Design Methodology for Feasible Railway Alignment

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ABSTRACT— *Designing a railway alignment is incredibly advanced process. Due to increasing urbanization, transportation system in urban areas is facing new challenges. Transportation planning coming up within geographical area has become complex because of modes involved, mixed traffic, multiple origins and multiple destinations. The task of adopting a specific route selection for transit systems is complex and challenging as it involves making decisions based on large set of spatial dimensions.*

So as to hold out this analysis, numerous alternatives are studied by Engineers and the therefore the feasible path is chosen based on factors such as soil condition, land acquisition, topography, socio-economic factors, cost benefits ratio. This research paper aims at designing of railway alignment for a particular possible route from Nimerkhedi Station situated at Madhya Pradesh until a power plant at Khargone(M.P) for the purpose of coal connectivity. Trail and error methods are used in this research to freeze the gradients and curves of the track to be laid.

Key words **— Railway alignment, Gradients, Curves.**

1. INTRODUCTION

The orientation provided to the centre line of the railway track on the ground within the 2-D plane ie; horizontal and vertical planes is called as the alignment of railway line. Horizontal alignment suggests the direction of the track and it includes straight path and curves (XY Cartesian plane). Vertical alignment defines the elevation, rise and fall within the vertical plane including level track, gradients and vertical curves (The Z component).The selection of alignment broadly depends upon the choice of gauge, dominant points, topography of the location, geological formation, climatic conditions and flood impact on the particular chosen area. The alignment of line should be so chosen that the development cost is least. This is only workable by providing balanced cuts and fill of earthwork, limiting rock cutting and drainage crossing. The alignment should be designed such that it provides safety to the users or merchandise. This can be attained by providing curves with appropriate transition lengths, designing vertical curves for gradients and incorporating other technical features.

2. PROPOSED METHODOLOGY

This analysis work has been carried out to formulate the need to develop a standardize procedure to carry out the survey work in order to provide coal connectivity for Power plant from nearest feasible railway station. The main work involved in the construction of new railway line is land acquisition. The land to be inherited should be adequate for the formation, berms and borrow pits. It should also have adequate provision for future enlargement. For station yard extra width of land is acquired; for small station width commonly adopted is 15m x 1000 m.In order to have a proper and satisfactory new route, various surveys are carried out:

1. Reconnaissance Survey
2. Preliminary Survey
3. Location Survey

2.1RECONNAISSANCE SURVEY

It is the primary engineering survey. It is administered in the territory that has not been antecedent surveyed for the purpose of laying a new railway line. A reconnaissance survey provides knowledge that permits design engineers to study the benefits and downside of a range of routes. Contour maps provide essential information regarding the relief of an area. Aerial photographs provide a quick means for preparing valuable sketches and overlays for the field. This consists of collection of information regarding physical characteristic of the country, the surface formation of the ground, nature of soil and its classification, streams and rivers of the immediate vicinity, especially those which are likely to cross the proposed railway line, positions of hills and lakes.

2.2PRELIMINARY SURVEY

The object of preliminary survey is to perform the survey work along the alternative routes (found out by reconnaissance survey) with the assistance of theodolite and levelling instruments and to determine the greater accuracy the cost of railway line along these alternative routes involving cost of removing obstruction, construction of bridges and then to decide the most economical and efficient route. The x-sections of all representative points along the route and feature of the country are marked. The cross sections are determined at 500ft interval normally. Similarly where the route crosses a river, the river is surveyed in detail for about one mile on either the upstream and downstream sides. The detail maps are prepared and the cost of different alternatives is calculated accurately to select the most economic routes.

2.3LOCATION SURVEY

It is the ultimate survey used to establish the centre line of railway line. Its objective is to conduct the elaborated survey along the finalised and most viable route from the knowledge of preliminary survey.The location survey aims to determine the center line of track which is to be constructed and hence as the location survey ends, construction work starts.

3. EXPERIMENTAL APPROACH

In an ideal world, railway alignment would be flat and thus becomes most economical and requires negligible maintenance. But in real world, it is not at all possible and thus need for design of horizontal and vertical alignment arises. This survey work had been started by first conducting the topographical survey and collecting all the knowledge about the entire route length to be laid, corresponding hindrances in between, soil characteristics, forest areas, rivers or craggy piece of land if any. For performing this, DGPS survey and Total station was used. The bench marks, formation level and ground levels had been marked ranging from Nimerkheri Station and heading towards power plant. As a result of hindrances like village area, hilly area and water bodies in between, the track has to be diverted in some places and so the necessity arises for geometric design of the alignment.

