"ROTARY INTERSECTION DESIGN AT SOLAN BYPASS"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Mr. Abhilash Shukla

Assistant Professor

By

Akshay Chauhan (131611)
Archit Jain (131685)

To

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173 234

HIMACHAL PRADESH, INDIA

MAY-2017

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"ROTARY INTERSECTION DESIGN AT SOLAN BYPASS"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Akshay Chauhan** (**Enrollment No. 131611**) and **Archit Jain (Enrollment No. 131685)** during a period from July 2016 to May 2017 under the supervision of **Mr. Abhilash Shukla, Assistant Professor**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: - ………………………

Dr. Ashok Kumar Gupta	Mr.Abhilash Shukla	External Examiner
Professor & Head of Department	Assistant Professor	
Civil Engineering Department	Civil Engineering Department	
JUIT Waknaghat	JUIT Waknaghat	

ACKNOWLEDGEMENT

We wish to express our earnest gratitude to our esteemed mentor Mr. Abhilash Shukla, for providing us invaluable guidance and suggestions, which inspired us to take up such a challenge. He not only cleared all our doubts but also generated a high level of interest in the subject.

The topic **"Rotary Intersection Design at Solan Bypass**" was very helpful to us in giving the necessary background information and inspiration in choosing this topic for the project. Our sincere thanks to our project guide, **Mr. Abhilash Shukla,** faculty advisor for having supported the work related to this project. His contributions and technical support in preparing this report are greatly acknowledged.

We wish to thank **Professor Ashok Kumar Gupta**, Head of the Department, Civil Engineering Department for all his support by the way of providing wonderful working environment and facilities for the study in general and this work in particular. We extent our deep appreciation and thanks to the authors of various research papers which we referred in order to do this project. We are forever grateful to our families for their unconditional support.

Akshay Chauhan (131611)

Archit Jain (131685)

DECLARATION

We hereby declare that the project entitled "**ROTARY INTERSECTION DESIGN AT SOLAN BYPASS"** submitted by us to Jaypee University of Information Technology, Waknaghat in partial fulfillment of the Degree of Bachelor of Technology in Civil Engineering is a record of bonafide project work carried out by us under the guidance of **Mr. Abhilash Shukla**. The information submitted here in is true and original.

Date:……………………..

Archit Jain

Enrollment No. 131685

B.Tech Civil Engineering

Akshay Chauhan

Enrollment No. 131611

B.Tech Civil Engineering

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This project involves design of Rotary Intersection at Solan bypass (H.P.) for smooth flow of traffic and also to avoid conflicts at the intersection. In recent years, the intense growth of vehicles has caused heavier traffic congestions on the roads and intersections, which are even worse during the peak traffic time. An intersection which is not proper designed as per IRC guidelines, will increase the travel time of the vehicles cause delays and also cause more traffic accidents or conflicts. Besides, if the channelization of the intersection is not reasonable, road surface deterioration will be more serious within the intersection area due to many factors such as frequent start-stop, slow speed. Therefore, it is necessary to make the design of the intersections more accurate and efficient. The basic principles considered for the design includes the principles of uniformity & simplicity, minimize conflict points, and alignment & profile. A detailed survey of the study area was conducted to determine the entry, and exit radius of rotary and peak hour traffic volume was estimated through traffic volume survey which is calculated manually.

Traffic volume is incrementing at an alarming rate, so it becomes extremely difficult for traffic police to control the traffic manually at the intersections. For proper management of traffic stream at the Solan bypass (H.P.) intersection and to reduce the accidents at the crossing, there seems to be an urgent need to design a rotary intersection at the junction.

Chapter 1: INTRODUCTION

1.1 General Introduction

An intersection is where two or more roads join or cross. At the intersection there are through, turning and crossing traffic and these traffic movements are controlled in different ways depending on the type of intersection and its design. The operating efficiency of a highway and the safety depends upon the design of intersections. The main use of an intersection is to enable the road user to make a route choice and pass the junction safely without any collisions and with a minimum delay in traffic flow. Hence the problems that are faced by the vehicles while passing through an intersection must be identified and the design should be made in such a way that the driving task is quite simple and all the traffic manoeuvres take place smoothly.

Intersection is also a point of large number of major conflicts, besides a point of decision. These conflicts may arise due to the crossing manoeuvres of vehicles coming from different directions. Good intersection design results from a minimization of the magnitude and characteristics of the conflicts, delays and potential hazards occurring due to improper traffic and pedestrian movements.

1.1.1 Classification of Intersections

Intersections may be classified into two broad groups: (i) At Grade Intersection and (ii) Grade Separated Intersection.

1.1.1.1 Intersection at-grade

These include all roads which meet at more or less the same level. The traffic manoeuvres like merging, diverging and crossing are involved in the intersections at grade. The intersections at grade are further classified into three categories:

1. **Un-channelized intersections**: In these type of intersections, the entire intersection area is paved and the vehicles are free to use any part of intersection area. They can be of several types like tee (plain), tee (flared), cross (plain), cross (flared on one end) and skew (plain). These type of intersections are generally suitable for very low traffic volume. As the traffic volume increases, the intersection will have to be upgraded to a channelized intersection.

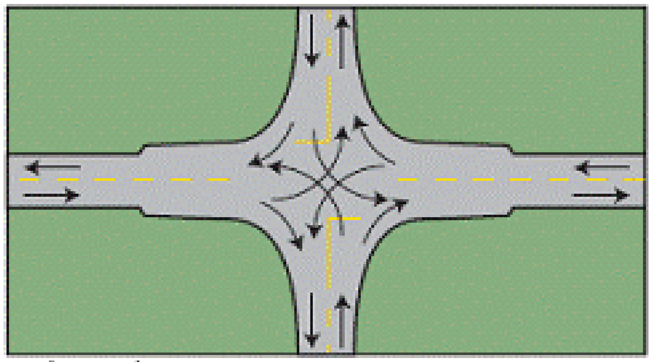


Fig. 1.1 (a) Un-channelized Intersection

2. **Channelized intersections:** It is achieved by introducing islands into the intersection area in order to channelize the traffic flow into appropriate streams. Channelizing islands 'channelize' the turning traffic into appropriate paths, control the angle of approach of vehicles coming from different legs, reduce the relative speed and decrease the conflict area at the intersections. If the relative speed of two vehicles is low then the chances of collision between them is less.

