<td>2.</td>
<td>Stabilizing Units</td>
<td>Has, two stabilizing units. Each stabilizing</td>
<td>Has, two stabilizing units. Each stabilizing</td>
<td>Three stabilizing units located at the middle part of the</td>
</tr>
</tbody>
</table>
unit consists of a frame with 4 running rollers with flange inside, a horizontal running guide rollers per rail and the vibration drive unit. The running rollers are pressed against the railhead from inside during the vibration process and the horizontal guide rollers from outside. The stabilizing units are designed that only horizontal vibration occurs by means of a cardan shaft.

The running rollers are so designed to enables the work in the turnouts. The roller balances are equipped with the blades, which guide the rollers through the crossing.

<table>
<thead>
<tr>
<th>3.</th>
<th>Vibration frequency</th>
<th>0-45 Hz (Favorable range 32 to 37 Hz)</th>
<th>0-40 Hz (Favorable range 32 to 35 Hz)</th>
<th>40-49 Hz (Vertical vibration) (Favorable range 40 to 45 Hz) 20-22.5 Hz (Horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>Working speed</td>
<td>0-2.5 Kmph</td>
<td>0-3.0 Kmph</td>
<td>0-2.5 Kmph</td>
</tr>
<tr>
<td>5.</td>
<td>Vertical preload</td>
<td>240 KN MAX. (120 KN on each stabilizing unit)</td>
<td>240 KN MAX (120 KN on each stabilizing unit)</td>
<td>320 KN MAX. (106.6 KN on each stabilizing unit)</td>
</tr>
<tr>
<td>6.</td>
<td>Leveling System</td>
<td>The measuring system of the leveling device works on the principle of three</td>
<td>No Leveling System</td>
<td>The measuring system of the leveling device works on the principle of four</td>
</tr>
<tr>
<td></td>
<td>Working Mode</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>--------------</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td>There are two working modes:</td>
<td>There are also two working modes:</td>
<td>There are two working modes:</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>i) Controlled Settlement mode.</td>
<td>i) Constant Drop Mode CDM.</td>
<td>i) Levelling mode which is computer controlled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii) Maximum Settlement mode</td>
<td>ii) Constant Thrust Mode CTM</td>
<td>ii) Constant Vertical Preload</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Max Drop Value</td>
<td>10 mm (Leveling mode)</td>
<td>In constant thrust mode –CTM-10 to 50 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>In constant drop mode-CDM-5 to 10 mm</td>
<td>Up to 20 mm (Leveling mode)</td>
<td></td>
</tr>
</tbody>
</table>

### 229 Working of DTS

1. **General** – The machine should be used in maximum settlement mode at renewal or deep screening sites. On maintenance site, it should be used in controlled settlement. Track should be consolidated by DTS following the tamping machine in the same block, to ensure faster and uniform consolidation.

2. **Precautions in DTS Working** – The following extra precautions are necessary in the operation of this machine:

   a. Complete and tight fittings to hold rails with sleepers are essential.

   b. Adequate pre-depositing of ballast for achieving the required profile is necessary.

   c. The vertical pre-load is to be selected, if the levelling system is used, in such a way that the determined maximum settlement is not exceeded.

   d. The selection of frequency (depending on track condition), working speed and vertical pre-load should be judicious according to the needs and with/without “Levelling” system in “ON” condition. The frequency to be properly set when the machine appears to be in smooth behaviour i.e. the vibrations are transmitted to the track and not back to the machine.

   e. When **stabilizing track on bridge with ballasted deck**, there are chances of resonance if applied frequency matches with the natural frequency of the bridge. The natural frequencies of bridges with span over 10 m lies below 30 Hz. Therefore, normally higher frequency of
40-45 Hz shall be selected when working on bridges. When working on major or important bridges, sufficient staff should be deputed to observe the bridge spans, especially the bearings, during stabilizing operations. If any unusual sounds/vibrations/movements are noticed, stabilizing operations shall be immediately stopped on that bridge and a speed restriction of 20 kmph shall be imposed on the bridge till it is examined minimum at the level of JE (Bridge).

(f) While working the machine in stretches adjacent to walls, trench walls, retaining walls, platform etc. no restrictions for the working of the machines are normally necessary. However, when these structures are defective, extra care is necessary in the proximity of 20 m on either side to avoid likely damages to the structure.

(g) No stabilizing work in tunnels is permitted.

(h) When working behind tamping machine attending track at maintenance site and deep screening site, DTS (Plasser make) should work with following parameters.

<table>
<thead>
<tr>
<th>Table 2.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
</tr>
<tr>
<td>A. Stabilization of Plain Track during maintenance tamping</td>
</tr>
<tr>
<td>ON</td>
</tr>
<tr>
<td>B. Stabilization after tamping of Plain Track at newly laid/deep screened track</td>
</tr>
<tr>
<td>After first tamping operation</td>
</tr>
<tr>
<td>After second tamping operation</td>
</tr>
<tr>
<td>After final tamping operation</td>
</tr>
<tr>
<td>C. Stabilization of Points and crossing during maintenance tamping</td>
</tr>
<tr>
<td>ON</td>
</tr>
</tbody>
</table>
(i) While stabilizing Points and Crossing, DTS should not be stopped at crossing portion.

