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Original Article

Improvements to Road Geometrics of Aluva to Kothamangalam Section of State Highway 16 in the State of Kerala

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Abstract - *The study aims to make geometric improvements to State Highway 16 Aluva town to Kothamangalam, situated in the district of Ernakulam in Kerala, India. The length of the project road is 34.340km. The paper deals with literature review and data collection, the identification of geometric deficiencies, possible realignments, geometric improvements to alignment, vertical profile and cross-sections and estimation of costs.*

Keywords **-** *Costs, Design, Deficiency, Geometry, Highway.*

1. Introduction

The project road is State Highway 16, situated in the district of Ernakulam in Kerala, connecting Aluva City to Kothamangalam along Perumbavoor town. The length of the project road is 34.340km. The route is a section of the roads leading to Munnar, one of Kerala's major tourist destinations. The highway also acts as an industrial corridor to exchange resources for local industries. The problems faced by road users are sharp curves which affect visibility, insufficient lane width, and lack of provisions for pedestrians, bus bays and road signs and markings. The project aims to assess the geometric deficiencies, conduct geometric improvement, and enhance road safety. The geometric improvement involves improvement to alignment, vertical geometry and cross sections as per the design standards.

2. Research Focus

The project focuses on collecting data and analysing, assessing geometric deficiencies, designing and improving the geometry and introducing project facilities.

3. Literature Review

Researchers conducted a study to determine the importance of geometric consistency for rural roadways. To promote safe travel on two-lane highways, the report advises against abrupt changes in road layout or increases in design speeds.[2]

In Kerala, India, researchers looked into the reliability of horizontal curves in relation to geometric aspects. The results show that safer curves are those with higher dependability values than those with lower ones.[1]

Studies are conducted on the benefits of geometrically designed access-controlled highways along Kerala state.[3]

Researchers developed brand-new geometric design methods to save vehicle costs and enhance traffic safety. Improvements to the road geometry can be made by adopting consistency in design to reduce the frequency of gear changes. A sedate driving style can be adopted to stay within the fuel economy range recommended by car manufacturers and prevent sudden acceleration or deceleration, among other suggestions to increase mileage**.**

Researchers presented a study article on the relationship between traffic, accident frequency, and road alignment. The study aids in analysing the planning and design requirements for a stretch of road to lower the likelihood of accidents. [12] Studies are conducted to evaluate design uniformity, which is crucial for improving road safety. To ensure design uniformity, the study included an evaluation of two-lane roadways without spiral turns. A model is created that can maintain consistency in the design along the entire route.[5]

4. Materials and Methods

Literature review: A extensive literature review is conducted to understand the studies conducted to date in the project area. Research studies in the state of Kerala as well as international journals, have been reviewed. Research studies focus on the necessity of geometric improvement and the relationship between geometric design variables and accident rates. Many studies on geometric improvement using Civil3D software have not been conducted in the Aluva region in the Ernakulam district.

Data collection and analysis: Engineering surveys and investigations have been conducted at the site to collect relevant information about the study stretch. A classified volume count survey is conducted to determine the existing traffic scenario. The subsequent sections describe the analysis and results of the primary traffic surveys conducted on the project corridor. Traffic is analysed and forecasted to arrive at the widening requirements.

Detailed Road inventory, pavement condition and Bridges and culvert inventory are carried out at the site as per IRC SP 19 specifications. The inventory data was analysed by comparing with codal provisions and inadequacies with respect to the carriageway, structures, road signs and marking is arrived at.

Assessment of geometric deficiencies: Map studies and Google Earth files were used for the initial assessment of the geometry of the existing road where geometrically deficient locations are located. Site visits are conducted to understand the feasibility of improvement of these stretches with respect to social and environmental facts and finalise alternative options. A topographic survey was carried out to collect the essential ground features along the existing alignment. This was undertaken with a topographic survey and developed a Digital Terrain Model (DTM), which was used to assess the existing situation and possible improvements in highway geometrics**.** A road alignment is created in Civil 3D using existing topographic survey data to arrive at the existing geometric details like horizontal curve radius, vertical gradients and available speed.

