

## **SUB: – WORKING PRINCIPLE**

**Lesson-I : Lining Session-56:** Principle of Lining, Single chord system, Type of lining i.e. 4 Point & 3 Point lining.

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### **PRINCIPLE OF LINING:**

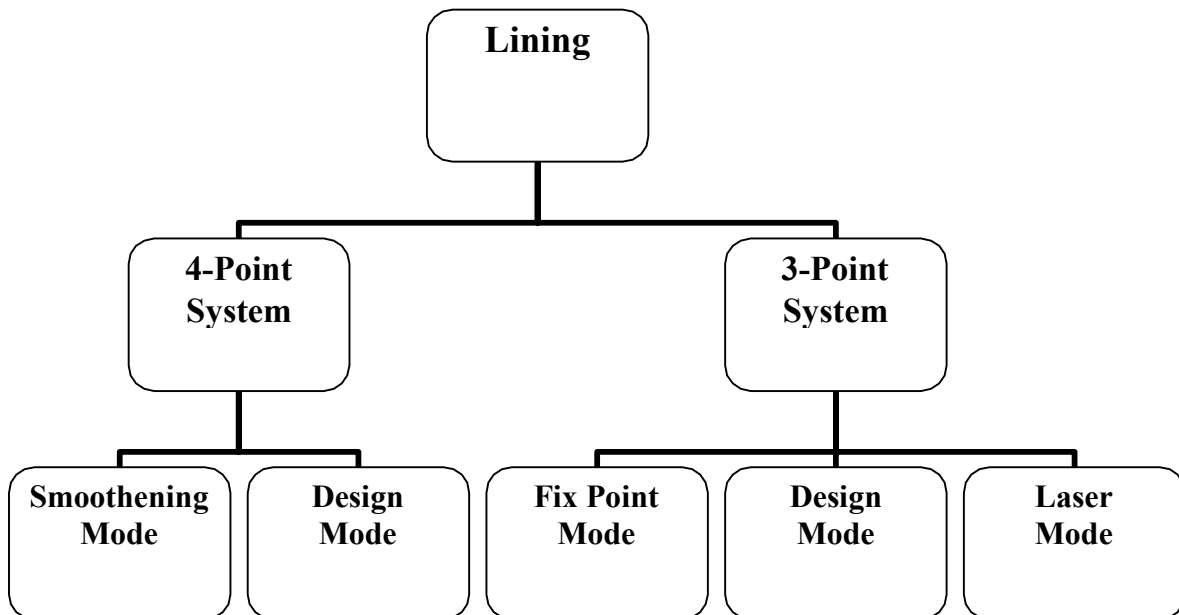
- Machine measures only one rail and rectify that rail i.e. datum rail.
- Other rail is fixed with the sleeper hence that is also rectified.
- If there is a gauge problem that will remain there.
- During alignment machine corrects versine.
- The versine of straight track is zero and
- Versine on curved track depends on radius of curves, measuring chord length and measurement method.

### **SINGLE CHORD SYSTEM:**

On UT machine double chord lining system was used. In this system, two chords i.e. long chords and short chords was used for measuring the versine. But in single chord lining system, one chord is used to measure the versine. This system is used in all machine except UT.

### **TYPE OF LINING:**

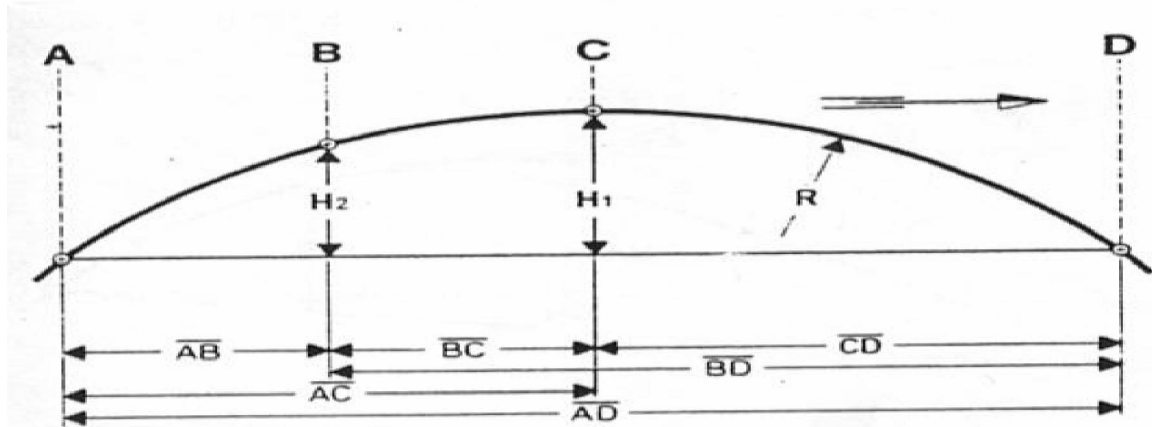
In single chord system there are two methods of lining.



### FOUR POINT LINING SYSTEM:

#### • GEOMETRICAL PRINCIPLE OF 4 - POINT LINING SYSTEM:

- In a circular curve, two Versines of a chord are related in a ratio, depending on the measuring point distance. This Versine ratio is independent of the radius of the circular curve and is always constant. It is also valid for a straight, which may be considered as a curve with infinite radius. In 4 - point lining system, the track is measured at 4 points (A, B, C & D) and Versines at two points are compared (B & C) to control the lining. The existing errors are reduced or eliminated by means of the Hydraulic Lining System.



From the above figure,

$$\text{Existing Versine } H_1 = \frac{AC \times CD}{2R}$$

$$\text{Theoretical Versine } H_2 = \frac{AB \times BD}{2R}$$

$$\text{Versine Ratio } i = \frac{H_1}{H_2} = \frac{AC \times CD}{AB \times BD}$$

$$H_1 = i \times H_2$$

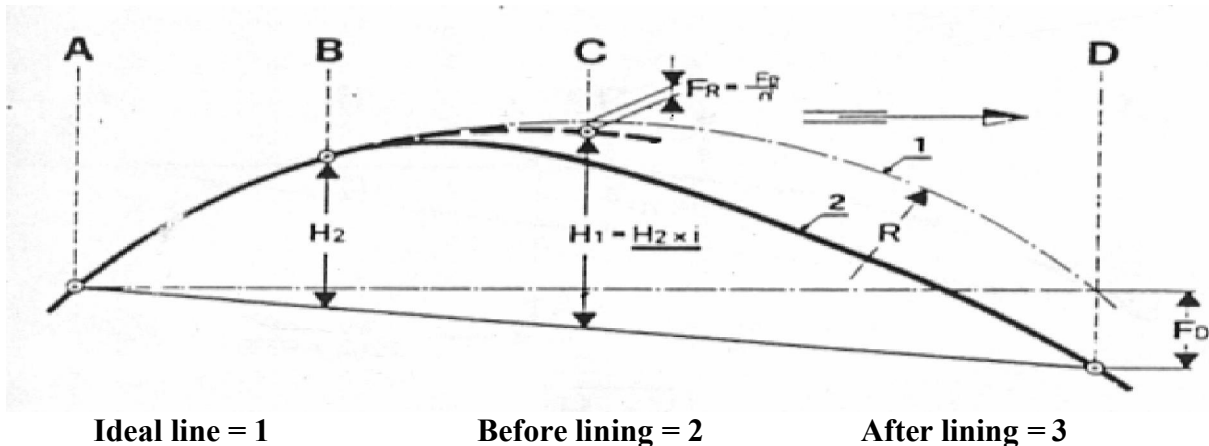
- Hence, lining is done at Point C until Versine  $H_1$  is in the correct ratio to  $H_2$  ( $H_1 = i \times H_2$ ) at Point B. **Versine Ratio 'i value' for different machines, is as under:**

| <u>Machine</u>          | <u>i Value</u> |
|-------------------------|----------------|
| • 08-UNO-DUO            | = 1.33         |
| • 08-275 UNIMAT         | = 1.35897      |
| • 08-275-3S             | = 1.62241      |
| • MP-2000               | = 1.395122     |
| • WST                   | = 1.3292       |
| • 09-32 CSM             | = 1.2157       |
| • 09-3X TAMPING EXPRESS | = 1.507        |

- The points A & B always remain on the corrected track and the Versine  $H_2$  at Point B represents the measuring base. Point D always remains on the disturbed track. Lining is done at Point C.  $H_2$  and  $H_1$  are separately measured by measuring and lining bogies of the machine, respectively.  $H_2$  is fed in PCB where it is multiplied with constant  $i$  and becomes " $H_2 \times i$ ". Thus  $H_2 \times i$  and  $H_1$  are then fed in difference amplifier and if the alignment is OK both will be equal and reading on the dial will indicate zero. If alignment is not OK, the difference of the two will be indicated on the dial as well as the current will flow to lining solenoids, the alignment will be corrected till both  $H_2 \times i$  and  $H_1$  are equal or the ratio  $H_1 / H_2 = i$ , is maintained. **The schematic diagram is as under:**

$$\begin{array}{ccccc}
 \text{ERROR} = & \text{THEORATICAL VERSINE (H}_2\text{)} & \sim & \text{EXISTING VERSINE (H}_1\text{)} & \\
 \uparrow & & \uparrow & & \uparrow \\
 \text{CALCULATED BY PCB} & \text{MEASURING TRANSDUCER} & & \text{LINING TRANSDUCER} & 
 \end{array}$$

• **ERROR REDUCTION ACCORDING TO THE 4 - POINT LINING SYSTEM:**



- In the above figure, Points A & B are on the already lined track behind the machine. The front end of the chord, Point D is on the disturbed position with lining error  $F_D$ , resulting in new Versine  $H_2$ . Point C is now lined until  $H_1$  is in the correct ratio to  $H_2$ . Depending on the measuring point distances (**Error reduction ratio 'n'**), an error remains at lining Point C, which is called **Left over error or Residual error 'F<sub>R</sub>'**.

$$\text{Error reducing ratio, } n = \frac{AD \times BD}{AC \times BC}$$

$$\text{Left over error } F_R = F_D / n$$

$$\text{For 08-Machine } F_R = F_D / 6 \quad n = (20 \times 15) / (10 \times 5) = 6$$

- **n depends on Bogie distances, which is as under for different machines:**

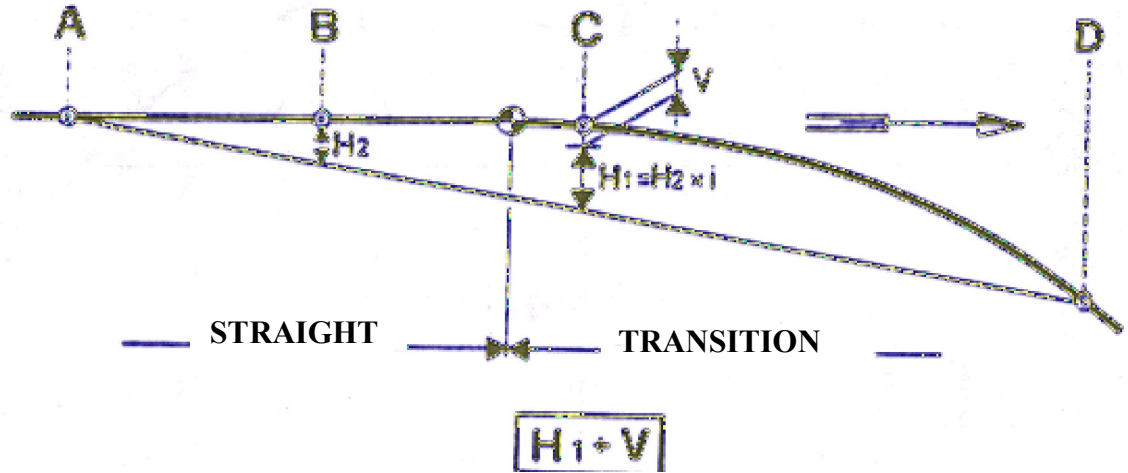
| <u>Machine</u>        | <u>n - value</u> |
|-----------------------|------------------|
| 08-UNO/DUO            | = 6              |
| 08-275 UNIMAT         | = 6.42720        |
| 08-275 UNIMAT         | = 7.61997        |
| 08-32 WST             | = 5.7411         |
| 9-32 CSM              | = 6.27692        |
| 09-3X TAMPING EXPRESS | = 6.47           |

- This error reduction ratio is valid under the presumption that the Points A and B are on the perfect alignment. Proceeding with further lining, points A and B are positioned at the remaining errors and determine therefore a new base for the following measuring and lining operation. These errors are reduced and adapted to another which results in a considerable improvement of the alignment.