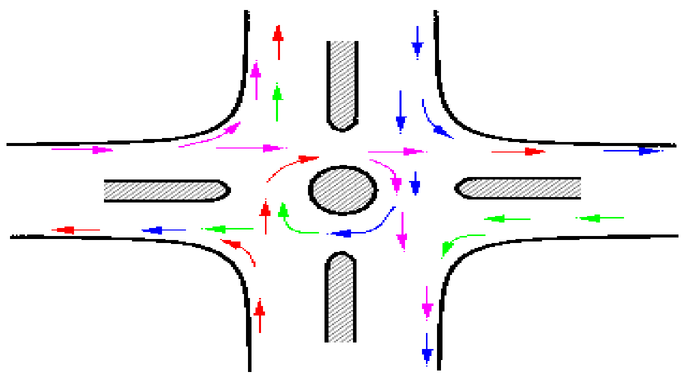


Fig. 1.1(b) Channelized intersections

1.1.1.2 Grade Separated Intersection

The grade separated intersections have roads which are separated by a difference in level, and eliminates the crossing manoeuvres. These are also known as interchanges. Grade separated intersections cause less hazard or conflicts and also reduce the traffic delay than at-grade intersections. The transfer of routes at grade separations take place through interchange facilities consisting of ramps. They are majorly classified as flyovers and interchanges.

Flyovers are sub-divided into overpass and underpass. At the crossing of two roads, when the road containing the major portion of the traffic stream is elevated to a higher grade, then it is known as an overpass and in case of depression of the major road, it is termed as an underpass.

An interchange is a road network in which the traffic in different roads flow at different levels. These can be trumpet, diamond or clover leaf type.

The main function of grade separated intersections is to eliminate all the crossing conflict points where possible path of two vehicles does not intersect or to reduce potential hazards by reducing the manoeuvre area and to accommodate other intersecting manoeuvres by merging, diverging and weaving at low relative speed to avoid collision between the vehicles.

1.1.2 Classification of Grade Separated Intersection

One of the differences made in type of interchange is between the directional and the non-directional interchange. Directional interchanges are those having ramps or turning roadways that tend to follow the natural direction of movement. They are preferred where two high-volume freeways intersect. They eliminate weaving movements, increase ramp speed and capacity, and reduce travel distance.
Non directional interchanges need a modification within the natural path of traffic flow.

1.2 Rotary Intersection

A traffic rotary or a roundabout is a special form of at-grade intersections wherein a unidirectional flow of traffic takes place around a large central island before the vehicles can weave out of traffic flow into their respective directions radiating from the central island. In India, ‘keep to the left’ regulation is followed and also clock-wise direction of flow around the central island is followed.

In a rotary intersection there is a smooth and efficient flow of traffic. All traffic proceeds at a fairly uniform speed. Frequent stopping and starting of vehicles are avoided. Crossing movements are converted into weaving or merging and diverging operations. Direct conflict is eliminated. Thus the journey is more consistent and comfortable.

The design of rotary elements needs special considerations, depending upon each site requirement. No standard design can be fitted into any given set of site conditions.

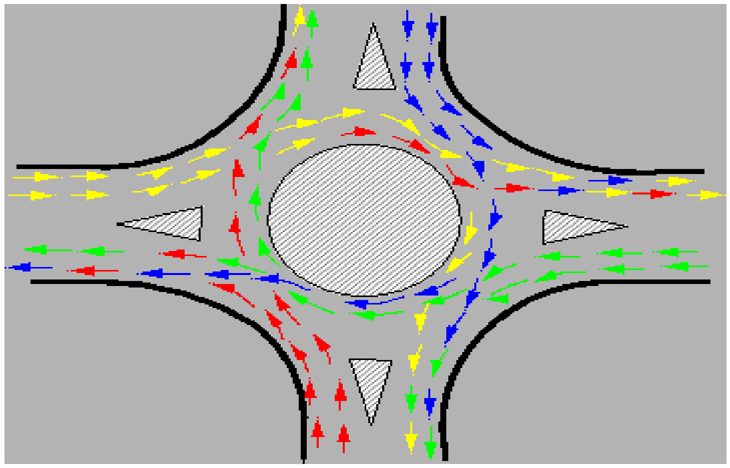


Fig 1.2(a) Traffic manoeuvres in a rotary

1.2.1 Advantages of Rotary Intersection

1. The vehicles entering a rotary are gently forced to reduce the speed and continue to move at slower speed which prevents the stopping of vehicles at the intersection.

2. Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.

3. They are ideally suitable for moderate or high traffic, or intersections with a minimum of three or four approaches.

4. Rotaries are self-governing and do not need practically any control by police or traffic signals.

5. Due to decrease in the speed of vehicles, severe conflicts and accidents are eliminated and their severity are much less in rotaries.

1.2.2 Limitations

1. All the vehicles are forced to slow down and negotiate the intersection. Therefore, the cumulative delay is higher.

2. Rotary construction is not justified for low traffic volume.

3. Rotary requires a large area of land which involves a high total cost.

4. At rotary, vehicles do not usually stop. They speed up and exit the rotary at relatively high speed. Therefore, they are not suitable when there is high pedestrian movements and large number of cyclists.

5. Rotaries are unsuitable when the angle of intersection of two roads is too acute or when there are more than seven intersecting roads.