(j) Ramp in and ramp out (1 in 1000) should be given while starting the work or restarting the work at any time.
### Annexure 2.1

**Position of Tamping Tools in Tamping Machines**

(1) **Position of Tamping Tools for 09-3X Tamping Machine**

<table>
<thead>
<tr>
<th>Tool</th>
<th>RDSO Drg. No</th>
<th>Total No Required (out of 48)</th>
<th>Tool Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RDSO/TM/15A/16</td>
<td>32</td>
<td><img src="image1.png" alt="Tool Sketch" /></td>
</tr>
<tr>
<td>5</td>
<td>RDSO/TM/15E/16</td>
<td>16</td>
<td><img src="image2.png" alt="Tool Sketch" /></td>
</tr>
</tbody>
</table>

(2) **Position of Tamping Tools for New CSM (MODEL CSM-955 On Ward) And DUOMATIC (New) Tamping Machine**

<table>
<thead>
<tr>
<th>Tool</th>
<th>RDSO Drg. No</th>
<th>Total No Required (Out of 32)</th>
<th>Tool Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RDSO/TM/15A/16</td>
<td>08</td>
<td><img src="image3.png" alt="Tool Sketch" /></td>
</tr>
<tr>
<td>2</td>
<td>RDSO/TM/15B/16</td>
<td>08</td>
<td><img src="image4.png" alt="Tool Sketch" /></td>
</tr>
<tr>
<td>3</td>
<td>RDSO/TM/15C/16</td>
<td>08</td>
<td><img src="image5.png" alt="Tool Sketch" /></td>
</tr>
<tr>
<td>4</td>
<td>RDSO/TM/15D/16</td>
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<td><img src="image6.png" alt="Tool Sketch" /></td>
</tr>
</tbody>
</table>
### (3) Position of Tamping Tools for CSM (upto CSM 954) & DUO Tamping Machine (Old Model)

**NOTE:**
1. NO. 2 & 4 CAN BE REPLACED BY EACH OTHER
2. DIMENSIONS ARE IN MM.

<table>
<thead>
<tr>
<th>Tool</th>
<th>RDSO Drg. No</th>
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<th>Tool Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>RDSO/TM/14A/16</td>
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</tr>
<tr>
<td>7</td>
<td>RDSO/TM/14B/16</td>
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<tr>
<td>8</td>
<td>RDSO/TM/14C/16</td>
<td>04</td>
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</tr>
<tr>
<td>9</td>
<td>RDSO/TM/14D/16</td>
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</tbody>
</table>

### (4) Position of Tamping Tools for UNIMAT-4S Tamping Machine

<table>
<thead>
<tr>
<th>Tool</th>
<th>RDSO Drg. No</th>
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<th>Tool Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RDSO/TM/01A/16</td>
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<td><img src="#" alt="Tool Sketch" /></td>
</tr>
<tr>
<td>2</td>
<td>RDSO/TM/01B/16</td>
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</table>

### (5) Position of Tamping Tools for UNIMAT-2S & 3S Tamping Machine

<table>
<thead>
<tr>
<th>Tool</th>
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<th>Total No Required (Out of 16)</th>
<th>Tool Sketch</th>
</tr>
</thead>
<tbody>
<tr>
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<td>08</td>
<td><img src="#" alt="Tool Sketch" /></td>
</tr>
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<td>3</td>
<td>RDSO/TM/01C/16</td>
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</tbody>
</table>
### Annexure 2.2

**Important Features/Dimensions of DUOMATIC & WST METEX**

#### DUOMATIC

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>WHEEL DIA</th>
<th>AXLE LOAD</th>
<th>WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-32 DUO</td>
<td>18940</td>
<td>17670</td>
<td>635</td>
<td>2125</td>
<td>1830</td>
<td>1455</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1080</td>
<td>3350</td>
<td>730</td>
</tr>
<tr>
<td>08-32C DUO</td>
<td>17670</td>
<td>16400</td>
<td>635</td>
<td>1800</td>
<td>1800</td>
<td>1600</td>
<td>2060</td>
<td>6440</td>
<td></td>
<td></td>
<td>1105</td>
<td>3715</td>
<td>850</td>
</tr>
<tr>
<td>VPR-02M2C DUO WITHOUT FLAT CAR</td>
<td>17740</td>
<td>16470</td>
<td>635</td>
<td>3130</td>
<td>1830</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1105</td>
<td>3780</td>
<td>732</td>
</tr>
</tbody>
</table>

All dimensions are in mm.

#### WST METEX (WITH FLAT CAR)

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>WHEEL DIA</th>
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<th>WIDTH</th>
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<tbody>
<tr>
<td>WST METEX</td>
<td>23550</td>
<td>2000</td>
<td>5800</td>
<td>11300</td>
<td>3130</td>
<td>1830</td>
<td>1105</td>
<td>3810</td>
<td>710</td>
<td>12.5t</td>
<td>3000</td>
</tr>
</tbody>
</table>

