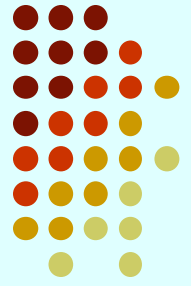
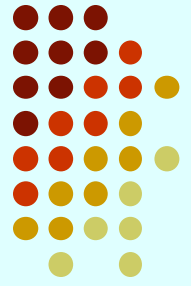


Track Tamping Machines

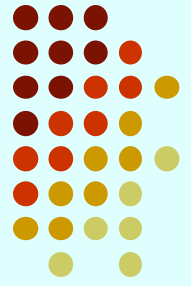


Topics to be discussed today



1. Why tamping, lining & lifting of track.
2. System of lining
3. 3 point lining method for straight & circular
4. 3 point lining method for transition curve
5. 3 point lining method in design mode

Introduction

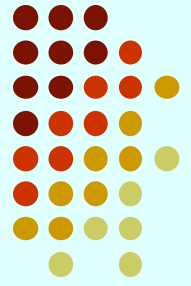


Safe and comfortable travel in a train is only possible on tracks lying in the correct geometrical position.

The first machines that made it possible to produce this state of the track quickly and reliably were built by Plasser & Theurer.

The hydraulic non-synchronous constant pressure tamping principle is used to hold the tracks in the correct position. →

Why tamping?



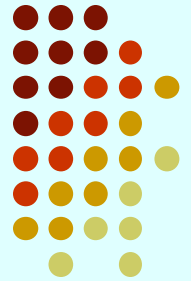
When a train travels over a track, it generates enormous forces.

The entire track that deforms and returns to its original position as an elastic system.

But over the long term this high stress results in deterioration of the ideal track geometry.

Then it becomes necessary to impose temporary speed restrictions.

Why tamping?

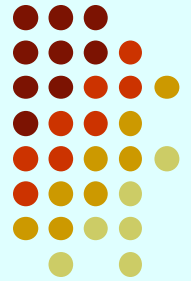


To avoid such a situation, tracks should be maintained at regular intervals* this includes levelling, lifting, lining and tamping. This ensures that the ideal geometry of the track is restored.

*Frequency of tamping (as per Para 5.7.4 of IRTMM) :

- (i) **On PSC Sleeper-** once in two year or 100 GMT whichever is earlier
- (ii) **Other then PSC Sleeper-**Once in a year

Why Machine Tamping ?

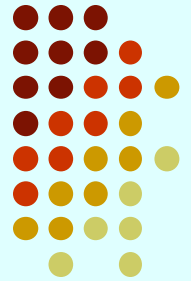


- Ever increasing traffic and axle load,
- Modern and heavy track structure,
- Availability of time for maintenance is reducing,
- Over aged maintenance staff,
- Quality of output is much better & superior,
- Economical.

Working Principle of Tamping Machines

LINING & LEVELLING
Smoothening & Design
Mode

FUNCTION OF TAMPING MACHINE

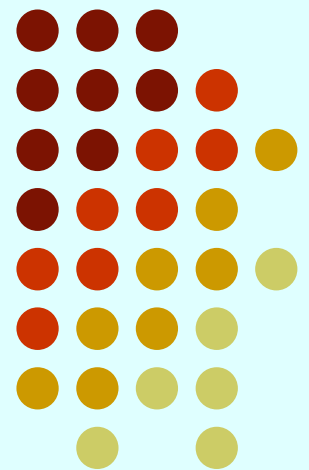


- Lining correction
- Longitudinal Level correction
- Cross Level correction
- Tamping/packing

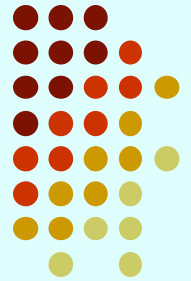
Only CSM, Tamping Express Machine & UNI-4S also do twist correction

LINING

LINING is a process of correction of alignment in horizontal plane

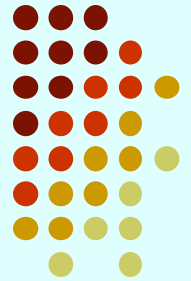


PRINCIPLE OF LINING



- 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.

LINING SYSTEM

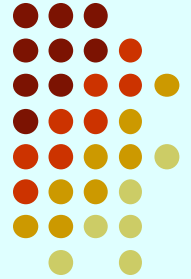


There are two types of lining system.

(a) Double chord lining system.

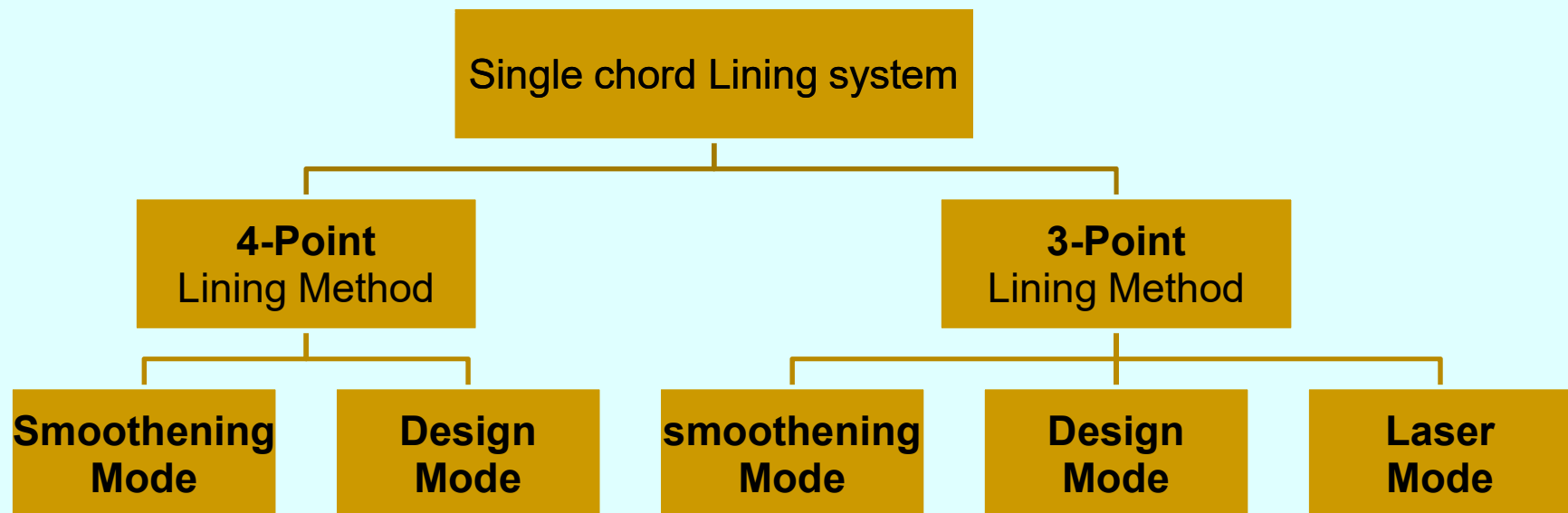
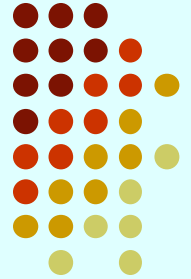
(b) Single chord lining system.

DOUBLE CHORD LINING SYSTEM

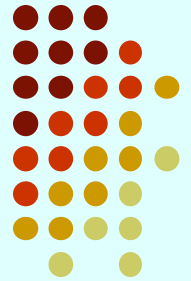


- used on UT machine
- two chords i.e. long chords and short chords were used for measuring the versine.
- Now, this machine is phased out & this lining system has become obsolete.

SINGLE CHORD LINING SYSTEM



SINGLE CHORD LINING SYSTEM

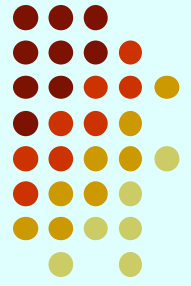


- used in all tamping machines except UT.
- only one lining chord is used.

- **3 POINTS LINING METHOD:**
 - 3 points are used on the curve and straight,

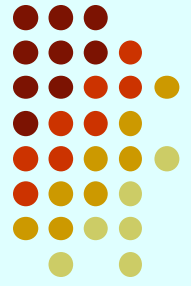
- **4 POINTS LINING METHOD:**
 - 4 points are used on the curve in smoothening mode only.

Smoothing Mode



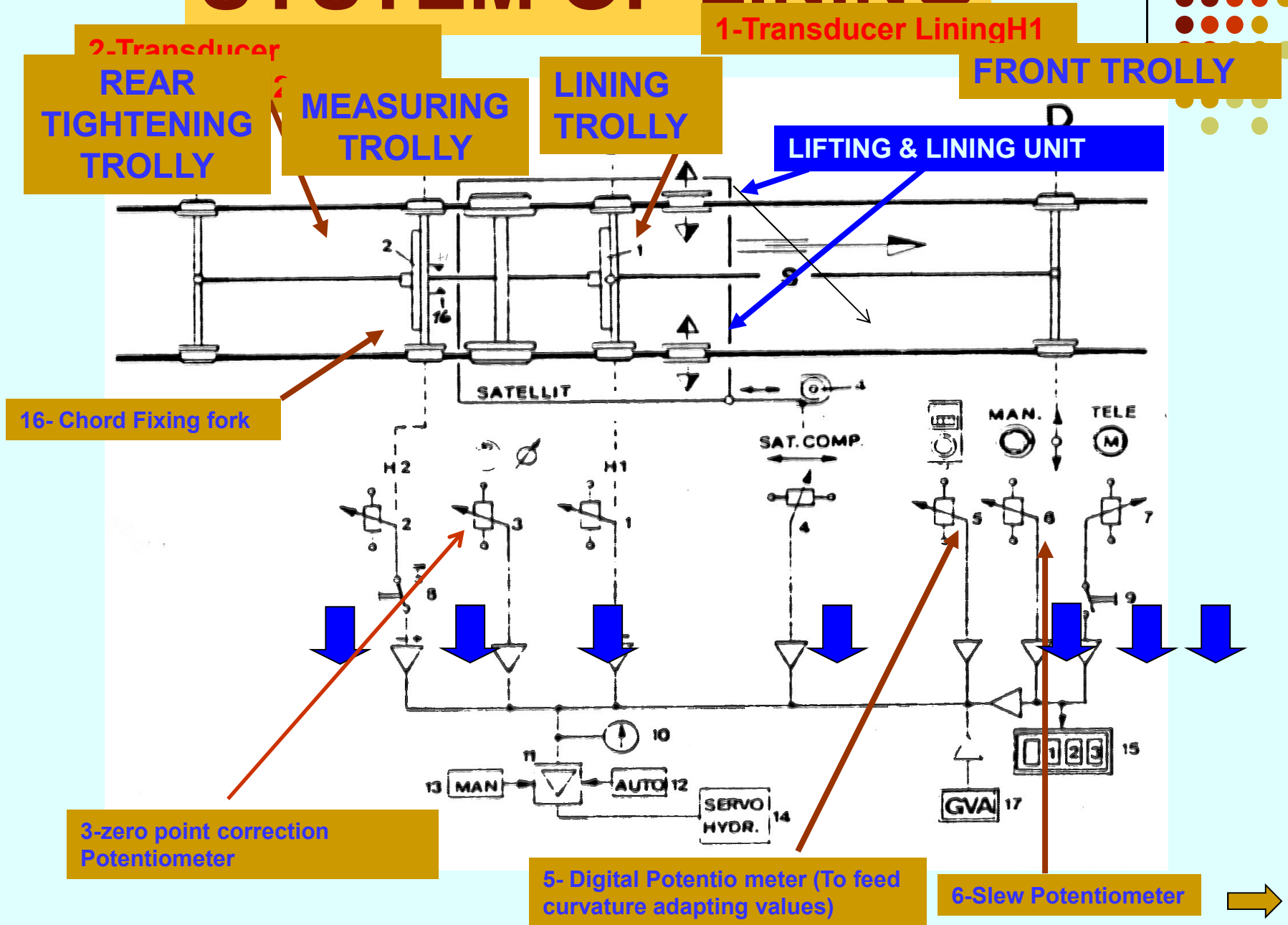
- For this track can be lined by 4 point method or 3 point method.
- track will not reach on designed specified parameters.
- Some error remains their after tamping.

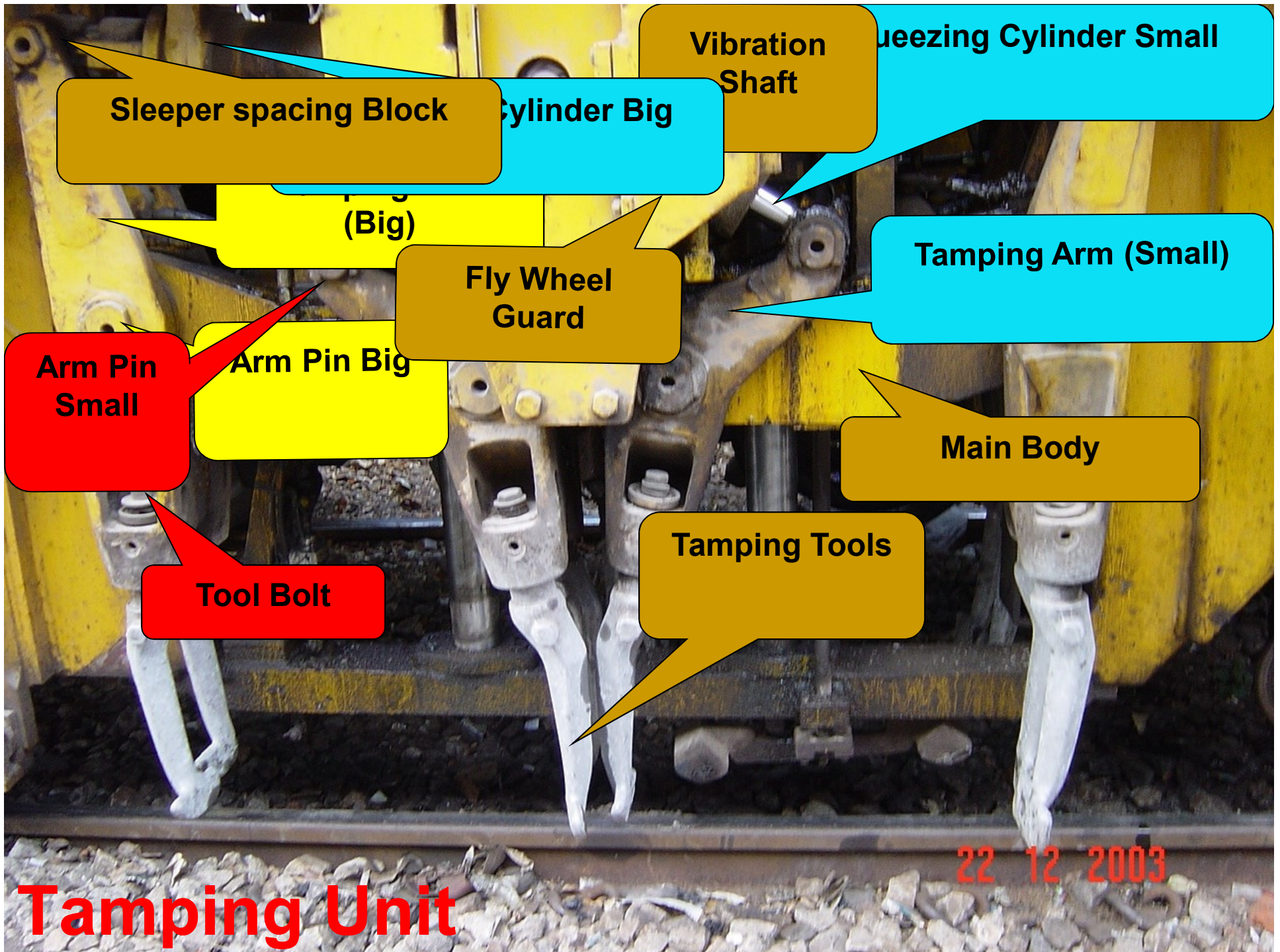
Design/Precision Mode



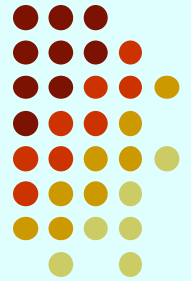
- In this mode precise track geometry data **must** be known before work commences.
- data (slew) should be input at the front cabin.
- for this 3 point method is mainly used.
- In this track is to be lined according to specified radius or versines

SYSTEM OF LINING





Potentiometer available in machine for Lining & leveling

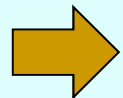


Values of slew, versine, unevenness and cant are fed in machine through potentiometers. These are provided in working cabin & front cabin

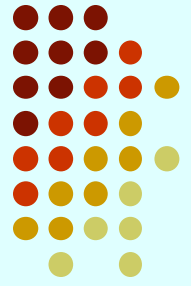
Potentiometer in Working Cabin-

Cant Value : feeding the cant value at working area.

Cross level correction— extra lift provision up to +/- 3 mm to base rail for correcting cross-level in addition to general lift.

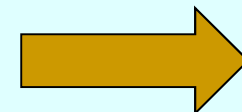


Functions available in machine for lining & leveling

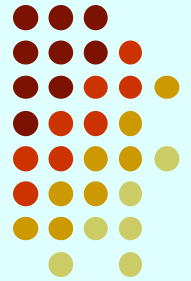


Potentiometer in Front Cabin -

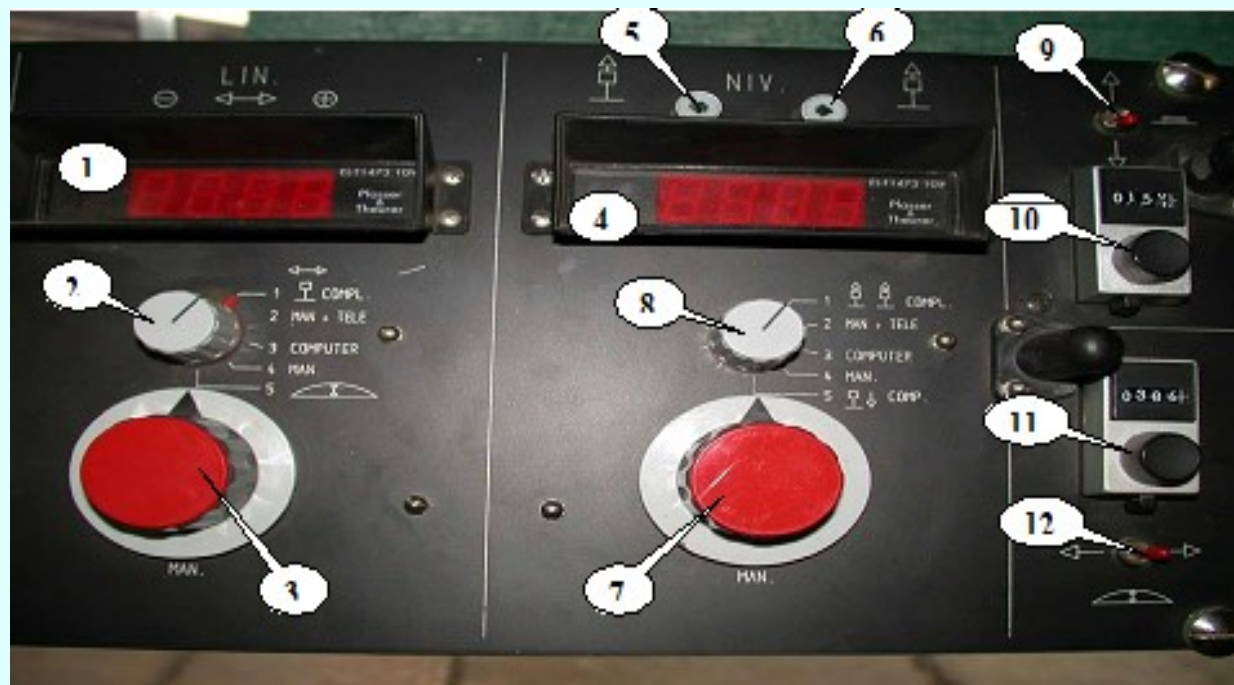
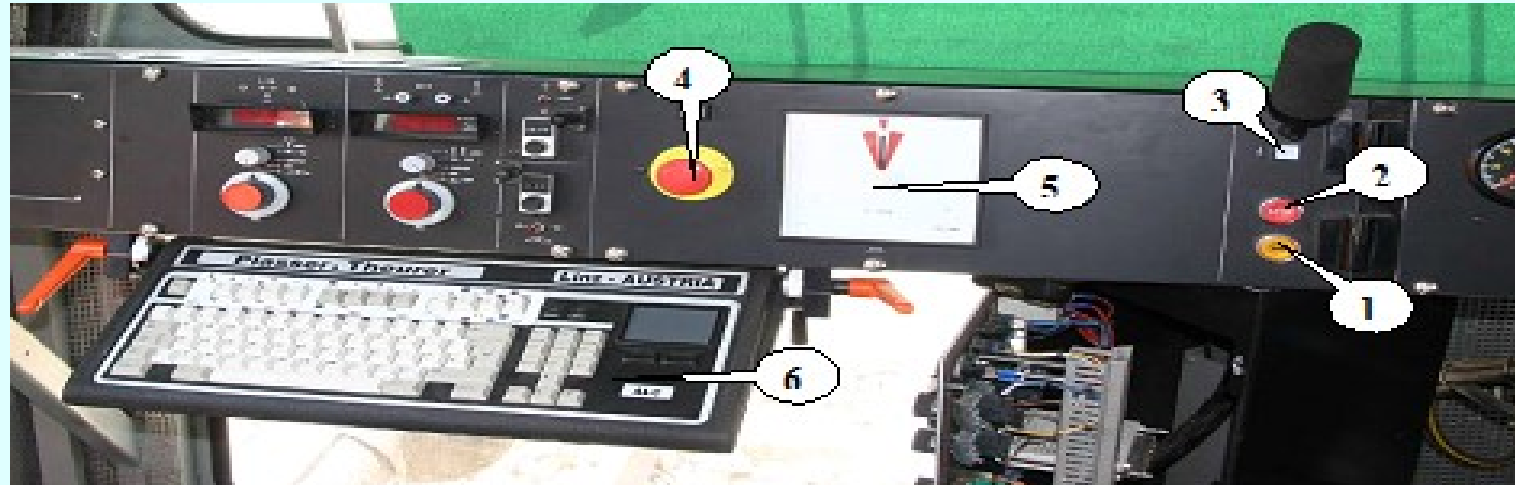
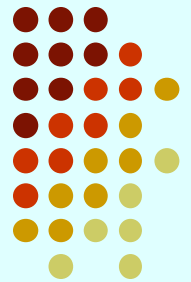
- **Slew (FD Value)**
(Feeding options –Manual/LASER/Computer)
- **Versine value and Vm-**
(Feeding options -manual through potentiometer and geometric value assessment (GVA computer) /ALC)
- **General Lift-** selected on the basis of cross level difference(+/-)longitudinal level variation
- **Superelevation/Cant** – for feeding SE/Cant value

