INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 5, Issue 3)
Available online at: www.ijariit.com

Analysis of deficits of highway to propose for better geometry

Hardik Sharma
hardikrbsharma@gmail.com
G. H. Raisoni College of Engineering, Nagpur, Maharashtra

ABSTRACT

For the Design of any roadway, there are many governing parameters that affect the total efficiency output as perceived by the driver. The roadway should be designed for perfect Geometric features. This paper involves the analysis or in other words the complete finding the wear-about of the deficits of an existing roadway and to come up with a proposal for the improved Geometric proposal for the roadway using DMRB as the basis for the design. There is much research going on the same deficiency improvement related aspects and still needs a lot of further scope of improvement in order to achieve the complete safety of a proposed roadway. Considering the ongoing research on the geometric improvements on the existing roadways the optimistic user as well as Eco-friendly design is to opted for our site

Keywords— *Geometric design, Highway geometry*

1. INTRODUCTION

Today's highway designer faces a wealth of safety information emerging from guidelines, manuals, handbooks, and research findings. This continuously accumulated information marks a new era in the field of highway geometric design. The novel safe-system approach to road safety represents a radical evolution in strategies for further improving road-safety outcomes (OECD/ITF 2008). In a safe system, road-safety problems are dealt with by considering how several components of the road transport system interact, rather than by implementing individual countermeasures in relative isolation (i.e., a system assumes the development of high levels of local and national coordination).

Sweden's Vision Zero (Swedish Road Administration 2006) is one breakthrough safe-system approach, based on the ethical standpoint of zero fatalities or serious permanent injuries in road accidents. The Dutch Sustainable Safety program (SWOV 2006) similarly constitutes a state-of-the-art safe-system approach, the goal of which is to prevent crashes and (where this is not feasible) minimize the probability of severe injuries. This is achieved by following a human-oriented proactive approach that recognizes people's physical vulnerabilities along with their capabilities and desired courses of action. Infrastructure and vehicles are expected to meet these human-oriented requirements. Furthermore, the safe-system approach has also been formally adopted by Austroads on the basis of the same rationale as the Vision Zero and Sustainable Safety programs and forms a key component of the Australian National Road Safety Strategy (Turner et al. 2009). New Zealand is also likely to adopt this vision (Turner et al. 2009). In the United States, several state departments of transportation (e.g., Utah, Washington, and Minnesota) have already started to apply the Vision Zero approach. A Transportation Research Board (TRB) Web workshop entitled Toward Zero Deaths: A National Strategy on Highway Safety recently took place in Washington, D.C. (TRB 2010a). It was proposed that the national strategy will have two parts: (1) a national safety plan and outreach program and (2) a process for implementing the plan.

The Report is based on the geometric designing of highway comprising of the Horizontal as well as Vertical Design Using Civil 3D software as per the standards mentioned in the DMRB (Design Manual of Road and bridges) or any other amendments mentioned by the Bedfordshire council manuals. To solve the problems, we had collected the preliminary survey data of Leighton Buzzard (United Kingdom). Complete Geometric Design of the section that is about 2.740 Km in length along a Greenfield is done. New Junction and a roundabout are proposed at the southern arm for proper and smooth traffic flow.

Another road-safety field is that of human-centred design. Indeed, the need for a user-centred and behavioural approach has been emphasized in recent research, specifically regarding highway design and operation (Dewar and Olson 2007; Fuller et al. 2005; Kanellaidis 1996a). Human Factors Guidelines for Road Systems is an ongoing study (TRB 2010b) that aims to provide the best of road users to facilitate safe highway design and operational decisions. On the other hand, the Highway Safety Manual (AASHTO 2010) provides highway engineers with a synthesis of validated highway research and proven procedures for integrating safety into both new and improvement projects. Specific guidelines and recommendations have also been developed to accommodate older road users, who are the fastest growing population group (Staplin et al. 2001).