All dimensions are in mm.
## Annexure 2.3

### Important Features/Dimensions of Points & Crossing Tamping Machine

#### POINT & CROSSING TAMPPING MACHINE

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>WHIFFI DIA</th>
<th>AXLE LOAD</th>
<th>WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-275 UNIMAT</td>
<td>19140</td>
<td>17900</td>
<td>11500</td>
<td>1500</td>
<td>620</td>
<td>1530</td>
<td></td>
<td></td>
<td>3200</td>
<td>1040</td>
<td>3300</td>
<td>730</td>
<td>11.5t</td>
<td>3050</td>
</tr>
<tr>
<td>08-275 3S</td>
<td>21670</td>
<td>20400</td>
<td>14000</td>
<td>1800</td>
<td>635</td>
<td>1830</td>
<td></td>
<td></td>
<td>3200</td>
<td>1105</td>
<td>3550</td>
<td>730</td>
<td>17.34t</td>
<td>3000</td>
</tr>
<tr>
<td>08-475 4S</td>
<td>28370</td>
<td>27100</td>
<td>14000</td>
<td>1800</td>
<td>635</td>
<td>1830</td>
<td>1160</td>
<td>10110</td>
<td>3200</td>
<td>1105</td>
<td>3743</td>
<td>920</td>
<td>19.8t</td>
<td>3000</td>
</tr>
</tbody>
</table>

**ALL DIMENSIONS ARE IN mm.**
Annexure 2.4

Important Features/Dimensions of UNIMAT Split Head MFI & Multipurpose Tamping Machine

### UNIMAT SPLIT HEAD MFI

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>WHEEL DIA</th>
<th>AXLE LOAD</th>
<th>WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIMAT SPLIT HEAD MFI</td>
<td>28570</td>
<td>19000</td>
<td>12000</td>
<td>1830</td>
<td>635</td>
<td>1435</td>
<td>1300</td>
<td>8350</td>
<td>3500</td>
<td>1105</td>
<td>3350</td>
<td>730</td>
<td>15.75t</td>
<td>3000</td>
</tr>
</tbody>
</table>

All dimensions are in mm.

### MULTIPURPOSE TAMPPING (UNIMAT-COMPACT/M)

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>WHEEL DIA</th>
<th>AXLE LOAD</th>
<th>WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>MULTI PURPOSE TAMPPING MACHINE</td>
<td>19270</td>
<td>18000</td>
<td>635</td>
<td>12000</td>
<td>1800</td>
<td>1500</td>
<td>9600</td>
<td>3000</td>
<td>1105</td>
<td>3793</td>
<td>730</td>
<td>11.5t</td>
<td>3100</td>
<td></td>
</tr>
</tbody>
</table>

All dimensions are in mm.
Annexure 2.5

Important Features/Dimensions of Continuous Tamping Machine 09-32-CSM

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>WHEEL DIA</th>
<th>SATELLITE DIA</th>
<th>AXLE LOAD</th>
<th>WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-32-CSM</td>
<td>20670</td>
<td>19400</td>
<td>13700</td>
<td>1800</td>
<td>4170</td>
<td>1100</td>
<td>3500</td>
<td>730</td>
<td>730</td>
<td>13.0t</td>
<td>3040</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE IN mm.
Annexure 2.6

Important Features /Dimensions of Tamping Express (09-3X) (Plain Track Tampers) of Different Models

WORKING DIRECTION

WORKING DIRECTION

REAR CABIN
SPACIOUS
CABIN

3 SLEEPER TAMPING UNIT

SUBFRAME

LIFTING AND LINING UNIT

MAIN MACHINE

FRONT CABIN

NAME OF MACHINE

TAMPING EXPRESS

09-3X

AXLE LOAD 18.5t

AXLE LOAD 20.0t

AXLE LOAD 21.0t

TAMPING EXPRESS 09-3X

AXLE LOAD 18.5t

AXLE LOAD 20.0t

AXLE LOAD 21.0t

TAMPING EXPRESS 09-3X

AXLE LOAD 20.0t

AXLE LOAD 21.0t

NAME OF MACHINE

TAMPING EXPRESS 09-3X

AXLE LOAD 18.5t

TAMPING EXPRESS 09-3X

AXLE LOAD 20.0t

TAMPING EXPRESS 09-3X

AXLE LOAD 21.0t

TAMPING EXPRESS

09-3X

AXLE LOAD 18.5t

AXLE LOAD 20.0t

AXLE LOAD 21.0t

TAMPING EXPRESS

09-3X

AXLE LOAD 18.5t

AXLE LOAD 20.0t

AXLE LOAD 21.0t

NAME OF MACHINE

TAMPING EXPRESS 09-3X

AXLE LOAD 18.5t

TAMPING EXPRESS 09-3X

AXLE LOAD 20.0t

TAMPING EXPRESS 09-3X

AXLE LOAD 21.0t

TAMPING EXPRESS

09-3X

AXLE LOAD 18.5t

AXLE LOAD 20.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t

AXLE LOAD 21.0t
Laser Sighting System

LASER lining is used on straight track in 3-point mode to remove long misalignment or false curve on otherwise straight track. The LASER system consists of LASER gun (transmitter) and LASER receiver. The LASER trolley, which consists of laser gun, is placed in front of the machine up to 200-300m away. The receiver mounted on the front tightening trolley is adjustable so that it follows the LASER beam and the position is detected by a transducer that provides an input to the lining system equivalent to the offset of the front of the chord. As the machine is working, it moves up to the LASER trolley until the distance is a minimum of 20 m away. LASER system operates fully automatically and is able to cope with distances of up to 300 m. But LASER lining is only applicable for straight track. Important details are given below:

(1) By means of a special device, the LASER beam is fanned vertically in such a way that, the eventual change in track height has no influence on the system.

(2) By means of an automatic follow up control, the LASER receiver is always positioned at the centre of the LASER beam and therefore determines the input of the slewing values.

