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Junction Designs Examples and Improvements in Junction Designs

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Abstract

Junction design and application principles are very important because traffic accidents occur mostly at junctions. Insufficient infrastructure and driver errors constitute a significant part of accidents. In this study, two junction designs in the 11th Regional Directorate of Highways and the 16th Regional Directorate of Highways on the at-grade junction, which is one of the highway junction designs, were examined. The improvements made in the design of these junctions are examined. By using satellite images of roads, junction designs were made with the help of the Microstation inroads program. The findings obtained because of the study were evaluated and suggestions were presented.

Key Words

“Junction, Highway, Plan, Traffic”

1. Introduction

Junctions are defined as areas where multidirectional inbound traffic flows intersect or diverge. If these movements are in the same plane, it is called an at-level junction, and if they are in a different plane, it is called bridged junction. Highway junctions are frequently encountered on urban and extra-urban roads (Yetgin, 2000). Road performance is very important on highways as it affects features such as safety, speed, operating cost, and capacity. The principles required in junction design are as follows:

- Safety: the main purpose of junctions is for users to enter and exit the junction safely.
- Adequate level of service: it is desirable that the junctions serve a high number of users, but the time lost is low.
- Economy: of course, another important factor as well as other factors is the economy.
- Environmental Compatibility: it is important that the last work is aesthetically compatible with the environment.

Junctions should be designed with information obtained as a result of research. These are data from regional and traffic information. So regionally; topographic structure, road geometry, and zoning plans. Traffic data is the amount of vehicles on the roads, peak hour values, vehicle speeds, pedestrian mobility, accident reports at the junction, etc. It can be summarized as (KGM,2005). The junctions, defined as junctions, are the critical points where the accidents are most common (Tiwari and Mohan, 2016; Elvik et.al.,2009; Ogden, 1996). It has been determined that 2 of them are at the junction points (Novák et.al., 2018). According to the studies, it has been determined that 93% of the fatal and injury accidents that occur in the city occur at the junctions (TUİK, 2013). For this reason, junctions should be designed and implemented according to appropriate criteria (Güncü, 2019; Saplıoğlu and Karasahin, 2010). With the improvements to be made at the junctions, it is thought that there will be a decrease of approximately 50% in the accidents occurring in the city and 25% in the accidents occurring in the intercity roads.

In this study, two junction designs located in the 11th Regional Directorate of Highways and the 16th Regional Directorate of Highways on the same level junctions, which are among the designs of the Highways junctions, were examined and the improvements made in the designs of these junctions were studied. Junction designs, Çaldıran-12th, it is located at km 0+710 of the District Border Road and Sivas-Kovalı-Şarkışla-6th, the region is located at 10+922.39 km of Border Road.

Before the junction designs are made in both regions, some criteria should be reviewed by the regions. Regardless of its type, the following objectives should be considered in junction design (Rodegerdts, 2007):

- Controlling the speed.
- Ensuring its continuity.
- Increasing security.
- Reducing delays.
- Ensuring an adequate level of service.
- Reducing the operating costs of vehicles.

Table 1 and Table 2 show the necessary data for the junction design and the factors affecting the design (Yayla, 2004; Tunç, 2004).

Table 1. Required Data for Design

DATA REQUIRED FOR JUNCTION DESIGN	
Regional Data	Map, topography and plank out of the area where the junction is held Vertical and horizontal geometries, cross-section types and pavement type information of intersecting roads Situations that will bring legal restrictions for the area to be crossed Current ground condition and drainage information Roads, zoning roads, categories and types of planned junctions belonging to the junction area Existing zoning corridor and expropriation Relevant local government needs Location of featured facilities Traffic counts for all directions of main roads or secondary roads

Table 1 (cont.). Required Data for Design

DATA REQUIRED FOR JUNCTION DESIGN	
Traffic Data	Peak hour values
	Vehicle types and characteristics
	Velocities of vehicles for intersecting roads
	Pedestrian traffic counts, especially in city crossings
	Accident reports and statistics in the area
	Capacity analysis of existing junctions
	Capacity analysis of the junctions to be planned