Safety principles and an analysis of design features from a road-user perspective have already been successfully applied in road-safety audits (Austroads 2009b; IHT 2008). This has allowed potential safety problems for road users to be highlighted at various highway-design stages by identifying the elements of design that contribute to unsafe behaviour. The European Commission recently issued a directive (European Parliament and of the Council on Road Infrastructure Safety Management 2008) that requires "the establishment and implementation of procedures relating to road-safety impact assessment, road-safety audits, the management of road network safety, and safety inspection by the member states." The directive applies to "roads which are part of the trans-European road network, whether they are at the design stage, under construction, or in operation." Different road-assessment programs (RAP), such as Europe's EuroRAP, Australia's AusRAP, the United States's USRAP, and the international iRAP, have recently been developed. The intent of these programs is to classify road sections according to their level of safety and to assign star ratings similar to those used in the European new car assessment program (NCAP) crashworthiness program for cars.

For the aforementioned information to be a substantial aid, rather than a burden, to highway-design engineers, there is an urgent need to support and guide them so that they can become familiar with recent safety developments. To achieve this objective, this paper proposes that relevant information from the fields of the safe-system approach, including user-centred design and road-safety auditing, should be integrated into highway geometric design guidelines in a concise, comprehensive, and designer-friendly way. This paper explores recent developments in road safety, proposes a framework for integrating safety and human-factors issues into highway geometric design guidelines to support highway designers so that they become familiar with recent safety and human-factor developments, and discusses topics related to the proposed safety framework. Informing and communicating with highway de-signers through familiar highway-design guidelines is the best and most effective way to develop a safety-conscious design.

2. LITERATURE REVIEW

The geometric design of highway comprises of the design of features of highway such as cross-sectional elements, visible sight distances, Horizontal alignment, curves, superelevation, and other allied features. Plan and design of the geometric elements of the road during the initial alignment stage itself by considering future traffic growth. Once the construction is complete any change in the Geometric features causes a handsome addition to the expenditure cost. This paper presents has covered the past work on the geometric design of highway and elaborately presented the planning and designing of geometric features.

Although there is a number of factors that influences the design of the highway, the suitable geometric design has the objective of giving optimum efficiency in traffic operation with contentment safety measures at a reasonable cost. The research paper includes the road safety parameter directly influenced by the Geometric parameters of the Road. The insight is given by the Paper "Highway Geometric Design from the Perspective of Recent Safety Developments" (George Kanellaidis-ASCE-2008). Research of human factors in highway engineering includes these two main areas: change in driver behaviour due to Geometric Design. A critical review of pertinent research and related provision. For the research purpose, the review of the Geometric design of Germany and Great Britain is considered as presented in the paper "Human Factors In Highway Geometric Design" (By George Kanellaidis-ASCE-1996).Review of the paper "Maximum curving speed" (Nazmul Hasan -ASCE 2018) supporting the idea of the maximum curving speed modelled to ensure comfort and safety, considering two primary parameters: the curve parameters and the vehicle characteristics. "Exploring the Association between Traffic Safety and Geometric Design Consistency Based on Vehicle Speed Metrics" (Kun-Feng Wu, Eric T. Donnell, Scott C. Himes, and Lekshmi Sasidharan-ASCE-2013) research has demonstrated the relationship between operating speeds and geometric design features on two-lane rural highways. Review of the paper "Aspects of Superelevation Design" (G. Kanellaidis -ASCE-1991), the paper shows the Superelevation design using the AASHTO design standards based on the relationship between the degree of curve and actual operating speeds, to harmonize highway Superelevation design with drivers' actual speed behaviour, which could enhance highway safety. The paper "Safety Evaluation and Adjustment of Superelevation Design Guides for Horizontal Curves Based on Reliability Analysis" (Hamid Farhad Mollashahi, Kasra Khajavi, and Asieh Khadem Ghaeini-ASCE-2017) gave a brief idea about the use of Superelevation and changes in a road's transverse slope and how they are typically based on the road's design speed to provide safety and comfort for a vehicle driving on a horizontal curve. However, due to the difference between operating and design speeds, there has always been uncertainty in determining the margin of safety using Superelevation. The paper "Method of trading of Highway" (J. Tainganidis and G. Kanellaidis -ASCE-1992)The grading plan of a highway is mainly determined by the alignment, profile, cross sections, and drainage requirements of the highway. In the case of an intersection, the grading is determined through the consideration of the aforementioned elements of intersecting highways as a whole with adjacent roads, structures, and surrounding topography (AASHO: A policy 1965). The review of the paper "Method for Balancing Cut-Fill and Minimizing the Amount of Earthwork in the Geometric Design of Highways" (A. Burak Goktepe, A.M.ASCE, and A. Hilmi Lav - 2003) focuses on the economic considerations as important as other design controls and elements of design. Hence, the designer should maintain the cut-fill balance with focus on.