(3) The distance of the LASER gun from the machine is also dependent on the ambient conditions (rain, snow, fog, high ambient temperature). In good ambient conditions (clear, dry air) the lining distance can be extended considerably.

Working Sequence of Design Lining with the Laser Sighting System

Phase 1 (Initial Setting) - LASER transmitter is positioned as far as possible from the machine. If the lining error (F) at P is known, the laser transmitter can be, adjusted laterally by amount of lining error F.

Phase 2 and 3 when the design lining commences, the front end of the chord with the LASER receiver is shifted by an amount of the error F₀ in the direction of the emitted laser from transmitter. The track is lined at point C and matches exactly with the line of sight.
Phase 4 and 5: The machine drives forward and the front end of the chord is matched up again with the line of sight. The machine is ready for the next lining operation.
Annexure 2.8

**Automatic Guiding Computer (ALC) System**

It is advanced computer software loaded on on-board computer, which automatically calculates target output for the lining, levelling and cant based on manual input of required track geometry or measuring run data. The alignment, cant (SE) and level (gradient) are also displayed on the computer screen.

(1) Known Track Geometry mode

(a) Lining - If the track geometry is known, the data required for lining to be fed in ALC are

(i) Beginning of transitions
(ii) Transition lengths
(iii) Radius of circular curve
(iv) Front offset (Fd) Value

ALC software draws the curve according to input data of curve and displays on computer screen. The ALC also calculates theoretical H, Hx, Hy, Hz and HW values for 3-Point lining or Vm/F values for 4-Point lining system accordingly for different locations.

While working in 4-point lining system, on curves, Vm/F values can be supplied by ALC, based on fed geometry viz. radius of circular curve and transition curve details etc.

In 3-Point lining system, ALC feeds the relevant theoretical value of H, Hx, Hy, Hz and HW calculated on basis of fed geometry for that location to printed circuit board (PCB). The difference (error) in existing track parameters and fed values is calculated by (PCB) and track is corrected accordingly to eliminate the differential.

In addition, by conducting field survey for alignment, the slew values (Fd) are calculated and fed into the machine either manually or through ALC by creating a front offset data file, for design mode working.

While working on straight track, the ALC works in 3-Point lining system only by taking H values as zero.

Location of track geometry where alignment has to be fed into the machine is shown below. The input will be displayed in the same format.

(b) Levelling - If the track geometry is known, the data required for leveling and cant correction to be fed in ALC are:

(i) Beginning of transitions
(ii) Transition lengths

(iii) Maximum Cant (super-elevation)

(iv) Beginning and end of vertical curve (circular) and its radius or gradient detail.

The ALC feeds the calculated SE value, K value and X value at different locations for correction by the machine. At any location (point) required cant and lift value can be seen on screen by positioning the curser.

Target height (Y) values for datum rail are fed in general lift potentiometer (values may be written on sleepers) or through a data file of distance and target height (prepared separately) for automatic leveling by ALC.

Location where superelevation and gradient are fed into ALC are shown below:

(2) Unknown Track Geometry or Measuring run mode

(a) Lining - Measuring run and correction to alignment is done in 3-Point system only. The ALC measures the existing track geometry by taking a measuring run at a speed up-to 10 km/h. The existing track geometry is also displayed on computer screen. The target curve alignment can be decided on the basis of measuring run data and the curve can be corrected accordingly. Front offset value is automatically calculated by ALC and fed based on existing and proposed geometry.

(b) Levelling - Measuring run records the vertical profile of the track and the level is smoothened to best profile within the maximum and minimum lifting value fed through ALC computer.
### Machine Trolley Distances

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Machine</th>
<th>Trolley Distances, I, N, Constant Value 7 System constant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AB</td>
<td>BC</td>
</tr>
<tr>
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<td>5</td>
</tr>
<tr>
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<td>5</td>
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</tr>
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<td>3</td>
<td>4.2</td>
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</tr>
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</table>
Annexure 2.10

Sample-Versine compensation (V) in 4 point lining at Location with changing curvature (DUO-0832C)

<table>
<thead>
<tr>
<th>V-VALUES</th>
<th>Transition - curve</th>
<th>Transition - straight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjustment from Front Cabin</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Vo</td>
<td>1.00</td>
<td>0.98</td>
</tr>
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<table>
<thead>
<tr>
<th>V-VALUES</th>
<th>straight - transition</th>
<th>curve - transition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjustment from front cabin</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Vo</td>
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<td>0.02</td>
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|          | 8    | 0    | 0    | 0    | 1    | 1    | 2    | 2    | 3    | 4    | 5    | 6    | 7    | 7    | 8    | 8    | 8    | 0    | 0    | 0    | 0
Annexure 2.11

Sample- F- Values with reference to radius of circular curve

<table>
<thead>
<tr>
<th>F-VALUES (for circular curves without transitions)</th>
<th>R</th>
<th>Fm</th>
</tr>
</thead>
<tbody>
<tr>
<td>990</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>980</td>
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<tr>
<td>970</td>
<td>9</td>
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</tr>
<tr>
<td>960</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>950</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>940</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F-VALUES</th>
<th>Adjustment from front cabin</th>
</tr>
</thead>
<tbody>
<tr>
<td>straight - curve</td>
<td>curve - straight</td>
</tr>
<tr>
<td>Adjustments from front cabin</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>2.0</td>
</tr>
<tr>
<td>Fo</td>
<td>0.04</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
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<td>6</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

83
Annexure 2.12

Example: Sequence of tamping of track by WST 08-32C.