1.2.3 Guidelines for the selection of rotaries

1. A rotary intersection is effective when the traffic volume ranges between 500-3000 vehicles per hour.

2. Rotaries are suitable when there is a minimum difference in traffic entering from each of the approach roads.

3. Rotaries are suitable when there are more than three or four approaches or if there is no separate lanes available for right-turn traffic.

4. A rotary is incredibly helpful when the proportion of the right-turn traffic is incredibly high, (if around 30 percent).

1.2.4 Traffic operations in a rotary

The traffic operations in a rotary are of three types: diverging, merging and weaving. The conflicts are converted into these three less severe conflicts.

1. **Diverging:** It is an activity operation in which the vehicles moving in a single direction are dispersed into various streams as per their destinations.

2. **Merging:** Merging is the opposite of diverging. It is the process of joining the traffic coming from different directions and meeting into a single stream.

3. **Weaving:** Weaving is the combined operation of both merging and diverging movements in the same direction. Crossing manoeuvre is changed over into weaving or merging and divergent operations. It is basically a type of crossing manoeuvre in which the angle of intersection is quite less.

The weaving manoeuvre consists of:

(i) A merging manoeuvre from the left and diverging out to the right.

(ii) A merging from the right and a diverging out to the left.

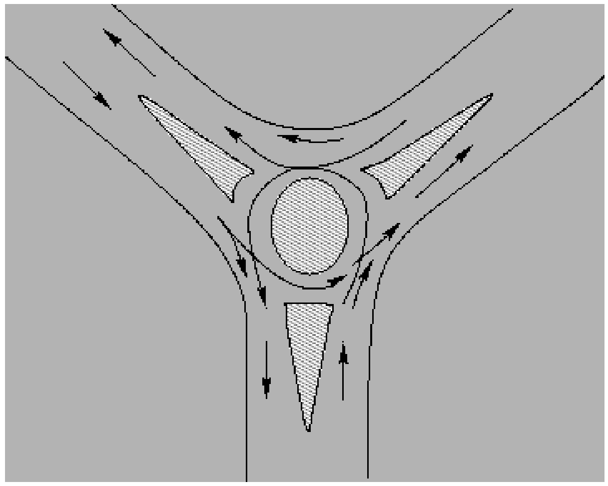


Fig 1.2(b) Traffic operations in a 3-way rotary

1.3 Need of Design

From site observations, we see that the intersection of Solan market and the highway is an uncontrolled intersection. Neither of the intersecting points has a rotary for controlling the traffic movement. There are no proper pavement markings and traffic signals. Moreover, physical dividers and channelizing islands would be required after the widening of the national highway. The situation is also affected by the encroachments and temporary vendors like tea stalls, shops on the intersection. An auto stand is located on intersection on both the approach roads of Solan-Chandigarh and Shimla-Solan. The vehicles are generally parked in a haphazard manner which leads to reduction of capacity of the roads. All these factors have an adverse impact on road user's behavior which enhances the possibility of accidents. Also to accommodate a large traffic volume of around 2300 veh/hr and 2645 veh/hr, there is a need to channelize the traffic. Therefore it became imperative to design the intersection and increase the capacity of road for smoother and safer traffic movement.

1.4 Scope of the Project

The scope of this project is to design an efficient rotary intersection to deal with the increasing traffic volume and reduce the number of conflicts, accidents and their severity at the junction of the highway and Solan city. It extends up to taking into consideration the changes in the geometry of the roads at the junction and the increased traffic volume due to four laning of the National Highway-22.

The project extends upto the determination of the capacity of the intersection in terms of traffic volume. If the capacity of the junction exceeds after the widening of the highway then it would be necessary to design an efficient signal system for the intersection or design a grade separated intersection (if the traffic volume is increased abnormally).

1.5 Study Area

The area of study for this project is Solan bypass, district Solan, H.P. There exists a three-way intersection in which one road stretches towards Shimla, the other towards Chandigarh and the third one towards Solan city. The manoeuvre of Chandigarh to Shimla consists of a hill at the left hand side of the intersection. The manoeuvre of Shimla to Chandigarh consists of some land which is occupied by the Indian Railways for the Kalka-Shimla rail network. The highway is currently undergoing a widening or four laning of Parwanoo - Solan section of NH-22 (Now NH 5) from 67.000 km to 106.139 km on EPC mode under NHDP Phase-III. This project is taken up by G.R Infra Projects Ltd. and funded by the National Highways Authority of India. The traffic study conducted at the site shows that there exists a large traffic volume at the junction and there is no proper channelized intersection. This creates a havoc for different traffic movements and increases the chances of conflicts which may lead to accidents.

Fig 1.5(a) Traffic flow at Solan bypass

Fig 1.5(b) Intersection view from NH-22

Fig 1.5(c) View of existing un-channelised island

Fig 1.5(d) Shimla-Chandigarh highway (NH-22)