## SUB: – WORKING PRINCIPLE

**Lesson-I :Lining Session-58:**Calculation of  $V_m$  value on Transition Curve, Direction of Toggle switch.

**VERSINE COMPENSATION VALUE ( $V_m$ ) FOR VARIABLE VERSINE:**The constant Versine ratio is only valid for tracks with the constant curvature e.g. circular curve, straight. But when there is change in curvature (variable Versine), the Versine ratio is adapted to the curvature by input of correction values called Versine Compensation ( $V$ ) values. Generally, the  $V$  values are fed manually to the Versine Potentiometer in the front tower. With the provision of GVA/ALC,  $V$  values are calculated automatically and fed in the Lining system. The cut off zero point of the Versine  $H_1$  is corrected accordingly. As an example, let us



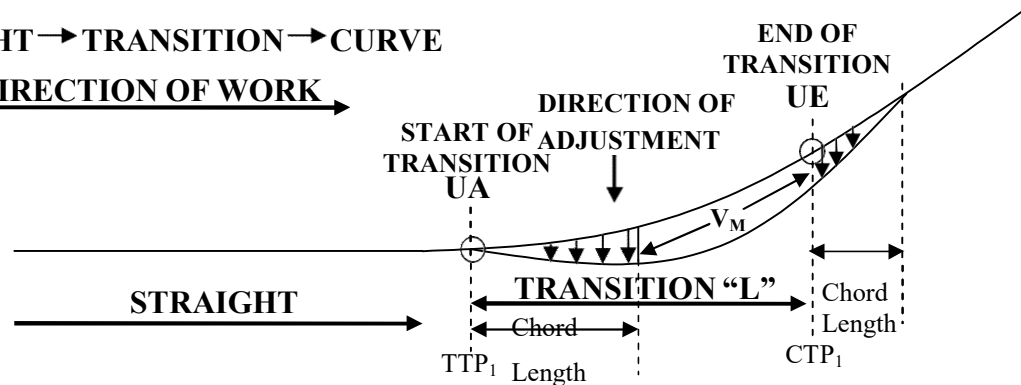
consider a case of the

machine entering from straight to transition.

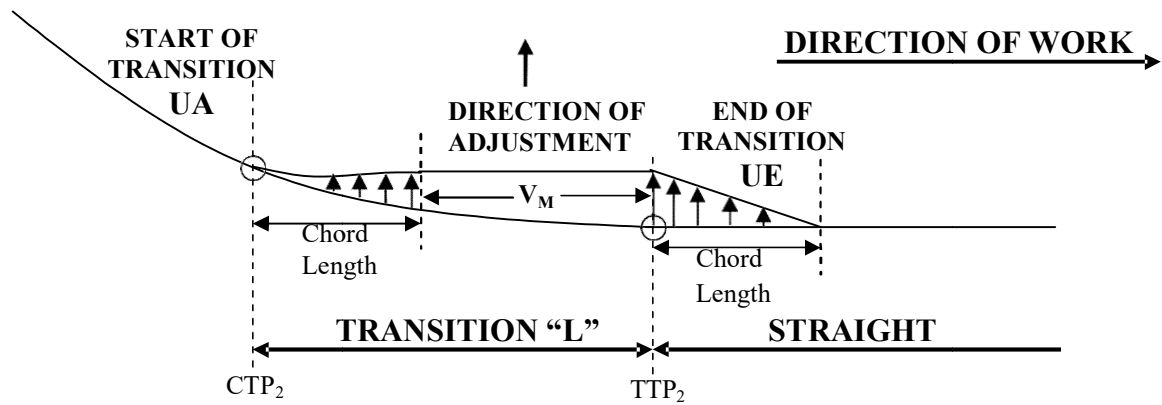
In the position of the machine shown in the above figure, Machine measures the Versine  $H_2$  at the measuring bogie and the Versine  $H_1$  at the lining bogie. Had the machine been on a circular curve the relationship  $H_1 = i \times H_2$  would have been true, but because of the changing curvature, we actually have  $H_1 = i \times H_2 \pm V$ . Therefore, even though the curvature of the transition is true the machine still experiences an error  $V$ . Therefore, we have to apply some adjustment at the lining bogie to compensate for  $V$ . **The procedure of applying  $V$  values and direction of toggle switch for different situations is given below:**

**STRAIGHT → TRANSITION → CURVE**

**DIRECTION OF WORK** →



## CURVE → TRANSITION → STRAIGHT



### DIRECTION OF TOGGLE SWITCH:

IF MACHINE IS INTERING:

- (i) High radius to low radius = outside
- (ii) Low radius to high radius = inside

**CALCULATION OF V<sub>M</sub> VALUE ON REVERSE CURVE:**

For the reverse curve or compound curve the value of V is decided as under:

Say R<sub>1</sub> & R<sub>2</sub> are the radius of the two curves and V<sub>1</sub> & V<sub>2</sub> are the corresponding adjustment for the individual curve (page no. 4 & 5)

1. If the R<sub>1</sub> is bigger than R<sub>2</sub>, the net adjustment, V<sub>0</sub> will be  $V_0 = V_2 - V_1$  or  $V_{0m} = V_{2m} - V_{1m}$ ,
2. The applicable of adjustment will start as soon as the front tightening starts entering the transition.

- **Calculation of V<sub>m</sub>**

- Readymade tables are given on each machine.
- V<sub>m</sub> value may be calculated by following formula:

$$V_m = \text{Constant Value} / (\text{Radius} \times \text{Transition Length})$$

- Constant value depends on Machine Chord length as under:

| <u>Machine</u> | <u>Constant value</u> |
|----------------|-----------------------|
| 08-UNO/DUO     | 83000                 |
| CSM            | 82485                 |
| UNIMAT 2S      | 88333                 |
| UNIMAT 3S      | 116603                |
| WST            | 84000                 |

- **Direction of Compensation**

- Toggle switch is given in front cabin to decide compensation direction as under:

**High radius to low radius = Toggle switch outside +ve**

**Low radius to high radius = Toggle switch inside –ve**

This during coko king 1/6 of the error will be left and therefore it is called smoothening lining of some procedure is available with which it is possible to give exact location of various points like beginning & end of transition and amount of fault at a particular location established with some permanent works these, by shifting front and f the chord by the amount of fault. We can achieve exact alignment. But in the field it is difficult to obtain correct reference marks as such generally smoothing system is adopted which is fairly accurate for smooth running of trains.

If we are tamping constructed line we can always, lay a parallel reference line from which difference can be calculated for feeding into the machine to achieve exact alignment.

**NON-SUITABILITY OF 4-POINT LINING ON STRAIGHT:**

On Straight Track H<sub>2</sub> is zero hence machine corrects versine at C with respect to H<sub>2</sub> as

$$H_1 = 1.33 \times 0 = 0$$

If at any point F<sub>D</sub> = 12mm

then FR = F<sub>D</sub>/6 i.e. 12/6 = 2mm.

On next sleepers H<sub>2</sub> = 2mm

$$H_1 = 1.33 \times 2 = 2.66\text{m}$$

again H<sub>2</sub> = 2.66mm\

$$\text{then } H_1 = 1.33 \times 2.66 = 3.53$$

As per above calculation if machine is leaving any error that will again accumulates. Hence machine forms a false curve. Therefore 4 point is not suitable for straight track.

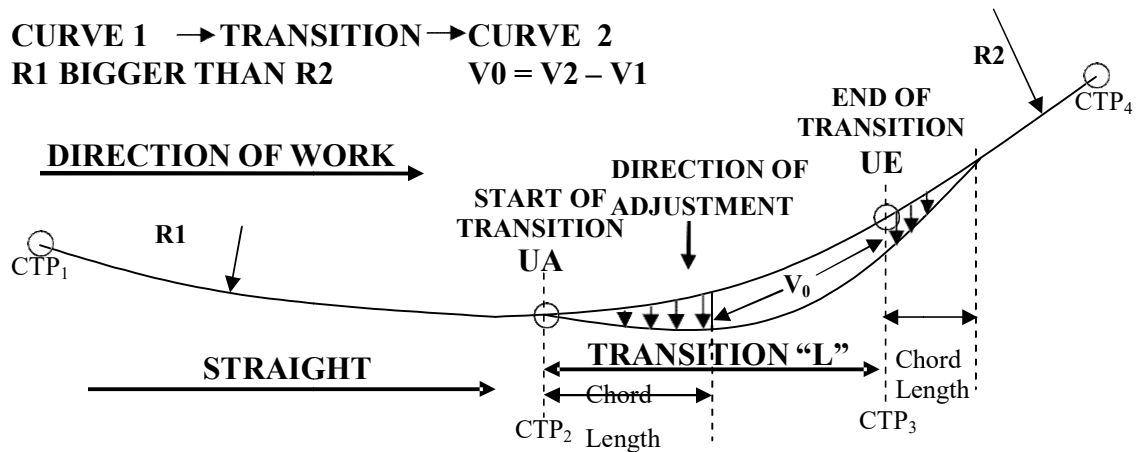
**SUB: – WORKING PRINCIPLE**

**Lesson-I :Lining**

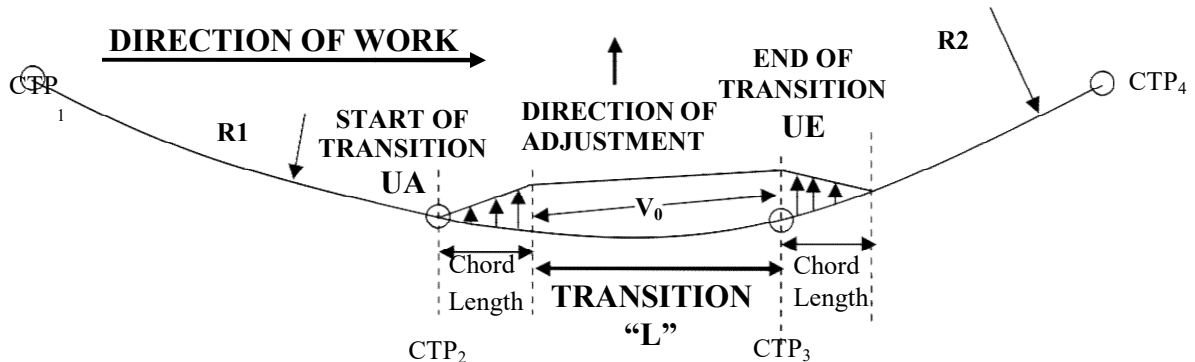
**Session-60:** Feeding method of  $V_m$  value at Reverse and Compound curve.

**FEEDING METHOD OF  $V_M$  VALUE AT REVERSE AND COMPOUND CURVE:**

**CURVE 1 → TRANSITION → CURVE 2**  
 **$R_1$  BIGGER THAN  $R_2$**        **$V_0 = V_2 - V_1$**



**CURVE 1 → TRANSITION → CURVE 2**  
 **$R_1$  SMALLER THAN  $R_2$**        **$V_0 = V_1 - V_2$**



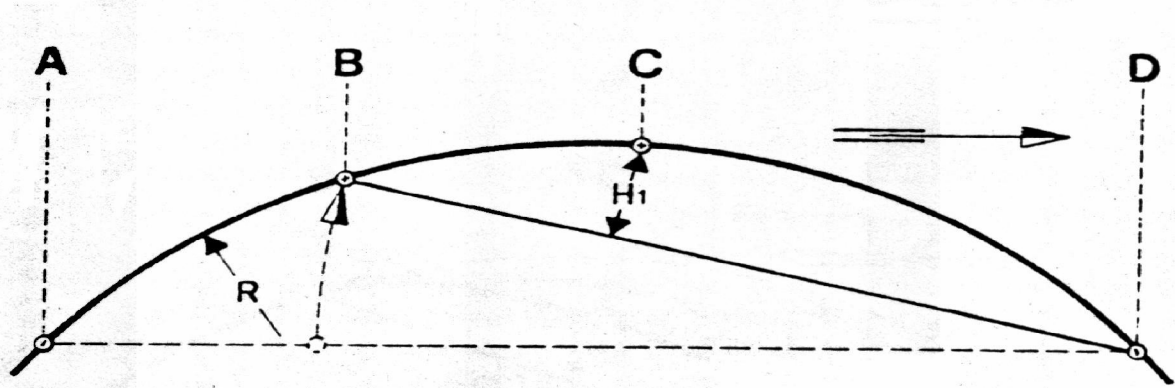
## SUB: – WORKING PRINCIPLE

Lesson-I :Lining

Session-61: 3- Point lining & Left over error.

