Improvement in Geometric Design of SH-18: A Case Study

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1 Introduction

In India moreover as within the whole world transport system plays a vital role in the development of the country as an economic method and within the alternative ways in which additionally like the development of agriculture and industries. It additionally helps us to cut back financial condition by making employment.

The Planning Commission has prepared Model Concession Agreement (MCA) for State Highways. These MCAs follow the Design, Built, Finance and Operate (DBFO) approach that needs the holding in turn the responsibility for comprehensive design. However, the responsibility for providing safe and ultimately rests with the government. Safety on rural highways is of high concern because nearly 2/3 of road deaths are found on such roads. Geometry is the key factor that affects it like speed of the vehicle which consequently results in crash incidents [1, 5].

Alignment of the road is one amongst the parts of geometry that abrupt into Rural Highways. An elongated tangent or edged curve after a flat curve is an example of inconsistency within the alignment. These alignments induce unwanted and haphazard changes in speed which will cause crashes. So, highway design must be evaluated for compatibility in geometry [2–4]. Several developed countries like The United Kingdom, Australia, Switzerland, Canada, France, and Germany have adopted numerous geometric consistency evaluation techniques for the design process [12].

In the present study, the project area is taken as part of SH-18 which starts at Badnawar and ends in Kardawad village (near Petlawad town) Madhya Pradesh (India).

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1.1 Difficulties in Existing Project Section

(1) Accidents due to Narrow curves: It is habitual nature of drivers to overtake moving vehicles that are moving on curves which leads to a collision between them, which results in an accident, since once the driver attempts to overtake on an unseeing curve, the overtaking sight distance is nearly negligible, lead to the overturning of the vehicle.

(2) Slipping of the vehicle in season: The road constructed in hilly and terrain area experience fog in winters and because of fog sight distance for the driver is reduced. During raining season due to precipitation, the road surface becomes slippery which reduces the coefficient of friction between the tyre and the paved surface is greatly reduced. This result is in the slithering of vehicles, particularly 2-wheelers.

(3) Poor curve negotiation: Due to hilly terrain, driving a vehicle depends purely on the sight distance of the headlight of the vehicle, this is also another reason for accidents because the driver doesn't consider the sharp curves.

(4) Geometry of road: With the existing condition of road geometry, which has poor stretches. The project section passes through villages and rolling terrain, wherever there are sharp curves. The present vertical curves are typically unsatisfactory except for the Mahi River approach area. Camber provided was found to be flat, for superelevation at most of the curves was inadequate.

There is a primary need to improve the present State Highway(SH)-18, a minimum of 2-Lane standard because the Average Daily Traffic (ADT) and passenger car unit of the project section is 10095 veh/day and 101,056 PC/day respectively in which 8.62% is heavy traffic. The Annual Daily Traffic is increasing by 15% in recent years. Therefore, improving the traffic and travel condition in this section is required by improving the existing geometry of the project section: 1) To confirm balanced road interconnectivity within the state; 2) To reduce specific kinds of accidents; 3) To rupture the period of travelling; 4) To improve the geometrical design of road as per IRC (Indian Roads Congress) and conjointly prep-end all safety measures with high design preciseness; 5) To save time, achieved by using software tool; 6) To subtilized saving in vehicle operation value and less pollution; 7) To uplift economic factor due to quicker higher accessibility.

The aim of the study is to improve geometrical design parameters, horizontal and vertical curves in the existing project section.

2 Study Area

The highways in the state are continuous routes, connecting the headquarters of the district and other important towns inside the state and further joining with major national highways or connecting with other nearby states, Madhya Pradesh, INDIA, the state has a good network of roads.

