CHAPTER 4

GEOMETRIC DESIGNING PARAMETERS & ALIGNMENT DESCRIPTION

TABLES

Chapter - 4

GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

4.1 GENERAL

This chapter deals with geometrical standards adopted for horizontal and vertical alignments, route description, etc. The proposed corridors under Nagpur Metro Rail Project network will consist of Standard Gauge (SG) lines. For underground corridors, track centres are governed by spacing of tunnels and box design.

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. Planning for any higher speed is not desirable as the average inter-station distance is about 1.30km and trains will not be able to achieve higher speed.

The elevated tracks will be carried on box-shaped elevated decking supported by single circular piers, generally spaced at 25-m centres and located on the median of the road. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

The underground tracks will be carried in separate tunnels to be drilled by Tunnel Boring Machine. Stations will, however, be constructed by cut and cover method.

4.2 GEOMETRIC DESIGN PARAMETERS

The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

4.2.1 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On elevated sections minimum radius of 160 m has been used at one location having speed potential upto 40 km/h. However in underground section desirable minimum radius of curve shall be 300 m for ease of working of Tunnel Boring Machine (TBM). However in exceptional situation on this project, curves of 200 m radius (safe speed of 55 km/h) have been adopted where New Austrian Tunneling Machine (NATM) shall be used.

For maximum permissible speed on curve with various radii, Table 4.1 may be referred.

Horizontal Curves

Description	Underground Section	Elevated Section
Desirable Minimum radius	300 m	200 m
Absolute minimum radius	200 m (only c/c)	120 m
Minimum curve radius at stations	1000 m	1000 m
Maximum permissible cant (Ca)	125 mm	125 mm
Maximum desirable cant	110 mm	110 mm
Maximum cant deficiency (Cd)	85 mm	85 mm

4.2.2 Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth riding on the curves and to counter act centrifugal force. Due to change in gradients at various locations in the corridor, it is necessary to provide frequent vertical curves along the alignment. In case of ballast less track, it is desirable that the vertical curves and transition curves of horizontal curves do not overlap. These constraints may lead to reduced lengths of transition curves at certain locations. The transition curves have certain minimum parameters:

- Length of Transitions of Horizontal curves (m)

  Minimum : 0.44 times actual cant or cant deficiency (in mm), whichever is higher.

  Desirable : 0.72 times actual cant or cant deficiency, (in mm), whichever is higher.

- Overlap between transition curves and vertical curves not allowed.
- Minimum straight between two Transition curves (in case of reverse curves): either 25 m or Nil.
- Minimum straight between two Transition curves (in case of same flexure curves): either 25 m or both curves should be converted in to the compound curve by introducing single transition between the two circulars.
- Minimum curve length between two transition curves: 25 m

4.2.3 Vertical Alignment and Track Centre

(a) Elevated Sections

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the 'Box' shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 13.5 m above the road level with concourse at mezzanine. These levels will, however, vary marginally depending upon where the stations are located.

The track center on the elevated section is kept as 4.1 m uniform throughout the corridor to standardize the superstructure, except at few locations, wherever scissors crossovers are planned, it is kept 4.5 meter.

(b) Underground sections

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level. At stations, the desirable depth of rail below ground level is 13.5 m, so that station concourse can be located above the platforms.

Track center in underground sections are follows:

Sections where stations are to be constructed by cut & cover and running section by TBM to Accommodate 12 m wide platform lesser width of platform, track center to be reduced.)	:	15.05 m (for
Sections where stations are to be constructed by NATM and running section by TBM to facilitate Construction of stations	:	22.00 m
Sections where stations as well as running section both are to be constructed by cut and cover method	:	4.50 m

(c) Gradients

Normally the stations shall be on level stretch. In limited cases, station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 3.0 %. However, where existing road gradients are steeper than 2 %, or for Switch Over Ramps gradient up to 4% (compensated) can be provided in short stretches on the main line.

(d) Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%. However, it is recommended to provide vertical curves at every change of gradient.

(e) Radius of vertical curves:

- On main line (desirable) : 2500 m
  (Absolute minimum) : 1500 m
- Other Locations : 1500 m
- Minimum length of vertical curve : 20 m

4.2.4 Design Speed

The maximum sectional speed will be 85 km/h. However, the applied cant, and length of transition will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations. Computerized train simulation studies need to be conducted with proposed gradients at the time of detailed design stage. This is with the objective of keeping down the wear on rails on curves to the minimum.

