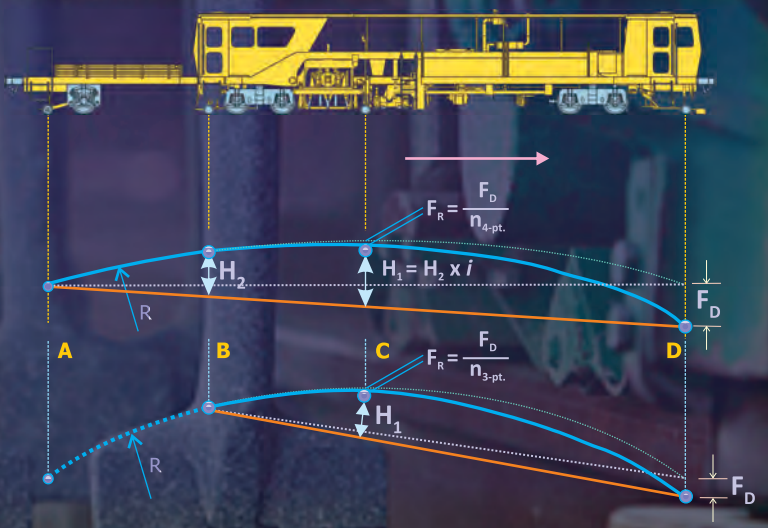
ज्ञान ज्योति से मार्गदर्शन
To Beam As A Beacon of Knowledge

MECHANISED TAMPING & STABILISATION



An IRICEN Publication

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Forward to Second and Revised Edition

This first edition of the book was printed in year 2016 and authored by Sh. C.S Sharma, then Sr Prof/IRICEN and Sh. Anil Choudhary, then Director/Track Machine, RDSO. A need was felt to elaboratein detail, working of ALC provided in tamping machines andalso Survey trolleys now being used for design mode of tamping.

This book has accordingly been revised and updated by Sh.Anil Choudhary, Sr Prof/IRICEN, adding a separate chapter on "Automatic Process Control Computer-WinALC". Also feature of new 3x-Dynamic Tamping Express machine and in detail working of UNIMAT has been incorporated.

A separate chapter on " Track geometry rectification using survey trolleys" written by Sh.Satya Prakash, Dean/IRICEN has also been added.

I hope this revised and updated version will be useful to field engineers. The suggestion for improvement is welcome.

Pune
March, 2022

Ashok Kumar
Director General
IRICEN

Foreword

For long, routine maintenance of track on Indian Railways, is being carried out with the help of heavy on-track machines. Mechanised Tamping of track is a regular activity to keep the track parameters within acceptable limits. The ballast bed stabilisation, immediately after tamping, enables prolongation of tamping cycle.

For effective maintenance of track by *'on-track machines'*, deeper understanding of systems of working, as deployed in tamping machines, for correction to track geometry, and packing of ballast is thus tremendously essential.

Hitherto there has been no comprehensive publication, available on working of track maintenance machines, though it being one of the important area of work for the engineers vested with responsibility of track maintenance.

The first of this kind of publication on "Mechanised Tamping and Stabilisation" will help field engineers in understanding the intricacies of track geometry correction by tamping machines and stabilisation.

1st November, 2016

N.C. Sharda
Director
IRICEN

Preface

Indian Railways had began mechanisation of track maintenance way back during 1960's, and in past 15-20 years the fleet of heavy on-track machines has become sizable to undertake entire track maintenance.

While dealing with the subject of Track Machines at IRICEN and RDSO, it was felt that, though widely used, the field engineers are generally not familiar with the working systems of track machines, particularly track tamping and stabilisation machines, resulting in inability to utilize these machines to full potential.

Although there are few publications on railway engineering, however a little space is allocated to track tamping & stabilisation machines. This is probably due to the fact that literatures and information available in the form of OEM manuals, that accompany the machine, are largely machine specific.

With the persuasive support from Director/IRICEN, an attempt has been made to prepare a comprehensive publication to cover aspects relating to working of machines in field.

The authors are grateful to a large number of individuals, who have helped us in understanding machine working, made literature available and also made notable contribution in various ways to enable compilation and preparation of this publication especially Shri Muslim Ahmed, ARE/TM/RDSO, and Mr. Siegfried Fink of M/s Plasser India.

The contributions of Shri Awadhesh Rai, SSE/Engg/RDSO, Shri Shambhu Dayal SSE/Design/RDSO, in preparation of drawings are deeply acknowledged.

The services and help of Shri Prakash Kadiya, Sr.Instructor/Track-7/ IRICEN in proof reading and corrections to the manuscript and efforts of Shri Pravin Kotkar Sr. Instructor/Track-1/IRICEN in design and publication of this book are highly appreciated.

The authors feel and hope that this publication will be of immense help to all the field engineers concerned with the track maintenance. The authors would deeply honor any suggestions or feedback regarding this publication.

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Sr. Prof. (Track-1)
IRICEN

Anil Choudhary
Director/TM-III
RDSO

1st November, 2016

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1
Introduction

1.1. General

Railway, being safer and economical, has been a preferred mode for transportation of passengers as well as freight. For long, the maintenance of railway tracks were carried out by manual means, which was not only labour intensive and time consuming but also had other attendant limitations of difficulty in handling heavier track structure, limited work window due to higher frequency of trains, safety of track maintenance personnel, and irregular quality of output amongst others.

One of the key requirements for a viable railroad system is presence of robust and economic maintenance strategy. The inadequacy or absence of appropriate track maintenance scheme will have definite severe impact on the life of the assets and in turn drain on resources.

1.2. Track Maintenance

The primary functions of permanent way and track foundation involves guidance to the flanged wheel and transfer of loads from rolling stock to the formation capable of withstanding cyclic loading without any distress. *(Fig. 1.01)*

In dynamic conditions the incorrect/variations in track geometry parameters have a significant bearing not only on fluctuation of stresses during the transfer of loads but also act as sources of undesirable accelerations resulting in degraded ride quality. Therefore it is desirable to control variation in track geometry

parameters to lessen consequent stresses. The ballast layer below the sleepers serves many purposes like transfer of loads down below, providing resistance to deformation, drainage and acting as elastic bed. This ballast layer also provides an effective medium for correction of track geometry.

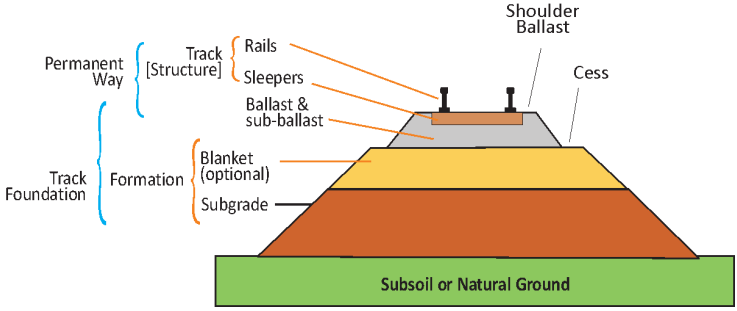


Fig. 1.01 – Track cross-section showing its constituents

The major track maintenance activities, mentioned below, are undertaken, either periodically or need based, to make sure that the track is always in serviceable condition.

i) Management of Track parameters:

   a. Packing/Tamping on plain track and switches & crossings to keep track geometry parameters within acceptable limits.

   b. Stabilization of ballast bed immediately after Packing/ Tamping for better retentivity and slower deterioration of track parameters.

ii) Ballast Management:

   a. Screening of ballast on plain track and switches & crossings to ensure that its designated functions are not impaired.

   b. Ballast consolidation and ballast redistribution/profiling for optimal longitudinal, vertical and lateral resistance and consequent stability.

1.3. Mechanisation of Track Geometry Maintenance

Till the end of Second World War in 1945, the track geometry was maintained manually. However with progressively increasing demand for quicker movement, the speed and frequency of trains increased rapidly to keep pace with the industrial development. This situation necessitated better quality of track geometry at the time of installation, with heavier track structure needing lesser inputs, and during service thereafter. The modern track structure, being heavier, is less amenable for manual handling. The manual means for handling or maintenance are, therefore, not advisable except for unavoidable sporadic minor attentions. The tracks laid and maintained to high standards have longer service life and consequently offer beneficial cost advantage.

The increased volume of traffic and frequency of trains, depending on the track structure, initial laying quality, and conditions of formation etc. could place higher demand for track attentions. This inter-alia implies that with limited window for maintenance between successive trains, if input is to be given by manual means (i.e. with expensive and generally unwilling manpower to do physically strenuous work), it could not only be prohibitively expensive due to low productivity but also reliable and consistent high quality is not guaranteed to allow full speeds with confidence. Furthermore, despite best efforts, it may not be possible to achieve the consistently acceptable track geometry parameters, necessitated for high speeds and requisite comfort level.

Mechanization of track maintenance offers reliable, objective, consistent quality and high productivity and enables maintaining longer stretches in shorter time frame. This would also mean quicker relaxation of speed restrictions after screening or renewal works. For undertaking track maintenance activities a number of machines have been designed and developed to perform one or more functions. Though the current generation of sophisticated track maintenance machines require substantial investment upfront for acquisition, however the long-term costs

are significantly lower apart from substantial unquantifiable intangible benefits.

1.4. Tamping and Stabilization of ballast bed

Tamping machines are used for correcting track geometry or restoring the track position to one that is geometrically correct and packing of ballast to retain corrected track position. Packing of ballast results in a well-compacted sleeper supports to improve the load distribution across several sleepers, The Dynamic Track Stabilizer deployed, immediately after tamping/packing of ballast, improves anchoring of the track skeleton in the ballast bed for enhanced durability of track geometry under traffic.

The use of tamping machines and dynamic track stabilizers, for correction of track geometry parameters and stabilization of ballast bed immediately after Packing/Tamping for better retentivity and slow down rate of deterioration are de-facto standard for almost all railways world over.

1.5. Evolution

During 1920s and 1930s mechanical devices for carrying out packing were tried. However the correction to geometry and holding it into the position, had to be done by manual means..

With the development of first hydraulic tamping machine in 1953 by two Austrians Franz Plasser and Josef Theurer led to beginning of new era, in mechanization of track maintenance, being witnessed now. The newer machines are being developed with aim to improve work performance (speed and quality) with innovative solutions like hydraulic asynchronous tamping, integration of lining and levelling systems, continuous action tamping, simultaneous tamping on two, three and upto four sleepers, digital inputs and control with on-board computers etc.

Current generation of tampers, with in-built measurement

system can automatically smoothen irregularities in the track geometry, with 20-30 m wavelength both in alignment and level.

1.6. Scenario on Indian Railways

Mechanization of track maintenance on Indian Railways began during early 1960s with purchase of on-track tampers produced by Swiss manufacturer Matisa, which used to pack one sleeper at a time. In 1965, first machine manufactured by M/s Plasser& Theurer was supplied, who also began production of tamping machine in India and in February 1968, the first track maintenance machine manufactured in India by M/s Plasser & Theurer was handed over to Indian Railways. Over a period, substantial number of machines have been sourced from world over and deployed on Indian Railway, of which a large proportion has been supplied by M/s Plasser India.

1.6.1. Types of Track Tamping and stabilization Machines

Depending on features, capabilities and model, the various tamping and stabilization machines deployed on Indian Railways are as under.

(a) Plain Track Tamping Machines

i) 06-16 Universal Tamping Machine (UT)- mostly phased out *(Fig. 1.02)*

ii) 08-16 Unomatic *(Fig. 1.03)*

iii) 08-32 Duomatic (Plasser/Russian) *(Fig. 1.04)*

iv) 09-32 Continuous Action Tamping Machine (CSM)*(Fig. 1.05)*

v) 09-3X Tamping Express *(Fig. 1.06)*

vi) 09-3X Dynamic Tamping Express *(Fig. 1.07)*

b) Points and Crossing Tamping Machines
   i) PLM-07-275-S Unimat *(Fig. 1.08)*
   ii) 08-275 Unimat *(Fig. 1.09)*
   iii) 08-275-3S Unimat *(Fig. 1.10)*
   iv) 08-475-4S Unimat *(Fig. 1.11)*
c) Multi-Purpose Tamper (MPT) *(Fig. 1.12)*
d) Dynamic Track Stabilizer (DTS) *(Fig. 1.13)*

The population of Tamping and stabilization machines on various Zonal Railway on IR as on Sept. 2021 is shown in *Table 1.01*. It has been mentioned earlier *(para 1.3)* that the heavy-duty on-track machines need substantial investment upfront for acquisition. Therefore due care in maintenance of these machine and their effective utilization is the key for a favourable return on investment and turn it into economically viable proposition. The indicative cost (year 2021) for some of the tamping and stabilization machines can be seen in *Table 1.02*.



Fig. 1.02 - 06-16 Universal Tamping (UT) Machine



Fig. 1.03 - 08-16 Unomatic Tamping Machine



Fig. 1.04 (a) - 08-32 Duomatic (Plasser make) Tamping Machine



Fig. 1.04 (b) - 08-32 Duomatic (Russian make) Tamping Machine



Fig. 1.05 – 09-32 Continuous Action Tamping Machine (CSM)



Fig. 1.06 - 09-3X Tamping Express



Fig. 1.07 - 09-3X Dynamic Tamping Express



Fig. 1.08 - PLM-07-275-S Unimat Tamping Machine



Fig. 1.09 - 08-275 Unimat Tamping Machine



Fig. 1.10 - 08-275-3S Unimat Tamping Machine



Fig. 1.11 - 08-475-4S Unimat Tamping Machine



Fig. 1.12 - Multi-purpose Tamper (MPT)



Fig. 1.13 - Dynamic Track Stabilizer (DGS)

Table 1.01 –Population of Tamping & Stabilization Machines on IR as on Sept-2021

Rly.	HOT-S-3X	HOT-3X	CSM	WST	UNI	MPT	DTS	TOTAL
CR	2	2	7	12	8	3	8	42
ECoR	3	1	2	7	7	3	5	28
ECR	2	1	4	11	7	2	7	34
ER	2	1	5	9	8	3	7	35
NCR	2	1	6	8	8	6	10	41
NER	2		2	5	4	1	4	18
NFR	3	1	3	9	6	4	4	30
NR	4	2	6	12	12	6	12	54
NWR	2	1	4	8	5	2	6	28
SCR	4	2	8	12	9	3	12	50
SECR	2	1	3	7	6	5	6	30
SER	1	1	6	9	8	3	7	35
SR	3	1	6	10	7	3	8	38
SWR	3		4	7	4	5	4	27
WCR	2	2	4	9	8	3	9	37
WR	4	1	5	10	10	4	9	43
IR	41	18	75	145	117	56	118	570

Table 1.02 – Indicative Cost of Machines (Sept. 2021)

Sl. No.	Machine Type	Indicative Cost (₹ Cr.)
1	09-3X	26.81
2	CSM	17.50
3	WST	8.7
4	UNI	27.28
5	MPT	8.6
6	DTS	6.3

■ ■ ■

2

Tamping Machines

Features, Assemblies & Parameters

2.1. General

A tamping machine essentially measures the existing track parameters and then lifts it to correct (or provide) cross-level and align to target/pre-determined position. Thereafter ballast under the sleepers is squeezed by tamping tools, fitted on tamping unit, to retain the corrected geometry and provide well-compacted supporting bed to retain track in corrected position. This enables load distribution over several sleepers, improves durability of track and lessens accelerations for a ride of acceptable comfort level.

The basic tamping machine is, therefore, capable of:

- Correction to Alignment
  - a) Lining (horizontal plane)
  - b) Levelling (vertical plane); including provision of super-elevation
- Tamping (Packing) of ballast under the sleepers

Some variants of the tamping machines may have provisions for shoulder ballast compaction or dynamic ballast stabilization system.

General layout and important units of a Tamping machine are shown in *Fig.2.01:*

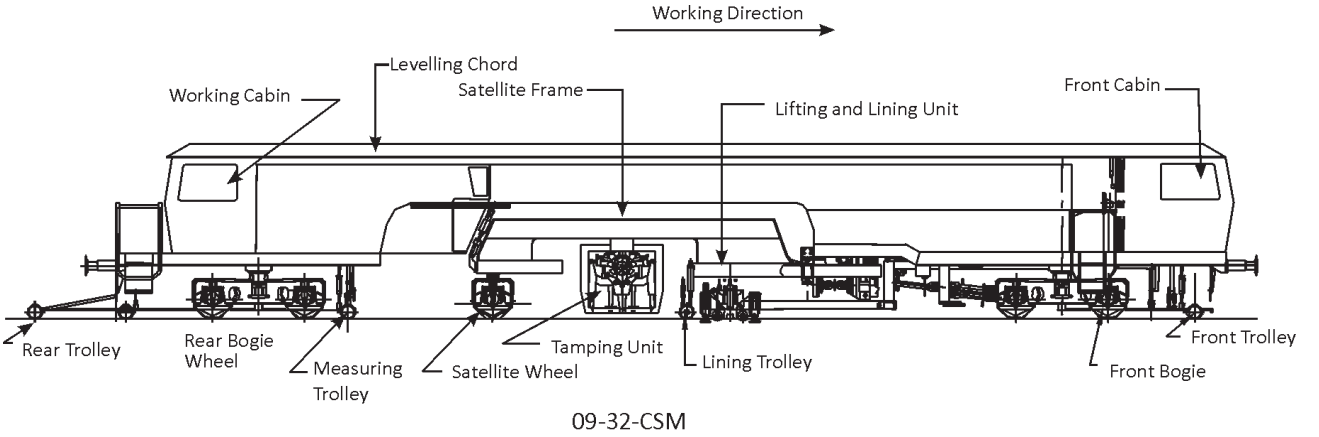


Fig. 2.01 – General layout and important units of a Tamping machine

2.2. Main Assemblies of Tamping Machines

2.2.1. Engine

Diesel engine is the main source of power. The engine converts chemical energy of fuel into mechanical energy, which is further converted into four different forms of power for the working of machine.

a) *Mechanical Power through Gear Boxes*

A part of mechanical power is used, by means of hydrodynamic gearboxes (in most of the machines), for running of tamping machine. Remaining mechanical power is converted to other forms mentioned hereunder.

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, which is used for brakes and locking/unlocking system of assemblies, up and down movements of feelers, operation of lining bogies, horn etc.

d) *Electrical Power through Alternator and Batteries*

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

2.2.2. Tamping Units

Two or more independent tamping units are provided in a tamping machine (one or more for each rail). These are mounted/fixed to the machine frame by means of vertical guiding columns. In some of the machines the tamping units are fitted to a satellite unit within machine frame.

The tamping units may be capable of packing one sleeper or two/three/four sleepers at a time depending upon type and model of the tamping machine. A total of 16 tamping tools are provided for packing ballast under each sleeper. The tools are arranged in pairs and ballast is packed by 8 such pairs for each sleeper.

The tamping units are held by horizontal guiding column in order to slide sideways, which allows its 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. 2.02*

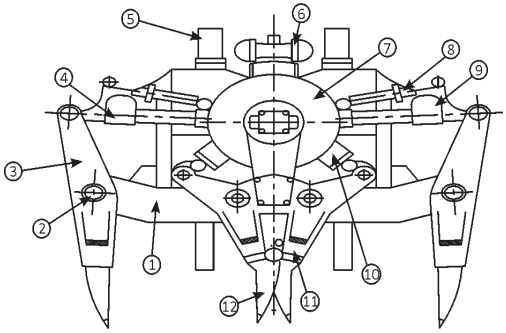


Fig. 2.02 – A typical layout of a tamping unit and its components

1. Taming Bank
2. Center Pin
3. Big Tamping Arm
4. Big Squeezing Cylinder
5. Guide Rod
6. Oil Bath
7. Plate Guard
8. Clapper Cylinder
9. Securing Plate
10. Small Squeezing Cylinder
11. Small Tamping Arm
12. Tamping Tool

2.2.3. Tamping Tools

The tamping tools (tamping tines), which packs ballast underneath sleepers, are mounted on tamping unit. The size/shape of tamping tool blade is a design parameter and it could be different for various machines depending on model/make/manufacturer.

2.2.4. Lifting and Lining Unit *(Fig. 2.03)*

The lifting and lining unit is positioned in front of the tamping units. Lifting is carried out using one lifting cylinder with help of 2 sets of roller clamps/hook on each side. The lining is done by two hydraulic cylinders, which act on the each rail via a lever arm. The lining operation begins simultaneously along-with lifting operation and stops automatically when the target values for both line and level are reached.



Fig. 2.03 - Lifting and Lining Unit

2.2.5. Satellite Unit

For some models, the tamping and lifting cum lining unit are provided on the satellite unit of the tamping machine. The satellite unit is placed under mainframe of the machine and supported on wheels. It is a separate unit capable of cyclic movement from sleeper to sleeper and moves independent of the main frame.

2.2.6. Trolleys

These are wheels mounted units provided with sensing feelers for measurement of track parameters. The trolleys, generally used in tamping machines, are front trolley, lining trolley, measuring trolley, and rear trolley.

2.3. Types of Tamping Machines

2.3.1. Tampers without satellite unit

The tamping unit and the lifting and lining unit are attached to the main machine body itself. The entire machine moves as single unit and stops at every/alternate sleeper for lining, levelling and packing of ballast. Following machines belong to this category.

(a) *Duomatic (Plain Track Tamper)*

It is a plain track tamper and with 32 tamping tools capable of packing two sleepers simultaneously. These machines are also known as Work Site Tampers (WST), due to its primary application at work sites. Various models of duomatic tamping machines, presently in use, on Indian Railways are as under:

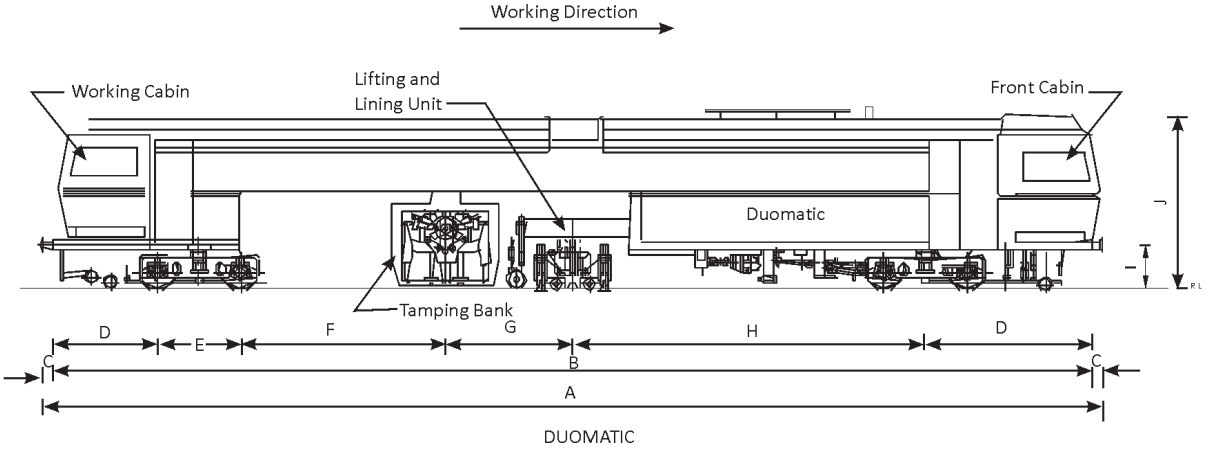
i) 08-32 Duomatic (M/s Plasser India make)

ii) 08-32C Duomatic (M/s Plasser India make)

iii) 08-32 WST with flat car (M/s Metex Russia Make)

iv) VPR-02M without flat car (M/s Kalugaputmash Russia Make)

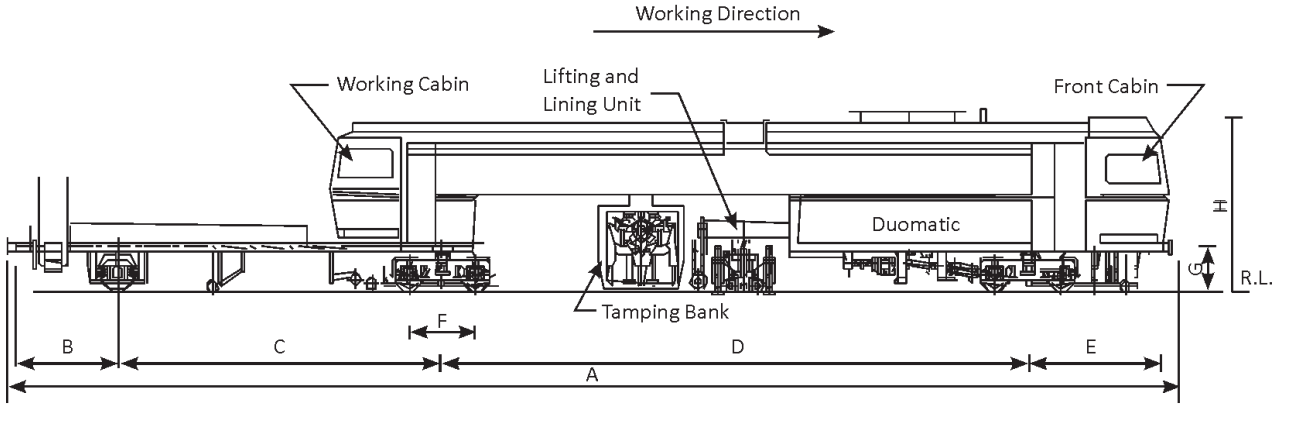
The important features/dimensions of these machines are given at *Fig. 2.04* and *2.05*.



NAME OF MACHINE	A	B	C	D	E	F	G	H	I	J	WHEEL DIA	AXLE LOAD	WIDTH
08 - 32 DUO	18940	17670	635	2125	1830	1455			1080	3350	730	10.5t	2900
08 - 32C DUO	17670	16400	635	1800	1800	1600	2060	6440	1105	3715	850	12.5t	3000
VPR - 02M DUO WITHOUT FLAT CAR	17740	16470	635	3130	1830				1105	3780	732	13.0t	2970

All dimensions are in mm

Fig. 2.04 – Features/dimensions of Duomatic Tamping machines



WST METEX

NAME OF MACHINE	A	B	C	D	E	F	G	H	WHEEL DIA	AXLE LOAD	WIDTH
WST METEX WITH FLAT CAR	23550	2000	5800	11300	3130	1830	1105	3810	710	12.5t	3000

All dimensions are in mm

Fig. 2.05 – Features/dimensions of Duomatic Tamper (Metex make)

(b) *Unimat (Points and Crossing Tamper)*

The Unimat is tamping machine capable of working on points & crossing as well as on plain track. The tamping unit of Unimat has 16 tamping tools, which have tilting arrangement and can pack one sleeper at a time. Tamping tool(s), which is(are) infringing track component, can be tilted individually or in pairs to avoid infringement and rest of the tools can pack the ballast underneath the sleeper. Tamping unit in most of these machines can be rotated (upto $\pm$ 8.5° to tackle skewed sleepers (which are not square) in points & crossing. Some Unimat machines are provided with arrangement for third rail lifting and some models may have both third rail lifting and packing. Various models of Unimat machines, presently in use, on Indian Railways are as under:

i) 08-275 Unimat (M/s Plasser India make)

ii) 08-275-3S Unimat (M/s Plasser India make) having arrangement for third rail lifting.

iii) 08-475-4S Unimat (M/s Plasser India make) having arrangement for third rail lifting and packing. *(Fig. 2.06)*

The important features/dimensions of these machines are given in *Fig. 2.07*.

(c) *Multi Purpose Tampers (MPT)*

These machines are meant for spot attentions on plain track as well as on points & crossing. These may also have a flat platform at rear end with crane facility for loading, un-loading and transportation of P.Way materials/tools. Various models of Multi Purpose Tampers, presently in use on Indian Railways are -

i) Unimat Compact (MPT) (M/s Plasser India make)

ii) Unimat Compact Split Head MFI (M/s Plasser India make)

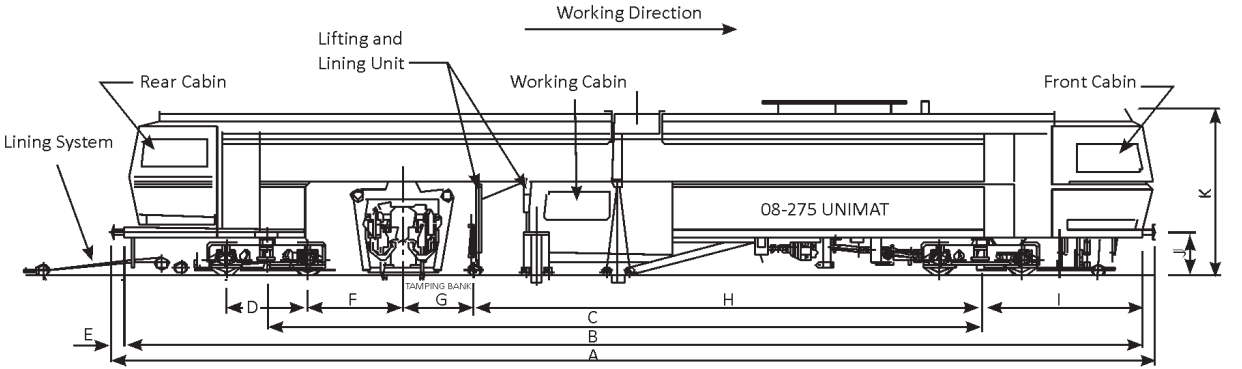


Fig. 2.06 - Third Rail Lifting Arrangement in UNIMAT 08-475-4S

The important features/dimensions of these machines are given at *Fig. 2.08 and 2.09.*

2.3.2. Tampers with satellite unit

These machines consist of a satellite unit, which moves independent of the main frame of machine in working mode. Tamping unit, lifting & lining units are provided on this satellite unit. While the main frame of the machine moves at a uniform speed, the satellite unit moves proportionally and stops at sleepers for its lining, levelling and packing. The following machines belong to this category -

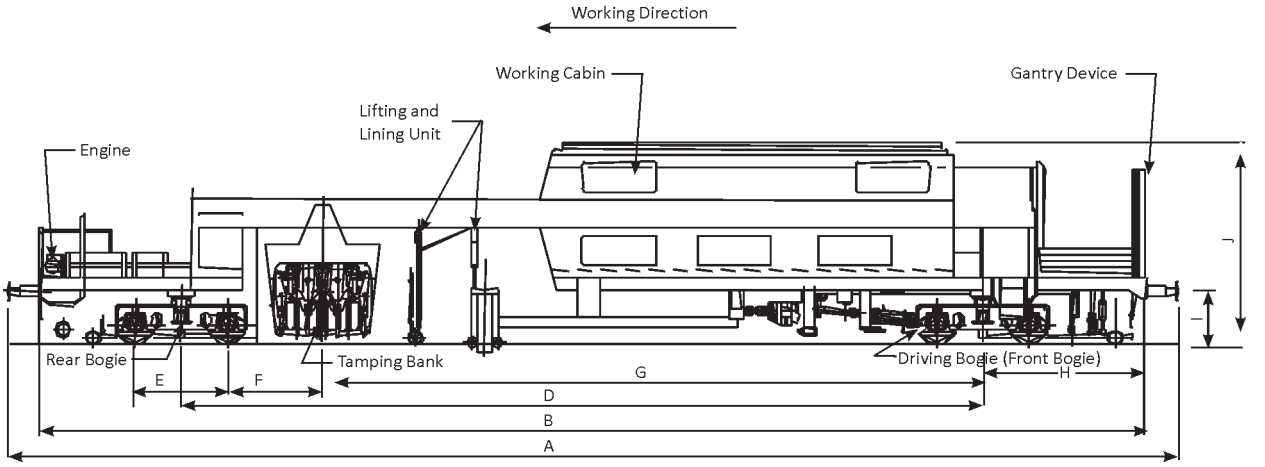


POINT & CROSSING TAMPING MACHINE

NAME OF MACHINE	A	B	C	D	E	F	G	H	I	J	K	WHEEL DIA	AXLE LOAD	WIDTH
08 - 275 UNIMAT	19140	17900	11500	1500	620	1530	-	-	3200	1040	3300	730	11.5t	3050
08 - 275 3S	21670	20400	14000	1800	635	1830	1050	10220	3200	1105	3550	730	17.34t	3000
08 475 4S	28370	27100	14000	1800	635	1830	1150	10110	3200	1105	3743	920	19.8t	3000

All Dimensions are in mm

Fig. 2.07 – Features/dimensions of Points and Crossing Tamping Machine (UNIMAT)

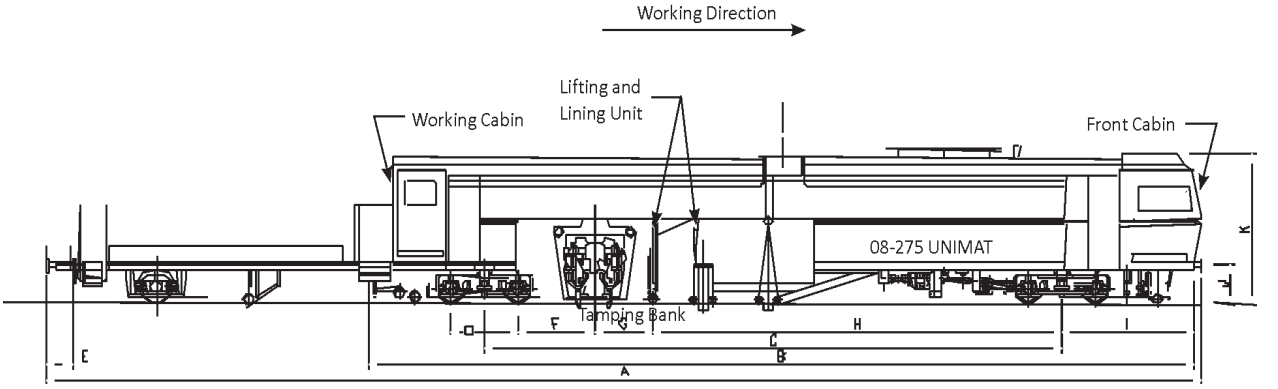


MULTI PURPOSE TAMPING MACHINE
(UNIMAT - COMPACT /M)

NAME OF MACHINE	A	B	C	D	E	F	G	H	I	J	WHEEL DIA	AXLE LOAD	WIDTH
UNIMAT COMPACT-M	19270	18000	635	12000	1800	1500	9600	3000	1105	3793	730	11.5t	3100

All Dimensions are in mm

Fig. 2.08 – Important features/dimensions of Multi-purpose Tamping Machine



UNIMAT - SPLIT HEAD MFI

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

All dimensions are in mm

Fig. 2.09 – Features/dimensions of UNIMAT split head

(a) 09-32 CSM (Plain Track Tampers)

CSM is a tamper designed for lining, levelling; twist correction and packing of sleepers on plain track. It has a rear pendulum for measurement and providing input for correcting twist. It has tamping unit with 32 tamping tools to enable packing of two sleepers at a time. Single chord Lining and double chord parallel levelling systems are used.

The important features/dimensions of these machines are given in *Fig. 2.10 and 2.11*.

(b) Tamping Express (09-3X) (Plain Track Tampers)

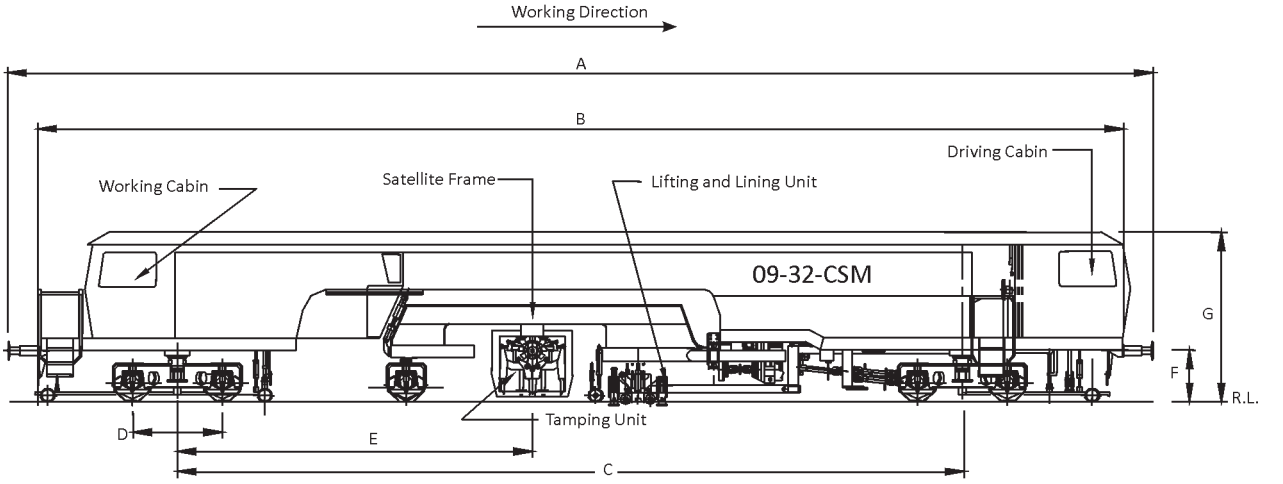
It is a Plain track tamper designed for lining, levelling, twist correction and packing of sleepers. It also has a rear pendulumm for measurement end providing input for corrcting twist. It has 48 tamping tools to pack three sleepers at a time. Single chord Lining and double chord parallel levelling systems are used.

The important features/dimensions of these machines are given in *Fig. 2.12*.

(c) Dynamic Tamping Express (Dynamic 09-3X) (Plain Track Tampers):

It is a tamper similar to Tamping Express with Dynamic Track stabiliser attached to it.

The important features/dimensions of these machines are given in *Fig.2.13*.

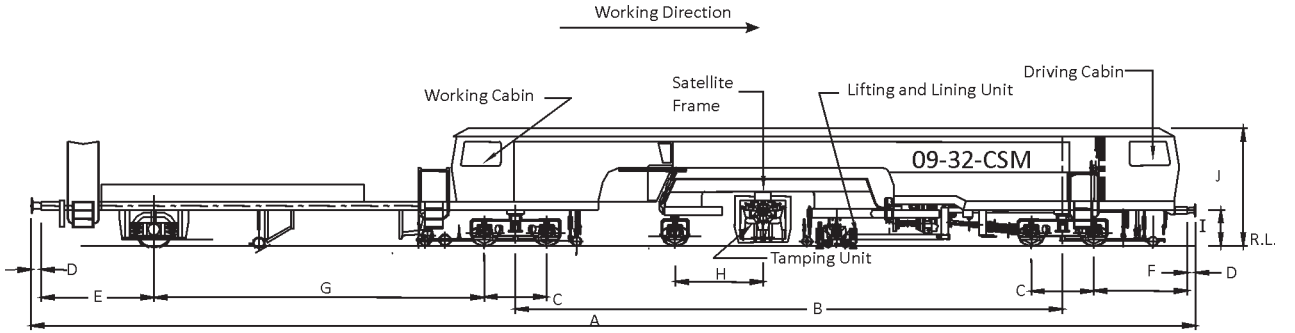


09-32-CSM

NAME OF MACHINE	A	B	C	D	E	F	G	WHEEL DIA	SATELLITE WHEEL DIA	WIDTH	AXLE LOAD
09-32 CSM	20670	19400	13700	1800	4170	1100	3500	730	730	3040	13.0t

All Dimensions are in mm

Fig. 2.10 – Important features/dimensions of 09-32 CSM

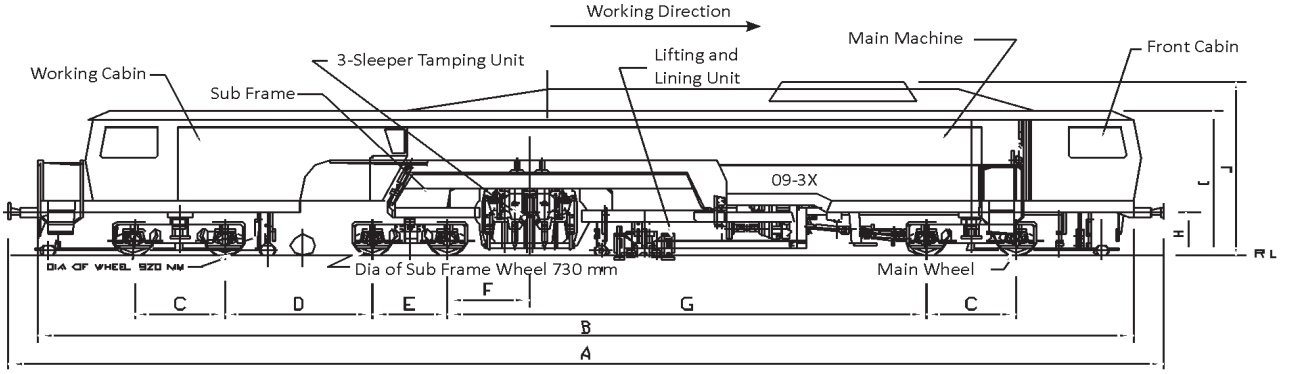


09-32-CSM

NAME OF MACHINE	A	B	C	D	E	F	G	H	I	J	WHEEL DIA	AXLE LOAD	WIDTH
09-32-CSM	27670	13700	1800	635	2000	2300	6600	1550	1100	3500	730	13.0t	3040

All dimensions are in mm

Fig. 2.11 – Important features/dimensions of 09-32 CSM (with rear trolly)



TAMPING EXPRESS

NAME OF MACHINE	A	B	C	D	E	F	G	H	J	MAIN WHEEL DIA	SATELLITE WHEEL DIA	WIDTH	AXLE LOAD
TAMPING EXPRESS 09-3X AXLE LOAD 18.5 TON	22940	21700	1800	2936	1600	-	-	1105	4000	850	730	2900	18.5 t
TAMPING EXPRESS 09-3X AXLE LOAD 20.0 TON	22940	21700	1780	2936	1600	1800	9455	-	4000	730	730	2900	20.0 t
TAMPING EXPRESS 09-3X AXLE LOAD 21.0 TON	22940	21700	1800	-	1600	1800	-	1105	3805	920	730	32900	21.0 t

All dimensions are in mm

Fig. 2.12 – Important features/dimensions of 09-3X Tamping Express

DYNAMIC TAMPING EXPRESS

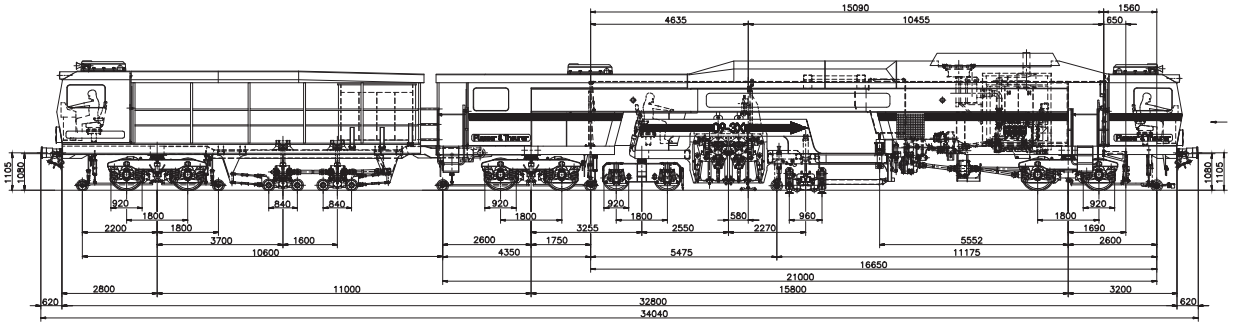


Fig 2.13 Important feature and Dimensions of Dynamic 09-3X Tamper.

2.4. Tamping Mechanism

For packing of ballast, underneath the sleepers, tamping tools penetrate into the ballast bed and perform a closing movement with sinusoidal vibrations superimposed for packing. Each tamping tool arm is squeezed with the same force as shown in *Fig. 2.14*. Tamping unit as fitted on 09-32 machine (CSM) and Tamping Express (09-3X) can be seen in *Fig. 2.15 and 2.16* respectively.

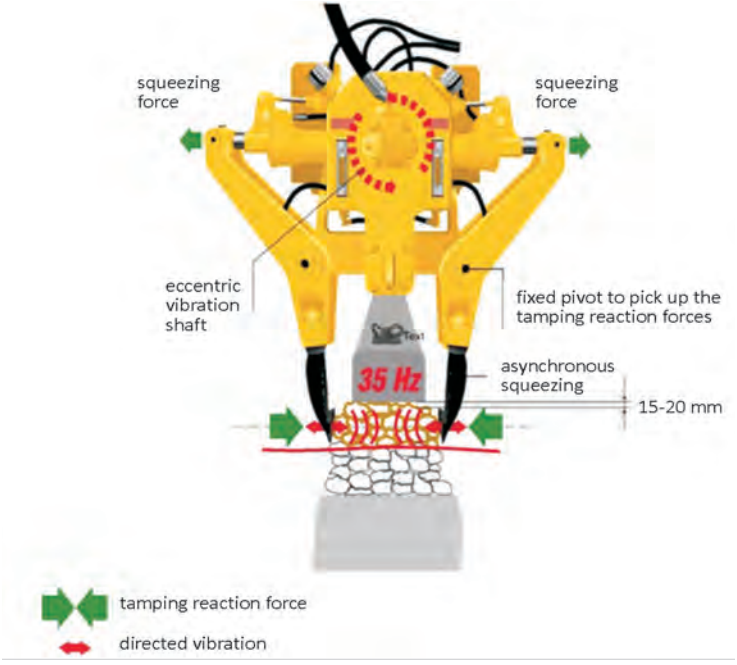


Fig. 2.14 - Tamping Mechanism



Fig. 2.15 - Tamping unit fitted on 09-32 machine (CSM)



Fig. 2.16 - Tamping unit as fitted on 09-3X (Tamping Express)

The tamping units work according to the asynchronous uniform pressure tamping principle. For tamping a sleeper, the tamping tools penetrate into ballast bed and perform a closing, "squeezing", movement. On this squeezing movement a sinusoidal directed rectilinear vibration having frequency of 35 Hz is superimposed. During packing all tools apply the same amount of pressure to the ballast being packed independent of their movement in the ballast bed; thereby there is a perfect equilibrium of forces between the individual tool pairs and the specific surface pressure of all tools. The movement of the tool being completely independent, according to the resistance encountered during tamping; and once this resistance from the ballast reaches the preselected pressure, the corresponding tool pair stops squeezing automatically. However other tool pair(s) continues to squeeze till the resistance becomes equal to preselected pressure amongst them, leading to asynchronous tamping tool movement so that all areas tamped by the individual pairs tools are consolidated equally. Therefore the individual tools may have unequal closing movements (viz. W_1, W_2, W_3 and W_4) as shown in *Fig. 2.17*.