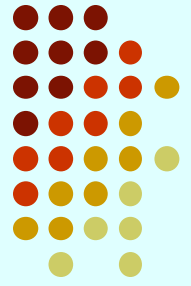


Front Input Panel of DUOMATIC



Front Input Panel of WST





1 = Digital display for lining input data

2 = Lining input data selector switch:

pos. 1 =total input value

pos. 2 =manual and tele inputs (design lining data)

pos. 4 =manual inputs (design lining data)

pos. 5 =lining versine (manual and computer curvature data)

3 = Lining value setting potentiometer (designed lining):

4 = Digital display for leveling input data

5 = L.h. cant indicator lamp

6 = R.h. cant indicator lamp

7 = Lifting value setting potentiometer (designed lifting):

8 = Levelling input data select or switch:

pos. 1 = total value of inputs

pos. 2 = manual and tele inputs

pos. 4 = manual lift settings

pos. 5 = curvature lift correction data

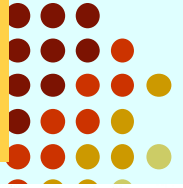
9 = Change over switch for cross level value input range (plus / minus range)

10= Digital potentiometer setting knob for manual cross level value input

11 = Digital potentiometer setting knob for manual input of versine value

12 = Change over switch for versine value range(always towards the outer side of curve)

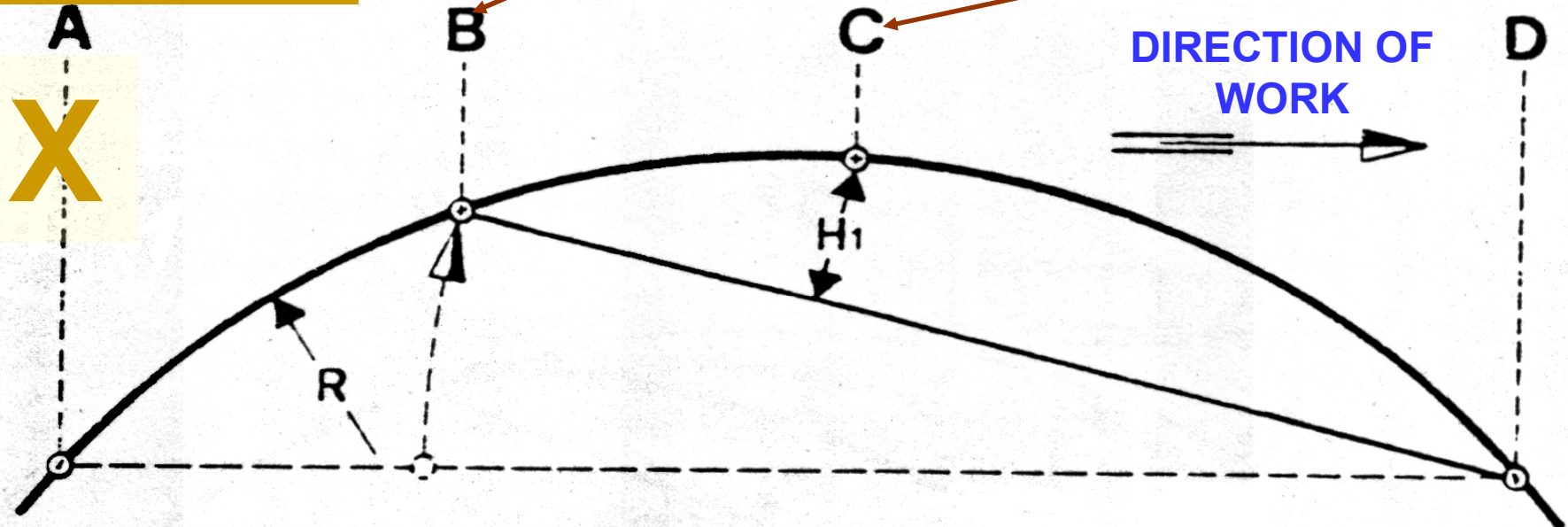
3 POINTS LINING METHOD



REAR TROLLEY IS FOLDED

MEASURING TROLLEY IS CLAMPED TO ZERO

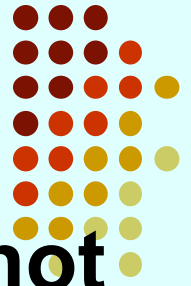
LINING TROLLEY - ONLY H1 IS MEASURED



For any circular curve

$$H1 = a * b / 2R$$

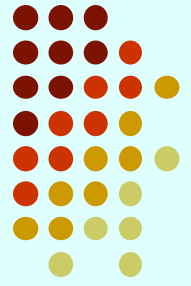
3 POINTS LINING METHOD



- 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.

3 POINTS LINING METHOD

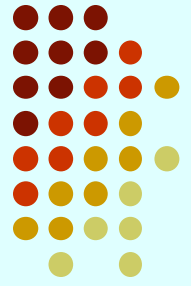
continue....



- The chord is fixed on the measuring trolley "B" by means of the fork "16". The measuring transducer "H2" is not in use. Only the lining versine "H1" is measured which is added to the specified THEORETICAL versine (HV, HF, HW) as lining adjusting value.
- The difference between the THEORETICAL- and ACTUAL versine represents the lining value.

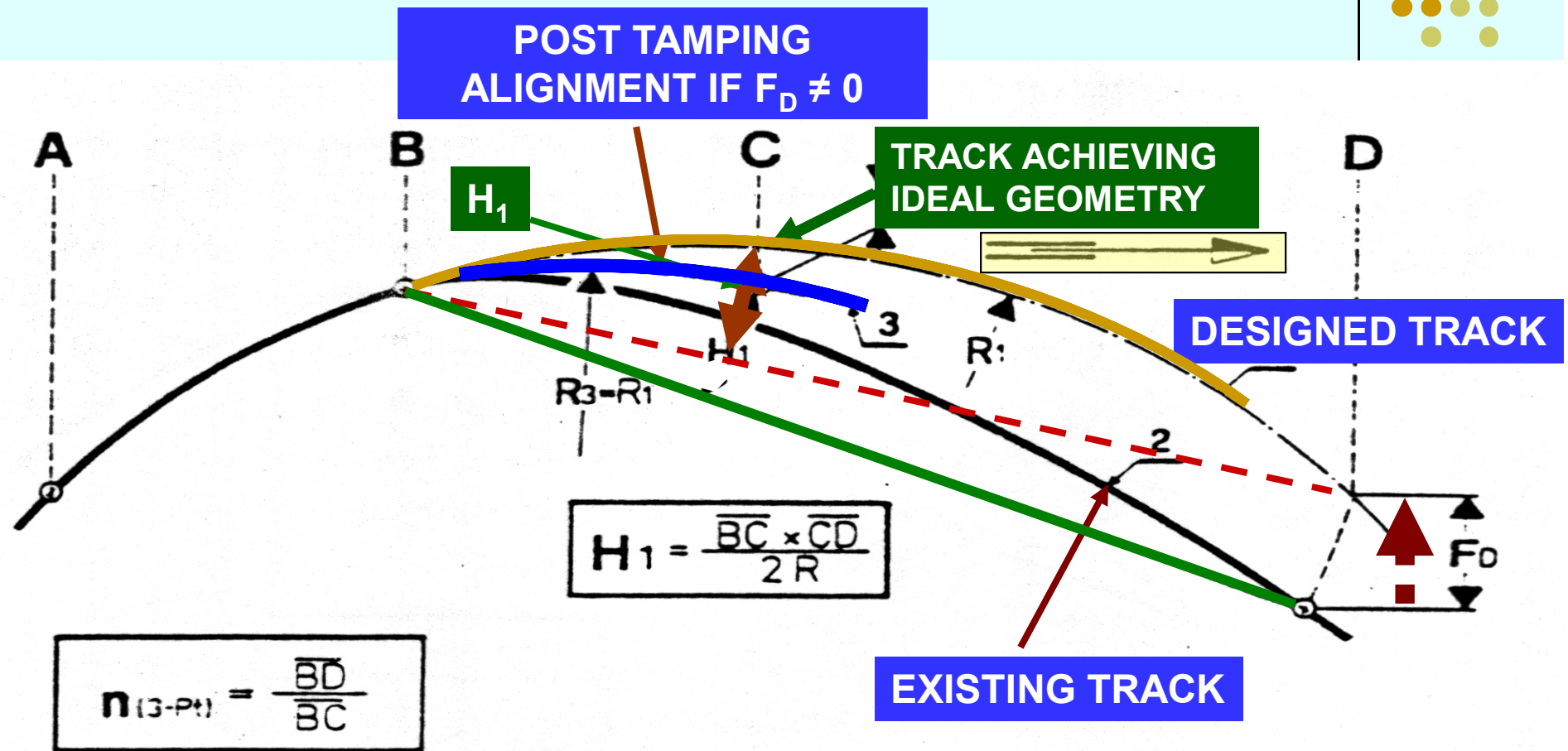
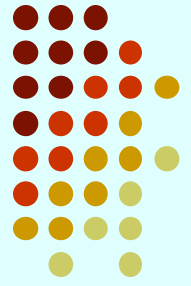
3 POINTS LINING METHOD

continue....



- **ERROR = THEORETICAL VERSINE – EXISTING VERSINE**
- **Error---Calculated by PCB**
- **Theoretical Versine-----Fed Manually or by Computer**
- **Existing Versine-----Measured by Machine through Transducer.**

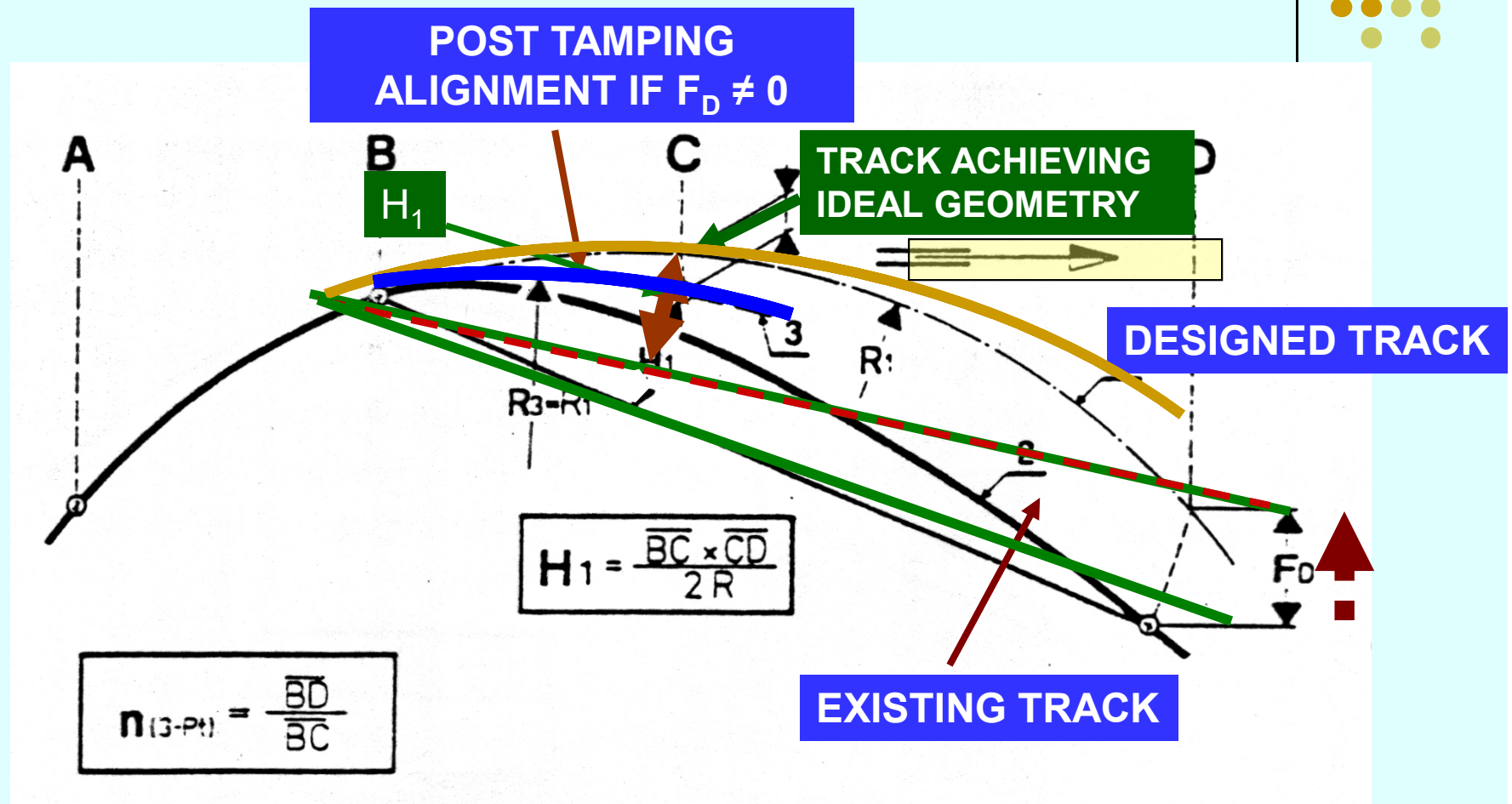
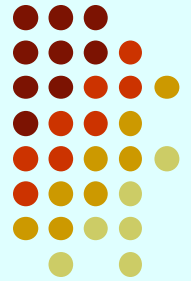
3 POINTS LINING PRINCIPLE



Error Reduction Ratio

$$n = 14.75 / 4.7 = 3.14$$

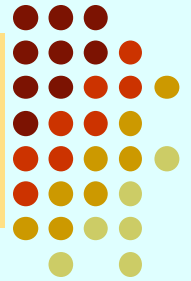
3 POINT LINING PRINCIPLE



Error Reduction Factor

$$n = 14.75 / 4.7 = 3.14$$

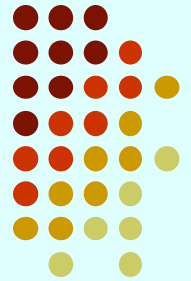
3 POINTS LINING



- **Straight track - Smoothing Mode,**
 - $H_1 = 0$,
 - Error reduces to $1/3$.
- **Straight track in Design Mode,**
 - $H_1 = 0$,
 - Feed slews in **slew potentiometer**,
 - **Error** is completely eliminated.

3 POINTS LINING

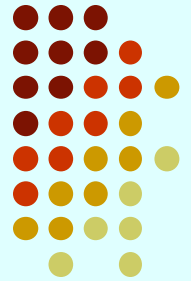
Curves in construction



- May be used to lay designed curvature,
- **Smoothing mode**,
 - H1 fed in VPM (based on calculated value of R),
- **Design mode**,
 - Feed the slews,
 - H1 fed in VPM (based on calculated value of R).

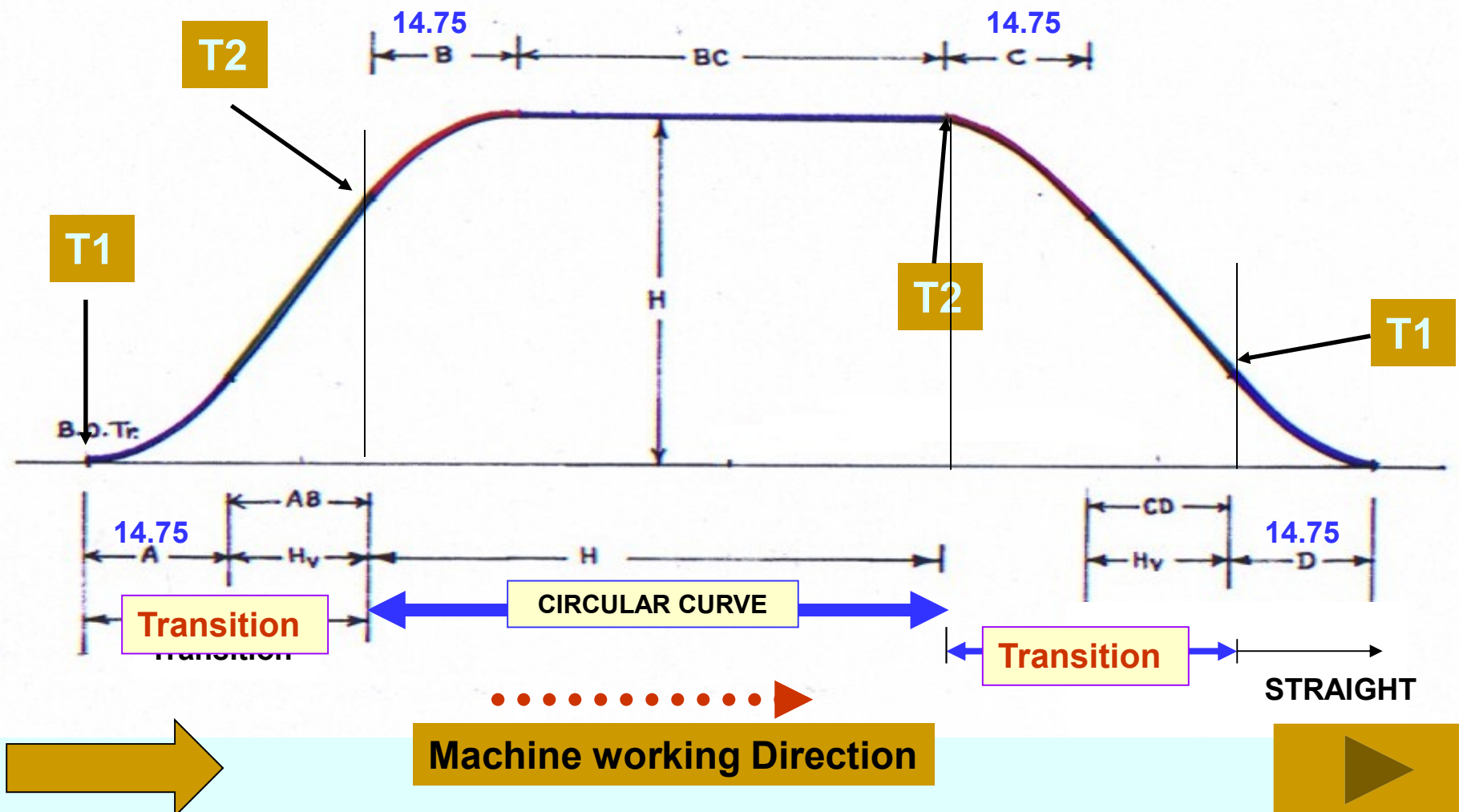
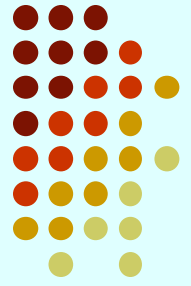
3 POINT LINING

Curves in O / L

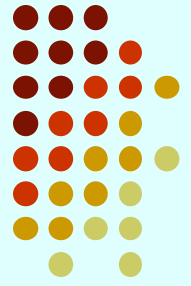


- Not very popular,
- R based on average versine calculated after ROC,
- $H1 = 23617/R$ & fed,
- Slews from ROC in design mode.

CALCULATION OF VERSINES ON TRANSITION FOR CIRCULAR CURVE WITH TRANSITION



CURVE WITH TRANSITION



- Calculate $H = 23617 / R$,
- Calculate $H_v = 23617 / R * L$,
(23617 is System constant value= $\frac{a \times b}{2} \times 1000$)
- Versine in **section A**, $H_A = K_{AC} / R * L$,
(K_{AC} is Operation constant value)
- Versine increases from **end of A** to end of transition @ H_v **per meter**,
- Versine in **section B**, $H_B = H - H_D$
- Versine in **section C**, $H_c = H - H_A$

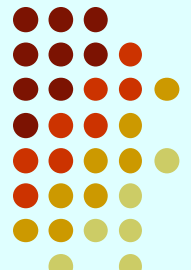
CURVE WITH TRANSITION

...Contd...

- Versine decreases from **end of C** to end of transition @ **H_v per meter**,
- Versine in **section D**, **$H_D = K_{BD} / R * L$** .
(**K_{BD} is Operation constant value**)

Sample calculation

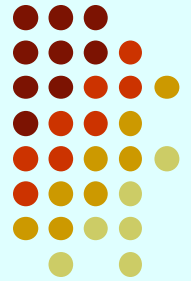
$R=300$ m, $L=50$ m, $H=23617/R=78.7$ mm,
 $Hv=23617/(R \times L) = 1.57$, $R \times L=300 \times 50=15000$



Constant for 'A' (K_{AC})	0	425	3399	11417	27191	53107	90534	135455	153120
Meter after T1/T2	0	2	4	6	8	10	12	14	14.75
Versine in section 'A' = $K_{AC}/R \times L$	0	0	0.2	0.8	1.8	3.5	6	9	10.2
Versine in section 'C' = $H - A$	78.7	78.7	78.5	77.9	76.9	75.2	72.7	69.7	68.5
Constant for "D" (K_{BD})	195238	148428	104167	65004	33489	12170	2362	48	0
Meter after T1/T2	0	2	4	6	8	10	12	14	14.75
Versine in section "D" = $K_{BD}/R \times L$	13	9.9	6.9	4.3	2.2	0.8	0.2	0	0
Versine in section 'B' = $H - D$	65.7	68.8	71.8	74.4	76.5	77.9	78.5	78.7	78.7

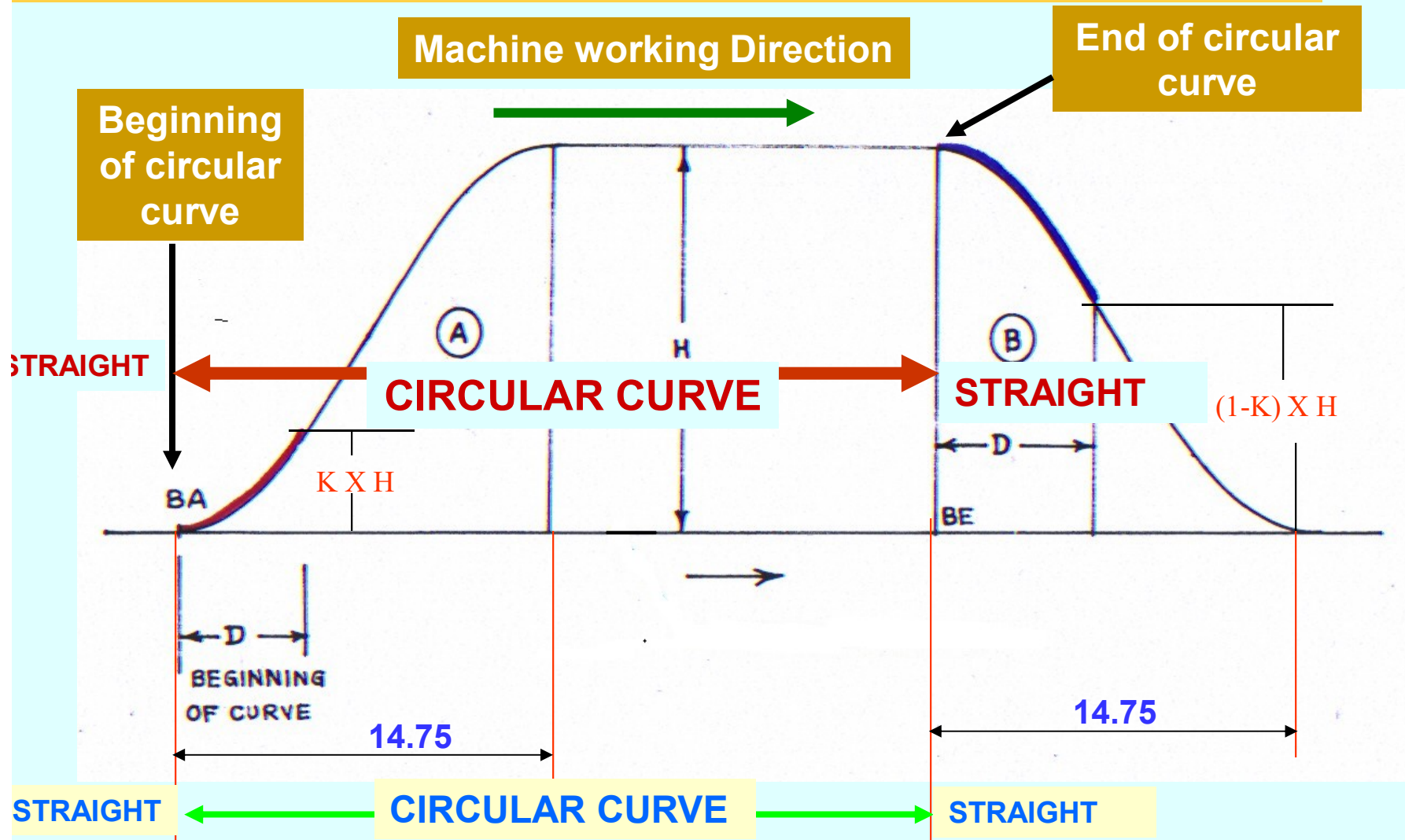
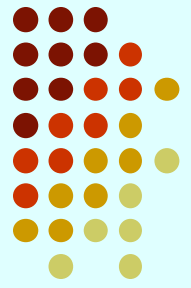


CIRCULAR CURVE WITHOUT TRANSITION



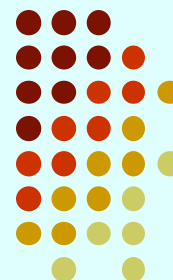
- Calculate $H = 23617^* / R$ (Value of * changes with machine, for DUO $^* = 25064$)
- Calculate the value of H from the beginning of curve till machine is completely on circular curve
 - It varies from 0 to H over a distance of measuring base which is 14.750m,
- Similarly work out the value of versine while machine is coming out of curve,
 - It varies from H to 0 over a distance of measuring base which is 14.750m.