A. Detail about track & general input.
   i) SE= 50 mm. R=400 m. Transition Length L1 & L2=50 m.
   ii) General lift required 30 mm (based on general survey)
   iii) Starting and closing shall not be in curve.

B. Detail about Machine 08.32C.
   i) Lining chord
      \[ AC=10.30 \quad CD=9.35 \quad BC=5.30 \quad AB=5 \text{ m} \]
      \[ BD=14.65 \text{ m} \quad AD=19.65 \text{ m}. \]
   ii) Levelling Chord.
      \[ RM=5300 \text{ mm} \quad MF=9350 \text{ mm} \quad RF=14650 \text{ mm} \]

C. Sequence of working

1. Tamping parameters setting.
   i) Set tamping depth=Sleeper height + Rail height+6 mm (Pad)
   ii) Set Sq. time as prescribed in instruction manual for that machine.
   iii) Deciding on squeezing pressure.

2. General lift (manual feeding through front potentiometer)
   Calculation method is given in Annexure 2.10 should be followed.

Length of ramp in and ramp out = 30.1000 = 30,000 mm
No. of sleepers in which this ramp is achieved = 30,000/600 = 50
No. of sleepers in length RM(a) = 5.3/0.6 = 9
No. of sleeper in length MF(b) = 9.35/0.6 = 16
Rate of lift per sleeper = 30/50 = 0.6 mm
So, feeding of lift value on 66 sleepers in ramp in will be 66X 0.6 = 39.6 mm (40 mm)
Lift at other locations can accordingly be calculated.

3. 4-Point Lining
   Calculation Vm value is done by Formula \[ Vm = \frac{AC.CD.BC}{6RL} \]
   Vm value also given in respective machine catalogue
Here \( V_m = \frac{10.30 \times 9.35 \times 5.30}{6 \times 400 \times 50} = 4.25 \text{ mm} = 4 \text{ mm} \)

Distribution of 4 mm is given in machine catalogue and shall be fed through versine potentiometer. The direction and distribution of \( V \) value (compensation Value) will be as below

4. **3 – Point Lining**

If machine is working in 3 point Lining then calculate following versines for input.

I) \( H \) value = \( \frac{BC \times CD}{2R} = \frac{5.30 \times 9.35}{2 \times 400} = 62 \text{ mm} \) or constant \( / R = \frac{24778}{400} \)

II) \( H_v \) (versine varying per meter) = \( \frac{BC \times CD}{2RL} = \frac{62}{50} = 1.24 \text{ mm/m} \)

It may also be calculated as

\[ H_v = \frac{\text{versine at starting Y-verseine at end of x}}{(\text{Transition Length} - \text{Machine chord length})} \]

Length of \( X, Y, Z \) & \( W \) i.e. \( =BD=14.75 \)

\( H_x, H_y, H_z \) and \( H_w \) shall be calculated as given in Example-2

5. **Levelling System**

   a) **Cant**

   If fed through front tower, cant should be fed as given in Para 224 (1)
Divide cant value (Max) by transition length = 50mm/50m = 1mm/m
Cant value to be distributed in full transition as shown above. Similar to the method shown for feeding general lift the cant value in front tower for getting a cant of 50 mm at TC will be

\[ = (50 \text{ mm} + 0.6 \times 16) \times 1 = 59.6 \text{ mm} \]

Cant at other locations can be calculated accordingly.
If fed in working cabin, the actual cant at that location (M) shall be fed, with maximum value as 50 mm.

b) **K Correction Value** - While working in curve general lift has to be reduced by K value as given in para 224 (2). The value of K correction is supplied by manufacturers in their manual.

K value of given data = 3 mm, which means 3 mm will be subtracted from general lift 30 mm in circular position i.e. max between TC to CT and Zero at ST and TS.

![](image)

K=0
K=3
K=0

\([\text{ST} \quad \text{TC} \quad \text{CT} \quad \text{TS}]\)

![Diagram](image)

K=0

K=0

c) **X Value** - For vertical curve, X value should be fed as described in manual.

*In machines with ALC, all the above parameters are either fed or are automatically calculated by ALC itself on the basis of input of track geometry.*

6. **Additional Input for Design Mode of Lining and Levelling:**

I) **Lining:** \(F_D\) value (offset value) fed in the front cabin by slew potentiometer. \(F_D\) is amount by which track is shifted from its desired/design position

II) **Levelling:** target height value (Y) i.e. Desired lift over the Datum rail.

\(F_D\) and Y are determined by field survey and calculating slew and lift manually/using software and can also be fed by making a data file for ALC or by using laser (3-Point Lining) system as applicable.