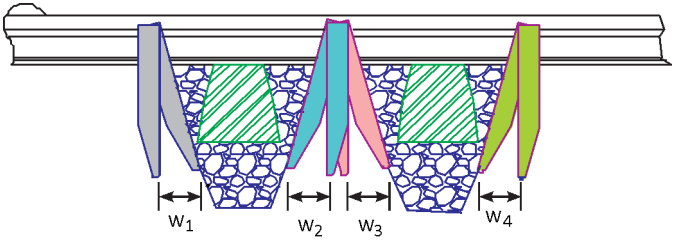


Fig. 2.17 – Unequal closing movement of tamping tools performing asynchronous constant pressure tamping

2.4.1. Tamping tools

As evident, the tamping tools fitted on tamping machines are one of the crucial components, which subjected to highly abrasive wear and tear conditions occurring while penetration into & withdrawal from ballast bed and during tamping/squeezing operation. This implies that the size, shape and quality of tamping tool material is of

vital importance.

The detailed specification of tamping tools has been issued by RDSO vide no. No TM/HM/6/26 (Rev-1 April-2001). These tamping tools are expected to have service life of about 8,000 to 12,000 insertions only, which calls for frequent replacement/refurbishment.

2.4.2. Tungsten Carbide Tamping Tools (TCTT) *(see Fig. 2.18)*



Fig. 2.18

To overcome the drawback of frequent changing of ordinary tamping tools, the Tungsten Carbide Tamping Tools (RDSO specification No TM/HM/6/320-Rev-1) are used on most machines now a days, which has a service life of at-least 2,50,000 insertions. The TCTT consists of tungsten carbide inserts (having minimum hardness HRA 84/HRC 65 or its equivalent) joined with the steel spade by brazing/other proven method. The brazing/joining is strong enough to have high wear resistance to improve service life. Depending on use in normal working conditions, the TCTT may need replacement 2-3 times in a year.

Annexure 2.01 at the end of this chapter shows various standard drawings for tamping tools for tamping machines presently working on Indian Railways.

2.5. Tamping Parameters

The efficacy of packing of ballast i.e. output quality of tamping and in turn retentivity of corrected track parameters is a function of many parameters attributable right from system and mode of working (described in subsequent chapters), to size of ballast and extent of fouling, to health of machine in general and maintenance condition of various assemblies and components etc. and tamping parameters set in machine. Some of the key consideration in respect of aforesaid are dealt hereunder, which may have significant impact on output quality; if not taken care or chosen appropriately.

2.5.1. Tamping tool surface area

The tamping tools, mounted on tamping unit, transfer vibration to ballast bed and squeezes ballast particles to form denser mass through its contact surface area are subject to high wear and tear as elaborated earlier. The Surface area of tamping tool blades should, therefore, be not less than 80% of the original surface area (i.e. tamping tools with more than 20% wear of the original surface area should not be used). The dimensions of tamping tools being used for various machines, presently working on Indian Railways, are given in *Annexure-2.01.*

2.5.2. Tamping depth

For effective packing of the ballast right below the sleeper bottom, the gap between top edge of the tamping tool blade and bottom edge of sleeper in closed position of the tamping tool needs to be adjusted depending upon the type of sleeper to impart compacting energy at correct location. The larger gap between bottom of sleeper and top of edge tamping tool blade may result in slipping out of ballast (from the gap between bottom of sleeper and top edge of tamping tool blade). In addition, it would result in packing an area well below sleeper bottom with uneven and incomplete compaction, thus creating loose

pockets right under sleepers causing poor retentivity. If the gap is too low, the ballast would get pressed against the sleeper flank, whereby no/little compaction would occur. This gap could range from 15-30 mm as per BS EN 13231 - 1 : 2013 However for Indian conditions the desirable gap between top edge of the tamping tool blade and bottom edge of sleeper for different types of sleepers should be as under *(Fig. 2.19)*:

Type of sleeper	Desirable gap between top edge of the tamping tool blade and bottom edge of sleeper
Flat bottom sleeper	15-20 mm
Metal sleeper	22-25 mm

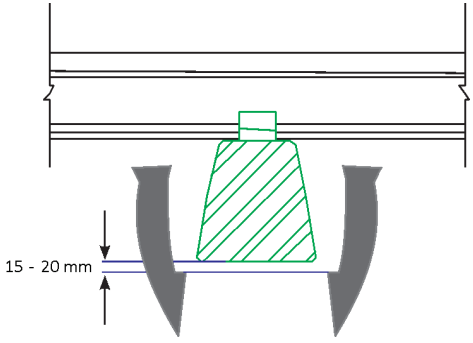


Fig. 2.19 – Position of tamping tool below the bottom of sleeper

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. 2.20 (a)*.

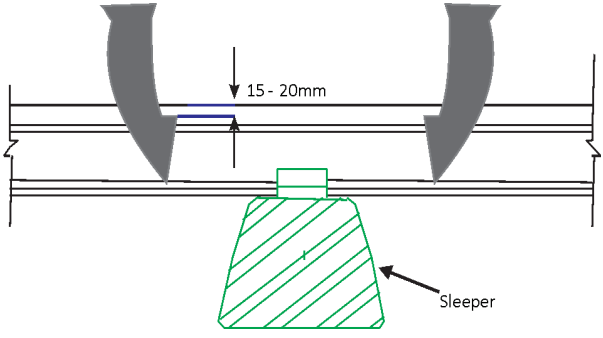


Fig. 2.20 (a) – Zero position setting for tamping tools

Tamping tool depth is calculated as under: *(see example 2.01)*

Tamping tool depth = sleeper height (at rail seat)
plus rail height
plus rubber pad thickness

The squeezing depth is set through a counter (see *fig. 2.19 (b)*) in millimeters after zero position setting is carried out as mentioned above.

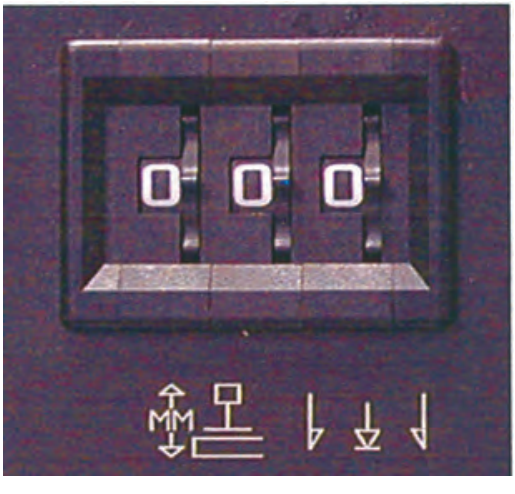


Fig. 2.20 (b) – Counter to set squeezing depth

Example 2.01:

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

= 172 mm	(rail height)
+ 210 mm	(sleeper depth)
+ 6 mm	(rubber pad thickness for IRS T-3711)
= 388 mm	

2.5.3. Lifting of track

For an evenly compacted base for sleeper support and positioning of track in geometrically improved position, lifting of the track is necessary. In absence of lifting, no improvement in track geometry and consequent track stability might be possible. All tamping machines are, therefore equipped with lifting mechanism and a certain amount of minimum lifting of track is always carried out during tamping. This is covered in greater detail in *Chapter-5*.

2.5.4. Tamping tool vibration, amplitude & frequency

For ease in penetration of tamping tools and to aid in packing of ballast, vibration with 35 Hz frequency with an amplitude of 4-5 mm are imparted, which results in even and forceful uplift with minimal ballast deformation for maximum stability.

The vibration frequency and its amplitude have a significant influence on tamping. If the frequency of vibration is lower, the resistance to penetration becomes higher. However, if the vibration frequency is higher than 40 Hz, liquefaction of ballast can occur and effective packing cannot be achieved *(Fig. 2.21)*.

The frequency of about 35 Hz allows fulfilment of another important requirement of lift to create voids under sleepers, for even compaction process that enables formation of new ballast bed structure. The absence or insufficiency of lift would hamper effective rearrangment of the ballast, which may cause uneven compaction and in extreme cases, it can even lead to "centre bound sleepers". On the other hand higher lift may not result in evenly compressed, load bearing ballast structure, due to the limited working area of the tamping tools.

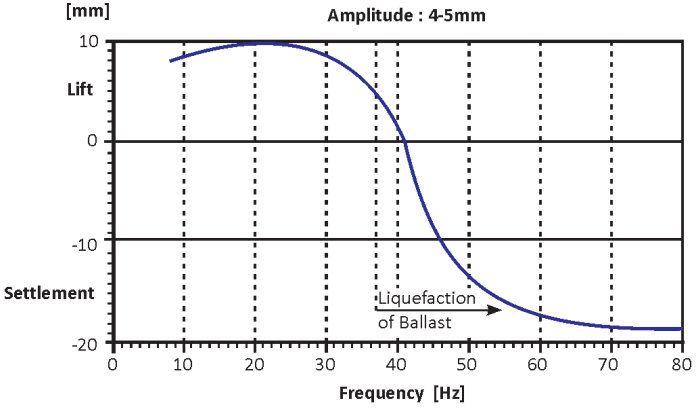


Fig. 2.21 – Effect of Tamping Frequency on lift

For packing of ballast, tamping tool pair perform a closing (squeezing) movement, whereupon sinusoidal vibration is superimposed *(Fig. 2.22)*

At a vibration frequency of 35 Hz the re-organization of ballast particles and resultant consolidation occurs during short phase of squeezing movement of tamping tools by short power blast of positive sine half shaft.

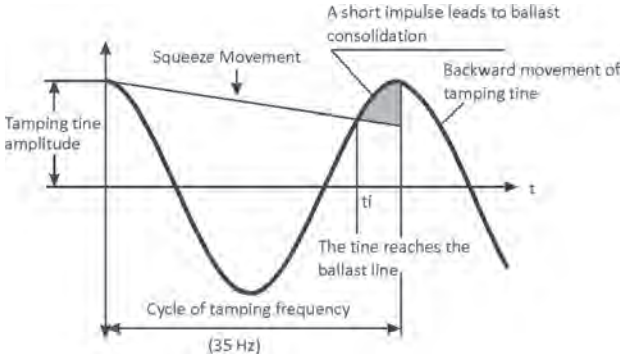


Fig. 2.22

The tamping tools are vibrated by piston rods pivoted on eccentric shaft driven by hydraulic motors with following parameters:

Sl. No.	Parameters	Value
1	Rate of revolution of vibration shaft	2000 - 2100 rpm (approx.)
2	Vibration frequency of tamping tool	33 - 35 Hz. (approx.)
3	Amplitude of oscillation	4 -5 mm

These values may, however, vary depending on design/ model/make of tamping machine.

2.5.5. Vibration pressure

To prevent slowing down or stoppage of tamping tools, while penetrating the ballast bed, the vibration pressure is to be adjusted. The vibration pressure varies from machine-to-machine ranging from 150 to 210 Kg/cm^2.

2.5.6. Squeezing Pressure (Tamping Pressure)

The force, build up, at face of tamping tool for consolidation of ballast is known as squeezing force. Squeezing force per unit effective area of squeezing piston is called squeezing pressure. The tamping operation completes only when pre-set squeezing pressure is reached.

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

Sl. No.	Type of Track and Sleeper	Squeezing Pressure
1	Plain Track (CST-9)	90-100 Kg/cm^2
2	Plain Track (ST & Wooden)	100-110 Kg/cm^2
3	Plain Track (PSC)	110-120 Kg/cm^2
4	P&C (ST/ Wooden Sleepers)	110-115 Kg/cm^2
5	P&C (PSC)	125-135 Kg/cm^2

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. If the squeezing pressure is set too high, flow of ballast at sleeper end will be visible during squeezing movement of tamping tools or tool shafts regularly comes in contact with sleeper flanks. However if very little or no squeezing movement is seen, it would mean that the squeezing pressure setting is low.

2.5.7. Tamping cycle & Squeezing time

A complete tamping cycle involves lowering of tamping unit to the required depth, squeezing of ballast (till all tool pairs encounter 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. The total time taken in squeezing and holding of tools in that position is called the squeezing time.

Lifting and lining of track starts as 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 pre-set squeezing time is completed and tamping unit is withdrawn and lifted. Lifting and lining circuit is also cut-off 100 mm before reaching the Zero position. *Fig. 2.23* depicts a typical tamping cycle pictorially.

For packing of ballast, squeezing time of 0.8 second to 1.2 second should normally be adequate. Higher squeezing time may be required for track with caked up ballast.

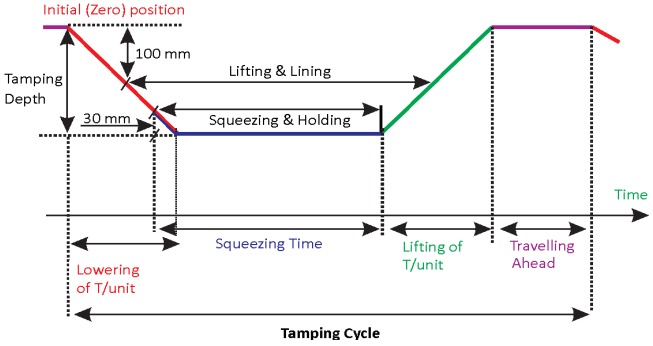


Fig. 2.23 – Pictorial representation of a Tamping Cycle

The squeezing time is set in a potentiometer *(Fig. 2.24)*, in terms of units of 0.2 seconds, however the counter setting at 0 refers to squeezing time of 0.2 second. Therefore to set squeezing time of 0.8 seconds, counter should be set at 3.

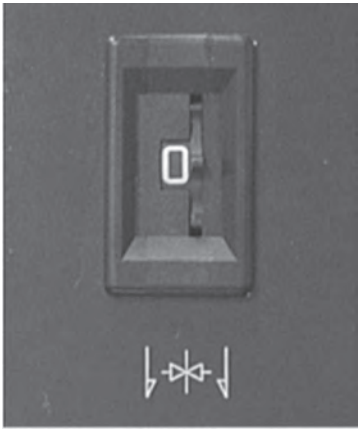


Fig. 2.24 – Counter to set squeezing time

2.6. Output Rating

The work output of the machine depends on its design & construction, condition of various assemblies and maintenance standards. Typical indicative output rating of various machines is given in *Table 2.01* and *Table 2.02* for plain track tamping machines and points and crossing tamping machines respectively. While evaluating the output, care should be taken to reduce the ineffective time (generally around 30 min.), which may include time taken for travel to work site, setting-up time for the machine before the beginning of actual work, closing time after completion of work, and time taken for travel back from work-site.

Table 2.01 - Output of Various Plain Track Tamping Machines

Sl. No.	Machine Type	Model No.	Year of Introduction on IR	Manufacturer	Rated output/ (effective block hour)	Salient Features
1	Super Lining Control Tamper	06-16-SLC	1968	Plasser & Theurer, Austria	400 to 500 Sleepers	Double chord lining. Obsolete.
2	Universal Tamper	06-16-USLC	1972	Plasser & Theurer, Austria	500 to 600 Sleepers	Double chord lining. Obsolete.
3	Tamper (Single Sleeper)	08-16-Unomatic	1985	Plasser & Theurer, Austria	800 to 1000 Sleepers	Single chord lining. One end driving due to Mechanical Gear Box.
4	Tamper (Double Sleeper)	08-32-Duomatic	1986	Plasser & Theurer, Austria	1400 to 1600 Sleepers	Single chord lining. One end driving due to Mechanical Gear Box.
5	Continuous Action Tamping Machine (Double Sleeper)	09-32-CSM	1989	Plasser & Theurer, Austria	2200 to 2400 Sleepers	ZF Gear Box. Satellite unit. Both end driving.
6	Tamping Express & Dynamic T Express (Three Sleeper)	09-3X-CSM	2000 / 2016	Plasser & Theurer, Austria	2800 to 3500 Sleepers	Two Engines. ALC & Laser.
7	Tamper (Double Sleeper)	08-32-New Duomatic	2003	Plasser & Theurer, Austria	1800 Sleepers	ZF gear Box, ALC. Both end driving.

table contd...

Table 2.01 - Out put of Various Plain Track Tamping Machines (Contd.....)

8	Tamper (Double Sleeper)	08-32C Fully Imported	2008	Plasser & Theurer, Austria	1800 Sleepers	ALC, PCB 819 for fast locking and unlocking.
9	Russian Tamper (Double Sleeper)	VPR-02M-18	2004	Metex, Russia	2000 Sleepers	Computer in front cabin.

Table 2.02 - Output of Various Points and Crossing Tamping Machines

Sl. No.	Machine Type	Model No.	Year of Introduction on IR	Manufacturer	Rated output/ (effective block hour)	Salient Features
1	Points & Crossing Tamper	07-275-Unimat	1984	Plasser & Theurer, Austria	1 Turnout in 90 min.	Tool tilting 85° outside & 5° inside. Obsolete
2	Points & Crossing Tamper	08-275-2S Unimat	1990	Plasser & Theurer, Austria	1 Turnout	Tool tilting 85° outside & 5° inside.
3	Points & Crossing Tamper	08-275-3S Unimat	1993	Plasser & Theurer, Austria	1 Turnout	Tool tilting 85° outside & 5° inside. Cantilever for 3rd rail lifting. T/Unit can be turned upto 8½°.
4	Points & Crossing Tamper	08-475-4S Unimat	2009	Plasser & Theurer, Austria	1 Turnout	Tool tilting 85° outside & 5° inside. 4 Tamping unit with 2 sets of split head tools & 2 telescopic arms that can be extended out to LH or RH side up to 3300 mm from track centre. Synchronous 3-rail lifting and 4-rail tamping.
5	Multi Purpose Tamper (MPT)	Unimat Compact-M	1998	Plasser & Theurer, Austria	1 Turnout or 600 sleepers on Straight	For Spot Attention. Lifting Hooks and Jib Crane

2.7. Ancillary Devices/Equipment (Optional)

Depending on make/model of the tamping machine, it may have one or more following optional devices/accessories/equipment for data collection, feeding into tamping system, and monitoring etc.

i) Sleeper end Compactor
ii) LASER Beam/Sighting System for lining
iii) Levelling system with remote control and Sighting device:
iv) LASER System for levelling
v) Geometry Value Assessment (GVA) System
vi) ALC System
vii) Computerised Measuring System (CMS)
viii) Computerised Working System (CWS)
ix) Data Recording Processor (DRP) system

These accessories/equipment, being optional may not be present in all machines, are quite helpful in improving the quality of output by tamping machines by eliminating/reducing manual work and associated error proneness. Therefore, wherever present, these must be used to full extent to achieve substantially better quality of track geometry after tamping and keeping documentation thereof. Some of these devices/accessories/equipment are mentioned below.

2.7.1. Sleeper end Compactor

These hydrauliclly powered sleeper end compactor can be mounted with the tamping units or the rear bogie, during tamping, these units pushes ballast in the empty gaps, that may occur at the ends of sleepers, during lining process, resulting in optimum fixation of the track in lifted and lined position.

2.7.2. LASER beam/Sighting System for lining

Laser Beam/Sighting system for lining, if available with the machine, can be used only on straight track in 3-point

mode to remove long misalignment or false curve. 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 200-300 m away. The receiver system, having photocells mounted on tamping machine on the front trolley is adjustable so that it receives and follows fanned out LASER beam and its position is detected by a transducer, which provides an input to the lining system equivalent to the offset of the front of the chord. Thus, front tower end of chord is shifted laterally by the amount of error to enable design lining. The machine can work and move closer to the LASER trolley until the distance is at least 20 m. Thereafter the LASER trolley needs to be moved farther by extending the already established straight alignment.

LASER system operates automatically and is able to cope with distances of up to 300 m. Some of the important features of LASER system are:

i) Fanning of the LASER beam, by means of a special device, in such a way that, the eventual change in track height has no influence on the system.

ii) With 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. In case of unbalanced laser input received by photocells, a corresponding differential signal activates an electric motor, to move the whole receiver assembly alongwith front end of the chord to the centre of the laser beam.

iii) 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.

2.7.3. Levelling system with remote control and Sighting device

It's a levelling system that works with Plasser machines wherein by means of a special device, fixed to the track in front of the machine, a target board is adjusted to correct height by means of the remote control. The resultant adjustments are added automatically to the lift setting.

2.7.4. LASER system for levelling

In this system a laser beam, which is aimed at a receiver on the front end of the levelling feeler produces a parallel base for the required level of the track. During work, the receiver is automatically adjusted to the height of the laser beam and controls the lifting adjustment.

2.7.5. Geometry Value Assessment (GVA) System

GVA system works through a small computer, which eliminates the feeding of various adjustment values from pre-defined tables and marking on sleepers. However the locations of features on curve i.e. beginning of transition(s), transition length(s), radius of circular portion, super elevation etc. needs to be fed into the computer.

The use of GVA system eliminates the necessity of attention by Operator for feeding various values and thus avoids possible errors in manual calculations and/or feeding. This also results in higher output by tamping machine with better quality.

2.7.6. Automatic Guiding Computer (ALC) System

It is an advanced System, on Plasser machines, built on Windows platform, 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 allows

flexibility to choose the desired track geometry. It also saves the operator from entering various parameters to be fed, which are done automatically. ALC system is also equipped with fault finding diagnostic software. The computer program (of ALC) could handle tasks when:

i) The track geometry is known, by direct input of target geometry data for automatic calculation and output of the required target values for both lining and levelling system, including target super-elevation values.

ii) Input of correction values are available from track surveying, which can be loaded in working mode together with target geometry data.

iii) The track geometry is unknown, it can record relative condition of the track geometry and automatically calculates compensation values and output of the required target values for the lining and levelling system.

ALC working is discussed in detail in Chapter 8.

2.7.7. Computerized Measuring System (CMS)

This is on board computer used for displaying track parameters i.e. super elevation, Versine and Longitudinal level etc. It also displays the nominal values fed by the operator. It also displays lifting and lining values fed manually, through Laser system and ALC. It is used for general setting, digital calibration of lining and levelling systems & diagnosis of signals for proper working of different units.

2.7.8. Computerized Working System (CWS)

This computer receives the various machine working parameters 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, braking pressure of 2bar and 5bar etc.

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

It is also used for setting of tamping parameters like tamping depth, squeezing time, squeezing pressure, satellite unit lowering / raising speed etc.

2.7.9. Data Recording Processor (DRP) system

It is a system, on Plasser machines, for recording track parameters at equidistant intervals (e.g. 0.25 m) in order to document the quality of track parameters achieved by tamping machine after work. The limits of individual parameters can be predefined to evaluate and classify the measurement results. The recorded parameters can also be displayed graphically along with calculated standard deviations. Apart from track parameters it can also record machine working parameters like squeezing time, squeezing pressure, squeezing depth etc.

2.8. Lining and Levelling (Lifting) Systems

2.8.1. Lining system

Lining system is meant for measurement and correction of track alignment. Single chord lining system is used in all tampers working on Indian Railways. The versine on a curved track depends on radius of curves, chord length for measurement and location of measurement. The versine on straight track would, therefore, be zero irrespective of location of measurement. The chord stretched between

front and rear trolley of the machine 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 position. The following principle is applied for lining of track.

i) Measurement of alignment of pre-selected *reference rail* and rectification of that rail (i.e. reference rail).

ii) The alignment of other rail, being fixed with the sleeper, automatically gets rectified. However if there is a variation of gauge, alignment will not get corrected as expected.

For correction of alignment, the machine has two systems of working.

(a) 4-Point lining system (Only for Curved Track)

The selected reference rail is measured using four points on curves for two versine measurements, which are compared to control the lining system. It reduces existing error and adapts them to significantly improve the track alignment.

More details on 4-point lining system can be found in *Chapter -3*

(b) 3-Point lining system (for Curved and Straight Track)

The selected reference rail is measured using three points and the lining is performed until the measurement at middle measuring point reaches the pre-set target versine value.

More details on 3-point lining system can be found in *Chapter -4.*

2.8.2. Levelling (lifting) system

For levelling of track fixed double parallel chord proportional levelling system is used to measure and

correct the track geometry. The track is measured at three locations; at the front of the machine for determination of actual level and front measuring reference point, tamping unit area for the proportional control of the hydraulic track lifting system and at the rear of the tamping units on the already corrected track for determination of the rear measuring reference point.

For this purpose a chord is stretched above each rail, between the front and the rear reference points, to form two independent references for longitudinal level to determine requisite lifting on pre-set reference known as ***datum rail***, which in-turn act as reference for other rail to bring it to desired cross level.

Simultaneously cross-level is measured at all the three locations by means of electronic precision pendulums. The difference between the measured actual cross level at the front measuring point and set theoretical cross level at the middle measuring point is automatically transmitted to the lifting adjustment, corresponding to the side.

The measurement of cross level at the rear measuring point enables verification of cross level on track that has already been worked on, for correction of the lifting cut off point in case of remaining cross level errors (on some machines, which are capable of twist correction), and recording of the cross level by means of an optional electronic recorder.

The tamping machines, which are capable of twist correction, the cross-level information from rear reference point is transferred to lifting circuit as additional feed to enable elimination of any undesirable residual cross-level variation.

More details about Levelling (lifting) can be found in *Chapter -5*.

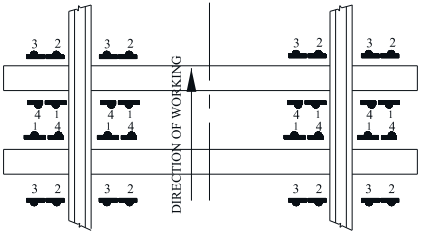
Annexure 2.01 (a)

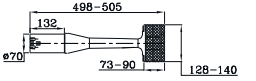
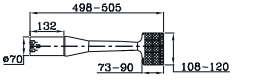
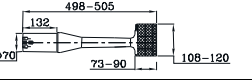
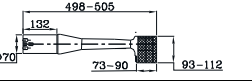
Position of Tamping Tools for 09-3x Tamping Machine

Tool description for Tamping Express (09-3X)

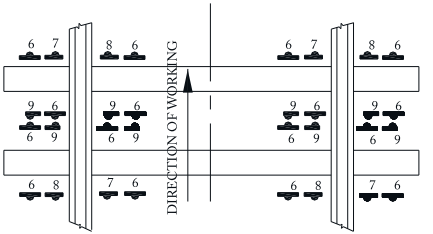
Tool	RDSO Drg. No	Total No Required (out of 48)	Tool Sketch
1	RDSO/TM/ 15A/16	32	
5	RDSO/TM/ 15E/16	16	

Position of Tamping Tools for New CSMs (Model CSM – 955 Onward) and Duomatic Tamping Machines (New Models)



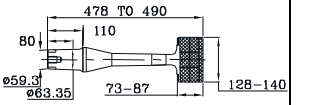
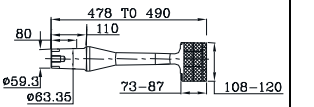
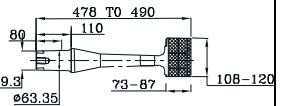
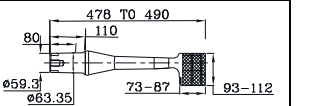
Tool description for new CSM and Duomatic			
Tool	**RDSO Drg. No**	**Total No Required (out of 32)**	**Tool Sketch**
1	RDSO/TM/ 15A/16	08	
2	RDSO/TM/ 15B/16	08	
3	RDSO/TM/ 15C/16	08	
4	RDSO/TM/ 15D/16	08	

Position of Tamping Tools for CSM (upto Model CSM - 954) & Duomatic Tamping Machines (Old Models).



NOTE :

1. No. 2 &4 can be replaced by each other
2. Dimensions are in mm.

Tool description for new CSM and Duomatic (Old Models)			
Tool No.	RDSO Drg. No	Total No . Required (Out of 32)	Tool Sketch
6	RDSO/TM / 14A/16	16	
7	RDSO/TM / 14B/16	04	
8	RDSO/TM / 14C/16	04	
9	RDSO/TM / 14D/16	08	

Annexure 2.01 (d)

Position of Tamping Tools for UNIMAT-4S Tamping Machine

Tool description for UNIMAT-4S Tamping Machine

Tool	RDSO Drg. No	Total No. Required (Out of 16)	Tool Sketch
1	RDSO/TM/ 01A/16	08	
2	RDSO/TM/ 01B/16	08	

Annexure 2.01 (e)

Position of Tamping Tools for UNIMAT-2S & 3S Tamping Machine

Tool description for UNIMAT-2S&3S Tamping Machine			
Tool	**RDSO Drg. No**	**Total No. Required (Out of 16)**	**Tool Sketch**
1	RDSO/TM/ 01A/16	08	
3	RDSO/TM/ 01C/16	08	

■ ■ ■

3

4-Point Lining System

3.1. Lining Systems

As mentioned in previous chapter, single chord lining system is deployed in all tampers working on Indian Railways, wherein versine at identified locations are measured on specified chord length within the machine length for a pre-defined reference rail. It has also been brought out that the versine on a curve is a function of its radius, chord length for measurement and location of measurement. This information is used to determine extent of alignment correction required to be applied at lifting-cum-lining trolley location to bring track to target position. Under this scheme, rectification of pre-selected reference rail takes place and other rail is assumed to be in correct position, if there is no gauge defect. Therefore it becomes an essential pre-requisite, amongst other, to rectify gauge defect, if any, before undertaking tamping operation.

For correction of alignment, the machine has two systems of working.i.e. 4-point lining system (described in this *Chapter-3*) and 3-point lining system (described in *Chapter - 4*). The 4-point lininig system is suitable only for curved tracks, whereas 3-point lining system can be used on straight as well as on curved tracks.

3.2. Reference Rail

As the system of lining suggests, the measurement and rectification happens for the pre-selected reference rail only. Therefore selction of *reference rail* is a vital decision in order to obtain improvement in track geometry. Based on requirements

and experience, the *reference rail* for carrying out attentions to alignment should be selected as given below:

(i) On curved track – outer rail

(ii) On straight track on single, double and middle line(s) in multiple line section - any of the two rails, whichever is less disturbed.

3.3. 4-Point Lining Principle

This method is used for correcting curves and can not be used for straight track. In this method track is measured using 4 references point and versines measured at two intermediate points are compared to control the lining. The principle followed is that, in a circular curve, two versines of a chord are always related in a particular ratio, depending on the position of measuring points. This versine ratio is, therefore, independent of the radius of the circular curve and remains constant. However the versine ratio remains a function of disposition of the four points involve in measurement, which may differ from machine to machine.

The four points involved in measurement and rectification are shown in *Fig. 3.01*

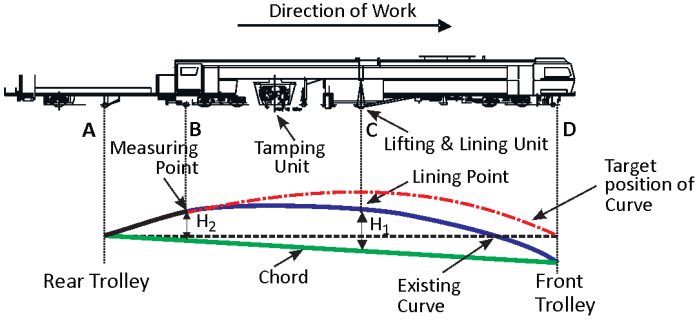


Fig. 3.01 - Schematic Diagram of 4-Point Lining

In *Fig. 3.01*, **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 pre-selected *reference rail* for correction to alignment. A wire chord is stretched between A and D represents "base Line" and 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 called H_1 and H_2. The geometrical property used in this method is given in *Fig. 3.02*.

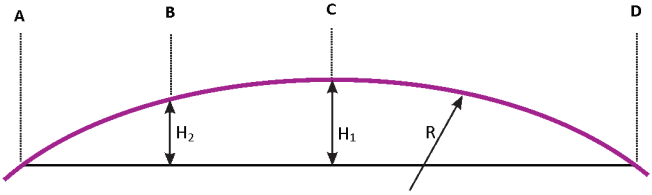


Fig. 3.02 - Versine Measurement in 4-Point Lining System

From the *Fig. 3.02,*

Theoretical Versine at C $$H_1 = \frac{\overline{AC} * \overline{CD}}{2R}$$

Theoretical Versine at B $$H_2 = \frac{\overline{AB} * \overline{BD}}{2R}$$

Ratio of Versine at C and B

$$i = \frac{H_1}{H_2} = \frac{\overline{AC} * \overline{CD}}{\overline{AB} * \overline{BD}}$$

$$i.e.\ H_1 = i * H_2$$

The alignment correction at Point C is carried out until versine H_1 is in the correct proportion to H_2 (i.e. H_1= **i** * H_2). The versine ratio **'i'** being a property of machine, depends on distances between various trolleys. The machine trolley distances and Values of **'i'** for machines currently deployed on IR are indicated in *Annexure 3.01*.

In 4-point lining system, beginning point is taken as first reference point for subsequent corrections. It is, therefore, imperative to choose correct location to begin work, as pre-existing error at initial point will get transmitted to next location being corrected and therefore all subsequent corrections would have accumulated errors from such previous positions.

As the theory suggests, the position A & B are assumed to be on the corrected track with reference to previous positions. Point D always remains on the disturbed location. Lining correction is applied at point C. The machine system feeds H_2 in PCB, where it is multiplied with constant *i* and becomes "**i** * H_2". This calculated value (**i** *H_2) and H_1, as measured at C, are then fed in difference amplifier and error, if any, is indicated on the lining indicator. The alignment is corrected at C by lining units so that H_1 becomes equal to (H_2 x **i**) or the ratio (H_1/ H_2) = **i** is maintained and lining indicator shows zero position.

In the machines having satellite unit, the constant value **i** may change due to relative movement of position C. To overcome this problem a compensation system is provided to automatically adjust for measurement locations.

3.4. Application of 4-Point Lining System

The 4-point lining system is generally used in following situations:

(a) When track alignment geometry is not known and track is aligned according to geometrial 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 alignment on curves.

However, lining can also be carried out according to reference points or previously set slewing values.

3.5. Corrections to be Applied in 4-Point Lining System

The alignment corrected as mentioned above needs further corrections to be applied:

(a) Due to front trolley being on disturbed track.

(b) Due to 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 entering or exiting from straight to transition, transition to circular curve, while on transition curves, or exiting and entering from one curve to another curve.

3.6. Correction (F_D) due to Front Trolley being on Disturbed Track

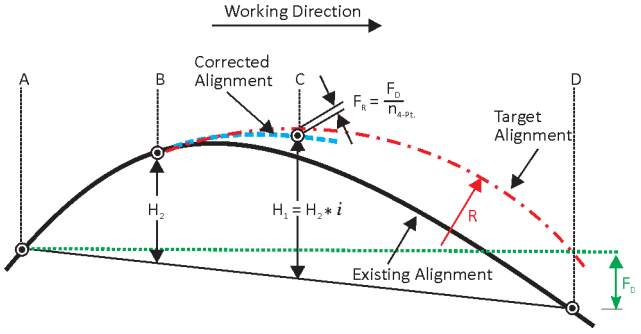


Fig. 3.03 – 4-Point Lining System

In *Fig. 3.03* target alignment of track (red), existing position of track (black) being attended and corrected alignment while front trolley is on disturbed track position (blue) are shown.

The points A and B are on the previously aligned track, the front end of the chord i.e. front trolley (point D) is on the disturbed track with an error F_D resulting in deviation in measurement of versine H_2. Point C is now lined until H_1 is in the correct ratio to inaccurately measured H_2. Therefore depending on the measuring point (B) location, an error would remain at lining Point (C), which is, as shown in *Fig.3.03* known as left over

error or residual error F_R.

$$F_R = H_2 * i + F_D * \frac{AC}{AD} - \left\{ H_2 + \left(F_D * \frac{AB}{AD} \right) \right\} * i$$

$$F_R = F_D * \frac{AC}{AD} - \left(F_D * \frac{AB}{AD} \right) * i$$

$$F_R = \frac{F_D}{AD} \left\{ AC - \left(AB * i \right) \right\}$$

$$F_R = \frac{F_D}{AD} \left\{ AC - \left(AB * \frac{AC * CD}{AB * BD} \right) \right\}$$

$$F_R = F_D * \frac{AC}{AD} \left\{ 1 - \left(\frac{CD}{BD} \right) \right\}$$

$$F_R = F_D * \frac{AC}{AD} \left\{ \frac{BD - CD}{BD} \right\}$$

$$F_R = F_D * \frac{AC * BC}{AD * BD}$$

The left over error (F_R) can also be written as $F_R = \frac{F_D}{n_{4-Pt.}}$

Where,

$n_{4\text{-Pt.}}$ is Error reducing ratio given by expression

$$n_{4-Pt.} = \frac{AD * BD}{AC * BC}$$

Value n_{4pt} depends on trolley distances and its value for various machines are given in *Annexure 3.01*.

A correction, therefore, equal to F_D (in opposite direction) needs to be fed in front tower for eliminating left over error (F_R).

The F_D value can be found by field survey, before undertaking

lining of track by tamping machine, by

(a) Measurement of versine on *reference rail* for existing (i.e. disturbed) track and calculating slews by any suitable method for realignment of curves.

(b) Survey with respect to documented fixed references. (refer *Chapter – 6 & 7*)

3.7. Versine Compensation (V) at Locations with Changing Curvature for Curves with Transitions

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

(a) For entry of machine from straight to transition curve and exit from transition curve to straight track.

(b) For machine working in transition curve.

(c) For entry of machine from transition curve to circular curve and exiting from circular curve to transition curve.

When machine enters from straigh track to (leading) transition curve with front trolley on transition curve and rear trolley on straight track, the measurement of H_2 and H_1 are as shown in *Fig. 3.04*.

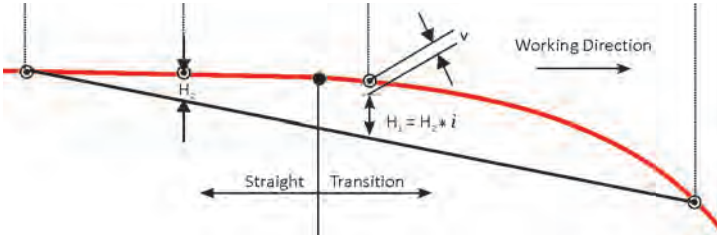
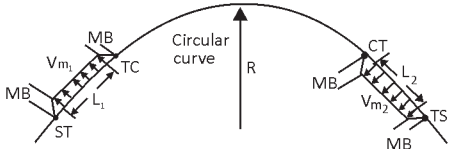


Fig. 3.04 – Versine Measurement on entry from Straight track to Transition Curve

The correct versine at C will be H_2^* **i** +V, where V is the versine compensation required to move track to target position. In the above case, this compensation will be towards outside of the

curve. The value of compensation increases as transition curve is third degree parabolic curve (cubic parabola) and will become maximum (V_m) when entire machine is on transition curve and remains constant as long as it remains on transition curve.

When the machine enters from leading transition to circular curve, the compensation reduces from V_m and will eventually become zero, when the entry of machine into the circular curve is complete (i.e. entire machine is on circular curve). Similarly as the machine enters from circular curve to (trailing) transition curve and from trailing transition curve to straight, the versine compensation is applied in opposite direction as shown in *Fig. 3.05* wherein R is the radius of circular curve, L_1 and L_2 are the transition length at either end, L is the chord length of machine and V_{m1} and V_{m2} are maximum versine compensations at the two ends.



R – Radius of Circular portion of curve
MB – Machine Base (Chord Length)
L_1/L_2 – Leading/Trailing Transition Length

Fig. 3.05 – Versine Compensation for straight-transition circular portion of curves at both ends

The value of V_m depends on position of trolleys involved in measurement of versines (i.e. machine design parameter), length of transition curves and radius of circular curve. The value of V_m can be worked out by an expression as under:

$$V_m = \frac{\text{Machine Constant}}{L * R}$$

Where,

$$\text{Machine Constant} = \frac{AC^{*}\ CD^{*}BC}{6}$$

3.7.1. Versine Compensation Value (V)

The value of V_m for different length of transitions and radius of circular curve along with corresponding values of V at intermediate locations are given in manufacturer's instruction manuals (RT-4 in case of M/s. Plasser & Theurer machines) that accompany each machine. A sample of the chart accompanying the track machine indicating V_m values is shown in *Table 3.01,* which is applicable for a machine with distances AD = 19.65 m, AC = 10.30 m, and AB = 5.00 m, given by expression

$$V_m = \frac{85.069}{R * L}$$

Table 3.01 – Value of V_m (in mm) based on Machine Design Parameters, Radius of Circular Curve (R) and Transition Length (L)

Meter R \ L	20	25	30	35	40	45	50	55	60	65	70	75	80
120	35	28	24	20	18	16	14	13	12	11	10	9	9
130	33	26	22	19	16	15	13	12	11	10	9	9	8
140	30	24	20	17	15	14	12	11	10	9	9	8	8
150	28	23	19	16	14	13	11	10	9	9	8	8	7
160	27	21	18	15	13	12	11	10	9	8	8	7	7
170	25	20	17	14	13	11	10	9	8	8	7	7	6
180	24	19	16	14	12	11	9	9	8	7	7	6	6
190	22	18	15	13	11	10	9	8	7	7	6	6	6
200	21	17	14	12	11	9	9	8	7	7	6	6	5
220	19	15	13	11	10	9	8	7	6	6	6	5	5
240	18	14	12	10	9	8	7	6	6	5	5	5	4
260	16	13	11	9	8	7	7	6	5	5	5	4	4
280	15	12	10	9	8	7	6	6	5	5	4	4	4
300	14	11	9	8	7	6	6	5	5	4	4	4	4
320	13	11	9	8	7	6	5	5	4	4	4	4	3
340	13	10	8	7	6	6	5	5	4	4	4	3	3
360	12	9	8	7	6	5	5	4	4	4	3	3	3
380	11	9	7	6	6	5	4	4	4	3	3	3	3
400	11	9	7	6	5	5	4	4	4	3	3	3	3
420	10	8	7	6	5	5	4	4	3	3	3	3	3
440	10	8	6	6	5	4	4	4	3	3	3	3	2
460	9	7	6	5	5	4	4	3	3	3	3	2	2
480	9	7	6	5	4	4	4	3	3	3	3	2	2
500	9	7	6	5	4	4	3	3	3	3	2	2	2
520	8	7	5	5	4	4	3	3	3	3	2	2	2
540	8	6	5	5	4	4	3	3	3	2	2	2	2
560	8	6	5	4	4	3	3	3	3	2	2	2	2
580	7	6	5	4	4	3	3	3	2	2	2	2	2
600	7	6	5	4	4	3	3	3	2	2	2	2	2
650	7	5	4	4	3	3	3	2	2	2	2	2	2
700	6	5	4	3	3	3	2	2	2	2	2	2	2
750	6	5	4	3	3	3	2	2	2	2	2	2	1
800	5	4	4	3	3	2	2	2	2	2	2	1	1
850	5	4	3	3	3	2	2	2	2	2	1	1	1
900	5	4	3	3	2	2	2	2	2	1	1	1	1
950	4	4	3	3	2	2	2	2	1	1	1	1	1
1000	4	3	3	2	2	2	2	2	1	1	1	1	1
1500	3	2	2	2	1	1	1	1	1	1	1	1	1
2000	2	2	1	1	1	1	1	1	1	1	1	1	1
2500	2	1	1	1	1	1	1	1	1	1	0	0	0
3000	1	1	1	1	1	1	1	1	0	0	0	0	0
3500	1	1	1	1	1	1	0	0	0	0	0	0	0
4000	1	1	1	1	1	0	0	0	0	0	0	0	0
4500	1	1	1	1	0	0	0	0	0	0	0	0	0
5000	1	1	1	0	0	0	0	0	0	0	0	0	0
6000	1	1	0	0	0	0	0	0	0	0	0	0	0
7000	1	0	0	0	0	0	0	0	0	0	0	0	0
8000	1	0	0	0	0	0	0	0	0	0	0	0	0

SAMPLE

Table 3.02 – Variation in V value (in mm) applicable for Straight to Transition Curve and Circular Curve to Transition Curve

ADJUSTMENT FROM FRONT CABIN

Meter	2,0	4,0	6,0	7,0	8,0	9,0	10,0	11,0	12,0	13,0	14,0	15,0	17,0	19,0	19,7	0,0	0,0	0,0	0,0
Vo	0,00	0,02	0,08	0,13	0,19	0,27	0,37	0,49	0,61	0,72	0,82	0,90	0,98	1,00	1,00	0,00	0,00	0,00	0,00
2	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	0	0	0	0
4	0	0	0	1	1	1	1	2	2	3	3	4	4	4	4	0	0	0	0
6	0	0	0	1	1	2	2	3	4	4	5	5	6	6	6	0	0	0	0
8	0	0	1	1	2	2	3	4	5	6	7	7	8	8	8	0	0	0	0
10	0	0	1	1	2	3	4	5	6	7	8	9	10	10	10	0	0	0	0
12	0	0	1	2	2	3	4	6	7	9	10	11	12	12	12	0	0	0	0
14	0	0	1	2	3	4	5	7	8	10	12	13	14	14	14	0	0	0	0
16	0	0	1	2	3	4	6	8	10	12	13	14	16	16	16	0	0	0	0
18	0	0	1	2	3	5	7	9	11	13	15	16	18	18	18	0	0	0	0
20	0	0	2	3	4	5	7	10	12	14	16	18	20	20	20	0	0	0	0
22	0	1	2	3	4	6	8	11	13	16	18	20	22	22	22	0	0	0	0
24	0	1	2	3	5	7	9	12	15	17	20	22	24	24	24	0	0	0	0
26	0	1	2	3	5	7	10	13	16	19	21	23	26	26	26	0	0	0	0
28	0	1	2	4	5	8	10	14	17	20	23	25	27	28	28	0	0	0	0
30	0	1	2	4	6	8	11	15	18	22	25	27	29	30	30	0	0	0	0
32	0	1	3	4	6	9	12	16	19	23	26	29	31	32	32	0	0	0	0
34	0	1	3	4	6	9	13	17	21	25	28	31	33	34	34	0	0	0	0
36	0	1	3	5	7	10	13	17	22	26	30	32	35	36	36	0	0	0	0
38	0	1	3	5	7	10	14	18	23	27	31	34	37	38	38	0	0	0	0
40	0	1	3	5	8	11	15	19	24	29	33	36	39	40	40	0	0	0	0
42	0	1	3	5	8	11	16	20	25	30	35	38	41	42	42	0	0	0	0
44	0	1	4	6	8	12	16	21	27	32	36	40	43	44	44	0	0	0	0
46	0	1	4	6	9	12	17	22	28	33	38	41	45	46	46	0	0	0	0
48	0	1	4	6	9	13	18	23	29	35	39	43	47	48	48	0	0	0	0
50	0	1	4	6	10	14	19	24	30	36	41	45	49	50	50	0	0	0	0
51	0	1	4	6	10	14	19	25	31	37	42	46	50	51	51	0	0	0	0
54	0	1	4	7	10	15	20	26	33	39	44	49	53	54	54	0	0	0	0
56	0	1	4	7	11	15	21	27	34	40	46	50	55	56	56	0	0	0	0
58	0	1	5	7	11	16	22	28	35	42	48	52	57	58	58	0	0	0	0
60	0	1	5	8	11	16	22	29	36	43	49	54	59	60	60	0	0	0	0
62	0	1	5	8	12	17	23	30	38	45	51	56	61	62	62	0	0	0	0
64	0	2	5	8	12	17	24	31	39	46	53	58	63	64	64	0	0	0	0
66	0	2	5	8	13	18	24	32	40	48	54	59	65	66	66	0	0	0	0
68	0	2	5	9	13	18	25	33	41	49	56	61	67	68	68	0	0	0	0
70	0	2	6	9	13	19	26	34	42	50	58	63	69	70	70	0	0	0	0
72	0	2	6	9	14	20	27	35	44	52	59	65	71	72	72	0	0	0	0
74	0	2	6	9	14	20	27	36	45	53	61	67	73	74	74	0	0	0	0
76	0	2	6	10	14	21	28	37	46	55	63	68	75	76	76	0	0	0	0
78	0	2	6	10	15	21	29	38	47	56	64	70	77	78	78	0	0	0	0
80	0	2	6	10	15	22	30	39	48	58	66	72	79	80	80	0	0	0	0
Meter	-8	-6	-4	-2	-1	0	1	2	3	4	5	6	7	9	11	0	0	0	0

ADJUSTMENT BEFORE ÜA / ÜE

ADJUSTMENT AFTER ÜA / ÜE

ADJUSTMENT FROM REAR CABIN

SAMPLE

Table 3.03 – Variation in V value (in mm) applicable for Transition Curve to Circular Curve and Transition Curve to Straight

ADJUSTMENT FROM FRONT CABIN

Meter	2,0	4,0	6,0	7,0	8,0	9,0	10,0	11,0	12,0	13,0	14,0	15,0	17,0	19,0	19,7	0,0	0,0	0,0	0,0
Vo	1,00	0,98	0,92	0,87	0,81	0,73	0,63	0,51	0,39	0,28	0,18	0,10	0,02	0,00	0,00	0,00	0,00	0,00	0,00
2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0
4	4	4	4	3	3	3	3	2	2	1	1	0	0	0	0	0	0	0	0
6	6	6	6	5	5	4	4	3	2	2	1	1	0	0	0	0	0	0	0
8	8	8	7	7	6	6	5	4	3	2	1	1	0	0	0	0	0	0	0
10	10	10	9	9	8	7	6	5	4	3	2	1	0	0	0	0	0	0	0
12	12	12	11	10	10	9	8	6	5	3	2	1	0	0	0	0	0	0	0
14	14	14	13	12	11	10	9	7	6	4	2	1	0	0	0	0	0	0	0
16	16	16	15	14	13	12	10	8	6	4	3	2	0	0	0	0	0	0	0
18	18	18	17	16	15	13	11	9	7	5	3	2	0	0	0	0	0	0	0
20	22	18	18	17	16	15	13	10	8	6	4	2	0	0	0	0	0	0	0
22	22	21	20	19	18	16	14	11	9	6	4	2	0	0	0	0	0	0	0
24	24	23	22	21	19	17	15	12	9	7	4	2	0	0	0	0	0	0	0
26	26	25	24	23	21	19	16	13	10	7	5	3	0	0	0	0	0	0	0
28	28	27	26	24	23	20	18	14	11	8	5	3	1	0	0	0	0	0	0
30	30	29	28	26	24	22	19	15	12	8	5	3	1	0	0	0	0	0	0
32	32	31	29	28	26	23	20	16	13	9	6	3	1	0	0	0	0	0	0
34	34	33	31	30	28	25	21	17	13	9	6	3	1	0	0	0	0	0	0
36	36	35	33	31	29	26	23	19	14	10	6	4	1	0	0	0	0	0	0
38	38	37	35	33	31	28	24	20	15	11	7	4	1	0	0	0	0	0	0
40	40	39	37	35	32	29	25	21	16	11	7	4	1	0	0	0	0	0	0
42	42	41	39	37	34	31	26	22	17	12	7	4	1	0	0	0	0	0	0
44	44	43	40	38	36	32	28	23	17	12	8	4	1	0	0	0	0	0	0
46	46	45	42	40	37	34	0	24	18	13	8	5	1	0	0	0	0	0	0
48	48	47	44	42	39	35	30	25	19	13	9	5	1	0	0	0	0	0	0
50	50	49	46	44	40	36	31	26	20	14	9	5	1	0	0	0	0	0	0
51	51	50	47	45	41	37	32	26	20	14	9	5	1	0	0	0	0	0	0
54	54	53	50	47	44	39	34	28	21	15	10	5	1	0	0	0	0	0	0
56	56	55	52	49	45	41	35	29	22	16	10	6	1	0	0	0	0	0	0
58	58	57	53	51	47	42	36	30	23	16	10	6	1	0	0	0	0	0	0
60	60	59	55	52	49	44	38	31	24	17	11	6	1	0	0	0	0	0	0
62	62	61	57	54	50	45	39	32	24	17	11	6	1	0	0	0	0	0	0
64	64	62	59	56	52	47	40	33	25	18	11	6	1	0	0	0	0	0	0
66	66	64	61	58	53	48	42	34	26	18	12	7	1	0	0	0	0	0	0
68	68	66	63	59	55	50	43	35	27	19	12	7	1	0	0	0	0	0	0
70	70	68	64	61	57	51	44	36	28	20	12	7	1	0	0	0	0	0	0
72	72	70	66	63	58	52	45	37	28	20	13	7	1	0	0	0	0	0	0
74	74	72	68	65	60	54	47	38	29	21	13	7	1	0	0	0	0	0	0
76	76	74	70	66	62	55	48	39	30	21	13	8	1	0	0	0	0	0	0
78	78	76	72	68	63	57	49	40	31	22	14	8	1	0	0	0	0	0	0
80	80	78	74	70	65	58	50	41	32	22	14	8	1	0	0	0	0	0	0
Meter	-8	-6	-4	-2	-1	0	1	2	3	4	5	6	7	9	11	0	0	0	0

ADJUSTMENT BEFORE **ΔA / ΔE**

ADJUSTMENT AFTER **ΔA / ΔE**

ADJUSTMENT FROM REAR CABIN

SAMPLE

3.7.2. Distribution of versine compensation value (V)

The variation of V from zero to V_m is not linear (as could possibly be wrongly interpreted from the *Fig. 3.05*) from zero to maximum value (V_m), The distribution of versine compenastion value (V) is also a function of machine design parameters and shape of the transition curve. A sample profile as V changes over the chord length of L (measuring base of the machine in 4-point system) as given in manufacturer's instruction manual is shown in *Table - 3.02* and *3.03*.