CALCULATION OF VERSINES ON TRANSITION FOR CIRCULAR CURVE 'WITHOUT TRANSITION'



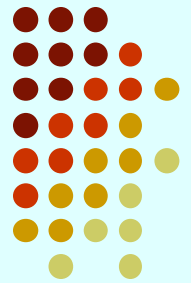
VERSINE FOR CURVES WITHOUT TRANSITION CURVE

R = 300, H = 23617/R = 78.7



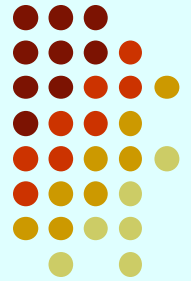
	SECTION A		SECTION B	
METERS AFTER BA/BE	CONSTANT	VERSINE= CONSTANT×H	CONSTANT	VERSINE= CONSTANT×H
BA/BE	0	0	1 X 78.7	78.7
1	0.007	0.6	0.993	78.1
2	0.027	2.1	0.973	76.6
3	0.061	4.8	0.939	73.9
4	0.108	8.5	0.892	70.2
5	0.169	13.3	0.831	65.4
6	0.243	19.1	0.757	59.6
7	0.331	29	0.669	52.7
8	0.432	34	0.568	44.7
9	0.546	43	0.454	35.7
10	0.675	53.1	0.325	25.6
11	0.797	62.7	0.203	16
12	0.891	70.1	0.109	8.6
13	0.956	75.2	0.044	3.5
14	0.992	78.1	0.088	0.6
14.75	1	78.7	0	0

VERSINES FOR TRANSITIONS IN REVERSE CURVES



- Versine in **section A of second (reverse) transition**, $H_{A2} = K_{AC} / R * L$,
(K_{AC} is Operation constant value)
- Versine in **section D of previous transition**, $H_{D2} = K_{BD} / R * L$,
(K_{BD} is Operation constant value)
 $H_A \text{ reverse} = H_{D1} - H_{A2}$

VERSINES FOR REVERSE CURVES (WITHOUT TRANSITION)



- Versine in **section A of second curve,**

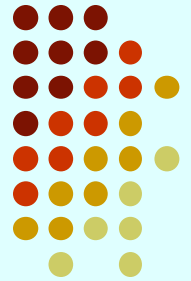
$$H_{A2} = K_{A2} * H_2,$$

- Versine in **section B of previous curve,**

$$H_{B1} = K_{B1} * H_1,$$

$$H_A \text{ reverse} = H_{B1} - H_{A2}$$

OVER SLEW

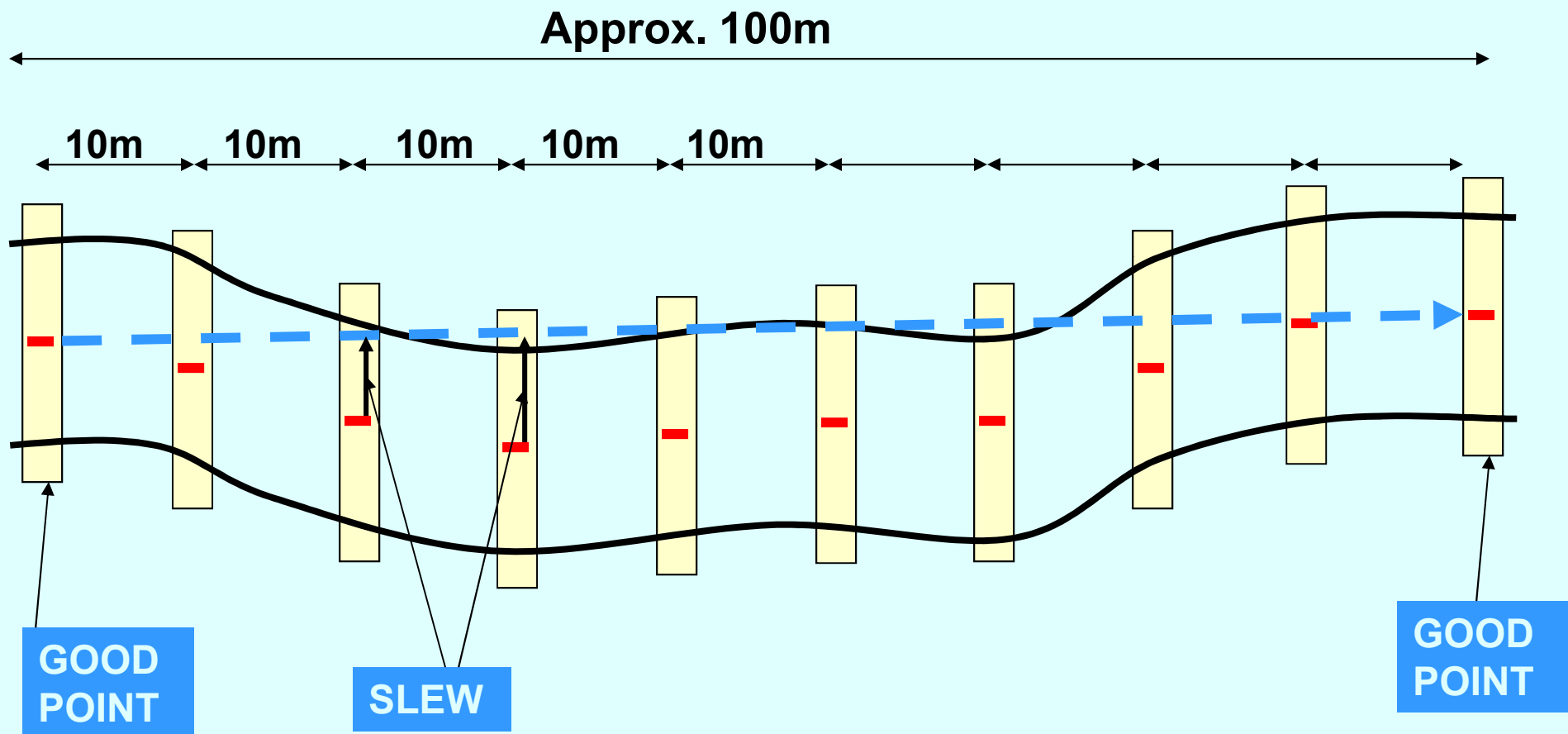
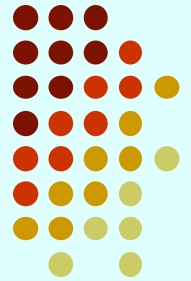


- In case of heavy slews or places where ballast resistance is very heavy, track may go back by small part of the slew, actually given,
- **Over slew switch** can be utilized at such locations to ensure that proper alignment is achieved after tamping.

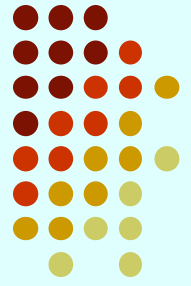
DESIGN LINING –3 POINTS ON STRAIGHT

- Curve of infinite radius- $H_1=0$,
- Find out slews on long chord (80-300 m),
- Correction of kinks at joint & weld,
- Distribute slews on every 2nd /3rd sleeper,
- Run the CSM/Tamping Express & feed the slews.

MEASUREMENT OF SLEWS ON STRAIGHT TRACK

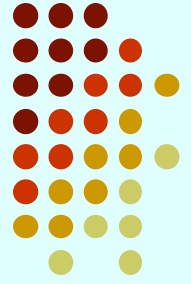


Topics to be discussed today



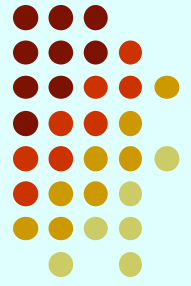
1. 4 point lining method for straight & circular
2. 4 point lining method in transition curve
3. 4 point lining method in design mode

4 POINTS LINING SMOOTHENING MODE



- Not on straights:
- On curve:
 - Versine is not required to fed.
 - Transition curve requires correction.

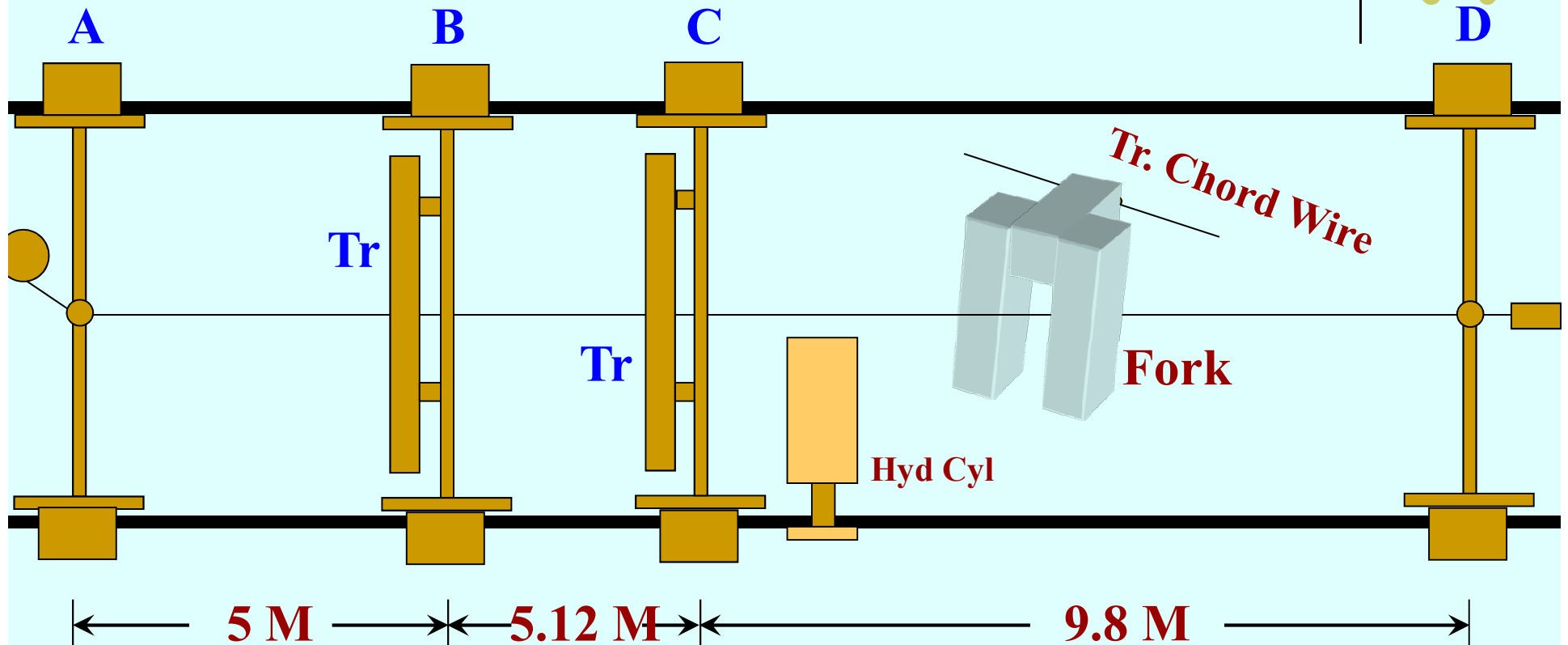
4 POINTS LINING- DESIGN MODE



- Not on straights,
- On curves:
 - Determine slews by ROC,
 - Enter slews in the **slew potentiometer**,
 - Correction in Transition curve in **versine potentiometer**,

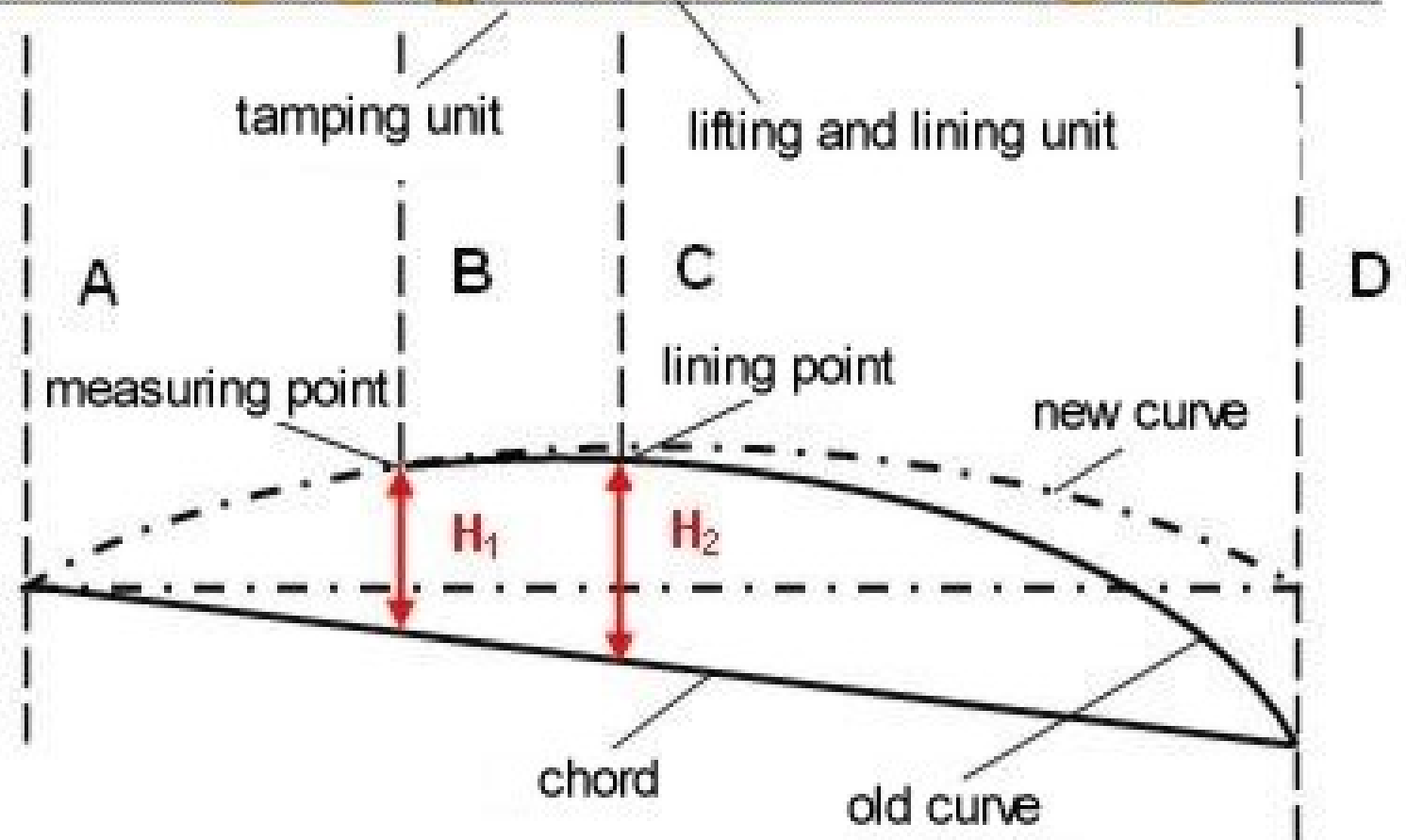
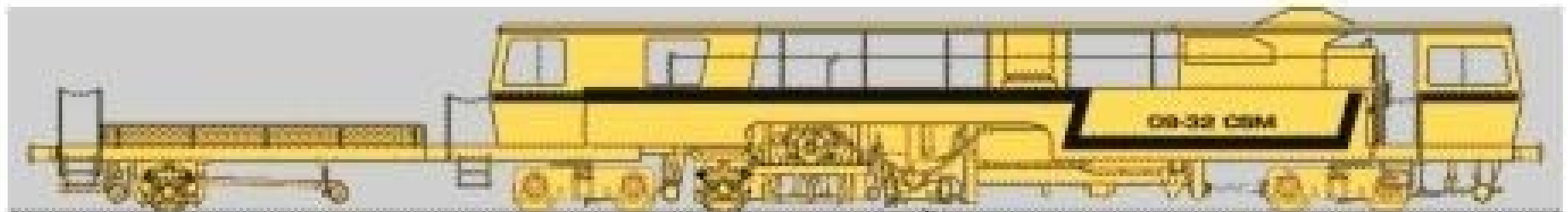
4 POINT LINING METHOD

Versine measuring Arrangement in WST machines

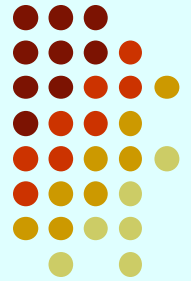


A = Rear Bogie : B = Measuring Bogie : C = Lining Bogie : D = Front Bogie
Tr = Versine Measuring Transducer
(For other tamping machines Chord length may vary)

direction of work



4 POINTS LINING PRINCIPLE

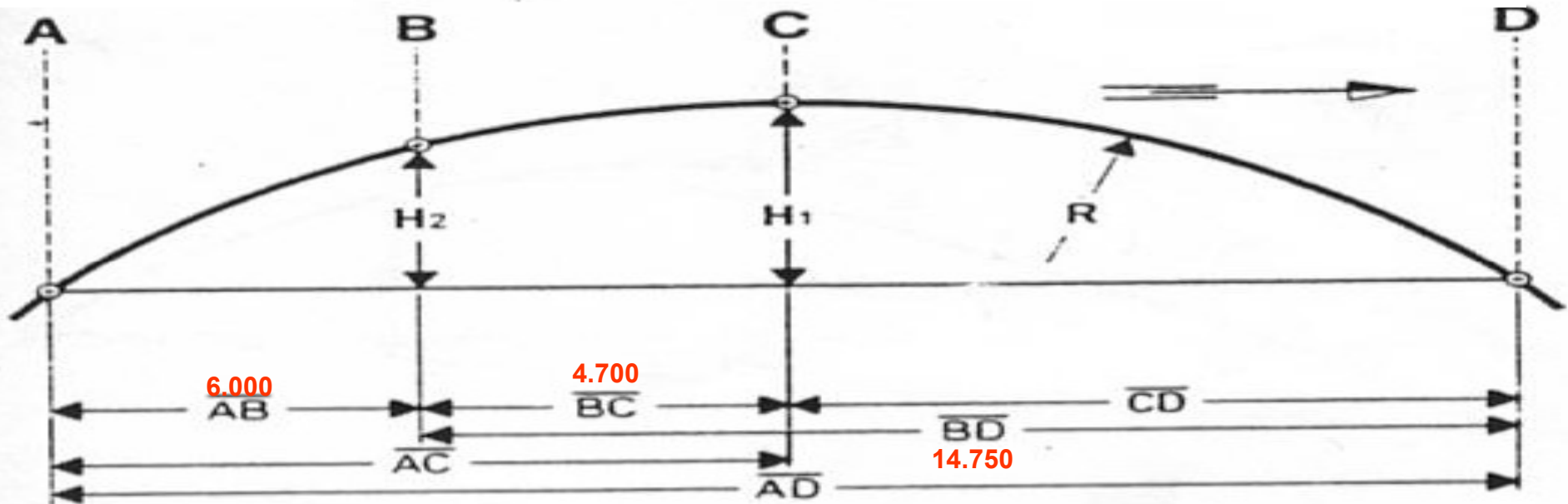


REAR TIGHTENING
TROLLY

MEASURING TROLLY

LINING TROLLY

FRONT
TROLLY



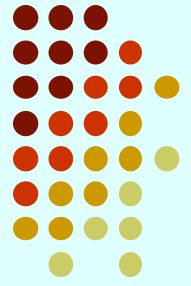
$$i = \frac{H_1}{H_2} = \frac{AC \times CD}{AB \times BD}$$

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

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

For various distances for CSM, $i = 10.70 \times 10.050 / 6.000 \times 14.750$

$i = 1.21508$



- 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 .