Table 4.1: Cant, Permitted Speed & Minimum Transition Length for Curves

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			UNDERGROUND	ELEVATED AND AT-GRADE
meters	mm	kmph	mm	Mm
3000	15	80	3500	3650
2800	15	80	3500	3650
2400	20	80	3500	3650
2000	20	80	3500	3650
1600	25	80	3500	3650
1500	30	80	3500	3650
1200	35	80	3500	3650
1000	45	80	3500	3700
800	55	80	3550	3700
600	70	80	3550	3750
500	85	80	3600	3750
450	95	80	3600	3800
400	105	80	3650	3800
350	110	75	3650	3800
300	110	70	3700	3850
200	110	55	3800	3950
150*	110	45	4000	4050
150*	0	30	4000	4050
120*	110	40	4000	4150
120*	0	25	4000	4150
100**	110	40		

Notes: (a) The track spacing is without any column/structure between two tracks and is with equal cant for both outer and inner tracks.

(b) Track spacing shown is not applicable to stations which should be calculated depending on specific requirement.

(c) Figures for any intermediate radius of curvature may be obtained by interpolating between two adjacent radii. For higher radii, values may be extrapolated.

4.2.5 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible. The average spacing of stations is close to 1.2 km.

4.3 TRACK STRUCTURE

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy in view.

Two types of track structures are proposed for the corridors under Nagpur Metro Rail Project network. The normal ballasted track in Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is recommended on Viaducts and inside tunnels as the regular cleaning and replacement of ballast at such locations will not be possible.

For the depots, ballasted track is recommended as ballastless track on formation is not suitable due to settlement of formations. Ballastless track in depot is required inside the workshop, on inspection lines and washing plant lines.

From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts will have to be incorporated in LWR/CWR.

The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

4.4 RAIL SECTION

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg. /m) rail section. Since on main lines, sharp curves and steep gradients would be present, the grade of rail on main lines should be 1080 Head Hardened as per IRS-T-12-2009. As these rails are not manufactured in India at present, these are to be imported. For the Depot lines, the rails of grade 880 are recommended, which are available indigenously.

4.5 BALLASTLESS TRACK ON MAIN LINES

On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths. Further, it is proposed to adopt fastening system complying to performance criteria laid down by Indian Railways on ballastless track structures, with a base-plate spacing of 60 cm. on viaducts.

In the underground sections, similar track structure with a base plate spacing of 70 cm is proposed on slab after 1st stage concrete.

4.6 BALLASTLESS/BALLASTED TRACK IN DEPOT

The ballastless track in Depot may be of the following types:

- Supported on steel pedestal for inspection lines.
- Embedded rail type inside the Workshop.

- Plinth type for Washing line.
- Track is to be laid on PRC sleepers with sleeper spacing of 65 cm. All the rails are to be converted into rail panels by doing flash butt/Thermit welding.

4.7 TURNOUTS

All turn-outs/crossovers on the main lines and other running lines shall be as under:

Table 4.2: Turn-Outs

S. No.	Description	Turn out Type
01	Main Line	1 in 9
02	Depot/Yard Lines	1 in 7

4.8 BUFFER STOPS

On main lines and Depot lines, friction buffer stops with mechanical impact absorption (non-hydraulic type) will be provided. In elevated portion, the spans on which friction buffer stops are to be installed will be designed for an additional longitudinal force, which is likely to be transmitted in case of Rolling Stock hits, the friction Buffer Stops.

4.9 RAIL STRUCTURE INTERACTION

For continuing LWR/CWR on Viaducts, the elevated structures will be adequately designed for the additional longitudinal forces likely to be transmitted as a result of Rail-Structure interaction. Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) required to be provided.

4.10 ROUTE ALIGNMENT

Two Corridors have been identified for implementation in phase I of Nagpur Metro Rail Project network as per details given underneath:-

i) Automotive Square to KHAPRI
ii) Prajapati Nagar to Lokmanya Nagar

The main features of these corridors along with the details of route alignment have been described below:-

4.10.1 Alignment from Automotive Square to KHAPRI

This corridor originates from Automotive Square on Kamptee Road; move along Kamptee Road and reach the intersection point of Amravati Road and Vardha Road, then after crossing Fly Over moves towards Munje Square, moves towards Dhantoli and along nala moves towards Empire/Dr Munje Marg, leads towards Congress Nagar T-Point, then on Rahate Colony Road and then falls on Wardha Road, leads towards NEERI, then moves along Wardha Road and then west of Railway Track in MIHAN area. And passes through 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot.
There are 17 Statuions proposed on this alignments.