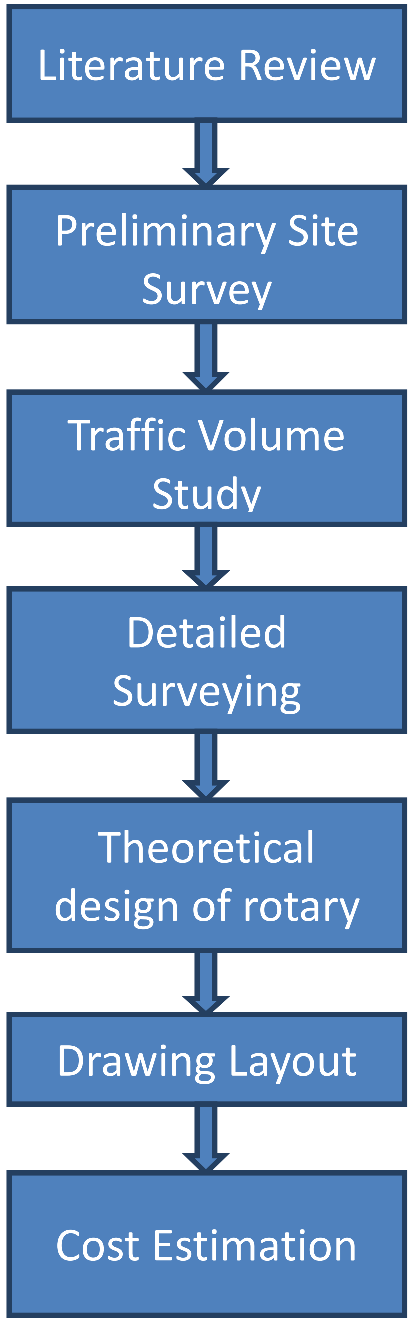
Fig 1.5(e) Aerial view of Solan bypass

1.6 Project Schedule

S.No	ACTIVITIES	ESTIMATED TIME TO ACHIEVE THE TASKS
1.	Literature review	AUGUST 2016
2.	Preliminary site survey	SEPTEMBER 2016
3.	Traffic study for different manoeuvres	NOVEMBER 2016-JANUARY 2017
4.	Detailed site survey	JANUARY 2017
5.	Theoretical design of rotary	FEBRUARY 2017
6.	Drawing Layout	MARCH 2017
7.	Cost Estimation	APRIL 2017

Table 1.1: Project schedule

1.7 Flowchart of Project Activities



Chapter 2: LITERATURE REVIEW

2.1 General Introduction

According to Indian Roads Congress (1994), road intersections are a critical element of road sections. The design of a safe intersection depends on many factors:
1. Human Factors.
2. Traffic Considerations.
3. Road and Environmental Conditions.
4. Economic factors

The human factors include driving habits, driver's ability to make decision, driver expectancy, and conformance to natural path of movement. The traffic considerations include design and actual capacities, design hour turning movement, size and operating characteristics of vehicles, vehicle speed, and traffic mix. The road and environmental conditions include character and use of adjoining property, sight distance, and conflict area, area of intersection, geometrical features, traffic control devices and lightning equipment, vertical and horizontal alignment at the intersection and also the need for future upgrading of at-grade intersection to a grade separated intersections. The economic factors include cost considerations and improvements or controlling the effects of limiting right-of-way on abutting commercial or residential properties where channelization restricts the vehicular movements.

The main purpose of designing the intersections are safety, smooth and efficient flow of traffic.
The design must consider the capabilities and limitation of driver, pedestrian movements and vehicles using the intersection. Even if the driver is stranger to the area, all the intersection movements should be obvious to the driver. Complex design parameters which enhances complicated decision making by drivers should be avoided to reduce the accidents. The basic design includes the principles of uniformity & simplicity, minimize conflict points, safety, and alignment & profile.
The main purpose of designing the intersections is to minimize the number and severity of potential conflicts between cars, buses, trucks and the pedestrians. This can be achieved by space separation by accessing control islands through channelizing the traffic stream. Pedestrian pathways should also be designed which are effective in separating the vehicular and pedestrians movements.

2.2 IRC-65: 1976

At-grade intersections have points of conflict which cause potential hazards and several severities. Their design should provide for the drivers to readily discern the danger and make the necessary manoeuvres to negotiate the intersection with adequate safety and minimum of interference of vehicles. The various design parameters and their specifications are adopted as per the code. The design of the rotary elements needs special considerations depending upon the site requirements. No standard design can be fitted into any given set of site conditions and each has to separately dealt with. From this code we have taken general guidelines for selection of rotary intersections. The various design parameters like shape of rotary island, radius of central island, entry and exit radius etc. These all design steps are taken from this code or followed during our design and how to calculate each parameter is understand from this code and at last capacity of rotary is determined. Channelizing islands are also provided at the entry and exit of rotary which reduces the conflict area where possible path of two vehicles intersect and also promote safe and orderly movement of vehicles. At the rotary the sight distance should be adequate for vehicles entering in the rotary to see vehicles to their right at a safe distance and also driver can see the rotary island clearly. As per the guidelines, the sight distance for a speed of 30-40 kmph varies between 30-45m.

The radii of the exit curve should be larger than that of the central island and at entry so as the driver can pick up the speed and clear away from the rotary. For this reason the radius of exit curve is always kept 1.5-2 times the radius of entry curve. If there is a large pedestrian traffic across the exit road, the radius of exit and entry curve should be kept equal. This is done to keep the exit speed reasonably low.

According to IRC 65:1976, the radius of central island should be equal to the entry radius. However, the radius of central island should is kept slightly larger than that of the entry radius. This is done to give slight preference to the traffic already on the rotary and to slow down the approaching traffic. Generally it is kept 1.33 times of radius of entry curve.

2.3 Reduction in traffic congestion due to rotary

The authors **Junaid Yaqoob & Er. Amir Lone** discovered different methods which can be used for conducting traffic volume studies. There are basically two different methods for speed studies, namely manual or mechanical methods and automatic methods. The moving observer method is a special method which helps to obtain various traffic characteristics like data on travel time of vehicles, delays at the junctions, and traffic flow speed. Photographic technique is another widely used technique for determining traffic flow characteristics.

2.4 IRC SP-41: 1994

This code suggests simultaneous right turn movements at intersection with four signal phases for traffic operation. The traffic safety is ensured with this recommendation, the intersection delay does not improve significantly due to four signal phases.

The PCU values for different vehicles have been taken from the code as per the following:

Vehicles	**PCU Value**
Cars and light commercial vehicles	1.0
Buses and trucks	3.0
Two wheelers	0.5
Trailers	4.5

Table 2.1: PCU values for different vehicles

The various methods and techniques that are used to reduce the conflict points are taken from this code. Some of the common methods that are used to reduce conflict points are by providing signalize intersection or channelizing islands are used. By reducing the conflict pont or conflict area the collision between two vehicles is removed and number of potential hazards occur are less. A common method to reduce conflict points is channelizing the directional traffic by selective use of channelizing islands and medians.