Alternatively, in machines with ALC where Measuring run is taken all the required feedings (included front offset \(F_D\) and lift Y) are automatically taken into account based on final alignment decided.
In brief the input required in different mode of working on curves are

<table>
<thead>
<tr>
<th>Mode of working</th>
<th>Values to be fed</th>
<th>Slew</th>
<th>cant</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Versine/versine compensation</td>
<td>Yes (Versine compensation)</td>
<td>Yes</td>
<td>1. Existing curve radius and Transition length required for calculating versine compensation (Vm).</td>
<td></td>
</tr>
<tr>
<td>4 pt. smoothening/compensation mode</td>
<td>Yes (Versine compensation)</td>
<td>-</td>
<td>2. Desired cant should be known.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. K-value should be calculated and adjusted in general lift.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. X-value if required should also be adjusted in general lift.</td>
<td></td>
</tr>
<tr>
<td>4 point design /Precision mode</td>
<td>Yes (versine compensation)</td>
<td>Yes (F₀ Values)</td>
<td>1. Designed curve radius and Transition length required for calculating versine compensation (Vm).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Designed cant should be known.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. K-value should be calculated and adjusted in lift value (Y).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. X-value if required should also be adjusted in lift value (Y).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. In addition to above, F₀ and Y should be ascertained by field survey for designed curve.</td>
<td></td>
</tr>
<tr>
<td>3 point Elementary mode</td>
<td>Yes (Versine values H, Hₓ, Hᵧ, Hzw, Hᵥ, HFₓ, HFw)</td>
<td>yes</td>
<td>1. Existing curve radius and Transition length required for calculating Versine values.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Designed cant should be known.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. K-value should be calculated and adjusted in general lift.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. X-value if required should also be adjusted in general lift.</td>
<td></td>
</tr>
<tr>
<td>3 point design or precision mode</td>
<td>Yes (Versine values H, Hₓ, Hᵧ, Hzw, Hᵥ, HFₓ, HFw)</td>
<td>Yes (F₀ Value)</td>
<td>1. Designed curve radius and Transition length required for calculating Versine values.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Designed cant should be known.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. K-value should be calculated and adjusted in lift value (Y).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. X-value if required should also be adjusted in lift value (Y).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. In addition to above, F₀ and Y should be ascertained by field survey for designed curve..</td>
<td></td>
</tr>
</tbody>
</table>


Annexure 2.13

Example – Ramp In and Ramp Out (Fed through front potentiometer)

Diagram For Feeding of Ramp In and Ramp Out

Say general lift is 20mm and track has sleeper spacing of 60 cm.

Length of track in which gradient of 1 in 1000 is achieved = 20×1000 = 20,000 mm

No of sleepers in which ramp is achieved = 20000/600 = 34

Rate of lift per sleeper would be: 20/34 mm i.e. 0.6 mm

Machine used has a=4.0 m b=8.0 m c=12.0 m and r=3

No of sleepers in between FM = b/0.6 = 13

No of sleepers between RM = a/0.6 = 7

The calculation is tabulated below, however it must be noted that

1. This is only a sample calculation shown. The lift values should be rounded off when applied in field.

2. The above sample may also be used for tamping by machines by tamping 2/3 sleepers at a time by properly selecting the lift value.

3. In design mode tamping, ramp should be provided as per actual lift value at the close of work.
<table>
<thead>
<tr>
<th>Sleeper No From start of Ramp in nth sleeper (Xn)</th>
<th>LIFT at nth sleeper (Fn)</th>
<th>FEED at Front tower (Fn)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.6</td>
<td>1.8</td>
<td>Xn=n<em>0.6, Fn=Xn</em>r</td>
</tr>
<tr>
<td>2</td>
<td>1.2</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.8</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2.4</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.6</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4.2</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.8</td>
<td>13.2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>5.4</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>6.6</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>7.2</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>7.8</td>
<td>16.2</td>
<td>Xn=n*0.6, Fn=F7 + (n-7)*0.6</td>
</tr>
<tr>
<td>14</td>
<td>8.4</td>
<td>16.8</td>
<td>And will continue till n=34</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>9.6</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>10.2</td>
<td>18.6</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>10.8</td>
<td>19.2</td>
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</tr>
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<td>19</td>
<td>11.4</td>
<td>19.8</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>20.4</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>12.6</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

Ramp in feed value Contd.. |

<table>
<thead>
<tr>
<th>Sleeper No From start of Ramp in nth sleeper (Xn)</th>
<th>LIFT at nth sleeper (Fn)</th>
<th>FEED at Front tower (Fn)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>12.6</td>
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</tr>
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<td>22</td>
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<td>21.6</td>
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<td>23</td>
<td>13.8</td>
<td>22.2</td>
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<tr>
<td>24</td>
<td>14.4</td>
<td>22.8</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>15</td>
<td>23.4</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>15.6</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>16.2</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>16.8</td>
<td>25.2</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>17.4</td>
<td>25.8</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>18</td>
<td>26.4</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>18.6</td>
<td>27</td>
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</tr>
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<td>32</td>
<td>19.2</td>
<td>27.6</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>19.8</td>
<td>28.2</td>
<td></td>
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<tr>
<td>34</td>
<td>20.4</td>
<td>28.8</td>
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<td>27.6</td>
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</tr>
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<td>36</td>
<td>20.4</td>
<td>26.4</td>
<td></td>
</tr>
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<td></td>
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<td>20.4</td>
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<td>22.8</td>
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</tr>
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<td></td>
</tr>
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<td>43</td>
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<td>20.4</td>
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</tr>
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<td>44</td>
<td>20.4</td>
<td>20.4</td>
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<td>20.4</td>
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<td>20.4</td>
<td>20.4</td>
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<td>51</td>
<td>20.4</td>
<td>20.4</td>
<td></td>
</tr>
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<td>52</td>
<td>20.4</td>
<td>20.4</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>20.4</td>
<td>20.4</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>20.4</td>
<td>20.4</td>
<td></td>
</tr>
</tbody>
</table>