### THREE POINT LINING SYSTEM:

- GEOMETRICAL PRINCIPLE OF 3 - POINT LINING SYSTEM:**



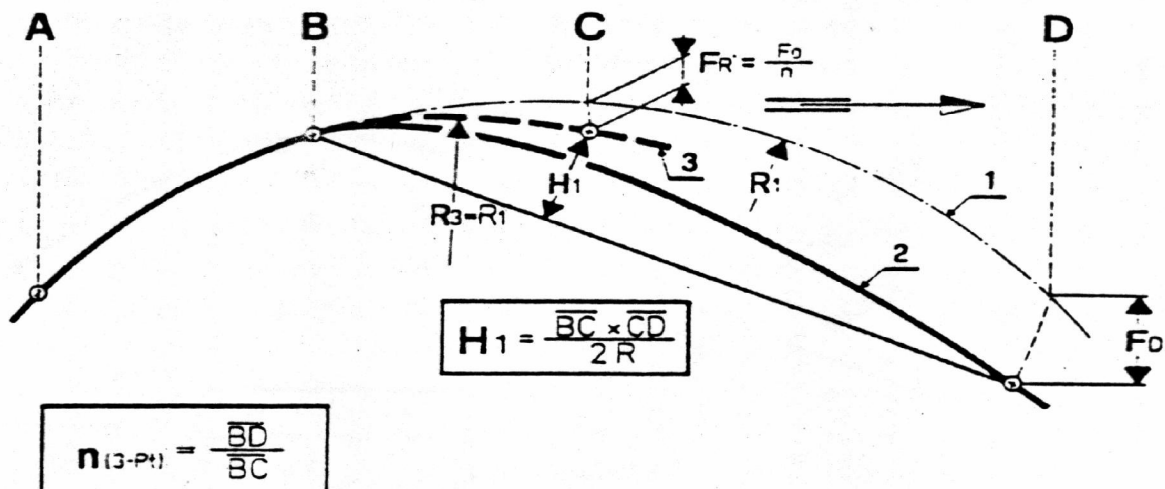
$$H_1 = (BC \times CD) / 2R$$

- The Versine  $H_2$  at Point B is not measured. The track is measured at three points. The lining Versine  $H_1$  at point C is specified according to the curvature. Lining commences until the Theoretical Versine  $H_1$  is achieved. Using the 3-point system, the chord is generally fixed at point B, which results in a reduction of the distance A-B.

$$\text{ERROR} = \text{THEORETICAL VERSINE} - \text{EXISTING VERSINE}$$



- ERROR REDUCTION ACCORDING TO THE 3 - POINT LINING SYSTEM**



- Point B is on the already lined track behind the machine. The front end of the chord, point D is at the lining error  $F_D$ . Point C is lined until  $H_1$  corresponds with the specified Theoretical Versine. Specifying the Theoretical Versine,  $H_1$  shifts Point C in a position which corresponds with the required radius R. The remaining error  $F_R = F_D / n$ , is a result of the ratio of the measuring point distances. Proceeding with the lining, Point B is at the remaining error and influences therefore the next measurement.

- $n_{(3-Pt)}$  - value for different machines is as under:

| Machine              | $n_{(3-Pt)}$ - value |
|----------------------|----------------------|
| 8-UNO/DUO            | = 3                  |
| 08-275 UNIMAT        | = 3.12               |
| 08-275 UNIMAT -3S    | = 3.297              |
| 08-32 WST            | = 2.91               |
| 09-32 CSM            | = 3.138              |
| 9-3X TAMPING EXPRESS | = 3.04               |

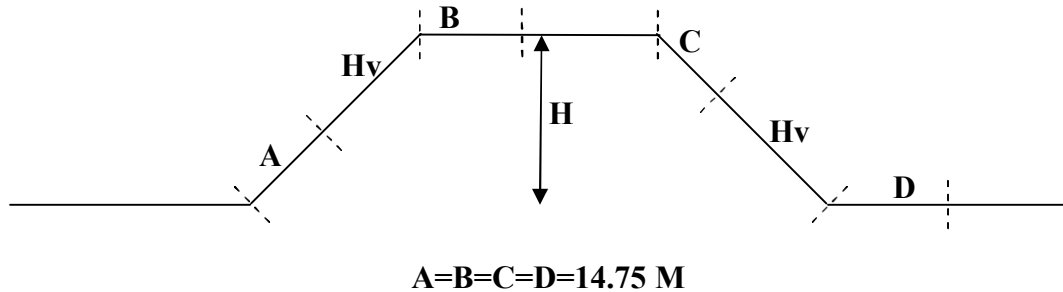


**SUB: – WORKING PRINCIPLE**

**Lesson-I :Lining**

**Session-63: Method of feeding 'V' value.**

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Step 1: Calculate the value of H (as above chart).

Step 2: Calculate versine value of sections A, B, C & D (as above chart).

Step 3: For the calculation of 'Hv' value there are two methods:

Method 1:  $HV = \frac{\text{CONSTANT}}{R \times L}$  mm/metre

Method 2:  $\frac{\text{Versine at starting of B} - \text{Versine at the end of A}}{\text{Transition length} - \text{machine chord length}}$  mm/metre

Step 4: The calculation of versine is for two metres interval as above. This may be divided for alternate sleeper.

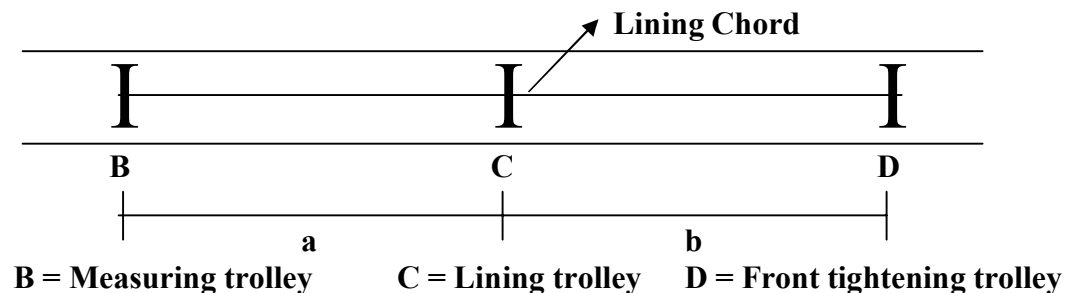
### Lesson-I :Lining method.

### Session-64: Design lining, Laser lining and measuring run

- Maintenance of track geometry to desired parameter is very important for the safe and smooth running of trains. Track machines have facilities of measurement and rectification of track defects for achieving design geometry. 5 CSMs & all 3x machines are also equipped with Automatic Guide Computer (ALC) for track geometry measurement and LASER Sighting System (LSS) for lining besides other features for design tamping. However, only few machines are working in design mode mainly due to the inadequate knowledge of field staff. On NCR, there is not much problem of leveling due to stable formation and good initial laying. Hence, this Circular is to enrich knowledge of Design lining among field staff. Smoothing mode lining details are also given in **Annexure-I**.

## DESIGN LINING

- Modern Track Machine always corrects Versine during Alignment correction using single chord. Machine measures only one rail i.e. Datum rail and rectify it. Other rail is fixed with the sleeper, hence that is also rectified. Four trolleys are provided for alignment measurement. In design lining, only three trolleys are used. The trolleys are pneumatically pressed against Datum rail and transducer provided on lining trolley measures offset of alignment at C i.e. distance between lining chord and center of lining trolley. After measuring the offset, track is slewed so much that specified Versine is achieved at lining trolley, which is zero for straight track and certain value on curved track.



- In the lining process Front trolley always remains on disturbed track and Measuring trolley always remains on corrected track. Because of misalignment in track at front trolley, front end of the chord will be out of its correct position equal to the alignment defect at that point. Due to incorrect position of the front end proportional alignment error will remain after lining. **Left over error at C,  $F_R = F_D/n_{(3-Pt)}$ , where  $F_D$  = Lining offset at front trolley and  $n_{(3-Pt)} = BD/BC = (a+b)/a$ .**

- GEOMETRICAL PRINCIPLE OF 3 - POINT DESIGN LINING SYSTEM:**  
 1 = Perfect alignment      2 = Before lining      3 = After lining without error input  
 4 = Lining Value          5 = Actual position of the lining chord  
 6 = Theoretical position of the lining chord      7 = After lining with error input

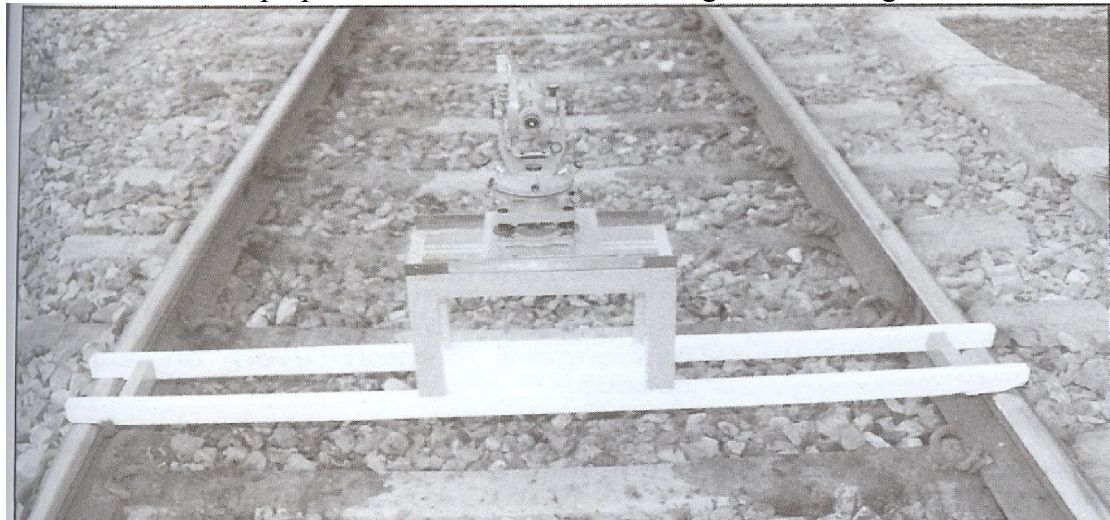
- For achieving such chord length, if the Theodolite with the standard tripod stand is used it takes about 10-12 minutes for centering, leveling and measurements. In the saturated high density routes, so much time is not available and whenever a train

approaches, the Theodolite is required to be removed and reset. It is even difficult to ensure verticality of Ranging rod at target.

- For making it more practicable, fast and efficient, some specially designed gadgets, as given below may be developed, which makes the direct slew measurement with Theodolite quite easy. Using these gadgets, a chord of upto 1 km may be taken between 2 good points, which is the line of collimation of Theodolite at a fixed lateral distance from gauge face of reference rail of existing track and the slew measurements at every 5 m intervals are directly measured on specially designed Satellite with reference to the line of collimation. The equipments and specially designed gadgets used are as under:

- **Theodolite:** Normal Theodolite.

- **Scaled Sliding Table:** It may be made of wood or metal with 1.85 m Length and 0.45 m Height. On upper side, one horizontal graduated table is fixed in which a plate is mounted on which Theodolite slides laterally to keep it at any required lateral distance from the reference rail. A lug is provided similar to that provided in gauge-cum-level. Touching Hook is on left side of the sliding table stand to bypass the burr on rail. SST will be perpendicular to rail, when both lugs are touching reference rail.