Minimizing earthwork which may significantly decrease construction costs. In practice, one way to reduce the amount of earthwork is to set the grade line as closely as possible to the ground line while also considering cut and fill balance. However, this practice may be misleading since balancing is achieved along the centre line of the road. In reality, the centre line ground elevation rarely represents the whole cross-section in terms of cut and fills balancing. Especially in mountainous terrain, transverse changes in ground elevation with respect to the centre-line elevation of the cross section are abrupt. Consequently, confirming the grade line to the weighted ground line integration of the weighted ground elevations along the centre-line would give a balanced cut and fill and reduced the amount of earthwork, giving a more economic result. The paper "Innovative Roadside Design Curve of Lateral Clearance: Roadway Spiraled Horizontal Curves" (Qing Chong You and Said M. Easa, M. ASCE-2017) presents an innovative design method for determining lateral clearance needs on a spiralled horizontal curve to satisfy sight distance requirements. Review of the paper "Reliability Analysis of Vehicle Stability on Combined Horizontal and Vertical Alignments: Driving Safety Perspective" (Kesi You1 and Lu Sun, M. ASCE-2013) A driver/vehicle/road closed-loop dynamic simulation model 3D alignment was made using Matlab/Simulink for reliability analysis of vehicle stability on the alignment and profile i.e. horizontal and vertical curves.

3. HORIZONTAL DESIGN

3.1 Fixation/Finalization of the 2D design file (Auto CAD 2018)

- This involves deciding all the parameters and are finalized using the Auto CAD software.
- Center alignment
- Curves and deflections
- Carriageway Width
- Footpath width
- Verge width
- Curve widening
- Set back Distances
- Design of the Horizontal Alignment and all other horizontal components

  – Center alignment Design
  – Circular curve
  – Transition Curves (Spiral)
  – Strait alignment for the non-interchange paths.
  – Junction / Intersection Design including the Design of the Junction, and Roundabout Design.
  – Assigning the Assembly as per the proposed scheme and the pre-determined scheme.
  – Design of Superelevation
  – Assigning the superelevation to the alignment and the required curves.
  – Calculate the rate of change of superelevation as per the DMRB standards
  – Assigning the smooth transition of the superelevation on the alignment.

3.2 Vertical Design

Design of the Vertical profile accompanies the alignment with the vertical Levels once the horizontal design has been finalized.

- The major governing parameter of the vertical design is the K(constant - Rate of change of vertical gradient per unit length). this parameter comes for the curves.
- The other factor is the visible sight distance, this parameter is taken care of once all the K constant values have been satisfied.
- The minimum and the maximum gradients of the profile to accompany the drainage of the surface water and also to have a safe rise gradient.
- The position of the vertical and horizontal curves and tried to have a coincident intersection point to have a pleasant ride.
- The difference of the existing to the proposed levels is maintained as per our design requirement.

3.3 Building up the final 3D Model

The horizontal and vertical design combined along with the proposed assemblies gives the proposed 3D surface having a smooth contour plan to cross-check the variation and errors of our proposal. This is also done on Civil 3d.