Xn remains constant and Fn reduces to 20.4 in next 7 sleepers @ (28.4-20.4)/7 = 1.2 mm/sleeper
<table>
<thead>
<tr>
<th>Sleeper No From start of Ramp out</th>
<th>LIFT at nth sleeper (Xn)</th>
<th>FEED at Front tower (Fn)</th>
<th>Remarks</th>
<th>Corresponding sleeper at Front tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20.4</td>
<td>20.4</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>19.8</td>
<td>18.6</td>
<td>Xn=20.4-0.6<em>r F7= 16.2-0.6</em>13</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>19.2</td>
<td>16.8</td>
<td>F1 to F7 shall be distributed in between decreasing @1.7 mm/per sleeper</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>18.6</td>
<td>15</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>13.4</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>17.4</td>
<td>11.8</td>
<td></td>
<td>18</td>
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<td>6</td>
<td>16.8</td>
<td>10.2</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>7</td>
<td>16.2</td>
<td>8.4</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>15.6</td>
<td>7.8</td>
<td>Both Xn and Fn will reduce uniformly @ 0.6 mm per sleeper till n is 34</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>7.2</td>
<td></td>
<td>22</td>
</tr>
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<td>10</td>
<td>14.4</td>
<td>6.6</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>11</td>
<td>13.8</td>
<td>6.0</td>
<td></td>
<td>24</td>
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Corresponding sleeper at Front tower: Xn=0, Fn will increase to zero in next 7 sleepers @ 1.1mm/sleeper.
# Sample-Correction (K) for Curvature

**GAUGE = 1676 mm**

\[ K = 41 \times \frac{SE}{R} \]

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### Sample-Value of X for Vertical Curves

**GAUGE = 1676 mm**

**FOR 09-32 CSM**

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**GAUGE = 1676 mm**

**FOR 09-32 CSM**

\[ X = \frac{83586}{R} \]
Guidelines for surveying of track for getting offset values for Design mode of tamping

By working the tie tamping machines in design mode, the long wave length irregularities of longitudinal level and alignment can be rectified. Hence, the tamping machines for projects and other work sites should be worked in Design mode and proper survey for getting offset values should be done.

(1) Survey for Longitudinal/Vertical Profile Correction:

(a) The identified section should be divided by marking stations at 10 m interval. The starting point should be opposite a km post and the starting station should be marked 0. Station locations and station numbers should be painted in yellow paint on the web of the datum rail.

(b) Bench Marks - Benchmarks should be established at 200-1000 m interval, relating them to the GTS benchmark levels so that the plotted drawings are properly related to the existing index section. Fixing benchmarks in relation to arbitrary levels shall be avoided. These benchmarks can be established on the top of concrete foundation of OHE masts in electrified sections with conspicuous markings.

(c) Recording of Existing Rail Levels - The SSE/JE(P.Way) should record the actual rail levels at all the stations of the datum rail, making use of the established benchmarks. However, on the stretches where the datum rail is super-elevated, being on a horizontal curve, the rail levels should be taken on the other rail of the track, opposite the station locations. The stretch, for which station levels are taken on “non-datum” rail, shall be noted in the level book.

(d) Formation Levels - At every 5th station i.e. Station No. 0, 5, 10 etc., the SSE/JE(P.Way) should remove ballast below the rail seat where rail levels are recorded, up-to a level, below which it is not desirable to go, while carrying out deep screening work known as formation level and record the same. For example, in the redesigned vertical profile the rail level should be 700 mm (approx.) and 680 mm (approx.) above the formation level in case of 60 kg and 52 kg rail respectively on PSC sleepers with 300 mm ballast cushion, if sub-ballast is not provided.

(e) Obligatory Points - While carrying out the survey, the SSE/JE (P.Way) should record the location of obligatory points like level crossings, girder bridges, points and crossings, overhead structures etc., in reference to the station numbers as well as running kilometre. The location of km posts and gradient posts should also be noted.

(2) Plotting of Vertical Profile

(a) The existing vertical rail profile (of datum rail) and formation profile should be plotted on a graph sheet with the length of track as abscissa and elevation of rail top and formation as ordinate. The scale adopted should be: Horizontal Scale: 1:1000 (1 cm = 10 m); and Vertical Scale: 1:10(1 mm = 10 mm)

(b) Having plotted the formation levels, the desired rail levels should be marked on the graph e.g. by adding 70 cm to the formation level in case of 60 kg rail on PSC sleepers (with 30 cm ballast cushion) and 68 cm in case of 52 kg rail on PSC sleepers (with 30 cm ballast cushion). The desired rail level so plotted should be taken into account, while marking the proposed
vertical profile on the graph.

(3) Proposed Rail Profile - While deciding the final levels, the following considerations shall be taken into account:

(a) Sub sections shall be selected keeping in view high points and obligatory points.

(b) As far as possible, long stretches of uniform gradient shall be planned keeping in view the depth of construction to be provided and relative implications of lifting or lowering of track. In no case the grade should exceed the ruling gradient of the section. While designing vertical curves, provisions of IRPWM should be observed.

(c) The clearance to overhead structures (including OHE) shall be maintained within permissible limits.

(d) The redesigned profile should not normally involve lifting or lowering of obligatory points like girder bridges, Level crossing, and turnouts. For this purpose the SOD infringements, if any, shall also be considered.

(e) The redesigned profile should aim at easing the sags and humps with manageable lift and lowering. It is not necessarily the intention that the original longitudinal section of the line should be restored.