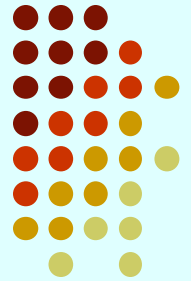
$$\text{Existing Versine } H1 = \frac{AC \times CD}{2R}$$

$$\text{Theoretical Versine } H2 = \frac{AB \times BD}{2R}$$

$$\text{Versine Ratio } i = \frac{H1}{H2} = \frac{AC \times CD}{AB \times BD}$$

$$H1 = i \times H2$$

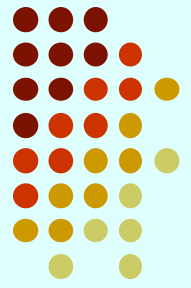
Hence, lining is done at Point C until Versine H1 is in the correct ratio to H2 ($H1 = i \times H2$) at Point B.



- 
- 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.

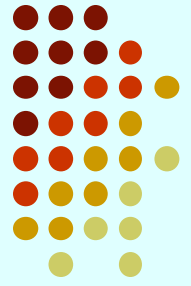


For CSM ERROR REDUCTION RATIO,
 $n = AD \times BD / AC \times BC = 20.750 \times 14.750 / 10.700 \times 4.700 = 6.0859$



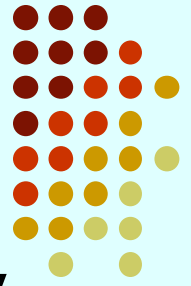
- Points A & B are on the already lined track behind the machine.
- Point D is on the disturbed position with lining error **FD**, resulting in new Versine H2.
- Point C is now lined until H1 is in the correct ratio to H2.
- Depending on the measuring point distances (**Error reduction ratio 'n'**), an error remains at lining Point C, which is called **Left over error or Residual error 'FR'**.
- **$FR = FD/n$**

$$F_R = F_D / N$$



- N = Error reduction ratio which depends on bogie distances and does not depend upon R .
- $N = (AD \times BD) / (AC \times BC)$
- FOR 08- MACHINE $AD = 20M$; $BD = 15M$; $AC = 10M$ & $BC = 5M$
- $N = (20 \times 15) / (10 \times 5) = 6$
- HENCE $F_R = F_D / 6$

Calculation of n

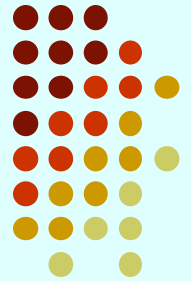


- Initial alignment defect is F_d at front trolley.
- Proportionate error at Lining trolley
 $X_1 = F_d \times AC / AD$
- Proportionate error at Measuring trolley
 $X_2 = F_d \times AB / AD$.

Measuring potentiometer measures $H_2 + X_2$

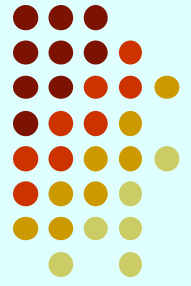
Lining potentiometer measures $H_1 + X_1$.

Calculation of n



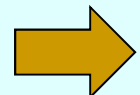
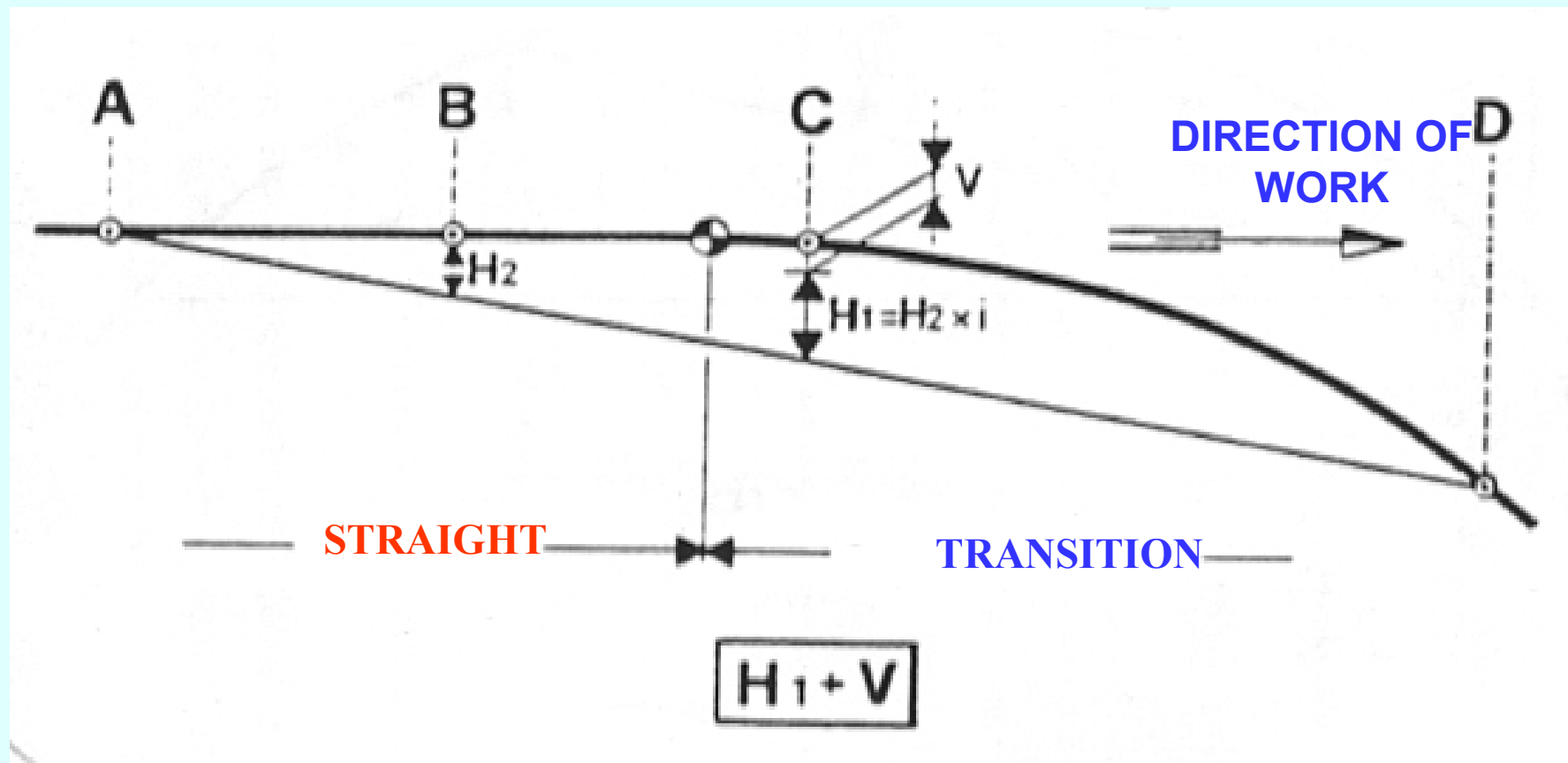
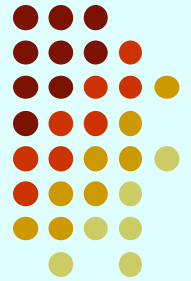
- $H1 + X1 - (iH2 + iX2)$
- $iH2 + X1 - iH2 - iX2 = X1 - iX2 = Fd \times AC/AD$
– $\{AC \times CD / AB \times BD\} \times Fd \times AB/AD$
- $Fd \times AC/AD \{1 - CD/BD\}$
- $Fd \times AC \times BC / (AD \times BD)$
- $Fd / (AD \times BD / AC \times BC)$
- Fd/n where $n = (AD \times BD / AC \times BC)$

**n depends on bogie distances,
which is as under for different
machines**

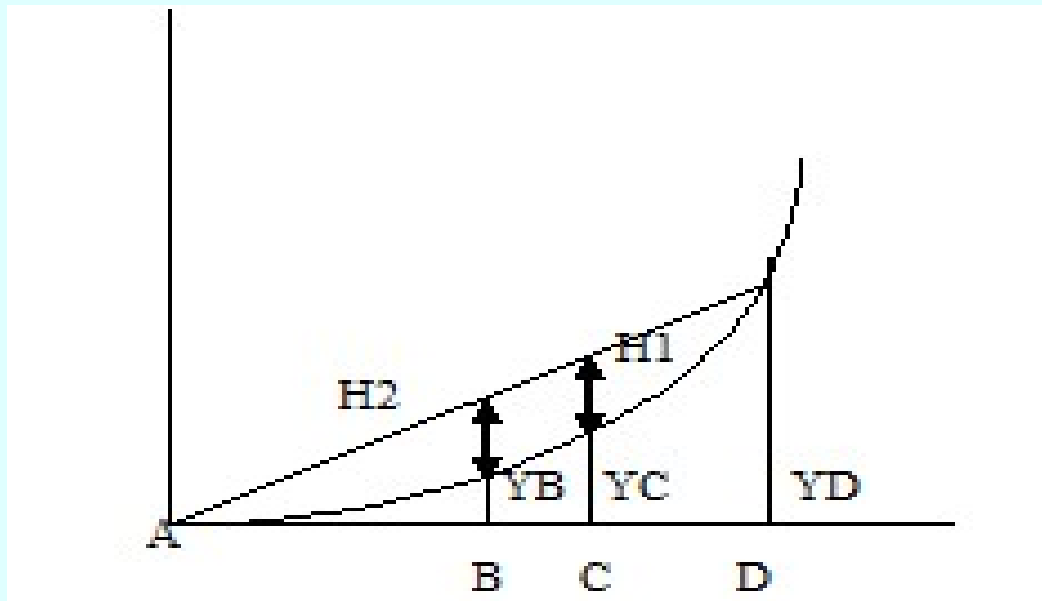
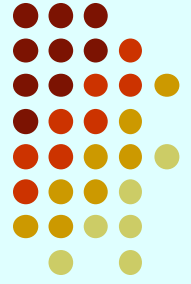


● <u>Machine</u>	<u>n - value</u>
● 08-UNO/DUO	= 6
● 08-275 UNIMAT	= 6.42720
● 08-275 UNIMAT 3S	= 7.61997
● 08-32 WST	= 5.7411
● 9-32 CSM	= 6.27692
● 09-3X TAMPING EXPRESS	= 6.47

PRINCIPLE OF ADJUSTMENT ON TRANSITION



CALCULATION OF V_m VALUE

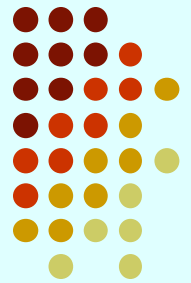


$$YD = AD^3/6RL$$

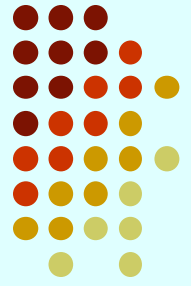
$$YC = AC^3/6RL$$

$$YB = AB^3/6RL$$

CALCULATION OF V_m VALUE

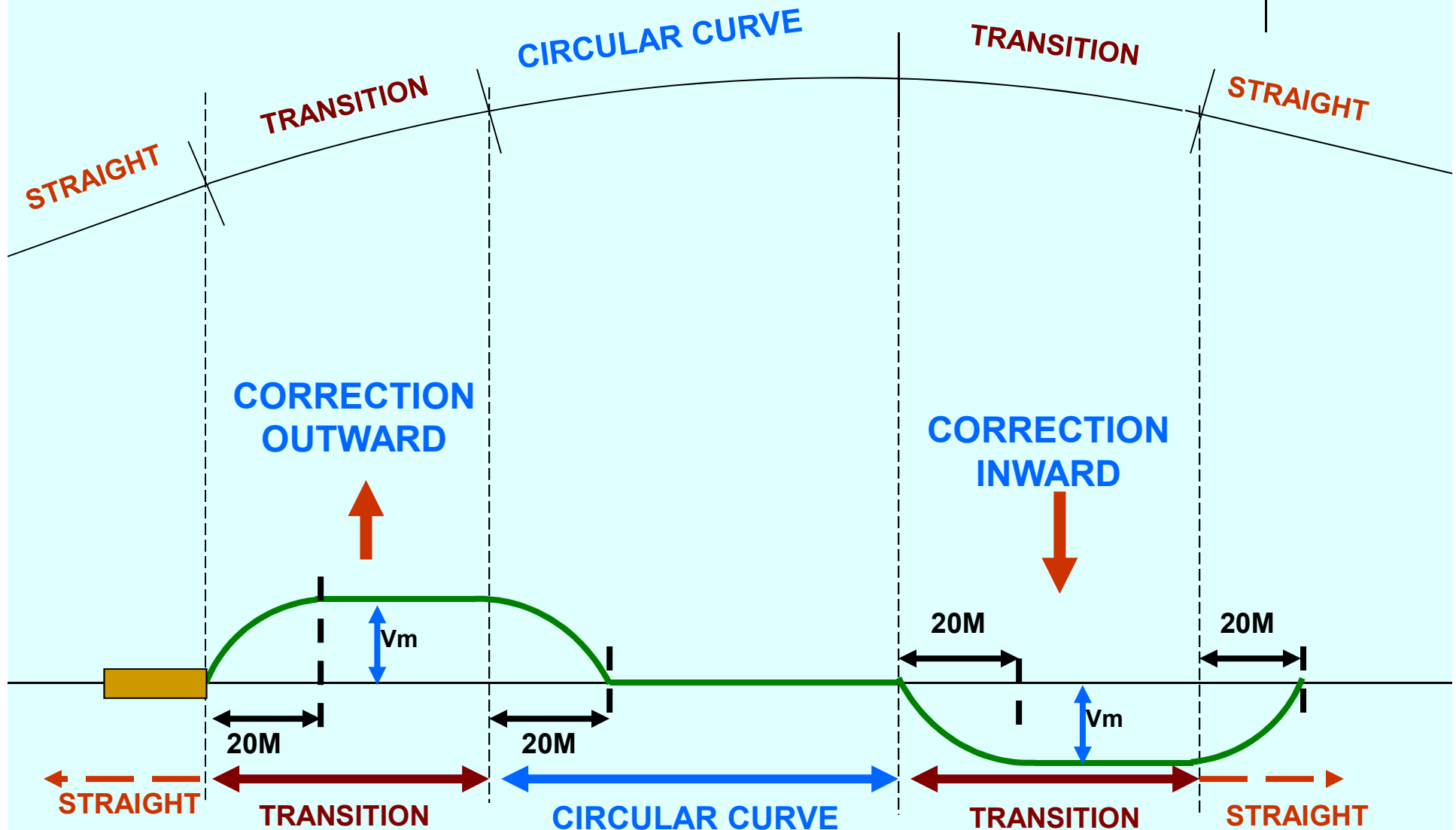
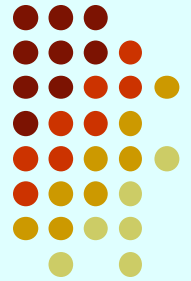


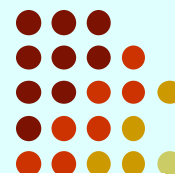
- $H1 = YD * AC/AD - YC$
- $H1 = YD * AC/AD - AC^3/6RL$
- $H1 = AD^3/6RL * AC/AD - AC^3/6RL$
- $H1 = AC/6RL(AD^2 - AC^2)/6RL$
- $H1 = AC(AD - AC) * (AD + AC)/6RL$
- $H1 = AC * CD * (AD + AC)/6RL$
- $H2 = YD * AB/AD - YB$
- $H2 = AD^3/6RL * AB/AD - AB^3/6RL$
- $H2 = AB * (AD^2 - AB^2)/6RL$
- $H2 = AB * (AD - AB) * (AD + AB)/6RL$



- $H2 = AB \cdot BD \cdot (AD + AB) / 6RL$
- $i = AC \cdot CD / AB \cdot BD$
- $iH2 = AC \cdot CD \cdot AB \cdot BD \cdot (AD + AB) / AB \cdot BD \cdot 6RL$
 $= AC \cdot CD \cdot (AD + AB) / 6RL$
- $H1 - iH2 = AC \cdot CD \cdot (AD + AC) / 6RL -$
 $AC \cdot CD \cdot (AD + AB) / 6RL$
 $= AC \cdot CD [AD + AC - AD - AB] / 6RL$
 $= AC \cdot CD [AC - AB] / 6RL$
- **$V_m = AC \cdot CD \cdot BC / 6RL$**

ADJUSTMENTS DUE TO TRANSITION IN 4 POINTS LINING





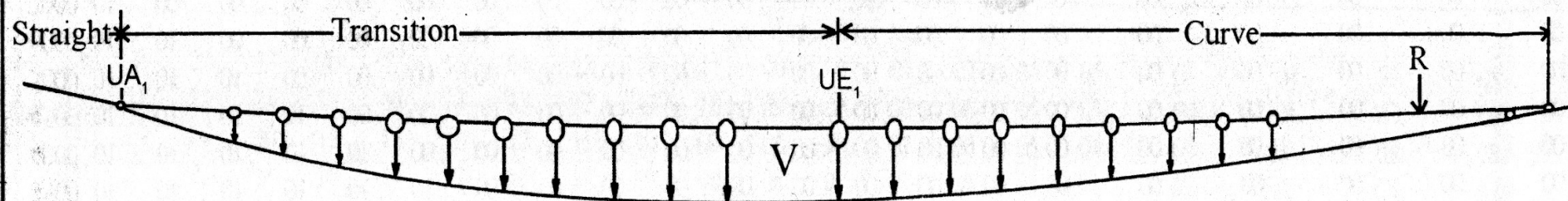
$L \rightarrow$ $R \downarrow$	20	25	30	35	40	45	50	55	60	65	70	75	80	100	120
	Values of V_m														
120	34	27	23	20	17	15	14	12	11	11	10	09	09	07	06
130	32	25	21	18	16	14	13	12	11	10	09	08	08	06	05
140	29	24	20	17	15	13	12	11	10	09	08	08	07	06	05
150	27	22	18	16	14	12	11	10	09	08	08	07	07	05	05
160	26	21	17	15	13	11	10	09	09	08	07	07	06	05	04
170	24	19	16	14	12	11	10	09	08	07	07	06	06	05	04
180	23	18	15	13	11	10	09	08	08	07	07	06	06	05	04
190	22	17	14	12	11	10	09	08	07	07	06	06	05	04	04
200	21	16	13	12	10	09	08	07	07	06	06	05	05	04	03
220	19	15	12	11	09	08	07	07	06	06	05	05	05	04	03
240	17	14	11	10	09	08	07	06	06	05	05	05	04	03	03
260	16	13	11	09	08	07	06	06	05	05	05	04	04	03	03
280	15	12	10	08	07	07	06	05	05	05	04	04	04	03	02
300	14	11	09	08	07	06	05	05	05	04	04	04	03	03	02

[illegible]



V- Values Adjustment Table (Approaching the Curve)

To Adjust Front Tower



Adjust after UA_1

Sleeper	0	11	14	16	17	18	20	21	23	25	32
Metres	0	6.6	8.4	9.6	10.6	11.5	12.4	13.2	14.2	15.5	20
Vm	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2	0	0	0	1	1	1	1	1	2	2	2
4	0	0	1	1	2	2	2	3	3	4	4
6	0	1	1	2	2	3	4	4	5	5	6
8	0	1	2	2	3	4	5	6	6	7	8
10	0	1	2	3	4	5	6	7	8	9	10
12	0	1	2	4	5	6	7	8	10	11	12
14	0	1	3	4	6	7	8	10	11	13	14
16	0	2	3	5	6	8	10	12	13	14	16
18	0	2	4	5	7	9	11	13	14	16	18

Adjust after UE_1

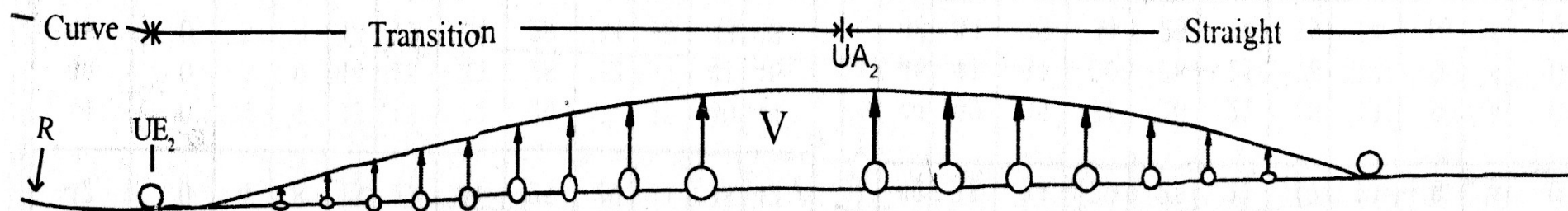
	0	11	14	16	17	18	20	21	23	25	32
	0	6.6	8.4	9.6	10.6	11.5	12.4	13.2	14.2	15.5	20
	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
2	2	2	2	1	1	1	1	1	0	0	0
4	4	4	3	3	2	2	2	1	1	0	0
6	5	5	5	4	4	3	2	2	1	1	0
8	7	6	6	6	5	4	3	2	2	1	0
10	9	8	8	7	6	5	4	3	2	1	0
12	11	10	10	8	7	6	5	4	2	1	0
14	13	11	11	10	8	7	6	4	3	1	0
16	14	13	13	12	10	8	6	5	3	2	0
18	16	14	14	13	11	9	7	5	4	2	0

↑ V-VALUE ADJUSTMENT ↓



V- Values Adjustment Table (Leaving the Curve)