- **Satellite:** It may be prepared from existing gauge-cum-level. In middle portion of the vertical face towards Theodolite, a teathed scale made of luminous red strip is pasted for a length 20 cm either side of zero (centre) point. The height of triangular teeth is 10 mm and distance between the two apexes of teeth is 10mm. This is further divided into 5 equal parts by 4 nos. of black horizontal lines to give a least count of 1 mm. *Alternatively, the Satellite may be made like the Target described below with a movable vertical arm of length 30 cm and height 45 cm in 'reverse T shape' †, painted white with a black vertical central line pointer towards Theodolite and a Satellite scale (30 cm Steel scale with Least Count – 1mm) on the upper side at either ends starting at 15 cm distance from the centre point on which the vertical arm slides laterally. During survey, this movable vertical arm is sighted and brought in line with the alignment of line of collimation of Theodolite and Target. The shifting of movable vertical arm from centre point is read from Satellite scale and deviation is directly recorded as slew at that point.*

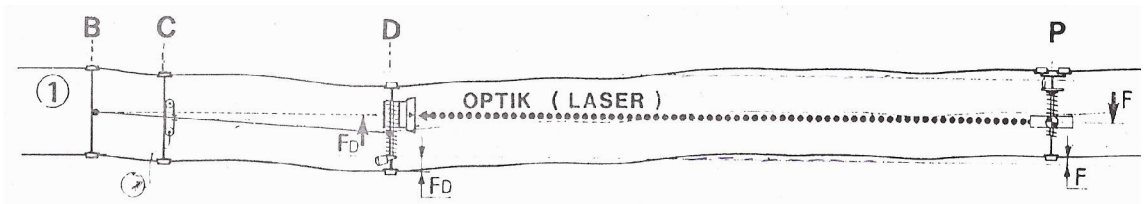
- **Target:** It may be made of wood. One end of its horizontal board ensures reference rail contact and zero point has a **fixed vertical pointer** of 0.75 m height painted white and has got a red vertical central line passing through zero point towards Theodolite.



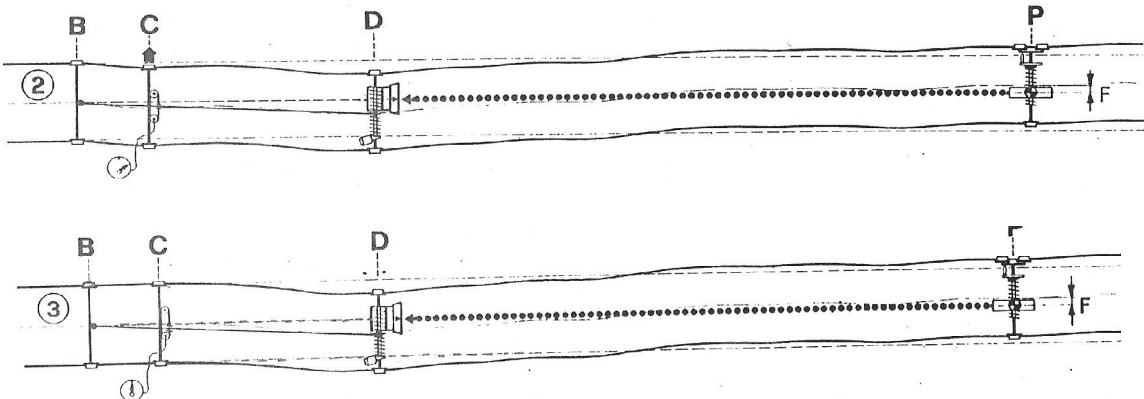
- **VHP Sets:** One each at Theodolite, Satellite and Target i.e. total 3 Nos.
- **Method of Working:**
  - **Preliminary Works:**
    - a) Marking of stations at 5 m apart at the centre of track.
    - b) Selecting good point at about  $\frac{1}{2}$  to 1 km apart. These good points should have their position in the mean alignment of the existing track.
  - **Slew Recording:**
    - **Step 1** – Check squaring of SST with reference rail by touching it's both the notches on gauge face.
    - **Step 2** – Set the Sliding table at zero point, place Theodolite and level it.
    - **Step 3** – Sight the Target and fix the line of collimation.
    - **Step 4** – With the alignment of line of collimation, read deviation at Satellite scale by seeing through telescope of Theodolite.
    - **Step 5** – Take and record deviations of subsequent stations till the readings are visible with the telescope of Theodolite.
    - **Step 6** – Leaving satellite on last recorded station, SST is shifted on second last recorded station.
    - **Step 7** – Slide SST as per slew reading of the station on which it is shifted, place Theodolite, level it at site the target again so that initial line of collimation is maintained for further measurement of slews. Repeat the steps till Slews of each stations at 5 m apart are recorded for full length.
- **An example on Field measurement for design lining offset by Theodolite is given in Annexure-II.**
- **LASER SIGHTING SYSTEM:**
  - 5 CSMs and all 3x machines are provided with a LASER Sighting System (LSS) that can be used to extend the measuring system on straight track. LASER lining is used 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 300 m away. The receiver mounted on the front tightening trolley is adjustable so that it follows the

LASER beam and the position is detected by a transducer that provides an input to the lining system equivalent to the offset of the front of the chord. As the machine is working it moves up to the LASER trolley until the distance is a minimum of 20 m away. LASER system operates fully automatically and is able to cope with distances of up to 300 m. But LASER lining is only applicable for straight track. Important details are given below:

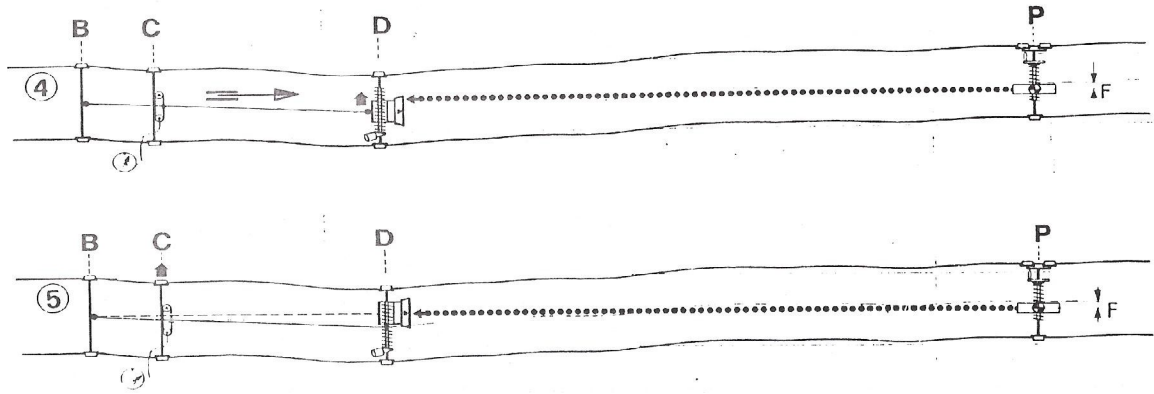
- By means of a special device, the LASER beam is fanned vertically in such a way that, the eventual change in track height has no influence on the system.
- By means of an automatic follow up control, the LASER receiver is always positioned at the centre of the LASER beam and therefore determines the input of the slewing values.
- The distance of the LASER gun from the machine is also dependent on the ambient conditions (rain, snow, fog, high ambient temperature). In good ambient conditions (clear, dry air) the lining distance can be extended considerably.
- **Working Sequence of Design Lining with the Laser Sighting System:**
  - **Phase 1:** When the design lining commences the front end of the chord with the LASER receiver is shifted by the amount of the error  $F_D$  in the direction of the THEORETICAL alignment, whereby the follow up control is switched off. If the lining errors exceed certain amount, a transition is necessary for the new alignment. LASER transmitter is positioned as far as possible from the machine, adjusted laterally over the amount of the lining error  $F$ , aimed at the LASER receiver and fixed in this position.



- **Phase 2 and 3:** The design is set; the follow-up control is switched on. The track is lined at point C and matches exactly with the line of sight.



- **Phase 4 and 5:** The machine drives forward and the front end of the chord is matched up again with the line of sight. The machine is ready for the next lining operation.

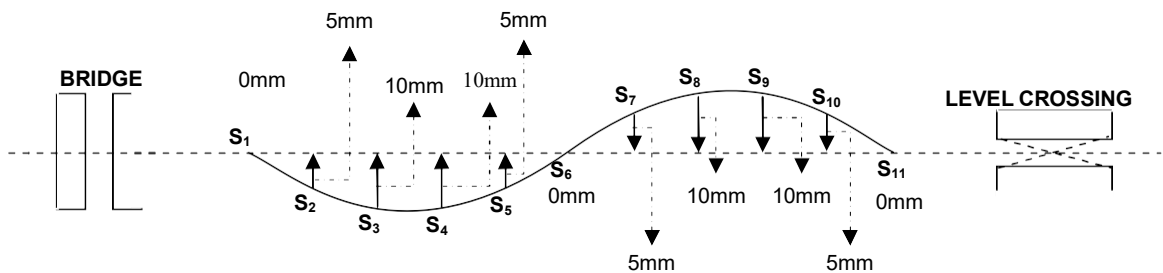


## ANNEXURE-II

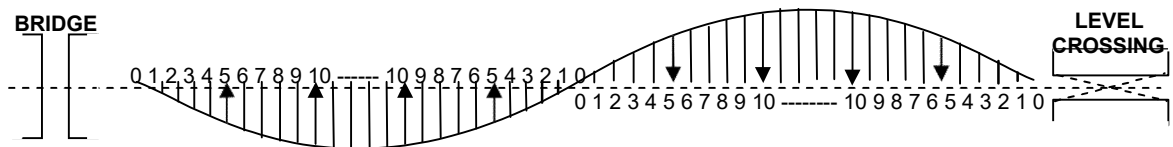
### A. FIELD MEASUREMENT FOR DESIGN LINING OFFSET BY LONG CHORD

#### • Surveying and Marking of Slews without any Infringement to SOD:

- Surveying should be done between two good points, which may be on well maintained obligatory points i.e. girder bridges, level crossings, points & crossings, permanent structure etc, with the centre line of track on the design or original theoretical position.
- In case of any shift in alignment of the centre line at obligatory points from the design or original position, the centre line must be brought to design or original theoretical position, manually for a minimum track length of 50m before surveying.
- The lining errors are to be determined by measuring offsets at every 5 m intervals on 40 m chord on straight track and at every 10 m intervals on 20 m chord on curves track and marked on the track.

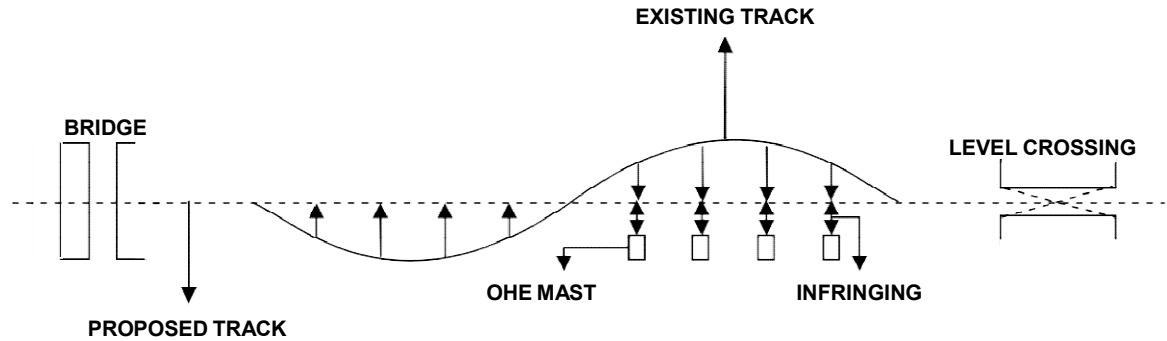


- The required slew at every alternate sleeper is worked out by interpolating the offsets. The slews are then marked on alternate sleepers and Design tamping done by feeding the slew values to Slew Potentiometer in the Front tower.

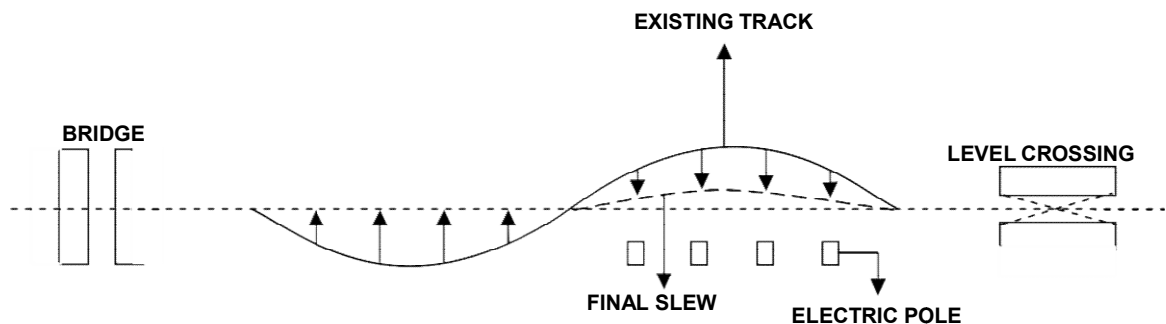


#### • Surveying and Marking of Slews in case of Infringement to SOD:

- If the required slew is infringing the SOD viz OHE Mast etc, the slew has to be worked out taking note of the obligatory points and ensuring that there are no infringements to moving dimensions as shown below.