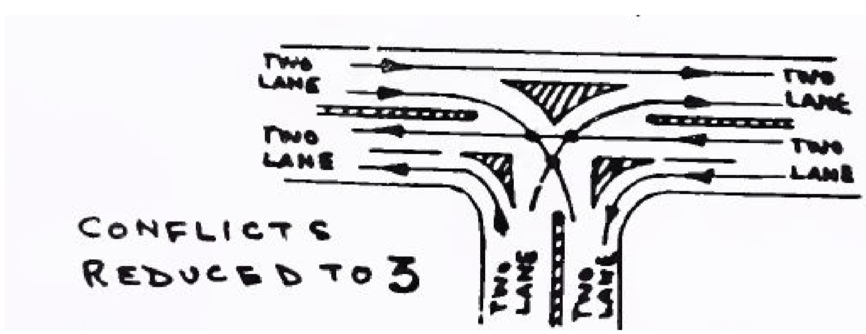


Fig 2.3(a) Reduced conflict points on a 3-armed intersection

2.5 IRC-67: 1977

To properly guide and control the traffic approaching junctions, traffic signs and signals are installed. This code provides a detailed description of various traffic signs and their applications. While providing traffic signs at the intersection, care must be taken to ensure the effectiveness of the sign posted. It must be also noted that too many signs with inadequate spacing may result in confusion and accidents. In urban areas the lowest edge of any traffic sign should not be lower than 2.1m from the pavement when posted on sidewalks. In rural areas the clear height of sign from the edge of pavement should be 1.5m. The posting of traffic sign must be done with proper care for better functioning. For this the sign must be posted ahead of the spot to which it refers. For posting of more than one signs, adequate spacing must be provided so as to seen one at a time and covey the message with complete effect. Signs with reflective properties must be used so as to meet the requirements of night traffic. Some of the traffic signs which are useful in regulating the traffic at the intersections are shown in the following figure:

Fig. 2.4(a) Road signs at intersection

2.6 Analysis & Design of a three-way intersection

The authors **S Rokade, M Jain, P Goyal & V Sharma** highlight the different design considerations for a 3-way intersection. The primary considerations are smooth, safe and efficient flow of traffic. The limitations and capabilities of vehicles, drivers and pedestrians at the intersection are also given due consideration. The design should be kept simple and uniform just to provide a level of comfort to travelers and minimize conflicts with a minimum delay to the traffic stream.

2.7 IRC-52:2001

The design speeds for various categories of hill roads should be as given in the table:

Sr. No.	Road classification	Mountainous terrain		Steep terrain	
		Ruling	Minimum	Ruling	Minimum
1.	National and State Highways	50	40	40	30
2.	Major District Roads	40	30	30	20
3.	Other District Roads	30	25	25	20
4.	Village Roads	25	20	25	20

Table 2.2: Design speeds for hill roads

The minimum radius curves should be adopted only when absolutely necessary. Similarly, curves with little or no tangent length between them should be avoided as far as possible and replaced with a single curve.

At sharp horizontal curves, on a two –lane wider roads, it is necessary to widen the carriage way to facilitate safe passage of vehicles. It includes two components, mechanical widening and psychological widening. Both these components should be carefully catered for so that the lateral clearance between vehicles on curves is maintained equal to the clearance available on straight paths.

2.8 IRC SP-48: 1998

The various methods and techniques of surveying in hilly areas will be adopted as per those mentioned in SP-48:1998.A rotary should preferably be located on level ground. It may be sited to lie on a plane which is inclined to the horizontal at not more than 1 in 50.

The following values are adopted as per IRC SP-48:1998:

S.NO	Item	Slopes of Cutting
1	Ordinary soil/Heavy soils	1:1
2	Soil rock	$^1/_4$: 1
3	Hard rock	80° to 90°

Table 2.3: Side slope in cutting

The minimum length of vertical curve as per IRC SP-48:1998:

Design speed km/h	**Maximum grade change (percent)**	**Minimum length of vertical curve(m)**
35	1.5	15
40	1.2	20
50	1.0	30

Table 2.4: Minimum length of vertical curve

2.9 Guidelines from government authorities

Some design parameters such as design speed, road width acquired by NHAI, and the width of extended road after four-laning of NH-22, have been adopted by the recommendations of Manager Technical, NHAI, Shimla and PWD department Solan. The previous plan of the Solan bypass is also taken from the PWD department Solan which is useful for our design. Also the NHAI has told that they are planning to make a flyover from Solan bypass to Chambaghat because due to the presence of railway line.

2.10 Objectives

a) To design the intersection on the basis of outcomes of traffic volume survey.
b) To determine the capacity of rotary which should be greater than the present traffic volume.
c) To check whether the road has adequate capacity to accommodate future traffic volume.
d) To minimise the number & severity of potential conflicts.

Chapter 3: PROJECT ACTIVITIES

3.1 Preliminary site survey

A preliminary inspection was conducted at Solan bypass to gather information for a design or an estimate to complete the initial tasks required for an outdoor activity. The purpose of the survey was to determine the feasibility of a rotary intersection at site. A rough traffic survey was conducted to determine a gross traffic volume and verifying them with the provisions of IRC-65:1976. Different traffic manoeuvres were studied and major conflict points were established. An estimate of land use for the widening of the national highway was planned through the survey. The restricting areas and encroachments were also established.

3.2 Traffic Volume Study

The traffic survey was conducted at week days and weekends. The traffic volume was analysed manually and the average traffic volume was calculated by taking the average of the values obtained during peak hours of weekends and weekdays.