To Adjust Front Tower



Adjust after UE_2

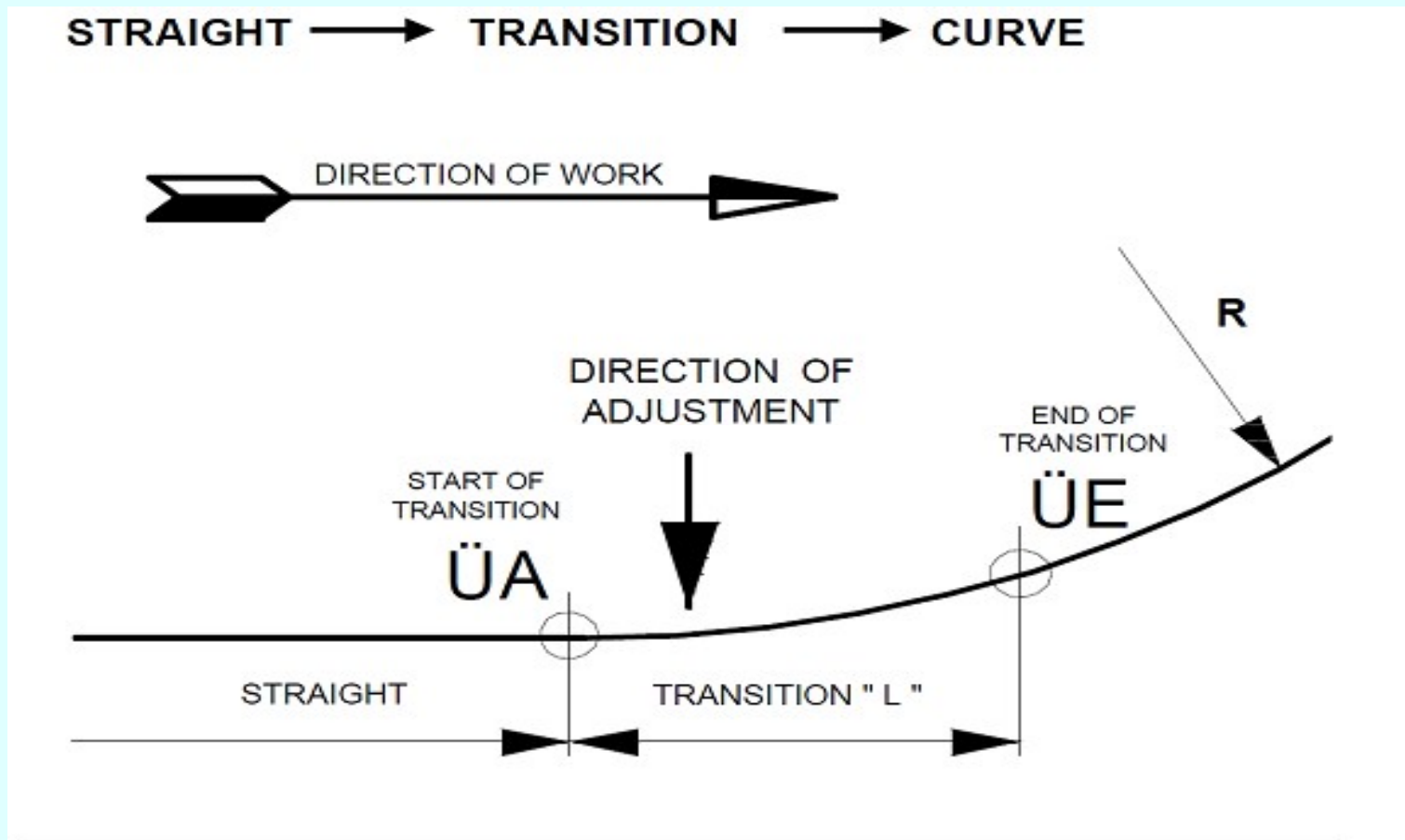
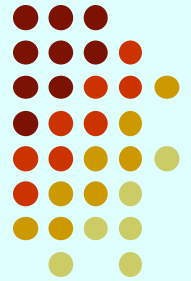
Sleeper	0	11	14	16	17	18	20	21	23	25	32
Metres	0	6.6	8.4	9.6	10.6	11.5	12.4	13.2	14.2	15.5	20
Vm	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2	0	0	0	1	1	1	1	1	2	2	2
4	0	0	1	1	2	2	2	3	3	4	4
6	0	1	1	2	2	3	4	4	5	5	6
8	0	1	2	2	3	4	5	6	6	7	8
10	0	1	2	3	4	5	6	7	8	9	10
12	0	1	2	4	5	6	7	8	10	11	12
14	0	1	3	4	6	7	8	10	11	13	14
16	0	2	3	5	6	8	10	12	13	14	16
18	0	2	4	5	7	9	11	13	14	16	18

Adjust after UA_2

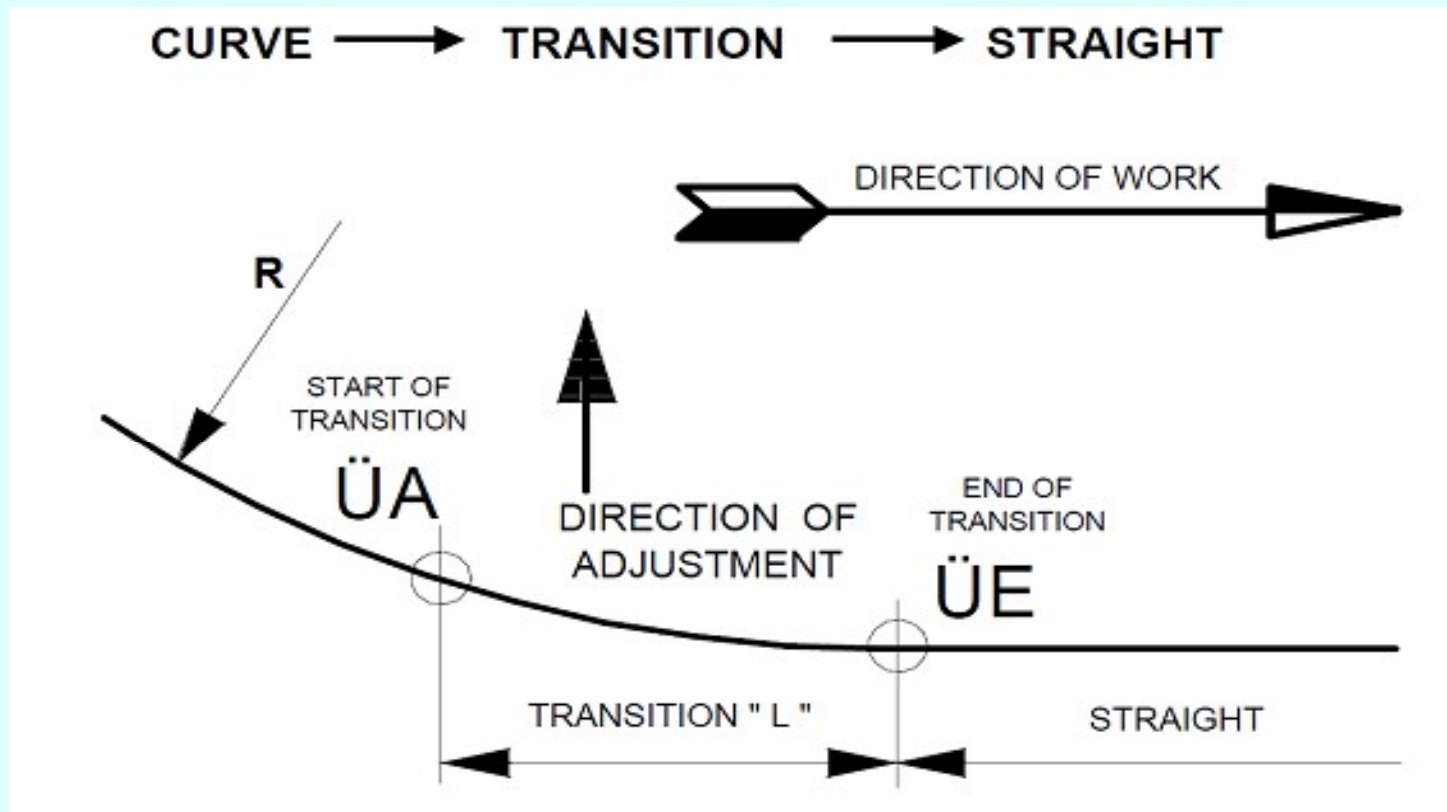
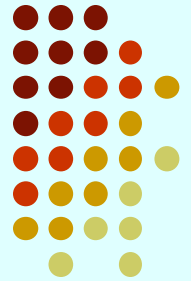
	0	11	14	16	17	18	20	21	23	25	32
	0	6.6	8.4	9.6	10.6	11.5	12.4	13.2	14.2	15.5	20
	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
2	2	2	2	1	1	1	1	1	0	0	0
4	4	4	3	3	2	2	2	1	1	0	0
6	5	5	5	4	4	3	2	2	1	1	0
8	7	6	6	6	5	4	3	2	2	1	0
10	9	8	8	7	6	5	4	3	2	1	0
12	11	10	10	8	7	6	5	4	2	1	0
14	13	11	11	10	8	7	6	4	3	1	0
16	14	13	13	12	10	8	6	5	3	2	0
18	16	14	14	13	11	9	7	5	4	2	0

V-VALUE ADJUSTMENT

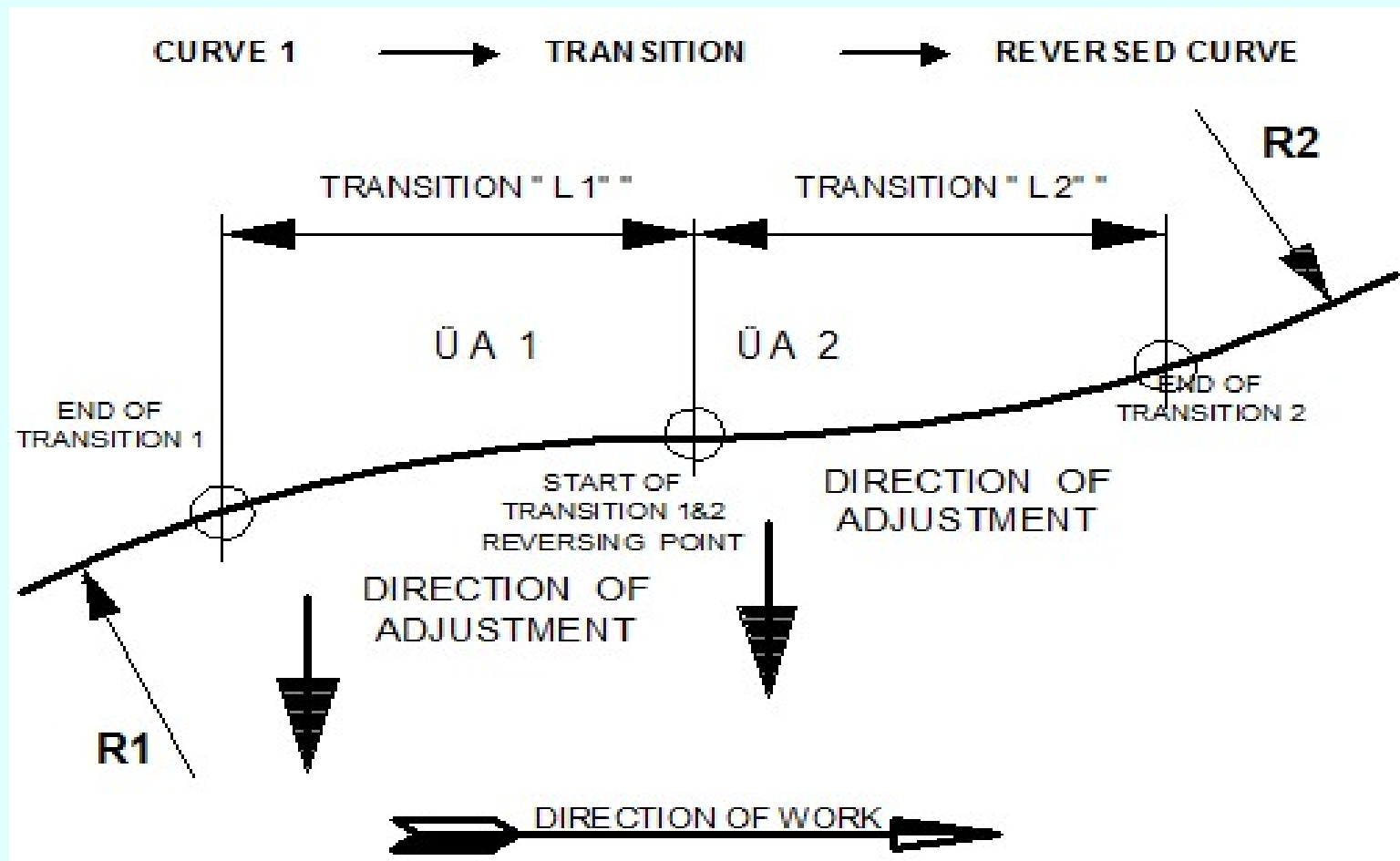
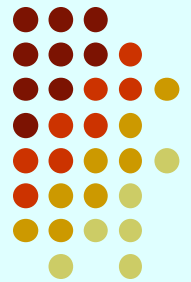
Direction of Toggle switch for Vm



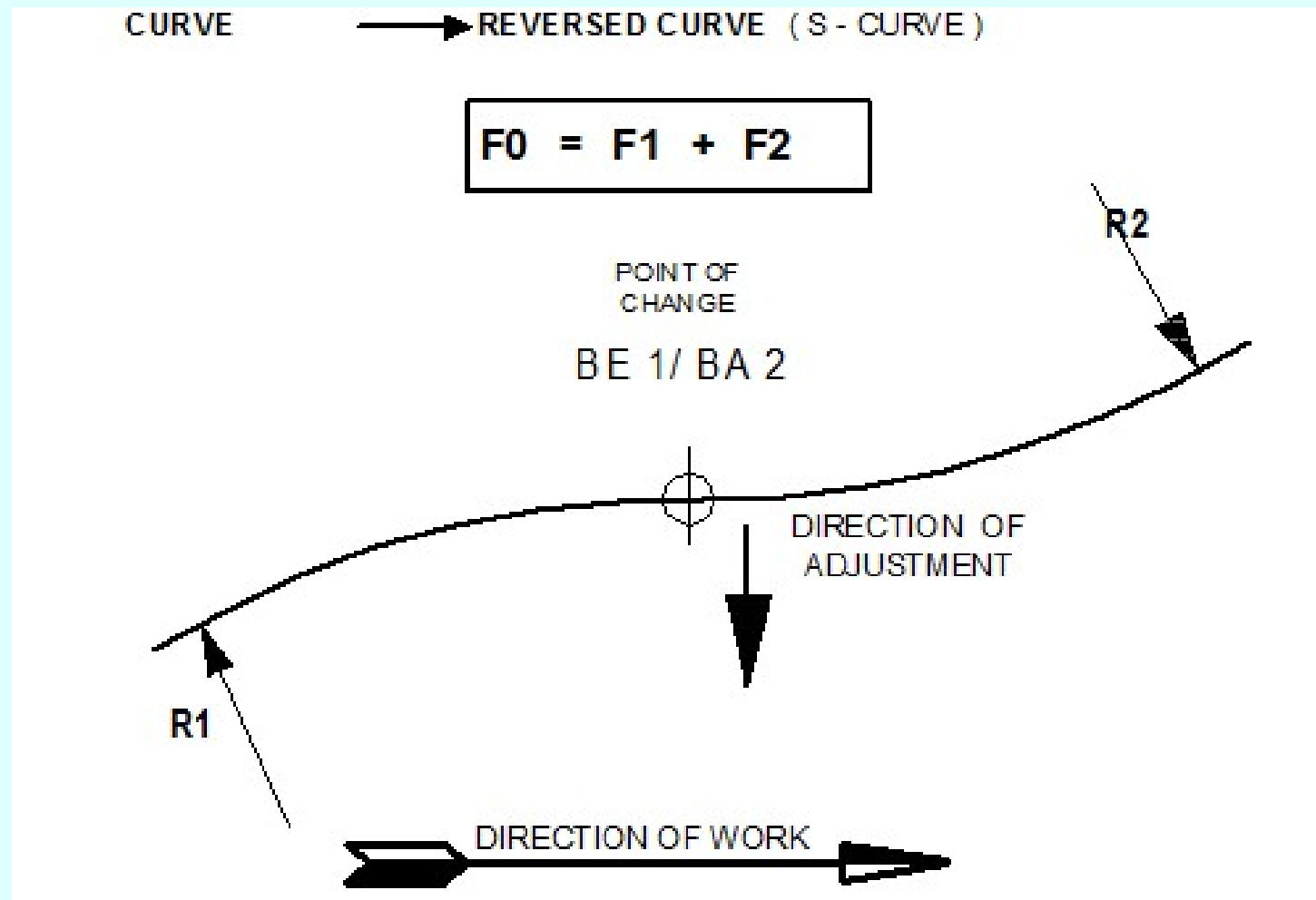
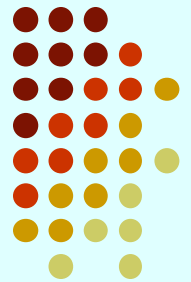
Direction of Toggle switch for Vm



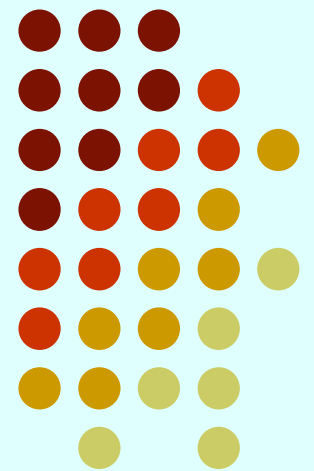
Direction of Toggle switch for Vm



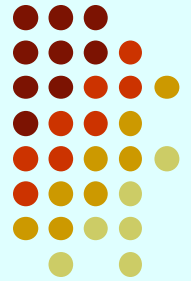
Direction of Toggle switch for Vm



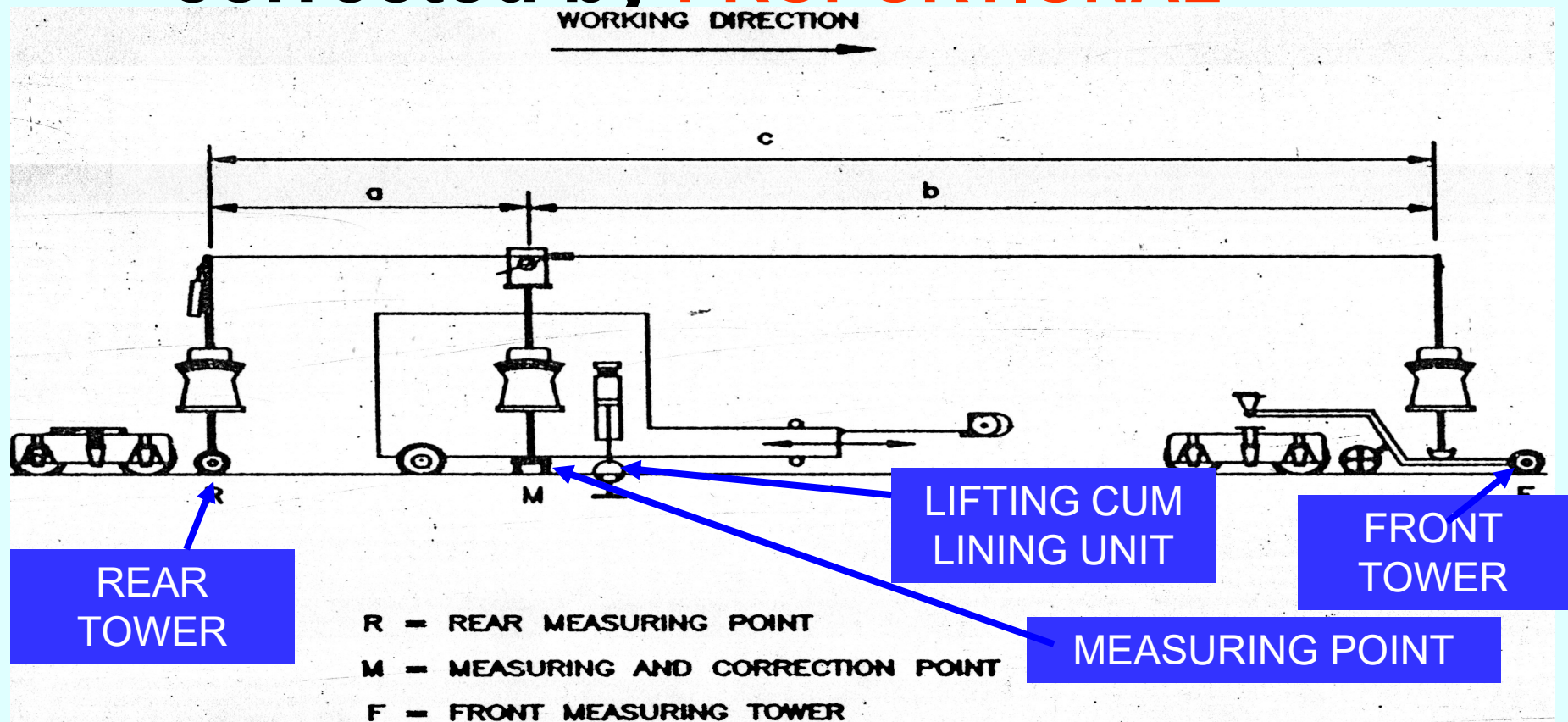
LEVELLING



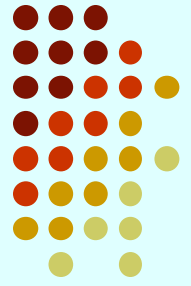
PRINCIPLE OF LEVELLING



- Longitudinal level of track is corrected by **PROPORTIONAL**

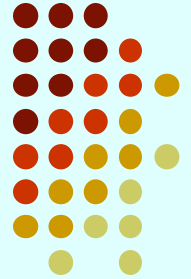


FUNCTION OF PENDULUMS & HEIGHT TRANSDUCER



- **FRONT PENDULUM:** For automatic cross level correction.
- **MIDDLE PENDULUM:** For indication only.
- **REAR PENDULUM:** For twist correction, recording purpose.
- **HEIGHT TRANSDUCER:** For measuring & correcting longitudinal level.