### **Required Slew Values Infringing SOD**



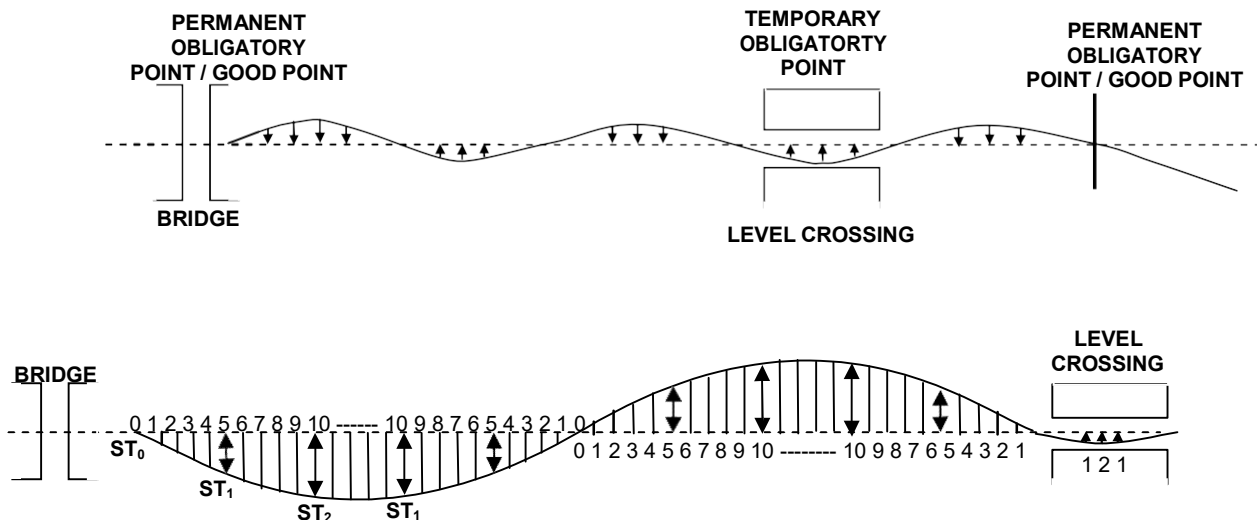
### **Final Slew Values With No SOD Infringement**

- The final worked out slews are then marked on alternate sleepers and Design tamping done by feeding the slew values to Slew Potentiometer in the Front tower.

## **B. FIELD MEASUREMENT FOR DESIGN LINING OFFSET BY THEODOLITE**

### **• Surveying and Marking of Slews without any Infringement to SOD:**

- Preliminary Works and Slew Recording Steps are already given in the Circular. However, the following procedure may be followed for Permanent (Girder Bridges, Fixed Structure etc.) and Temporary Obligatory points (Level crossings etc):
  - In case of any shift in alignment of the centre line at Permanent obligatory points (Girder Bridges, Fixed Structure etc.) from the design or original theoretical position, the centre line must be brought to design or original theoretical position, manually for a minimum track length of 50m before selection of good points.
  - Either the Permanent obligatory points or any other points at about ½ and 1 km apart having their position in the mean alignment of the existing track are taken as good points. Thereafter, the Working Method as given in the Circular is followed.
  - Temporary Obligatory points (Level crossings etc) should be opened out and may be shifted to the extent possible after ensuring that there are no infringements to moving dimensions as shown below.
  - Any shifting of Temporary Obligatory points should be approved by the ADEN.



### MEASURING RUN METHOD:

#### ALC MEASURING METHOD:

The measuring method is used where the track data is not known. The data for the track is obtained via measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radius, etc. After computation by the “ALC” computer the tamper is set to work with the “ALC” automatically entering the computed lift and line data.

#### SEQUENCE OF OPERATION:

The machine can either measure in the working direction or the reverse. If the track is measured in the working direction, the tamping machine must reverse back to the start of the work site before commencing tamping. There is a “fast measuring drive” key switch on the front and rear driving desks. These enable the machine to use the second gear of the main drive to make the measuring run.

#### PERFORMING A MEASURING RUN:

Set up the machine for normal working, although there is not necessary to have the tamping banks running. The tamping banks slew switch on the B2 panel should be set to automatic. If it is on manual the fast measuring function will be disabled. It is advisable to drive the machine for a short distance using the normal working drive. Thus checking that the lifting and lining system is in working order before the start of the measuring run by avoiding errors at the start of the measuring run, due to poor bogie alignment or incorrect pre-loading. It is important to select the correct float rail. if the wrong rail is selected, the design for the lift will not be correct. It is also a good idea to mark the position of the machine on the rail before the start of the measuring run, so that the machine can be repositioned accurately at the start position after the measuring run has been completed (Forward measuring run). The lining system has to be set to 3-point. Use the can switch to select the datum rail for the longitudinal height recording. The reference rail for the versine recording is selected by turning on the lining system and selecting the required pre-load.

#### END OF MEASURING RUN:

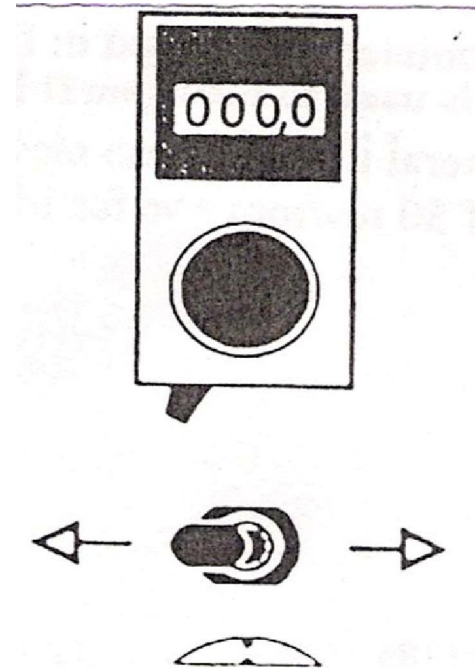
At the end of the measuring run return the key switch to the normal position. The computer will automatically produce a “run in from” the old track geometry to the new target geometry at the beginning and end of the measuring run. The measuring run should therefore only cover the length of rail on which the work has to be carried out.

**CALIBRATION OF VERSINE POTENTIOMETER(4f1):**

This potentiometer converts versine value to electrical signal at the rate of **50mv/mm +ve for RH side and –ve for LH side.**

For calibration of versine potentiometer select Multicheck address **F00**. Select “0” value in versine potentiometer then output voltage of versine potentiometer should be zero on display. If not , loose the screw of digital counter and take out the counter and now rotate shaft of potentiometer to get zero volt on display. Now set all digits to zero of counter then fit counter on shaft of potentiometer. When voltage of versine potentiometer is checked at multicheck address **F00** then polarity will be –ve for RH and +ve for LH side.

Before starting calibration +10V & -10V to this potentiometer should be checked and adjusted by potentiometer P1 & P2 in EK 813SV of front input .

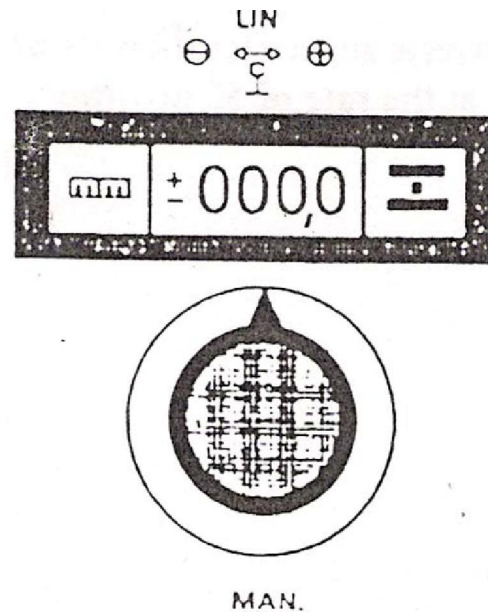


**CALIBRATION OF SLEW POTENTIOMETER(4f4):**

This potentiometer is provided in front cabin on panel B4. This potentiometer converts slew value to electrical signal at the rate of **50mv/mm +ve for RH side and –ve for LH side.**

For calibration of this potentiometer , keep slew potentiometer at zero position then output voltage should be zero, if not then take out the knob of potentiometer then rotate the shaft of potentiometer to get zero volt. Then by matching the knob at zero position fit on shaft of potentiometer. When voltage of slew potentiometer is checked at multicheck address **F06** then polarity will be –ve for RH and +ve for LH side.

Before starting calibration +10V and –10V should be checked . If there is any variation then adjust by P1 & P2 in EK813SV of front input .



**GENERAL LIFT POTENTIOMETER (4f3):**

This potentiometer is provided in panel no. B4 in front cabin. This potentiometer converts given general lift value to electrical signal at the rate of 50mv/mm output of this potentiometer can be checked at multichack address F22.

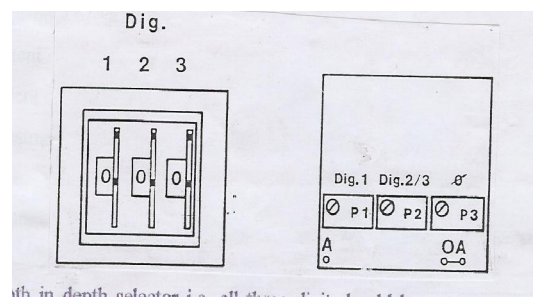
For calibration of this potentiometer keep general lift potentiometer on zero and check output of this potentiometer with the help of multi meter it should be 0V. If there is some signal on zero position first take out knob of potentiometer now rotate shaft of potentiometer to get zero volt. Now fit knob on shaft by matching zero position.

### **SUPER ELEVATION POTENTIOMETER(2f08):**

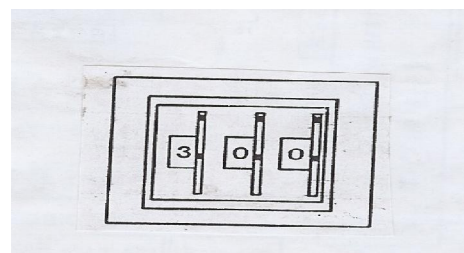
This potentiometer is provided in B2 panel in working cabin this potentiometer is used do feed super elevation or cant values on curves. This converts cant values to electrical signal at the rate of 50mv/mm.output of this potentiometer can be checked at multichack address F08.

For calibration of this potentiometer. Set zero value in this potentiometer.. Select multichack address F08 then check voltage on display. It should be 0V if there is some voltage then remove digital counter set it to zero and also set shaft of potentiometer to get zero volt on display then refit digital counter on shaft.

### **DEPTH SELECTOR CALIBRATION:**

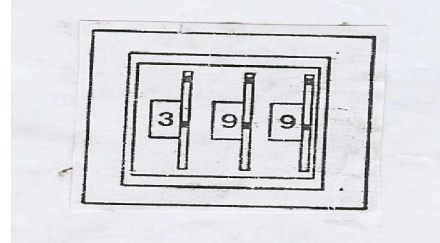


- (1) Select Zero depth in depth selector i.e. all three digit should be set to zero. Now select multichack address F13 in multiplex PCB and keep selector switch in 2<sup>nd</sup> position Now display should read 0V. If it is showing some value then adjust potentiometer P3 to get zero volt.



- (2) Now select 300 MM depth in depth selector then. Output of selector will be -7.5V if it is not showing -7.5V, then adjust P1.

showing -7.5V, then adjust P1.



