# Geometric Design of Suburban Roundabouts Considering A Case Study In Bhopal (M.P)- A Review

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***Abstract***- *A contemporary roundabout is a crossroads with a circulation roadway where traffic flows continuously in one direction around the central island that leads to the approach legs' exits. Vehicle speeds are also modest. The following steps make up the iterative process of modern roundabout design: (1) determining that the roundabout is the best traffic solution; (2) defining the number of lanes at the intersection based on the level of service and required capacity; (3) designing the roundabout geometry initially; (4) designing the vehicle swept path, the fastest path analysis, and visibility performance checks; and (5) designing the roundabout in detail if the performance checks' findings support the design criteria. Compatibility between the initial roundabout geometry design parts must be carefully considered because they are not independent. Roadway design includes the following steps: establishing the road alignment; calculating sight distances, radii of horizontal curves, and lengths of vertical curves; charting the alignment profile using bearings or co-ordinates (easting and northing); determining stations and elevations of points along the proposed route; calculating earthwork quantities; and many other studies and calculations. These computations are performed to find the optimal alignment while fulfilling design specifications. Manual geometric design is extremely time-consuming, labour-intensive, and prone to costly errors. There is currently a need for computer software to be used in the planning of roadway geometry. The software offers huge time and effort savings and is incredibly accurate. In this study, a comprehensive geometric design of a typical roundabout is presented using both AutoCAD and MX ROAD software considering three roundabouts in Bhopal (M.P) which have majorly reported fatal accidents. Enabling the 3D visualisation of the design saves money and time.*

***Keywords***- approach alignment; outer radius; circulatory roadway; apron; splitter island; roundabout entry; roundabout exit; longitudinal slope.

## I. INTRODUCTION

In the UK, the yield-at-entry regulation, which gave circulating traffic precedence over incoming traffic, was implemented in the 1960s, marking the beginning of the construction of contemporary roundabouts. During the 1980s, modern roundabouts began to appear in several European countries. Roundabout development has accelerated in Europe over the past three decades. Among European nations, France has the most roundabouts (63,212), followed by Spain (36,762) and Italy (30,917). Other nations that are pursuing major roundabout development programs include the Netherlands, Sweden, Switzerland, Denmark, Finland, Germany, and Austria.

The process of designing a modern roundabout is iterative and starts with determining that the roundabout is the best traffic solution under the circumstances. Choosing the outer radius to determine the intersection's size, drawing out the approach leg axis, and establishing the geometry of the design features on the roundabout entrance and exit lanes, circulation roadway, and central island are all included in the initial roundabout design. Following the roundabout's initial design, three performance tests are often conducted: the analysis of the fastest path, the visibility checks, and the design vehicle sweeping path. The geometry of the elements used in the first design phase is changed if the findings of these checks do not match the design suggestions.

Design standards and guidelines that are utilised in Croatia, Austria, France, the Netherlands, Germany, Serbia, and Switzerland are provided in this entry for the original design of individual geometric elements at a suburban single-lane roundabout. The following factors led to the selection of these documents. The outer radius, the circulatory route, the apron, the splitter islands, the entry and exit design, and the longitudinal slopes of the approaches and/or the intersection plane are the geometric components of suburban roundabouts that are typically defined by each of them. Second, the shapes and sizes of the intersection design elements are influenced by the various topography and geography of the nations from which these papers are derived. Switzerland and Austria, for example, have primarily mountainous topography, while the Netherlands has primarily flat landscape. In France, Germany, Croatia, and Serbia, all sorts of terrain are simultaneously represented. Third, the documents were chosen based on the year of their publication, which ranges from 1991 (when Swiss rules were published) to 2014 (when the most recent Croatian standards for suburban roundabouts were released).

In particular, the major building of roundabouts in all of the aforementioned countries occurred throughout this 23-year span, thus we think it would be interesting to see if and how roundabout design methodologies evolved during that time. In thisresearch, the Federal Highway Administration (FHWA) requirements are excluded due to the fact that the American design vehicles utilised in the sweeping path analysis (and, hence, the roundabout design elements' size) are larger than those seen on European roads. British and Australian traffic drives on the left, which is why the UK and Australian requirements are not included in this section.