Position of front pendulum

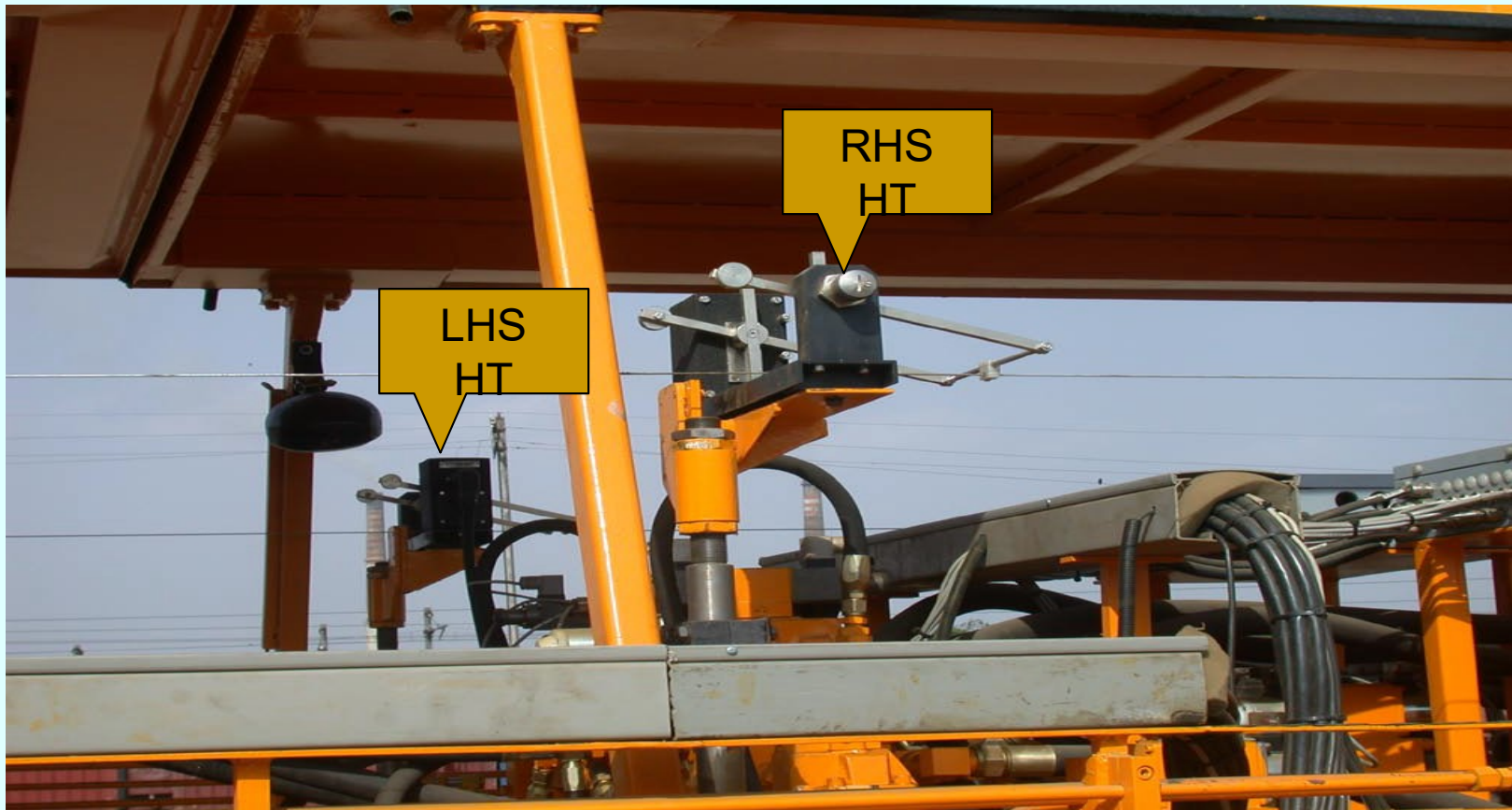
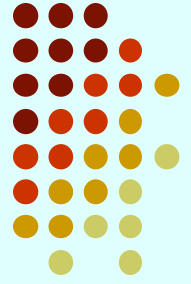


Front
pendulum

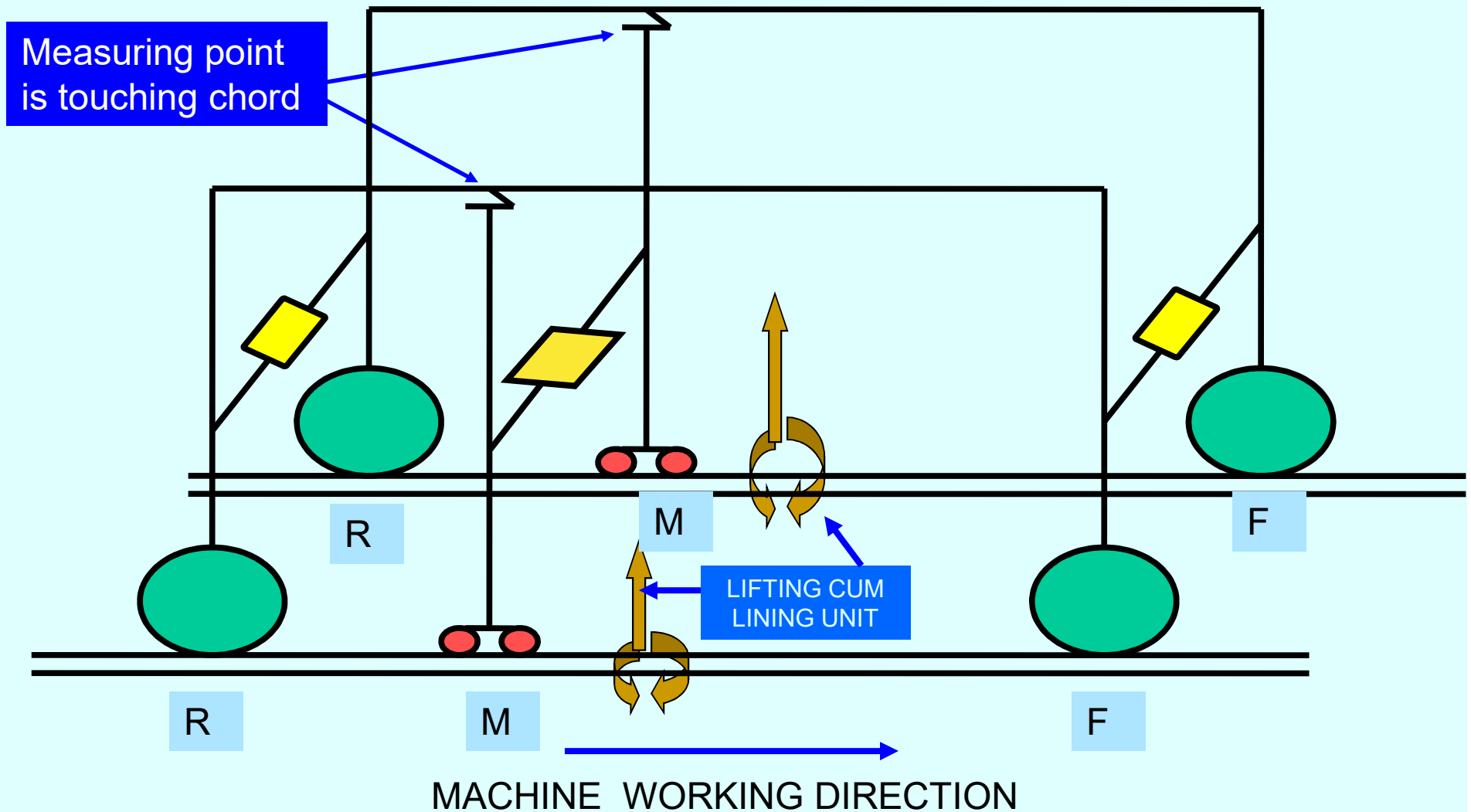
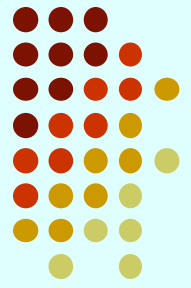
Front
Feeler rod



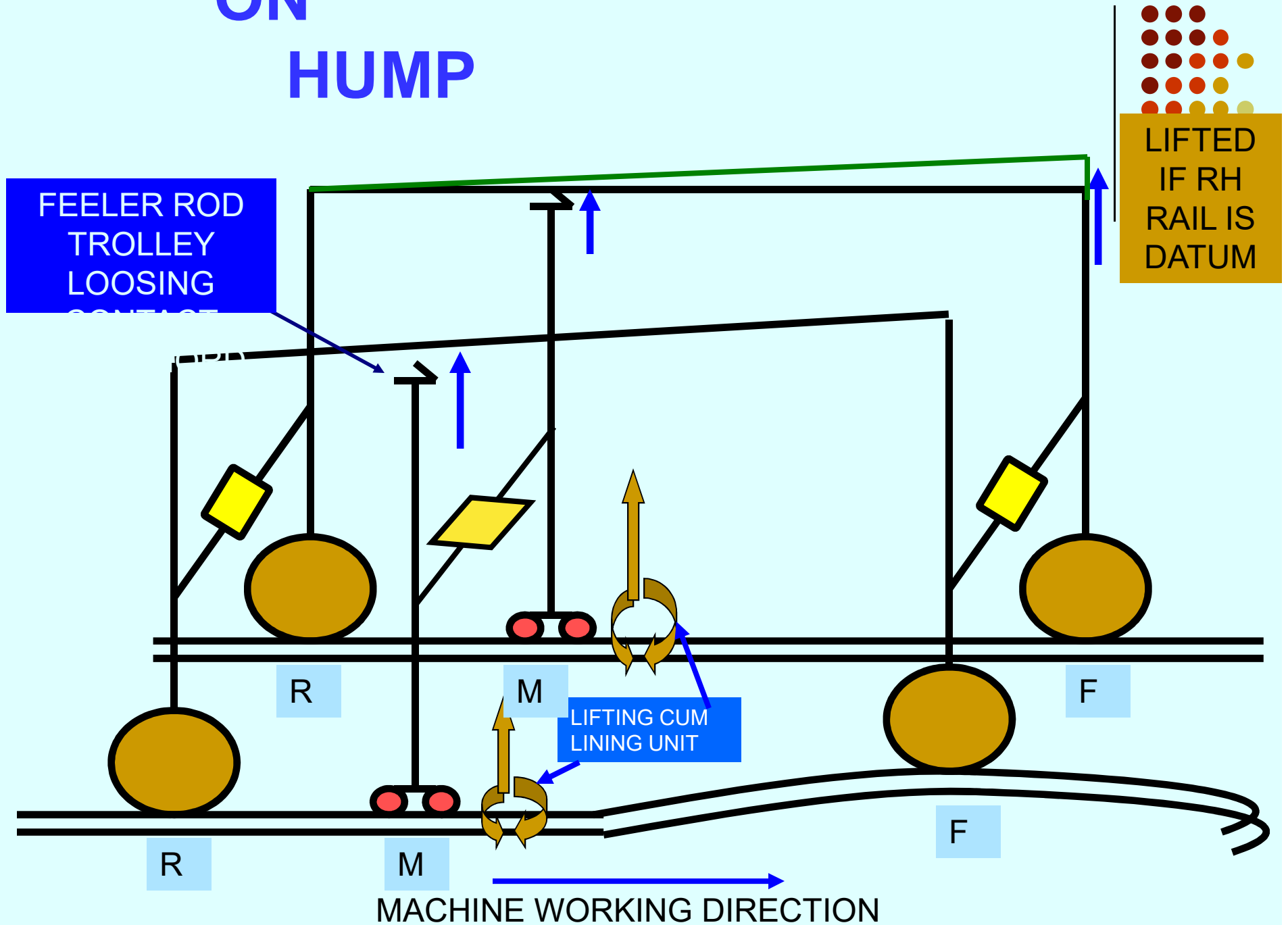
Height Transducer



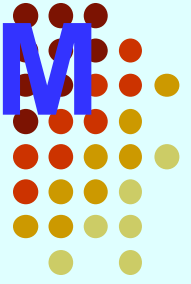
LEVELLING - MACHINE ON IDEAL TRACK



ON HUMP

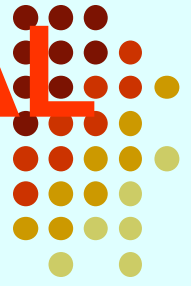


SELECTION OF DATUM RAIL



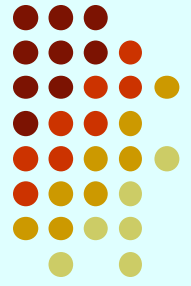
- **Curves-** **Inner Rail,**
- **Straight**
 - One with the **least** disturbance,
 - One which is **relatively higher,**
 - Double line- **Non cess Rail**
 - Single line- To be selected by **PWI**

DECISION FOR GENERAL LIFT

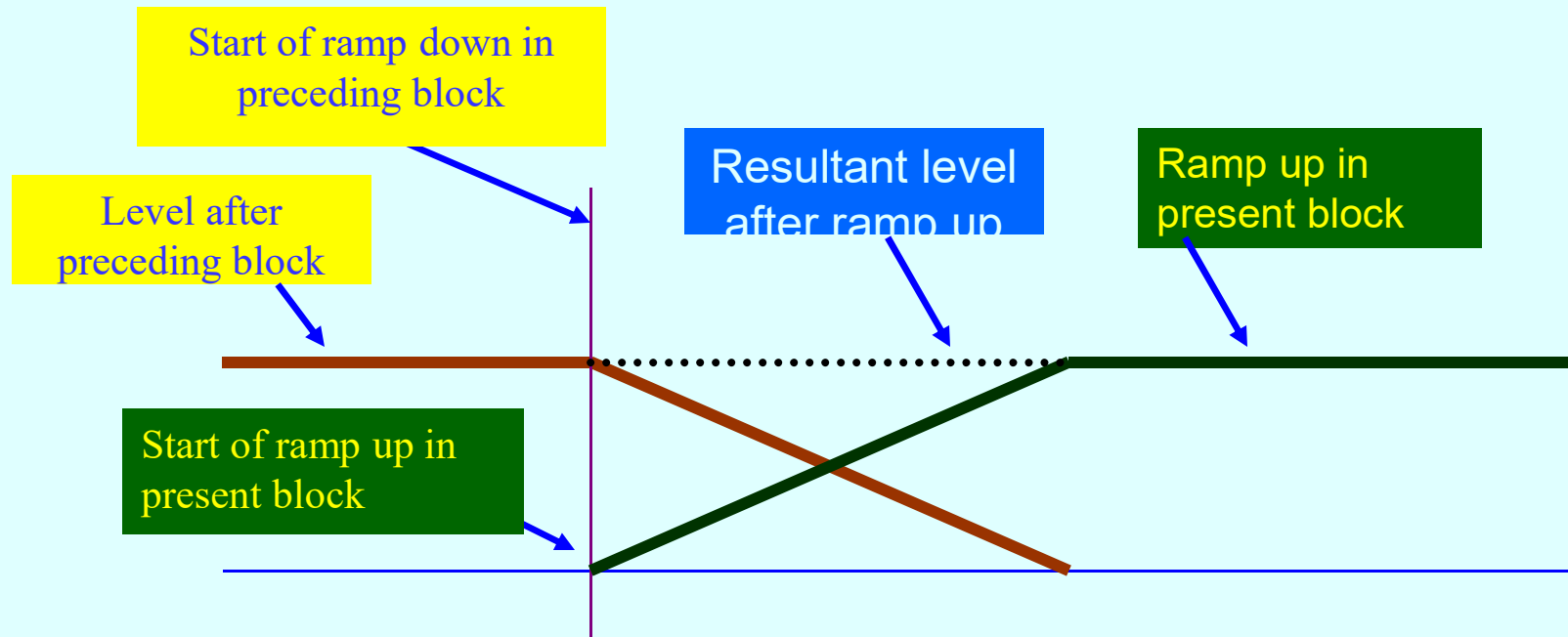


- **Lowering** is not possible,
- **Lifting-**
 - Upto **30mm**- - **1** insertion,
 - More than **30mm** - **2** insertions,
 - Not more than **50mm** at a time.
- **General Lift-** It should cover all existing undulations.
- Ramping up & down **1 in 1000**.

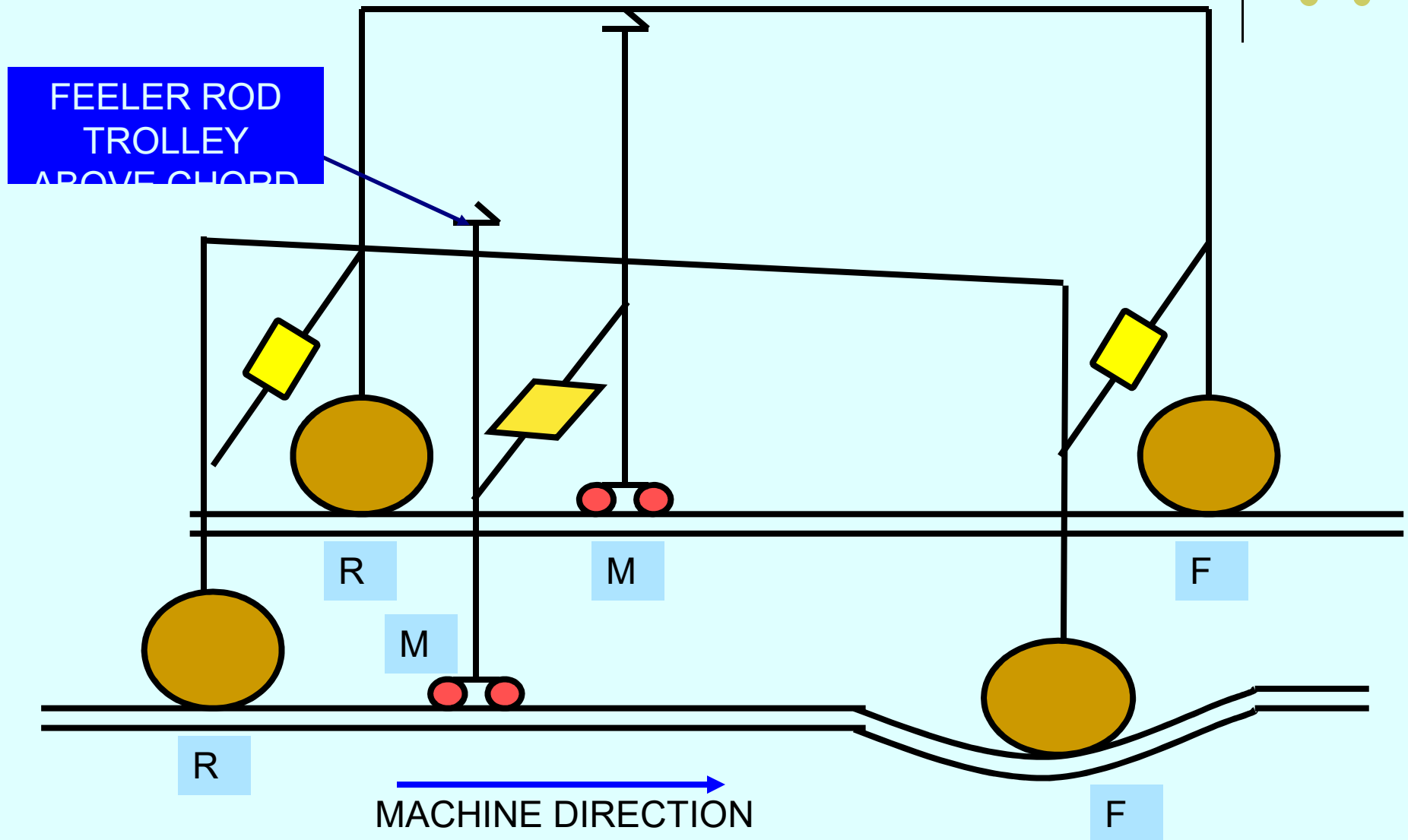
RAMP UP & RAMP DOWN OF GENERAL LIFT



- Ramping up & down is given at a rate of **1 in 1000**,
- While closing at the end of block, lift should be reduced to **zero** by ramp down,
- **While starting** ramp up, it should start at a place from where ramp down of last block was started.



LEVELLING – FRONT TOWER IN SAG

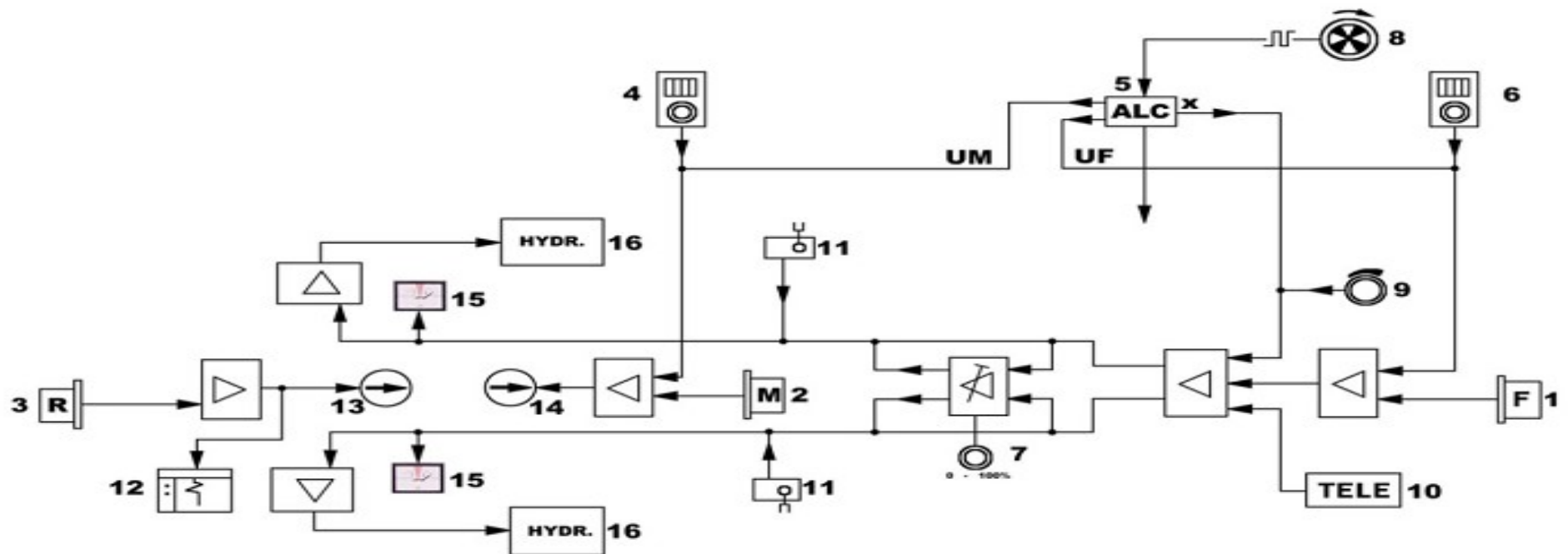
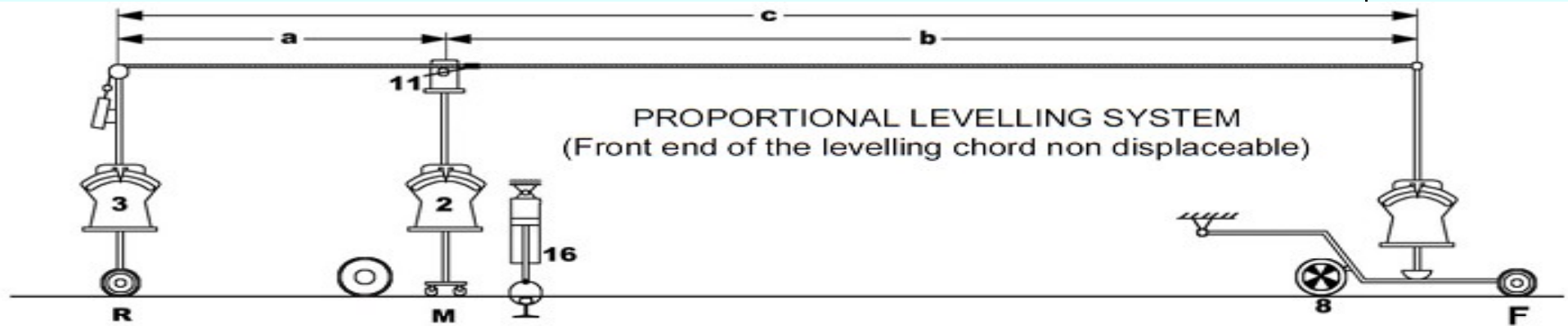
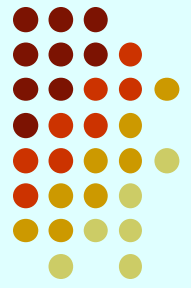


SAG
CORRECTED

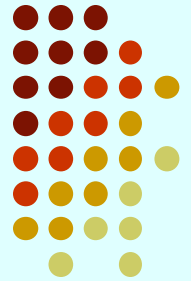


MACHINE
DIRECTION

LEVELLING -SYSTEM

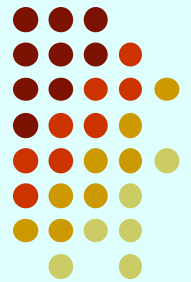


LEVELLING -SYSTEM



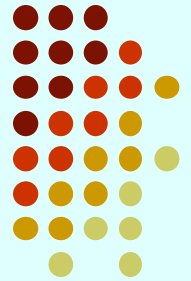
- 1 = Pendulum for measuring and automatic transmission of the cross level errors on the front levelling feeler rod "F".
- 2 = Pendulum for measuring the cross level on the centre levelling feeler rod (tamping area) "M".
- 3 = Pendulum for measuring the already tamped track at the rear levelling feeler rod "R" and for controlling the theoretical level automatically.
- 4 = Digital-potentiometer for manual input of the theoretical cross level for the pendulum, at the centre measuring point "M".
- 5 = Win ALC for automatic input of the theoretical cross levels and adjusting values of transition, inclinations, changes in lifting values, etc. (additional).
- 6 = Digital-potentiometer for manual input of the theoretical cross level for the pendulum, at the front measuring point "F".
- 7 = Regulator for the settlement compensation.
- 8 = Distance measuring transmitter for the Win ALC control.
- 9 = Manual input of the track lifting
- 10 = Remote control input of the track lifting values by means of radio control or laser (additional).