An *Example 3.01* explains the method of calculating V and V_m values.

Example 3.01

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

For DUOMATIC 08-32C from *Annexure 3.01*

AB = 5.00 m,

BC = 5.30 m,

CD = 9.35 m,

AC = 10.30 m,

BD =14.65 m, and

AD =19.65 m

Machine constant= (10.3* 9.35* 5.3)/6 = 85.069

$$V_m = \frac{85.069}{(70*583)} = 0.002\text{m i.e. } 2.0\text{mm}$$

From *Table 3.02* and *Table 3.03*

a) Straight to Transition Curve (ST) and Circular Curve to Transition Curve (CT) :

Distance from ST (Metre) and CT	0 to 8 m	9 to13 m	14 to 19.7m
V in mm	0	1	2

b) From Transition Curve to Circular Curve (TC) and Transition Curve to Straight (TS) :

Distance from TC (Metre) and TS	0 to 8 m	9 to13 m	14 to 19.7m
V in mm	2	1	0

For remaining portion of transition length V = V_m should be fed. Direction of feeding will be as shown in *Fig 3.05*.

3.7.3. Direction for correction (V)

The general principles followed to decide the direction of (toggle switch) for feeding versine compensation are as under:

If machine is entering:

- From High radius to Low radius = towards High rail
- From Low radius to High radius = towards Low rail

Versine compensation and its direction in different curve layout needs to be carefully worked out as described hereunder.

(i) Simple curve: *(Fig. 3.06 and 3.07)*

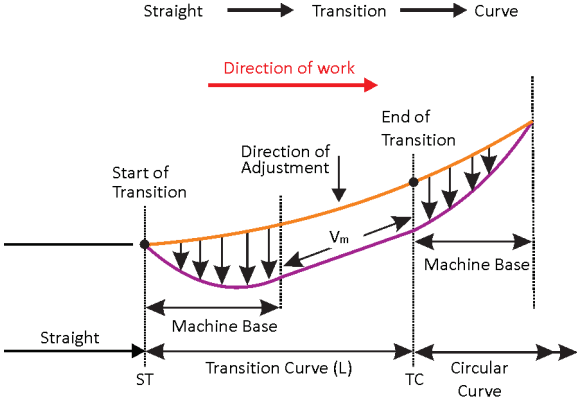


Fig. 3.06

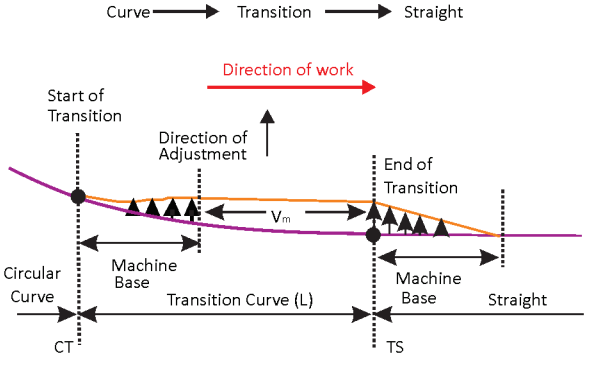


Fig. 3.07

(ii) Composite curves: *(Fig. 3.08 and 3.09)*

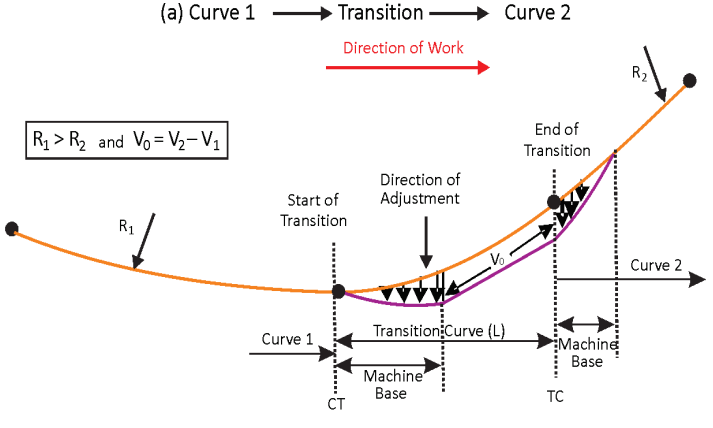


Fig. 3.08

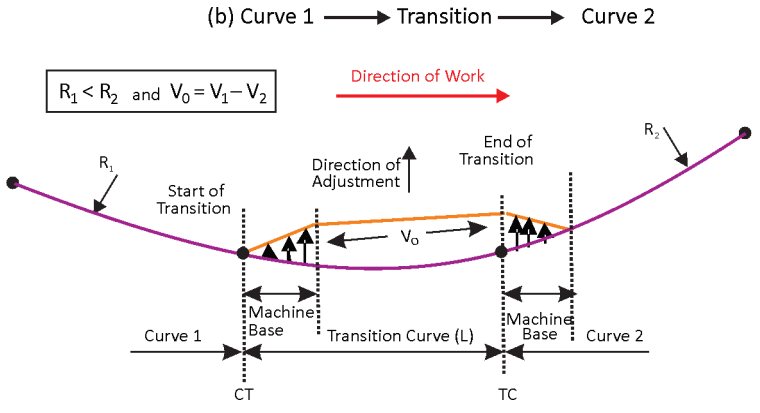


Fig. 3.09

(iii) Reverse Curve *(Fig. 3.10)*

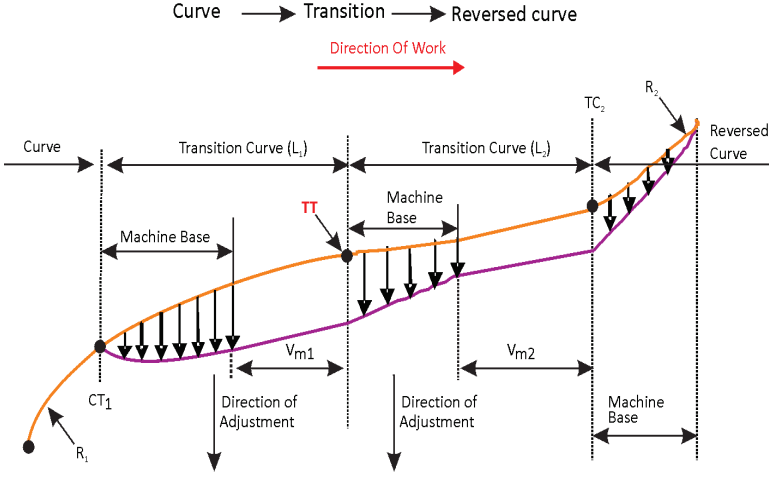


Fig. 3.10

3.8 Versine Compensation (F) for Curves without Transition

The versine compansation described in *para 3.7* and *para 3.8* does not apply to circular curves without any transition. For such cases compensation value 'F' is applied. The versine compensation correction F (see *Fig. 3.11*), when machine 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 SC Straight (Curve Junction). The value of F_m can be calculated as given below

$$F_m = \frac{\text{Constant } (C_f)}{R}$$

$$C_f = \frac{\overline{AC} * \overline{CD} * \overline{BC}}{2\left(\overline{AD} + \overline{BC}\right)}$$

F will increase to F_m at a distance X from SC and from CS, where X is given by

$$X = \frac{\overline{AD} * \overline{BD}}{\overline{AC} * \overline{BC}}$$

The variation of F, is also not linear and it depends on disposition of trolleys and Radius of circular curve.

3.8.1 Versine Compensation Value (F)

The value of F for different curves for a particular machine is given in machine manufacturer's instruction manual. (RT-4 in case of m/s Plasser & Theurer Machines) A sample of the chart, accompanying the track machineis shown in *Table 3.04,* for a machine with distances AD = 19.65 m, AC = 10.30 m, AB = 5.00 m,

F_{max} is given by following expression.

$$F_{max} = \frac{10.2287876}{R}$$

3.8.2 Distribution of Versine Compensation Value (F)

The variation of F is not linear (as could possibly be wrongly interpreted from the *Fig. 3.11*). It is a function of machine design parameters. A sample profile as V changes over the Chord length of Machine L (measuring base of the machine in 4-point system) as given in manufacturer's instruction manual is shown in *Table - 3.04 and Table -3.05*.

3.8.3 Direction for correction (F)

The general principles followed to decide the direction of (toggle switch) for feeding versine compensation are as under:

If machine is entering:

- From High radius to Low radius = towards High rail
- From Low radius to High radius = towards Low rail

Versine compensation and its direction in different curve layout needs to be carefully worked out as described hereunder.

Table 3.04 - Value of F based on Machine Design Parameters and Radius of Circular Curve

R	F	R	F	R	F	R	F
30000	0	1980	5	990	10	490	21
25000	0	1960	5	980	10	480	21
20000	1	1940	5	970	11	470	22
18000	1	1920	5	960	11	460	22
16000	1	1900	5	950	11	450	23
14000	1	1880	5	940	11	440	23
12000	1	1860	5	930	11	430	24
10000	1	1840	6	920	11	420	24
9000	1	1820	6	910	11	410	25
8000	1	1800	6	900	11	400	26
7000	1	1780	6	890	11	390	26
6500	2	1760	6	880	12	380	27
6000	2	1740	6	870	12	370	28
5500	2	1720	6	860	12	360	28
5000	2	1700	6	850	12	350	29
4800	2	1680	6	840	12	340	30
4600	2	1660	6	830	12	330	31
4400	2	1640	6	820	12	320	32
4200	2	1620	6	810	13	310	33
4000	3	1600	6	800	13	300	34
3900	3	1580	6	790	13	295	35
3800	3	1560	7	780	13	290	35
3700	3	1540	7	770	13	285	36
3600	3	1520	7	760	13	280	37
3500	3	1500	7	750	14	275	37
3400	3	1480	7	740	14	270	38
3300	3	1460	7	730	14	265	39
3200	3	1440	7	720	14	260	39
3100	3	1420	7	710	14	255	40
3000	3	1400	7	700	15	250	41
2950	3	1380	7	690	15	245	42
2900	4	1360	8	680	15	240	43
2850	4	1340	8	670	15	235	44
2800	4	1320	8	660	15	230	44
2750	4	1300	8	650	16	225	45
2700	4	1280	8	640	16	220	46
2650	4	1260	8	630	16	215	48
2600	4	1240	8	620	16	210	49
2550	4	1220	8	610	17	205	50
2500	4	1200	9	600	17	200	51
2450	4	1180	9	590	17	195	52
2400	4	1160	9	580	18	190	54
2350	4	1140	9	570	18	185	55
2300	4	1120	9	560	18	180	57
2250	5	1100	9	550	19	175	58
2200	5	1080	9	540	19	170	60
2150	5	1060	10	530	19	165	62
2100	5	1040	10	520	20	160	64
2050	5	1020	10	510	20	155	66
2000	5	1000	10	500	20	150	68

SAMPLE

Table 3.05 – Variation in F value

straight - curve
curve - straight
curve 1 - curve 2

F - VALUES

ADJUSTMENT FROM FRONT CABIN

Meter	2,0	4,0	6,0	7,0	8,0	9,0	10,0	11,0	12,0	13,0	14,0	15,0	17,0	19,0	19,7	0,0	0,0	0,0	0,0
Fo	0,04	0,15	0,33	0,45	0,59	0,75	0,91	0,99	0,99	0,92	0,76	0,53	0,17	0,01	0,00	0,00	0,00	0,00	0,00
2	0	0	1	1	1	2	2	2	2	2	2	1	0	0	0	0	0	0	0
4	0	1	1	2	2	3	4	4	4	4	3	2	1	0	0	0	0	0	0
6	0	1	2	3	4	5	5	6	6	5	5	3	1	0	0	0	0	0	0
8	0	1	3	4	5	6	7	8	8	7	6	4	1	0	0	0	0	0	0
10	0	1	3	5	6	8	9	10	10	9	8	5	2	0	0	0	0	0	0
12	0	2	4	5	7	9	11	12	12	11	9	6	2	0	0	0	0	0	0
14	1	2	5	6	8	11	13	14	14	13	11	7	2	0	0	0	0	0	0
16	1	2	5	7	9	12	15	16	16	15	12	9	3	0	0	0	0	0	0
18	1	3	6	8	11	14	16	18	18	16	14	10	3	0	0	0	0	0	0
20	1	3	7	9	12	15	18	20	20	18	15	11	3	0	0	0	0	0	0
22	1	3	7	10	13	17	20	22	22	20	17	12	4	0	0	0	0	0	0
24	1	4	8	11	14	18	22	24	24	22	18	13	4	0	0	0	0	0	0
26	1	4	9	12	15	20	24	26	26	24	20	14	5	0	0	0	0	0	0
28	1	4	9	13	17	21	25	28	28	26	21	15	5	0	0	0	0	0	0
30	1	4	10	14	18	23	27	30	30	27	23	16	5	0	0	0	0	0	0
32	1	5	11	15	19	24	29	32	32	29	24	17	6	0	0	0	0	0	0
34	1	5	11	15	20	26	31	34	34	31	26	18	6	0	0	0	0	0	0
36	1	5	12	16	21	27	33	36	36	33	27	19	6	0	0	0	0	0	0
38	1	6	13	17	23	29	34	38	38	35	29	20	7	0	0	0	0	0	0
40	1	6	13	18	24	30	36	40	40	37	30	21	7	0	0	0	0	0	0
42	2	6	14	19	25	32	38	42	42	38	32	22	7	0	0	0	0	0	0
44	2	7	15	20	26	33	40	43	44	40	33	23	8	0	0	0	0	0	0
46	2	7	15	21	27	35	42	45	46	42	35	25	8	0	0	0	0	0	0
48	2	7	16	22	28	36	44	47	48	44	36	26	8	0	0	0	0	0	0
50	2	7	17	23	30	38	45	49	50	46	38	27	9	1	0	0	0	0	0
51	2	8	17	23	30	38	46	50	51	47	39	27	9	1	0	0	0	0	0
54	2	8	18	25	32	41	49	53	54	49	41	29	9	1	0	0	0	0	0
56	2	8	19	25	33	42	51	55	56	51	43	30	10	1	0	0	0	0	0
58	2	9	19	26	34	44	53	57	58	53	44	31	10	1	0	0	0	0	0
60	2	9	20	27	36	45	54	59	59	55	46	32	10	1	0	0	0	0	0
62	2	9	21	28	37	47	56	61	61	57	47	33	11	1	0	0	0	0	0
64	2	9	21	29	38	48	58	63	63	59	49	34	11	1	0	0	0	0	0
66	2	10	22	30	39	50	60	65	65	60	50	35	11	1	0	0	0	0	0
68	3	10	23	31	40	51	62	67	67	62	52	36	12	1	0	0	0	0	0
70	3	10	23	32	42	53	63	69	69	64	53	37	12	1	0	0	0	0	0
72	3	11	24	33	43	54	65	71	71	66	55	38	12	1	0	0	0	0	0
74	3	11	25	34	44	56	67	73	73	68	56	39	13	1	0	0	0	0	0
76	3	11	25	35	45	57	69	75	75	70	58	41	13	1	0	0	0	0	0
78	3	12	26	35	46	59	71	77	77	71	59	42	14	1	0	0	0	0	0
80	3	12	27	36	47	60	73	79	79	73	61	43	14	1	0	0	0	0	0
82	3	12	27	37	49	62	74	81	81	75	62	44	14	1	0	0	0	0	0
84	3	12	28	38	50	63	76	83	83	77	64	45	15	1	0	0	0	0	0
86	3	13	29	39	51	65	78	85	85	79	65	46	15	1	0	0	0	0	0
88	3	13	29	40	52	66	80	87	87	81	67	47	15	1	0	0	0	0	0
90	3	13	30	41	53	68	82	89	89	82	68	48	16	1	0	0	0	0	0
92	3	14	31	42	55	69	83	91	91	84	70	49	16	1	0	0	0	0	0
94	3	14	31	43	56	71	85	93	93	86	71	50	16	1	0	0	0	0	0
Meter	-8	-6	-4	-2	-1	0	1	2	3	4	5	6	7	9	11	0	0	0	0

ADJUSTMENT BEFORE **BA / BE**

ADJUSTMENT AFTER **BA / BE**

ADJUSTMENT FROM REAR CABIN

SAMPLE

(i) Simple curve *(Fig.3.11)*

Straight – Curve - Straight

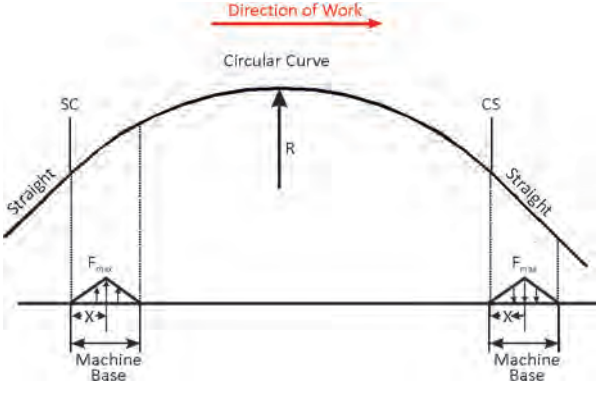


Fig. 3.11

(ii) Compound Curve

a) Curve1 to Curve2 (R_1 greater than R_2)

$$F_{m0} = F_{m2} - F_{m1}$$

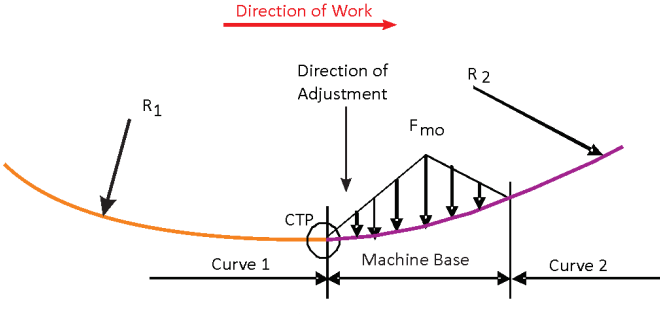


Fig. 3.12

b) Curve 1 to Curve 2 (R_1 Smaller than R_2)

$$F_{m0} = F_{m1} - F_{m2}$$

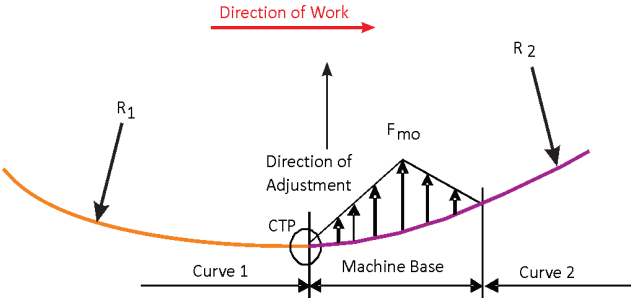


Fig. 3.13

(iii) Reversed Curve

Curve to Reversed curve (S-Curve)

$$F_{m0} = F_{m1} + F_{m2}$$

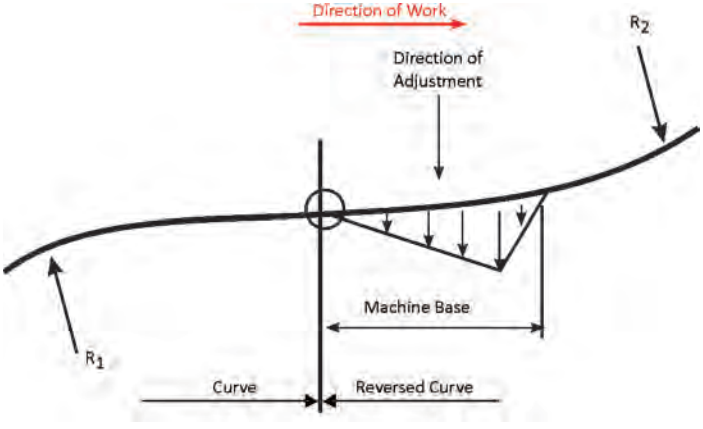


Fig. 3.14

3.8.4 IRICEN Software for finding versine compensation (values in RT-4 Manual)

Versine Compensation for different type of machine & curves can be obtained from IRICEN Software.

The same is discussed at Annexure 4.02.

3.9 Working Modes using 4-Point Lining System (Only for Curves)

The modes of working by 4-Point lining system for correcting curve are:

1) *Smoothening/Compensation mode Lining*

In this mode, tamping is done on the basis of known track geometry without conducting field survey for alignment. However radius of circular curve and transition details are required for versine compensation V or F as applicable for calculation and application.

In this mode curve is smoothened, however it is not being brought to any targeted position.

2) *Design mode Lining*

Here field survey of curve is done in advance to ascertain the error (F_D) from target profile at different locations. In addition to correction compensation V or F as applicable, correction F_D is also applied.

In this mode the curve is smoothened and also brought to near targeted position.

3.10. Feeds for Working in 4-Point Lining System

A summery of the feeds, which are to be supplied, while working in 4-point lining system in both smoothening and design modes on curves is given below:

Mode of working	Values to be fed			Remarks
	Versine (compensation)	**Slew (F_D)**	**Cant**	
Smoothening (Compensation) mode	Yes (V or F)	-	Yes	Curve Radius required for calculating versine compensation (V_m/F) is taken from measured data.
Design mode	Yes (V or F)	Yes (F_D Values)	Yes	1. Curve Radius required for calculating versine compensation (V_m/F) is taken from design curve proposed. 2. F_D should be ascertained by field survey in advance for achieving design curve.

Annexure 3.01 - Machine Trolley Distances, Versine Ratio, Error Reduction Factor and Machine Constant (4 - point lining system)

Sl. No.	Machine Type	Machine Nos.	Trolley Distances						*i*	n (4-Pt)	Constant Value (4 Pt)
			AB	BC	CD	AC	BD	AD			
1	0 8 – 32	8018-8045	5.00	5.00	10.00	10.00	15.00	20.00	1.330	6.000	83.33
2	0 8-32 New	8049-8059	5.00	5.12	9.80	10.12	14.92	19.92	1.329	5.741	84.51
3	08-32 C	8128-8140	5.00	5.30	9.35	10.30	14.65	19.65	1.315	5.273	85.07
4	08-275	8249-8060	5.00	5.00	10.60	10.00	15.60	20.60	1.359	6.427	88.33
5	08-275 UNIMAT-3S	8261-8291	4.20	5.18	12.82	9.38	18.00	22.20	1.591	8.224	103.82
6	08-275 -3S	8292-8312	4.20	5.69	12.71	9.89	18.40	22.60	1.627	7.390	119.21
7	08-475 UNIMAT-4S	8401-8418	5.85	6.09	12.71	11.94	18.80	24.65	1.380	6.373	154.03
8	UNIMAT COMPACT- M	2000-2002	5.00	5.40	11.00	10.40	16.40	21.40	1.395	6.249	102.96
9	UNIMAT COMPACT- M	2003-2008	5.00	5.60	10.80	10.60	16.40	21.40	1.396	5.912	106.85
10	UNIMAT MFI SPLIT HEAD	2009-2018	5.00	6.05	11.20	11.05	17.25	22.25	1.435	5.741	124.79
11	0 9- 32CSM	901-953	6.00	4.70	10.05	10.70	14.75	20.75	1.215	6.086	84.24
12	0 9- 32CSM	954-967	6.00	3.79	10.96	9.79	14.75	20.75	1.212	8.249	67.78
13	09-32 CSM	968 -984	6.00	3.79	10.96	9.79	14.75	20.75	1.212	8.249	67.78
14	0 9-3X Tamping Express	3954-3963	4.35	5.48	11.08	9.83	16.55	20.90	1.511	6.430	99.29
15	0 9-3X Tamping Express	3964-3965	4.35	5.48	11.08	9.83	16.55	20.90	1.511	6.430	99.29
16	0 9-3X Tamping Express	3966-3971	4.35	5.48	11.08	9.83	16.55	20.90	1.511	6.430	99.29

■ ■ ■

4

3-Point Lining System

In the previous Chapter, while describing 4-point lining system, it was mentioned that the rectification of pre-selected reference rail only takes place and other rail is considered to be in correct position, if there is no gauge defect. It, therefore, is an essential pre-requisite, amongst other that there is no gauge defect before undertaking tamping operation. The same remains true for 3-point lining system also, which uses 3 points to make corrections, to bring track to its target position in horizontal plane.

4.1. Reference Rail

The principles to select the *reference rail* remain exactly the same as described in *Chapter – 3*. All measurement and rectification takes place for the pre-selected reference rail. Based on requirements and experience, the *reference rail* for carrying out attentions to alignment should be selected as given below:

(i) On curved track – outer rail

(ii) On straight track on single, double and middle line(s) in multiple line section - any of the two rails, whichever is less disturbed.

The selected reference rail is measured using three points and the lining is performed until the measurement at intermediate measuring point reaches the pre-set target versine value.

4.2. 3-Point Lining System

3-Point lining method can be used on straight as well as curved track. The track is measured using three points B, C and D and alined according to pre-specified versine at point C. The chord at measuring position B, is fixed by the fork and the potentiometer is switched off. The versine at C is measured on chord BD and compared with preset versine value (see *Fig. 4.01*). Any difference detected will activate the lining control to affect the necessary correction.

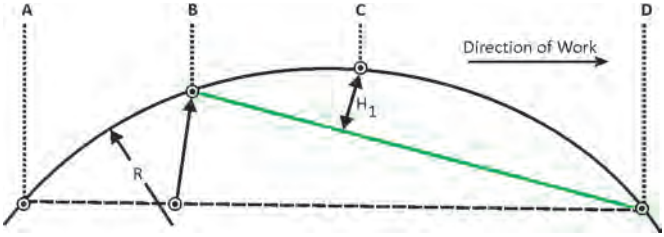


Fig. 4.01 – Measurement of Versine (ordinate) at C in 3-Point Lining System

As the measuring chord is fixed at Points B and D,

Geometrically

$$H_1 = \frac{BC * CD}{2R} = \frac{\text{System Constant Value}}{R}$$

The target versine (H_1) at point C (a function of chord length and curvature) is known beforehand. Alignment correction is carried out until the versine H_1 is achieved at point C.

4.3. Application of 3-Point Lining System

The 3-point method is mainly used if:

(i) The track is to be lined according to specified radii/ versines.

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

4.4. Corrections to be applied in 3- point lining system

The alignment corrected as mentioned above needs to be further corrected for errors due to front trolley (point D) being on disturbed track.

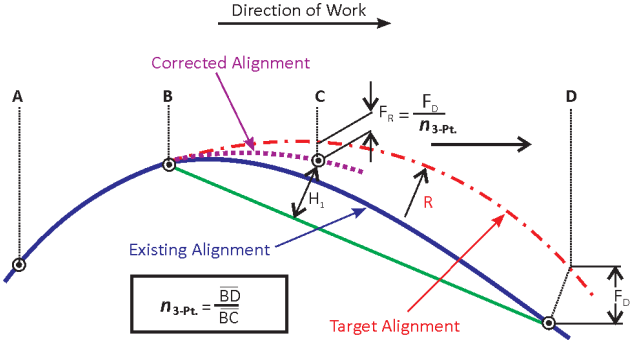


Fig.4.02 – 3-Point Lining Errors

In *Fig. 4.02*, Point B is on the already aligned track. The front end of the chord, point D is having lining error F_D. Point C is, therefore, aligned until H_1 becomes equal to preset versine value. The residual error, $F_R = F_D / n_{3\text{-Pt.}}$ could still remains, which needs to be corrected. This error, if not corrected, will results in further wrong positioning of point B, as machine moves forward, and the error, therefore accumulates. The error reduction factor, while working in 3-point system without correction of lining error at D is given by

$$n_{3\text{-Pt.}} = \frac{BD}{BC}$$

The error reduction factor is a property of machine, which depends on the position of point C as well as the base used for measurement i.e. distance between B and D.

The value of n_{3pt} for tamping machines available on Indian Railway is listed in *Annexure-4.01*

A correction, therefore, equal to F_D (in opposite direction), needs to be fed in front tower for eliminating left over error (F_R).

The F_D values are computed from the readings taken during field survey prior to taking up tamping. Any of the following three methods may be adopted for the field survey.

- Measurement of versine on reference rail of the track (what is generally termed as disturbed track) and calculating slews by any suitable software for realignment of curves.
- Survey with respect to fixed references *(refer Chapter – 6)*

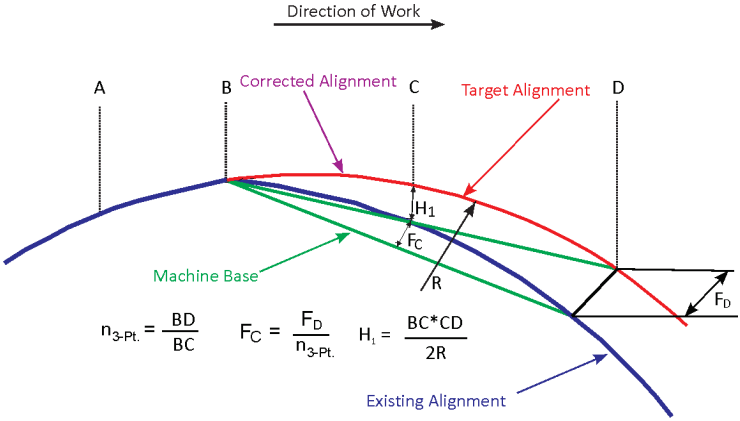


Fig. 4.03 – Correction for Front Trolley Position

The F_D value to be applied as shown in Fig.4.03 at trolly D for getting correct Curve.

4.5. Determination of Target Versine Values

Since the track is to be lined according to a specified radius, which need versine input, target versine values as applicable for the particular machine base and location of lining trolley are calculated. The target versine for every machine is different from the versine written on curve for 20m chord as each machine has a different chord length (BD) and also different location of lining trolley. Plasser & Theurer has given these versine valve in RT-3 manual supplied with each m/c. Following nomenclature is used for target versines in this book.

H = Target versines of circular curve.

H_V, H_X, H_Y, H_Z, H_W = Target versines for parabolic transitions. (For Machines Manufactured by M/s.Plasser, these parameters are shown as H_V, H_A, H_B, H_C, H_D)

H_{FX}, H_{FW} = Target versines for curves without transitions.

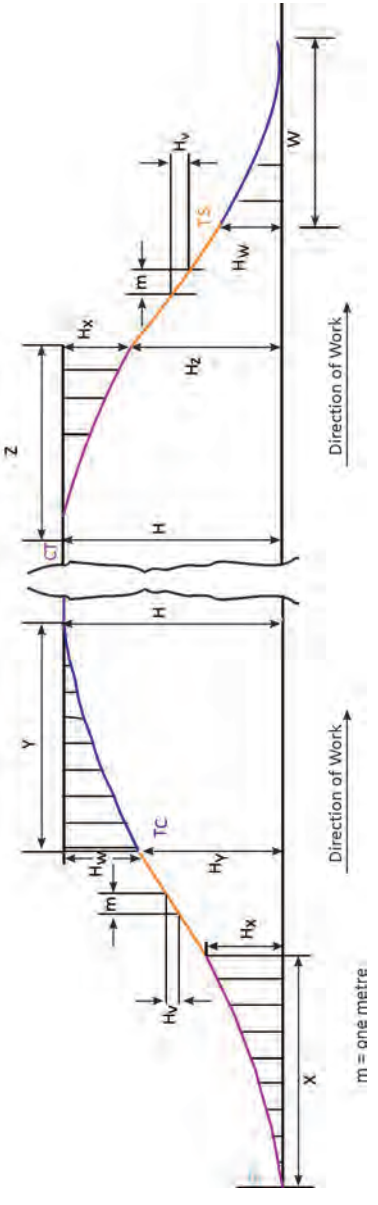


Fig. 4.04 – Target Versines in Different Portions, for Curves with Transitions (parabolic)

4.5.1. Curve with Parabolic Transitions

The target versines for different portion of curve are calculated as shown in *Fig. 4.04.*

The versine for circular curve is

$$H = \frac{\text{System Constant Value}}{R}$$

Section X, Y, Z and W equal to machine chord length (BD) for 3-point lining.

(i) Section X:

The versine H_X for section X are calculated by dividing the operation constant value 'C_{XZ}' for X and Z portions, by the product "R* L", where L is the length of transition.

$$H_x = \frac{\text{Operation Constant Value for X \& Z } (C_{XZ})}{R * L}$$

(ii) Between section X and Y:

After section X till TC (end of the transition) the versines are increased by adding one "H_V" per meter (m)

$$H_V = \frac{\text{System Constant Value}}{R * L} = \frac{H}{L}$$

(iii) Section Y:

H_Y for the section 'Y' are calculated as

$H_Y = H - H_W$

Where, H_W is as defined in (vi) below

(iv) Section *Z*:

H_Z for the section 'Z' is

$H_Z = H - H_X$

(v) Between Section Z and W:

After section "Z" till "TS" the versine are decreased by subtracting of one "H_V" per meter (m)

(vi) Section D:

The Versine "H_W" is obtained from formula

$$H_w = \frac{\text{Operation Constant Value for Y \& W } (C_{VW})}{R * L}$$

The operational constant C_{XZ} and C_{YZ} are given in manufacturers manual and can also be calculated.

An *example 4.01* illustrates the calculations of various versine values for 3-point lining system

Example - 4.01.

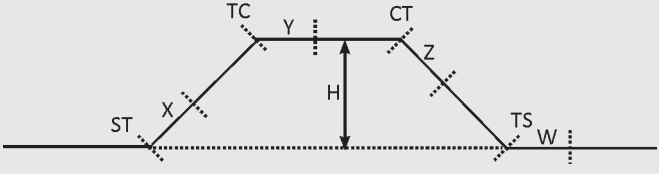
Method for attending a curve of Radius 583 m and transition length 70 m by 09-32 CSM using 3-Point lining system.

For 09-32 CSM (*from Annexure 4.01*)

BC = 4.70 m, CD = 10.05 m, and BD = 14.75 m,

$$H = \frac{BC * CD}{2R} = \frac{23.617}{R} = 40.5\text{mm}$$

$$H_V = \frac{40.5}{L} = 40.5\text{mm}$$



Length of X, Y, Z and W (i.e.BD) = 14.75 m (Machine Base)

(A) Versine for sections X, Y, Z and W									
Distance from ST, TC, CT & TS (in m)	0	2	4	6	8	10	12	14	14.75
Section X and Z									
R * L	40810								
Constant* for sections X & Z (C_{XZ})	0	425	3399	11417	27191	53107	90534	135455	153120
$H_X = \frac{C_{XZ}}{R * L}$	0	0.01	0.08	0.3	0.6	1.3	2.2	3.3	3.7
$H_Z = H - H_X$	40.5	40.5	40.4	40.2	39.9	39.2	38.3	37.2	36.8
Section Y and W									
Constant* for sections Y & W (C_{YW})	195238	148428	104167	65004	33489	12170	2362	48	0
$H_Y = H - H_W$	35.7	36.9	37.9	38.9	39.7	40.2	40.4	40.5	40.5
$H_W = \frac{C_{YW}}{R * L}$	4.8	3.6	2.6	1.6	0.8	0.3	0.06	0	0

* Constants are available at one metre interval

The operational constant's value C_{XZ} and C_{YZ} are provided by manufacturers for every one meter interval. Therefore, it has to be distributed for alternate sleepers as per sleeper spacing.

For portion between X and Y in transition, the versine at end of section X is increased at the rate of H_V per metre for the length of (Transition Length – Machine Base), wherefore at the end it will become equal to versine at beginning of section Y.

For portion between section Z and W, the versine at end of section Z is reduced at the rate of H_V per metre for the length of (Transition Length-Machine Base), wherefore at the end it will become equal to versine at beginning of section Z.

H_V, therefore is also equal to:

$$H_V = \frac{(\text{Versine at starting Y}) - (\text{Versine at the end of X})}{\text{Transition Length - Machine Base}} \text{ mm/meter}$$

The calculation below has been shown at 10 m interval, which for practical purposes be calculated at every alternate sleeper accordingly.

(B) Versine for portion between section X and Y

Distance from end ST	14.75	24.75	34.75	44.75	54.75	64.75	70
Distance from end of X(x)	0	10	20	30	40	50	55.25
$H_{XY} = 3.7 + x * H_V$	3.7	9.5	15.3	21.1	26.9	32.7	35.7

(C) Versine for portion between section Z and W

Distance from end CT	14.75	24.75	34.75	44.75	54.75	64.75	70
Distance from end of Z(z)	0	10	20	30	40	50	55.25
$Hzw=36.8 - z * H_V$	36.8	31.0	25.2	19.4	13.6	7.8	4.8

4.5.2. Curve without Transitions

For curves without transitions the versine are calculated as under:

The versine H for the circular curve is obtained from formula

$$H_1 = \frac{\text{System Constant Value}}{R}$$

For versine in section X and W, i.e. while entering and exiting from circular curves.

$H_{FX} = H * F_X$

$H_{FW} = H * F_W$

The operational (system) constant values F_X and F_W are made available in documentation provided by manufacturer. (In their RT-3 Manual)

4.5.3. IRICEN Software for finding versine value (Value in RT-3 Manual)

Versine values for different curves and for different machines can be obtained from IRICEN Software also. The same is discussed at *Annexure 4.02*.

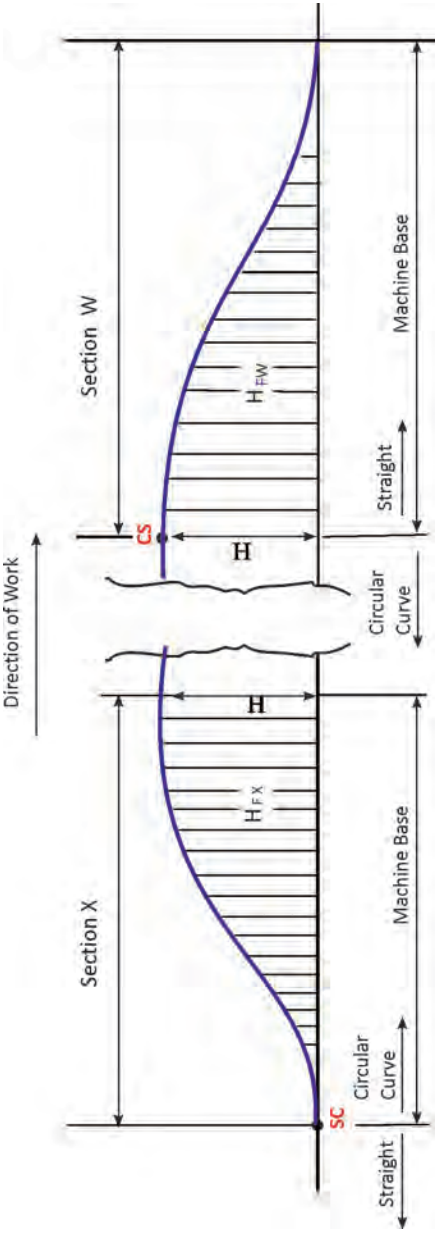


Fig. 4.05 – Versine for Circular Curves without transition

4.6. Modes of Tamping using 3-Point Lining Method

The modes of tamping by 3-Point lining method for correcting curve are

(i) *3- point Elementary mode lining* – In this mode, alignment correction is done on the basis of known (theoretical) track geometry without conducting field survey and tamping is done using calculated versines H, H_X, H_Y, H_Z and H_W or H_F as applicable on the basis of theoritical/ average track geometry as ascertained based on versine measurments.

In this mode of lining, curve is brought to the geometry fed, however it is not brought to the desired or designed location.

(ii) *3- point Design mode lining* – In this mode also, alignment correction is done on the basis of known (theoritical) track geometry. However in addition, field survey of track to be attended is carried out in advance to ascertain the error (F_D) at different locations from desired or designed alignment to bring it to the desired location. Here, calculated versines i.e. H, H_X, H_Y, H_Z and H_W or H_{FX} and H_{FY} as applicable, on the basis of theoritical/average track geometry as ascertained base on versine measurmants and correction F_D is applied.