(f) Generally, the redesigned profile should be so arrived at as to have only lifting, as machines can lift but can’t lower. Lowering shall be resorted to in exceptional circumstance only.

(g) Prescribed minimum ballast cushion as per IRPWM should be ensured. However, the requirement of ballast, over and above that for the prescribed cushion, can be optimised by designing suitable vertical curves.

(h) At locations where lifting or lowering is not possible, suitable ramping out preferably in the form of reverse curves in vertical plane should be provided on both approaches. In case lift is proposed at level crossings, the field staff should be prepared to simultaneously raise the road surface and re-grade the approaches.

(i) High points on the turn out and approaches should be determined and general lift of minimum 10 mm (generally 20 mm) must be given at that point.

(4) In Redesigning the Profile, the requirements to be met are

(a) For other than vertical curves - The unevenness on 80 m chord should not exceed as under:

   (i) On high-speed routes with speed above 110 km/h – 40 mm (corresponding to 20,000m vertical radius).

   (ii) On other lines - 65 mm (corresponding to about 12,000 m vertical radius).

(b) For vertical curves - The unevenness on 20 m chord should not exceed 10 mm (corresponding to 5,000 m vertical radius)

The profile designed should be analytically verified so that the above-mentioned unevenness limits are not exceeded. The final levels at various points should be calculated, rather than scaling-out from the drawing, which mainly serves the purpose of visual appreciation.

(i) The proposed levels should be approved by an officer not below the rank of DEN/XEN. The working plan so prepared should be distributed to the concerned field staff and AEN.

(ii) Designing vertical profile with the help of computer
For designing of vertical profile, aid of a computer with software developed by IRICEN/Pune may be taken to speed up the design work.

(5) Surfacing Operation (By calculating Lifting value \( Y \) from Plotted Graph)

(a) The finally proposed levels of rail top may be marked on the OHE masts/permanent reference pillars for executing the lifting/lowering operation. In case of non-electrified section, permanent level pegs should be provided at every 5th station (50 m approx.).

(b) Actual work of lifting and lowering may be carried out in keeping with the instructions laid down in IRPWM.

(c) The finished profile may not exactly conform to the redesigned profile, and the resurfaced levels may vary from the design profile. It is, therefore, necessary to check the finished levels in relation to the levels marked on the OHE masts/permanent reference pillars. The difference between the finished levels and designed levels should not exceed 10 mm, provided that the variation of unevenness from station to station is not more than 20 mm. To ensure this, SSE/JE (P.Way) will work out the unevenness at all stations in relation to the finished levels and the machine in-charge shall apply correction to levels, to bring the station-to-station variation of unevenness within the prescribed limit.

(6) Survey For Alignment Correction

(a) All the weld and rail kinks should be rectified/eliminated by de-kinking or cutting and welding, before measurement for alignment defects are taken. Hydraulic jim-crows may be used for removing kinks.

(b) In case some horizontal curves on the section to be surfaced warrant realignment, then the process of realignment should be carried out along with surfacing.

(c) Alignment should be measured on a long chord (at least 200 m) on straight track and required slews, at alternate sleeper, should be worked by measuring the offsets at every 5 m interval and interpolating the offsets. The slews \( (F_D) \) should be written on alternate sleeper.

(d) On curved track, versines should be measured on 20 m chord at 10 m intervals. The required slews at the stations are worked out taking note of the obligatory points and interpolated to give slews at every alternate sleeper. The slews are then written on alternate sleepers.

(e) While working out slews \( (F_D) \), position of fixed structures should be noted and infringement to moving dimensions shall not be allowed.

(f) Pre-tamping and Post-tamping operation and machine related track works as detailed in para 226 shall be ensured by the SSE (P.Way).

(g) The beginning and end of curve/transition curves should be identified and marked in the form of permanent reference pillars. These reference pillars should also be installed at every 50 m alongside the length of track and documented for future reference for alignment as well as level. OHE mast in electrified sections can also be used for reference marks after markings and its documentation with intermediate reference pillars.
Annexure 2.17

Sequence of Tamping of Different Points & Crossing (UNIMAT-2S)

NOTE: Wooden blocks to be placed at 'K' position shown above in case only main line track is tamped and turn out side is left while passing train.
Important Features/Dimensions of Dynamic Track Stabilizer

WORKING DIRECTION

NAME OF MACHINE  |  A  |  B  |  C  |  D  |  E  |  F  |  G  |  H  |  I  | WHEEL DIA | AXLE LOAD | WIDTH | REMARKS    
-----------------|----|----|----|----|----|----|----|----|----|----------|-----------|-------|------------
DTS/BHEL         | 18066 | 16800 | 633 | 11200 | 2200 | -   | -   | 1092 | 3930 | 1000   | 20t        | 2850  | 2 VIB. UNIT |
DTS/MATEX        | 18270 | 17000 | 635 | 13000 | 1830 | -   | -   | 1105 | 3815 | 860    | 15t        | 2900  | 3 VIB. UNIT |
DGS-62N/PLASSER  | 17250 | 16010 | 620 | 12000 | 1500 | -   | -   | 1105 | 3790 | 730    | 14.5t      | 2800  | 2 VIB. UNIT |

ALL DIMENSIONS ARE IN mm.
## Dynamic Track Stabilizer (DTS)

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<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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ALL DIMENSIONS ARE IN mm.