3.4 Determination of Design speed

The Design at the existing road approach is looked into for the “Hockliffe Road” & the existing road is designed for the National speed (NS) that is 30mph/48Kmph

Fig. 1: Existing Sign Board, Hockliffe Road

Table 1: Design Speed table from (DMRB TD 9/93)

SPEED LIMIT		DESIGN SPEED
MPH	KPH	KPH
30	48	60B
40	64	70A
50	80	85A
60	96	100A

3.5 Finalizing the cross-sectional elements of the roadway

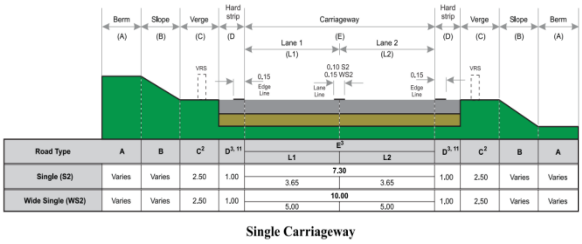

Fig. 2: Dimensions of cross-section components for rural all-purpose road machine

3.6 Design of intersections and roundabouts

The intersections are properly accompanied by signalised junction development on the Hockliffe road and a roundabout design on the Leighton Road. The junctions play a vital role in affecting the traffic flow speed and are provided for the driver/user’s safety on the road. All the Junction Design parameters are taken into consideration from the DMRB Volume 6 Section 1TD50/04 and the Roundabout is designed as per the DMRB Volume 6 Section1 TD16/07.

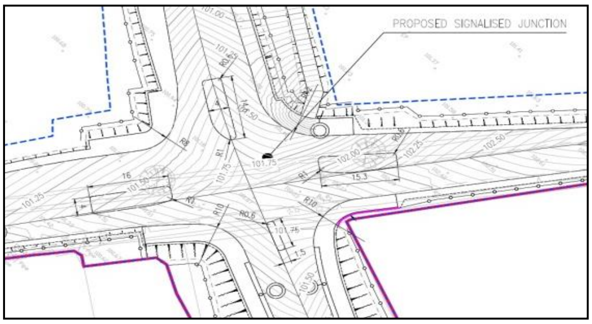

Fig. 3: Junction design at Hockliffe Road using DMRB Volume 6 Section1 TD50/04

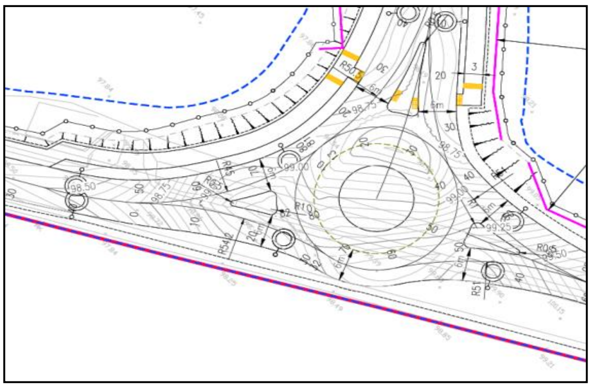

Fig. 4: Roundabout design at Leighton Road using DMRB Volume 6 Section1 TD16/07

3.7 Horizontal Design Layout

Before the detail, three-dimensional designs commence the finalization of the 2D design is more important. The 2D design is the Top view projection of our project stretch. The "2D view design" comprises of the two-dimensional fixation of the boundary limits and its proper positioning of the different cross-sectional elements in the X-Y plane. The most important parameter is to define the Boundary Site Limits (Right of way) i.e. the site constraints within which the limits of our project are defined. All the cross-sectional elements – (a) Carriageway centreline & Edges, (b) Verges, (c) Footpaths, (d) Ponds, (e) Junction approaches, (f)Leisure tracks, (g) Position of Utility services (e.g. Bus-Shelter, Lighting Poles, Pedestrian Crossings), (h)Position of Krebs it up stands and drop. The parameters required for the Horizontal Design of the roadway are mainly taken from the DMRB TD 9/93.