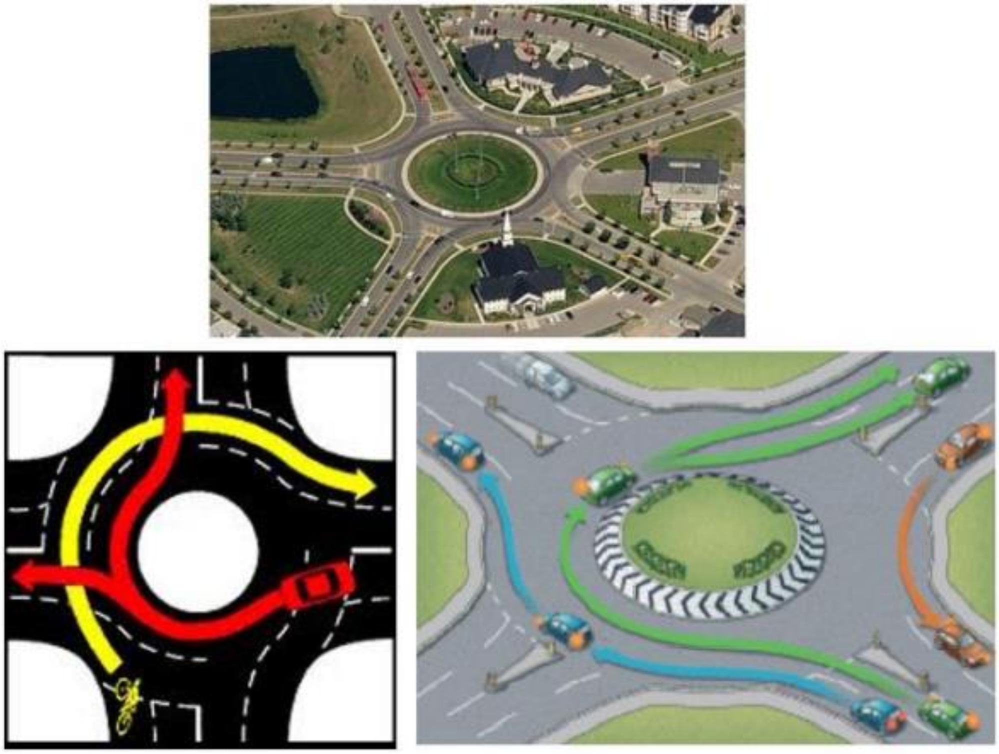

Fig 1: **Roundabout and movement of vehicles**

## II. REVIEW OF LITERATURE

**Aman Mewara and Rakesh Mehar (2024)** used smart city principles to develop the perfect smart road for Vidisha City and to show how accurate geometric design can be completed quickly.

From an engineering standpoint, precise horizontal alignment was produced utilising the AutoCAD Civil3D software, which is both practical and sound. Proper vertical geometry is crucial for any road to facilitate vehicle movement, so we used the data from the codes to define and sketch the road's requisite vertical profile. The efficiency of the road will also be increased and vehicles will be able to travel through the intersections safely, securely, and without congestion if they are designed using the same software at both ends. The practical and sound road may be more efficiently aligned by collecting traffic information and examining the existing research area. AutoCAD Civil 3D's capabilities eliminate the main disadvantages of a manual design process, which is time-consuming, tedious, and extremely prone to expensive mistakes. Through the support of design checks for several codes, AutoCAD Civil 3D provides a global platform for design and analysis.

**Bara Al-Mistareh et.al (2024)** sought to create models for forecasting the circulating speed for through movement as a function of the roundabout's land use, geometric features, and the approaching highway free-flow speed by examining the speed profiles before, at, and after thirty chosen roundabouts in Jordan. Video images were analysed for geometric features, and speed data was recorded using a laser radar gun. The circulating speed was simulated using several characteristics, such as the roundabout diameters, free flow speed, entry deviation angle, approaching highway exit width, circulating roadway width, and introduction width. Six different types of roundabouts with varying land uses and geometric features have speed profiles created for them. The roundabout impact was shown to reduce speed upstream of the entry and downstream of the exit for 150 meters.

The street free flow speed (FFS) upstream influences the rate of decline, with the last 50 meters upstream of the entry showing the biggest drops, according to the results. The speed at the exit was higher than the speed at the entry, and there was variation in the speed readings about the middle of the cycle lane.

**Raffaela Cefalo et.al (2024)** showed that operating speeds on horizontal curves and tangents on two-lane rural highways with low tortuosity alignments regularly surpassed both the design speeds and the maximum allowable design speed for the road category. Therefore, it is considered unfeasible to use the design speed to evaluate consistency on these roads, and using operational speed presents difficulties because of speeds that are higher than the maximum allowable limit. Insufficient research has been done on two-lane rural highways with low tortuosity alignments, so the goals were to investigate the relationship between design consistency and safety levels and to suggest speed-control measures to keep the maximum operating speed within the maximum allowable speed range.
Operating speeds on roads with low tortuosity alignment are shown to be significantly more dependent on the alignment's general features (as measured by the required speed in operating speed models). It is also only possible to evaluate speed consistency when the maximum operating speed (desired speed) is strictly controlled. Furthermore, it is advised to use a particular kind of speed control, which is accomplished by setting a restriction on the road section's curvature change rate (CCR) according to the intended speed (environmental speed), the assessment of which becomes essential.

**Ankit Verma and Akhilesh Nautiyal (2023)** Using NH-05 as a case study, the research considered future traffic forecasts and all safety measures recommended by the Indian Road Congress (IRC) to build the existing highway to improve its geometric features. All designs were created using the OpenRoads software, which held the design speed constant at 50 kmph. The carriageway width is set at 7.5 meters, the shoulder width is set at 2.4 meters, and the overall width of the road is 13.0 meters. The maximum super-elevation is 7%, and the cross-slope or camber is 2.4% for bituminous surfaces and 3.6% for earthen surfaces.