LEVELLING -SYSTEM



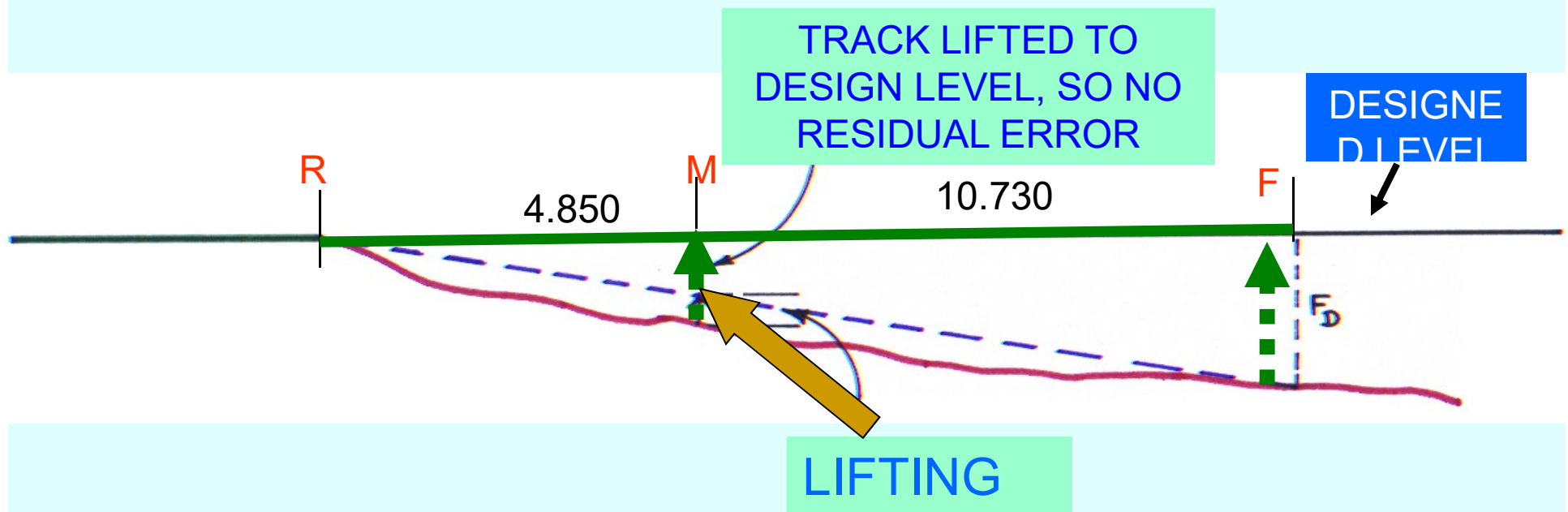
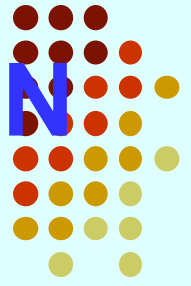
- 11 = Proportional transmitter on the centre levelling feeler rod (left and right) for measuring and automatically cut off of the track lifting.
- 12 = Cross level recorder (optional).
- 13 = Indication of the cross level after tamping (optional).
- 14 = Indication of the cross level after tamping (optional).
- 15 = Indication of the lift (left or right).
- 16 = Servo control of the hydraulic lifting (left and right).

MODE OF LEVELLING



- **SMOOTHENING MODE,**
 - Longitudinal levels of track are smoothened – **Errors are reduced.**
- **DESIGN MODE,**
 - Longitudinal levels are provided as per design.

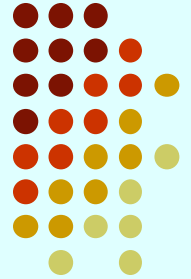
SMOOTHENING MODE/DESIGN MODE



$$\text{RESIDUAL ERROR} = F_D \times RM / RF$$

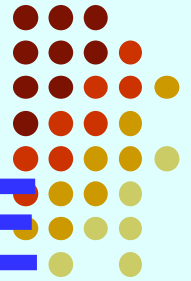
$$F_R = F_D \times 4.850 / 15.580 = F_D / 3.2$$

LIFTING RATIOS (c/a)



- **UT** - 4.3
- **UNO,DUO,CSM,MPT** - 3.0
- **UNIMAT** - 3.2

SMOOTHENING MODE

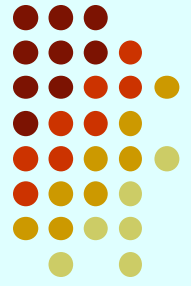


- **IN PLAIN / STRAIGHT TRACK,**
 - Decision of datum rail,
 - General lift
 - To be decided by **PWI /AEN,**
- **REDUCTION OF ERROR & NOT THE ELIMINATION.**

SMOOTHENING MODE



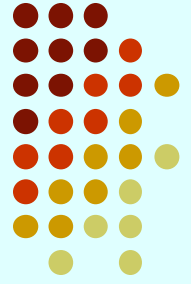
- **CURVED TRACK-**
 - Datum rail -Inner rail,
 - General lift,
 - Super elevation
 - To be decided by **PWI /AEN.**
 - **ADJUSTMENT IN TRANSITION.**
- **REDUCTION OF ERROR & NOT ELIMINATION.**



DESIGN MODE

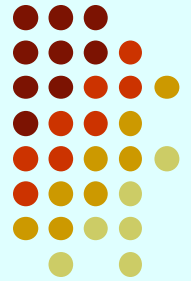
- **IN PLAIN / STRAIGHT TRACK-**
 - ❖ Decision of datum rail,
 - ❖ Lift values,
 - ❖ To be decided by **PWI /AEN**,
 - ❖ To be fed **in lift potentiometer**- In front cabin,
- **COMPLETE ELIMINATION OF ERRORS.**

DESIGN MODE



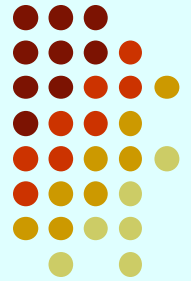
- **CURVED TRACK-**
 - ❖ Datum rail - Inner rail,
 - ❖ Super elevation,
 - ❖ Lift values & Adjustments in transition,
 - ❖ To be decided by **PWI /AEN**,
 - ❖ To be fed **in lift potentiometer**- In front cabin,
- **COMPLETE ELIMINATION OF ERRORS.**

SURVEY FOR VERTICAL PROFILE CORRECTION



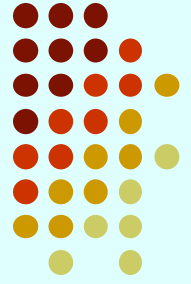
- Bench Marks fixing,
- Decide **datum rail**,
- Recording of Actual Rail levels **@10 m**,
- Plotting of existing level on graph paper,
- Decide **final track level and plot on same graph** – Considering **high points, low points any other** obligatory points,
- Formation Levels may also be plotted.

SURVEY FOR VERTICAL PROFILE CORRECTION



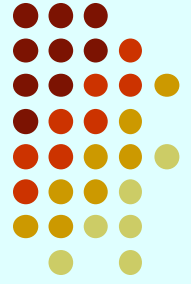
- Calculate lift at every station from graph,
- Alternatively- Calculate **lift** at **every station** by use of **TOP TRACK** software,
- Interpolate lift amount **on alternate** sleepers,
- Write down lift amount on sleepers,
- Enter into lift potentiometer **(in front cabin)**.

DESIGN LEVELLING



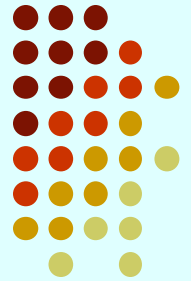
- In case of **CTR & NEW CONSTRUCTION**,
 - Even station to station variation may not be linear,
 - One round of **smoothing**,
 - Followed by **DESIGN MODE**.

TRANSFER FUNCTION

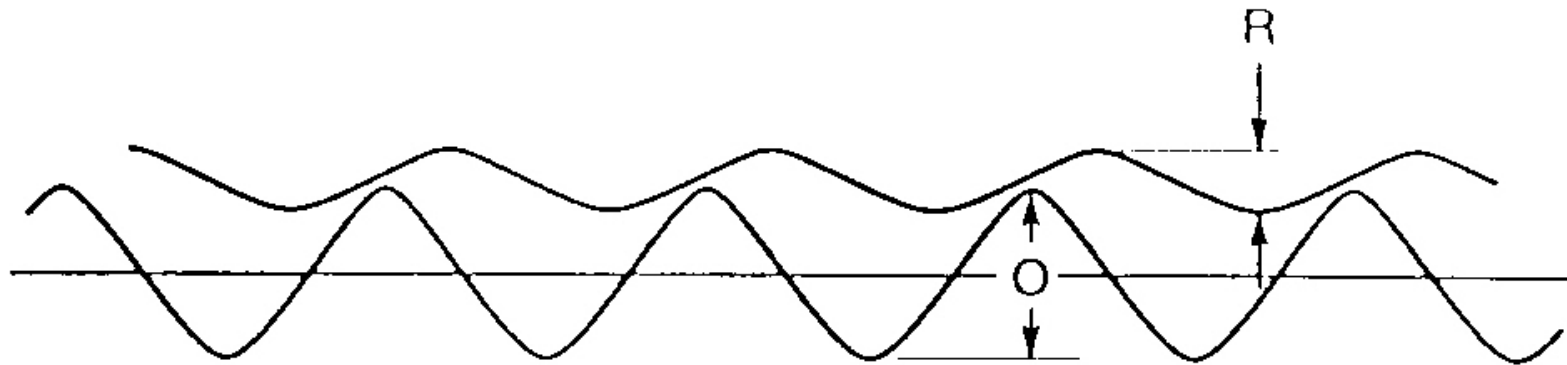


- The track may have defects of varying wave lengths,
- Machines have limited chord length, so the correction achieved by **smoothing mode** will certainly have residual defects on different wave lengths,
- It is the ratio of amplitude of fault remaining after tamping to fault before tamping.

TRANSFER FUNCTION

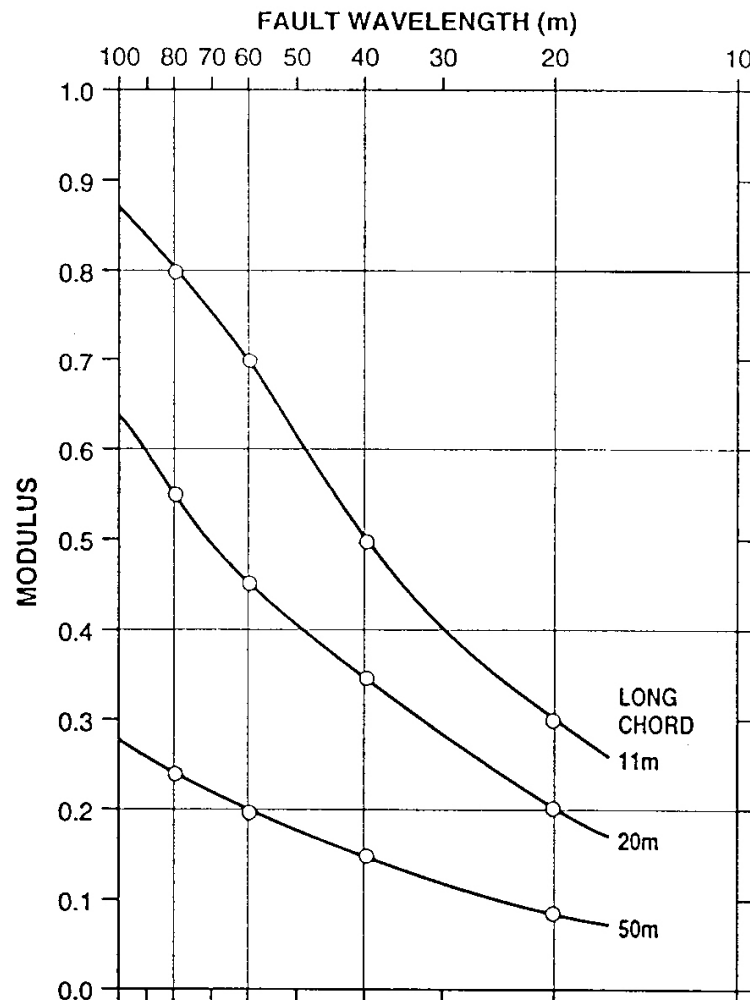
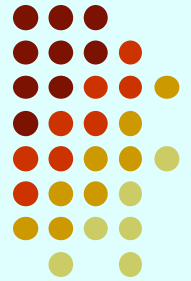


- By tamping in smoothening mode, the amplitude of defect reduces and the peak location is also shifted towards opposite the direction of machine working because of transfer function.



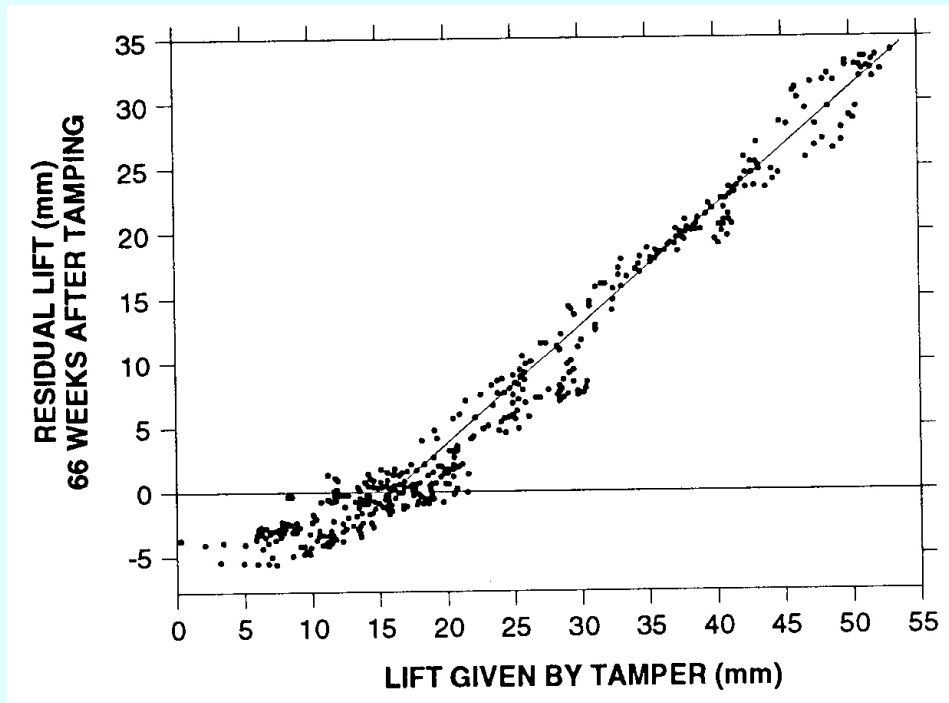
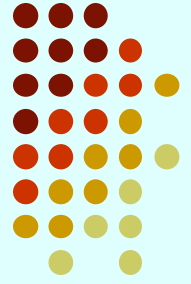
$$\text{MODULUS} = \frac{\text{RESIDUAL FAULT}}{\text{ORIGINAL FAULT}} = \frac{R}{O}$$

CHANGE IN TRANSFER FUNCTION WITH WAVE LENGTH



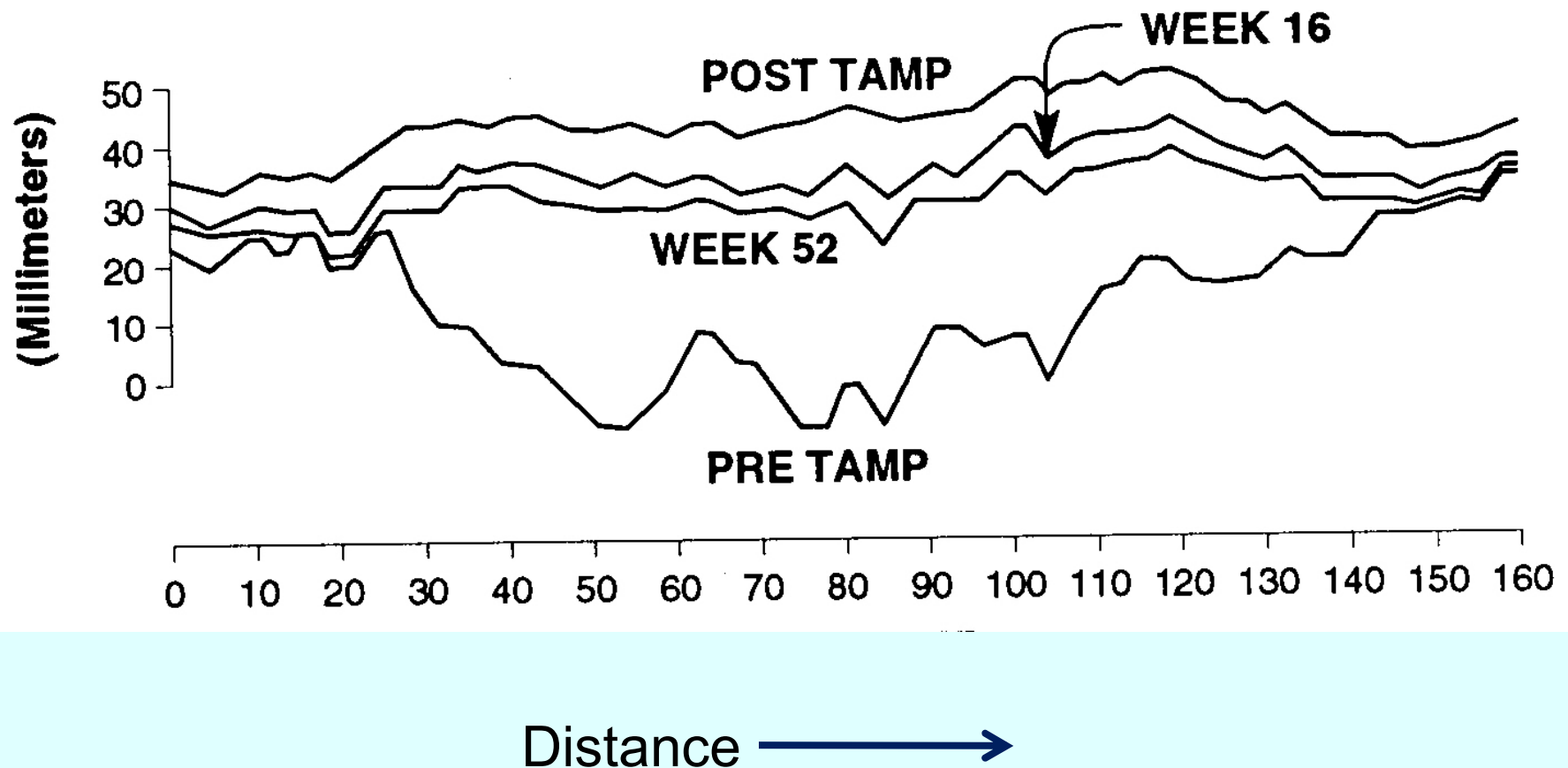
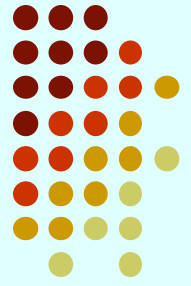
In order to achieve better results on long chords, design leveling and lining should be utilized.

RELATION BETWEEN LIFT AND SETTLEMENT

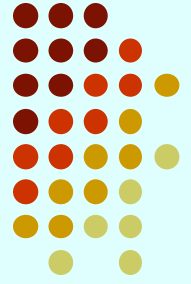


- ❖ For lift less than 20mm after tamping cycle, residual lifts are zero, hence no permanent improvement in longitudinal level takes place.
- ❖ For permanent improvement, lift has to more than 20 mm.