The track is brought to the designed or desired target geometry and location.

4.7. Feeds for Working in 3-Point Lining System

A summery of the feeds, to be supplied, while working in 3-point lining system in both smoothening and design mode are summerised below:

Mode of working	Values to be fed			Remarks
	Versine	Slew (F_D)	Cant	
3-point Elementry mode	Yes (Applicable Versine values H, H_X, H_Y, H_Z, H_W, H_V, H_{FX}, H_{FW})	-	Yes	1. Design radius of curve is required for calculating versine values. Existing radius is taken for the purpose
3-point Design mode	Yes (Versine values H, H_X, H_Y, H_Z, H_W, H_V, H_{FX}, H_{FW})	Yes (F_D Value)	Yes	1. Designed curve radius required for calculating versine values. 2. In addition, F_D should be ascertained by field survey in advance.

4.8. Comparison between 3-Point and 4-Point Lining Systems

3-Point lining system can be used for both straight and curves tracks while 4-Point lining system is only meant for curves. Other differences while working on curves are listed below:

(a) Elementary /Smoothening mode comparision

Sl. No.	3-Point Lining in Elementary Mode	4-Point Lining in Smoothening/ Compensation Mode
1	Versine of desired curve ie H, H_X, H_Y, H_Z and H_W etc. (or H_{FX} & H_{FW}) are calculated based on Radius of curve, Transition Length and Machine Base. The calculated versine values are fed through versine potentiometer.	For circular portion of curve, machine measures versine at measuring trolley (H_2) and versine at lining trolley (H_1) is corrected on the basis of versine ratio. In transitions, V_m (or F) correction is applied in addition by feeding through versine potentiometer.
2	Residual error is F_D /$n_{3\text{-Pt.}}$ Depending on Machine Base, the value of $n_{3\text{-Pt.}}$ is generally between 3 to 3.5. ($F_R \approx 33\ \%\ F_D$)	Residual error is $F_D/n_{4\text{-Pt.}}$ The value of $n_{4\text{-Pt.}}$ is generally between 6 to 7.5. ($F_R \approx 16\ \%\ F_D$)

Note:

(i) The residual error in 4–Point lining in Smoothening mode is less as compared to that in 3–Point lining system in Elementry mode. When curve is not measured in advance and existing track is very much disturbed, the curve achieved on the basis of the theoretical average versine (calculated in 3–point system on the basis of known track geometry or average measured versine without input of F_D) may not be to the acceptable alignment.

(ii) In 4–Point linning system, left over error at any station would influence the track alignment at next station. However, it may still be desirable to use this method for smoothening of curve, as it reduces station to station variation of versine.

(b) Design mode comparision

Sl. No.	3-Point Lining in Elementary Mode	4-Point Lining in Smoothening/ Compensation Mode
1	Versine of desired curve ie H, H_X, H_Y, H_Z and H_W etc. (or H_{FX} & H_{FW}) are calculated based on Radius of curve, transition length and chord length of machine. The calculated versine value is fed through versine potentiometer. In addition slew values (F_D) are fed in the front tower in slew potentiometer.	For circular portion of curve, machine measures versine at measuring trolley (H_2) and versine at lining trolley (H_1) is corrected on the basis of versine ratio. In transition, V_m (or F) correction is applied in addition by feeding through versine potentiometer. In addition to above slew values (F_D) are fed in the front tower in slew potentiometer
2	The curve can be brought to the designed or desired target alignment and position.	The curve here can be smoothened and brought to near designed/ target alignment/position.
3	Can be used with LASER system	Not applicable.

Note:
(i) If the track is desired to be brought to the known position and geometry using fixed references, 3- Point lining in design mode should be followed. (ii) In absence of fixed references, it is advisable to use measuring run design mode of tamping. (refer para 4.6) (iii) 4-Point design mode should normally be used only when it is intened to smoothen the curve and bring it close to desired alignment.

Annexure - 4.01

Machine Trolly Distances, Error Reduction Factor & Machine Constant (3 - point linning system)

Sl. No.	Machine Type	Machine No.	Trolley Distances			$n_{3\text{-}Pt.}$	Constant Value
			BC	CD	BD		
1	0 8 – 32	8018-8045	5.000	10.000	15.000	3.000	25.000
2	0 8-32 New	8049-8059	5.115	9.800	14.915	2.916	25.063
3	08-32 C	8128-8140	5.300	9.350	14.650	2.764	24.777
4	08-275	8249-8060	5.000	10.600	15.600	3.120	26.500
5	08-275 UNIMAT-3S	8261-8291	5.180	12.820	18.000	3.475	33.203
6	08-275 -3S	8292-8312	5.690	12.710	18.400	3.234	36.159
7	08-475 UNIMAT-4S	8401-8418	6.090	12.710	18.800	3.087	38.701
8	UNIMAT COMPACT- M	2000-2002	5.400	11.000	16.400	3.037	29.700
9	UNIMAT COMPACT- M	2003-2008	5.600	10.800	16.400	2.929	30.240
10	UNIMAT MFI SPLIT HEAD	2009-2018	6.050	11.200	17.250	2.851	33.880
11	0 9- 32CSM	901-953	4.700	10.050	14.750	3.138	23.617
12	0 9- 32CSM	954-967	3.790	10.960	14.750	3.892	20.769
13	09-32 CSM	968 -984	3.790	10.960	14.750	3.892	20.769
14	0 9-3X Tamping Express	3954-3963	5.475	11.075	16.550	3.023	30.317
15	0 9-3X Tamping Express	2964-3965	5.475	11.075	16.550	3.023	30.317
16	0 9-3X Tamping Express	3966-3971	5.475	11.075	16.550	3.023	30.317

Annexure -4.02

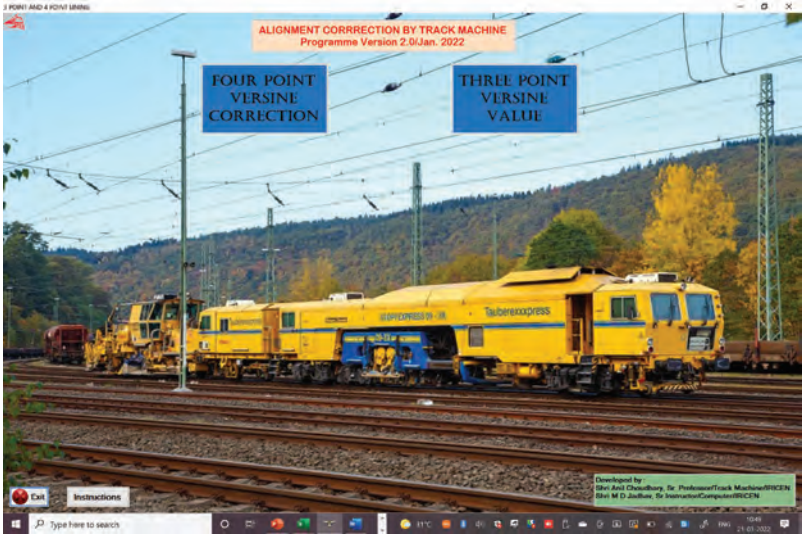
Software (Version 2.0 of January 2022) for versine values in 3-point lining and versine correction in 4-point lining

For 3 point lining, versine values to be fed in machine is different from versine values written on curves. These versine values are machine dependent and can be obtained from RT-3 manual provided by the machine supplier (M/s Plasser India).

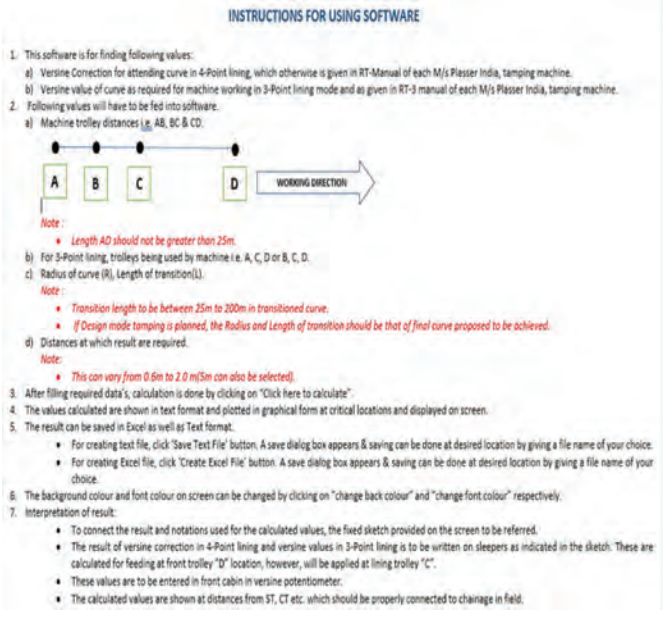
For 4-point lining similarly, versine correction is to be obtained from RT-4 manual provided with each machine by the manufacturer (M/s Plasser India).

For using manufacturers manual, the method of calculation has been given and for each different curve (R and L), separate calculation is done. These values are then to be written as discussed in chapter 3 and 4. IRICEN has developed a software for finding these values and is discussed below

Home screen



Read the instructions given for properly understanding the use of software. The instructions are produced here also



INSTRUCTIONS FOR USING SOFTWARE

1. This software is for finding following values:
   a) Versine Correction for attending curve in 4-Point lining, which otherwise is given in RT-Manual of each M/s Plasser India, tamping machine.
   b) Versine value of curve as required for machine working in 3-Point lining mode and as given in RT-3 manual of each M/s Plasser India, tamping machine.
2. Following values will have to be fed into software.
   a) Machine trolley distances i.e. AB, BC & CD.

Note :
- *Length AD should not be greater than 25m.*

   b) For 3-Point lining, trolleys being used by machine i.e. A, C, D or B, C, D.
   c) Radius of curve (R), Length of transition(L).

Note :
- *Transition length to be between 25m to 200m in transitioned curve.*
- *If Design mode tamping is planned, the Radius and Length of transition should be that of final curve proposed to be achieved.*

   d) Distances at which result are required.

Note:
- *This can vary from 0.6m to 2.0 m(5m can also be selected).*

3. After filling required data's, calculation is done by clicking on "Click here to calculate".
4. The values calculated are shown in text format and plotted in graphical form at critical locations and displayed on screen.
5. The result can be saved in Excel as well as Text format.
   - For creating text file, click 'Save Text File' button. A save dialog box appears & saving can be done at desired location by giving a file name of your choice.
   - For creating Excel file, click 'Create Excel File' button. A save dialog box appears & saving can be done at desired location by giving a file name of your choice.
6. The background colour and font colour on screen can be changed by clicking on "change back colour" and "change font colour" respectively.
7. Interpretation of result:
   - To connect the result and notations used for the calculated values, the fixed sketch provided on the screen to be referred.
   - The result of versine correction in 4-Point lining and versine values in 3-Point lining is to be written on sleepers as indicated in the sketch. These are calculated for feeding at front trolley "B" location, however, will be applied at lining trolley "C".
   - These values are to be entered in front cabin in versine potentiometer.
   - The calculated values are shown at distances from ST, CT etc. which should be properly connected to chainage in field.

For 4 point Versine correction Click on	FOUR POINT VERSINE CORRECTION
For 3 point Versine values, click on	THREE POINT VERSINE VALUE

A. 4-Point Versine values:-

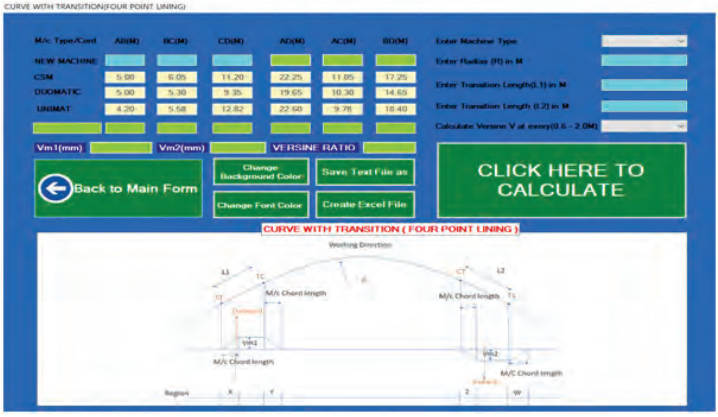
After clicking on the icon, following screen will be displayed



Four different cases versine values are covered and can be accessed using four icons given at bottom i.e

Circular Curve with parabolic transition	**Curve With Transition**
Circular Curve without Transition	**Curve Without Transition**
Reverse Curve in opposite direction	**Reverse Curve**
Compound curve in same direction	**Compound Curve**

(a) Curve with transition



Following information needs to be filled up for getting versine correction value

- Machine type
- Machine Chord information i.e. AB,BC and CD
- Curve information i.e R and L
- Versine correction to be obtained at what interval

Preferably choose New machine and then enter chord information based on machine being used.

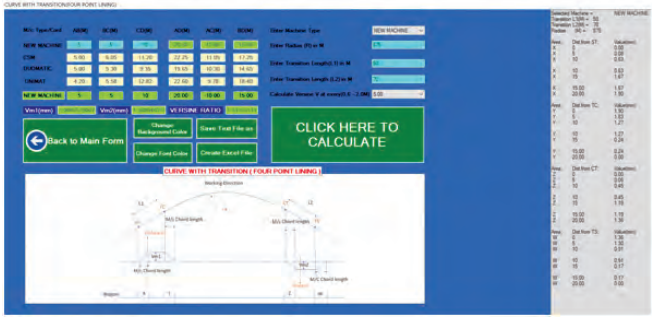
Taking a case with below parameters

- Machine with chord length of AB=5, BC=5 and

CD = 10

- Is to attend a curve of R=875 m and L1=50, L2=70 m
- Vm is to be obtained at every 5 m

The result obtained is



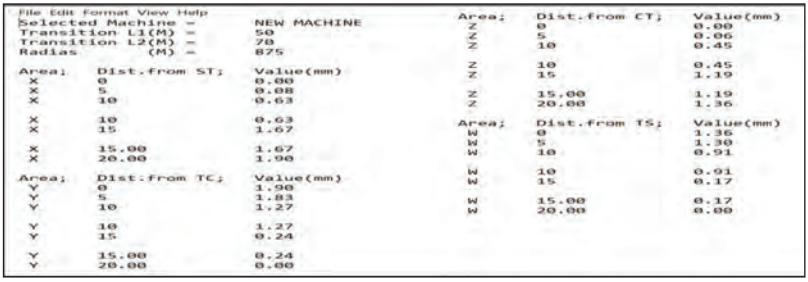
The data can be saved as text file or excel file by clicking on the relevant icon. In this case, data saved in excel file.

CURVE WITH PARABOLIC TRANSITION 4 POINT							
SELECTED MACHINE = NEW MACHINE, RADIUS(M) = 875 , Transition L1 (M)= 50, Transition L2 (M)= 70							
Dist. from ST (M)	**VALUE in X (mm)**	**Dist. from TC (M)**	**VALUE in Y (mm)**	**Dist. from CT (M)**	**VALUE in Z (mm)**	**Dist. from TS (M)**	**VALUE in W(mm)**
0	0	0	1.9	0	0	0	1.36
5	0.08	5	1.83	5	0.06	5	1.3
10	0.63	10	1.27	10	0.45	10	0.91
10	0.63	10	1.27	10	0.45	10	0.91
15	1.67	15	0.24	15	1.19	15	0.17
15	1.67	15	0.24	15	1.19	15	0.17
20	1.9	20	0	20	1.36	20	0

Vm1=1.9 mm and Vm2=1.36 mm

These are accordingly written on the sleepers. Region X, Y, Z and W are shown in sketch below.

For saving as text file, add txt at end.The text file will appear as



```
File Edit Format View Help
Selected Machine =          NEW MACHINE
Transition L1(M) =          50
Transition L2(M) =          70
Radius      (M) =          875

Area;    Dist.from ST;      Value(mm)
 X          0                0.000
 X          5                0.08
 X          10               0.63

 X          10               0.63
 X          15               1.67

 X          15.00            1.67
 X          20.00            1.90

Area;    Dist:From TC;      Value(mm)
 Y          0                1.90
 Y          5                1.83
 Y          10               1.27

 Y          10               1.27
 Y          15               0.24

 Y          15.00            0.24
 Y          20.00            0.00

Area;    Dist.from CT;      Value(mm)
 Z          0                0.00
 Z          5                0.06
 Z          10               0.45

 Z          10               0.45
 Z          15               1.19

 Z          15.00            1.19
 Z          20.00            1.36

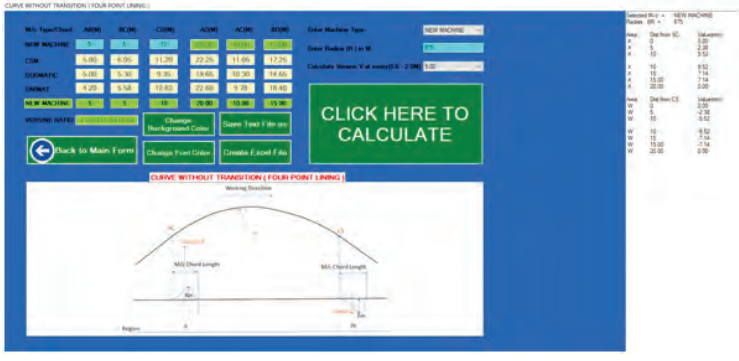
Area;    Dist.from TS;      Value(mm)
 W          0                1.36
 W          5                1.30
 W          10               0.91

 W          10               0.91
 W          15               0.17

 W          15.00            0.17
 W          20.00            0.00
```

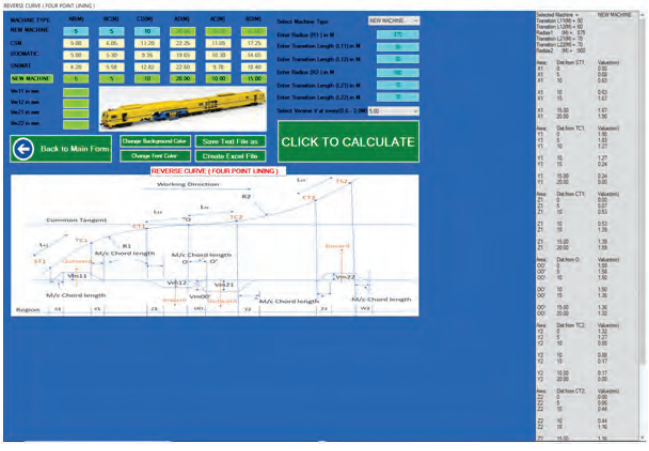
Vm1=1.90 mm and Vm2= 1.36 mm
These values to be written on sleepers at location shown in sketch

b. Curve without Transition



CURVE WITHOUT TRANSITION - 4 POINT				
SELECTED MACHINE = NEW MACHINE, RADIUS(M) = 875				
Dist. from SC (M)	**VALUE in X (mm)**		**Dist. from CS (M)**	**VALUE in W(mm)**
0	0		0	0
5	2.38		5	-2.38
10	9.52		10	-9.52
10	9.52		10	-9.52
15	7.14		15	-7.14
15	7.14		15	-7.14
20	0		20	0

c. Reverse Curve



value click on and for 3 point versine values, click on the icon

REVERSE CURVE (4 POINT)
SELECTED MACHINE = NEW MACHINE
R1(M) = 875, Transition L11(M) = 50, Transition L12(M) = 60
R2(M) = 900, Transition L21(M) = 70, Transition L22(M) = 70

Dist. from ST1 (M)	Value (mm) in X1
0	0
5	0.08
10	0.63
10	0.63
15	1.67
15	1.67
20	1.9

Dist. from TC1 (M)	Value (mm) in Y1
0	1.9
5	1.83
10	1.27
10	1.27
15	0.24
15	0.24
20	0

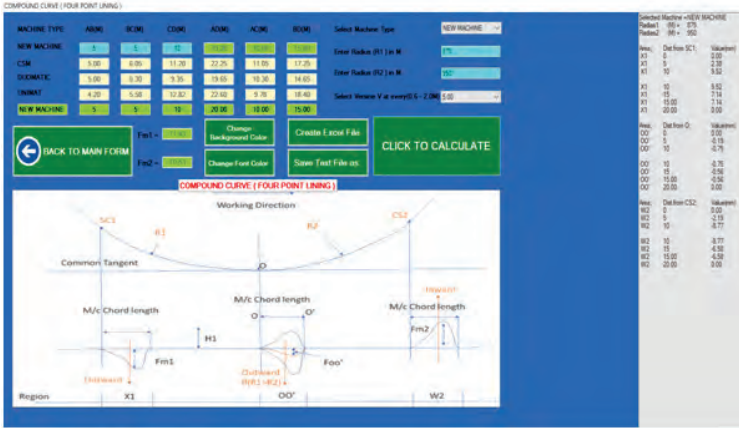
Dist. from CT1 (M)	Value (mm)in Z1
0	0
5	0.07
10	0.53
10	0.53
15	1.39
15	1.39
20	1.59

Dist. from O(M)	Value (mm) in OO'
0	1.59
5	1.58
10	1.5
10	1.5
15	1.36
15	1.36
20	1.32

Dist. from TC2 (M)	Value (mm) in Y2		Dist. from CT2 (M)	Value (mm) in Z2		Dist.from TS2 (M)	Value (mm) in W2
0	1.32		0	0		0	1.32
5	1.27		5	0.06		5	1.27
10	0.88		10	0.44		10	0.88
10	0.88		10	0.44		10	0.88
15	0.17		15	1.16		15	0.17
15	0.17		15	1.16		15	0.17
20	0		20	1.32		20	0

Vm11=1.9 mm, Vm12=1.59 mm, Vm21=1.32 mm, Vm22=1.32 mm

d. Compound Curve



COMPOUND CURVE (4 POINT)	SELECTED MACHINE = NEW MACHINE
R1(M) = 875	
R2(M) = 950	

Dist. from SC1 (M)	Value (mm) in X1		Dist. from O (M)	Value (mm) in OO'		Dist. from CS2 (M)	Value (mm) in W2
0	0		0	0		0	0
5	2.38		5	-0.19		5	-2.19
10	9.52		10	-0.75		10	-8.77
10	9.52		10	-0.75		10	-8.77
15	7.14		15	-0.56		15	-6.58
15	7.14		15	-0.56		15	-6.58
20	0		20	0		20	0

B. Three Point Lining

On clicking on 3-point lining, the screen that appears is

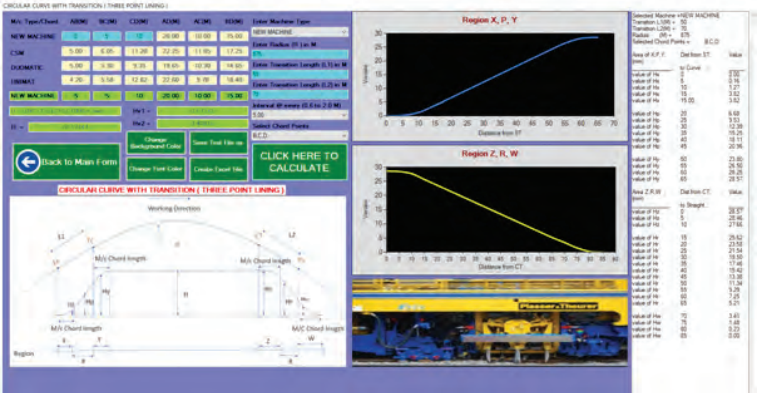


Four different cases versine values are covered and can be accessed using four icons given at bottom i.e.

Circular Curve with parabolic transition	**Curve With Transition**
Circular Curve without Transition	**Curve Without Transition**
Reverse Curve in opposite direction	**Reverse Curve**
Compound curve in same direction	**Compound Curve**

In 3-point, we can use B, C, D or A, C, D which needs to be selected.. The versine values for same curve and same machine is given below

a. Curve With Transition



CURVE WITH PARABOLIC TRANSITION								
SELECTED MACHINE = NEW MACHINE, RADIUS(M) = 875, Transition L1(M) = 50, Transition L2(M) = 70, SELECTED CHORD PTS.= B, C, D								
Dist. from ST (M)	VALUE (mm) in X, P, Y		Dist. from CT (M)	VALUE (mm) in Z, R, W				
0	0		0	28.57				
5	0.16		5	28.46				
10	1.27		10	27.66				
15	3.82		15	25.62				
15	3.82		20	23.58				
20	6.68		25	21.54				
25	9.53		30	19.5				
30	12.39		35	17.46				
35	15.25		40	15.42				
40	18.11		45	13.38				
45	20.96		50	11.34				
50	22.38		55	9.29				
50	23.8		60	7.25				
55	26.5		65	5.21				
60	28.25		70	4.31				
65	28.57		70	3.41				
			75	1.48				
			80	0.23				
			85	0				

H= 28.57 mm

The result in text file will appear as

3 point - Notepad

File Edit Format View Help

```
Selected Machine =        NEW MACHINE
Transition L1(M) =        50
Transition L2(M) =        70
Radias       (M) =        875
Selected Chord Points = B,C,D

Area of X,P,Y;  Dist.from ST;   Value(mm)
              ;  to Curve   .;
value of Hx     0               0.00
value of Hx     5               0.16
value of Hx     10              1.27
value of Hx     15              3.82
value of Hx     15.00           3.82

value of Hp     20              6.68
value of Hp     25              9.53
value of Hp     30              12.39
value of Hp     35              15.25
value of Hp     40              18.11
value of Hp     45              20.96

value of Hy     50              23.80
value of Hy     55              26.50
value of Hy     60              28.25
value of Hy     65              28.57
```

```
Area Z,R,W  ;   Dist.from CT;   Value(mm)
            ;   to Straight.;
value of Hz     0               28.57
value of Hz     5               28.46
value of Hz     10              27.66

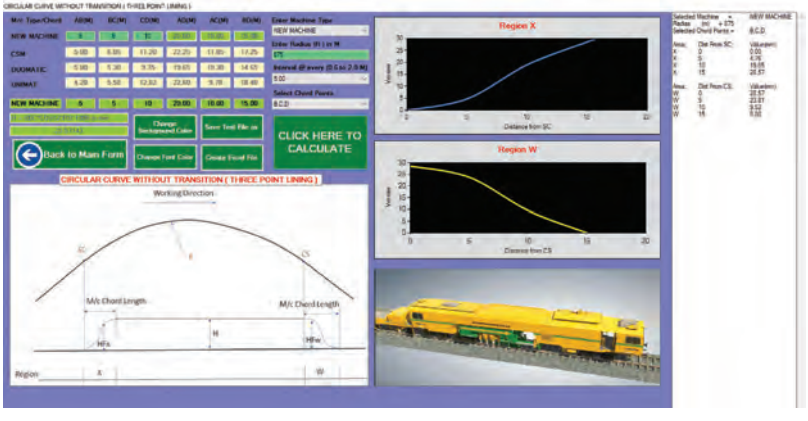
value of Hr     15              25.62
value of Hr     20              23.58
value of Hr     25              21.54
value of Hr     30              19.50
value of Hr     35              17.46
value of Hr     40              15.42
value of Hr     45              13.38
value of Hr     50              11.34
value of Hr     55              9.29
value of Hr     60              7,25
value of Hr     65              5.21

value of Hw     70              3.41
value of Hw     75              1.48
value of Hw     80              0.23
value of Hw     85              0.00
```

H=28.57 mm

These values to be directly written on sleepers at position shown in the sketch.

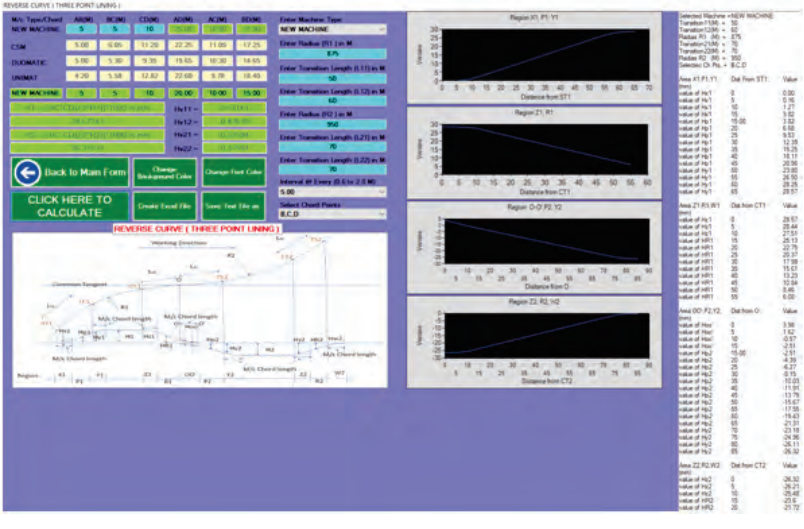
b. Curve without transition



The result in excel will show

CURVE WITHOUT TRANSITION				
SELECTED MACHINE = NEW MACHINE, RADIUS (M) = 875, SELECTED CHORD PTS.= B, C, D				
Dist. from SC (M)	**Value (mm) in X**		**Dist. from CS (M)**	**Value (mm) in W**
0	0		0	28.57
5	4.76		5	23.81
10	19.05		10	9.52
15	28.57		15	0

c. Reverse Curve



REVERSE CURVE	SELECTED MACHINE = NEW MACHINE SELECTED CHORD POINTS = B, C, D
R1 (M) = 875, Transition L11 (M) = 50, Transition L12 (M) = 60	
R2 (M) = 950, Transition L21 (M) = 70, Transition L22 (M) = 70	

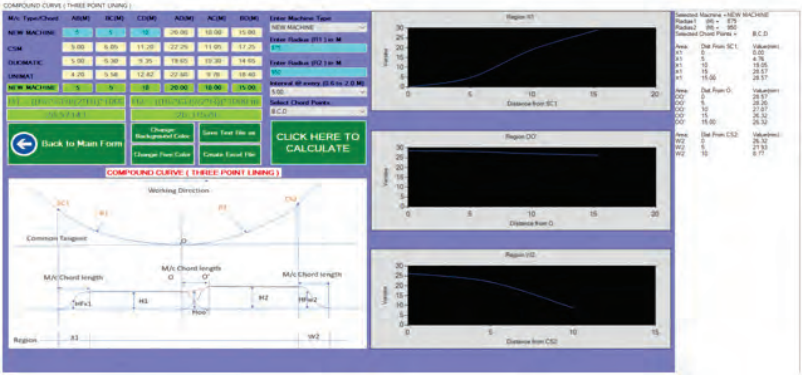
Dist. from ST1 (M)	Value (mm) in X1, P1, Y1		Dist. from CT1 (M)	Value (mm) in Z1, R1
0	0		0	28.57
5	0.16		5	28.44
10	1.27		10	27.51
15	3.82		15	25.13
15	3.82		20	22.75
20	6.68		25	20.37
25	9.53		30	17.99
30	12.39		35	15.61
35	15.25		40	13.23
40	18.11		45	10.84
45	20.96		50	8.46
50	23.8		55	6.08
55	26.5			
60	28.25			
65	28.57			

Dist. from O (M)	Value (mm) in OO', P2, Y2		Dist. from CT2 (M)	Value (mm) in Z2, R2, W2
0	3.98		0	-26.32
5	1.62		5	-26.21
10	-0.57		10	-25.48
15	-2.51		15	-23.6
15	-2.51		20	-21.72
20	-4.39		25	-19.84
25	-6.27		30	-17.96
30	-8.15		35	-16.08
35	-10.03		40	-14.2
40	-11.91		45	-12.32

45	-13.79		50	-10.44
50	-15.67		55	-8.56
55	-17.55		60	-6.68
60	-19.43		65	-4.8
65	-21.31		70	-3.14
70	-23.18		75	-1.36
75	-24.96		80	-0.21
80	-26.11		85	0
85	-26.32			

H1-28.57 mm, H2-26.32 mm

d. Compound Curve



COMPOUND CURVE					
SELECTED MACHINE = NEW MACHINE, R1(M)= 875, R2(M)= 950, SELECTED CHORD PTS. = B, C, D					
Dist. from SC1	**Value (mm) in X1**	**Dist. from O**	**Value (mm) in OO'**	**Dist. from CS2**	**Value (mm) in W2**
0	0	0	28.57	0	26.32
5	4.76	5	28.2	5	21.93
10	19.05	10	27.07	10	8.77
15	28.57	15	26.32	15	0

General Instructions for using the software:

1. *Since we are finding Fd value at every 10 m from ROC, it is easier to write Fd at every 5 m by interpolating the adjacent station slew values obtained.*
2. *The Versine correction in 4-Point Lining and Versine values in 3-Point Lining should preferably be calculated at every 5m.*
3. *Table in the format as given below should be prepared for use of field people.*

Curve distance	Station	Fd	Versine	Remark
From ST	-3	0	0	
	Mid of stations	-3	0	
0	-2	-6	0	ST
5	Mid of stations	-13	0.05	
10	-1	-20	0.4	
15	Mid of stations	-28	1.28	

Note: IRICEN has developed a software called "Curve designing, Existing speed, Increasing speed, Realignment and Tamping machine data" which can be used for getting Front offset and versine values required for machine at every 5m. The software is explained in IRICEN publication "Railway Curves-chapter 6".

4. The value in between to be achieved will be approximated by machine operator.
5. One complete case has been discussed in field problem-2, in Chapter 12
6. In next version, it is proposed to add
   - Reverse curve without transition and Compound curve with transition.

■ ■ ■

5
Levelling

5.1. General

As mentioned in *Chapter-2,* fixed parallel chord proportional levelling system is deployed for measurement, and correction, of longitudinal and provision of correct cross-level, wherefore measurements are made at the front of the machine, in tamping unit area and at the rear on the already corrected track. A chord is stretched for this purpose, above each rail, between the front and the rear reference points, to form two independent references to determine requisite lifting of pre-set reference rail known as *datum rail*. The *datum rail* in-turn act as reference for other rail to bring it to desired/target cross level with aid from pendulums.

5.2. Levelling and Lifting System

The levelling system consists of two chord wires one for each rail, stretched tightly from Front tower (F) to Rear tower (R) (see *Fig. 5.01*). The tamping machine rectifies level defects in one of the pre-decided refernce rail (*datum rail*) by lifting it with reference to the levelling chord. Height Transducers are mounted on middle feeler rods (M), which rest on track near lifting & tamping unit (see *Fig. 5.02*), measures the gap between its zero level and chord wire. The *datum rail* is then lifted to eliminate this gap and other rail (Cant rail) is lifted to provide specified cross level (super elevation), which is kept zero in straight track or a certain value on curved track.

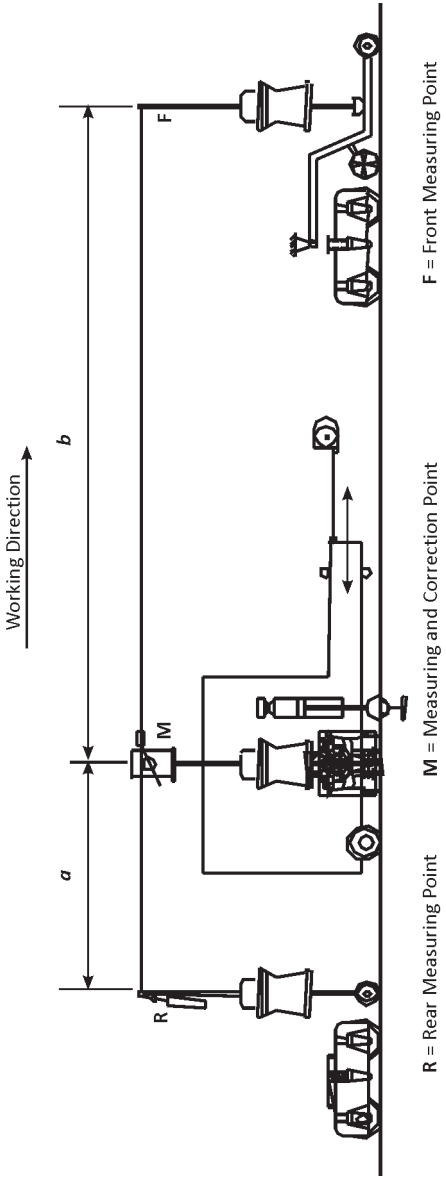


Fig. 5.01 – Schematic Arrangement of Levelling indicating R, M and F locations

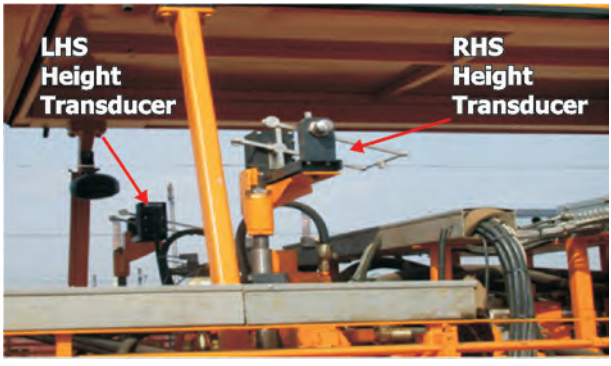


Fig. 5.02 (a) – Height Transducer Mounting on Middle Feeler rod (M)

The height transducer working principle is based on the arm movement as given below,

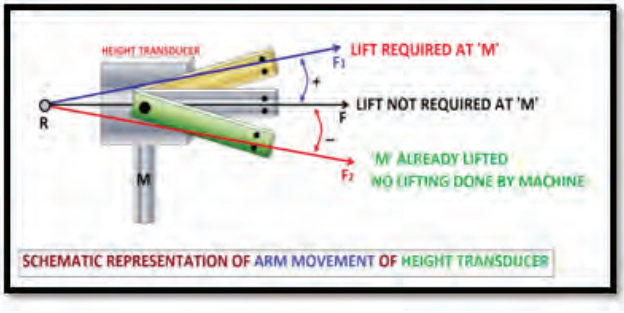


Fig. 5.02 (b) Movement of Height Transducer

If rotation is upward, M i.e track is lifted, If Rotation is downward, M i.e track is lowered and if no rotation means track is level

In addition pendulums are also mounted *(see Fig. 5.03)* at locations R, M and F for designated purposes as under;

(i) Front Pendulum- for automatic cross level adjustment at front tower.

(ii) Middle Pendulum - for display only at location of

correction.

(iii) Rear Pendulum - for twist correction, display and recording.

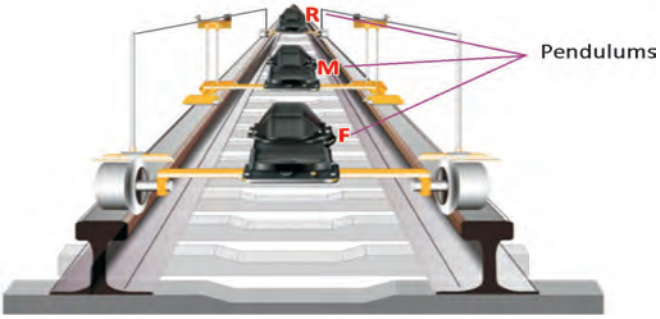


Fig. 5.03 – Schematic Arrangement of Levelling System

5.3. Datum/Cant Rail

Similar to ***reference rail*** mentioned in case of lining, the selection of ***datum rail*** has tremendous significance for levelling operation. It must be borne in mind that the ***datum rail*** (aka base rail) chosen for levelling may not be the same rail, which is chosen as reference rail for lining.

For selection of *datum rail* for levelling the following principles are followed:

(a) On curves - inner-rail

(b) On straight track in double line - higher/less disturbed rail, which is generally non-cess rail.

(c) On straight track in single line and straight middle track in multiple lines section, higher/less disturbed rail.

In machines, manufactured by M/s Plasser, Cant Selector Switch is provided to select ***cant rail***, which is kept opposite to the datum rail. In Russian tampers, datum selector switch is provided for selecting ***datum rail***.

5.4. Reduction Ratio

In levelling process, front tower always remains on disturbed track and rear tower on corrected track. Because of level defect offset (Y) 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 would remain after levelling.

Thus, the leveled track at M would have,

$$\text{Level Error} = \frac{Y^* a}{(a+b)} = \frac{Y}{r}$$

Where

"Y" = Level offset at front tower, and

$$\text{Reduction ratio} = r = \frac{(a+b)}{a}$$

The tamping machines have different reduction ratio (c/a) for lifting, being design feature. as can be seen for some of the machines in *Table 5.01*.

Table 5.01 – Reduction ratios for various machines working Indian Railway

	08-275 Unimat	08-275-3S Unimat	08-475-4S Unimat	09-32 CSM	Unimat Compact (MPT)	09-3X (Tamping Express)	08-32C (Duomatic)
RM(a)	3.32	4.85	6.12	3.90	5.10	4.56	5.3
MF(b)	8.89	10.73	11.12	8.90	9.05	10.67	9.35
RF(a+b)	12.21	15.58	17.24	12.80	14.15	15.23	14.65
Reduction Ratio (r)	3.678	3.212	2.817	3.232	2.775	3.333	2.764

5.5. Modes of Levelling

The available modes for levelling to correct longitudinal and cross-level are as under:

(a) *Smoothening or Compensation levelling mode*

In smoothening mode, general lift to be given for the datum rail is generally fixed and smoothening action takes place. Errors in Longitudinal level is not corrected entirely thereby some residual error (F_R) still remains. Only short wave defects, within the base of the machine (a+b) can be removed. *(see Fig. 5.04)* Superelevation in curves and correction values 'K' and 'X' are also applied. The same is covered in 5.9 & 5.10.

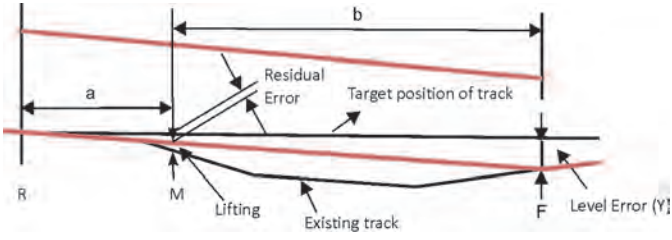


Fig. 5.04 – Residual Error in Smoothening levelling Mode

(b) *Design or Precision levelling mode (Fig. 5.05 (a))*

In precision mode of levelling instead of general lift, the target heights (difference of target and existing track position) are fed, for each location for the *datum rail.* By adjusting the front reference point of the chord with the corretion value (target heights), the levelling errors are completely eliminated, for both long and short wave length defects.

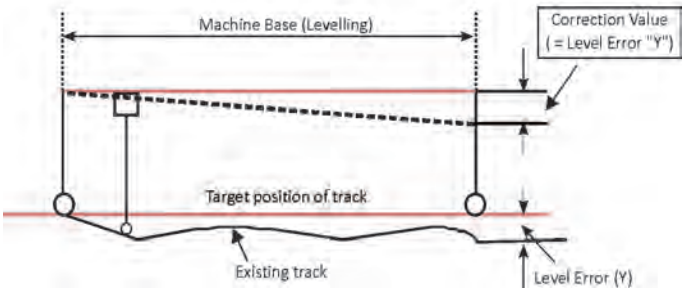


Fig. 5.05 (a) – Levelling in Design Mode

5.6. General Lift

Under service loads, the settlement of track occurs. The various study reports suggest that for making good the settlement of track after previous round of tamping, a minimum lift of about 20 mm is necessary to restore the level of track and bring lasting improvement. *(see Fig. 5.05(b)).*

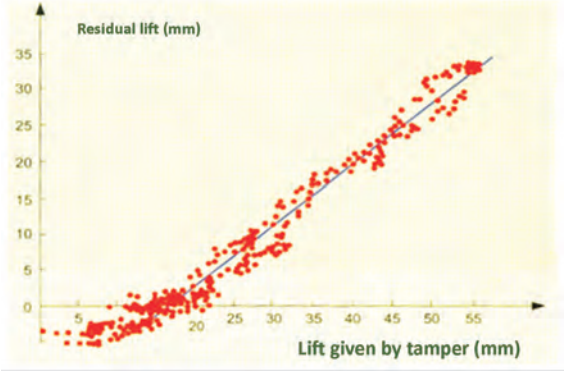


Fig. 5.05(b) – Lift and Long Term Settlement Relation (5)

Therefore some amount of lift, popularly known as *General Lift* is given to compensate for the settlement occurred after tamping previous and also 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.***

5.6.1. Basic Principles

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, duly increased by a *general lift* value of at least 10 mm at high points to achieve a uniform top surface of rail *(see Fig 5.06)*.

Therefore the maximum 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 by preliminary survey of *datum rail* in chord equal to machine chord length (15 m) approximately for eliminating short wave length defects. However where *datum rail* is lower than other rail, it should be more than maximum cross level difference. (5.6.3)

5.6.2. Quantum of lift and Overlifting

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 in two passes of tamping machine. If lifting required is more than 30 mm but less than 50 mm, double insertion tamping in single pass can be done.

On some of the Railway systems (other than Indian Railways), lifting of track upto 75mm with triple insertion has also been permitted.

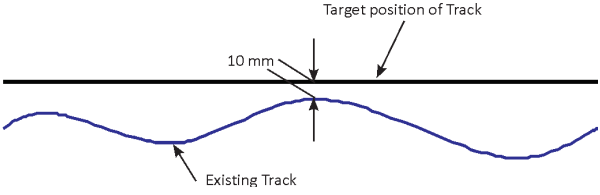


Fig. 5.06 (a) – General Lift at high points

To bring the track to level, lifting required at different locations will be different. However under train load, the locations with more lifting will settle more and therefore after some traffic, the track will again get undulated. It is therefore suggested to give some overlifting in terms of percentage i.e. if lifting required is x then actual lfting will be say 30 % more or 1.3x. The track therefore will not be levelled immediately after tamping but subsequently it settle in proportion to lift and become level and the level shall be retained. The same is explained through the *Fig. 5.06 (b)*

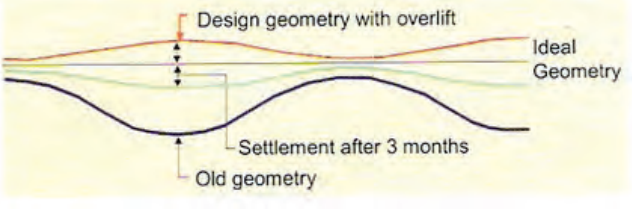


Fig. 5.06 (b) – Overlifting of track

This should be followed at all locations where the lift variation are high like construction or track renewal site.

5.6.3. 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.

Thus if existing SE = 60mm, desired SE = 40mm.

Minimum general lift will be 20 mm (60mm - 40 mm) + irregularities over datum rail.