4.10.2 Prajapati Nagar to Lokmanya Nagar

This Corridor originates from Prajapati Nagar (meeting point of CA Road and Ring Road), then along Central Avenue Road moves towards Vaishno Devi Chowk, then Mayo Hospita and then takes left turn towards Nagpur Station Entry on Railway Feeder Road, then on Ghat Road alignment takes right turn and crosses over box culvert on existing railway line and falls on State Highway 255, Then after crossing Wardha Road alignment moves along North Ambajharee Road upto Ambajharee Lake and takes left State Highway 255, Then falls on Hingna Road and moves towards Lokmanya Nagar.
There are 19 Stations proposed on this alignments.

4.10.3 Main features of Alignment from Automotive Square to KHAPRI (North-South Corridor)

Main features of Alignment from Automotive Square to KHAPRIare detailed below:

a) This corridor provides direct metro connectivity to Automotive Square, RBI, Vidhan Sabha, NIT, Zero Mile, Nagpur University, Sitaburdi, Yashvant Stadium, Central Jai, NEERI, Wardha Road, Chhatrapati Shivaji Chowk, Airport, Khapri, MIHAN. Many other prominent places and Government offices are covered in this Corridor.
b) Corridor is integrated with East West corridor at Sitaburdi and this integration provides metro connectivity to new development at Lokmanya Nagar.
c) Corridor integrates with other modes of transport. Bus Terminus near Jhansi Chowk .
d) Entire length (19.658 Km.) of this corridor is proposed as elevated except in 4.6 Km at grade after Airport Station and in MIHAN area near Khapri Railway Station.
e) Total 17 stations have been proposed on this corridor; out of these stations 15 stations are elevated and remaining 2 stations are at grade..
f) Future extension of corridor in both directions is feasible.

4.10.4 Main features of Alignment from Prajapati Nagar to Lokmanya Nagar (East-West Corridor)

Main features of Alignment from Prajapati Nagar to Lokmanya Nagar are detailed below

a) This corridor provides direct metro connectivity to Central Avenue Road and North Ambajharee Road. This corridor covers many important location like Vardhman Nagar, Mangalwari, Mayo Hospital, Nagpur Railway Station, Santara Market, Sitaburdi, Jhansi Rani Chowk, LAD Square, Ambajharee Lake, Hingna Road, Lokmanya Nagar.

b) Corridor is integrated with North South corridor at Sitaburdi and through that integration prominent location falling on NS Corridor get connected.

c) Corridor integrates with other modes of transport such as Bus Stand near Jhansi Rani Square and Nagpur railway station

d) Entire length of this corridor is proposed as elevated.

e) There are total 19 stations on this corridor and all are elevated.

4.11 TECHNICAL FEATURES

4.11.1 Automotive Square to KHAPRI (North-South Corridor)

(a) Horizontal Curves : Horizontal curve details are as per the table below :

Table 4.3: Statement of Horizontal Curves (North-South Corridor)