Date: 20/01/2017 Time: 10.30 to 11.30 am

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	AUTO	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	1 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	70	192	59	42	34	0	3	527.5 PCU
FROM SHIMLA TO CHD.	37	151	47	27	28	0	2	390.5 PCU
FROM SHIMLA TO SOLAN	162	95	23	16	0	30	0	279 PCU
FROM SOLAN TO SHIMLA	140	175	33	17	1	32	0	367 PCU
FROM CHD. TO SOLAN	145	178	15	7	17	55	0	392.5 PCU
FROM SOLAN TO CHD.	80	165	9	3	1	70	0	293 PCU
								2249.5 PCU

Table 3.1: Traffic volume study

Date: 29/01/2017 Time: 4.30 to 5.30 pm

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	99	187	64	44	35	7	569 PCU
FROM SHIMLA TO CHD.	129	221	60	41	30	7	590 PCU
FROM SHIMLA TO SOLAN	140	88	26	19	1	0	244 PCU
FROM SOLAN TO SHIMLA	124	161	17	25	3	0	324 PCU
FROM CHD. TO SOLAN	254	332	27	7	2	0	513 PCU
FROM SOLAN TO CHD.	238	243	19	5	3	0	405 PCU
							2645 PCU/hr

Table 3.2: Traffic volume study

Date: 20/11/2016 Time: 10.30 to 11.30 am

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	127	186	59	41	43	3	574 PCU
FROM SHIMLA TO CHD.	50	100	48	30	38	2	386 PCU
FROM SHIMLA TO SOLAN	113	78	24	10	2	0	194.5 PCU
FROM SOLAN TO SHIMLA	67	62	13	18	2	0	168.5 PCU
FROM CHD. TO SOLAN	133	127	18	3	1	0	223.5 PCU
FROM SOLAN TO CHD.	143	124	11	0	4	0	218.5 PCU
							1765 PCU/hr

Table 3.3: Traffic volume study

Date: 20/11/2016 Time: 4.30 to 5.30 pm

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	127	166	63	49	54	3	615 PCU
FROM SHIMLA TO CHD.	57	111	54	36	38	1	420 PCU
FROM SHIMLA TO SOLAN	140	88	30	12	4	0	236 PCU
FROM SOLAN TO SHIMLA	78	81	16	22	3	0	211 PCU
FROM CHD. TO SOLAN	150	159	17	2	2	0	263 PCU
FROM SOLAN TO CHD.	152	139	17	1	6	0	253 PCU
							1998 PCU/hr

Table 3.4: Traffic volume study

Date: 26/11/2016 Time: 5.00 to 6.00 pm

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	132	164	59	52	59	2	631 PCU
FROM SHIMLA TO CHD.	62	118	54	37	40	2	443 PCU
FROM SHIMLA TO SOLAN	148	89	30	12	5	0	244 PCU
FROM SOLAN TO SHIMLA	86	82	21	26	5	0	239 PCU
FROM CHD. TO SOLAN	164	163	22	4	2	0	285 PCU
FROM SOLAN TO CHD.	178	146	15	2	4	0	268 PCU
							2110 PCU/hr

Table 3.5: Traffic volume study

Date: 26/11/2016 Time: 11.30 am to 12.30 pm

MANOEUVRE	BIKES	CARS	JEEP/VAN	BUS	TRUCK	TRAILER	NET PCU IN SINGLE MANOEUVRE
	0.5 PCU	1 PCU	1 PCU	3 PCU	3 PCU	4.5 PCU	
FROM CHD. TO SHIMLA	153	171	66	38	36	5	**558 PCU**
FROM SHIMLA TO CHD.	63	100	42	28	31	3	**364 PCU**
FROM SHIMLA TO SOLAN	112	63	24	7	3	0	**173 PCU**
FROM SOLAN TO SHIMLA	60	52	14	15	2	0	**147 PCU**
FROM CHD. TO SOLAN	116	128	13	4	1	0	**214 PCU**
FROM SOLAN TO CHD.	136	108	12	3	2	0	**203 PCU**
							1659 PCU/hr

Table 3.6: Traffic volume study

3.3 Chain Surveying

In order to verify step 3 of the rotary design procedure, chain surveying was conducted at Solan bypass.

The steps followed on site are as follows:

1. A tangent point was established on each curve at the intersection.
2. A 20m chain was laid along the tangent point on the curve.
3. Several points on the curve were established by using the 3 4 5 method and measurements were taken with the help of a measuring tape.

The radius of each of the three curves was found at site and plotted on paper to the particular scale to get the radius of the three horizontal curves. These radii were found to be greater than the minimum radius of horizontal curve (from step 3 of design procedure).

So, this check was verified and found to be correct.