5.7. Ramp-in and Ramp-out

While giving the *general lift*, at the time of beginning of work a ramp-in and while closing the work a ramp-out of 1 in 1000 should be given to the track for smooth transition. *(see Fig. 5.07)*

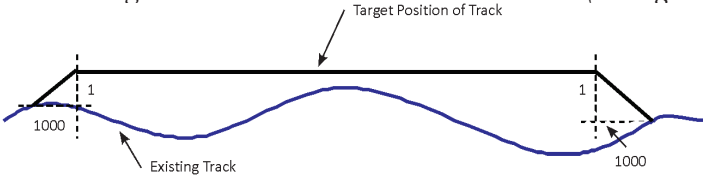


Fig. 5.07 – Ramp-in and Ramp-out of General Lift

(i) Method of Ramp-in Ramp-out for closing and opening of two successive blocks. *(see Fig. 5.08)*

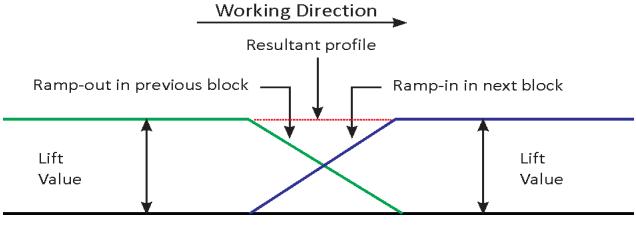


Fig. 5.08 – Ramp-in and Ramp-out

(ii) The principle of feeding lift values for front tower is shown in *Fig. 5.09*.

$$\frac{L}{X} = \frac{c}{a}$$

The reduction ratio = $r = \frac{c}{a} = \frac{(a+b)}{a}$

As this machine is ahead to next position and suppose a lift of Y has been given at the front tower position/location, total actual lift at lifting point (M') can be written

$$T = X + \frac{Y - X}{r}$$

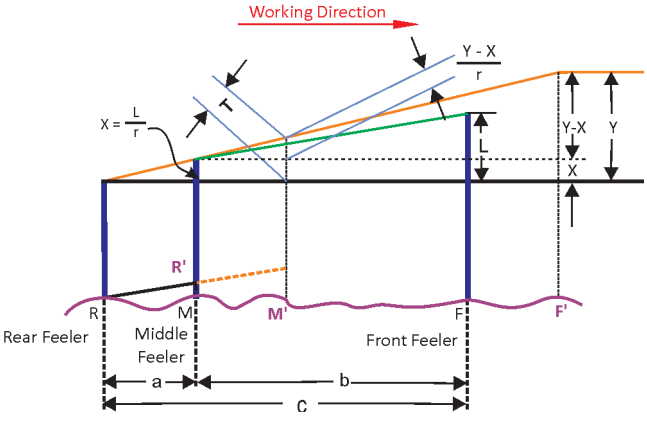


Fig. 5.09 – Run-in Ramp Principle

here,

T = Total lift at particular sleeper

X = Actual lift achieved on previous sleeper

Y= Lift given to the front cabin at point r = ratio of the distance

In other words, if T is the lift required at any position, the y value at front tower would be

Y = (T - X) * r + X

An *Example 5.01* illustrates calculations for Ramp-in and Ramp-out.

Example 5.01

Ramp at Start (Ramp-in) and Ramp at Close (Ramp-out) of Tamping

(fed through front potentiometer)

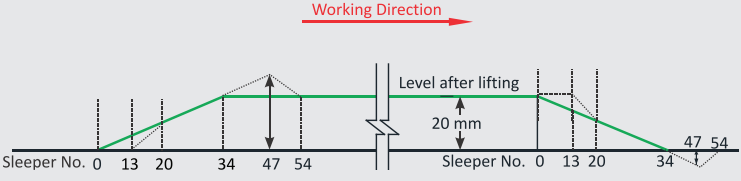


Fig. 5.10 – Diagram for feeding of ramp in and ramp out

If *General Lift* is 20 mm and sleeper spacing is 60 cm.

Length of track to achieve a gradient of 1 in 1000 (ramp length)

= 20 * 1000 = 20,000 mm

No of sleepers in ramp length = 20000/600 = 34

Rate of Lift per sleeper = 20/34 mm i.e. 0.6 mm

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

No. of sleepers between FM (b) = $\frac{8.0}{0.6} \approx 13$

No. of sleepers between RM (a) = $\frac{4.0}{0.6} \approx 7$

Note:

(a) This example is only for illustration. The actual lift values should be calculated based on field data and rounded off.

(b) The calculated values may also be used for machines (tamping 2/3 sleepers at a time) by proper selection the lift values.

(c) In design mode tamping, ramp should be provided as per actual lift value (instead of *General Lift*).

Ramp out feed value				
Sleeper No From start of Ramp out	LIFT at n^{th} sleeper (X_n)	FEED at Front tower (F_n)	Remarks	Corresponding Sleeper No. at Front tower
0	20.4	20.4	X_n=20.4-0.6*r F_7= 16.2-0.6*13 F_1 to F_7shall be distributed in between decreasing @1.7 mm/per sleeper	13
1	19.8	18.6		14
2	19.2	16.8		15
3	18.6	15		16
4	18	13.4		17
5	17.4	11.8		18
6	16.8	10.2		19
7	16.2	8.4		20
8	15.6	7.8	Both X_n and F_n will reduce uniformly @ 0.6 mm per sleeper till n is 34	21
9	15	7.2		22
10	14.4	6.6		23
11	13.8	6.0		**24**
12	13.2	5.4		25
13	12.6	4.8		**26**
14	12	4.2		27
15	11.4	3.6		28
16	10.8	3.0		29
17	10.2	2.4		30
18	9.6	1.8		31
19	9	1.2		32
20	8.4	0.6		33
21	7.8	0		34
22	7.2	-0.6		35
23	6.6	-1.2		36
24	6	-1.8		37
25	5.4	-2.4		**38**
26	4.8	-3.0		**39**
27	4.2	-3.6		40
28	3.6	-4.2		41
29	3	-4.8		42
30	2.4	-5.4		43
31	1.8	-6.0		44
32	1.2	-6.6		45
33	0.6	-7.2		46
34	0	-7.8		47
35	0	-6.7	X_n=0 F_n will increase to zero in next 7 sleepers @ 1.1 mm/sleeper	48
36	0	-5.6		49
37	0	-4.5		50
38	0	-3.4		51
39	0	-2.3		52
40	0	-1.2		53
41	0	0		54

Ramp in feed value				
Sleeper No. From start of Ramp in (n)	LIFT at n^{th} sleeper (X_n)	**FEED at Front tower (F_n)**	Remarks	**Corresponding Sleeper No. at Front tower**
0	0	0		13
1	0.6	1.8		14
2	1.2	3.6		15
3	1.8	5.4	X_n=n*0.6	16
4	2.4	7.2	F_n=X_n*r	17
5	3	9		18
6	3.6	10.8		19
7	4.2	12.6		20
8	4.8	13.2		21
9	5.4	13.8		22
10	6	14.4		23
11	6.6	15		**24**
12	7.2	15.6		25
13	7.8	16.2		**26**
14	8.4	16.8		27
15	9	17.4		28
16	9.6	18		29
17	10.2	18.6		30
18	10.8	19.2		31
19	11.4	19.8	X_n=n*0.6	32
20	12	20.4	F_n=F7 + (n-7)*0.6	33
21	12.6	21	and will continue till n=34	34
22	13.2	21.6		35
23	13.8	22.2		36
24	14.4	22.8		37
25	15	23.4		**38**
26	15.6	24		**39**
27	16.2	24.6		40
28	16.8	25.2		41
29	17.4	25.8		42
30	18	26.4		43
31	18.6	27		44
32	19.2	27.6		45
33	19.8	28.2		46
34	20.4	28.8		47
35	20.4	27.6		48
36	20.4	26.4	X_n remains constant andF_n reduces to 20.4 in next 7 sleepers @ (27.6-20.4)/7 =1.2 mm/sleeper	49
37	20.4	25.2		50
38	20.4	24		51
39	20.4	22.8		52
40	20.4	21.6		53
41	20.4	20.4		54

5.7.1. Input of the Lifting Values

The adjustments of the track lifting value (General lift/ target height) are fed at the front reference point F (front cabin) 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.

5.8. Method of feeding of Cant (Superelevation) in curves

For levelling a fixed reference base move along the length of track. In situations, when cant increase or decrease is encountered on transition curves, machine requires compensation feed, to adjust levelling chord, during working for application of correct super-elevation. *(see Fig. 5.11)*

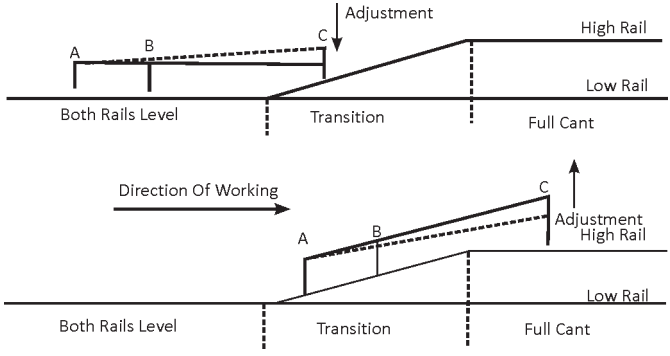


Fig. 5.11 – Chord Adjustment for Provision of Correct Super-Elevation

5.8.1. In machines designed for feeding Cross Level (SE) through front cabin, i.e. at F, following steps are followed. *(see Fig. 5.12)*

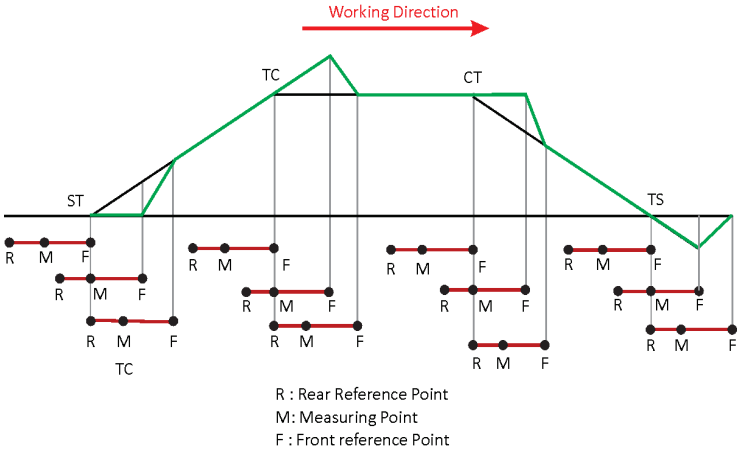


Fig. 5.12 – Cant (Superelevation) Feeding through Front Cabin

a) Total superelevation value (cross-level) 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. (or *datum rail*)

c) Do not start feeding superelevation when front F reaches at ST. Start feeding SE value when M reaches ST. At this location F is at "b" distance (in transition curve) from ST i.e. distance between M and F.

d) Superelevation feeding 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. For this purpose super elevation values for feeding at F is accordingly adjusted at rate steeper than the cant gradient.

e) SE (cant) value from there is increased at a uniform rate (i.e. at cant gradient) till M reaches TC and full SE is achieved there. The value of SE fed at F would, therefore, be more than SE at this position as seen in *Fig 5.12*.

f) Value of SE feeding at F is now decreased at uniform

rate to make it equal to SE in a distance of "a" (distance between R and M).

g) SE feed 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 SE feed till R reaches CT (i.e. in a distance of "a") where the SE value at M should be same as required.

i) Thereafter SE feed at F is further reduced at a uniform rate equal to cant gradient, till M reaches TS. The value of SE being feed at this position would be negative.

j) Beyond this the negative SE feed is increased to Zero in a distance of "a" (i.e. till R reaches TS).

5.8.2. In some machines like CSM/ TEX and UNIMAT-4S, the Super-elevation (cross level) is entered in the working cabin i.e. at location M. However, in older version such machines additional correction feed would also be necessary through ±10 mm potentiometer in front cabin.

For newer machines, provided with SE potentiometer in working cabin and encoders, there is no adjustment from front cabin is necessary.

5.9. Correction ("K") in cross level error created by curvature

While working in horizontal super-elevated curve, the levelling chords shift towards centre of curve and the height transducer board also gets inclined, which causes over lifting of *datum rail* resulting in provision of excessive super-elevation. The inside chord used as reference (on *datum rail)* is therefore lowered to obtain correct level on datum rail as was before the machines entered transition and for provision of correct super elevation at all places on the horizontal curve. This correction value, known as "K" correction, is a function of radius of curve, super elevation (SE) and gauge of the track apart from machine parameters included in constant value.

$$K = \text{Constant}^* \frac{SE}{R}$$

The correction value "K" (also known as lowering value) is always deducted from the lift values (or general lift) to be fed in the front tower. The pattern of "K" correction is given in in *Fig. 5.13*.

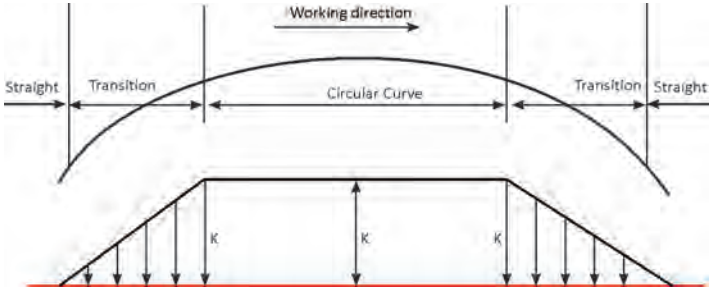


Fig. 5.13 – Pattern of Lowering Value ("K" correction)

As the "K" correction is a function of machine parameter as mentioned above, the correction values are included in the instruction manuals accompanying the track machine as shown in *Table 5.01*.

Table 5.01 – "K" correction value depending on Gauge

GAUGE = 1676mm K = 41 * Ü / R

Ü	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
RADIUS																
60	7	14	20	27	34	41	48	54	61	68	75	82	89	95	102	109
70	6	12	18	23	29	35	41	47	53	58	64	70	76	82	88	93
80	5	10	15	20	26	31	36	41	46	51	56	61	66	72	77	82
90	5	9	14	18	23	27	32	36	41	45	50	54	59	64	68	73
100	4	8	12	16	20	25	29	33	37	41	45	49	53	57	61	65
110	4	7	11	15	19	22	26	30	33	37	41	45	48	52	56	59
120	3	7	10	14	17	20	24	27	31	34	37	41	44	48	51	54
130	3	6	9	13	16	19	22	25	28	31	35	38	41	44	47	50
140	3	6	9	12	15	18	20	23	26	29	32	35	38	41	44	47
150	3	5	8	11	14	16	19	22	25	27	30	33	35	38	41	44
160	3	5	8	10	13	15	18	20	23	26	28	31	33	36	38	41
170	2	5	7	10	12	14	17	19	22	24	26	29	31	34	36	38
180	2	5	7	9	11	14	16	18	20	23	25	27	30	32	34	36
190	2	4	6	9	11	13	15	17	19	22	24	26	28	30	32	34
200	2	4	6	8	10	12	14	16	18	20	22	25	27	29	31	33
220	2	4	6	7	9	11	13	15	17	19	20	22	24	26	28	30
240	2	3	5	7	9	10	12	14	15	17	19	20	22	24	26	27
260	2	3	5	6	8	9	11	13	14	16	17	19	20	22	24	25
280	1	3	4	6	7	9	10	12	13	15	16	18	19	20	22	23
300	1	3	4	5	7	8	10	11	12	14	15	16	18	19	20	22
320	1	3	4	5	6	8	9	10	11	13	14	15	17	18	19	20
340	1	2	4	5	6	7	8	10	11	12	13	14	16	17	18	19
360	1	2	3	5	6	7	8	9	10	11	12	14	15	16	17	18
380	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17
400	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
450	1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	15
500	1	2	2	3	4	5	6	7	7	8	9	10	11	11	12	13
550	1	1	2	3	4	4	5	6	7	7	8	9	10	10	11	12
600	1	1	2	3	3	4	5	5	6	7	7	8	9	10	10	11
650	1	1	2	3	3	4	4	5	6	6	7	8	8	9	9	10
700	1	1	2	2	3	4	4	5	5	6	6	7	8	8	9	9
750	1	1	2	2	3	3	4	4	5	5	6	7	7	8	8	9
800	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8
850	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
900	0	1	1	2	2	3	3	4	4	5	5	5	6	6	7	7
950	0	1	1	2	2	3	3	3	4	4	5	5	6	6	6	7
1000	0	1	1	2	2	2	3	3	4	4	4	5	5	6	6	7
1100	0	1	1	1	2	2	3	3	3	4	4	4	5	5	6	6
1200	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5
1300	0	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5
1400	0	1	1	1	1	2	2	2	3	3	3	4	4	4	4	5
1500	0	1	1	1	1	2	2	2	2	3	3	3	4	4	4	4
2000	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3
2500	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3
3000	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2
3500	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2
4000	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2
5000	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1

SAMPLE

5.10. Levelling on Vertical Curves

While levelling on vertical curves, the levelling chord and track profile do not remain parallel. The requirement of lift is either more or less than that given by machine due to curvature in case of summit and valley curve respectively. To take into consideration this situation the lift values (or *General Lift*) is adjusted accordingly depending on type of curve by a correction value (X).

5.10.1. For Summit Curves (See *Fig. 5.14*)

In case of summit curves, the correction starts from AA. The correction value of "X" gets added to the existing lifting value (or *General Lift*) & reaches maximum value when the complete levelling chord is on the vertical curve and remain constant thereafter till end of vertial curve (AE). The correction value "X" reduces from AE and becomes zero at a point,when the complete levelling chord is out of vertical curve.

In *Fig. 5.14*

L is levelling chord length (of machine)

AA is beginning of summit curve

AE is end of summit curve

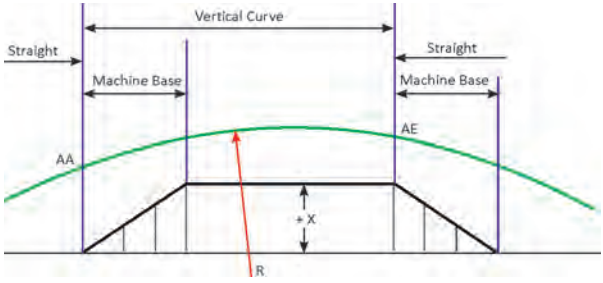


Fig. 5.14 – Positive Correction for Summit Curves

5.10.2. For Valley (Sag) Curves (See *Fig. 5.15*)

For velley (sag) curves, the correction starts from AA. The correction value of "X" gets subtracted from the existing lifting value (or *General Lift*) & reaches maximum when the complete levelling chord is on the vertical curve and remain constant through out till end of vertical curve (AE). The value "X" reduces from AE and becomes zero at a point, when the complete levelling chord is out of vertical curve.

In *Fig. 5.15*

L is levelling chord length (of machine)

AA is beginning of valley (sag) curve

AE is end of valley (sag) curve

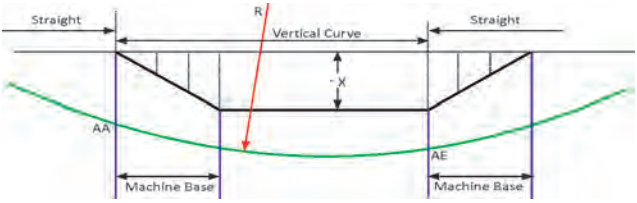


Fig. 5.15 – Negative Correction for Valley (Sag) Curves

5.10.3. As the value of "X"correction is a function of the machine parameters apart from radius of vertical curve, the manufacturer provide charts for correction values in the instruction manuals that accompany the machines. A sample of the chart can be seen in *Table 5.02* and *Table 5.03*. It is to be noted that same charts are applicanle for both summit as well as valley (sag) curves.

Table 5.02 – Correction value ("X") for verticle curves (Entering into curve)

$$X = \frac{68489}{R}$$

Part of X	0,00	0,01	0,03	0,07	0,12	0,18	0,26	0,36	0,47	0,59	0,68	0,75	0,82	0,89	0,96	1,00	1,00	1,00
ml after AA	0,00	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00	14,65	16,00	17,00
RADIUS																		
2000	0	0	1	2	4	6	9	12	16	20	23	26	28	30	33	34	34	34
2200	0	0	1	2	4	6	8	11	15	18	21	23	26	28	30	31	31	31
2400	0	0	1	2	3	5	8	10	13	17	19	21	23	25	27	29	29	29
2600	0	0	1	2	3	5	7	9	12	16	18	20	22	23	25	26	26	26
2800	0	0	1	2	3	4	6	9	11	14	17	18	20	22	23	24	24	24
3000	0	0	1	2	3	4	6	8	11	14	16	17	19	20	22	23	23	23
3500	0	0	1	1	2	4	5	7	9	12	13	15	16	17	19	20	20	20
4000	0	0	1	1	2	3	5	6	8	10	12	13	14	15	16	17	17	17
4500	0	0	0	1	2	3	4	5	7	9	10	11	12	14	15	15	15	15
5000	0	0	0	1	2	3	4	5	6	8	9	10	11	12	13	14	14	14
5500	0	0	0	1	1	2	3	4	6	7	9	9	10	11	12	12	12	12
6000	0	0	0	1	1	2	3	4	5	7	8	9	9	10	11	11	11	11
6500	0	0	0	1	1	2	3	4	5	6	7	8	9	9	10	11	11	11
7000	0	0	0	1	1	2	3	4	5	6	7	7	8	9	9	10	10	10
8000	0	0	0	1	1	2	2	3	4	5	6	6	7	8	8	9	9	9
9000	0	0	0	1	1	1	2	3	4	5	5	6	6	7	7	8	8	8
10000	0	0	0	0	1	1	2	2	3	4	5	5	6	6	7	7	7	7
12000	0	0	0	0	1	1	2	2	3	3	4	4	5	5	5	6	6	6
15000	0	0	0	0	1	1	1	2	2	3	3	3	4	4	4	5	5	5
20000	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	3	3	3
30000	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	2	2
50000	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
100000	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

SAMPLE

Table 5.03 – Correction Value ("X") for Verticle Curves (Leaving the curve)

$$X = \frac{68489}{R}$$

Part of X	1,00	0,93	0,86	0,80	0,73	0,66	0,55	0,43	0,32	0,23	0,16	0,10	0,05	0,02	0,00	0,00	0,00	0,00
mm after AE	0,00	1,0	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00	14,65	0,00	0,00
Radius																		
2000	34	32	30	27	25	23	19	15	11	8	5	3	2	1	0	0	0	0
2200	31	29	27	25	23	21	17	13	10	7	5	3	2	1	0	0	0	0
2400	29	27	25	23	21	19	16	12	9	7	5	3	1	1	0	0	0	0
2600	26	25	23	21	19	17	14	11	9	6	4	3	1	1	0	0	0	0
2800	24	23	21	19	18	16	13	10	8	6	4	2	1	0	0	0	0	0
3000	23	21	20	18	17	15	12	10	7	5	4	2	1	0	0	0	0	0
3500	20	18	17	16	14	13	11	8	6	5	3	2	1	0	0	0	0	0
4000	17	16	15	14	12	11	9	7	6	4	3	2	1	0	0	0	0	0
4500	15	14	13	12	11	10	8	7	5	4	2	1	1	0	0	0	0	0
5000	14	13	12	11	10	9	7	6	4	3	2	1	1	0	0	0	0	0
5500	12	12	11	10	9	8	7	5	4	3	2	1	1	0	0	0	0	0
6000	11	11	10	9	8	8	6	5	4	3	2	1	1	0	0	0	0	0
6500	11	10	9	8	8	7	6	5	3	2	2	1	1	0	0	0	0	0
7000	10	9	8	8	7	6	5	4	3	2	2	1	1	0	0	0	0	0
8000	9	8	7	7	6	6	5	4	3	2	1	1	0	0	0	0	0	0
9000	8	7	7	6	6	5	4	3	2	2	1	1	0	0	0	0	0	0
10000	7	6	6	5	5	5	4	3	2	2	1	1	0	0	0	0	0	0
12000	6	5	5	5	4	4	3	2	2	1	1	1	0	0	0	0	0	0
15000	5	4	4	4	3	3	2	2	1	1	1	0	0	0	0	0	0	0
20000	3	3	3	3	2	2	2	1	1	1	1	0	0	0	0	0	0	0
30000	2	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0
50000	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
100000	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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SAMPLE

6

Survey and Design of Track Profile

6.1. General

This chapter deals with an important aspect of preparatory activities, essentially required for carrying out tamping of track in planned manner to obtain a high quality track parameters essentially required not only for comfortable ride quality, but also for prolonging maintenance cycle and consequent longer life of assets.

It must be borne in mind that every tamping operation cause thrashing of ballast particles, which results in deterioration by breakage and loss of material leading to impairment of ballast bed quality. Therefore it is desirable to have a larger time period between successive maintenance (tamping) operations, without compromising with threshhold limits set for acceptable track parameters.

A well-laid track structure, including its foundation and other elements, with track parameters having low standard deviation, would necessitate lesser maintenance in service and consequently be more cost effective. Therefore at the time of initial laying and during successive maintenance cycles, all efforts must be taken to turn out the track geometry having minimum deviations from desirable level.

It is preferable that the guidelines mentioned hereinafter for operations of Tamping Machine in design mode are followed in right earnest to attain objectives outlined above.

During the tamping process correction to track geometry profile in vertical and horizontal plane is undertaken. To ascertain need and extent of corrections required, based on data collected during survey of existing profile, target profile is redesigned, if originally laid profile is not known or cease to be available.

6.2. Survey for Longitudinal/Vertical Profile Correction

The identified section is divided by marking stations marked at 10 m interval. The starting point should be opposite a km post and the first station should be marked 0. The station locations and station numbers should be painted in yellow colour on the web of the datum rail *(refer Para 5.3).*

6.2.1. Benchmarks

The benchmarks should be established at 200 -1000 m interval, relating them to the GTS benchmark levels so that the plotted drawings are related to the existing index section. These benchmarks are established in the form of permanent structure, which could include top of existing concrete foundation of OHE masts in electrified sections or any such structure with conspicuous markings (referred as reference pillars hereinafter).

6.2.2. Recording of Actual Rail levels

The actual rail levels are recorded at all stations of the datum rail as well as other rail (to make sure that the datum rail is chosen correctly), making use of the established benchmarks. However, on the stretches where the **datum rail** (so chosen for straight track) is super-elevated, on horizontal curves, the rail levels should be taken on the other rail of the track, opposite the station locations. The stretch, for which levels are taken on "non-datum" rail, shall also be noted in the level book.

6.2.3. Formation levels

At every 5th station i.e. Station No. 0, 5, 10 etc., ballast is removed 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 a redesigned vertical profile the rail level should be 688 mm (rounded to 700 mm) and 673 mm (rounded to 680 mm) above the formation level in case of 60 kg and 52 kg rail respectively with 6 mm thick rubber pads on PSC sleepers and 300 mm ballast cushion, if sub-ballast is not provided.

In points and crossings, the ballast cushion may be checked in switch and in crossing area.

6.2.4. Obligatory Points

While carrying out the survey, the locations of obligatory points like level crossings, girder bridges, points and crossings, overhead structures etc., are also recorded with reference to the station numbers as well as running kilometre (location). The location of km posts and gradient posts are also noted along with station number reference.

6.2.5. Plotting of Vertical Profile

(a) The existing vertical profile of *datum rail* and formation should be plotted on a graph sheet with 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 is described below.

6.2.6. Proposed Vertical Profile

While deciding the vertical profile of rail top the following aspects are considered.

(a) Sub-sections are selected keeping in view high points and obligatory points.

(b) As far as possible, long stretches of uniform gradient are planned duly considering the depth of construction, and relative implications of lifting or lowering of track. In no case the grade should exceed the ruling gradient of the section, including compensation for curve as per Indian Railways Perment Way Manual (IRPWM). While designing vertical curves, provisions contained in IRPWM are also observed.

(c) The clearance to overhead structures (including OHE) shall be maintained, as permitted.

(d) The redesigned profile should not normally involve lifting or lowering at obligatory points like girder bridges, Level crossings, and turnouts.

(e) For designing of the profile the provisions contained in Indian Railways Schedule of Dimensions - 2004 (with all correction slips), must be considered along with relevant provisions of Indian Railways Permanent Way Manual.

(f) The redesigned profile aims at easing the sags and humps with manageable lifting and lowering. Practically the redesigned profile should be such that only lifting is involved, which could be done by tamping machine. The lowering of track must resorted to in exceptional circumstance only, which is to be carried out in accordance with relevant provisions of IRPWM & extent instructions therefor.

(g) Prescribed minimum ballast cushion required as per IRPWM would be available with reference to redesigned profile. However, requirement of ballast, over and above that for the prescribed cushion, should be optimised by provision of suitably designed vertical curves.

(h) At locations where lifting or lowering is not feasible, suitable ramping out preferably in the form of reverse curves in vertical plane should be provided on both sides. In case lifting is proposed at level crossings, the simultaneous raising of the road surface and re-grading of the approaches would be necessary and it should be specifically mentioned.

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

(j) While redesigning the profile, the requirements to be met on Indian Railways are:

(i) For other than vertical curves

The unevenness on 80 m chord should not exceed as under:

(a) On high-speedlines with speeds above 110 km/h – 40 mm (corresponding to 20,000 m vertical radius).

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

(ii) For vertical curves

The unevenness on 20 m chord should not exceed 10 mm (corresponding to 5,000 m radius)

The profile designed should be analytically verified to check for exceedences in terms of uneveness.

(k) The final levels at various points should be calculated,

rather than scaling-out from the drawing.

(l) The proposed levels should be approved by authorised engineer. The working plan so prepared should be distributed to the concerned field personnel.

6.2.7. Designing of Vertical profile with the help of Computer

For designing of vertical profile, aid of a computer with any spread sheet program or specific software developed for this purpose may be taken to expedite the process.

6.2.8. Surfacing (Longitudinal Levelling) operation

(a) The proposed levels of rail top may be marked on the OHE masts/permanent reference pillars for executing the lifting/lowering work. In case of non-electrified section, permanent level reference pillars should be provided at every 5th station. (50 m interval) The locational details of these permanent reference pillars may also be documented for identification along with horizontal and vertical track position with reference to these pillars. An indicative arrangement of reference pillars can be seen in *Annexure – 6.01*.

(b) The finished profile, after work, may not exactly conform to the target profile, and the resurfaced levels may vary from the target/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 target/designed levels should not exceed $\pm$ 10 mm (or as specified specifically) For this purpose the unevenness at all stations is worked out in relation to the finished levels and correction to levels undertaken to bring the station-to-station variation of unevenness within the prescribed limit.

6.3. Survey For Alignment Correction

6.3.1. In case some horizontal curves on the section warrant realignment, then the process of realignment is also carried out along with surfacing.

6.3.2. All the weld and rail kinks should be rectified/eliminated by de-kinking, or cutting and welding, before survey and measurement for alignment defects are taken.

6.3.3 The beginning and end of curve/transition curves are identified and marked in the form of permanent reference pillars. The permanent reference pillars should also be installed at every 50 m along side 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. (*Ref. Annexure – 6.01*)

6.3.4. Alignment is measured on a long chord of at least 200-300 m long on straight track. The slews required, at alternate/every 3rd sleeper, should be worked out by measuring the offsets at every 5 m interval and linearly interpolating it.

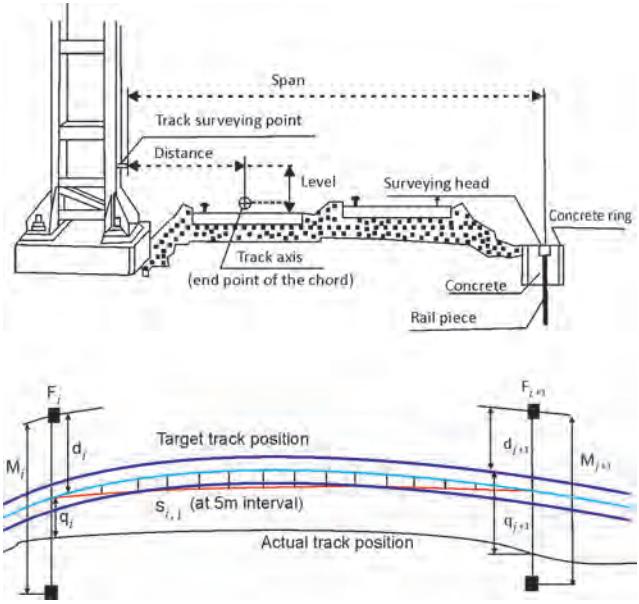
6.3.5. On curved track, versines are measured on 20 m chord at 10 m intervals. The required slews at the stations are worked out, manually or by using suitable computer program, duly considering obligatory points and interpolated to obtain slews at every alternate/3rd sleeper.

6.3.6. Care must also be taken to verify the position of fixed structures and any infringement to moving dimensions shall not be allowed in any case.

Annexure – 6.01

Reference pillars for locating horizontal and vertical Track position

In Austria and Germany, fixed reference poins are in use since 1972, generally on OHE masts, allowing the position of track to be defined in relation to the fixed point and the versines in between (*see Fig)*. In other countries e.g. United Kingdom, France and Switzerland also similar systems have been introduced.



F_i- ... surveying points (catenary poles, etc..)

$S_{i,j}$ ... distances between the central axis of the target track and the chord (at 5 m interval)

d_i ... distances between the surveying points and the central axis of the target track

q_i ... target displacement of the actual track at the surveying points (pre-determined in the case of track maintenance)

m_i ... span

■ ■ ■

7

Track Geometry Rectification using Survey Trolleys

7.1. General

Indian Railways are increasing speeds of Rajdhani/Shatabdi routes to 160 kmph and other routes to 130 kmph. The increase in speed requires upgrading maintenance standards of track to higher level. The track has to be maintained at tighter tolerances as per provisions of IRPWM. To achieve the level of tolerances required for higher speeds, the system of maintenance has to be upgraded in terms of better methods of pre-tamping survey and tamping in design mode.

Design mode tamping is essential for achieving track geometry suitable for high speed railway lines. IRPWM and IRTMM requires most of the tamping to be done in design mode. In case of alignment of curve the existing versines on 20 m chord are measured and realignment calculations are done either manually or on computer software to get slews at every station. In case of tangent track the offsets on long chords set up between good points are measured at every 5m interval by optical instruments. Selecting good points is a matter of judgment of the surveyors or the track engineers. In case of vertical profile levels have to be taken at 10/20 m interval and longitudinal section is to be prepared on graph sheet. The longitudinal section (L-section) has to be designed keeping obligatory points and design requirement in view while keeping the lifts within practical limits.

The method of measurement of versines/offsets of long chord is relative geometry measurement method in which position of one point is dependent on position of other point, Track geometry gets altered after every round of tamping and no reference can be made to designed alignment and profile. Even after several rounds of tamping the defects remain in track.In order to achieve high accuracy and reliability, absolute track geometry measurement approach is necessary by using modern surveying techniques. In the modern surveying techniques, 3D geospatial coordinates of track axis (track central line) are obtained by conducting pre-tamping survey with Total Station following references connected to global coordinate system. As the designed alignment and profile data i.e. track axis coordinates of existing alignment are not available for most of the track,track alignment and profile has to be redesigned by carrying out regression of existing alignment data to get optimum designed alignment keeping slews and lifts within practical limits with the help of modern software. The comparison of designed alignment and profile with the existing alignment and profile gives FD value (slew) and Y value (lift) for tamping by the tamping machines. 2-3 rounds of tamping and survey may be necessary to achieve design alignment in view of limits of slew and lift which can be given to tamping machines. The details of survey method are elaborated as under –

7.2. Global coordinate system

Earth being ellipsoid whose radius changes from equator to poles, a standard coordinate reference system is needed. World Geodetic System (WGS) 1984 as datum was developed by US defence department in 1984 as illustrated in Fig. 7.01 below, is widely used in surveying. Further the surface of earth is curvilinear, for cartesian coordinate system to be used for measurement of position by measuring distances, earth surface is divided in small zones and reprojected as flat surface (with required corrections), as done in case of maps. This is done in UTM (Universal Transverse Marketer) grid system widely used in surveys. Globe is divided

into 60 zones @ 60^0 longitudes starting from 180^0 longitude towards east. By defining UTM zone, the global coordinates in the form of Easting and Northing are established in Cartesian system of coordinates. Each point on the globe is uniquely defined in this coordinate system. In modern surveying global coordinates system is used as defined for each UTM zone. In track geometry survey,global coordinate system as mentioned above is used.

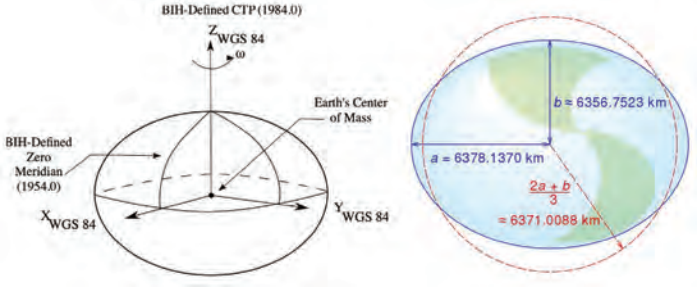


Fig. 7.01 WGS 84

7.3. Setting up of base station

For conducting survey a reference system is required to be established which can either be linked with Ground Control Points (GCP) established by Survey of India or the reference points established with the help of DGPS (Differential Global Positioning System) by observing navigation satellites for a period of 48 hours. In this reference system, base station is set up with DGPS by observing constellation of navigation satellites for 48 hours to accurately establish the position of base station. The reference marks are provided on concrete posts (pucca structure) so that they are available for reference in future.

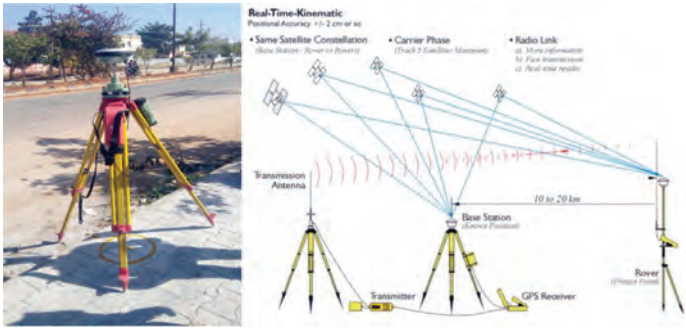


Fig.7.02 Use of DGPS in setting up of Base Station

7.4. Reference system for track geometry survey

Three tier reference system is required to be setup for achieving accuracy of survey and subsequently achieving track geometry in millimeterlevel accuracy. Primary reference system comprises of base station and other stations established with DGPS at the interval of 10-20 km. Secondary reference system comprises of control points at 1-2 km interval established by triangulation with total station along the track to be surveyed. Tertiary reference system comprises of control points at 150-200 m interval along the track to be surveyed. Alternatively they can be established on alternate OHE mast foundations. Primary, secondary and tertiary references are connected with triangulation with total station and error adjusted as per norms.

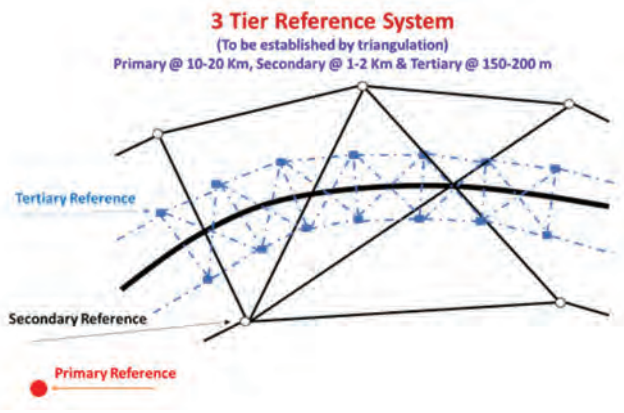


Fig. 7.03 Reference System for Track Geometry Survey

7.5. Survey Trolley system

Track geometry survey can be done with single trolley or double trolley system. Double trolley system is more convenient and faster. In single trolley system Total Station is placed by the side of track on tripod and prism is placed on trolley which moves along centre line of track. Double trolley system comprises of two light weight trolleys. On one trolley high precision robotic total station is mounted, on second trolley prism is mounted coinciding with the centre line of track. It also has controller (hand held computer) for controlling the operations, recording the data and carrying out computations etc. For communication amongst total station, prism and controller, 2.4GHz radio communication system is used. Both the total station trolley and prism trolley have pressurized gauge sensors and calibrated inclination sensors for measuring gauge and cant respectively, while the trolleys are moved on the track by operator/surveyor. It is capable of recording track centre line coordinates while moving on track at walking speed. In case design data is available, the controller compares measured alignment and profile with designed alignment and profile and displays slew and lift real

time along with gauge and cant. In case designed alignment data is not available as in case of existing tracks, in the pre-tamping survey centre line coordinates in 3D (easting, northing and altitude) are collected along with coordinates of obligatory points for designing the alignment and profile using software made for the purpose.



Fig. 7.04 Single Trolley and Double Trolley Track Geometry Survey System

7.6. Method of track geometry survey by survey trolleys

i) To start with total station trolley is placed opposite (perpendicular) to the first control point from where survey is to be started and locked by its own braking system as shown in *Fig7.05(a)*

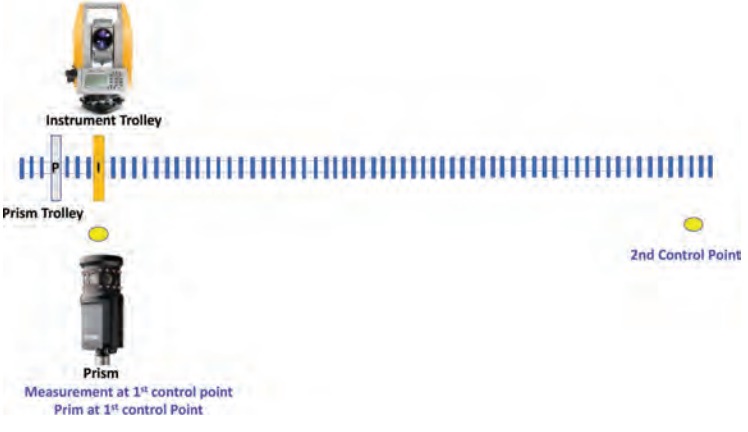


Fig.7.05 (a) Method of Track Geometry Measurement

ii) Hand held prism is placed on the first control point, the robotic total station aligns itself to the hand held prism and takes the measurement on the prism placed on the first control point thereby establishing the position of total station with respect to coordinates of first control point.

iii) Instrument trolley i.e. trolley with total station is moved and placed perpendicular to 2nd control point and locked with its braking system as shown in *fig.7.05(b)* below.

iv) Hand held prism is taken to 2nd control point and placed on the second control point. The total station placed perpendicular to 2nd control point aligns itself to prism placed on 2nd control point and takes the measurement on 2nd control point. With this coordinates of total station placed at centre line of track opposite to 2nd control point are established.



Fig. 7.05(b) Method of Track Geometry Measurement

v) Prism trolley is placed opposite to the 1st control point where total station trolley was placed and locked by its braking system.

vi) Total station which is placed perpendicular to 2nd control point aligns itself to the prism placed on the prism trolley at 1st control point and establishes long chord between

centre line of track perpendicular to 1st control point and central line of track perpendicular to 2nd control point shown in *Fig 7.05 (c)* below.



Fig. 7.05(c) Method of Track Geometry Measurement

vii) The prism trolley is moved towards the total station trolley. While moving towards the total station trolley centre line measurements at every 5m interval are recorded by the controller along with gauge and cant as shown in *Fig. 7.05(d)* below.



Fig. 7.05 (d) Method of Track Geometry Measurement

viii) The coordinates and the restrictions of obligatory points are also collected by placing hand held prism on the obligatory points.

ix) Once the prism trolley reaches near the total station trolley, total station trolley is moved to the 3rd control point and locked perpendicular to 3rd control point.

x) Hand held prism is placed on the 3rd control point and total station aligns itself to the hand held prism placed on the 3rd control point and takes the measurement to establish centre line coordinates of track where total station trolley is placed.

xi) Prism trolley is placed opposite to the 2nd control point and locked with its braking system. The total station aligns itself to prism trolley and takes the measurement to establish long chord between central line of track opposite to 2nd control point and central line of track opposite to 3rd control point and process mentioned above is repeated to take central line coordinates of track.

xii) The track centre line coordinate data along with obligatory points and special features recorded by controller is transferred to the computer having software to design alignment and profile as per the requirement of the railway.

xiii) Software compares the design alignment and profile with existing alignment and profile and gives the slew and lifts for tamping machine. These slews and lifts at every 5m interval collected from the computer are loaded into ALC (Automatic Guiding Computer) of the tamping machine.

xiv) Before starting the tamping, tamping machine is synchronized by placing front trolley of the tamping machine opposite any of the control points or known chainage on the track.

xv) Tamping is done in stages keeping in view limitations of slews and lifts which can be executed by the tamping machine.

xvi) After 1st round of tamping, pre-tamping survey has to be done again to collect the central line coordinates of the track and transferred to the computer which compares them with the designed alignment and profile to give slews and lifts again.

xvii) These slews and lifts will again be fed into the ALC on tamping machine for another round of tamping. The process is repeated till designed alignment is achieved.

xviii) Post tamping measurements are taken for comparing with the designed alignment and for record purpose for furture use.

xix) In subsequent tampings the designed alignment is used for getting slews and lifts after pre tamping survey.

xx) In this way track alignment and profile is achieved within accuracy of 2mm.

7.7 Advantages

i) High accuracy, absolute and relative alignment and profile of track is achieved with respect to designed profile.

ii) 3D coordinates are captured in single operation and the data can be used for future activities.

iii) Hardware and software are specially tailored for railway task to streamline field and office work.

iv) As the surveying and data delivery to the tamping machine is done reasonably fast, utilization of tamper for design mode tamping is improved.

v) The track parameters achieved are of very high order resulting in smooth running on track. OMS run and track recording car results are substantially improved.

■ ■ ■

8

Automatic Process Control Computer-WinALC (AutometischerLiet Computer)

8.1. General

ALC is a window based software provided in an on-board computer in the tamping machine & is used to rectify the lining and levelling parameters, as required, of the railway track. It is a normal computer having additional interface.These interfaces helps the computer to collect data from the machine circuits. Lining and Levelling data is collected within the chord length. ALC also process collected data. The collected data is processed and is then fed back to the machine, as input to the respective circuits.Also theoretical data from records can be entered and be fed to the machine as input.

Direct import of correction data values from various surveying trolleys (Trimble, Amberg, etc.). All data files can be imported/ exported via USB or disks.Collected data can be copied and analysed, in any other computer having the ALC program installed in it.