Curve No	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
			D M S							Start of Alignment -408.17
1	Right	1002.05	15 53 53.325	25	25	139.921	278.044	328.044	123.879	
2	Left	1002.05	04 15 34.281	25	25	37.265	74.495	124.495	94.245	
3	Left	5002.05	00 27 08.585	15	15	19.747	39.494	69.494	269.95	
4	Right	9002.05	00 11 27.395	15	15	15	30	60.000	339.022	
5	Right	3002.05	00 42 36.030	20	20	18.601	37.201	77.201	544.771	
6	Left	3502.05	00 30 04.329	15	15	15.317	30.635	60.635	367.154	
7	Left	1002.05	06 45 54.827	25	25	59.228	118.318	168.318	301.632	
8	Right	232.05	06 16 17.226	54	54	12.712	25.4	133.400	86.568	
9	Left	422.05	03 26 24.925	50	50	12.675	25.341	125.341	148.858	
10	Left	252.05	08 29 03.979	40	40	18.696	37.324	117.324	238.516	
11	Right	1002.05	12 49 33.520	25	25	112.628	224.314	274.314	307.758	
12	Left	1402.05	01 08 18.096	25	25	13.929	27.856	77.856	158.651	
13	Left	202.05	08 02 56.113	55	55	14.215	28.384	138.384	87.306	
14	Left	1002.05	13 02 11.452	25	25	114.493	227.997	277.997	27.26	
15	Left	1502.05	01 14 10.942	20	20	16.207	32.412	72.412	138.678	
16	Right	1602.05	00 59 35.134	20	20	13.884	27.768	67.768	412.871	
17	Left	352.05	04 52 14.818	50	50	14.973	29.928	129.928	54.485	
18	Right	1002.05	06 40 35.630	25	25	58.45	116.767	166.767	77.21	
19	Left	502.05	05 45 16.536	40	40	25.233	50.424	130.424	316.656	
20	Left	182.05	27 01 23.322	55	55	43.745	85.863	195.863	27.279	
21	Right	202.05	12 35 59.711	40	40	22.306	44.433	124.433	26.194	
22	Left	1002.05	02 06 31.401	25	25	18.442	36.88	86.880	98.957	
23	Left	172.05	27 05 31.584	50	50	41.452	81.353	181.353	0	
24	Right	172.05	78 39 13.695	50	50	140.956	236.185	336.185	333.31	
25	Left	1002.05	05 59 38.020	25	25	52.462	104.828	154.828	140.502	
26	Right	162.05	66 12 09.831	55	55	105.645	187.242	297.242	121.779	
27	Left	162.05	30 15 35.895	55	55	43.815	85.584	195.584	148.782	

Curve No	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
28	Left	172.05	19 52 02.909	50	50	30.132	59.659	159.659	166.886	
29	Right	1202.05	01 17 56.100	25	25	13.626	27.251	77.251	397.271	
30	Right	6002.05	00 19 34.888	20	20	17.094	34.188	74.188	317.309	
31	Left	1502.05	05 42 54.796	25	25	74.976	149.829	199.829	235.665	
32	Left	552.05	02 41 59.255	50	50	13.009	26.013	126.013	0	
33	Right	522.05	02 49 13.936	50	50	12.852	25.699	125.699	579.688	
34	Right	552.05	03 36 42.328	50	50	17.406	34.8	134.800	0	
35	Left	552.05	03 31 51.745	50	50	17.016	34.022	134.022	226.15	
36	Left	3002.05	00 48 18.068	20	20	21.09	42.179	82.179	1733.186	
37	Right	30002.05	00 03 22.518	10	10	14.728	29.457	49.457	435.34	
38	Right	232.05	16 10 34.304	55	55	32.976	65.514	175.514	0	
39	Left	262.05	07 11 41.399	55	55	16.475	32.907	142.907	437.137	
40	Left	402.05	08 05 13.876	50	50	28.421	56.749	156.749	322.908	
41	Right	402.05	09 15 09.718	55	55	32.534	64.927	174.927	125.738	
42	Left	1002.05	03 00 14.782	25	25	26.276	52.539	102.539	313.763	
43	Right	1002.05	01 56 22.429	25	25	16.962	33.921	83.921	169.615	
44	Left	1502.05	01 19 49.060	25	25	17.438	34.875	84.875	476.925	
45	Right	3002.05	00 31 05.547	20	20	13.576	27.152	67.152	436.794	
46	Right	5002.05	00 37 06.348	15	15	26.995	53.99	83.990	409.015	
47	Right	1002.05	06 27 04.991	25	25	56.474	112.829	162.829	112.905	
48	Left	202.05	08 30 29.460	45	45	15.029	30.004	120.004	0	
49	Right	402.05	05 55 36.776	40	40	20.813	41.59	121.590	460.532	
50	Left	1002.05	03 02 09.968	25	25	26.556	53.099	103.099	0	
51	Right	1002.05	03 35 02.177	25	25	31.35	62.68	112.680	591.009	
52	Left	1002.05	04 41 31.197	25	25	41.052	82.059	132.059	467.894	
53	Left	1002.05	02 35 16.664	25	25	22.634	45.261	95.261	101.752	End of alignment 19250

Abstract of Horizontal Curves(N-S Corridor)				
S. No.	**Radius (m)**	**Nos. Occurrences**	**Curved Length (m)**	**% w. r. t. total curved length**
1	>160m -200m	9	1748.707	24.10%
2	>200m - 500m	10	1408.104	19.41%
3	>500m - 1000m	19	2894.656	39.89%
4	>1000m - 1500m	5	512.223	7.06%
5	>1500m - 2000m	1	67.768	0.93%
6	>2000m - 5000m	6	440.651	6.07%

7	>5000m	3	183.645	2.53%
	Total	**53**	**7255.75**	100.00%

(b) Gradient

A statement showing details of gradients provide along the N S corridor is given in the following Table No. 4.4.