Table 2. Factors affecting the design

FACTORS AFFECTING JUNCTION DESIGN	
Human Factor	Drivers habits
	Decision-making abilities of drivers
	Perception and reaction times
	Adaptation to the movement environment
	Frequency of use of the junction by pedestrians
Traffic Factor	Current road and design capacity
	Traffic volume value
	Peak hour value
	Dimensions and features of vehicles
	Movement distribution of vehicles
	Vehicle speeds
Physical Factors	Pedestrian movements
	Geometric features of the junction area
	Environmental factors
	Zoning situations
	Security situations
	Traffic signs
Economic Factors	Pedestrian crossings
	Construction costs
	Maintenance and operating costs

Considering the main criteria in the design of the junction, the junctions in question were made with appropriate consideration by the regions. Since there is no junction at km 0+710 of Çaldıran 12th Region Border Road, it was considered by the 11th Regional Directorate of Highways to design a junction for the aforementioned area, since vehicle entrances and exits from the secondary road to the main road are uncontrolled and there are traffic accidents. Since Çaldıran Regional Boarding School and Industrial Zone are located at the place where the junction design will be made, these were also taken into consideration while designing the junction. While designing the junction at the mentioned place, it is aimed to ensure the passage of vehicles by making improvements in the design of the junction in order to ensure traffic safety in the entrances and exits of the heavy tonnage vehicles, especially the secondary road and the Industrial Connection Road, since it is an industry. Satellite images of the region are shown in Figures 1 and 2.



Figure 1. Çaldıran-12. District Border Road Junction

Due to the Sivas traffic accidents at the 10+922.39 km of Kovalı-Şarkışla-6. Region Border Road, at the junction with the shelter, the design of the rotary junction type was considered by the 16th Regional Directorate of Highways. The said junction design, it is aimed to allow u-turns and at the same time to provide vehicle entrances and exits in a controlled way of the carriageway connection. Satellite images of the region are shown in Figure 2.

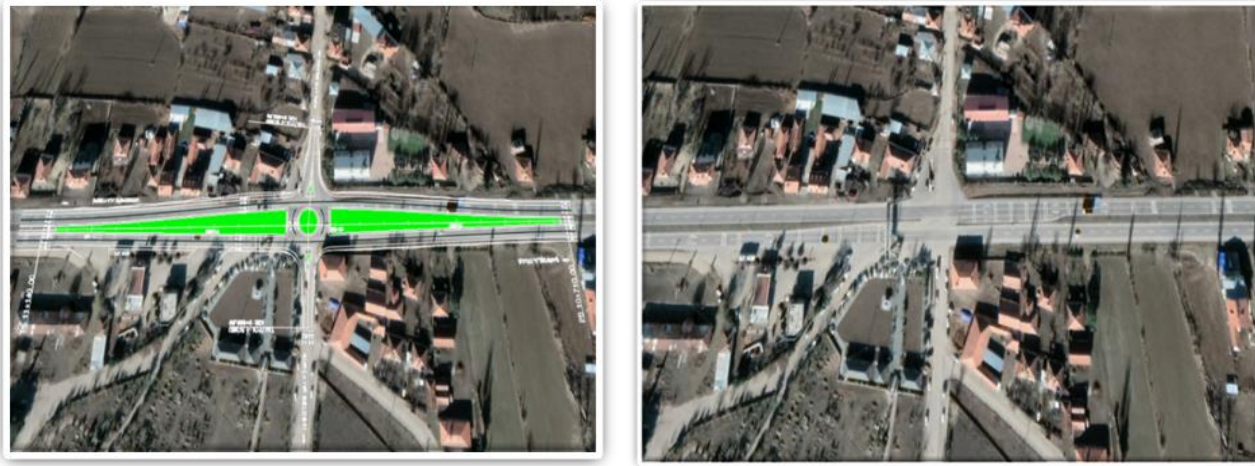


Figure 2. Sivas-Kovalı-6th Region Border Road Gürçayır Junction

2. Material and Method

As mentioned in the introduction section, the junction designs made to revise the existing junction in junction designs and to prevent uncontrolled crossings due to the absence of an existing junction have been examined and these junction designs are located within the borders of the 11th Regional Directorate of Highways and the 16th Regional Directorate of Highways. Çaldıran-12. The junction designed by the 11th Regional Directorate of Highways on the 0+710 km of the Regional Border Road and the junctions designed by the 16th Regional Directorate of Highways on the 10+922.39 km of the Sivas-Kovalı-Şarkışla-6th District Border Road were examined. Çaldıran-12. The junction designed for 0+710 km of the Regional Border Road is located in the Çaldıran District of Van province. The junction was designed for 10+922.39 km of Sivas-Kovalı-Şarkışla-6. Region Border Road is located in Gürçayır Municipality of Sivas Province.