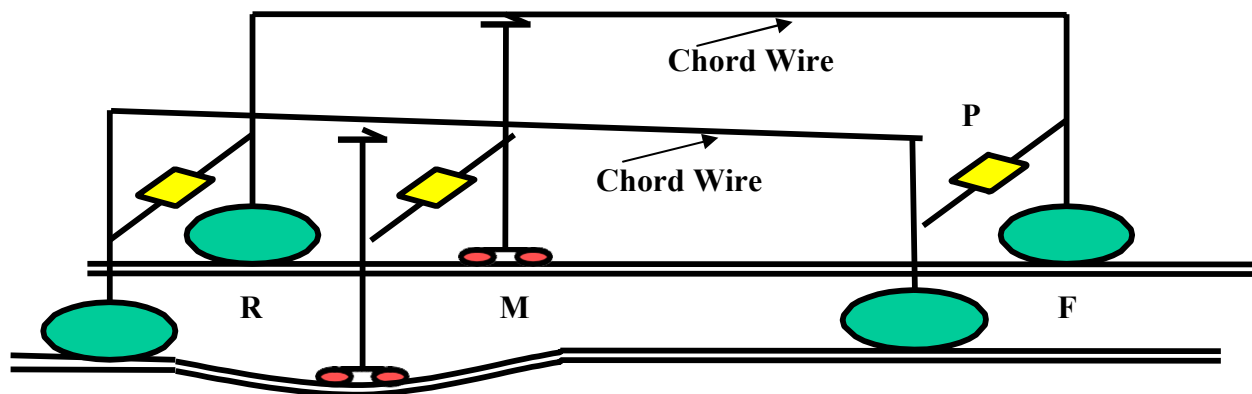
- (3) Now select 399m depth in depth selector output of depth selector in display should be -9.975V if it is not, adjust potentiometer P2.

## SUB: – WORKING PRINCIPLE

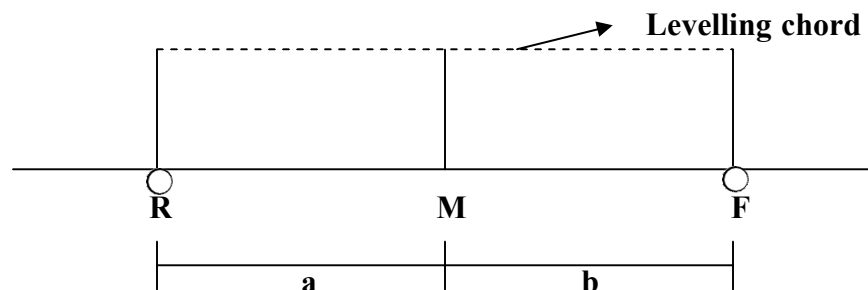
### Lesson-II:Leveling

### Session-66: Types of leveling system, Double chord system.

- Tamping Machine corrects the leveling error in the following two modes:
  - **Proportional or Compensation mode-** In this mode, General lift over the Base rail is generally fixed and smoothening action takes place. Longitudinal level and Cross-level are not completely corrected and the Machine leaves some error. Only short wave defects are removed. **Details are given in Annexure-I.**
  - **Design or Precision mode-** In this mode instead of General lift, the target heights are fed over the Base Rail to rectify 100% error. All long wave and short wave defects are fully removed. **This PCE Circular is to enrich knowledge of Design Levelling.**
- **Levelling and Lifting System** consists of two chord wires one for each rail, stretched tightly from Front tower (F) to Rear tower (R). Tamping machines rectify level defects in track by lifting it with reference to these levelling chords. Height Transducers are mounted on Middle feeler rods (M), which rest on track at the place where tamping is actually done and these are also lifted when the track is lifted. Both rails are controlled separately. For Cross-level/Super-elevation correction, Pendulums (P) are provided. Only CSM & 3x are designed for twist correction also. Schematic diagram is given below:



- Height transducers provided on Middle feeler rod measures the gap between its zero level and chord wire. Base rail is lifted to eliminate this gap and other rail is lifted to bring specified cant between two rails, which is kept zero in straight track and a certain value on curved track. Values of unevenness and cant are fed through potentiometers.



**R = Rear measuring point    M = Measuring & correction point    F = Front measuring point**

- In levelling process, front tower always remains on unlevelled track and rear tower on levelled track. Because of level defects in track at front trolley, 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 error remains after levelling.

- Thus, the leveled track at M is having

**Level error =  $LF \cdot a / (a+b) = LF/r$ , where  $LF$  = Level offset at front tower &  
 $r$  = Reduction Ratio =  $(a+b)/a$**

- **Bogie Distances and Reduction Ratio for different machines are as under:**

| <b>Bogie Distance (m)</b> | <b>UNO/DUO</b> | <b>UNI-2S</b> | <b>UNI-3S</b> | <b>O9-CSM</b> | <b>MP-2000</b> | <b>09-3X</b> |
|---------------------------|----------------|---------------|---------------|---------------|----------------|--------------|
| RM (a)                    | 4.04           | 3.32          | 4.85          | 3.90          | 5.10           | 4.56         |
| MF (b)                    | 9.64           | 8.89          | 10.73         | 8.90          | 9.05           | 10.67        |
| RF (a+b)                  | 13.68          | 12.21         | 15.58         | 12.80         | 14.15          | 15.23        |
| Reduction Ratio (r)       | 3.326          | 3.678         | 3.212         | 3.232         | 2.775          | 3.333        |

- **In Design levelling, this error is eliminated by raising or lowering front end of the chord equal to level offset at that point. In CSM, UNIMAT and 3x, chord wire is not physically shifted but electronic signals are relayed through microprocessor to leveling unit and track is lifted accordingly.**

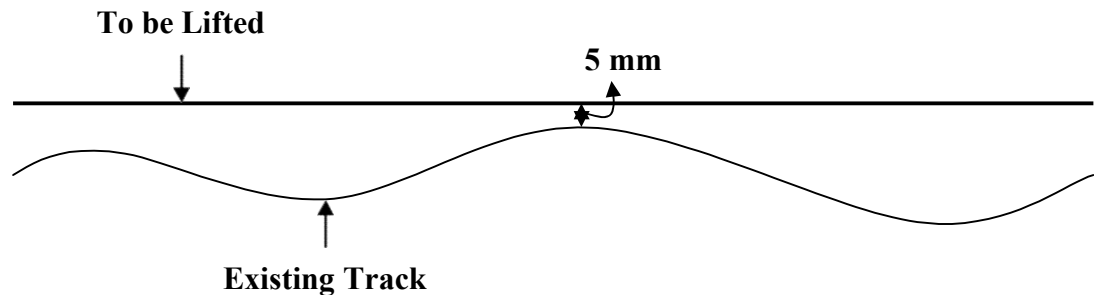
## SUB: – WORKING PRINCIPLE

### Lesson-II: Leveling

### Session-67: General lift, ramp in & ramp out.

**General Lift:** The amount of lift, which is given to track while tamping to cover all undulations over the Base Rail, is called General Lift. It is decided on the magnitude of the dips/peaks generally available in the track. General Lift should always be more than the largest of dips which shall be ascertained by P.Way supervisor in advance.

- It is given to the Base Rail. **General Lift is the algebraic difference of higher and lower point of Base rail + 5mm. At one time, General Lift value should not exceed 50 mm. If more than 50 mm lift is required, it can be achieved by lifting two times.**



- While giving the General Lift, ramp in of 1:1000 and also while closing the work ramp out of 1:1000 should be given to the track for smooth transition.



- For Curves, when the existing Super-elevation (SE) is less than equilibrium SE, General Lift will be equal to track irregularities over the Base Rail (Inner Rail + 5mm) and when the existing SE is more than equilibrium SE, General Lift will be the track irregularities in the Base Rail + max difference between existing and equilibrium SE.

## SUB: – WORKING PRINCIPLE

Lesson-II: Leveling

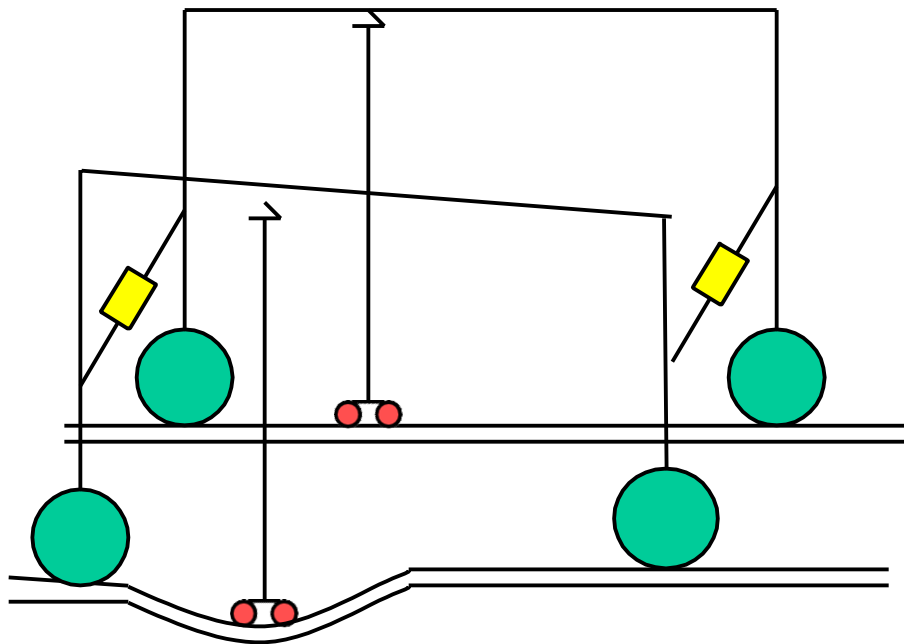
Session-68: Criteria for selection of Base line.

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**Base Rail:** For carrying out attention to longitudinal profile, one rail is kept as Base or Datum Rail. Machine corrects Cross-level w.r.t. Base Rail, which should be selected as under:

- On straight track in single line and middle track in multiple lines, **higher/less disturbed rail** is kept as Base Rail.
- On straight track in double line, **non-cess rail** is kept as Base Rail.
- On curves, **inner-rail** is kept as Base Rail.
- In Plasser Tamper, direction of Cant Selector Switch is to be always kept opposite to the Base Rail.

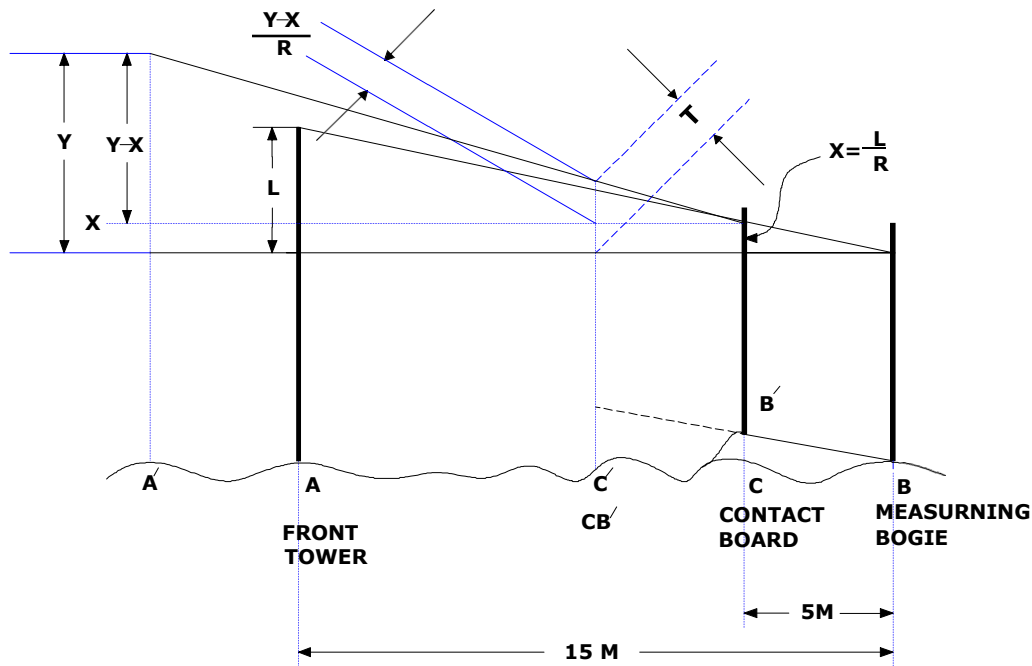
In Russian Tamper, Base Selector Switch is provided for selecting Base Rail.