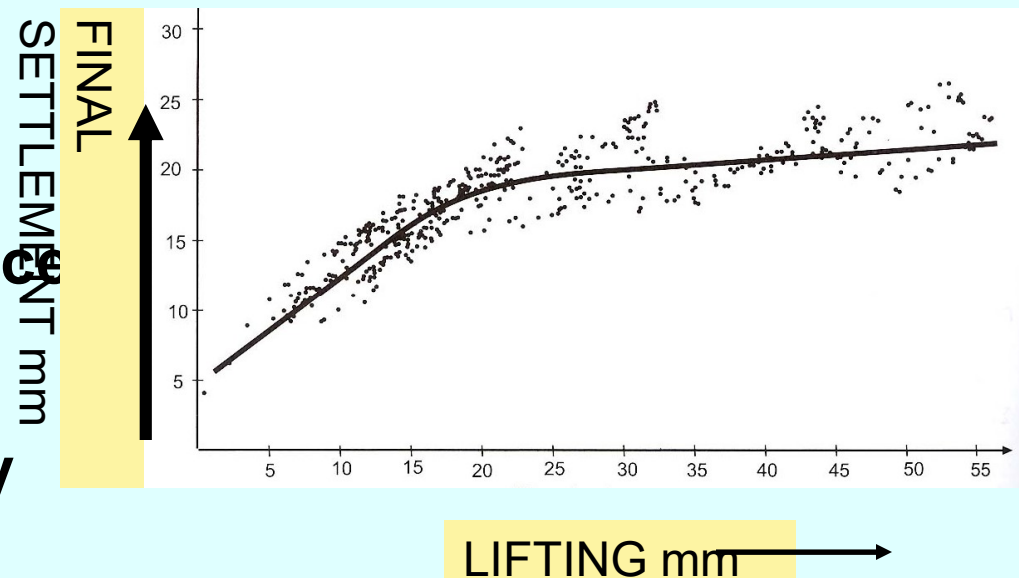
RELATION BETWEEN LIFT AND SETTLEMENT



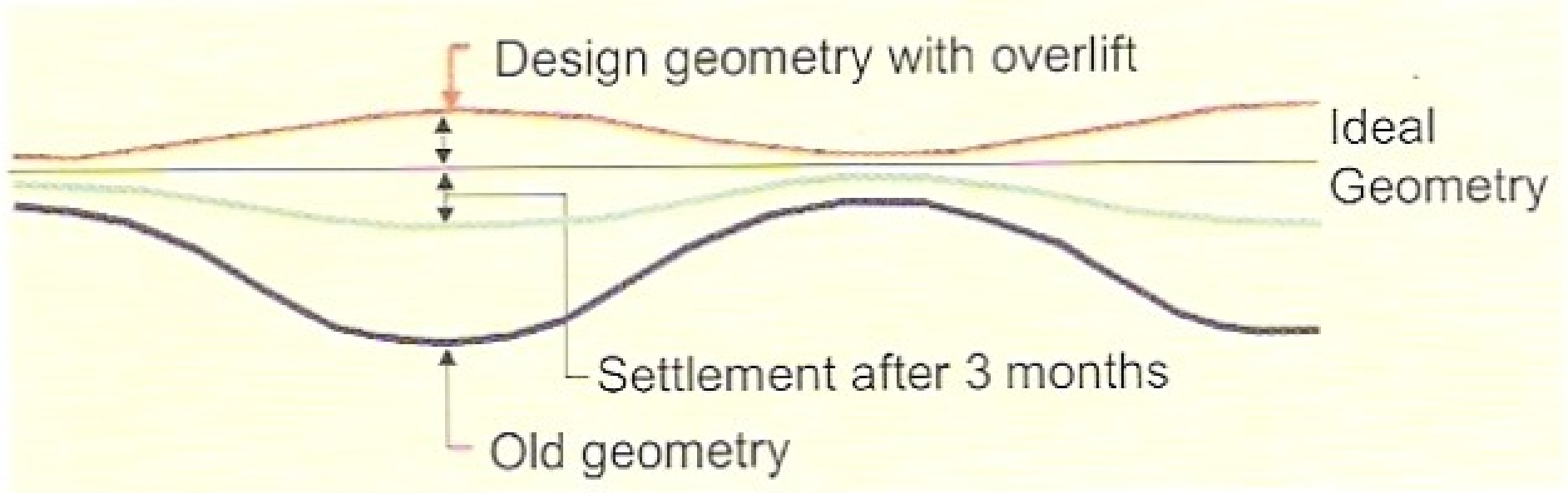
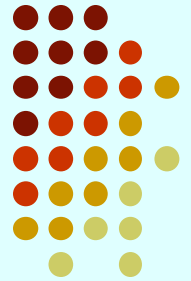
LIFTING Vs SETTLEMENT



- Track undergoes settlement after lifting.
- Part of settlement takes place early say 2-3 GMT.
- This settlement takes place at relatively fast rate. Normally this part of settlement is achieved by DTS.
- Still rate of settlement is high for first 3 months after tamping. **So over-lifting may be designed to take care of settlement in first 3 months.**

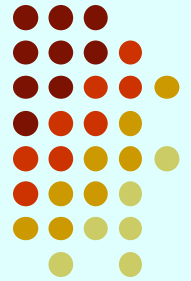


DESIGN OVERLIFT



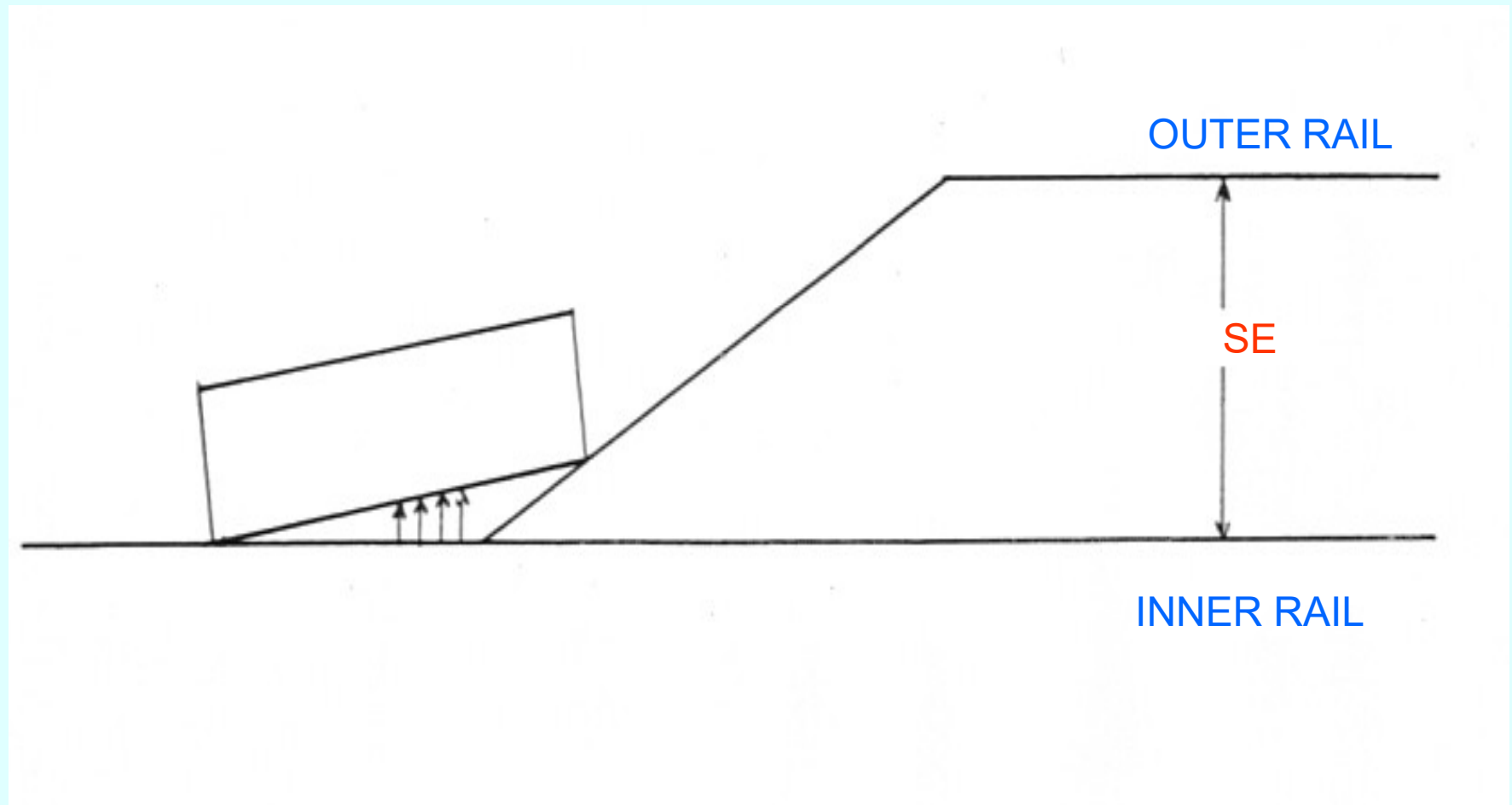
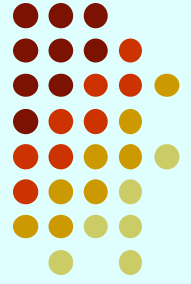
Maximum over lift of 30% can be provided by machine.

DESIGN LEVELLING- CURVES



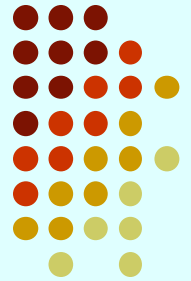
- Inner rail as datum rail,
- Feed super elevation in **SE potentiometer**-
 - CSM/DUO - in front cabin,
 - 09-3X - in working cabin,
- Lift & adjustments in **lift potentiometer** in front cabin,

DESIGN LEVELLING - CURVES

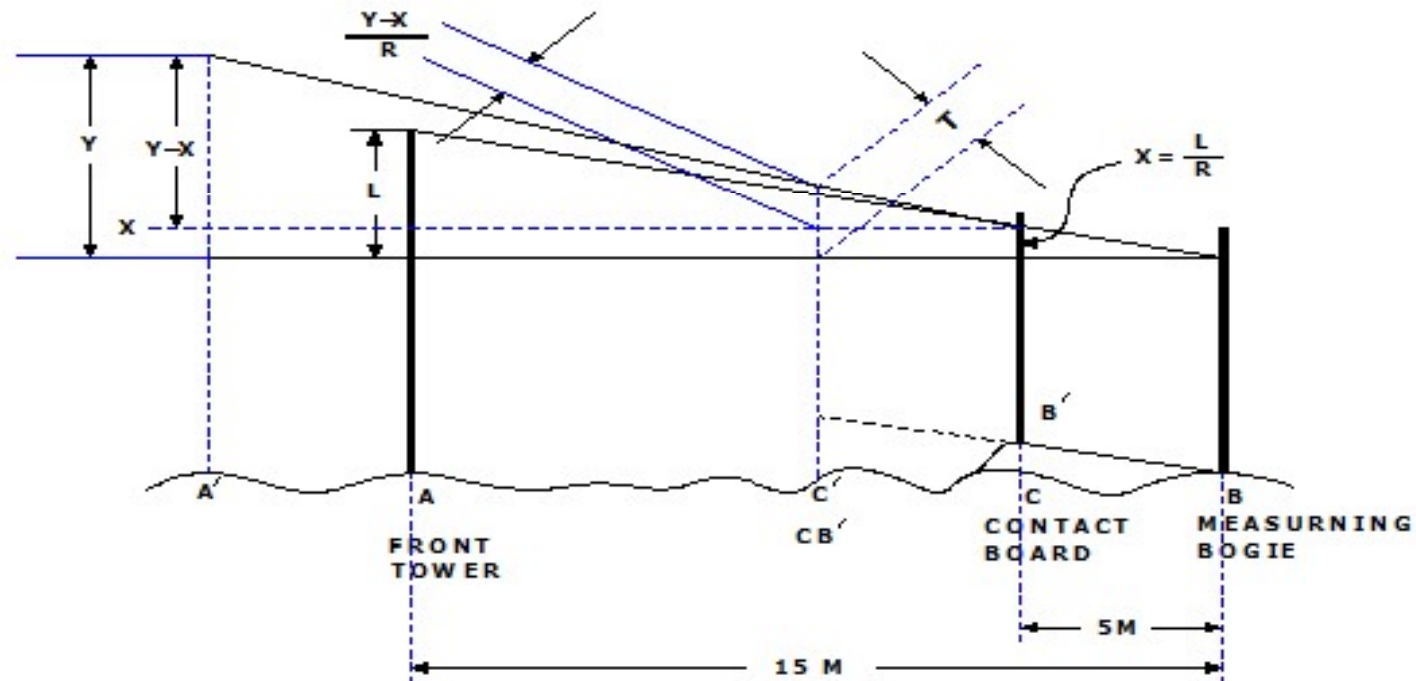


CURVES

Run in ramp

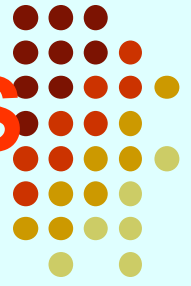


RUN IN RAMP



DESIGN LEVELLING – CURVES

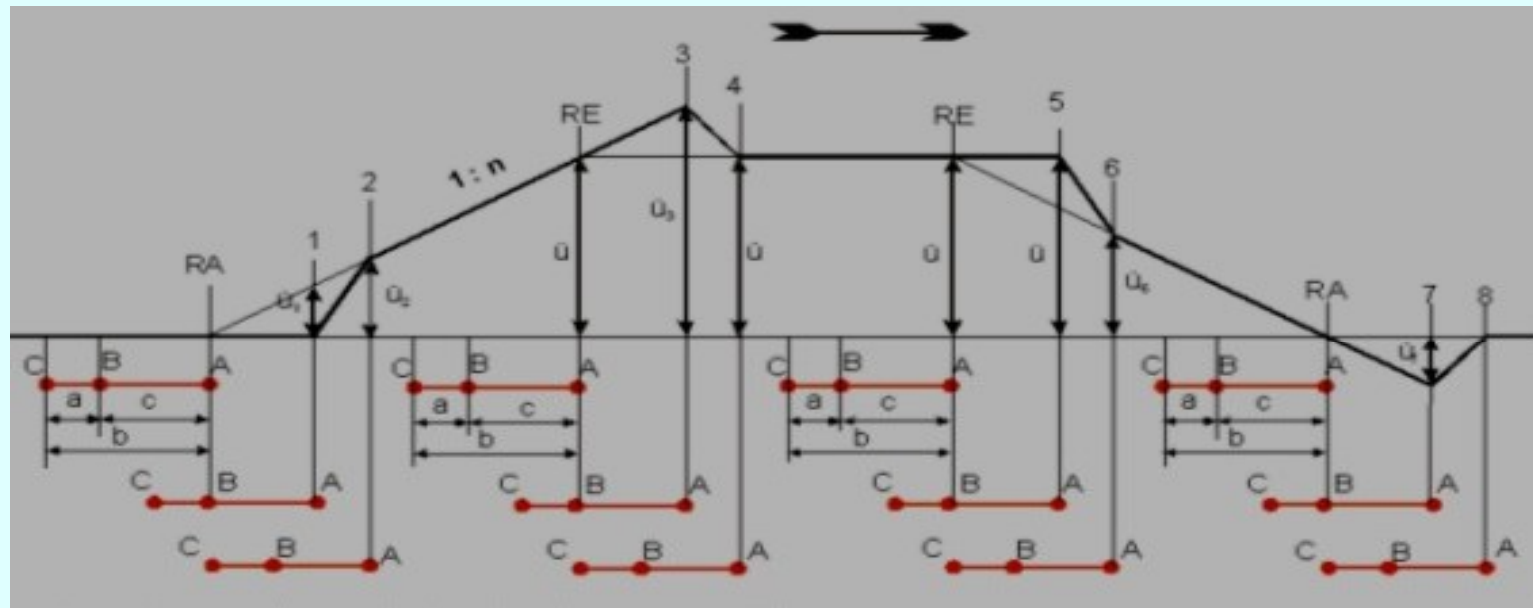
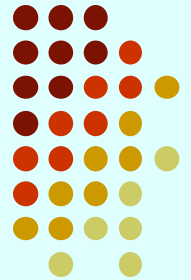
Run in ramp



- $AB/BC=R$, $L/X=R$ or $X=L/R$
- As this machine max. ahead to next position and suppose a total lift of 'Y' has been given on front tower.
- Total lift at Height Transducer or T.U. can be written as
- $T= X + (Y-X)/R$
- T= Total lift at a particular sleeper.
- X= Actual lift achieved on previous sleeper.
- Y=Lift given to front tower at that point.

CURVES

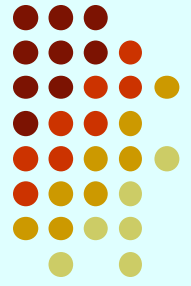
Method of feeding Cant/SE



levelling system: A: front reference point
B: measuring point
C: rear reference point

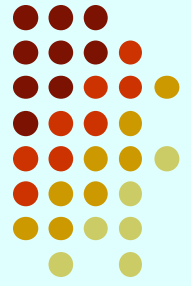
Adjustment of the chord in the superelevated rail in a linear cant ramp

Correct Method of Feeding Cant/SE



- Generally, 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

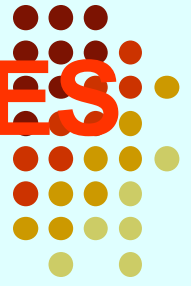
CURVES Method of feeding Cant/SE



- Cant should not fed till point B i.e. the working cabin reaches over TTP1 (RA1).
- When front cabin reaches at point 1, then cant value to be fed according to (c/a) rate of the transition curve till front feeler rod reaches at point 2 or the rear filler rod of the machine reaches at TTP1 (RA1).
- then the cant value of same rate as of transition portion is to be given and keep continue when front cabin reaches at point 3.

DESIGN LEVELLING – CURVES

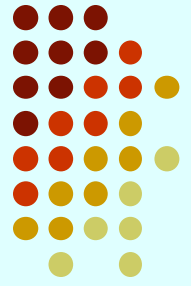
Method of feeding Cant/SE



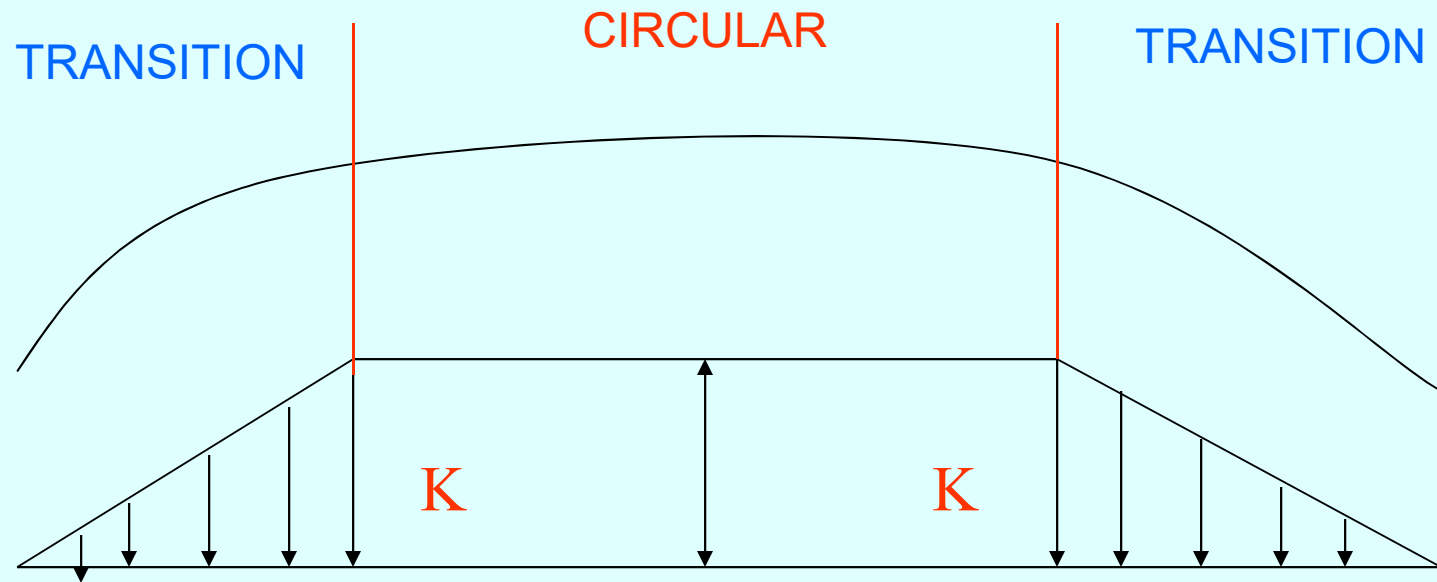
- When front cabin reached at point 3, then decrease the cant value according to (b/a) rate of transition curve till front cabin reached at point 4 or complete machine enter into the circular portion
- then full cant value is to be given till front cabin reaches at point 5
- then decrease the cant value according to the (c/a) rate of transition curve till front reaches at point no. 6
- then decrease the cant value same rate as of transition portion till the front cabin reaches at point 7 then it increases the cant value according to the (b/a) rate of transition curve till the front cabin reaches at

DESIGN LEVELLING –

CURVES CORRECTION VALUES IN TRANSITION

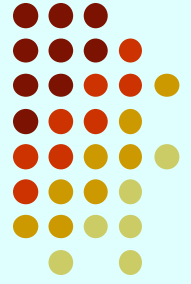


Adjustment in lift setting (in full curve) for ensuring correct lifting on transition & circular curves



$$K = 36 * SE / R$$

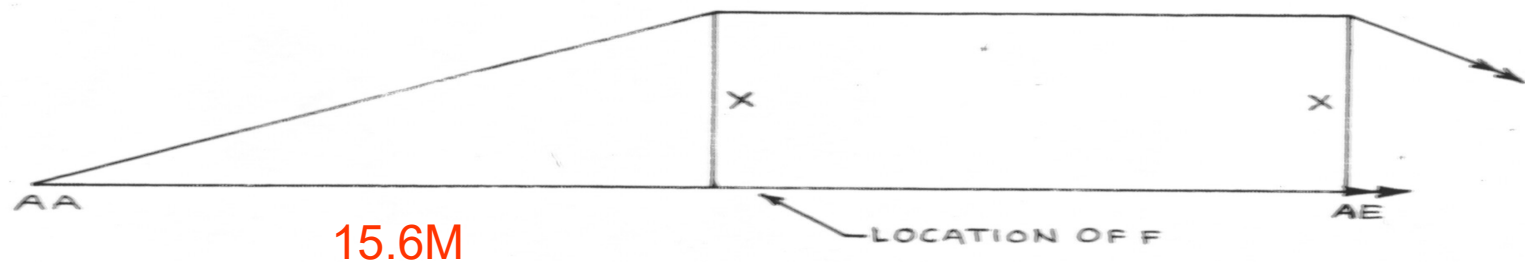
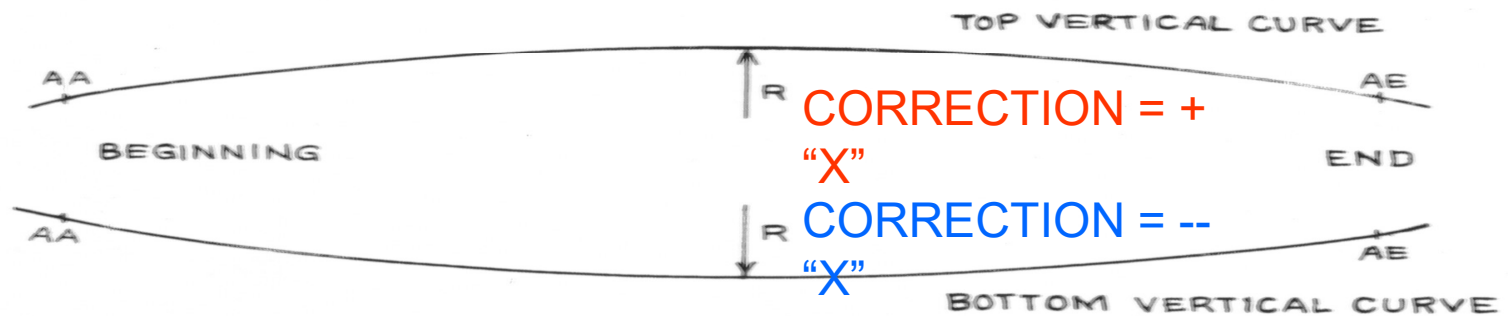
DESIGN LEVELLING VERTICAL CURVES

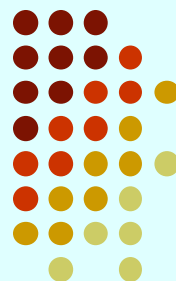


- ADJUSTMENT / CORRECTION

$$X = 83586^* / R$$

* Varies machine to machine





THANK YOU