Table 4.4: Statement of Gradients (N-S Corridor)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-408.2	300.0	708.170	303.9	303.9	0.000%	Level
2	300.0	490.0	190.000	303.9	303.5	-0.211%	Fall
3	490.0	840.0	350.000	303.5	308.9	1.543%	Rise
4	840.0	1110.0	270.000	308.9	308.9	0.000%	Level
5	1110.0	1410.0	300.000	308.9	309.5	0.200%	Rise
6	1410.0	1740.0	330.000	309.5	311.5	0.606%	Rise
7	1740.0	2020.4	280.403	311.5	314.4	1.034%	Rise
8	2020.4	2270.0	249.598	314.4	314.4	0.000%	Level
9	2270.0	2460.0	190.000	314.4	310.7	-1.947%	Fall
10	2460.0	2820.0	360.000	310.7	310.1	-0.167%	Fall
11	2820.0	3050.0	230.000	310.1	318.4	3.609%	Rise
12	3050.0	3312.0	262.010	318.4	318.4	0.000%	Level
13	3312.0	3680.0	367.990	318.4	318.3	-0.027%	Fall
14	3680.0	3910.0	230.000	318.3	320.9	1.130%	Rise
15	3910.0	4080.0	170.000	320.9	320.9	0.000%	Level
16	4080.0	4258.4	178.443	320.9	323.2	1.289%	Rise
17	4258.4	4550.0	291.557	323.2	323.2	0.000%	Level
18	4550.0	4756.4	206.404	323.2	322.2	-0.484%	Fall
19	4756.4	5030.0	273.596	322.2	326.3	1.499%	Rise
20	5030.0	5280.0	250.000	326.3	326.3	0.000%	Level
21	5280.0	5800.0	520.000	326.3	322.4	-0.750%	Fall
22	5800.0	6050.0	250.000	322.4	319.6	-1.120%	Fall
23	6050.0	6264.0	214.000	319.6	319.6	0.000%	Level
24	6264.0	6572.8	308.756	319.6	310.9	-2.818%	Fall
25	6572.8	6930.0	357.245	310.9	310.9	0.000%	Level
26	6930.0	7200.0	270.000	310.9	305.2	-2.111%	Fall
27	7200.0	7400.0	200.000	305.2	310.9	2.850%	Rise
28	7400.0	7760.0	360.000	310.9	317.9	1.944%	Rise
29	7760.0	8090.0	330.000	317.9	317.9	0.000%	Level
30	8090.0	8340.0	250.000	317.9	317.4	-0.200%	Fall
31	8340.0	8530.0	190.000	317.4	321.5	2.158%	Rise
32	8530.0	8840.0	310.000	321.5	321.5	0.000%	Level
33	8840.0	9121.7	281.737	321.5	322.4	0.319%	Rise
34	9121.7	9340.0	218.263	322.4	320	-1.100%	Fall
35	9340.0	9680.0	340.000	320	316.1	-1.147%	Fall
36	9680.0	9900.0	220.000	316.1	315.3	-0.364%	Fall
37	9900.0	10205.0	305.000	315.3	315.3	0.000%	Level