Mostly traversing rugged, mountainous terrain, the alignment has a high curvature of more than 200 degrees per km and a cross slope of 45% to 60%. There are even a few hard uphill points in the course. Because the road is orientated along the face of the hill, the project road has a valley on one side and a hill on the other. The maximum superelevation is 7%, and the cross-slope or camber is 2.5% for bituminous surfaces and 3.5% for clay surfaces. Furthermore, a 0.6-meter additional carriageway widening will be implemented at curves.

**Pankaj Raghuwanshi et.al (2023)** Utilising MX Road Software, the goal was to enhance the Balampur Ghat Section's vertical profile and horizontal alignment on the Bhopal-Vidisha State Highway Road (SH-18). For Madhya Pradesh's State Highway No. 18 (SH-18), the Alampur Ghat portion, which is around 2.0 km long, the horizontal alignment and vertical profile have been designed. Heavy commercial traffic travels on SH-18, which connects Bhopal in the Madhya Pradesh state to Vidisha. Balampur ghat section is hilly terrain and has two improper horizontal curves along with a 6.5% vertical gradient because of this reason the section is not safe for deriving, therefore, it has become an accident-prone area and the accident-prone area has human and economic losses so it should be improved and redesign of the horizontal and vertical alignment for safe design speed.

Both improved alignments adopt a desirable minimum radius for horizontal curves, with the exception of chainage km 14.213 in improved alignment-1, where the curve radius is less than the desirable minimum but still greater than the absolute minimum radius values. The adopted design speeds for mountainous terrain are 60 kmph for the ruling design speed and 40 kmph for the minimum design speed. The increased design speed for road users and the reduction of accident frequency and delay time at existing roads are the goals of both improved alignments.

**Prashant Agarwal et.al (2023)** Autodesk Civil 3D transforms roadway design while reducing errors and saving time. In addition to maintaining engineering standards, it offers comprehensive solutions. The process is accelerated by real-time analysis and tasks are automated. Future studies can look at a variety of data kinds and complex situations. Through the collection of traffic data and accurate road alignment, the program streamlines the process. Specifications are met by spiral transition curves, and all curves follow the guidelines. Geometric design enhances geometry, is easy to use, and enables checks when creating 3D roads with Autodesk Civil 3D. It facilitates accurate computations, the application of superelevation, and the design of corridors and assemblies. The last tool that Autodesk Civil 3D gives designers is useful for building highways.

## III. CONCLUSION

A growing body of literature has investigated the safety performance of roundabouts, with a particular focus on the incidence and nature of traffic accidents. Roundabouts, increasingly adopted as an alternative to signalized intersections, are widely recognized for their potential to enhance traffic flow and reduce severe collisions due to their geometric and operational characteristics. Numerous empirical

studies suggest that roundabouts are generally associated with lower rates of fatal and injury crashes when compared to traditional intersections. This reduction is primarily attributed to the elimination of right-angle and head-on conflicts, which are typically more severe. However, despite their overall safety benefits, roundabouts are not immune to traffic accidents. Several surveys and observational studies have identified that minor collisions, particularly those involving property damage only, remain common. These often stem from inadequate driver comprehension of yielding rules, improper lane usage, and insufficient signage or visibility.
Research by Daniels et al. (2010) and Elvik (2003) provides robust evidence that roundabouts lead to a significant decrease in severe crashes but can result in an increase in minor accidents. This paradox highlights the complexity of roundabout safety performance and the need for contextual analysis. For instance, the conversion of signalized intersections to roundabouts has been shown to reduce injury crashes by up to 75%, yet studies such as those by Retting et al. (2001) also report increases in rear-end collisions and side-swipes due to driver hesitation and abrupt stops. These types of crashes are often more frequent at multi-lane roundabouts, where lane discipline and navigation errors become more pronounced.

Vulnerable road users, such as cyclists and pedestrians, also present a critical dimension in roundabout accident research. Studies have shown mixed outcomes: while lower vehicle speeds in roundabouts enhance pedestrian survivability, cyclists face increased risks due to potential conflicts with motor vehicles, especially in poorly designed facilities lacking segregated bike lanes. Additionally, research from the United Kingdom and the Netherlands underscores the influence of roundabout design on accident rates. Features such as central island size, entry curvature, visibility, and the presence of splitter islands have been found to affect driver behavior and, consequently, accident occurrence.

Surveys employing both police crash records and self-reported data have further revealed that nighttime accidents, adverse weather conditions, and inadequate lighting contribute significantly to roundabout-related crashes. Driver unfamiliarity with roundabout navigation also remains a persistent issue, particularly in regions where such infrastructure is relatively new. Consequently, educational campaigns, improved signage, and enhanced design standards have been advocated in the literature as means of mitigating accident frequency.

In conclusion, while roundabouts offer substantial safety improvements over conventional intersections, particularly in terms of reducing severe crashes, they present ongoing challenges related to minor accidents and user comprehension. The literature advocates for a holistic approach encompassing engineering, education, and enforcement to maximize the safety benefits of roundabouts. Continued empirical research, especially with disaggregated data and long-term evaluation, remains essential to refining roundabout design and implementation strategies.

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