Geometric design: As the land use along both sides of the project highway consists of settlements, acquisition costs for widening and curve improvements and design to standards are very high. So, the Alignment options study is conducted by geometric design using Civil 3D software for speeds as per State highway and Major District Road standards. The alignment with moderate land acquisition and social impact is proposed for the project road. Curves with geometric deficiencies are improved by providing radius and transition curves as per IRC. Realignments are proposed where sharp curves exist.

4. Results and Discussion

4.1. Road and Bridge Inventory surveys

Detailed inventory and condition surveys are conducted at the site for an understanding of road assets. The project road starts from Pulinchode and ends at Thankalam, having a total length of 34.5 km. The land use is majorly settlements along both sides. Major towns along the route are Perumbavoor and Aluva. There are about 10 minor built-ups along the route. The carriageway width is of a two-lane configuration. The pavement condition is fair to poor, and the shoulders are not well maintained. There are 6 minor bridges, 1 Railway Overbridge and 102 culverts along the stretch. There are 19 major intersections along the stretch. All the intersections lack channelization, signages and markings. There are 67 bus shelters along the project stretch; however, dedicated bus-stopping facilities like bus bays are absent. Road signage and marking facilities of a planned nature are absent in the project road.

4.2 Traffic Study

4.2.1. Classified Volume Count Survey

Classified volume count surveys were intended to estimate the project corridor's traffic scenario and identify necessary requirements to provide a better facility. The survey has been carried out at two locations; the locations of the surveys are

Homogenous section 1 – Aluva to Perumbavoor at Colonypadi
Homogenous section 2 – Perumbavoor to Kothamangalam at Pattal
The traffic volume count data – CCTV footages- are collected for 3 days between 02/07/22 to 16/07/22.

The minimum annual growth rate of 5%, as specified in IRC 37 – 2018, was considered and is projected for 20 years. Projected traffic comes to 90000PCU in HS1 and 85000 in HS2. The project highway shall be widened to a 4/6 configuration.

4.3. Accident Data

Accident data for the year 2021 is collected from NATPAC and Police authorities. A total of 17 fatal crashes and 130 grievous injuries happened along the project corridor.

4.4. Assessment of Existing Highway Geometry

In the horizontal geometry analysis, it is found that the project road has around 374 curves. Out of these,43 curves do not meet the minimum design speed of 50 kmph speed, about 145 curves do not meet the design speed of 65 kmph, and about 236 curves do not meet the minimum design speed of 80 kmph.

Existing vertical geometry is generally smooth, and the gradients exceed the limiting gradients only at a few locations totaling 400m only. Stretches with a gradient steeper than the limiting gradient and gradient in between the limiting and ruling gradient are identified at 20 locations totalling 540m.

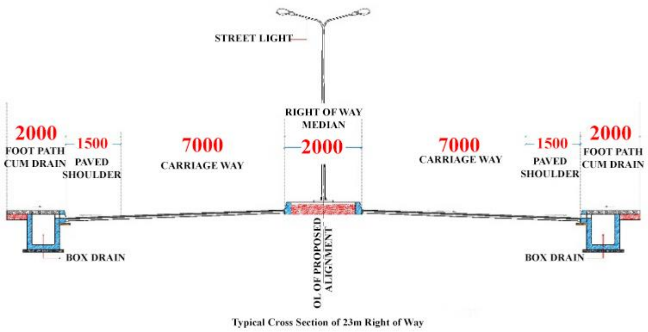

Fig. 1 Typical Cross section

4.5. Geometric Improvement

4.5.1. Design Standards

Developing design standards aims to establish project-specific guidelines for the many design components employed at various design stages that will be appropriate for the site's conditions. IRC codes and their specialized publications have been used to create design guidelines. IRC 73 – 1980 Geometric Design Standards for Rural (Non-Urban) Highways is adopted for the study

4.5.2. Typical Cross Section Adopted

A typical cross-section adopted for the study is in Fig 1

A typical configuration for a general section is:
Main Carriageway: 7m (2 x 7m Lane)
Paved Shoulder: 2m on either side
Footpathcum drain: 1m on either side/As per
Right of Way (ROW): 23m
Median : 2m

4.5.3. Alignment Options Study

Various alignment options have been explored for the four laning of the project road in consideration of the land acquisition constraints and traffic management during construction.