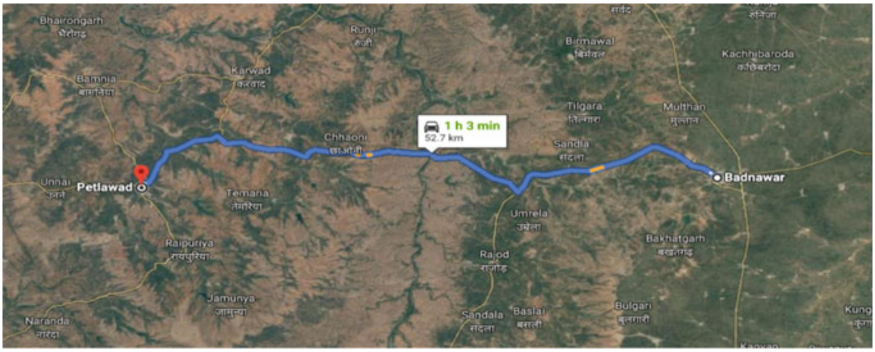

Fig. 1 Study area

The State Highway-18 starts from Bhopal city and ends at Thandala town. The total distance covered by SH-18 is 335 km. in Madhya Pradesh. Major towns covered by SH-18 are "Bhopal—Sehore—Ashta—Dewas—Ujjain—Badnawar—Petlawad—Thandala", as shown in Fig. 1.

The road section starts from Badnawar town and ends at Kardawad village (near Petlawad) and it covers 44.90 km. length. Town Badnawar is situated in Dhar District and town Petlawad is in Jhabua District. The River Mahi divides the Project Road into Dhar and Jhabua, which lies in the South East of Madhya Pradesh, India.

The aim of this study is to impart road geometrical design into the software system in addition as relate to the planning standards applied to the software system. Bentley MX ROAD (advanced, sting-based modelling tool) software was a system that permits the fast and correct design of all road varieties.

3 Data Collection

3.1 Preliminary Survey

Topographic data was taken by total station and GPS device given in Table 1.

3.2 Volume Count Survey

3.2.1 Average Daily Traffic (ADT) Survey

ADT survey was conducted at chainage no. 17300 and 20,500, as shown in Table 2.

Annual Average Daily Traffic (AADT) was observed by normalizing the ADT at all the locations.

Table 1 Data of total station survey

S.N	Nothing	Easting	Reduce level
1	2,546,315	523,349.9	505.641
2	2,546,349	523,313.0	505.48
3	2,546,382	523,276.1	505.495
4	2,546,416	523,239.1	505.937
5	2,546,450	523,202.1	505.841
6	2,546,482	523,164.1	506.168
7	2,546,510	523,122.7	505.737
8	2,546,538	523,081.2	505.039
9	2,546,565	523,039.5	504.828
10	2,546,593	522,997.9	504.411
11	2,546,863	520,665.0	497.066
12	2,549,275	483,825.9	394.216
13	2,549,277	483,796.0	394.191
14	2,549,279	483,766.0	393.804
15	2,549,277	483,736.3	392.566
16	2,549,273	483,706.6	391.36
17	2,549,268	483,676.9	391.05
18	2,549,264	483,647.3	390.868
19	2,549,259	483,617.6	390.536
20	2,549,256	483,595.1	390.143

3.3 Hourly Variation and Peak Hour Variation

The hourly variation and peak hour variation are shown in Table 3.

3.4 Terrain

The present road under consideration passes through typically plain/rolling terrain. The following terrain classification has been adopted (Table 4).

3.5 Design Speed

The design speed is the guiding criteria for correlating options such as sight distance, curvature and superelevation upon which the safe operation of the vehicles depends.

Table 2 Summary of ADT

Type of vehicle	At km. 17 + 300		At km. 20 + 500	
	Vehicles	PCU	Vehicles	PCU
Fast passenger vehicles				
2-Wheeler	4668	2334	5554	2777
Auto	111	111	71	71
Car/Jeep/Van	3624	3624	5321	5321
Mini Bus	58	87	71	107
2-Axle Bus	42	126	250	750
3-Axle Bus	13	39	151	453
Fast Moving Vehicles				
Mini LCV	344	344	771	771
LCV	312	468	1461	2192
2-Axle Truck	295	885	1259	3777
3-Axle Truck	276	828	1620	4860
MAV (4–6 axle)	190	855	1967	8852
MAV (>6 axles)	0	0	0	0
Tractor	36	54	22	33
Tractor with Trailer	70	315	160	720
JCB, HMV	4	12	2	6
Others	0	0	0	0
Slow Moving Vehicles				
Cycle	11	6	9	5
Cycle Rickshaw	0	0	0	0
Animal Drawn	2	12	0	0
Toll Exempted Vehicles				
Car	5	5	9	9
Bus	0	0	0	0
Truck	0	0	0	0
Total	**10,095**	**10,156**	**18,716**	**30,737**