The junction designs examined on the highways were made with the MicroStation program and the design criteria mentioned in the introduction section were taken into consideration during the design processes. The geometric standards of the junctions and the traffic safety principles were evaluated as a whole and their designs were made. The circular island of the junction is designed for 0+710 km of the Çaldıran-12. District Border Road is $R=10$ meters, the main road junction type cross-sections have a lane width of 3.5 meters, a lane width of 3.5 meters on the secondary road, and $wb15$ on the connection road. The road has been divided by the separation island to allow the entrances and exits of the vehicles, and it has been connected to the industrial junction with a platform width of 7 meters. The speed in the junction area is taken as 50 km/h and on the connection road as a minimum of 34 km/h. The existing sheltered junction

at km 10+922.39 of Sivas-Kovalı-Şarkışla-6. District Border Road was revised and designed, and city crossing-type cross-sections were used in the design. In order not to bring additional costs due to the demolition of the buildings due to expropriation, the circular island of the Junction was designed as $R=8$ meters. The lane width is taken as 3.5 meters on the main road and 3 meters on the secondary road. The speed is taken as 50 km/h on the main road and 30 km/h on the secondary road. At both junctions, their designs were made by paying attention to the stopping sight distances.

In the design of the junctions designed in the MicroStation program, first of all, map purchases should be made to cover the junction design. The design is realized by processing the zoning plan and expropriation plan into the map purchases. In the MicroStation inroads program, after the current purchases that we have mentioned as black jeans purchases are made, the black jeans purchases are printed on the screen in the MicroStation inroads program. With the help of the surface in the program, the black jeans triangulation method is surfaced. The purpose of the surfacing process is to reveal the profiles and create the red elevation and black elevation values on the vertical line. After the surfacing process is completed, by performing the junction design in accordance with the existing road, horizontal and vertical lines are created in the geometry section of the MicroStation inroads program. In the plan, a circular island, main road, secondary road connections, medians, inner and outer shoulders, and axis drawings are created. In the profile drawing, red elevation, black elevation, horizontal geometry, vertical geometry, and dev band are drawn. In addition, mileage, plumb curve length, and stance sight values are also shown in the profile drawing. Type cross sections are created from the modeller create template screen. The created type cross-sections are printed on the screen. At the same time, application values are also printed on the screen. The information that should be on the junction draft plan and profile sheets drawn with the MicroStation inroads program is follows:

- Landmark related to letterhead
- Road name on letterhead
- Scale, north arrow
- All section widths
- Junction geometry compatibility with manufacturing
- Compatibility of tables with medians
- Highway and secondary road tables
- Compatibility of boxes and geometries
- Compatibility of the speed in the box and the speed in the profile
- Guardrail shares must be processed on all sheets
- Layout names
- Sheet numbers must be sequential
- Side road some boxes should be written
- Posts should not overlap
- Slope scans should be done correctly
- Map inscriptions must be legible

3. Findings and Discussion

The plan, profile, type cross-section, and application studies made with the Microstation inroads program of the Sanayi Junction, which is designed for 0+710 km of the 12th District Border Road in Çaldıran, are shown in figures 3, 4, and 5. In the program studies, studies were started with the purchase of maps, and then plan drawing, profile drawing, type cross-section, and application drawings were made.