8.2. Overview of ALC features

The ALC computer screen features are shown below *(Fig.8.01)*

ALC Screen	Symbol	Represents
		New Geometry
		New front offset/Level correction
		Start Measurement
		Open Geometry
		Open front offset/Level correction
		Open measurement
		Start/Show work mode

Fig.8.01- ALC icons

By clicking on the icon, new geometry, new front offset/slew and new measurement can be taken and saved in files under icon marked as open geometry, open front offset/level correction and open measurement. If location of saving is not specified, it will automatically be saved under these heads. These files are used for subsequently correcting track parameters using icon start/ show work mode.

File *(Fig.8.02)* includes items which are self-explanatory

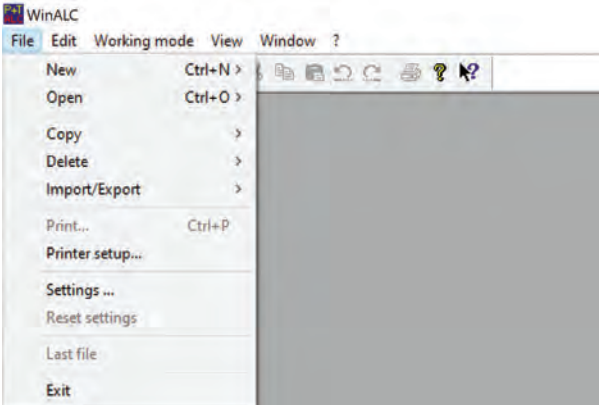


Fig.8.02- Operation of file

Instead of icon, new files can be created or saved files can be opened from here. Other items in file is self explanatory.

Under working mode, various flexibility is given as shown below *(Fig.8.03)*

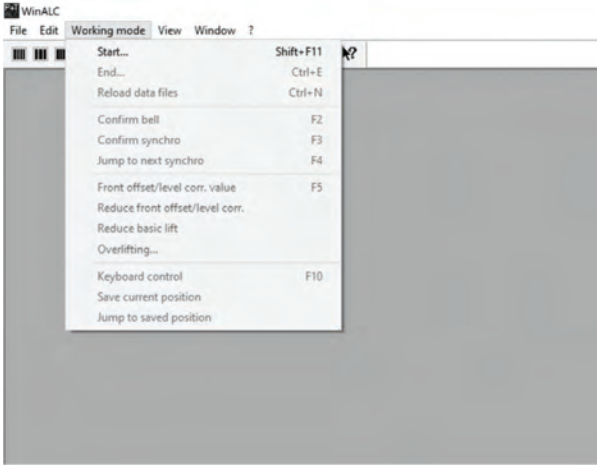


Fig.8.03- Operation of working mode

Start of tamping, end of work and other changes in data can be done from here also. After closing of work, the position can be saved and when starting the work next day, the tamping can be started from there by clicking jump to saved position.

8.3. Working modes of ALC:

There are two modes of correcting track using ALC-

- Manual input of Track Geometry or Known Track Geometry mode
- Measuring run data or Unknown Track Geometry mode

While in known track geometry mode , the track is measured in advance and final profile i.e level and alignment to be achieved is decided. The slews and lift required for achieving that is

accordingly calculated. This data is then used to achieve the desired track profile.

In measuring run mode, the track is measured using ALC. The ALC software then suggests the best fit alignment & level and accordingly calculates the slews and lifts required.

8.4. Manual input of Track Geometry or Known Track Geometry mode:

8.4.1 Entry of Known Track Geometry to be achieved-

Following inputs will be entered in ALC

- Track Geometry to be achieved by clicking on new geometry icon
- Front offset and Lift value required for achieving that geometryby clicking on new front offset/Level correction.

The new track geometry screen *(Fig.8.04)* for data entry will be-

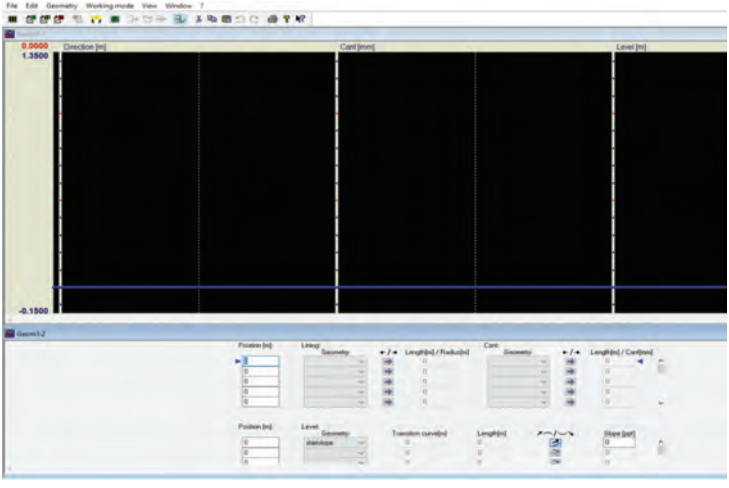


Fig.8.04- New Track Geometry entry screen

It must be noted that blue line indicates the front trolley position.

Example: A disturbed track from chainage Km 253.000 to Km 253.840 is to be corrected to achieve a straight track from Km 253.000 to Km 253.500 and then a curve of 2 degree and cant of 80 mm with transition length of 70 m on both side. The level correction is such as to achieve 1 in 500 up gradient upto Km 253.200 and then down gradient of 1 in 1000 till chainage Km 253.840. The existing and final alignment is represented in versine diagram. Similarly Level diagram is also plotted for understanding of requirement *(Fig.8.05)*.

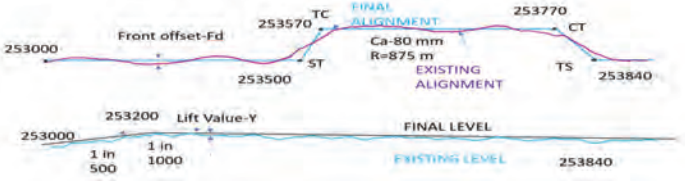


Fig.8.05- Alignment and Level proposed

If the same is entered as new track geometry in ALC the entry will be as shown below *(Fig.8.06)*. The same is saved with file name as -----. Geo. This will be available in open geometry folder.

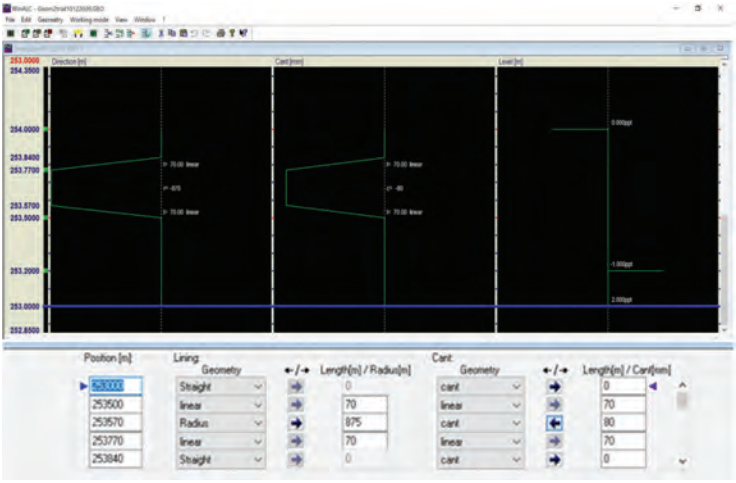


Fig.8.06- Screen after entry of Known track geometry

In addition some points are automatically marked as synchronisation points and shown as green block.

It may be noted that if vertical curve Radius is known and transitioned entry is to be provided, the data entry will be in the format (Radius and TL) as below *(Fig.8.07)*

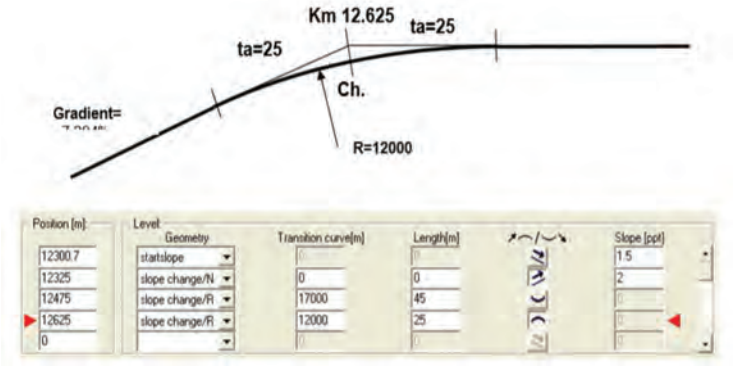


Fig.8.07- Entry of vertical profile

The front offset and lift values will be entered in new front offset/ level correction as shown below *(Fig.8.08)* and will be saved as ----. VER file. This will be available in open geometry/level correction folder.

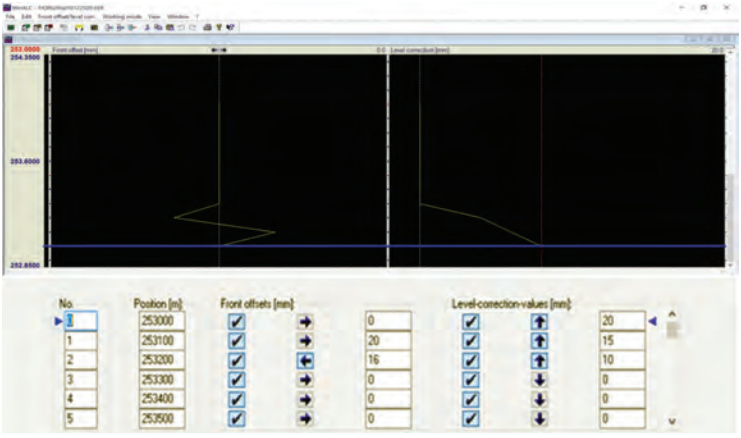


Fig.8.08- Entry of lift and slew values

Following important points to be noted during entry of these data's:

The direction of curve is based on centre of curve. Like in the above case, the curve is a right hand curve with centre on right side. Cant direction is towards the higher rail i.e opposite to Curve direction.

- The slew to be in proper direction.
- The lift should normally be positive.

8.4.2 The working mode-

After these files are prepared and saved, The tamping will be started by clicking on start and show work mode(Fig.8.09) by clicking on icon shown below

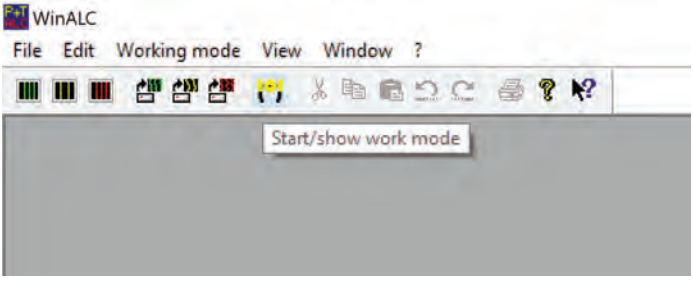


Fig.8.09- Start work mode

Following screen that will be displayed



Fig.8.10 Work mode screen

The files of New Geometry and Front Offset shall be displayed or can be chosen. Following will be observed.

1. The start chainage will be Trolley distance BD ahead, that means tamping bank should be at the location of start of work.

2. The end chainage will be 100 m ahead as a convention. However closing should be with front trolley at last chainage, i.e. upto where fd& y is known.

   This understanding should be used to close and restart the work.

3. Some basic lift i.e. a constant lift over and above the lift fed in data file and some percentage of over lifting may also be entered. For that basic lift, ramp distance with 1 in 1000 gradient to be entered.

4. In this mode machine will can work in both 3 point and 4 point mode.

5. The entry in lowering ref rail will be no and in scissor correction as yes.

   The entry *(Fig.8.11)* is displayed again

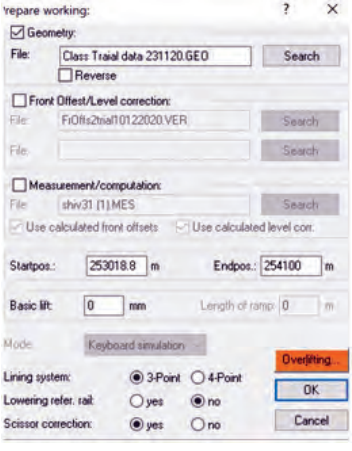


Fig.8.11 Work mode entry

After completing the entry, and after pressing "ok", the display will change to *(Fig.8.12)*

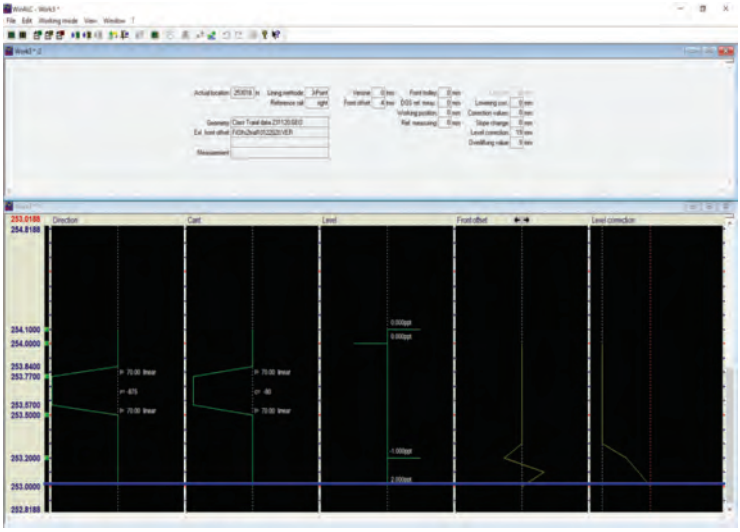


Fig.8.12 Working Screen

The blue line will indicate the position front trolley and chainage is also displayed. It also shows, the files taken, the mode of tamping selected and the ref rail chosen. Ref rail will be selected through nob in the machine.

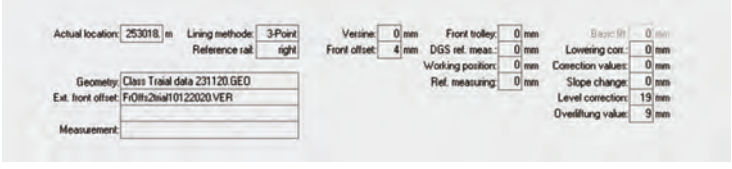


Fig.8.13- The details on screen

In addition, the data's in three columns (Fig.8.13) represents

a. Versine and front offset

b. Cant at different position

c. Level at different position.

As we proceed the values will be continuously changing as per position of the machine. The machine will achieve the desired alignment.

8.5. Measuring run data or Unknown Track Geometry mode:

8.5.1 Recording existing track parameters, the steps involved are:

1. The track in this is first recorded in 3-Point mode recording alignment (in terms of versine), level (also in terms of versine) and cant. The recording is displayed on the screen.
2. During measurement run, information's of critical and obligatory points are also entered and recorded.
3. After recording the measurement, the computations are done with the purpose to provide
   a. Desired Cant
   b. Best fit alignment
   c. Best fit level.

The alignment and level are suggested by the software and the same can be modified by selecting constant areas which is discussed below in detail.

For recording the measurement, as start measurement is clicked, the screen displayed *(Fig.8.14)* will be as below-

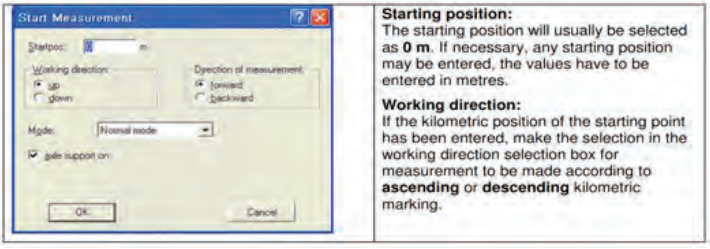


Fig.8.14 Start of measuring run

The recorded measurement *(Fig.8.15)* is displayed on screen as below

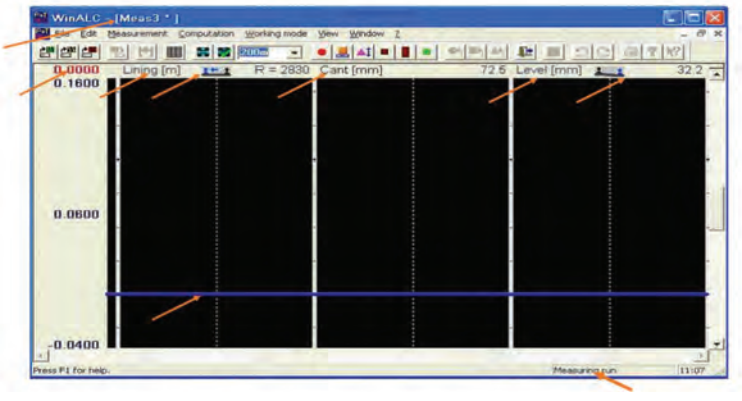


Fig.8.15 Measuring run screen

The blue line is the position of front trolley and its chainage is displayed in red at the top shown via arrow.

The measurement of alignment (in terms of Radius), Cant and Level are shown in three separate vertical areas. The corresponding values of Radius, Cant and level w.r.t the position of blue bar(front trolley) is also shown at the top.

During recording, the reference and cant rail are also to be selected (using selection switch) for alignment and Super elevation which is also displayed on screen by showing the rail in blue colour.

During recording following function buttons is used to mark references and obligatory points

F2	Alignment marker, control point (red dot)
F3	Super elevation marker, (light brown square)
F4	Longitudinal level marker (violet triangle)
F6	Reference point (dark brown square)
F7	Constraint (dark brown area)
F8	Synchronization points (green square)

Instead of using Function button, the corresponding symbols shown on the top bar can also be pressed on reaching the location. The recorded screen *(Fig.8.16)* will appear as -

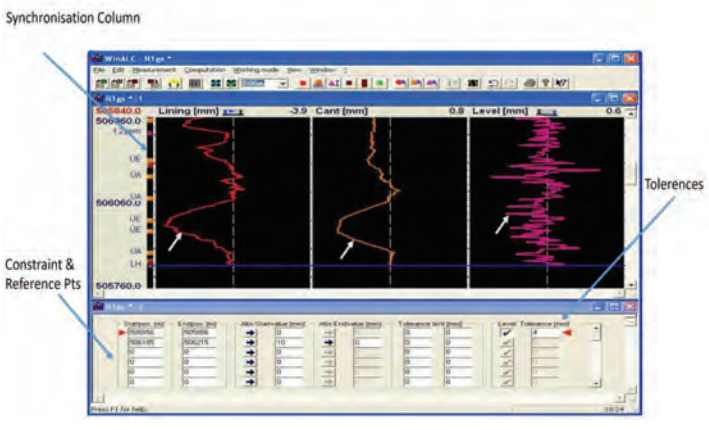


Fig.8.16 Measuring run record displayed

The value corresponding to any position can be known by taking the cursor to that position *(Fig.8.17)*.

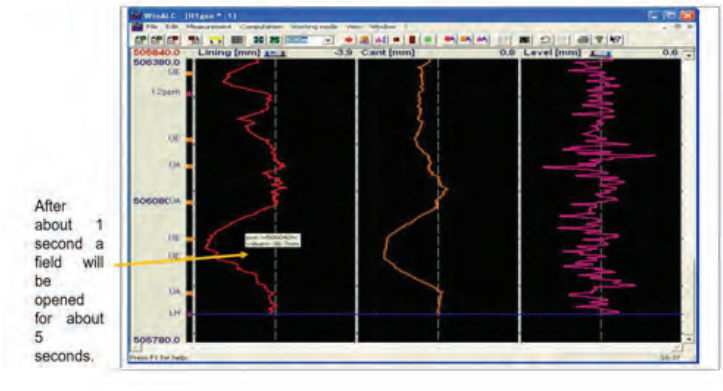


Fig.8.17 Values as recorded in measuring run

The synchronization column shows the important reference locations marked during recording. The obligatory locations are automatically also shown in below given table where tolerances of slews and lift can be entered.

It may be noted that new references and obligatory points can be entered subsequently. Also the entered locations can be modified. Following procedure *(Fig.8.18)* may be followed for this-

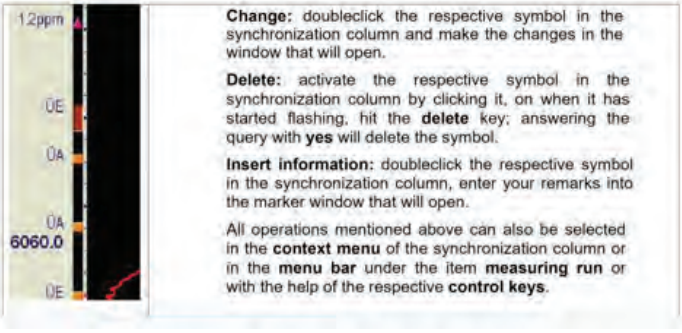


Fig.8.18 Changing references & obligatory points

Tolerances for reference obligatory points and constraints can be entered and modified also subsequently.

8.5.2 Computation of recorded measurement-

After recording, computation to decide the final result to be obtained is done. The steps involved are-

a) Determination of the compensation area

b) Alignment parameters-

- Target superelevation
- Curve versine compensation
- Entering constant areas

c) Level parameters-

- Longitudinal level compensation
- Entering constant areas

The machine can record a long stretch of track during measurement, however computation can be done for a small

patch which is called compensation area.

For this compensation/computation area *(Fig.8.19)* can be selected by clicking on icon as below-



Fig.8.19 Computation area

The next step will be fixing Target SE by using icon as shown below for entering nominal cant *(Fig.8.20)*:



Fig.8.20 Nominal cant icon

Firstly bring the blue line cursor to the position where cant is to be entered. By clicking on the iconthe chainage and cant at the position of cursor is shown. We can enter the desired cant and then take the cursor to the next location and again enter the desired cant. For circular length these values will be constant. For transition, the Linear *(Fig. 8.21)* will be entered at start of transition chainage. .

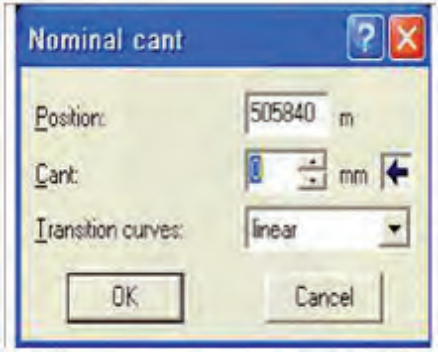


Fig.8.21 Nominal cant entry

The arrow should be directed on higher rail side. The entered SE will be displayed on screen as below *(Fig. 8.22)*-

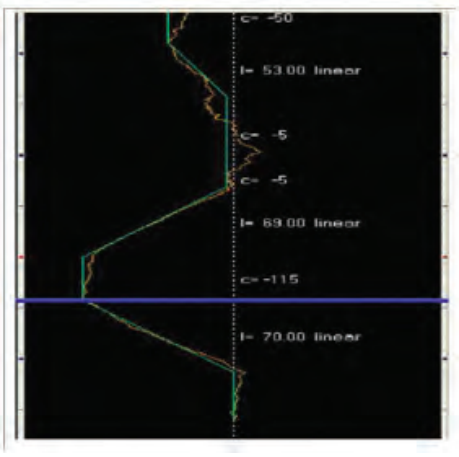


Fig.8.22 Start of measuring run

The alignment correction is done by clicking on versine computation *(Fig.8.23)*:

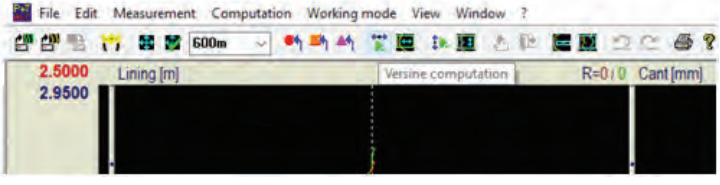


Fig.8.23 Versine Computation icon

By clicking, the software asks for speed potential of the curve being attend *(Fig.8.24)*

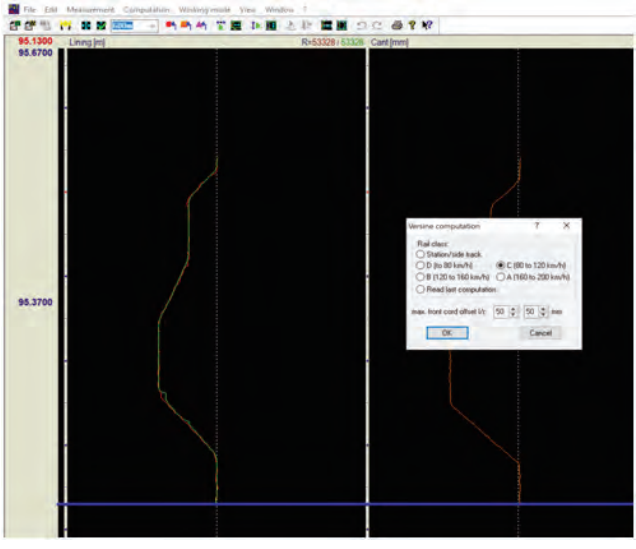


Fig.8.24 Versine Computation speed range

The category of track from A, B, C and D on the basis of speed is asked. Also slews limit on left and right can be specified. This gives, the limits within which the software will suggest the alignment.

In the present case the suggested alignment and corresponding Front offset (Slews) is shown as given below *(Fig.8.25)*-

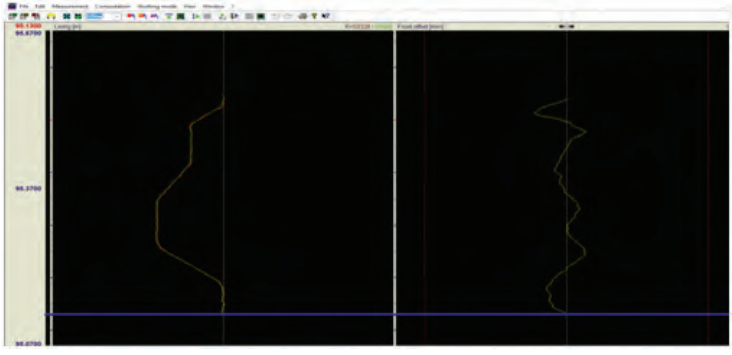


Fig.8.25 Suggested alignment and slews

The value corresponding to the position of blue cursor is displayed on the top like in this case the value is R=53328 both earlier (Shown in red) and 53328 later in this case (Shown in green). The front offset is Zero.

The suggested alignment may be modified by going for recalculation. For this constant areas may be selected by bringing the cursor to the initial point of start of constant area and clicking on the icon *(Fig.8.26)* given below.

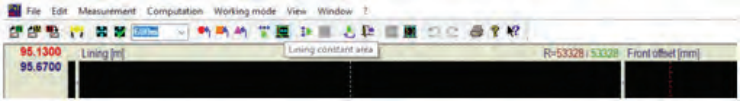


Fig.8.26 Lining constant area icon

As the cursor is moved forward using arrow button, at the next position, again press enter button. The selection of constant area *(Fig. 8.27)* will be shown as below-

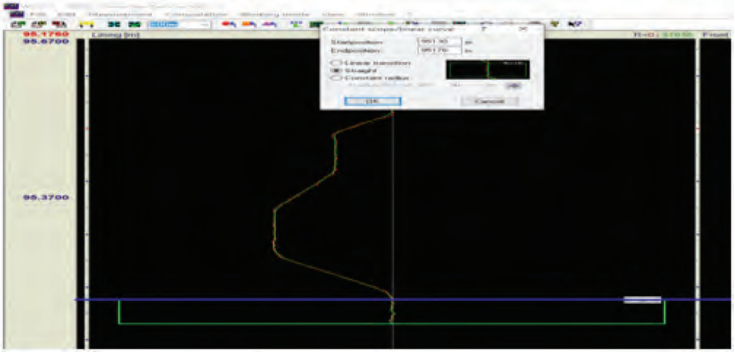


Fig.8.27 Versine Constant area selection method

This patch is desired to be straight. Similarly other constant areas will be selected keeping some gap between these selections as shown below *(Fig.8.28)*.

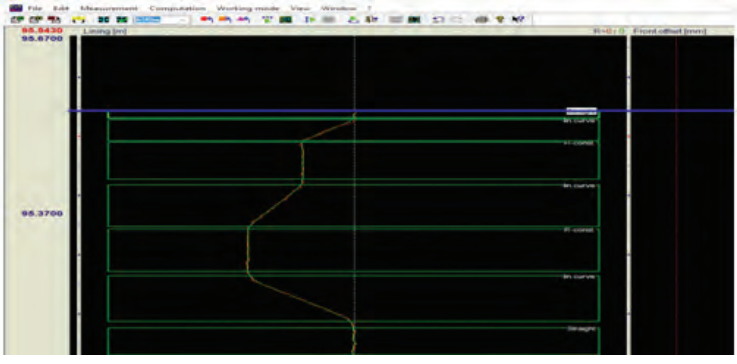


Fig.8.28 Versine Constant area selection

After specifying constant areas, the versine computation will again be done. The software will again ask for speed potential or will ask for recalculating based on previous result.

The result obtained can be agreed or else constant areas may be redefined. After final calculation, the file to be saved.

For level correction, the icon to be used is as given below *(Fig.8.29)-*

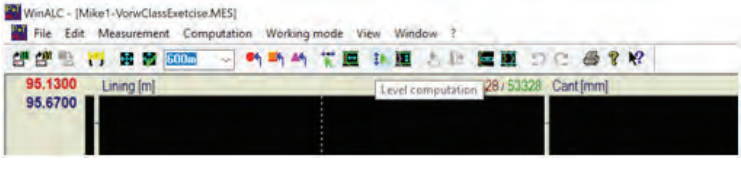


Fig.8.29 Level Computation icon

Similar to alignment correction ,it will ask for speed potential and level correction maximum and minimum limit. The suggested average level profile will be as shown below (Fig.8.30).

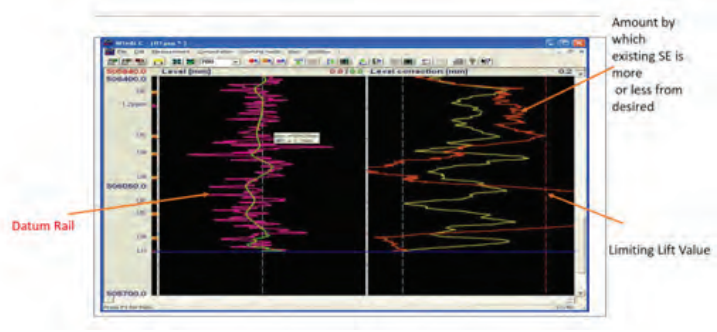


Fig.8.30 Suggested Level

On the left, pink line shows the existing level, yellow shows the suggested level profile. On the right, the yellow shows the lift value.

The orange line shows the amount by which existing SE is more or less from desired SE. The lift value for datum rail should always be more than the amount by which SE is more, hence yellow line should always be on the right of orange line. Additional lift may be provided to ensure this during tamping.

The constant area concept may be used to correct the level profile similar to what is done in alignment correction. The icon to be used is *(Fig.8.31)*-

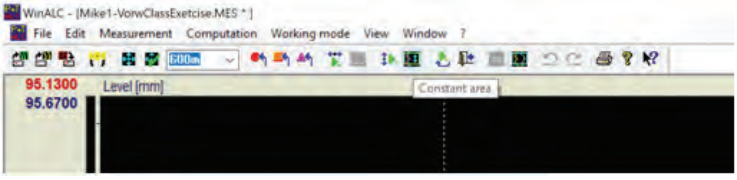


Fig.8.31 Level Constant area icon

The file is saved after that.

The saved file containing Cant, Alignment and Level as decided shall now be used for achieving the desired track profile and parameter.

8.5.3 Working Mode-

The machine will be taken to the location from where measurement was done. The yellow tamping icon will be clicked as shown below *(Fig.8.32)*-

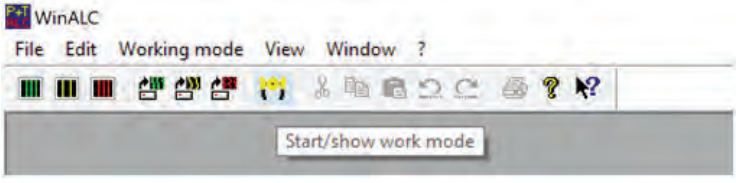


Fig.8.32 Start work icon

The tamping mode will open and file to be used for tamping will be opened as shown below *(Fig.8.33)*.

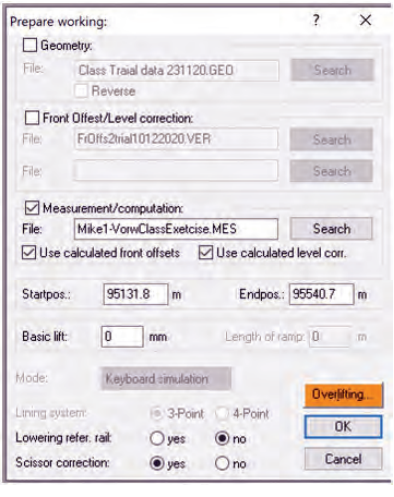


Fig.8.33 Working mode entry

Based on the final profile suggested, the ALC will automatically take the calculated offset and calculated level for correcting the track. Additional lift and corresponding ramp length can be provided in the similar fashion. After clicking "OK" the screen during tamping will be displayed as below(Fig.8.34)-

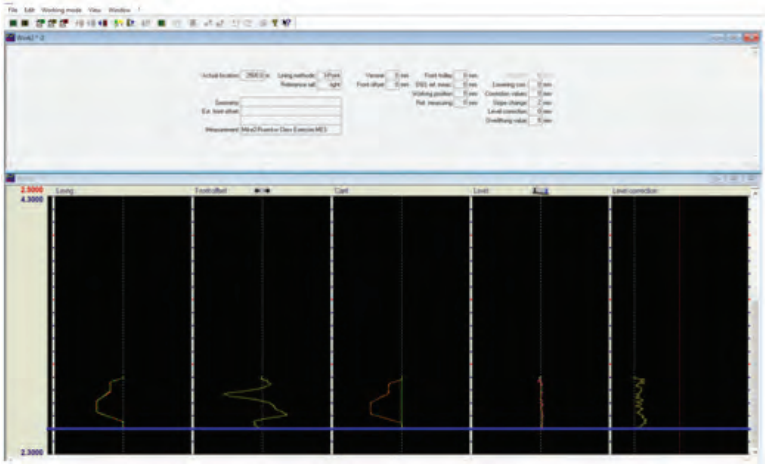


Fig.8.34 Working mode screen

The file selected for attention, the final alignment and corresponding front offset, the cant to be achieved and the final level and corresponding lift value will all be displayed.

■ ■ ■

9

Field Work for Tamping

9.1. General

This chapter deals with activities/works to be carried out before, during, and after deployment of heavy on-track tamping machines on Indian Railways. The tamping activity causes pulverization of ballast due to high stress concentration, therefore frequent tamping (packing) of ballast should be avoided as far as possible. It should be endevour of all track maintenance personnels to undertake tamping (packing) of ballast only when it's required in accordance with the optimized frequency for optimum service life of track.

9.2. Tamping Frequency

The periodicity of through tamping depends on many factors, as mentioned below, besides traffic (GMT) carried and the type of sleepers, as was generally believed:

(i) Traffic density on the route, Axle Loads and maximum permissible Speed of trains.

(ii) Track geometry i.e. Gradients & Curvature.

(iii) Track Structures and condition of track components.

(iv) Total Depth of ballast cushion, Availability of clean cushion below sleeper & on shoulders, and drainage characteristics.

(v) Type of formation i.e. embankment or cutting, type of soil, condition and stability of the formation.

(vi) Climatic conditions such as rainfall, snowfall etc.

(vii) Local conditions, such as adjoining built-up area, tress-passing, drainage problems etc.

(viii) Mode of tamping on previous occasion i.e. smoothening mode or design mode.

(ix) Stabilization, immediately after tamping, by dynamic stabilizer.

For maintaining the track in good geometrical parameters and good condition of packing for a good riding quality and considering the possible variation in aforesaid factors, no optimum universal frequency of tamping could be specified. It therefore would have to be laid down for each of the section separately for each road/line keeping in view the general position of the above factors for each road/line of each section.

The frequency of tamping, so decided, will require periodical review (say every two years), or whenever significant change occurs that significantly alters any of the parameters mentioned above like change in traffic pattern, improvement in track structure/geometry, deployment of new rolling stock with different axle loads etc.

Typically frequency of tamping could be as low as once in 4-5 years for tracks laid on stable formations with annual traffic density of 10-15 GMT and carrying axle loads of around 20 tonne.

9.3. Preperatory Works before Introduction of Tamping Machines for Plain Track and Turnouts

Before undertaking through maintenance tamping of plain track (including turnouts), advance planning and fulfilment of certain pre-requisite are necessary to ensure high quality work and better retentivity. For this purpose, process as detailed below may be followed to prepare a detailed project report duly incorporating location specific needs, if any.

9.3.1. A field survey is carried out to-

(i) Determine existing profile of track and availability of clean and total ballast cushion, to decide the extent of lift and assess ballast requirements. The levels for formation/cess are also taken, if felt necessary/required. *(refer chapter –7)*

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

(iii) Take census of hogged and battered joints, if any, which may require large scale attention.

(iv) Take census of broken and damaged sleepers on plain track as well as in turnouts needing replacement.

9.3.2. A minimum clean ballast cushion of 150 mm below the bottom of the sleepers, at rail seat location, should be available for quality output and retentivity of packing by the tamping machines.

9.3.3 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.

9.3.4. For aforesaid objectives planning and execution of deep screening of ballast, if required, training out of ballast/ploughing, and cess repair works should be done well in advance.

9.3.5. Make arrangements for adequate ballast in shoulders and cribs to allow required lift as per proposed vertical profile as per the relevant provisions, contained in the Indian Railways Schedule of Dimensions - 2004 (with all correction slips) and Indian Railways Permanent Way Manual, and to maintain prescribed ballast section after tamping activity.

9.3.6. Track drainage must be improved, as necessary, and pumping locations should be attended. Rounded ballast particles should be replaced with clean and angular ballast.

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

9.3.8. All broken and damaged sleepers are replaced including those in points and crossings.

9.3.9. The beginning and end of curve/transition curves are identified and marked in the form of permanent reference pillars, if not done already. OHE mast in electrified sections can also be used for reference marks after markings and its documentation. *(Refer Chapter 6)*

9.3.10. In case of tamping on turnouts, sufficient length of approach track, including the special track features on either side should also be planned. In case of the turnout, leading to loop line, the turn in-curve should also be planned for tamping along with turnout.

9.4. Pre-Tamping Works

The following pre-tamping works need to be carried out before undertaking tamping of track by heavy on-track tamping machines.

9.4.1. Another round of field survey may be carried out immediately prior to deployment of tamping machine to update the existing profile of track and rework proposed track profile.*(Refer Chapter 6)* The time gap between this field survey and actual tamping machine working should be as minimum as possible.

9.4.2. Calculation of relevant values/corrections (which are machine specific) – "H" values for 3 point lining, "V_m" / "F" (in 4-point lining), "F_D" (in both 3 and 4 point lining), "Y" (Lift values), "K" (lowering value for super-elevated horizontal curves), "X" (correction value for vertical curves) shall be done and verified.

9.4.3. In case permenent referance pillers have been installed

and documented, the slew and lift data can be obtained and used directly in conjuntion with field survey data.

9.4.4. Alternatively measuring run facility of tamping machine, if available, can also be used for surveying the existing track profile and for determination of proposed track profile during the same traffic block before commencing actual tamping operation.

9.4.5. The beginning and the end of curve/transition curves are written conspicuously on sleepers alongwith the various parameters, mentioned hereunder (*as shown in Fig. 9.01*) on every alternate/every third sleeper to act as guide for the operator for feeding.

(a) For straight track - Slew, lift values for designed longitudinal profile.

(b) For horizontal curves - slew (F_D), versine compensation (V_m/F) values (in 4-point lining system) or versine (H, H_X, H_Y, H_Z, and H_W) values (in 3-point lining system) Super-elevation and lowering values (K correction), lift values (Y) for designed longitudinal profile. (refer brief about inputs as per system of working at *Annexure 9.01* and an example included as *Annexure 9.02*)

(c) For vertical curves – Correction values for vertical curves (X corretion).

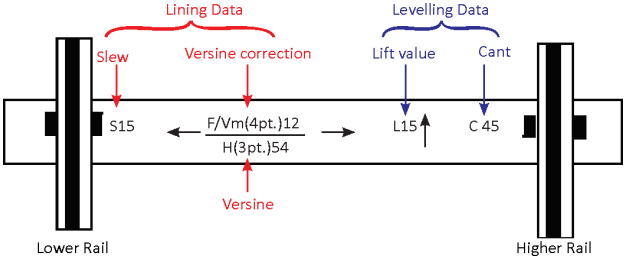


Fig. 9.01 – Marking on Sleeper for Feeding (Manually)

9.4.6. Ballast is heaped up in the tamping zone to ensure effective packing. However, sleeper top must be visible

to the operator and the ballast must not obstruct the working of lifting rollers.

9.4.7. Necessary attention to all remaining hogged/battered joints, as required, is given.

9.4.8. All low joints, if any, are attended.

9.4.9. Deficient fittings and fastenings are made good and all fittings and fastenings like fish bolts, keys, cotters, loose-jaws, elastic rail clips etc. are properly tightened. Broken/worn out fittings and rubber pads are also replaced.

9.4.10. Sleepers should be squared, uniformly spaced and gauge corrected.

9.4.11. De-stressing of rails, adjustment of creep, expansion gaps in joints and SEJs etc., if necessary, is carried out.

9.4.12. Guardrails at the approach of girder bridges and on ballasted deck bridges are removed temporarily.

9.4.13. All obstructions such as rail lubricators, signal rods & bonds, cable pipes, axle counters etc., which may obstruct the tamping tools are removed temporarily.

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

9.4.15. In electrified sections, the Earth/Structure/cross bonds are either removed temporarily or properly adjusted for unobstructed tamping.

9.4.16. Level Crossings are opened and check-rails are removed temporarily ahead of tamping machine.

9.4.17. Suitable speed restriction as per the policy guidelines issued by Railway shall be imposed, if existing Joggled fishplates, guardrails etc. are removed for tamping activity. This speed restriction is relaxed only after restoration of all those fixtures removed/disabled for carrying out tamping.

9.4.18. For turnouts:

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

(b) The broken/battered or worn nose of the crossing is either replaced or reconditioned, as necessary.

(c) Make sure that all broken/damaged sleepers in crossing portion have been replaced.

(d) High points on the turn out and approaches should be so determined that a general lift of minimum 10 mm is given at high points.

(e) In case of Unimat working on turnouts (being complex assembly), a joint inspection may be carried out, by track machine in-charge and field supervisors of permanent way, to make sure that necessary pre-requisite are fulfilled and preparatory work have been carried out, to obtain quality work after track machine working.

(f) Co-ordination with concerned departments is necessary for seamless hassle-free working of track machine.

(i) Operations: for planning and arrangement of sufficient traffic blocks for optimum use of tamping machines.

(ii) Electrical: for availability of OHE maintenance personnel, as required. Arrangement for illumination at work site, if work is being carried out during night.

(iii) Signal and Telecom: for availability of signal maintenance personnel, as required and to make communication arrangements.

9.5. Operations During Tamping

The following points should be observed by the machine operator and the field supervisors of permanent way during working of tamping machine.

9.5.1. The mode of working tamping machine in design mode, unless unavoidable or during initial/first round of tamping at worksite.

9.5.2. The machine is having full compliments of tamping tools. The tamping tools are not loose or worn out. The wear of the tool blade is not more than specified limits *(see Para 2.5.1)*

9.5.3. The gap between top edge of the tamping blade and the bottom edge of the sleeper in closed position of the tamping tools is adjusted depending upon the type of rail and sleepers. *(see Para 2.5.2)*

9.5.4. The tamping (squeezing) pressure is adjusted according to the type of sleeper. *(see Para 2.5.6)*

9.5.5. Care is being taken to ensure that tamping tools are inserted centrally between the sleepers into the ballast bed to avoid any damage to sleepers. The number of insertions of the tamping tools per sleeper varies with the type of sleeper and the amount of track lift to be given. *(see Para 5.6.1)*

9.5.6. During tamping the squeezing time is set as specified for ballast bed conditions. A lower squeezing time may be chosen for ballast in un-consolidated/partially consolidated conditions, whereas a higher Squeezing time may be required for track with consolidated/ partially contaminated ballast bed in service. *(see Para 2.5.7)*

9.5.7. Ramping-in and Ramping-out is being done. *(see Para 5.7)*

9.5.8. If work is being carried out during night there is sufficient illumination at work site to keep the work area well lit.

9.5.9. Correct feeding of relevant values – V_m, F, H, H_X, H_Y, H_Z, H_W, Y (with K and/or X correction as applicable) is being done along with slew values (F_D) for design mode working with manual input.

9.5.10. For machines equipped with laser sighting system, procedure outlined in *Annexure 6.03* is followed.

9.5.11. For machines equipped with ALC system, detailed procedure outlined in *Annexure 6.04* is followed.

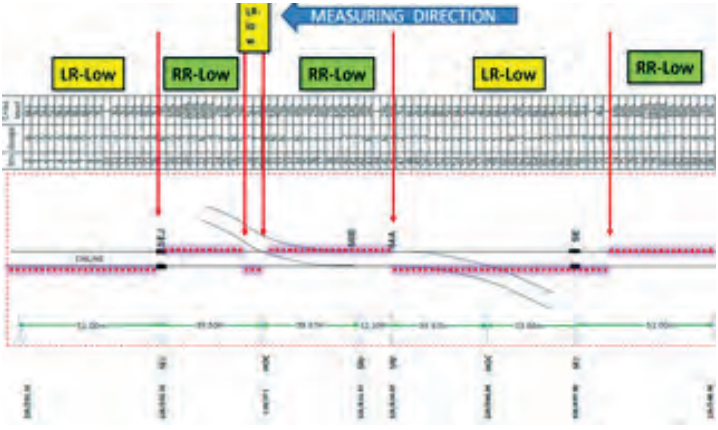
9.5.12. During tamping, the parameters of tamped track are checked immediately after tamping for cross-level and alignment and necessary corrective action, if required is also taken immidiately.

9.5.13. For turnouts:

(a) Sufficient length (at least 50 m) of approach track on either side are also tamped in continuation.

(b) For turnouts in quick succession, without sufficient length in between, adequate traffic block to be planned and adjacent turnouts are tamped together.