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
38	10205.0	10730.0	525.000	315.3	319.5	0.800%	Rise
39	10730.0	11283.4	553.428	319.5	319.5	0.000%	Level
40	11283.4	11670.0	386.572	319.5	320	0.129%	Rise
41	11670.0	11930.0	260.000	320	320	0.000%	Level
42	11930.0	12560.0	630.000	320	311	-1.429%	Fall
43	12560.0	12960.0	400.000	311	311	0.000%	Level
44	12960.0	13100.0	140.000	311	307.1	-2.786%	Fall
45	13100.0	13360.0	260.000	307.1	307.5	0.154%	Rise
46	13360.0	13680.0	320.000	307.5	313.3	1.813%	Rise
47	13680.0	14098.9	418.920	313.3	313.3	0.000%	Level
48	14098.9	14370.0	271.080	313.3	307.6	-2.103%	Fall
49	14370.0	14720.0	350.000	307.6	304.8	-0.800%	Fall
50	14720.0	15500.0	780.000	304.8	295.6	-1.179%	Fall
51	15500.0	15700.0	200.000	295.6	295.6	0.000%	Level
52	15700.0	16080.0	380.000	295.6	299	0.895%	Rise
53	16080.0	16330.0	250.000	299	299	0.000%	Level
54	16330.0	17080.0	750.000	299	307.6	1.147%	Rise
55	17080.0	17324.6	244.621	307.6	316	3.434%	Rise
56	17324.6	17550.0	225.379	316	316	0.000%	Level
57	17550.0	17740.0	190.000	316	308.5	-3.947%	Fall
58	17740.0	18020.0	280.000	308.5	310.7	0.786%	Rise
59	18020.0	18232.0	212.000	310.7	308.7	-0.943%	Fall
60	18232.0	18610.1	378.100	308.7	308.7	0.000%	Level
61	18610.1	19250.0	639.900	308.7	302.5	-0.969%	Fall
62	19250.0	20357.2	1107.242	302.5	292	-0.948%	Fall

Abstract of Gradients(N-S Corridor)				
S. No.	**Description**	**Nos. Occurrences**	**Length (m)**	**% w. r. t. total Alignment length**
1	Level	20	5233.013	26.62%
2	> 0% to = 1%	22	9040.247	45.99%
3	> 1% to = 2%	11	3340.303	16.99%
4	> 2% to = 3%	5	1108.756	5.64%
5	> 3% to = 4%	4	935.701	4.76%
	Total	**62**	**19658.2**	100.00%

4.11.2 Prajapati Nagar to Lokmanya Nagar (East-West Corridor)

(a) Horizontal Curves: The details of horizontal curves is shown in Table 4.5:

Table 4.5: Statement of Horizontal Curves (East-West Corridor)

Table 4.5

Curve No	Direc-tion	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
			D M S						66.102	
1	Right	202.05	37 10 46.630	55	55	67.957	131.112	241.112	172.073	Start of Alignment -392
2	Right	402.05	28 42 53.968	50	50	102.911	201.496	301.496	217.679	
3	Right	9002.05	00 10 19.132	15	15	13.51	27.021	57.021	381.216	
4	Right	1002.05	02 01 05.821	25	25	17.651	35.298	85.298	271.009	
5	Right	1169.05	00 00 07.186	25	25	0.02	0.041	50.041	25.558	
6	Left	1702.05	00 54 07.696	18	18	13.4	26.799	62.799	252.852	
7	Right	10002.05	00 12 45.237	10	10	18.554	37.107	57.107	200.823	
8	Left	7002.05	00 13 19.423	15	15	13.569	27.138	57.138	66.635	
9	Right	7002.05	00 13 05.332	20	20	13.33	26.66	66.66	1021.177	
10	Right	569.05	00 00 27.619	50	50	0.038	0.076	100.076	43.927	
11	Left	1012.05	01 25 23.106	25	25	12.569	25.137	75.137	28.087	
12	Right	397.05	00 00 13.516	55	55	0.013	0.026	110.026	83.8	
13	Left	502.05	03 17 15.703	55	55	14.408	28.808	138.808	192.455	
14	Right	297.05	00 00 58.433	48	48	0.042	0.084	96.084	0.298	
15	Right	3002.05	01 39 38.058	16	16	43.506	87.007	119.007	126.158	
16	Left	2002.05	00 45 17.113	20	20	13.187	26.373	66.373	151.853	
17	Left	1002.05	03 48 54.123	25	25	33.373	66.721	116.721	151.675	
18	Right	602.05	02 53 04.264	45	45	15.158	30.31	120.31	239.373	
19	Right	692.05	02 20 40.899	35	35	14.162	28.321	98.321	35.749	
20	Left	602.05	02 42 05.532	40	40	14.196	28.387	108.387	327.015	
21	Left	202.05	81 04 18.041	55	55	172.786	285.894	395.894	430.152	
22	Left	1052.05	01 35 05.786	25	25	14.552	29.102	79.102	0.117	
23	Right	1232.05	01 16 48.606	25	25	13.765	27.528	77.528	154.363	
24	Right	202.05	49 07 42.947	55	55	92.353	173.249	283.249	582.951	
25	Right	252.05	06 27 16.062	48	48	14.212	28.394	124.394	144.027	
26	Left	202.05	00 01 02.092	53.1	53.1	0.03	0.061	106.261	58.364	
27	Left	1002.05	02 03 21.390	25	25	17.98	35.957	85.957	149.618	
28	Right	802.05	02 52 10.786	40	40	20.09	40.171	120.171	55.329	
29	Left	852.05	01 56 34.348	35	35	14.448	28.893	98.893	249.973	
30	Left	1002.05	01 57 14.763	25	25	17.089	34.175	84.175	121.207	
31	Right	1002.05	02 39 41.054	25	25	23.277	46.545	96.545	319.866	
32	Right	602.05	02 41 41.338	50	50	14.161	28.316	128.316	264.291	
33	Left	1152.05	19 38 27.637	25	25	199.418	394.923	444.923	696.136	
34	Right	202.05	00 01 45.128	55.7	55.7	0.051	0.103	111.503	149.835	
35	Right	202.05	14 25 13.455	55	55	25.561	50.853	160.853	35.007	