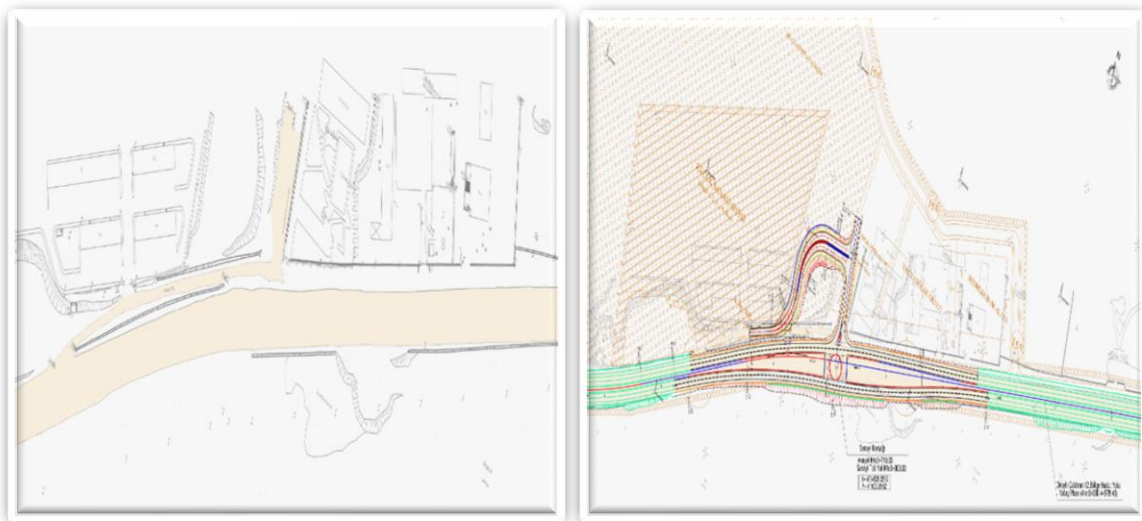
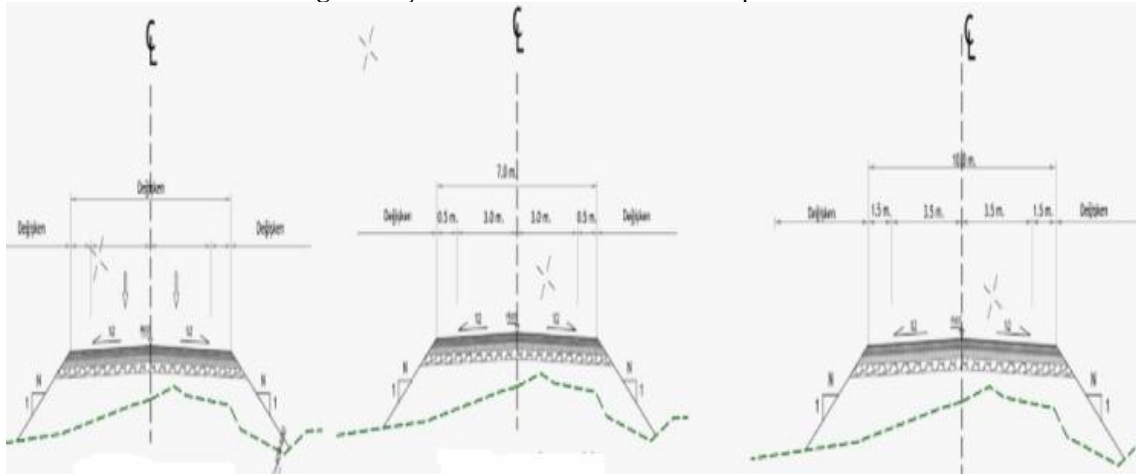
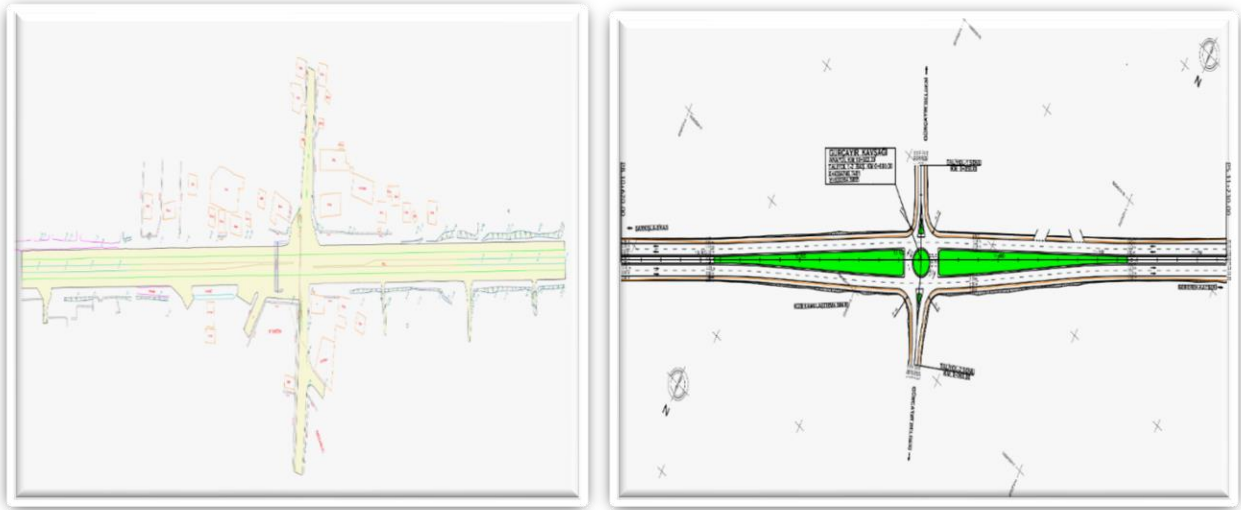