3.1HORIZONTAL ALIGNMENT DESIGN

The factors that influence the design of horizontal alignment are topography of the site, presence of water bodies,flaura and fauna, habitats, usage of land, impacts of community and its utility etc.The most important factor affecting the design of horizontal alignment is that the design speed of the trains. But in this survey as goods train has to travel under controlled speed and hence the design speed has been given second preference. In this study, topographical survey has been administered so as to determine the co-ordinate and Ground level at every 20 m interval along the particular route. All the information related to hindrances such as village area, wells or nallah etc has been collected. While establishing the co-ordinate, its X,Y and Z dimensions have been studied and formation levels, ground level has been established. Thorough study of the hindrances has been carried out and remedies to get rid of the obstructions or to divert the route has been done. As all the hindrances cannot be removed, therefore the situation arises to divert the track by providing the curves. Trial and error method has been used to determine the positioning of curves. Horizontal curves are provided when a change in direction of track is required and vertical curves are provided at point where two opposite gradients meets or wherever a gradient meets formation level. The data collected at site has been tabulated as Table No.01.

3.2 VERTICAL ALIGNMENT DESIGN

The vertical alignment analysis deals with gradient design. These are provided to counteract the rise and fall in the track level. Gradient design includes grade compensation, falling and rising gradient. Grade compensation aims at reducing the gradient in curved portion of the tracks. Standard grade compensation provided in Broad Gauge Tracks is 0.4% per degree. Gradients are further classified as ruling, momentum pusher and station yard gradient and have completely different applications according to the geometry of the track.

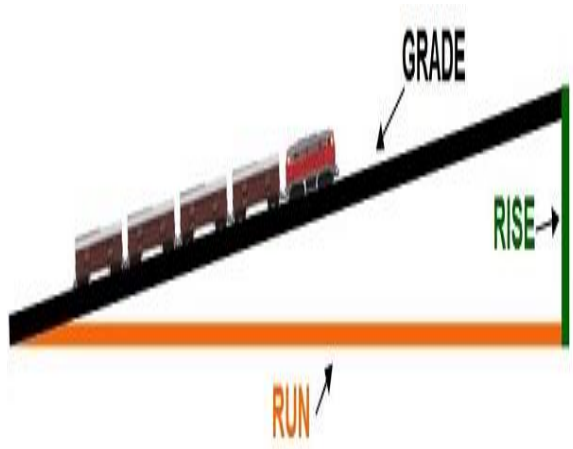

Fig.01.-Showing Gradient(*Ref*-modelbuilding.org)

The main objective behind providing the gradient during this survey work is to match the elevation difference of Nimerkheri Station and the power house at Khargone and additionally to cut back the cost of earthwork.

As per the data collected at site:-

Formation level at Nimerkheri Station	:- 212.874 m
Formation level at Power plant	:- 255 m
Difference in formation level	:- 42.126 m

As per Indian Railway Standards., ruling gradient of 1 in 200 has been fixed to facilitate the running of train without overturning. Thus survey has been administered to overcome the difference of formation levels and to determine the gradients to facilitate the joining of track for smooth running of train The gradient list has been tabulated as TableNo.02.

Table No.01: LIST OF CURVES

S.NO	CURVE NO	TTP1	CTP1	CTP2	TTP2	RADIUS	DEGREE OF CURVE	TOTAL CURVE LENGTH	TRANSITION LENGTH
Curve in Indore end									
31	1A	0.000	-1600.000	-1000.000	0.000	360	4.86	600.00	
Curve in Main Line									
1	C1	880.000	1304.351	930.847	1420.000	-355	4.93	373.50	489.153
2	C2	1800.000	1969.613	2412.253	2581.730	500	3.50	442.64	169.477
3	C3	2581.730	2697.225	2883.593	2998.593	-700	2.50	186.37	115.000
4	C4	3122.822	3217.822	3291.714	3386.714	-875	2.00	73.89	95.000
5	C5	3581.424	3621.424	3719.598	3759.598	2000	0.88	98.17	40.000
6	C6	3827.853	3872.853	3903.206	3948.206	-1750	1.00	30.35	45.000
7	C7	6893.446	6988.446	7022.788	7117.788	-875	2.00	34.34	95.000
8	C8	9198.768	9313.768	9404.447	9519.447	-700	2.50	90.68	115.000
9	C9	11014.430	11129.430	11318.477	11433.477	700	2.50	189.05	115.000
10	C10	13365.759	13480.759	13554.352	13669.352	-700	2.50	73.59	115.000
11	C11	14601.860	14696.860	14803.622	14898.622	875	2.00	106.76	95.000
12	C12	14977.086	15092.086	15388.016	15503.016	-700	2.50	295.93	115.000
13	C13	15622.346	15737.346	15979.540	16094.540	700	2.50	242.19	115.000
14	C14	17270.007	17315.007	17469.023	17514.023	1750	1.00	154.02	45.000
15	C15	18049.794	18094.794	18424.652	18469.652	-1750	1.00	329.86	45.000
16	C16	18854.160	18914.160	18973.036	19033.036	1000	1.75	58.88	60.000
17	C17	20561.085	20676.085	21242.730	21366.930	-700	2.50	566.65	124.200
18	C18	21366.930	21481.930	21967.531	22082.531	700	2.50	485.60	115.000
19	C19	22561.347	22676.347	23194.848	23309.848	700	2.50	518.50	115.000
20	C20	23373.547	23488.547	23962.715	24077.715	700	2.50	474.17	115.000
21	C21	24133.086	24228.086	24299.095	24394.095	-875	2.00	71.01	95.000
22	C22	25560.809	25675.809	26103.786	26218.786	-700	2.50	427.98	115.000
23	C23	26961.325	27076.325	27361.368	27476.368	-700	2.50	285.04	115.000
24	C24	28501.351	28616.351	28688.294	28803.294	-700	2.50	71.94	115.000
25	C25	30176.974	30291.974	30892.210	31007.210	-700	2.50	600.24	115.000
26	C26	31062.827	31177.827	31586.872	31725.661	700	2.50	409.04	138.789
27	C27	31725.661	31840.666	32351.134	32466.134	-700	2.50	510.47	115.000
28	C28	33031.412	33146.412	33399.509	33514.509	-700	2.50	253.10	115.000
29	C29	33569.995	33684.995	33800.416	33915.416	700	2.50	115.42	115.000
30	C30	35897.078	36008.078	36712.443	36823.443	500	3.50	704.36	111.000