In case of yards where more than one turn out are to be tamped in continuation, the tamping of all turnouts to be planned together in one block. It will normally be observed, that T/o side rail will be lower. The measurements of cross level to be taken for all turnouts and datum rail and general lift to be decided accordingly. Observed cross level will be as shown below-



(c) S&T connections and stretcher bars are opened/removed to allow tamping in switch portion.

(d) 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.

(e) For tamping of turnouts, main line portion is to be tamped first. Sequence of tamping on turnout is given in *Fig. 9.02*. The sequence of Tamping on crossover is given in *Fig. 9.03*.

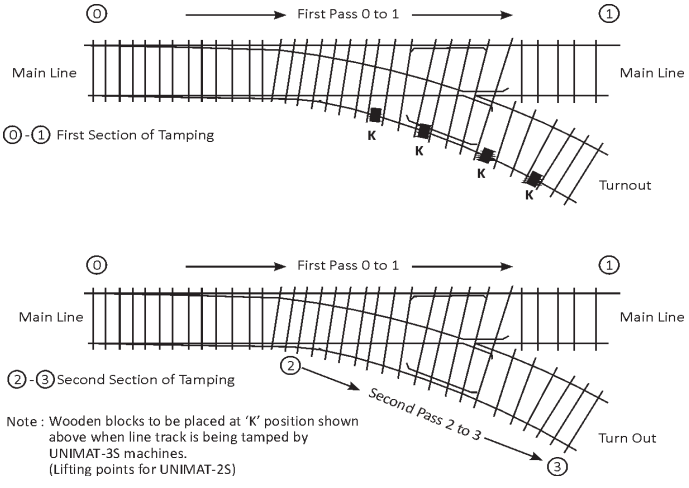


Fig. 9.02 (a) – Sequence of Tamping on a Turnout

(f) The XL and AL correction should be done while tamping on M/L or important routes but should be cutoff while tamping on other side as shown below, fig. 9.02 (b)

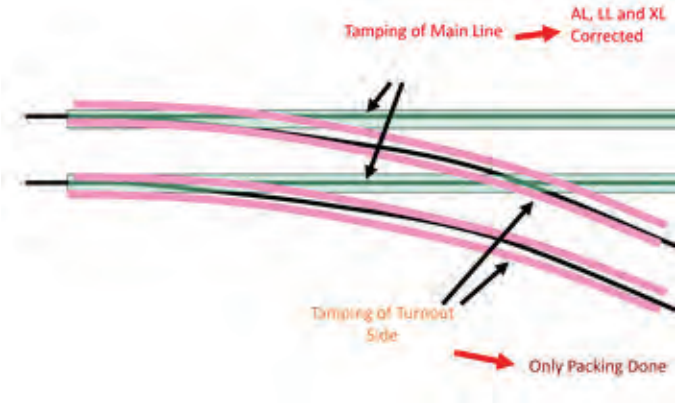


Fig. 9.02 (b) – Correction of XL and AL in M/L

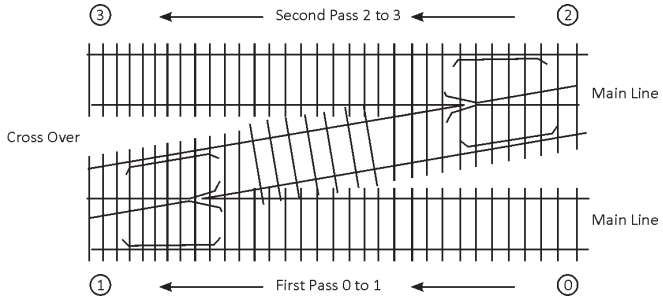


Fig. 9.03 – Sequence of Tamping on a Cross-Over

(g) In case of diamonds (with/without slips), direction of more traffic should be tamped first as shown in *Fig. 9.04*.

(h) While tamping mainline portion, UNIMAT-3S/2S machines, 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 or *(See Fig.9.02)* by filling ballast.

In newer models (eg. UNIMAT-4S) sleeper under third rail seat can also be packed/tamped.

While tamping by UNIMAT -4S, tamping of M/L and T/O should be done is such a manner that complete rail seat is packed. Since half rail seat at many locations (both M/L and on T/O sideparticularly in crossing portion) is only tamped while moving machine on M/L. The sequence of tampingshould be as given below Fig 9.04

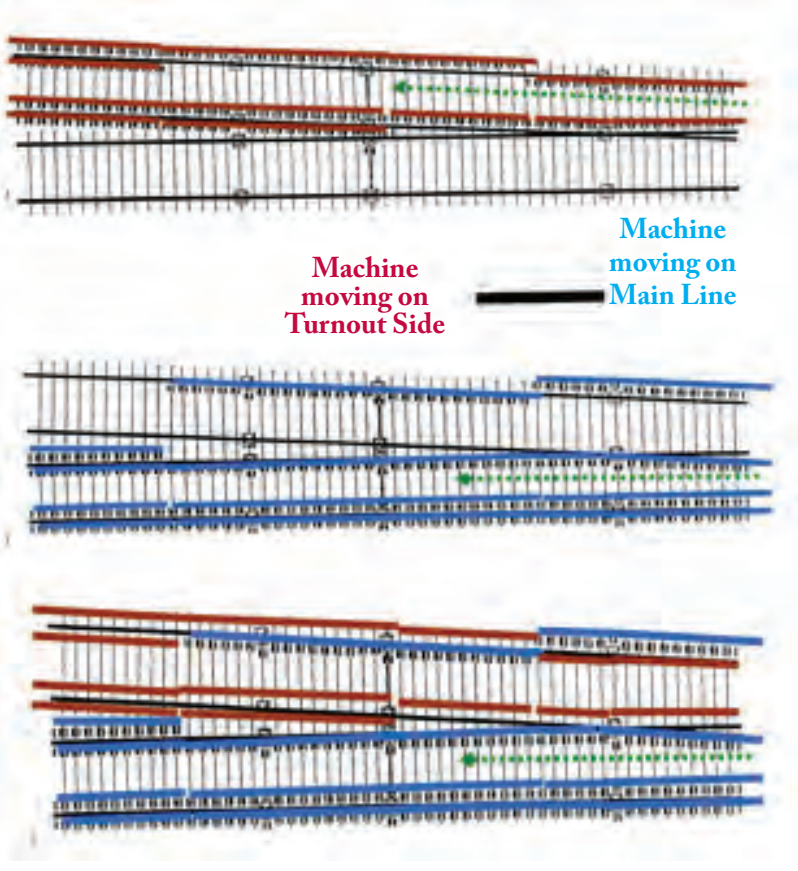


Fig. 9.04 – Sequence of operation by UNIMAT-4S

(i) In case of the turnouts leading to loop line, the turn in-curve is also tamped in continuation.

(j) The S&T and electrical staff are associated during the work.

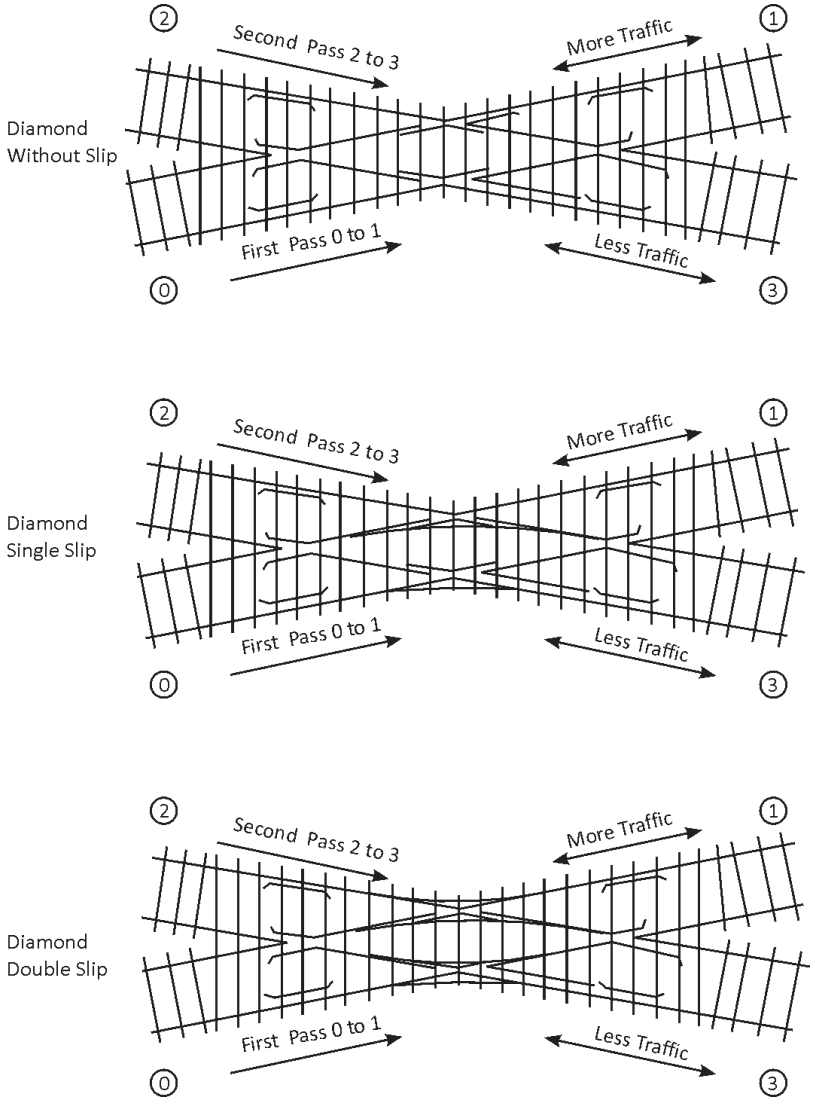


Fig. 9.05 – Sequence of Tamping on Diamond Crossings

9.5.14. All relevant provisions of G&SR regarding movement, protection and working of track machines must be adhered to. If the track is long/continuously welded, necessary precautions are also taken as required in accordance with manual provisions and extent instructions.

9.6. Post -Tamping Operations

After completion of tamping under traffic block, field supervisors of permanent way shall pay attention to the following items:-

9.6.1. Checking and tightening of all loose fittings.

9.6.2 Replacement of all broken fittings.

9.6.3. If the track is long/continuously welded, the relevant provisions are followed and precautions are taken as per IRPWM.

9.6.4. Actual output, of the work done, is compared with reference to rated output and analytical report prepared duly indicating ineffective time and loss of time and reasons therefore.(*see Para 2.6*).

9.6.5. 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 optional equipment like Data Recording Processor (DRP) or by a separate run of track measuring trolleys etc.

Note:

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

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

9.6.6. The machine should, after tamping, be able to generally achive track geometry as specified in IRPWM.

9.6.7. The fixtures like check-rails etc. removed during pre-tamping operation are restored.

9.6.8. Guard rails removed during preparatory work are re-fixed in position.

9.6.9. Distance blocks on platform lines, joggle fishplates, OHE bonds, signalling rods/bonds & cables pipes etc. are restored inposition and fittings are tightened.

9.6.10. Speed restrictions imposed, if any, due to removal/ disablement of any of the fixtures affecting safety are relaxed only after ensuring that the device/fixture are provided/enabled.

Inputs required based on mode of working (4-point system)

Mode of working	Values to be fed			Remarks
	Versine (compensation)	**Slew (F_D)**	**Cant**	
Smoothening (Compensation) mode	Yes (V or F)	-	Yes	1. Curve radius required for calculating versine compensation (V_m / F), shall be the exiting radius. 2. Design value of cant is required. 3. K correction value is calculated and adjusted in general lift. 4. X correction, if required, is also calculated and adjusted in general lift..
Design or (Precision) mode	Yes (V or F)	Yes (F_D Values)	Yes	1. Curve radius required for calculating versine compensation (V_m / F), shall be the proposed curve. 2. Design value of cant is required. 3. K correction value is calculated and adjusted in lift values (Y). 4. X correction, if required, is also calculated and adjusted in lift values (Y). 5. In addition to above, F_D is ascertained from field survey data will be the value.

Inputs required based on mode of working (3-point system)

Mode of working	Values to be fed			Remarks
	Versine	Slew (F_D)	Cant	
Elemantary mode	Yes (Applicable versine values H, H_X, H_Y, H_Z, H_W, H_V, H_{FX}, H_{FW})	-	Yes	1. Radius of curve is required for calculating versine values. It shall be taken as existing curve radius. 2. Design value of cant is required. 3. K correction is calculated and adjusted in general lift. 4. X correction, if required, is also calculated and adjusted in general lift.
Design (precision) mode	Yes (Applicable versine values H, H_X, H_Y, H_Z, H_W, H_V, H_{FX}, H_{FW})	Yes (F_D Values)	Yes	1. Design radius of curve required for calculating versine values. It shall be the radius of proposed curve. 2. Designe value of cant is required. 3. K correction value is calculated and adjusted in lift values (Y). 4. X correction value, if required, is also calculated and adjusted in lift values (Y). 5. In addition, F_D should be ascertained by field survey in advance & It shall be the value required for acheving design Curve.

Annexure 9.02

Example:

Sequence of Tamping of Track by WST 08-32C

A. Details about Track & General input.

i) SE = 50 mm. R = 400 m.

Transition Lengths L_1 & L_2 = 50m.

ii) General lift = 30 mm (based on general survey)

iii) Sleeper spacing = 60 cm

B. Detail about Machine 08-32C.

i) Lining chord

AC = 10.30 m, CD = 9.35 m,

BC = 5.30 m, AB = 5.00 m,

BD = 14.65 m, and AD = 19.65 m.

ii) Levelling Chord

RM = 5.30 m. MF = 9.35 m. RF = 14.65 m

C. Sequence of Working

Tamping Parameters setting

i) Set tamping depth = Sleeper height + Rail Height + 6 mm (GRSP T - 3711).

ii) Set squeezing time.

iii) Set Squeezing pressure.

D. General Lift (Manual feeding through front cabin potentiometer)

Calculation method given in *Example 5.01* can be followed.

Length of Ramp-in & Ramp-out = 30 *1000 = 30,000 mm

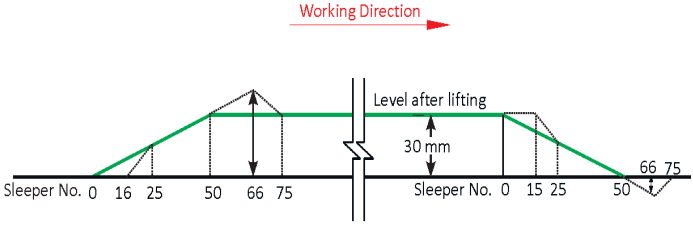
No. of sleepers in ramp length = 30,000/600 = 50

Rate of lift per sleeper = 30/50 = 0.6 mm

No. of sleepers in length RM(a) = 5.30/0.6 ≈ 9

No. of sleeper in length MF(b) = 9.35/0.6 ≈ 16

So, feeding of lift value on 66 sleepers in Ramp in will be 66 * 0.6 = 39.6 mm (40 mm)



Lift at other locations also can be calculated similarlly as shown in *Example 5.01.*

E. 4 -Point Lining System

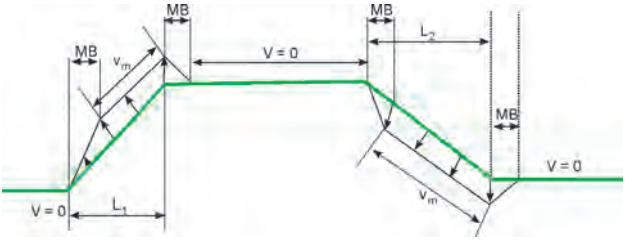
Calculation V_m value is done by Formula

$$V_m = \frac{AC*CD*BC}{6*R*L}$$

V_m values are also given in track machines catalogue

$$V_m = \frac{10.30 * 9.35*5.30}{6*400*50} = 4.25\ mm \approx 4mm$$

Distribution of 4 mm given in machine catalogue is fed through versine potentiometer. The direction and distribution of V value will be as under :



F. 3 – Point Lining System

If machine is working in 3-Point lining system then calculate following versines for input.

(i) H value

$$H = \frac{BC * CD}{2 * R} = \frac{5.30 * 9.35}{2 * 400} \approx 62\ mm$$

Alternatively,

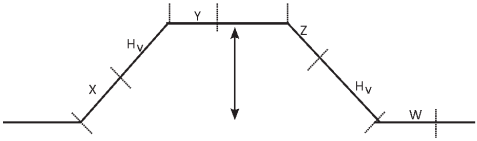
$$H = \frac{\text{Constant}}{R} = \frac{24.777}{400} = 61.945 \approx 62\,mm$$

(ii) H_V (versine variation per meter)

$$H_v = \frac{BC * CD}{2 * R * L} = \frac{62}{50} \approx 1.24 mm/m$$

It may also be calculated as

$$H_V = \frac{\text{Versine at beginning of Y - Versine at end of X}}{\text{Transition Length - Chord Length (Machine Base)}}$$



Length of X, Y, Z and W (i.e. BD) = Machine Base
Machine Base (Chord Length) = 14.75 m

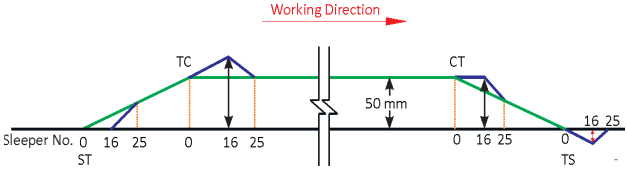
H, H_X, H_Y, H_Z, and H_W shall be calculated as given in *Example-2*.

G. Levelling system

Cant (Super-elevation)

Divide cant value (max.) by transition length

$$\frac{50\,mm}{50\,m} = 1mm/m$$



Cant value should be distributed and fed *(see Para 5.8)* as shown above, if fed through front tower.

Similar to the method shown for feeding General Lift the cant value feeding in front tower for getting a cant of 50 mm at TC will be

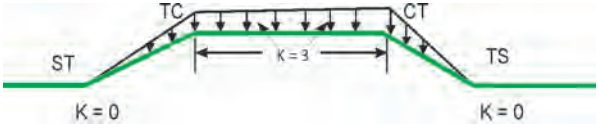
= (50mm + 0.6*16)*1=59.6 mm

Cant at other locations can also be calculated accordingly.

(ii) K correction Value:

While working in curve *General Lift* needs to be reduced by K value as mentioned in *Para 5.9*. The value of K correction is supplied by manufacturers in catalouge that accompany the machine.

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



(iii) X Value:

For vertical curve, X correction value should be added/ substracted as described in *Para 5.10.*

H. Additional input for Design Mode of lining and levelling:

(a) *Lining*

F_D value (offset value) is amount by which track is shifted from its target position.

(b) *Levelling*

Target height value (Y) i.e. desired lift for the *datum rail.*

F_D and Y are found after field survey by calculating manually / using software & feed all required data automatically.

Annexure 9.03

Laser Sighting System

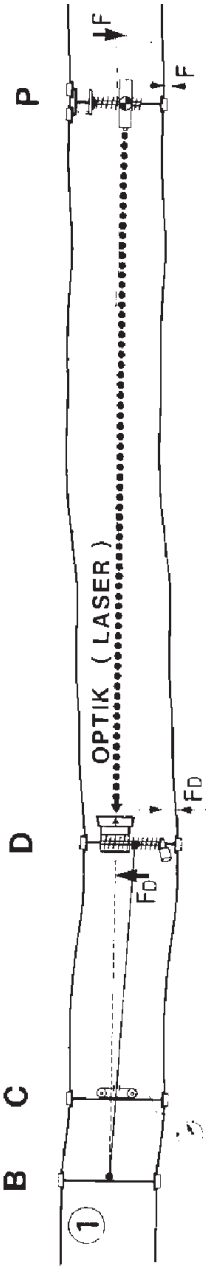
Some of the tamping machines may have optional equipment of laser sighting system for lining on straight track by extending reference chord to eliminate defects on longer wave length, which are relevant for higher speeds. The lining procedure with the help of laser equipment is briefly outlined here.

1. For lining of long straight sections a system consisting of laser receivers are mounted in front of the machine that receives feed from the laser transmitter set-up on a small trolley at a distance of 200-300 m. This system, which operates fully automatically provides input values for slews (F_D) at front trolley location.

2. **Working Sequence of Design Lining with the Laser Sighting System:**

   2.1. 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 an amount equal to lining error.


B
C
D
P
OPTIK (LASER)
FD
FD
F
F
1

2.2. **Phase 2 and 3 :**

When the design lining commences, the front end of the chord (point-D)with the LASER receiver gets shifted by an amount of the error (F_D) from the direction of the emitted laser from transmitter. The track is accordingly lined at point C and matched exactly with the line of sight.

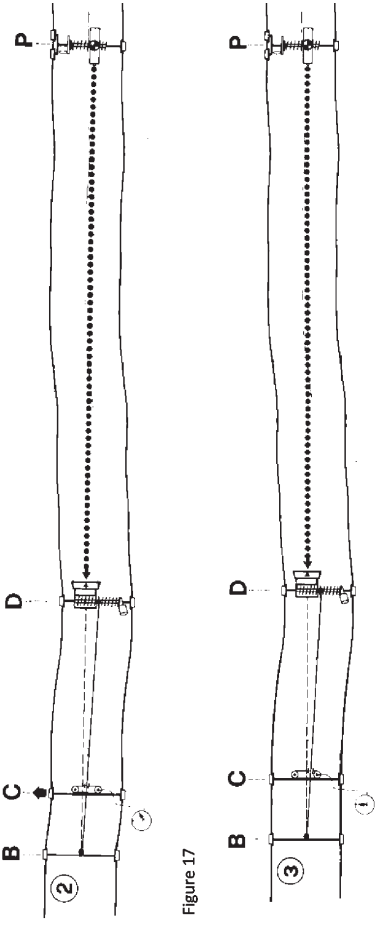
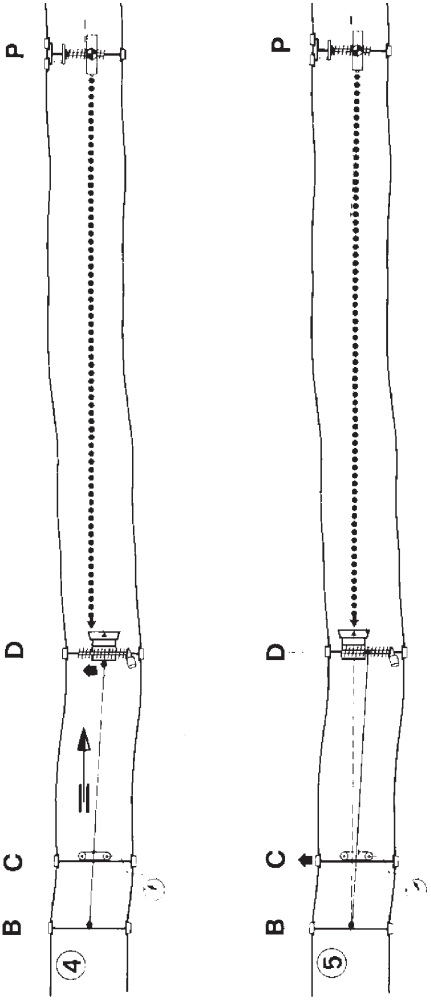


Figure 17

2.3. 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 set of lining operation.



■ ■ ■

10
Dynamic Track Stabilisation

10.1. General

The process of restoration of track geometry parameters such as longitudinal level, cross-level and alignment with the help of tamping machine, causes unavoidable reduction in track's resistance to lateral displacement, which may need speed restriction till such time the track consolidates, and build up lateral resistance, under the impact caused by the loads of a certain number of trains. The settlement of the track under traffic loading occurs due to the movement of ballast particles and their re-arrangement in available free spaces in ballast bed and consequent change in volume, which also decides the compaction structure of ballast particles.

The settlement under traffic (passage of trains) usually causes uneven settlement due to dynamic variations of load arising from various vehicle design characteristics, their maintenance conditions, and operational features in addition to imperfections and extent of track irregularities in dynamic conditions. On ballast particles, the traffic loading causes higher stresses on the contact points and edges (having small contact area) resulting in crushing on edges and contact points (to reduce stress level) and consequent uncontrolled uneven settlement leading to rapid progressive deterioration of track geometry.

10.2. Dynamic Track Stabilisation

With Dynamic Track Stabilisation, carried out immediately after tamping, the corrected track is stabilised by "controlled" settlement under uniform dynamic action with about 30% of maximum of the forces that may occur under service loads so that the ballast particles are not unduly stressed. The quality of track parameters are also retained well during stabilisation to slowdown rate of deterioration and enable extension of tamping cycle by up-to 30%.

Thus use of a Dynamic Track Stabiliser (DTS) enables faster and even compaction to build homogenous structure of ballast bed and therefore provide an effective way to substantially restore the resistance of the track, to lateral displacement (or buckling), in controlled manner. *(see Fig. 10.01)*. Therefore immediately after the DTS has passed the track may be opened for traffic without any speed restrictions.

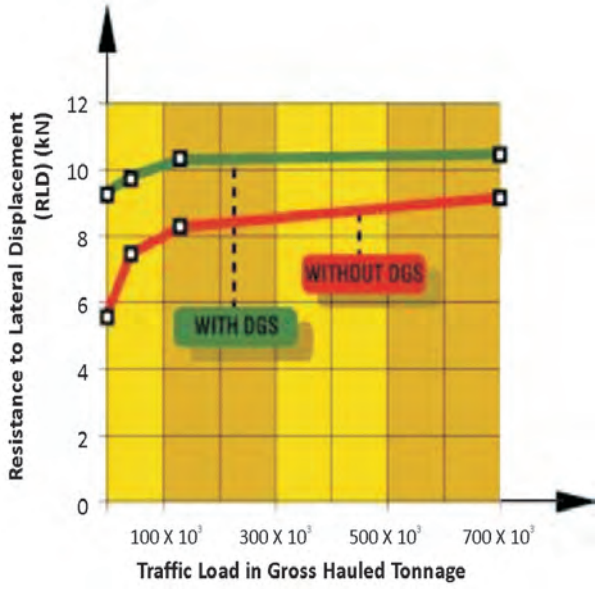


Fig. 10.01–Building of Resistance to Lateral Displacement with Traffic Load after Track Renewal

10.2.1. The consolidation by the DTS has the following major advantages:-

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

(ii) The track geometry achieved by tamping machines is retained for a longer duration under service.

(iii) Homogenous structure of ballast bed is built up.

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

(v) Speed restrictions can be relaxed faster.

10.2.2. The settlement achievable in consolidation process by DTS depends essentially upon height of the preceding lift, size of the ballast particles and mixture of various sized stones, degree of contamination of the ballast bed, and condition of the other permanent way components. On normal maintenance work the degree of settlement is usually around 25 – 30%, whereas on newly laid lines with loose ballast structure it could be upto 50% of the preceding lift.

10.2.3. Considering the tremendous direct as well as intangible benefits of stabilisation, it has now become de-facto standard to deploy DTS immediately after tamping. On some of the railway systems the stabilisation has been made compulsory, immediately after tamping. The general layout of a Dynamic Track Stabiliser can be seen in *Fig. 10.02.*

10.3. Working Principle

Two/three heavy dynamic consolidating units are pressed firmly against both rails by hydraulic pressure. Flywheels produce a horizontal oscillations (some of machines may also have vertical oscillations) directed laterally to the track, which together with a vertical load, is transmitted to the track and subsequently into the

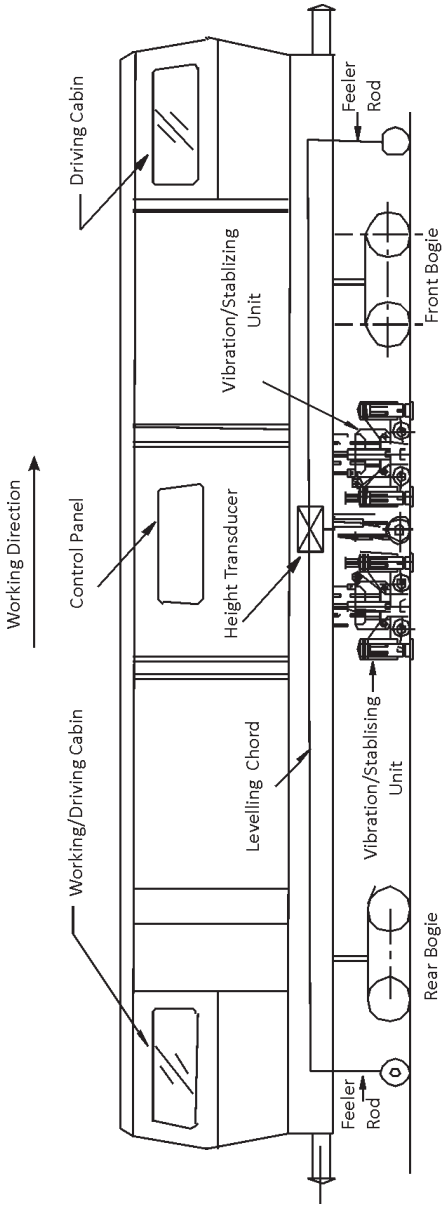


Fig. 10.02 - Layout of a Dynamic Track Stabiliser

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 particles, which settle closer by filling of the voids. *(see Fig. 10.03)*

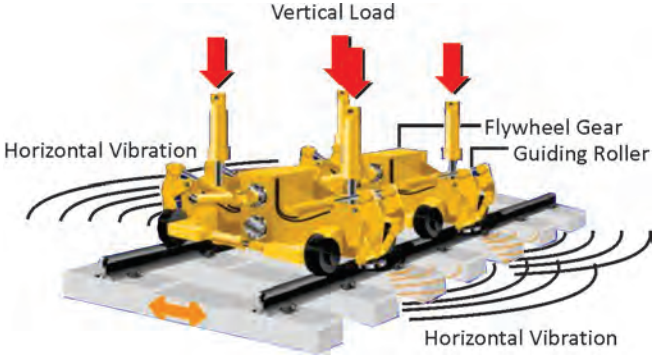


Fig. 10.03 – Working Principle of Dynamic Track Stabiliser

This compaction causes not only a controlled settlement of the track but also enhances friction between sleeper and compacted ballast bed resulting in increased lateral track resistance.

The vertical load helps in maintaining firm contact between the consolidating units and the track for transmitting the oscillation. The oscillation frequency is adjustable up-to 45 Hz, however for most permanent way conditions 32 – 37 Hz frequency is most favourable. The vertical static load also can be adjusted from around 165 kN to 355 kN, however for most tarck maintenance operations the optimum load is around 230 kN to 290 kN.

10.3.1. DTS is also equipped with a levelling system, which prevents the longitudinal and cross level values from varying appreciably due to differential settlement of various segments of track. The transducers of, longitudinal level and the cross level, measuring system recognizes the tendencies towards formation of faults and influences the load control with their measuring signal via the automatic governor, thus counteracting any tendency of propagation of the faults.

10.3.2. The speed of working can be controlled by an adjustable hydrostatic drive (working speed 200 m/h to 2.5 km/h, if working speed is set below 200 m/h oscillations stop). If the track geometry is corrected in several passes of tamping machine, then a low speed of working of 0.5 km/h to 1.0 km/h is selected for first and second pass. For subsequent passes, higher working speed of 1.0 km/h to 2.0 km/h is selected.

10.3.3. In a single pass, the DTS carries out stabilisation equivalent to passage of one-lakh tonnes of train traffic. It is possible to permit a speed of 40 km/h on freshly deep screened track, if ballast is adequate and DTS has been deployed after tamping.

10.4. Optional Accessories

Some of the DTS may have optional recorder, which enables up to 8 track geometry parameters to be recorded for documentation and assessment of work carried out.

The following parameters can be recorded:

(a) Longitudinal level of LH rail after stabilisation

(b) Longitudinal level of RH rail after stabilisation

(c) Mutual cross level before stabilisation

(d) Mutual cross level after stabilisation

(e) Track twist

(f) Versine (alignment)

(g) Resistance to lateral displacement (registration of long waves)

(h) Resistance to lateral displacement (registration of short waves)

10.5. Modes of Working

The Dynamic Track Stabiliser can work in any of the folllowing two modes :

(a) Maximum Settlement mode (with constant vertical pre-load)

(b) Controlled settlement mode (with regulated vertical pre-load)

10.5.1. Maximum settlement mode (with constant vertical pre-load)

In the settlement mode of working, the machine works to achieve higher consolidation through maximum thrust 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.

10.5.2. Controlled Settlement mode (with regulated vertical pre-load)

In the levelling mode of working the DTS machines are capable of settling the track in a controlled manner while maintaining the track geometry for both longitudinal and cross-level. In some machines measuring and control system has been installed, which can remove any residual fault in track geometry.

10.6. Types of Dynamic Track Stabilisers

10.6.1. There are three type of DTS machines in use over Indian railways

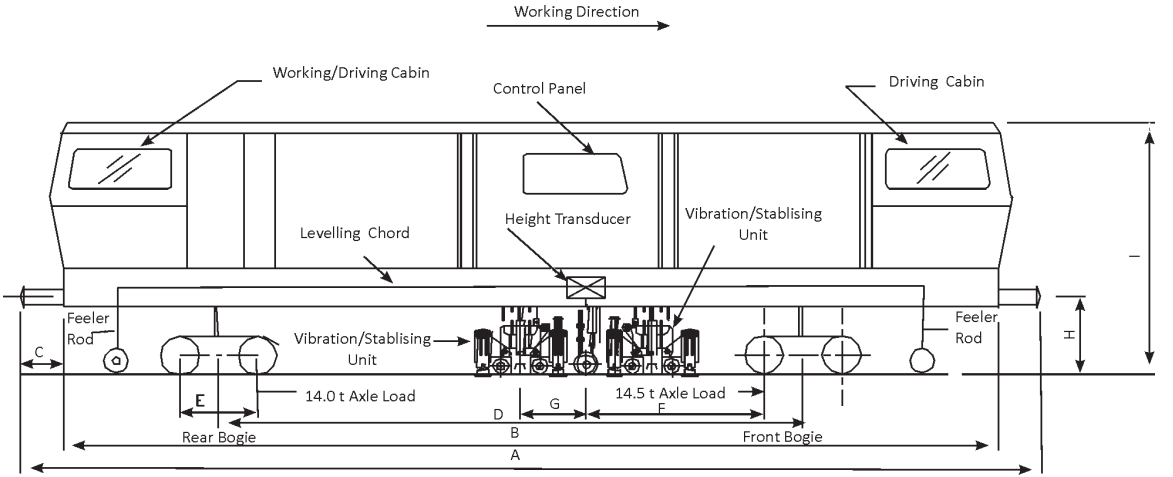
(i) DTS 62N (M/s Plasser India).

(ii) DTS VKL-404IN (M/s BHEL, India)

(iii) DTS DSP-C8T (M/s METEX-JSC, Russia)

10.6.2. The important dimensions of the DTS machines are given in *Fig. 10.04*

10.6.3. Salient features and Technology used in DTS machines, presently working on Indian Railways, are given in Table 10.01.



DYNAMIC TRACK STABILIZER (DTS)

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 Vibration Unit
DTS/METEX	18270	17000	635	13000	1830	-	-	1105	3815	860	15t	2900	3 Vibration Unit
DGS-62N/PLASSER	17250	16010	620	12000	1500	-	-	1105	3790	730	14.5t	2800	2 Vibration Unit

All dimensions are in mm

Fig. 10.04 – Important Dimensions and Features of DTS

Table 10.01 - Salient Features and Technology used in DTS Machines, Presently Working on Indian Railways

Sl. No.	Feature	Plasser's DTS DGS-62N	BHEL's DTS VKL-404IN	METEX's DTS DSP-C8T
1	Bogie	One bogie is powered bogie for travel drive and both bogie serves as powered bogie for working drive	One bogie is driving and second is idle. The driving bogie is equipped with two traction motors.	One bogie is driving and second is idle during running. However during working, both bogies are powered.
2	Stabilising Units	Two stabilising units. Each unit consist 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 rail	Two stabilising units. Each unit consists of a frame with 4 running rollers. The stabilising units are designed such that only horizontal vibration occurs by means of a cardan shaft. The rollers are so designed	Three stabilising units located at the middle part of the machine. Each unit consists of a frame with 4 guide rollers. The guide rollers are pressed against the rail head from inside during the vibration process

Table 10.01 - Salient Features and Technology used in DTS Machines, Presently Working on Indian Railways (Contd.)

Sl. No.	Feature	Plasser's DTS DGS-62N	BHEL's DTS VKL-404IN	METEX's DTS DSP-C8T
		head from inside during the vibration process and the horizontal guide rollers from out side. The stabilising units are designed that only horizontal vibrations occur by means of a cardan shaft.	to enable work in the turnouts. The roller balances are equipped with the blades, which guide the rollers through the crossing.	Vibration units drive is carried out by hydro motors and cardan shaft. Both horizontal and vertical vibrations are produced.
3	Vibration frequency	0-45 Hz (Favorable range 32 - 37 Hz)	0-40 Hz (Favorable range 32 - 35 Hz)	40-49 Hz (Vertical vibration) (Favorable range 40 - 45 Hz) 20-22.5 Hz (Horizontal)

table contd...

Table 10.01 - Salient Features and Technology used in DTS Machines, Presently Working on Indian Railways (Contd.)

Sl. No.	Feature	Plasser's DTS DGS-62N	BHEL's DTS VKL-404IN	METEX's DTS DSP-C8T
4	Working speed	0- 2.5 km/h	0- 3.0 km/h	0- 2.5 km/h
5	Working speed	240 kN (max) (120 kN on each stabilising unit)	0-240 kN (max) (120 kN on each stabilising unit)	320 kN (max) (106.6 kN on each stabilising unit)
6	Levelling System	The measuring system of the Levelling device works on the principle of 3- Point system.	No Levelling System	The measuring system of the levelling device works on the principle of 4 - Point system.
7	Working Mode	There are two working modes: i) Constant Drop mode/ levelling mode. ii) Constant thrust mode/ Settlement mode.	There are also two working modes: i) Constant Drop Mode (CDM) / Levelling Mode. ii) Constant Thrust Mode (CTM)/ Settlement mode.	There are two working modes: i) Levelling mode, which is computer controlled ii) Constant Vertical Preload /Settlement mode.

table contd...

Table 10.01 - Salient Features and Technology used in DTS Machines, Presently Working on Indian Railways

Sl. No.	Feature	Plasser's DTS DGS-62N	BHEL's DTS VKL-404IN	METEX's DTS DSP-C8T
8	Max Drop Value	10 mm (Levelling mode)	In constant thrust mode – CTM-10 to 50 mm In constant drop mode-CDM-5 to 10 mm	Upto 20 mm (Levelling mode)

10.7. Working of DTS

The machine is used in settlement mode at renewal or deep screening sites. On maintenance site, it is deployed in controlled settlement or levelling mode. Although the working of DTS does cause minor influence on rails, fastenings and the surroundings of the track. However, while working in vicinity of fixed structure as platforms, bridges, tunnels, retaining/ supporting walls, buildings etc. certain guidelines must be followed for safe operation.

10.9.1. Basic pre-requisite and guidelines for use of DTS

(a) The DTS must be deployed immediately following the lifting and tamping of track in the same traffic block, as application of DTS on a track already settled by traffic loads may not bring improvement to the track conditions.

(b) Application on new lines or re-laid or re-ballasted lines, for the structuring of consolidation, should be in layers after each tamping operation to produce a thoroughly uniform consolidation structure.

(c) The rails, sleepers and fastenings are devoid of defects and ballast bed is not contaminated.

(d) Complete and tight fittings to hold rails with sleepers are essential.

(e) Availability/training out of adequate ballast for achieving the required profile is necessary.

10.9.2. The following additional precautions are necessary in the operation of this machine:

(a) The vertical pre-load is to be selected (for levelling system) in such a way that the determined maximum settlement is not exceeded.

(b) 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 is

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.

(c) When stabilising on bridges with ballasted deck, the frequency selected must not be within the natural frequency of the bridges so as to avoid resonance conditions.

(d) To avoid resonance stabilisation work shall not be taken up on major or important bridges without sufficient staff being deputed to observe the bridge spans, especially the bearings, during stabilising operations. If any unusual sounds/vibrations/ movements are noticed, stabilising operations shall be immediately stopped on that bridge and a speed restriction of 20 km/h shall be imposed on the bridge until examined by authorised bridge engineer.

(e) It is advisable that stabilisation work is not commenced or stopped on the bridges.

(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 stabilising work in tunnels is permitted.

(h) When working behind tamping machine attending track at maintenance site and Deep screening site, DTS (M/s Plasser make) should work with parameters indicated in *Table 10.02 – Summery of setting to be made for different track conditions.*

(i) While stabilising Points and Crossing, DTS should not be stopped at crossing portion.

(j) Ramp-in and ramp-out should be given in 20 m track length while starting the work or restarting the work at any time.

Table 10.02 – Summery of setting to be made for different track conditions.

Condition	Levelling system	Settlement settings	Oscillation frequency	Working speed
A. Stabilization of Plain Track during maintenance tamping				
	ON	70 bar	30-35 Hz	600-1300 m/h
B. Stabilization after tamping of Plain Track at newly laid/deep screened track				
After first tamping operation	OFF	80 bar (Constant Loads)	30-35 Hz	600-1000 m/h
After second tamping operation	OFF	100 bar (Constant Loads)	30-35 Hz	600-1000 m/h
After final tamping operation	ON	70 bar	30-35 Hz	600-1300 m/h
C. Stabilization of Points and crossing during maintenance tamping				
	ON	50 bar	30-38 Hz	600-1300 m/h

■ ■ ■

11
Way forward

Although inseparable and unavoidable, more often than not, line occupation by heavy on-track machines is speciously perceived to be a cross-purpose activity for rail transport system due to the fact that no movement on occupied line would be possible resulting in hold-ups.

With increasing demand for capacity, being function of speed and frequency, and expectation for minimal line occupation, newer machines with higher output rating with better parameter quality after work to prolong the maintenance cycle are being developed, as evidenced from from *Fig. 9.01*, depicting the development of output of track maintenance machines and interval between successive maintenance. Further, combination machines for efficient and synchronized working are becoming norm due to its cost-effectiveness in addition to various other benefits.

For the aforementioned motivations, track machines manufacturers worldwide have developed a number of newer versions of various track maintenance machines with improved capabilities. Some of the machines developed by different manufacturers are shown in the *Table 9.01(a), (b), and (c)* along with salient features for appreciation. A few of these latest machines, which have already been deployed on IR are also indicated.

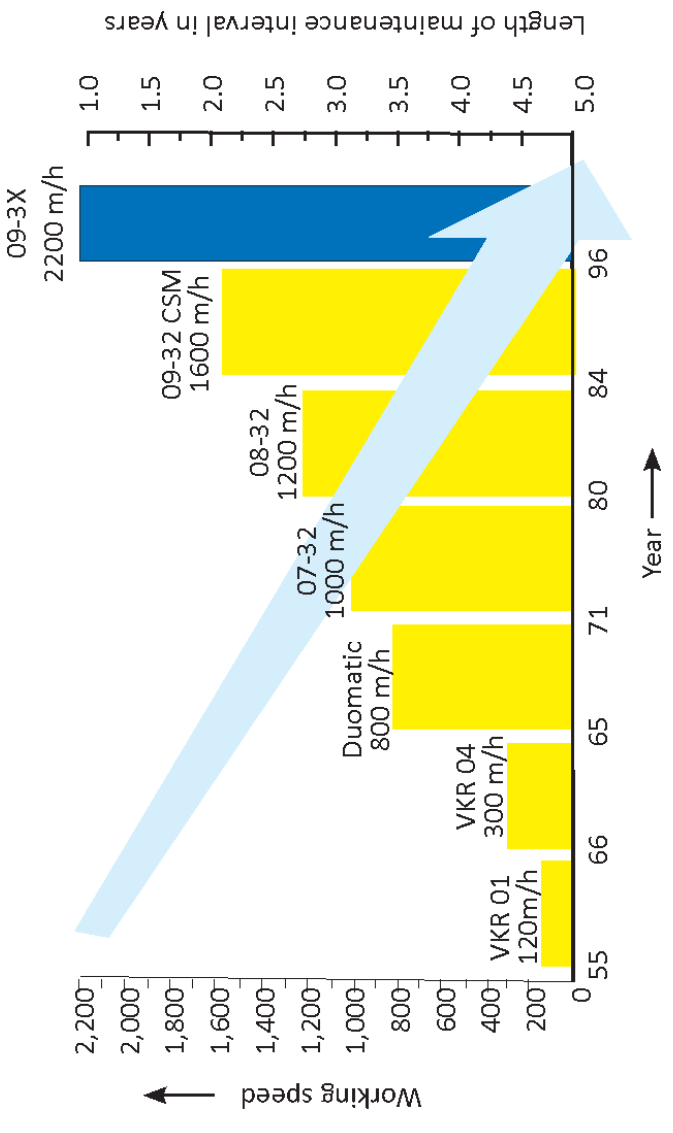


Fig. 11.01 – Development of Working Speeds (4)

Table 11.01 (a) – Plain Track Tamping Machines

Sl. No.	Manufacturer	Model	Salient Features	Capacity (Sleepers/hour)
1	M/S. Plasser & Theurer, Austria	09-32 CSM	Two Sleeper Tamping, Hydrodynamic Gear Box, Twist Correction auto data feeding System, Laser System (Optional) **(Available on Indian Railways)**	2200-2400
2		09-3X Tamping Express	Three Sleeper Tamping, Auto Data feeding System, Twist Correction, Satellite Bogie type, Laser System (Optional) **(Available on Indian Railways)**	2800-3500
3		09-3X Dynamic Tamping Express *(Fig. 9.02)*	Two in One Machine 09-3X and DTS, Centralized Control System, only one operators required for the operation	2800-3500
4		09-4X Dynamic Tamping Express *(Fig. 9.03)*	Four Sleepers tamping with DTS, can work for two sleeper & single sleeper also.	4400-4500
5	MATISA, Switzerland	B 50D *(Fig. 9.04)*	Two Sleeper tamping, Continues action, Plain line double headed tamper, best suitable for new line.	2650

table contd...