Figure 3. Çaldıran Industrial Junction Map and Plan**Figure 4.** Çaldıran Industrial Junction Connection Road, Secondary Road Type Cross-section

The plan, profile, type cross-section and application studies made with the Microstation inroads program of Gürçayır Junction, which is designed on the 10+922.39 km of Sivas-Kovalı-Şarkışla-6.District Border Road, are shown in figure 6,7,8. In the program studies, studies were started with the purchase of maps, and then plan drawing, profile drawing, type cross-section and application drawings were made. Since it is a city passage, the type cross-sections are designed as pavement and are also shown on the plan.

**Figure 5.** Gürçayır Junction Map and Plan

4. Results

The junction type designed for 0+710 km of Çaldıran-12.District Border Road, one of the junctions examined, was designed to allow vehicles to make u-turns due to the non-existing junction, and at the same time, uncontrolled crossings in traffic were prevented. Being an industrial connection road, the turns of heavy tonnage vehicles are designed to allow entrances and exits to the secondary road and connection road. In order to prevent traffic accidents and to allow u-turns at the existing left-hand sheltering junction on the 10+922.39 km of Sivas-Kovalı-Şarkışla-6.Region Border Road, an junction improvement was made with a rotary junction design.

The circular island junction design for Çaldıran Junction, one of the junction designs, was made to prevent uncontrolled exits of vehicles at the junction of the main road and the secondary road, and to prevent loss of life and property, since there is both a school and an industry in the area in question. In the first design made at the junction, it was seen that wb15 vehicles, which are heavy tonnage vehicles, do not provide mutual passage, especially in the transitions from the secondary road to the industrial connection road, and by considering traffic safety, the design was improved and the connection road was expanded with a drop island to ensure the passage of wb 15 vehicles. At the Gürçayır junction, the junction in question was revised and designed as a rotary junction, as there were accidents at the existing sheltered junction. When all these situations are evaluated, because Çaldıran industrial junction does not exist, and

Çaldıran-12. The fact that the Regional Border Road has heavy vehicle traffic has led to the need for an junction in this section. It is an alternative to junctions with different levels due to the decision-making at the circular island junction, being a roundabout type that is frequently used in places where the expropriation cost is high in our country and especially in urban crossings, allowing all necessary traffic movements, providing high operating speed for vehicles that will not make any turns, and the need for expropriation is relatively low. because it was preferred.

At the Gürçayır junction, on the other hand, in the section where the left sheltered junction is located in the middle median where the turn movement is provided, the number of overlaps is higher than other types of junctions, the vehicles in the junction area do not allow the return of the vehicles, there is no geometrical change in the entrance to the junction on the main road, so the drivers cannot understand that they have entered the junction area, the drivers stop and turn Since the storage capacity of the left shelter lane designed for traffic movements is lower than other junctions and there are traffic accidents, the junction was revised and the rotary junction type, which is a signalized junction type, was preferred. Rotary junctions serve their users differently from roundabouts. At the Gürçayır junction, the speed limit in the junction area is designed as 50 km/h, especially since there is a city crossing, pedestrians and vehicle drivers have important duties and they have to obey the horizontal and vertical traffic signs. At the junction with a circular island, one of the designed junctions, the tendency of vehicles coming over the main road and transiting the junction to pass through the junction area without slowing down is a very dangerous situation that is frequently observed. In particular, the vehicles making U-turns will join the traffic from the speed lane (left lane) of the opposite main road platform, and this may cause serious accidents if the vehicles in transit are traveling at high speeds. Especially on divided roads, it would be more accurate to eliminate the most correct type of junction in terms of traffic safety and heavy traffic with a different level junction.

In a good transport and traffic arrangement, junctions are defined as the most effective elements. For this reason, considering both its contribution to the country's economy with the budget spent on the roads and its role in reducing accidents, it is necessary to make the best design-project-maintenance-repair and operation of the junctions.

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