## Lesson-II: Leveling

**Session-69:** Double chord follow up system & fixed chord system, Proportional leveling, Error reduction ratio.

# RUN IN RAMP



(DIMENSIONS HAVE BEEN ASSUMED IN THIS EXAMPLE )

$$\frac{AB}{CB} = R$$

$$\frac{L}{X} = \frac{AB}{CB} = R$$

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

AS THIS MACHINE MAX. AHEAD TO NEXT POSITION  
AND SUPPOSE A TOTAL LIFT OF 'Y'  
HAS BEEN GIVEN ON FRONT TOWER,  
TOTAL ACTUAL LIFT AT C.B. OR T.U. CAN BE WRITTEN.

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

T = TOTAL LIFT AT A PARTICULAR SLEEPER

X = ACTUAL LIFT ACHIVED ON PREVIOUS SLEEPER

Y = LIFT GIVEN TO FRONT TOWER AT THAT POINT

R = RATIO OF DISTANCE

## **PROPORTIONAL LEVELLING SYSTEM**

The tamping machines with non-displaceable front end of the leveling chords are equipped with a proportional levelling and lifting system for measuring and correcting the track geometry.

### **1. Measuring of the Longitudinal Profile:**

The track is measured at three locations per rail:

- At the front of the machine (location “F”) for determination of the actual level and the front measuring reference point.
- In the area of the tamping units (location “M”) for the proportional control of the hydraulic track lifting system.
- At the rear of the tamping units (location “R”) on the already corrected track for determination of the rear measuring reference point.

A chord is stretched above each rail between the reference points “F” and “R” which forms two, independent from each other, measuring references for the longitudinal level.

Measuring transducers are mounted on the feeler rod of the centre measuring device. The control arms of the transducer are connected with the leveling chord. Proportional to the level of the track at point “M” the measuring transducers send electronic signals for the automatic control of the track lifting servo hydraulic system.

### **2. Measuring of the Cross Level:**

At the measuring points “F” and “M” the cross level is measured by means of pendulums.

The difference between the THEORETICAL and the measured ACTUAL cross level at the front measuring point “F” is automatically transmitted to the lifting adjustment, corresponding to the side.

During the lifting and tamping operation the cross level is checked at the centre measuring point “M” (in the area of the tamping units).

The measuring of the cross level at the rear measuring point “R” (optional) serves several functions:

- a) Checking the cross level of the track which has been lifted and tamped immediately beforehand.
- b) Recording of the cross level by means of an electronic recorder.

### **3. Input of the Lifting Values:** The adjustment of the track lifting takes place at the front reference point “F” and is automatically and in the right proportion transmitted to the cut off points of the measuring transducer mounted on the centre measuring device “M”. The leveling system may be used for the following methods:

#### **Compensating method:**

Without having the track surveyed, a required lifting value is selected. Existing longitudinal errors are reduced and the cross level errors are eliminated.

#### **Precision method:**

The track has to be surveyed beforehand and the lifting values of one rail are marked on the sleepers. During work the lifting values are set manually.

### **ERROR REDUCITON:**

| S. No. | Dist               | 08<br>DUO/UNO | 08 UNI-2S | 08 UNI-3S | 09 CSM | MP-2000 |
|--------|--------------------|---------------|-----------|-----------|--------|---------|
| 1      | Reduction<br>Ratio | 3.326         | 3.678     | 3.212     | 3.232  | 2.775   |

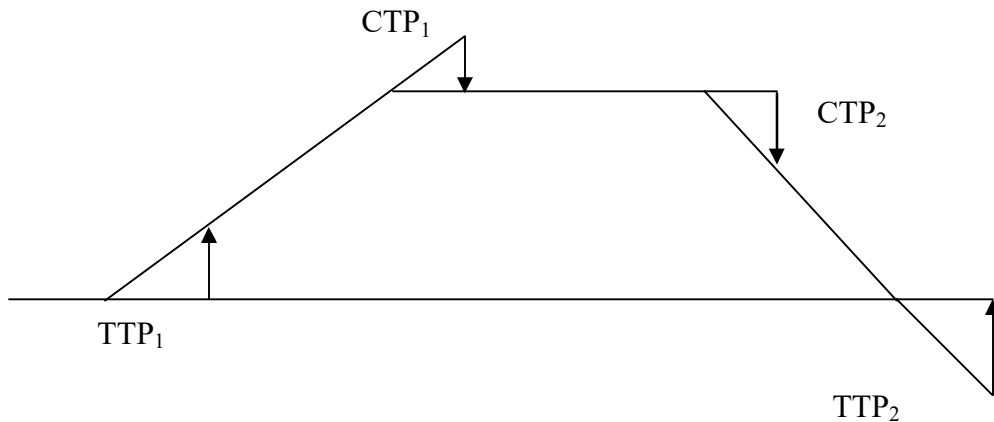
## SUB: – WORKING PRINCIPLE

Lesson-II: Leveling

Session-70: Method of feeding of Cant on CSM.

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### METHOD OF FEEDING OF CANT ON CSM: FEEDING OF CANT. VALUE IN CURVE:



- JE/P.Way will write down cant value of curve on the sleeper near inside rail seat of outer rail.
- Total cant value should be distributed through out the transition length in such a way that it is Zero at TP & Max. at CTP.
- Generally when the tamping machine enters into the transition position, the machine operator start feeding cant value according to the value written on the sleeper.
- In front cabin cant potentiometer is not provided, hence operator will not feed the value.
- Once machine completed entered into transition, the cant value which is written on the sleeper at measuring bogie is feeded.
- Similarly when front cabin reached at CTP1 the remaining bogie is stile in transition portion i.e. working has not reached at full cant value.
- Similarly when machine reached at CTP2 suddenly the cant value will be reduced to the value till TTP2 as per written on the sleeper when the front tower reached at TTP2 then although the reaching of cant value digital reached at zero but reduced it in ergative till measuring bogie reached at TTP2. no raise the cant value equal to zero.

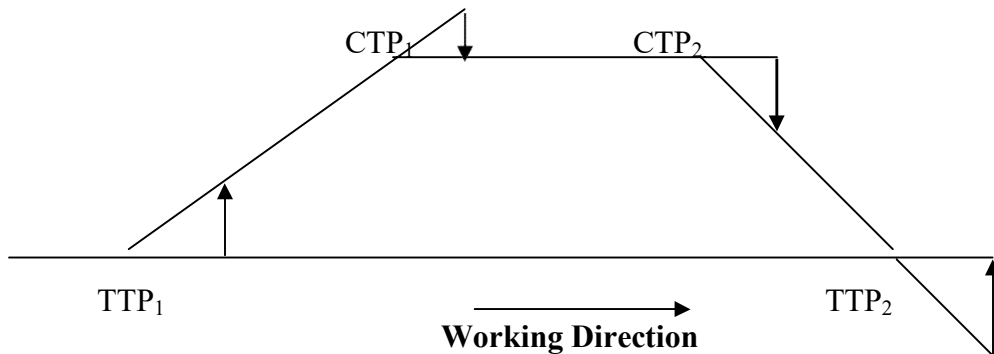
## SUB: – WORKING PRINCIPLE

Lesson-II: Leveling

Session-71: Method of feeding of Cant on other machines.

### METHOD OF FEEDING OF CANT ON OTHER MACHINES:

#### Feeding of Cant Value in Curve:



- In all tamping machines, generally there are two digital potentiometers for feeding the Cant value, one at front tower and another at working cabin except CSM in which there is only one potentiometer in working cabin.
- Cant value is written by JE/P.way on the sleeper near inside rail seat of outer rail.
- Total cant value should be distributed through out the transition length in such a way that it is Zero at TTP and Max. at CTP.
- *There is incorrect practice of feeding of Cant value wrongly in the field i.e. when tamping machine enters into the transition portion, the operator in the front cabin starts feeding cant value according to the value written on the sleeper. As soon as cant value is fed in front cabin when it is at TTP, the lifting starts and cant rail is also lifted. Since, lifting is not required till measuring trolley reaches over TTP, it creates hump.*
- So the operator of front cabin should not feed any cant value till the working cabin reaches over TTP. Thereafter, whatever value is written on the sleeper in front of the front cabin should be fed by the operator in the front cabin.
- When front cabin reaches at CTP<sub>1</sub>, the working cabin is still in transition portion i.e. it has not reached at full cant value. The operator in the front cabin should keep on feeding the Cant value at the same rate till the working cabin reaches at CTP<sub>1</sub>. Thereafter, the operator in the front cabin should instantaneously reduce the Cant value to Max. Cant written on the sleeper.
- Similarly when the front cabin reaches at CTP<sub>2</sub>, the cant value should be kept as Max. Cant till the working cabin reaches at CTP<sub>2</sub>, when suddenly the cant value is reduced to the value as written on the sleeper in front of the front cabin.
- When the front cabin reaches at TTP<sub>2</sub>, although the cant value becomes zero at TTP<sub>2</sub>, but the cant value should be fed at the same rate by changing the direction of the toggle switch i.e. negative cant value is fed, till working cabin reaches at TTP<sub>2</sub>, when suddenly the cant value is brought to zero.

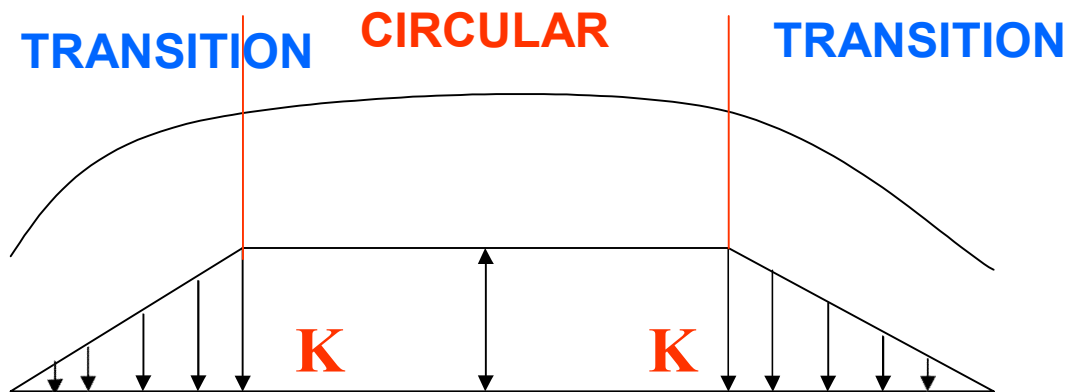
**SUB: – WORKING PRINCIPLE**

**Lesson-II:** Leveling

**Session-72:** Method of Calculation of Correction value ('K' Value),  
Function of Pendulum- Front, Middle, Rear Pendulum & Twist  
correction.

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**CALCULATION OF CORRECTION VALUE ('K' VALUE):**



$$K = 50 \times \frac{SE}{R}$$

**FUNCTION OF PENDULUMS:**

**FRONT PENDULUM:** For automatic cross level correction.

**MIDDLE PENDULUM:** For indication only.

**REAR PENDULUM:** For twist correction , recording purpose, versine correction and for indication.

**TWIST CORRECTION:**

Rate of change of level per unit length is called twist. Only CSM machine & 3 X machine is designed for the twist correction.

**SUB: – WORKING PRINCIPLE**

**Lesson-II:** Leveling  
Machines -  
(GVA&ALC)

**Session-73:** Method of data feeding on Tamping  
Manually and by Computer

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**METHOD OF DATA FEEDING ON TAMPING MACHINES( MANUALLY):**

**GENERAL LIFT:**

The value of general lift is decided by survey i.e. peak value plus 5 mm. This value is fed in general lift potentiometer in one to thousand ratio. In case of design mode target height is feeded in place of general lift.

**SUPER ELEVATION:**

The value of cant is zero for the straight track. But cant value is feeded in super elevation potentiometer whatever retain on the track on the circular curve this is constant but in case of transition this value varies. The cant value is retain on the sleeper of the track on the outer side.

**GEOMETRY VALUE ASSESSMENT (GVA):**

It is a small computer which eliminates the feeding of adjustment values from tables and marking on sleepers. The locations of main points of curve i.e. starting of transition, end of transition, transition length, radius, super elevation and vertical curve data etc are fed into the computer.

The attention of the Operator is not distracted by adjustment operation, mistake in calculation is avoided and therefore, the higher progress is achieved with improved quality.

**AUTOMATIC GUIDING COMPUTER (ALC):**The system have two modes, (i) geometry mode and (ii) measuring mode

In geometry mode parameter of curve is feed in computer ALC. WinALC software draw the curve as per parameters on screen then curve is corrected accordingly.

In measuring mode the parameters are measured first then mean value of each parameters i.e. versine, longitudinal level are taken and displayed by the computer. The correction is done by the computer as percentage of correction is fed by operator by seeing the position of the track after the correction. This is almost same to the design mode.