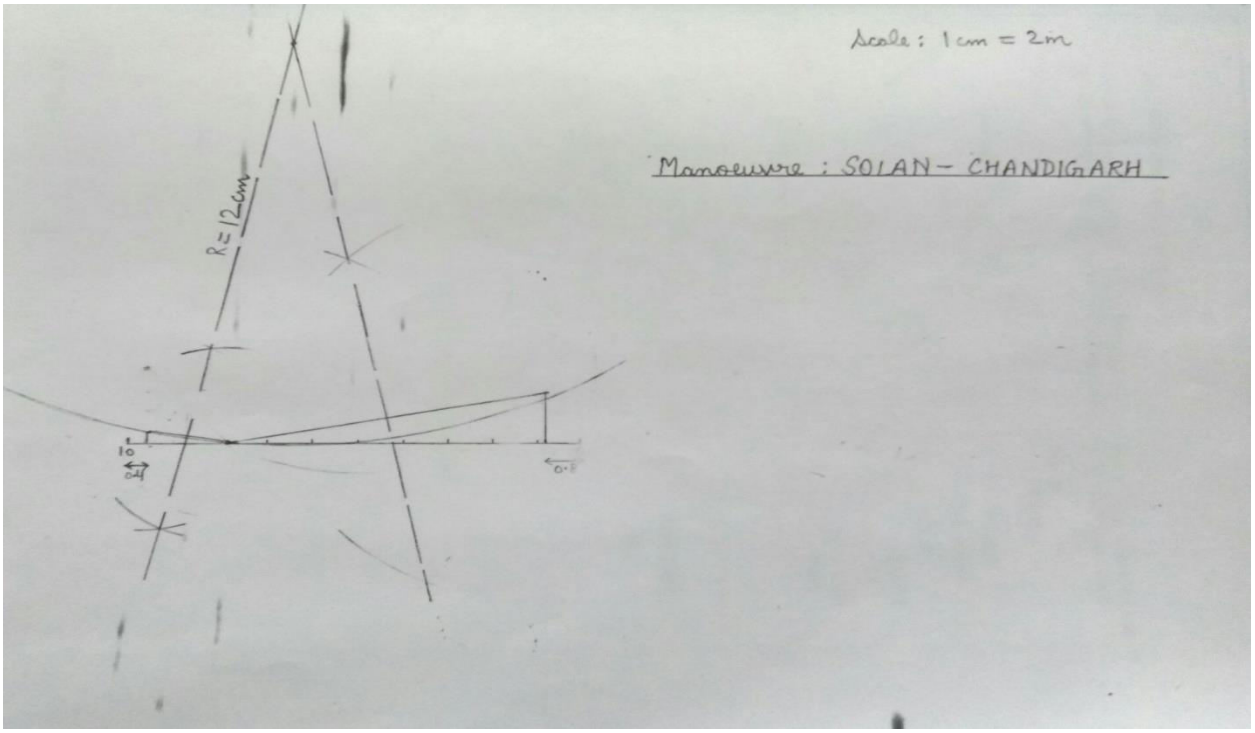


Fig. 3.3(a) Radius of Solan-Chandigarh curve

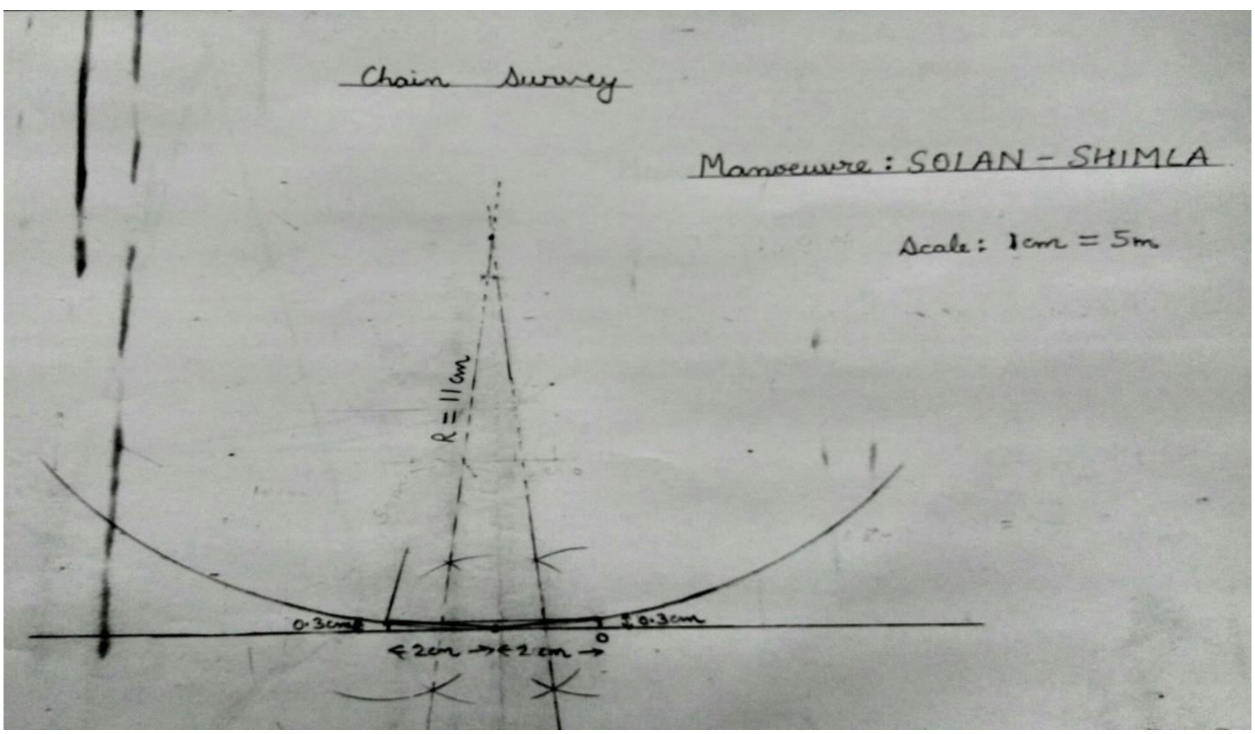


Fig. 3.3(b) Radius of Solan-Shimla curve

3.4 Theoretical Design of Rotary

The design procedure for rotary intersection and design values for rotary at Solan bypass are in excel sheet in which design procedure are followed and capacity of rotary is calculated.