Table 3 Peak hour factors observed at traffic count locations

S. No	Survey location	Peak hour volume (PCU)	ADT (PCU)	PHF (%)	Peak hour
1	km. 17 + 300	760	10,156	7.48	9:00 AM – 10:00 AM
2	km. 20 + 500	1976	30,737	6.42	9:00 AM – 10:00 AM

Table 4 Classification of terrain

S. No	Terrain	Cross Slope
1	Plain	$< 10\%$
2	Rolling	10–25%
3	Mountainous	25–60%
4	Steep	$> 60\%$

Table 5 Design speed guidelines

Terrain Nature	IRC: SP: 73–2015		IRC: SP 84–2014	
As per	Ruling	Minimum	Ruling	Minimum
Plain	100	80	100	80
Rolling	100	80	100	80
Mountainous	60	40	60	40
Steep	60	40	60	40

The design speed for plain and rolling terrain has been proposed as follows (Table 5).

Since, the project road passes through the Plain/Rolling terrain. Hence a design speed of 80 km/hr. has been proposed& IRC: SP: 73–2015 is followed.

3.6 Horizontal Alignment

Software MX Road is used to represent the horizontal alignment. The report is also generated according to the final alignment decided with all the detailing such as IP chainage, tangent, arc length, arc start chainage, arc end chainage, radius hand of arc etc. (Fig. 2).

4 Results and Discussion

With the considerations of IRC specification [6–11] and existing characteristics of the project road, the subsequent design value is taken for carrying out the design of the project work by using the software. The result drawn from the software output is as follows (Table 6).

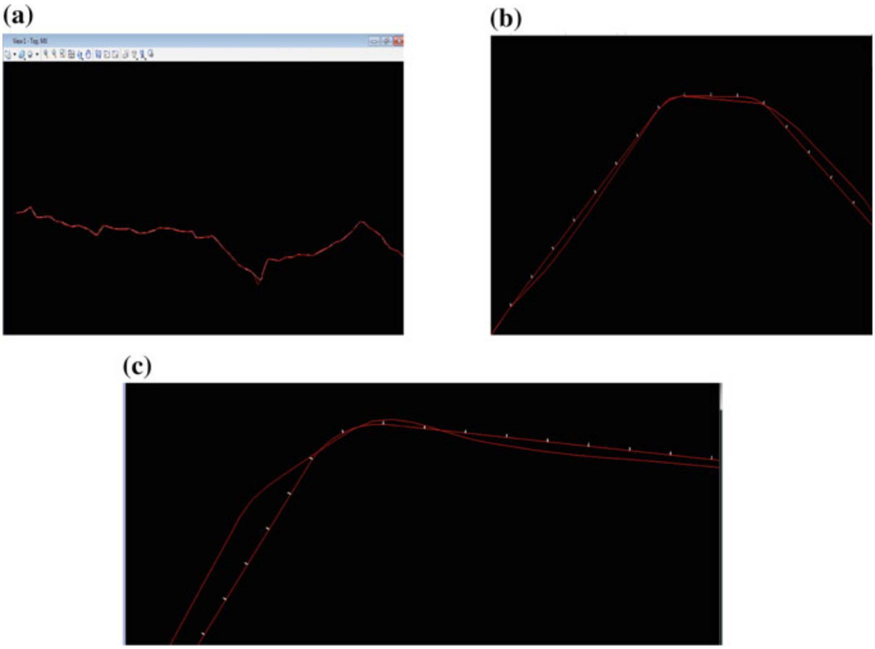

Fig. 2 **a** New alignment overlapping the existing alignment **b** Part of Horizontal alignment (Curve-1) **c** Part of Horizontal alignment (Curve-2).

4.1 Design Standard Proposed

4.2 Horizontal Curve Details

The location of the horizontal curve is given in Table 7.

The results for horizontal curves are shown in Table 8.

Where,

HC = Horizontal Curve, LC = Length of Curve, E = Existing, P = Proposed.

4.3 Vertical Curve Details

The location of the vertical curve is given in Table 9.

The results for horizontal curves are shown in Table 10.

Where,

VC = Vertical Curve, LC = Length of Curve, K = Design Rate of Vertical Curvature, E = Existing, P = Proposed.