**SUB: – WORKING PRINCIPLE**

**Lesson-II:** Leveling  
height.

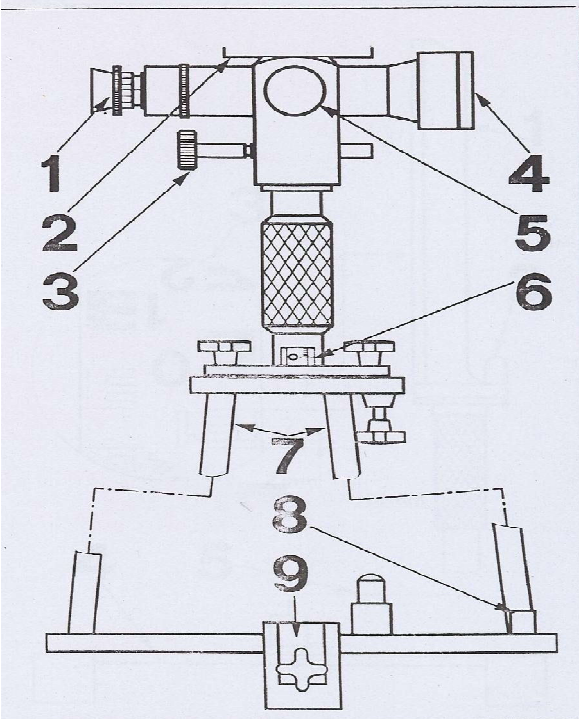
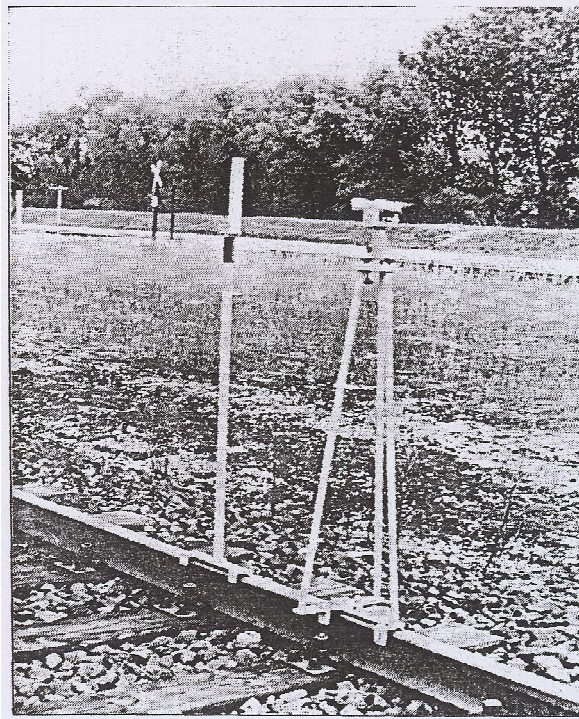
**Session-74:** Design leveling and feeding of target

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**DESIGN LEVELING:**Longitudinal section: Non-cess rail on straight track in double line section and inner rail on curves.For single and middle line in multiple line sections, any of the two rails which is less disturbed may be selected as datum rail, both for alignment and L-section in straight track.

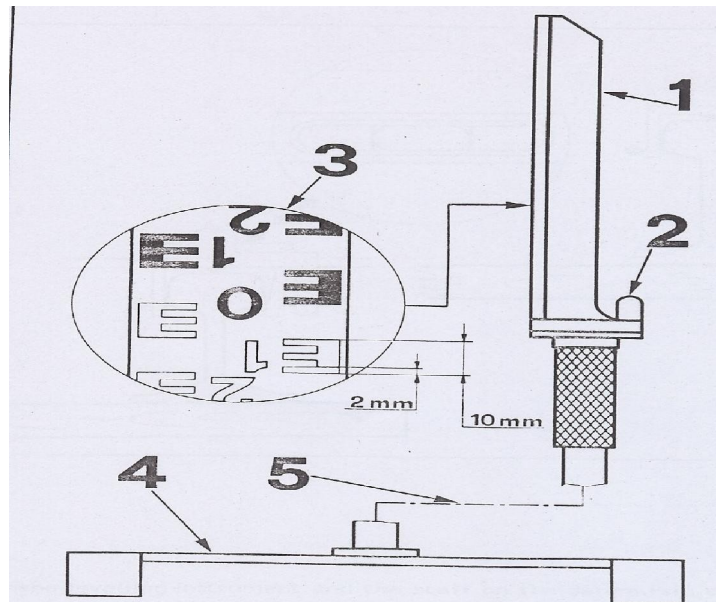
- **DETERMINATION AND ADJUSTMENT OF LEVELLING ERRORS:**Detailed guidelines on ‘**Survey for Vertical Profile Correction, Plotting of Vertical Profile and Surfacing Operations**’ etc. as contained in Para 2.0 to 5.0 of Ann 5.3 to IRTMM at stations marked at 10m interval using conventional level and staff are very time consuming because of repeated setting up (centering & leveling) of dumpy level, change in height of instrument, difficulty in taking precise reading on conventional staff and a lot of calculation work involved for interpolating the data. Hence, it cannot be used at the site immediately after taking data. **In view of the voluminous survey work involved, some specially designed gadgets as given below may be developed, which not only makes the direct measurement of ‘Design Level Offset’ quite easy with Theodolite kept on rail but it is also more practicable, fast, efficient and accurate.**

- **Theodolite Stand:** Stand is modified as shown below for easy fixing over rail head with the Theodolite at specified height (line of sight at 1.2m) to have a fixed height of instrument. No centering and levelling of the Theodolite is required for surfacing work in straight horizontal and inclined track as no turning of Theodolite is required. Only correct sighting of Target staff and parallax removal at Intermediate staff needs to be done.

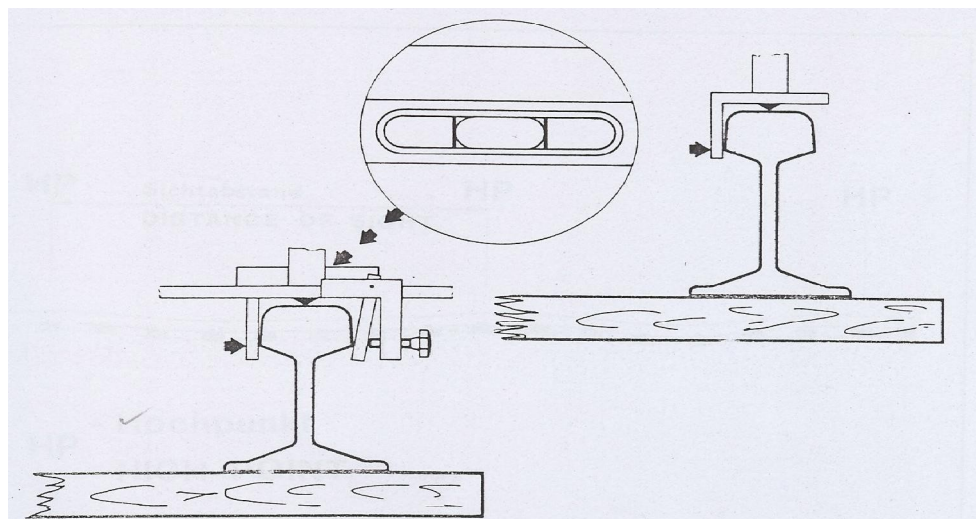


1- Diopter focusing eye-piece 2- Rough Pointer 3- Tilting Screw 4- Telescope 5- Focusing screw 6- mm graduation for height adjustment 7- Tripod 8- Air level 9- Clamping device

- **Target Staff:** Height of target point on target staff is to be kept equal to the height of instrument (1.2m) from the bottom of staff. It is designed using luminous strips for clear visibility and also to ensure verticality without much effort.
- **Graduated Intermediate Staff:** It is designed as shown below to take direct readings of lift required to be given to track, which can be transferred instantaneously. Graduation on Intermediate staff starts from height equal to height of instrument (1.2m) from the bottom of staff. It is designed using luminous strips for clear visibility and Air level is also provided to ensure verticality without much effort. No negative reading is indicated on staff, however, reading up to -25 mm can be incorporated in the staff which may some times be used to reduce general lift at isolated points.



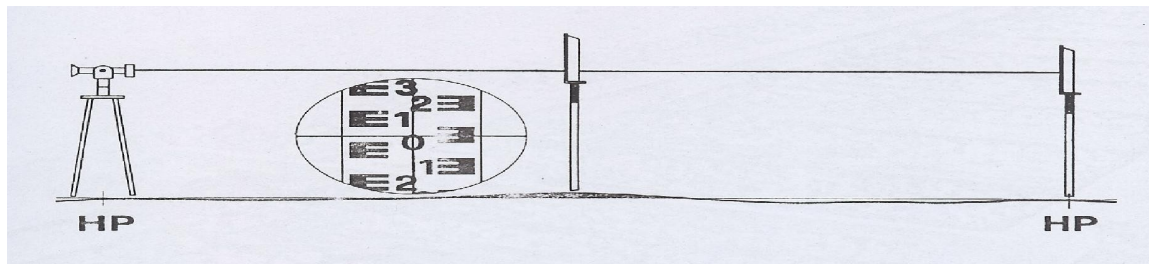
1- Staff 2- Air Level 3- Graduated scale 4- Application-angle 5- Supporting Tube



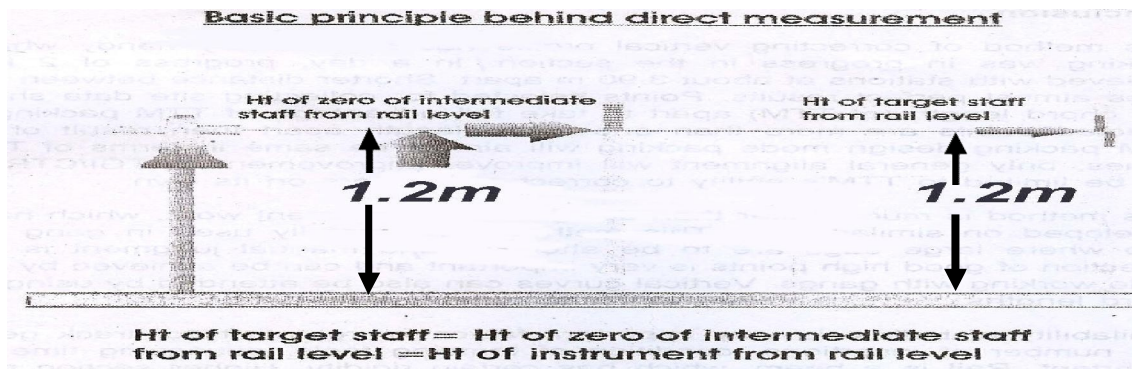
#### **Mono-rail Clamping Arrangement for Theodolite and Levelling Staff**

- **Method of Working:**

- Generally the rail, which is higher and has minimum undulation, is chosen as the Base or Datum rail for leveling. Guidelines for selection of Datum rail is contained in Para 1.0 of Ann 5.3 to IRTMM.
- Survey is started from obligatory points like bridges, level crossing, points & crossings. When survey is started from other point, a level track of 15 m is prepared and rail top level is transferred on traction mast or rail post as BM for record. Survey of dips is done at Stations marked at 5 m interval on Base rail.
- Two high point are chosen on Datum rail at required base length (80 to 300m interval within visual range). *Care should be taken while choosing higher points that no intermediate point is higher than the chosen points. In case negative value appears during leveling, this indicates that the High Point has been badly chosen.*



- Height of instrument (line of sight) is fixed with respect to datum rail level. For this fixed height of instrument the Target is sighted from Theodolite and intersection point of Target staff is fixed with respect to rail level, which is equal to height of line of sight with respect to rail level. Similarly height of zero point is fixed on Intermediate staff equal to height of line of sight with respect to rail level. Once the line of sight is fixed as above, the intermediate staff will read zero value on each point which is on straight line joining base of target staff and base of Theodolite stand. This is true for straight horizontal as well as inclined track. In this way height of instrument is automatically deducted on each reading and readings of sags are achieved without any calculations on site instantly. The required design level offset (lift) at every alternate sleeper is worked out by interpolating the level offsets taken at Stations. In this method neither plotting nor computer calculations are required.



### STRAIGHT HORIZONTAL