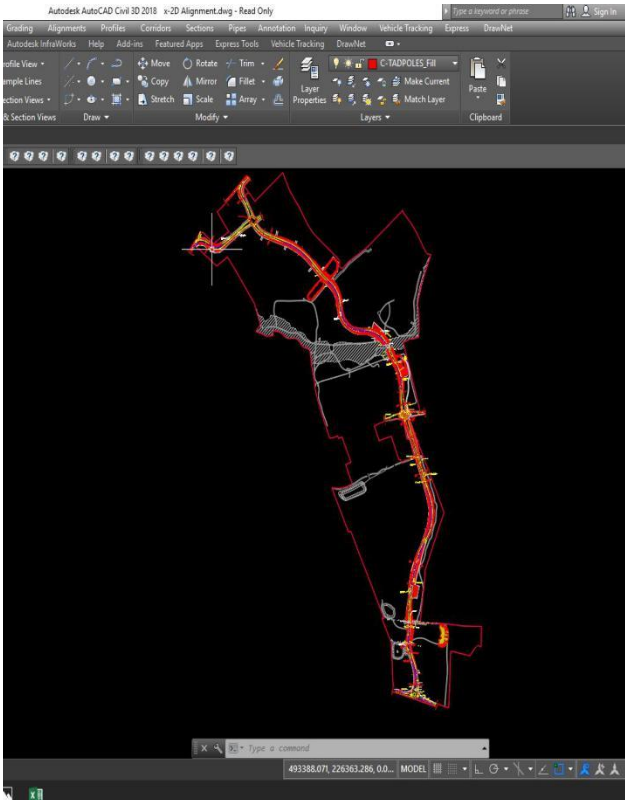

Fig. 5: Horizontal Design Layout

4. CONCLUSION

The paper has represented a detailed Geometric Design based on the Design Manual of Roads and Bridges (DMRB) of a site in Leighton Buzzard, the UK, intended to give a brief idea of all the parameters pertaining to the Road Geometric design and all other safety parameters being considered. The project inclination is towards providing a conceptual approach and preliminary insights regarding all the safety parameters regarding the Design of a roadway for a smart city.

The Improved Road geometry gives us the eye-sparkling results of improved capacity and operational efficiency of the traffic, Improve in the safety reducing the accidents and traffic jam incidents, increase in the productivity for commercial vehicle by optimizing the design speed for more efficient travelling, increase in the traveller comfort and convenience of the road users, improve in the transportation operation on the intersections and congested areas of roads with appropriate alternatives, with a reduction in the environmental pollution and energy impact & a vital Improvement in the public transportation services and operations to increase the growth of public transport The present study reported a positive association between the increased user comfort and safety-related parameters governed on the geometric design and its dynamic nature.

With regard to future research, it should be noted that all the design parameters, variables and formulae pertaining to the geometric design are taken directly from the DMRB and neither the derivations nor the factors being affected by the derivation are considered in this design. All values are directly taken from the DMRB.

Although the research has covered all the parameters pertaining to the Geometric Design of the Roadway, for the future research the Drainage design should also be considered to have a complete design ready as for the site requirement. This paper has provided a collective set of information that might be required or considered for the design of any roadway.

5. FUTURE SCOPE

With regard to future research, it should be noted that all the design parameters, variables and formulae pertaining to the geometric design are taken directly from the DMRB and neither the derivations nor the factors being affected by the derivation are considered in this design. All values are directly taken from the DMRB.

Although the research has covered all the parameters pertaining to the Geometric Design of the Roadway, for the future research the Drainage design should also be considered to have a complete design ready as for the site requirement. This thesis has provided a collective set of information that might be required or considered for the design of any roadway. There is also future scope for the software used for the same geometric design which might save the time taken in the elaborated process mentioned in the thesis.

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