Alignment Option -1 Improvements Retaining Existing Road

This option was explored with the objective of minimizing the land acquisition by following the existing alignment. An alignment following the existing road alignment can be developed in two ways - widening equally on both sides and widening the road to one side. Widening the road to one side will facilitate traffic management and minimize land acquisition. However, this option is not recommended due to the following reasons the one-sided acquisition will have an unfavourable impact on one side of the road and a favorable impact on the other side of the road, resulting in objections from the unfavourably impacted residents/establishments. Also, it is difficult to justify the selection of the side for widening. Considering the above, the alignment option that follows the existing road and widening on both sides was explored.

Table 1. Summary of curve improvement

Sl No	Curve Radius (m)	No. of curves	Remarks
1	<50	Nil	
2	50-100	1	Built-up
3	100-300	58	
4	300-500	24	
5	500-800	15	
6	800-1200	7	
7	>1200	3	

Alignment Option -2

The proposed road is under the state highway classification, and an 80 Kmph design speed is advised. When the geometry allows, an alignment option was devised to follow the existing road; however, when the geometry of the existing road cannot deliver the recommended design speed, the alignment option deviates from the existing road. Several realignment sections were incorporated in the final alignment.

Alignment Option - 3

Considering the significant realignment sections in alignment option -2, another alignment option – 3 was developed by limiting the road's design speed to the requirements of an MDR (50 Kmph to 65 Kmph). This alignment was developed by following the existing road wherever the existing road geometry complied with design speed and deviating from the existing road wherever the existing road geometry was deficient.

Recommended Project Alignment and Details

Alignment Option -3 is recommended in view of the lower impact on land and buildings. Further details of the recommended alignment option are provided in the following sections.

4.5.4. Improvements to a Horizontal and Vertical Geometry

The horizontal geometric design is carried out using Civil 3D software, and the design speed adopted is 50 to 65kmph considering land acquisition constraints. All curves are proposed for improvement with radius and transition to meet the design standards. Table 1 gives the summary of proposed curve improvements for the project.

Considering the terrain conditions, vertical geometry was improved to a design speed of a minimum of 50 kmph throughout the road stretch. Existing gradients steeper than 3.33% are proposed for moderation. The approaches of bridges were proposed with a gradient of less than 3.3%, as per the provisions of IRC: SP- 73. All vertical curves shall comply with the criteria of stopping sight distance.

4.5.5. Proposed Realignment Locations

New alignments of shorter lengths are proposed as a geometrical correction at stretches having a series of sharp curves and deficient geometry. Realignments are proposed at

6 locations in the project, considering social impact and improvement to existing road geometry. The total length of realignments proposed in this project is 4km. The list of locations where realignments are proposed is provided in Table 2.

Table 2. Realignment locations

Sl. No.	Realignment Location	Length of realignment (m)	Speed kmph along Existing Road	Improved speed in kmph along realignment
1	Karothukuzhi Hospital Junction	280	20	65
2	Edathala	720	20	65
3	Vazhakulam	620	20,40	65
4	Chemberakki	760	20,50	65
5	Rayamangalam	880	20,50	65
6	Nangelipady	350	20,30	50

4.5.6. Improvement Proposals

38 bus bays are proposed for the project corridor for the safe stopping of buses as well as for the uninterrupted flow of traffic. Major junctions are designed to include channelisation. Other improvements include pedestrian facilities, road signs and markings and lighting.

4.5.7. Project Costs

Approximate cost estimates for the geometric improvement and upgradation to four-lane standards are calculated. Rate analysis for the approximate estimate was worked out based on the current Delhi schedule of rates for 2018. MoRTH specifications through PRICE software.

Investigation charges are not included in the estimate. The cost per km comes to 15 crores per km.

5. Conclusion

The geometric deficiencies along the project stretch are rectified, and the road is improved to a design speed of 50 to 65 kmph. The project corridor is made pedestrian friendly by introducing dedicated space for sidewalks and crossing facilities. Intersections have been improved to design standards. 38 bus bays are proposed to ensure dedicated space for bus stops without interrupting the traffic flow. Other improvements include street lighting and the provision of truck laybyes.

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