Curve No	Direc-tion	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
36	Left	172.05	73 38 35.753	56	56	128.811	221.139	333.139	490.256	
37	Right	182.05	11 47 30.843	55	55	18.8	37.467	147.467	28.414	
38	Right	162.05	31 16 55.272	55	55	45.37	88.475	198.475	224.703	
39	Left	222.05	00 02 56.634	50	50	0.095	0.19	100.19	317.926	
40	Left	15002.05	00 07 51.774	15	15	17.157	34.313	64.313	360.846	
41	Left	9502.05	00 09 05.222	15	15	12.558	25.117	55.117	877.118	
42	Left	402.05	07 43 36.044	50	50	27.151	54.219	154.219	500.994	
43	Right	202.05	13 12 12.862	55	55	23.384	46.562	156.562	56.253	
44	Left	202.05	25 23 08.620	55	55	45.507	89.521	199.521	359.319	
45	Right	342.5	04 50 33.480	50	50	14.483	28.948	128.948	845.94	
46	Left	502.05	03 20 46.456	40	40	14.665	29.321	109.321	187.281	
47	Left	1002.05	09 09 50.512	25	25	80.306	160.27	210.27	0	18165 End of Alignment

Abstract of Horizontal Curves(E-W Corridor)				
S. No.	**Radius (m)**	**Nos. Occurrences**	**Curved Length (m)**	**% w. r. t. total curved length**
1	>160m -200m	3	679.081	10.64%
2	>200m - 500m	17	2918.441	45.72%
3	>500m - 1000m	13	1453.44	22.77%
4	>1000m - 1500m	5	726.731	11.39%
5	>1500m - 2000m	2	129.172	2.02%
6	>2000m - 5000m	1	119.007	1.86%
7	>5000m	6	357.356	5.60%

(c) Gradient

A statement showing details of gradients provide along the corridor is given in the following Table No. 4.6: -