Table 6 Design standards adopted

S. No	Items	Existing parameters	Adopted design standards
1)	Design speed	40 kmph	80 kmph
2)	Cross-sectional requirements		
3)	ROW	10 m	12 m
4)	Width of a carriageway on both sides of the median 2-lane carriageway with each lane of 3.5 m width	7.0 m	7.0 m
5)	Shyness	Not available	0.25 m
6)	Paved shoulder width	Not available	2.5 m
7)	Camber/Crossfall		
8)	Carriageway included paved shoulders	2.5%	2.5%
9)	Horizontal alignment		
10)	Ruling radius of horizontal curve	230 m	250 m
11)	Superelevation	5%	7%
12)	Minimum transition length	44.39 m	90 m
13)	Safe stopping sight distance	45 m	180 m
14)	Setback distance at horizontal curve	2.84 m	9 m
15)	Vertical alignment		
16)	Ruling gradient	3.9%	2.5%
17)	Minimum length of vertical curve	30 m	60 m
18	Gradient		
19)	Maximum	4.5%	3.3%
20)	Minimum	3.4%	0.3%

Table 7 Horizontal curve detail

Horizontal curve (HC)	Chainage No. (Km.)	
	Start	End
HC-1	10 + 690	10 + 750
HC-2	12 + 250	12 + 320
HC-3	25 + 610	25 + 700

Table 8 Results for horizontal curves

HC	LC (Km)	Speed (Kmph)		Radius (m)		Superelevation (%)		Transition length(m)		Setback distance (m)	
		E	P	E	P	E	P	E	P	E	P
HC-1	60	40	80	100	400	4	7	44.39	90	2.11	9.07
HC-2	70	40	808	100	400	4	7	44.39	90	2.12	9.47
HC-3	90	40	80	45	400	8.88	7	53.7	90	2.84	9.48

Table 9 Vertical curve detail

Vertical Curve (VC)	Chainage (Kmph.)	
	Start	End
VC-1	1 + 437	1 + 467
VC-2	2 + 173	2 + 223
VC-3	2 + 607	2 + 697
VC-4	3 + 988	4 + 108
VC-5	5 + 196	5 + 296

Table 10 Results for vertical curve

VC	LC (Km.)		Speed (Kmph)		Radius (m)		Gradient difference (%)		length of VC(m)	K
	E	P	E	P	E	P	E	P		
VC-1	30	159.33	30	80	769.2	7966.5	3.9	2	30	6.544
VC-2	50	132.29	30	80	1471	9992.5	3.4	1.33	50	24.524
VC-3	90	135.75	35	80	2571	16,161	3.5	0.84	90	35.662
VC-4	120	175.23	40	80	3000	13,575	4	-1	120	31.504
VC-5	110	129.29	25	80	2444	19,297	4.5	0.67	100	29.463

The further results are drawn as follows:

1 The design speed of alignment is 80 km/h and almost all existing road is utilized.
2 Within the proposed Right of Way, all geometrics are planned and farthermost all security measures are viewed.
3 Geometrics of the project corridor are designed as per IRC and all safety measures are considered.
4 Calculation and application of superelevation with location and link are developed.
5 The proposed alignment clashes minimum horizontal curve radius at the junction (minor), where the speeds are finite to a minimum.
6 For a few sections, limiting values are adopted where site restriction conquers.

5 Conclusions

The aim of the study is to improve the geometrical design of the existing State Highway. The important parameters of road components like horizontal alignment, vertical profile and side road activities and the combination of these elements were intended as the main influence. A segment that makes risky locations and or road sections and also a necessary factor of each element is considered.

According to the case study following findings were obtained.

a. Alignment has been designed for 80 Kmph speed in place of 40 kmph and a plan and working cross-sections are developed.
b. Design of Horizontal and Vertical curves as per the requirement of site condition for removing black spots on the curve.
c. The proposed superelevation for the horizontal curve is 7% whereas the superelevation for the existing road is less than 7%.
d. The proposed setback distance for the horizontal curve is 90 whereas the existing setback distance is less than 90.
e. The length of the vertical curve increases up to four times as compared to the existing length of the curve.
f. The existing gradient difference of vertical curves is less than the value given in codal provisions as per IRC and the proposed gradient difference of vertical curves is designed as per IRC i.e. 3.3%.

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