Table No.02: List of Gradients

SR. NO.	CHAINAGE	PROP. FORM. LVL.	DISTANCE (m.)	PROP. GRADIENT		
1	-2040	211.457				
			245.00	LEVEL	LEVEL	LEVEL
2	-1795	211.457				
			1105.00	RISE	1 IN	1204
3	-690.000	212.375				
4	627.700	212.874				
			282.30	LEVEL	LEVEL	LEVEL
5	910.000	212.874				
			1210.00	FALL	1 IN	1785
6	2120.000	212.196				
			880.00	LEVEL	LEVEL	LEVEL
7	3000.000	212.196				
			1360.00	RISE	1 IN	385.1
8	4360.000	215.728				
			580.00	FALL	1 IN	634.57
9	4940.000	214.814				
			760.00	FALL	1 IN	2945.74
	5700.000	214.556				
			820.00	FALL	1 IN	215.00
10	6520.000	210.742				
			490.00	RISE	1 IN	265.0
11	7010.000	212.591				
			410.00	FALL	1 IN	484.6
12	7420.000	211.745				
			320.00	FALL	1 IN	200.0
13	7740.000	210.145				
			440.00	RISE	1 IN	210.0
14	8180.000	212.240				
			340.00	RISE	1 IN	424.5
15	8520.000	213.041				
			1000.00	RISE	1 IN	670.2
16	9520.000	214.533				
			1200.00	FALL	1 IN	1200
17	10720.000	213.533				
			1000.00	RISE	1 IN	670.2
18	11720.000	215.025				
			1560.00	RISE	1 IN	199.974
19	13280.000	222.826				
			460.00	RISE	1 IN	250.136
20	13740.000	224.665				
			775.00	RISE	1 IN	200.000
22	14515.000	228.540				
			1625.00	FALL	1 IN	250.000
23	16140.000	222.040				
			1820.00	FALL	1 IN	220
24	17960.000	213.767				
			1420.00	FALL	1 IN	240
25	19380.000	207.851				
			1140.00	RISE	1 IN	465.1
26	20520.000	210.302				
			680.00	RISE	1 IN	270.06
27	21200.000	212.820				
			740.00	RISE	1 IN	734.86
28	21940.000	213.827				
			1620.00	LEVEL	LEVEL	LEVEL
29	23560.000	213.827				
			900.00	RISE	1 IN	265.408
30	24460.000	217.218				
			1020.00	RISE	1 IN	200.000
31	25480.000	222.318				
			780.00	RISE	1 IN	250.080
32	26260.000	225.437				
			1040.00	RISE	1 IN	669.7
33	27300.000	226.990				
			1540.00	RISE	1 IN	1200.3
34	28840.000	228.273				
			1280.00	RISE	1 IN	400.000
35	30120.000	231.473				
			2380.00	RISE	1 IN	250.0
36	32500.000	240.992				
			520.00	RISE	1 IN	201
37	33020.000	243.580				
			980.00	RISE	1 IN	250.000
38	34000.000	247.500				
			1500.00	RISE	1 IN	200.000
39	35500.000	255.000				
			1704.00	LEVEL	LEVEL	LEVEL
40	37204.000	255.000				

5. CONCLUSION

This study work namely design of railway alignment has been carried out using analytical approach. Feasibility study, if applied properly reveals most knowledge required for the construction purpose as well as for the adaptability of the project. The planning phase of the project should be carried out judiciously and precisely so as to avoid further alterations during construction phase. The detailed survey data containing chainages, Bench marks and many other levels needs to be plotted on paper so that construction according to the drawing can be carried out. It has all details about change in course, gradients, turnouts-connections etc. Railway feasible alignment requires a special attention on all its stage of work because it involves enormous financial expenditure, in consideration with appreciable amount of safety of the user or resource utilize, in its operation.Thus, proper geometric design of railway alignment is necessary to make it feasible and economical in respect of cost and its commencement.

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