Table 4.6: Statement of Gradients (East-West Corridor)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-392.00	180.00	572.000	301	301	0.000%	Level
2	180.00	430.00	250.000	301	297.2	-1.520%	Fall
3	430.00	700.00	270.000	297.2	300.5	1.222%	Rise
4	700.00	1087.35	387.348	300.5	305.3	1.239%	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
5	1087.35	1320.00	232.652	305.3	305.3	0.000%	Level
6	1320.00	1570.00	250.000	305.3	304.6	-0.280%	Fall
7	1570.00	1820.80	250.800	304.6	308.3	1.475%	Rise
8	1820.80	2078.76	257.955	308.3	308.3	0.000%	Level
9	2078.76	2440.00	361.245	308.3	308.9	0.166%	Rise
10	2440.00	2640.00	200.000	308.9	309.7	0.400%	Rise
11	2640.00	3020.00	380.000	309.7	311.6	0.500%	Rise
12	3020.00	3235.00	215.000	311.6	311.6	0.000%	Level
13	3235.00	3384.00	149.000	311.6	310.9	-0.470%	Fall
14	3384.00	3772.20	388.200	310.9	311.5	0.155%	Rise
15	3772.20	4180.00	407.800	311.5	311.5	0.000%	Level
16	4180.00	4340.00	160.000	311.5	311	-0.313%	Fall
17	4340.00	4652.53	312.525	311	319.5	2.720%	Rise
18	4652.53	4922.00	269.475	319.5	319.5	0.000%	Level
19	4922.00	5190.00	268.000	319.5	316.7	-1.045%	Fall
20	5190.00	5490.00	300.000	316.7	321.9	1.733%	Rise
21	5490.00	5750.00	260.000	321.9	321.9	0.000%	Level
22	5750.00	5940.00	190.000	321.9	325.5	1.895%	Rise
23	5940.00	6350.00	410.000	325.5	319.7	-1.415%	Fall
24	6350.00	6580.00	230.000	319.7	319.7	0.000%	Level
25	6580.00	6890.00	310.000	319.7	313.1	-2.129%	Fall
26	6890.00	7130.00	240.000	313.1	313.1	0.000%	Level
27	7130.00	7290.00	160.000	313.1	310.2	-1.813%	Fall
28	7290.00	7615.00	325.000	310.2	320.1	3.046%	Rise
29	7615.00	7856.99	241.990	320.1	320.1	0.000%	Level
30	7856.99	8200.00	343.010	320.1	313.9	-1.808%	Fall
31	8200.00	8523.50	323.499	313.9	313.9	0.000%	Level
32	8523.50	8770.00	246.502	313.9	311.6	-0.933%	Fall
33	8770.00	8965.00	195.000	311.6	315.4	1.949%	Rise
34	8965.00	9241.43	276.433	315.4	315.4	0.000%	Level
35	9241.43	9490.00	248.567	315.4	312.6	-1.126%	Fall
36	9490.00	9770.00	280.000	312.6	313.3	0.250%	Rise
37	9770.00	9965.00	195.000	313.3	316.9	1.846%	Rise
38	9965.00	10190.00	225.000	316.9	316.9	0.000%	Level
39	10190.00	10500.00	310.000	316.9	314.8	-0.677%	Fall
40	10500.00	10765.00	265.000	314.8	319.1	1.623%	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
41	10765.00	10990.00	225.000	319.1	319.1	0.000%	Level
42	10990.00	11360.00	370.000	319.1	318.8	-0.081%	Fall
43	11360.00	11845.00	485.000	318.8	329.5	2.206%	Rise
44	11845.00	12130.00	285.000	329.5	329.5	0.000%	Level
45	12130.00	12370.00	240.000	329.5	325	-1.875%	Fall
46	12370.00	12710.00	340.000	325	336	3.235%	Rise
47	12710.00	13160.00	450.000	336	336	0.000%	Level
48	13160.00	13550.00	390.000	336	333.2	-0.718%	Fall
49	13550.00	14060.00	510.000	333.2	338.8	1.098%	Rise
50	14060.00	14300.00	240.000	338.8	338.8	0.000%	Level
51	14300.00	14580.00	280.000	338.8	339.4	0.214%	Fall
52	14580.00	14875.00	295.000	339.4	340.4	0.339%	Rise
53	14875.00	15050.00	175.000	340.4	345.2	2.743%	Rise
54	15050.00	15270.00	220.000	345.2	345.2	0.000%	Level
55	15270.00	15532.00	262.000	345.2	342.5	-1.031%	Fall
56	15532.00	15770.00	238.000	342.5	339.2	-1.387%	Fall
57	15770.00	16020.00	250.000	339.2	336.3	-1.160%	Fall
58	16020.00	16289.74	269.742	336.3	336.3	0.000%	Level
59	16289.74	16500.00	210.258	336.3	332.4	-1.855%	Fall
60	16500.00	16800.00	300.000	332.4	332.2	-0.067%	Fall
61	16800.00	16960.00	160.000	332.2	333.3	0.688%	Rise
62	16960.00	17160.00	200.000	333.3	330.4	-1.450%	Fall
63	17160.00	17496.76	336.758	330.4	330.4	0.000%	Level

Abstract of Gradients(E-W Corridor)				
S. No.	**Description**	**Nos. Occurrences**	**Length (m)**	**% w. r. t. total Alignment length**
1	Level	20	6054.412	33.33%
2	> 0% to = 1%	16	4519.947	24.88%
3	> 1% to = 2%	21	5642.983	31.07%
4	> 2% to = 3%	4	1282.525	7.06%
5	> 3% to = 4%	2	665	3.66%
	Total	**63**	**18165**	100.00%