6	HARSCO, USA	Drone Tamper *(Fig. 9.05)*	Two Sleeper tamping, High output up to 1 Mile/hours, automatic start & stop, setup time very less (5 min)	2500
7	RPM Group, RUSSIA	NMA-1	Two Sleeper tamping, Continuous action, suitable for construction/Reconstruction.	2400
8		REM – 32 Exp. *(Fig. 9.06)*	Two Sleeper tamping, Servo controlled, Computerized system, High speed and self propelled.	2650
9	XFGE China (GEMAC Engineering, China)	DCL_2-32 *(Gauge-1435 mm)*	Two Sleeper tamping, shoulder compacting and sweeping operation for new construction, overhaul & maintenance purpose.	2500

Table 11.01 (b) – Tamping Machines for Turnouts

Sl. No.	Manufacturer	Model	Salient Features	Capacity (Time/Turnout)
1	M/S. Plasser & Theurer, Austria	08-475/4S	Single Sleeper Tamping with three rail lifting and four rails tamping for turnouts and plain track. *(Available on Indian Railways)*	1 hour
2		09-32/4S Dynamic	Tamps two sleepers at a time with DTS with fourth rail lifting & packing	1 hour
3		Unimat 09-475/4SN- Dynamic *(Fig. 9.07)*	Tamps single sleeper and combines ballasting, tamping profiling, stabilizing, track parameter measuring system with fourth rail lifting & packing.	1 hour
4		Unimat 09-4X4/4S *(Fig. 9.08)*	Continuous action, Single Sleeper Tamping with three rail lifting and four rails tamping for turnouts and plain track.	1 hour
5	XFGE China (GEMAC Engineering, China)	$CDC_2$16	Single sleeper, Optical measuring system incorporated for measurement of Track Geometry value, Three points or four point measuring system. Third rail lifting unit fitted for remote end rail lifting on the same switch sleeper simultaneously.	40 min. (Max. Speed 2.4 km/h)
6	MATISA, Switzerland	B 66UC *(Fig. 9.09)*	Single sleeper with third rail lifting device	20-25 min. (Plain track 950 m/h)
7	HARSCO, USA	Mark VI Tamper *(Fig. 9.10)*	Equally effective on wood or concrete ties, System V Lining System, Jupiter II Control System	-

Table 10.01 (c) – Dynamic Track Stabilizers

Sl. No.	Manufacturer	Model	Salient Features	Capacity (km/h)
1	M/S. Plasser & Theurer, Austria	DGS 62 N	Two vibrations units with vertical load of max. 356 KN, Horizontal vibration. *(Available on Indian Railways)*	2.5
2		DGS 90N *(Fig. 9.11)*	Two vibrations units with vertical load of max. 240 KN, Horizontal vibration.	-
3	RPM Group, Russia	ACn-C4 *(Fig. 9.12)*	Accelerated, adjustable and controllable consolidation without violation of its longitudinal profile, level and plan.	1-2
4		MDS *(Fig. 9.13)*	Accelerated, adjustable and controllable consolidation without violation of its longitudinal profile, level and plan.	2
5	METEX, Russia	DSP-C8T	Three vibration units, Horizontal & Vertical vibration,	-
6	HARSCO, USA	TS-30 *(Fig. 9.14)*	The operator can set the desired down-feed pressure for each rail and the machine maintains it until changed by operator.	-
7	REMTECHSTROY Group, Bulgaria	REMTECHSTROY REM 35 D (II Generation)	Full remote control for on-line diagnostics during operation, radars, geo-radars, GPS, 3D control and other REM systems.	2.5



Fig. 11.02 - 09-3X Dynamic Tamping Express (M/s. Plasser & Theurer)



Fig. 11.03 - 09-4X – Dynamic (M/s. Plasser & Theurer)



Fig. 11.04 - MATISA Tamper B50D (Switzerland)



Fig. 11.05 – Drone Tamper (M/s Harsco, USA)



Fig. 11.06 – REM 32 Exp. (RPM Group, Russia)



Fig. 11.07 - Unimat 09-32/4S Dynamic (M/s. Plasser & Theurer)



Fig. 11.08 - Unimat 09-4X4/4S (M/s. Plasser & Theurer)



Fig. 11.09- MATISA Tamper B66U (Switzerland)



Fig. 11.10 - Harsco Mark VI tamper (USA)



Fig. 11.11 - DGS – 90N (M/s. Plasser & Theurer)



Fig. 11.12 - ACn (RPM Group, Russia)



Fig. 11.13 - MDS (RPM Group, Russia)



Fig. 9.14 - Harsco TS-30 (USA)

■ ■ ■

12
Field Problem

12.1. General

Whenever, we try to attend any track,particularly curve, the decision on final desired profile and once final profile is decided, the decision on mode of working to be followed becomes crucial for getting best result. Two field problem has been discussed in detail, explaining how the decision should be taken for better output. The case taken only deals with alignment correction in curves.

12.2 Field Problem-1

A curve of known original design track parameters is required to be realigned. The design versine's and the existing versine as measured is tabulated below

R=537.63, L1=L2=110 m

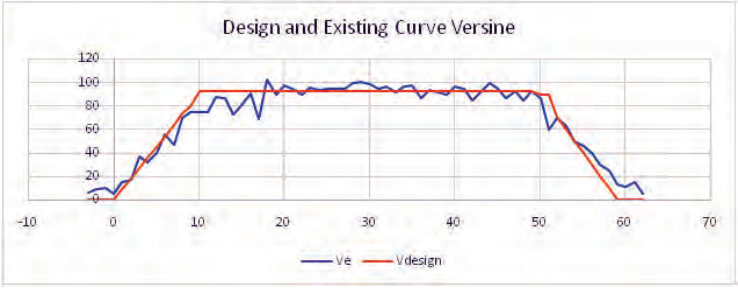
Stn	Ve	Vdesign
-3	6	0
-2	9	0
-1	10	0
0	5	0
1	15	9
2	17	18

Stn	Ve	Vdesign
30	99	93
31	95	93
32	97	93
33	92	93
34	97	93
35	98	93

3	37	27
4	32	36
5	40	45
6	56	54
7	47	64
8	70	74
9	75	80
10	75	93
11	75	93
12	88	93
13	87	93
14	73	93
15	81	93
16	91	93
17	69	93
18	103	93
19	90	93
20	98	93
21	95	93
22	90	93
23	96	93
24	94	93
25	95	93
26	95	93
27	95	93
28	100	93
29	101	93

36	87	93
37	94	93
38	92	93
39	90	93
40	97	93
41	95	93
42	85	93
43	92	93
44	100	93
45	95	93
46	87	93
47	93	93
48	85	93
49	93	93
50	87	90
51	60	90
52	70	71
53	63	60
54	50	50
55	46	40
56	40	30
57	30	20
58	25	10
59	13	0
60	11	0
61	15	0
62	5	0

The Versine diagram of existing and original design curve is also plotted for better appreciation.



Solution:

Initially we should plan to bring the track to original design profile as far as possible and for this go for 3-point design mode tamping. We can use manual method using versine given in RT-3 manual or use ALC in known track geometry mode. For both of this, R and L of the final curve should be well defined for using versine of RT-3 manual or for feeding geometry in ALC. The proposed curve should therefore have near perfect type trapezoid versine diagram.

Option-1 (For achieving original curve by 3-point design mode tamping, with or without ALC)

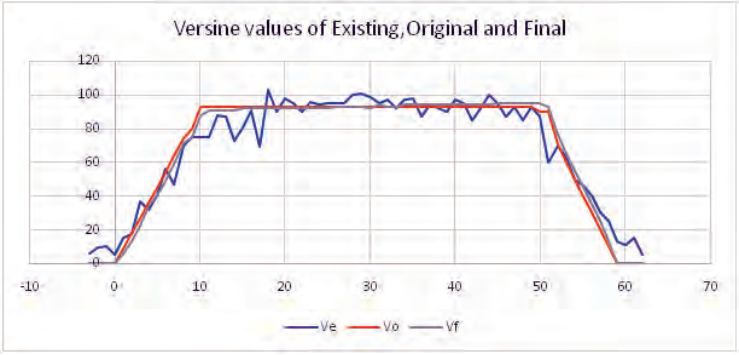
As an preferred correction method, it was decided to first try and bring the track to original alignment and use ALC in known track geometry mode for alignment correction. The ROC calculation done to bring the track close to original alignment is given below:

Stn	Ve	Vo	Vd (Vo-Ve)	FS Vd	SS Vd	C C	FS CC	SS	Vf	Half Slew	Slew
-3	6	0	-6	-6	0	0	0	0	0	0	0
-2	9	0	-9	-15	-6	0	0	0	0	-6	-12
-1	10	0	-10	-25	-21	0	0	0	0	-21	-42
0	5	0	-5	-30	-46	0	0	0	0	-46	-92
1	15	9	-6	-36	-76	-3	-3	0	6	-76	-152
2	17	18	1	-35	-112	-5	-8	-3	13	-115	-230

3	37	27	-10	-45	-147	-5	-13	-11	22	-158	-316
4	32	36	4	-41	-192	-2	-15	-24	34	-216	-432
5	40	45	5	-36	-233	-5	-20	-39	40	-272	-544
6	56	54	-2	-38	-269	-5	-25	-59	49	-328	-656
7	47	64	17	-21	-307	-5	-30	-84	59	-391	-782
8	70	74	4	-17	-328	-3	-33	-114	71	-442	-884
9	75	80	5	-12	-345	-5	-38	-147	75	-492	-984
10	75	93	18	6	-357	-5	-43	-185	88	-542	-1084
11	75	93	18	24	-351	-2	-45	-228	91	-579	-1158
12	88	93	5	29	-327	-2	-47	-273	91	-600	-1200
13	87	93	6	35	-298	-2	-49	-320	91	-618	-1236
14	73	93	20	55	-263	-2	-51	-369	91	-632	-1264
15	81	93	12	67	-208	-1	-52	-420	92	-628	-1256
16	91	93	2	69	-141	-1	-53	-472	92	-613	-1226
17	69	93	24	93	-72	-1	-54	-525	92	-597	-1194
18	103	93	-10	83	21	-1	-55	-579	92	-558	-1116
19	90	93	3	86	104	-1	-56	-634	92	-530	-1060
20	98	93	-5	81	190	-1	-57	-690	92	-500	-1000
21	95	93	-2	79	271	-1	-58	-747	92	-476	-952
22	90	93	3	82	350	-1	-59	-805	92	-455	-910
23	96	93	-3	79	432	-1	-60	-864	92	-432	-864
24	94	93	-1	78	511	-1	-61	-924	92	-413	-826
25	95	93	-2	76	589	-1	-62	-985	92	-396	-792
26	95	93	-2	74	665	0	-62	-1047	93	-382	-764
27	95	93	-2	72	739	0	-62	-1109	93	-370	-740
28	100	93	-7	65	811	0	-62	-1171	93	-360	-720
29	101	93	-8	57	876	0	-62	-1233	93	-357	-714
30	99	93	-6	51	933	-1	-63	-1295	92	-362	-724
31	95	93	-2	49	984	1	-62	-1358	94	-374	-748
32	97	93	-4	45	1033	0	-62	-1420	93	-387	-774
33	92	93	1	46	1078	0	-62	-1482	93	-404	-808
34	97	93	-4	42	1124	1	-61	-1544	94	-420	-840
35	98	93	-5	37	1166	1	-60	-1605	94	-439	-878

36	87	93	6	43	1203	1	-59	-1665	94	-462	-924
37	94	93	-1	42	1246	1	-58	-1724	94	-478	-956
38	92	93	1	43	1288	1	-57	-1782	94	-494	-988
39	90	93	3	46	1331	1	-56	-1839	94	-508	-1016
40	97	93	-4	42	1377	1	-55	-1895	94	-518	-1036
41	95	93	-2	40	1419	1	-54	-1950	94	-531	-1062
42	85	93	8	48	1459	1	-53	-2004	94	-545	-1090
43	92	93	1	49	1507	1	-52	-2057	94	-550	-1100
44	100	93	-7	42	1556	1	-51	-2109	94	-553	-1106
45	95	93	-2	40	1598	2	-49	-2160	95	-562	-1124
46	87	93	6	46	1638	2	-47	-2209	95	-571	-1142
47	93	93	0	46	1684	2	-45	-2256	95	-572	-1144
48	85	93	8	54	1730	2	-43	-2301	95	-571	-1142
49	93	93	0	54	1784	2	-41	-2344	95	-560	-1120
50	87	90	3	57	1838	5	-36	-2385	95	-547	-1094
51	60	90	30	87	1895	3	-33	-2421	93	-526	-1052
52	70	71	1	88	1982	5	-28	-2454	76	-472	-944
53	63	60	-3	85	2070	5	-23	-2482	65	-412	-824
54	50	50	0	85	2155	5	-18	-2505	55	-350	-700
55	46	40	-6	79	2240	5	-13	-2523	45	-283	-566
56	40	30	-10	69	2319	5	-8	-2536	35	-217	-434
57	30	20	-10	59	2388	5	-3	-2544	25	-156	-312
58	25	10	-15	44	2447	3	0	-2547	13	-100	-200
59	13	0	-13	31	2491	0	0	-2547	0	-56	-112
60	11	0	-11	20	2522	0	0	-2547	0	-25	-50
61	15	0	-15	5	2542	0	0	-2547	0	-5	-10
62	5	0	-5	0	2547	0	0	-2547	0	0	0

The versine value as achieved in ROC is close to original recorded versine values as shown in versine diagram



The maximum slew calculated was 1264 mm which is very high and practically difficult to achieve unless sufficient traffic block for multiple round of tamping is given. There can be other curves also closer to original with some reduced slew values, but these slew values would still be very high for attention by machine in one or two round of tamping.

Option-2 (To some other desired perfect circular curve close to existing for reduced slew and for working in 3 point design mode or with ALC in known track geometry mode).

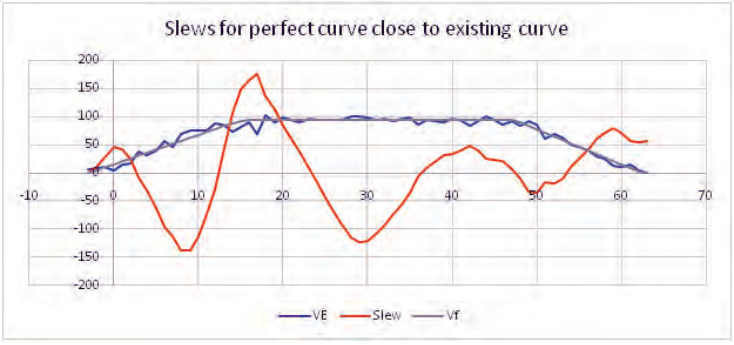
The best possible trapezoidal versine proposed curve (for well defined R and L) was found and minimum slew that could be obtained was 183 mm as given below-

Stn	VE	VP	Ve-Vp	FS diff	SSV diff	CC	FS	SS	Slew	Vf
-3	6	0.9	5.1	5.1	0	0	0	0	0	0.9
-2	9	5.2	3.8	8.9	5.1	0	0	0	10.2	5.2
-1	10	10.4	-0.4	8.5	14	0	0	0	28	10.4
0	5	15.6	-10.6	-2.1	22.5	0	0	0	45	15.6
1	15	20.8	-5.8	-7.9	20.4	0	0	0	40.8	20.8
2	17	26	-9	-16.9	12.5	0	0	0	25	26
3	37	31.2	5.8	-11.1	-4.4	0	0	0	-8.8	31.2
4	32	36.4	-4.4	-15.5	-15.5	0	0	0	-31	36.4
5	40	41.6	-1.6	-17.1	-31	0	0	0	-62	41.6
6	56	46.8	9.2	-7.9	-48.1	0	0	0	-96.2	46.8
7	47	52	-5	-12.9	-56	0	0	0	-112	52
8	70	57.2	12.8	-0.1	-68.9	0	0	0	-137.8	57.2

9	75	62.4	12.6	12.5	-69	0	0	0	-138	62.4
10	75	67.6	7.4	19.9	-56.5	0	0	0	-113	67.6
11	75	72.8	2.2	22.1	-36.6	0	0	0	-73.2	72.8
12	88	78	10	32.1	-14.5	0	0	0	-29	78
13	87	83.2	3.8	35.9	17.6	0	0	0	35.2	83.2
14	73	88.4	-15.4	20.5	53.5	0	0	0	107	88.4
15	81	93	-12	8.5	74	0	0	0	148	93
16	91	94.2	-3.2	5.3	82.5	0	0	0	165	94.2
17	69	94.2	-25.2	-19.9	87.8	0	0	0	175.6	94.2
18	103	94.2	8.8	-11.1	67.9	0	0	0	135.8	94.2
19	90	94.2	-4.2	-15.3	56.8	0	0	0	113.6	94.2
20	98	94.2	3.8	-11.5	41.5	0	0	0	83	94.2
21	95	94.2	0.8	-10.7	30	0	0	0	60	94.2
22	90	94.2	-4.2	-14.9	19.3	0	0	0	38.6	94.2
23	96	94.2	1.8	-13.1	4.4	0	0	0	8.8	94.2
24	94	94.2	-0.2	-13.3	-8.7	0	0	0	-17.4	94.2
25	95	94.2	0.8	-12.5	-22	0	0	0	-44	94.2
26	95	94.2	0.8	-11.7	-34.5	0	0	0	-69	94.2
27	95	94.2	0.8	-10.9	-46.2	0	0	0	-92.4	94.2
28	100	94.2	5.8	-5.1	-57.1	0	0	0	-114.2	94.2
29	101	94.2	6.8	1.7	-62.2	0	0	0	-124.4	94.2
30	99	94.2	4.8	6.5	-60.5	0	0	0	-121	94.2
31	95	94.2	0.8	7.3	-54	0	0	0	-108	94.2
32	97	94.2	2.8	10.1	-46.7	0	0	0	-93.4	94.2
33	92	94.2	-2.2	7.9	-36.6	0	0	0	-73.2	94.2
34	97	94.2	2.8	10.7	-28.7	0	0	0	-57.4	94.2
35	98	94.2	3.8	14.5	-18	0	0	0	-36	94.2
36	87	94.2	-7.2	7.3	-3.5	0	0	0	-7	94.2
37	94	94.2	-0.2	7.1	3.8	0	0	0	7.6	94.2
38	92	94.2	-2.2	4.9	10.9	0	0	0	21.8	94.2
39	90	94.2	-4.2	0.7	15.8	0	0	0	31.6	94.2
40	97	94.2	2.8	3.5	16.5	0	0	0	33	94.2
41	95	94.2	0.8	4.3	20	0	0	0	40	94.2
42	85	94.2	-9.2	-4.9	24.3	0	0	0	48.6	94.2
43	92	94.2	-2.2	-7.1	19.4	0	0	0	38.8	94.2
44	100	94.2	5.8	-1.3	12.3	0	0	0	24.6	94.2
45	95	94.2	0.8	-0.5	11	0	0	0	22	94.2
46	87	94.2	-7.2	-7.7	10.5	0	0	0	21	94.2
47	93	93.6	-0.6	-8.3	2.8	0	0	0	5.6	93.6
48	85	89	-4	-12.3	-5.5	1	1	0	-11	90

49	93	82.8	10.2	-2.1	-17.8	0	1	1	-33.6	82.8
50	87	76.6	10.4	8.3	-19.9	0	1	2	-35.8	76.6
51	60	70.4	-10.4	-2.1	-11.6	0	1	3	-17.2	70.4
52	70	64.2	5.8	3.7	-13.7	0	1	4	-19.4	64.2
53	63	58	5	8.7	-10	0	1	5	-10	58
54	50	51.8	-1.8	6.9	-1.3	0	1	6	9.4	51.8
55	46	45.6	0.4	7.3	5.6	0	1	7	25.2	45.6
56	40	39.4	0.6	7.9	12.9	0	1	8	41.8	39.4
57	30	33.2	-3.2	4.7	20.8	0	1	9	59.6	33.2
58	25	26.9	-1.9	2.8	25.5	0	1	10	71	26.9
59	13	20.7	-7.7	-4.9	28.3	0	1	11	78.6	20.7
60	11	14.5	-3.5	-8.4	23.4	0	1	12	70.8	14.5
61	15	8.3	6.7	-1.7	15	0	1	13	56	8.3
62	5	2.4	2.6	0.9	13.3	-1	0	14	54.6	1.4

The versine diagram and slews for this curve is



The maximum slew could be reduced to 175.6 mm, but still it is very high for getting achieved in single round of tamping.

Both option 1 and 2 is possible to be achieved if sufficient block is available. Ideally we should try to realign the curve in stages to bring it to perfect geometry i.e. perfect trapezoidal versine as given below-

- 1st tamping in 4-point smoothening mode.
- Measure the versine again and go for revised ROC calculation. Fd value should reduce further.
- 2nd tamping in 3 point design mode or 4 point design mode

by keeping maximum Fd as 50 -60 mm. Versine for 3 point and versine correction for 4 point lining to be calculated for revised R and L achieved in revised ROC above.

- Measure the versine again and go for revised ROC calculation. Fd value should reduce further.
- 3rd and subsequent tamping in 3 point design mode or 4 point design mode to continue keeping maximum Fd as 50 -60 mm as above and also taking R and L after each ROC as per new proposed curve .
- When in ROC, Fd finally reduces to less than 70 mm, go for 3-point design mode tamping as final tamping.

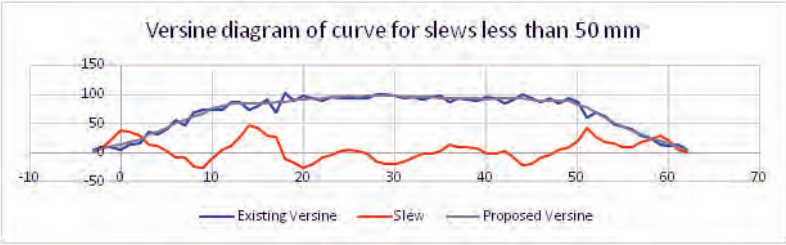
This will however require checking all infringements and other obligatory points also as total slew is large.

Option-3 (Obtaining average curve for keeping slew less than 50 mm)

For achieving a curve in single round of tamping, the slew needs to be restricted to 50 mm. Accordingly ROC was done using available softwares and the curve obtained was

SN	Existing Versine	Slew	Proposed Versine		SN	Existing Versine	Slew	Proposed Versine
-3	6	0	1.5		30	99	-19	97
-2	9	9	6.5		31	95	-14	95
-1	10	23	10		32	97	-9	96
0	5	37	13		33	92	-2	95
1	15	35	17		34	97	-1	96
2	17	29	22		35	98	2	94
3	37	13	30		36	87	13	94
4	32	11	35		37	94	10	93
5	40	3	41.5		38	92	9	92.5
6	56	-8	50.5		39	90	7	93.5
7	47	-8	55		40	97	-2	92
8	70	-24	62.5		41	95	-1	93.5

9	75	-25	67.5		42	85	3	92.5
10	75	-11	74.5		43	92	-8	93
11	75	4	79		44	100	-21	92.5
12	88	11	84		45	95	-19	91
13	87	26	84.5		46	87	-9	90
14	73	46	85		47	93	-5	90
15	81	42	85.5		48	85	5	88.5
16	91	29	85.5		49	93	8	88.5
17	69	27	87		50	87	20	82.5
18	103	-11	87.5		51	60	41	77.5
19	90	-18	90.5		52	70	27	68
20	98	-26	90.5		53	63	17	59
21	95	-19	93		54	50	15	51.5
22	90	-8	93.5		55	46	10	43.5
23	96	-4	95		56	40	10	36.5
24	94	2	96		57	30	17	31
25	95	4	97		58	25	22	24.5
26	95	2	96.5		59	13	28	20
27	95	-3	98		60	11	20	15
28	100	-14	97.5		61	15	4	9
29	101	-20	97.5		62	5	0	3



Rmin=510m, Rmax= 591.1 m, Ravg=540 m (Avg Versine is 92.585 mm)

The result averages out the existing versine, keeping slews within 46 mm. If we try to go for design mode of tamping using 3 point

design mode, we need defined R and L for getting versine values i.e H, Hx, Hy, Hz, Hw etc for the curve to be achieved. Similarly for 4 point design mode also R and L will be required for Versine correction in transition portion.

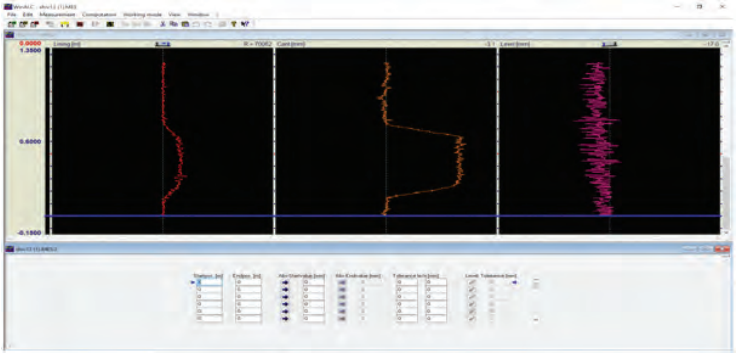
Since R is not constant and L is not very well defined, normally we go for approximation i.e R avg and L close to what we get from versine diagram. Because of this, the curve achieved will not be exactly as obtained in ROC.

In such situation where, R is nor well defined, it is better to go for 4 point design mode using average radius and approx. TL as obtained for final curve proposed.

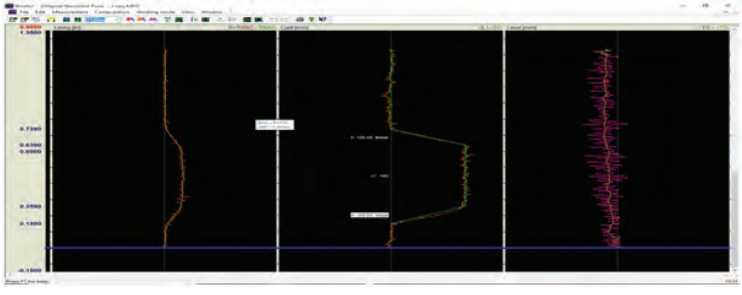
However if we have ALC, it is even better to go for unknown track geometry mode using measuring run facility of the ALC.

Option -4 (Using ALC in Measuring Run Mode)

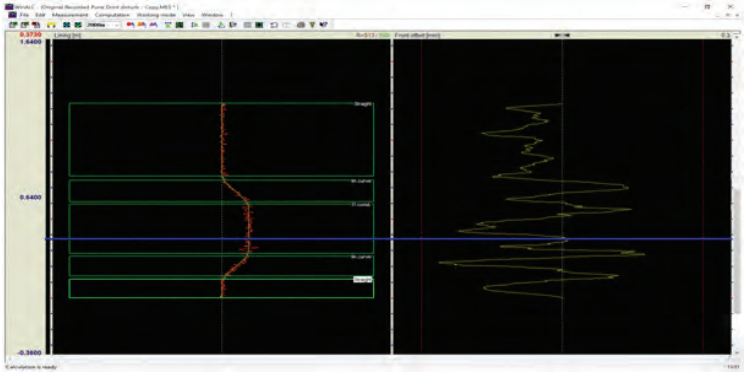
The curve was measured by ALC . No obligatory points were reported at site. The measured curve ALC is given below



After computation, the suggested curve is as below-



In alignment correction suggested, the versine is continuously changing even in circular portion i.e. radius is not constant in circular portion (varying between 515 to 600m around). To achieve a better curve we can go for constant area selection and revise our calculations as below-



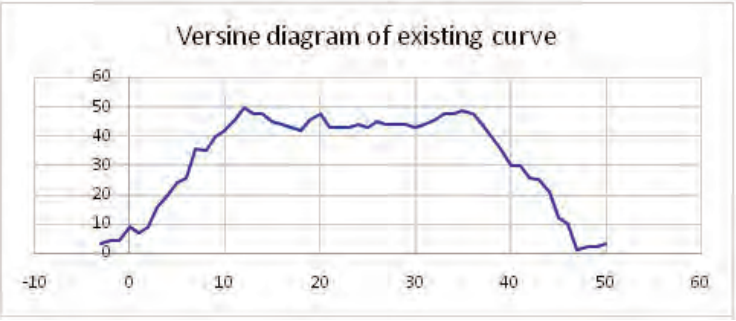
By choosing proper constant area, the circular curve constant Radius of 550 m obtained. The curve obtained after tamping should give the curve as shown after selecting constant area.

So in the above situation, using ALC in measuring run mode gives the best result.

12.3 Field Problem-2

A curve is required to be realigned. The existing versine as measured is tabulated below. The original curve data is not known.

Station	Ve		Station	Ve
-3	3		24	44
-2	4		25	43
-1	4		26	45
0	9		27	44
1	7		28	44
2	9		29	44
3	16		30	43
4	20		31	44
5	24		32	46
6	26		33	48
7	36		34	48
8	35		35	49
9	40		36	48
10	42		37	44
11	45		38	40
12	50		39	36
13	48		40	30
14	48		41	30
15	45		42	26
16	44		43	25
17	43		44	21
18	42		45	12
19	46		46	10
20	48		47	1
21	43		48	2
22	43		49	2
23	43		50	3

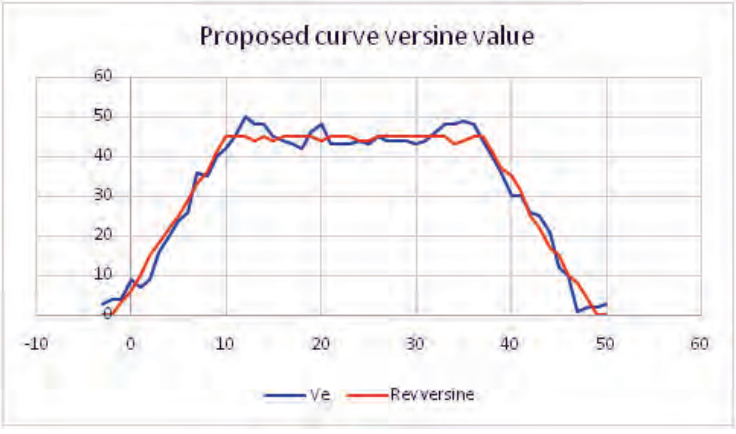


Solution

The Curve is planned to be corrected in 3 Point design mode. Accordingly ROC for getting a close to perfect curve is done and the result is given below

Station	Vp	Ve	Vp	Vd	FS Vd	SS Vd	Cc	FS cc	SS Cc	Half slew	Slew	Rev versine
-3	0	3	0	-3	-3	0	0	0	0	0	0	0
-2	0	4	0	-4	-7	-3	0	0	0	-3	-6	0
-1	0	4	3	-1	-8	-10	0	0	0	-10	-20	3
0	0	9	7	-2	-10	-18	-1	-1	0	-18	-36	6
1	4	7	10	3	-7	-28	0	-1	-1	-29	-58	10
2	8	9	15	6	-1	-35	0	-1	-2	-37	-74	15
3	12	16	18	2	1	-36	0	-1	-3	-39	-78	18
4	16	20	22	2	3	-35	0	-1	-4	-39	-78	22
5	20	24	25	1	4	-32	0	-1	-5	-37	-74	25
6	24	26	29	3	7	-28	0	-1	-6	-34	-68	29
7	28	36	33	-3	4	-21	0	-1	-7	-28	-56	33
8	32	35	36	1	5	-17	0	-1	-8	-25	-50	36
9	36	40	41	1	6	-12	0	-1	-9	-21	-42	41
10	40	42	45	3	9	-6	0	-1	-10	-16	-32	45
11	43	45	45	0	9	3	0	-1	-11	-8	-16	45
12	43	50	45	-5	4	12	0	-1	-12	0	0	45
13	43	48	44	-4	0	16	0	-1	-13	3	6	44
14	43	48	45	-3	-3	16	0	-1	-14	2	4	45
15	43	45	44	-1	-4	13	0	-1	-15	-2	-4	44
16	43	44	45	1	-3	9	0	-1	-16	-7	-14	45

17	43	43	45	2	-1	6	0	-1	-17	-11	-22	45
18	43	42	45	3	2	5	0	-1	-18	-13	-26	45
19	43	46	45	-1	1	7	0	-1	-19	-12	-24	45
20	43	48	45	-3	-2	8	-1	-2	-20	-12	-24	44
21	43	43	45	2	0	6	0	-2	-22	-16	-32	45
22	43	43	45	2	2	6	0	-2	-24	-18	-36	45
23	43	43	45	2	4	8	0	-2	-26	-18	-36	45
24	43	44	44	0	4	12	0	-2	-28	-16	-32	44
25	43	43	44	1	5	16	0	-2	-30	-14	-28	44
26	43	45	45	0	5	21	0	-2	-32	-11	-22	45
27	43	44	44	0	5	26	1	-1	-34	-8	-16	45
28	43	44	45	1	6	31	0	-1	-35	-4	-8	45
29	43	44	45	1	7	37	0	-1	-36	1	2	45
30	43	43	45	2	9	44	0	-1	-37	7	14	45
31	43	44	45	1	10	53	0	-1	-38	15	30	45
32	43	46	45	-1	9	63	0	-1	-39	24	48	45
33	43	48	45	-3	6	72	0	-1	-40	32	64	45
34	43	48	44	-4	2	78	-1	-2	-41	37	74	43
35	43	49	44	-5	-3	80	0	-2	-43	37	74	44
36	43	48	45	-3	-6	77	0	-2	-45	32	64	45
37	40	44	45	1	-5	71	0	-2	-47	24	48	45
38	36	40	41	1	-4	66	0	-2	-49	17	34	41
39	32	36	37	1	-3	62	0	-2	-51	11	22	37
40	28	30	35	5	2	59	0	-2	-53	6	12	35
41	24	30	30	0	2	61	1	-1	-55	6	12	31
42	20	26	25	-1	1	63	0	-1	-56	7	14	25
43	16	25	22	-3	-2	64	0	-1	-57	7	14	22
44	12	21	17	-4	-6	62	0	-1	-58	4	8	17
45	8	12	14	2	-4	56	1	0	-59	-3	-6	15
46	4	10	10	0	-4	52	0	0	-59	-7	-14	10
47	0	1	8	7	3	48	0	0	-59	-11	-22	8
48	0	2	4	2	5	51	0	0	-59	-8	-16	4
49	0	2	0	-2	3	56	0	0	-59	-3	-6	0
50	0	3	0	-3	0	59	0	0	-59	0	0	0



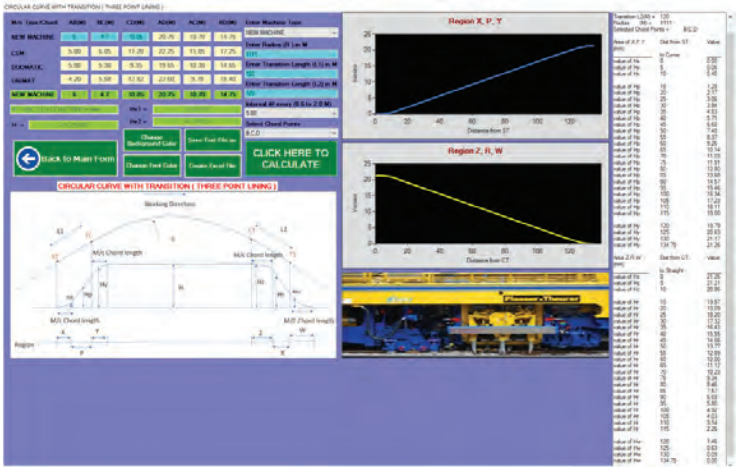
The proposed curve is almost perfect and the curve parameters are

R=1111

L1=L2=120 m

Maxm slew is 78 mm.

3-Point lining can comfortably be resorted to get good curve. For getting the versines (H,Hx,Hy,Hz and Hw etc), either RT-3 manual or IRICEN Software can be resorted to get versine value to be written on sleepers. In this case it is calculated at every 5m using IRICEN software.



The vaues to be written from ST to machine chord length beyond TC (i.e. Hx, Hp, Hy) and also from CT to Machine chord length beyond TS (i.eHz, Hr, Hw) is tabulated below as obtained from software

CURVE WITH PARABOLIC TRANSITION								
SELECTED MACHINE = NEW MACHINE, RADIUS(M) = 1111 , Transition L1(M) = 120, Transition L2(M) = 120, SELECTED CHORD PTS.= B, C, D								
Dist. from ST (M)	**VALUE (mm) in X, P, Y**		**Dist. from CT (M)**	**VALUE (mm) in Z, R, W**				
0	0		0	21.26				
5	0.05		5	21.21				
10	0.4		10	20.86				
15	1.28		15	19.97				
20	2.17		20	19.09				
25	3.06		25	18.2				
30	3.94		30	17.32				
35	4.83		35	16.43				
40	5.71		40	15.55				
45	6.6		45	14.66				
50	7.48		50	13.77				

55	8.37		55	12.89					
60	9.26		60	12					
65	10.14		65	11.12					
70	11.03		70	10.23					
75	11.91		75	9.34					
80	12.8		80	8.46					
85	13.68		85	7.57					
90	14.57		90	6.69					
95	15.46		95	5.8					
100	16.34		100	4.92					
105	17.23		105	4.03					
110	18.11		110	3.14					
115	19		115	2.26					
120	19.79		120	1.46					
125	20.63		125	0.63					
130	21.17		130	0.09					

For circular portion from machine chord length beyond TC to CT, versine for machine chord length is 21.26 mm.

For alignment correction in design mode, Fd from ROC and Versine from softwrae should be written on sleepers in format as given below- (The same can be obtained by using IRICEN software "Curve Designing, Existing Speed, Increasing Speed, Realignment and Tamping Machine Data" uploaded at IRICEN website.)

Curve distance	Station	Fd	Versine	Remark
From ST	-3	0	0	
	Mid of stations	-3	0	
0	-2	-6	0	ST
5	Mid of stations	-13	0.05	
10	-1	-20	0.4	
15	Mid of stations	-28	1.28	
20	0	-36	2.17	

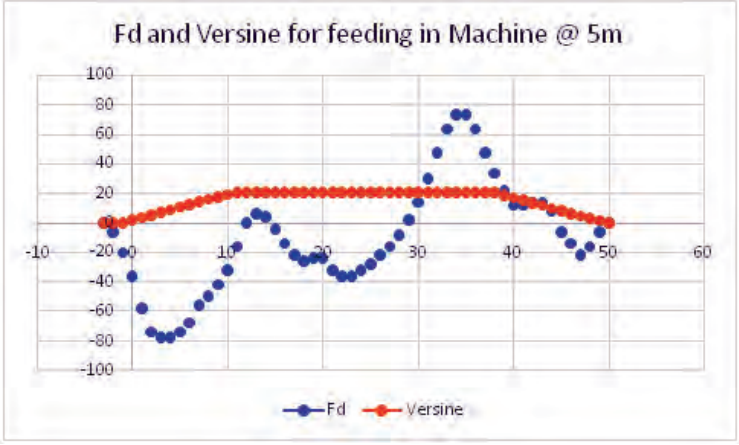
25	Mid of stations	-47	3.06	
30	1	-58	3.94	
35	Mid of stations	-66	4.83	
40	2	-74	5.71	
45	Mid of stations	-76	6.6	
50	3	-78	7.48	
55	Mid of stations	-78	8.37	
60	4	-78	9.26	
65	Mid of stations	-76	10.14	
70	5	-74	11.03	
75	Mid of stations	-71	11.91	
80	6	-68	12.8	
85	Mid of stations	-62	13.68	
90	7	-56	14.57	
95	Mid of stations	-53	15.46	
100	8	-50	16.34	
105	Mid of stations	-46	17.23	
110	9	-42	18.11	
115	Mid of stations	-37	19	
120	10	-32	19.79	TC
125	Mid of stations	-24	20.63	
130	11	-16	21.17	
135	Mid of stations	-8	21.26	
CIRCULAR PORTION	12	0	21.26	
	Mid of stations	3	21.26	
	13	6	21.26	
	Mid of stations	5	21.26	
	14	4	21.26	
	Mid of stations	0	21.26	
	15	-4	21.26	
	Mid of stations	-9	21.26	
	16	-14	21.26	
	Mid of stations	-18	21.26	

	17	-22	21.26	
	Mid of stations	-24	21.26	
	18	-26	21.26	
	Mid of stations	-25	21.26	
	19	-24	21.26	
	Mid of stations	-24	21.26	
	20	-24	21.26	
	Mid of stations	-28	21.26	
	21	-32	21.26	
	Mid of stations	-34	21.26	
	22	-36	21.26	
	Mid of stations	-36	21.26	
	23	-36	21.26	
	Mid of stations	-34	21.26	
	24	-32	21.26	
	Mid of stations	-30	21.26	
CIRCULAR PORTION	25	-28	21.26	
	Mid of stations	-25	21.26	
	26	-22	21.26	
	Mid of stations	-19	21.26	
	27	-16	21.26	
	Mid of stations	-12	21.26	
	28	-8	21.26	
	Mid of stations	-3	21.26	
	29	2	21.26	
	Mid of stations	7	21.26	
	30	14	21.26	
	Mid of stations	22	21.26	
	31	30	21.26	
	Mid of stations	39	21.26	
	32	48	21.26	
	Mid of stations	56	21.26	
	33	64	21.26	

CIRCULAR PORTION	Mid of stations	69	21.26	
	34	74	21.26	
	Mid of stations	74	21.26	
	35	74	21.26	
	Mid of stations	69	21.26	
	36	64	21.26	
Distance from CT	Mid of stations	56	21.26	
0	37	48	21.26	CT
5	Mid of stations	41	21.21	
10	38	34	20.86	
15	Mid of stations	28	19.97	
20	39	22	19.09	
25	Mid of stations	17	18.2	
30	40	12	17.32	
35	Mid of stations	12	16.43	
40	41	12	15.55	
45	Mid of stations	13	14.66	
50	42	14	13.77	
55	Mid of stations	14	12.89	
60	43	14	12	
65	Mid of stations	11	11.12	
70	44	8	10.23	
75	Mid of stations	1	9.34	
80	45	-6	8.46	
85	Mid of stations	-10	7.57	
90	46	-14	6.69	
95	Mid of stations	-18	5.8	
100	47	-22	4.92	
105	Mid of stations	-19	4.03	
110	48	-16	3.14	
115	Mid of stations	-11	2.26	
120	49	-6	1.46	TS
125	Mid of stations	-3	0.63	

130	50	0	0.09	

Mid of station value of Fd is interpolated from adjacent station value



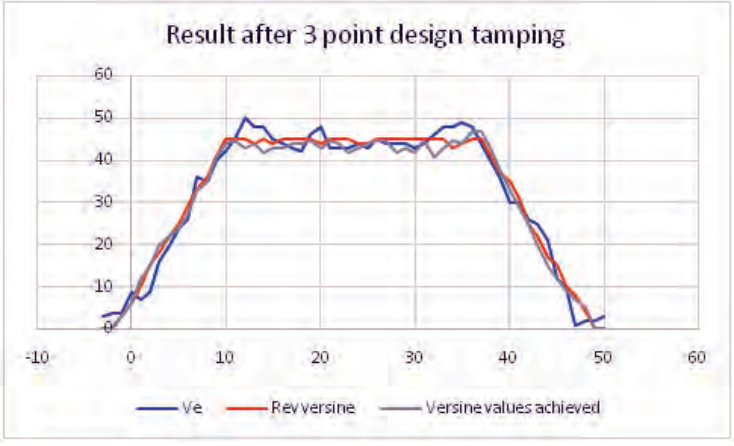
The curve was attended with a different machine (different BCD) using same method.

The resultant curve obtained was

Station	Ve	Rev versine	Slew	Vachieved
-3	3	0	0	0
-2	4	0	-6	0
-1	4	3	-20	3
0	9	6	-36	6
1	7	10	-58	12
2	9	15	-74	15
3	16	18	-78	20
4	20	22	-78	22
5	24	25	-74	24
6	26	29	-68	27
7	36	33	-56	33
8	35	36	-50	35
9	40	41	-42	41

10	42	45	-32	44
11	45	45	-16	45
12	50	45	0	43
13	48	44	6	44
14	48	45	4	42
15	45	44	-4	43
16	44	45	-14	43
17	43	45	-22	44
18	42	45	-26	44
19	46	45	-24	45
20	48	44	-24	43
21	43	45	-32	45
22	43	45	-36	44
23	43	45	-36	42
24	44	44	-32	43
25	43	44	-28	44
26	45	45	-22	45
27	44	45	-16	45
28	44	45	-8	42
29	44	45	2	43
30	43	45	14	42
31	44	45	30	45
32	46	45	48	41
33	48	45	64	43
34	48	43	74	45
35	49	44	74	44
36	48	45	64	47
37	44	45	48	47
38	40	41	34	43
39	36	37	22	38
40	30	35	12	33

41	30	31	12	29
42	26	25	14	25
43	25	22	14	20
44	21	17	8	15
45	12	15	-6	12
46	10	10	-14	9
47	1	8	-22	7
48	2	4	-16	5
49	2	0	-6	0
50	3	0	0	0



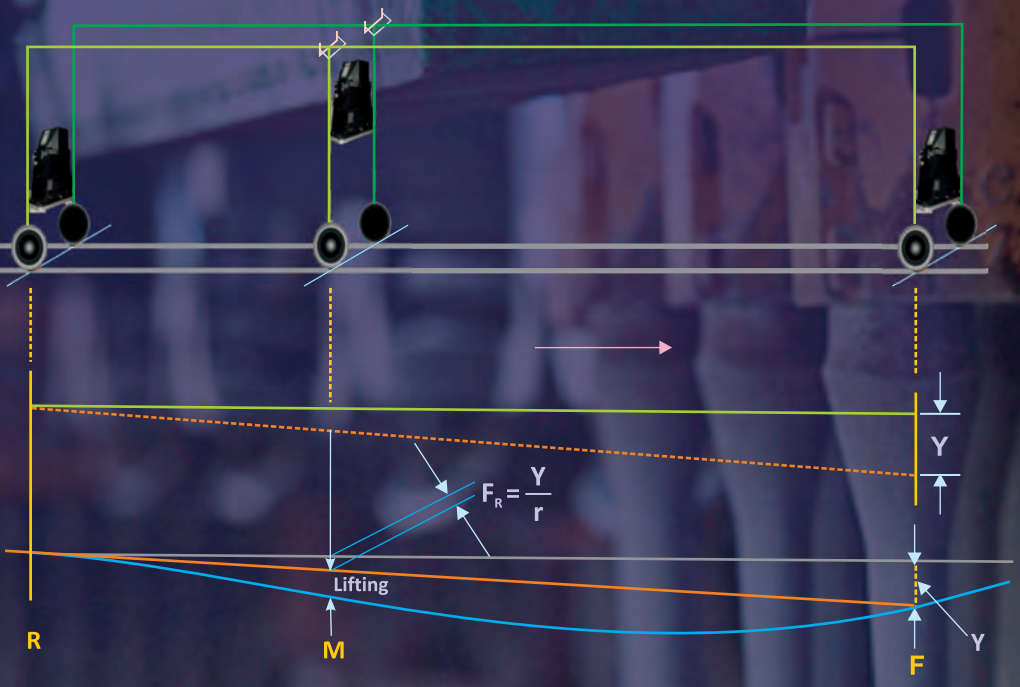
Thus the desired curve as proposed via ROC has been almost achieved.

■ ■ ■

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