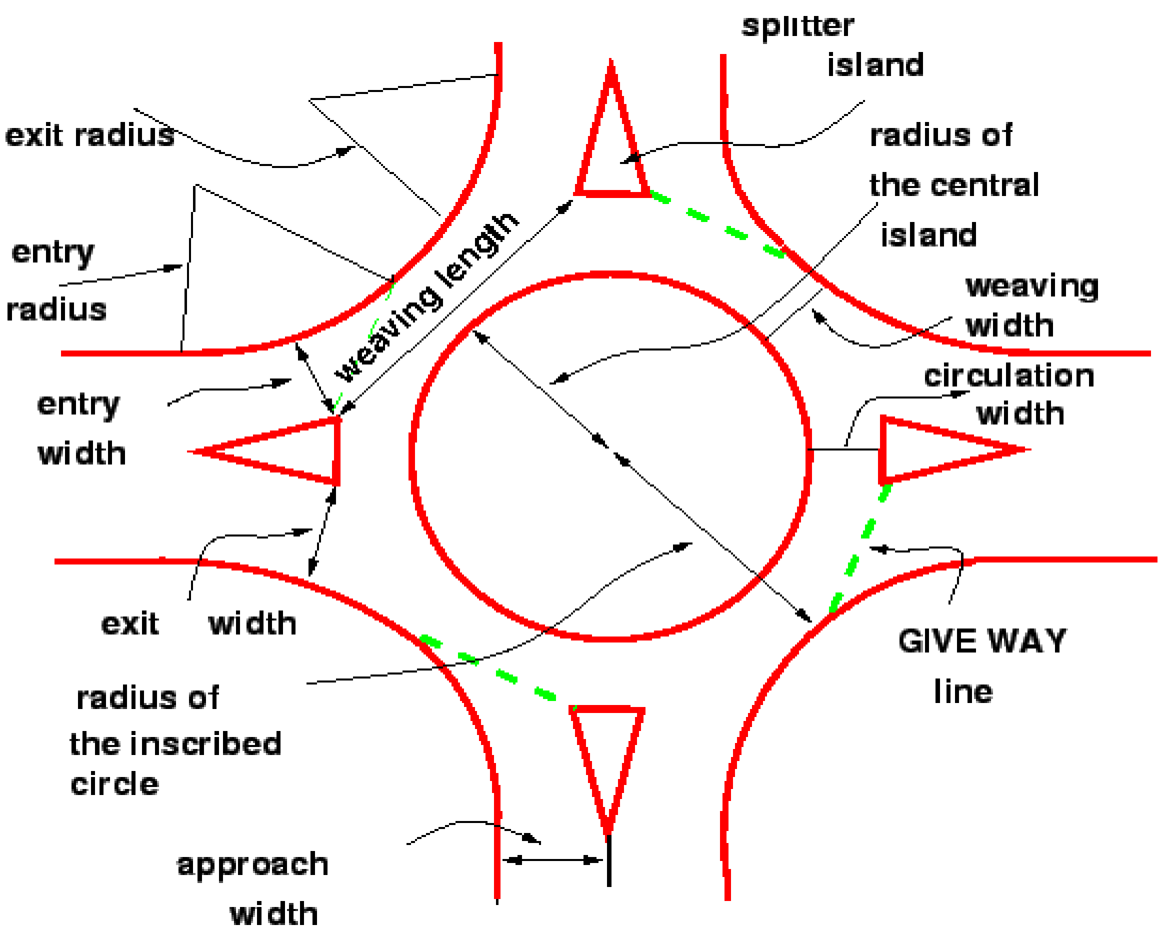


Fig. 3.4(a) A typical rotary intersection

	DESIGN PROCEDURE FOR ROTARY INTERSECTION		
1	Shape of the central island	Circular, Elliptical, Turbine, Tangential	
2	Design speed for mountainous terrain	v_{min}= 40 kmph	
		v_{ruling}= 50 kmph	
3	Minimun radius of horizontal curve	$R_{min}= v^2/127(e+f)$	e=0
4	Value of friction coefficient	f=0.43 for v=40 kmph	
		f=0.47 for v=30 kmph	
5	Radius of central island	$1.33*R_{entry}$	
6	Radius of entry curve	20-35m for v=40 kmph	
		15-25m for v=30 kmph	
7	Radius of exit curve	$(1.5 \text{ to } 2)*R_{entry}$	
8	Width of entry (e_1)	**Road width**	**e_1**
		7m	6.5m
		10.5m	7.0m
		14m	8.0m

9	Width of non-weaving section (e_2)	Generally $e_1 = e_2$ or $e_2 < W$	
10	Width of weaving section (W) Weaving angle > 15°	$[(e_1+e_2)/2+3.5]$	6-18m
11	Length of weaving section (L)	$L_{min} = 4W$	W/L = 0.12-0.4
12	Practical Capacity of Rotary	$$\frac{280W\left(1+\frac{e}{w}\right)\left(1-\frac{P}{3}\right)}{\left(1+\frac{W}{L}\right)}$$	PCU/hour
13	Weaving Ratio (P)		
		(b+c)/(a+b+c+d)	0.4-1.0
		a=left turning traffic moving along left extreme lane	
		d=right turning traffic moving along right extreme lane	
		b=weaving traffic turning right while entering	
		c=weaving traffic turning left while entering	
14	Average width of entry (e)	$e_1+e_2/2$	e/W = 0.4-1.0

Table 3.7: Rotary design procedure

	DESIGN VALUES FOR ROTARY AT SOLAN BYPASS		
		Morning Peak Traffic Volume **2300 PCU/hr**	**Evening Peak Traffic Volume** **2645 PCU/hr**
1	Shape of the central island	Circular	Circular
2	Design speed for mountainous terrain	25 kmph	25 kmph
3	Minimum radius of horizontal curve	10.0m	10.0m
4	Value of friction coefficient	0.49	0.49
5	Radius of entry curve	12.5m	12.5m
6	Radius of exit curve	18.75m	18.75m
7	Width of entry (e_1)	11.5m	11.5

8	Radius of central island	10m	10m
9	Width of non-weaving section (e_2)	11.5m	11.5m
10	Width of weaving section (W)	15.0m	15.0m
11	Length of weaving section (L)	60.0m	60.0m
12	Weaving Ratio (P)	0.678 (max.)	0.818
13	Practical Capacity of Rotary	4595 PCU/hr	4318 PCU/hr

Table 3.8: Design of rotary intersection

Note: -The radius of Central Island coming from the codal provisions is 16.6m. But due to space restrictions it is not possible to provide this radius. Hence, the radius of Central Island is to be taken 10m.

3.5 Calculation of Design Parameters

1. Shape of Central Island

The shape of Rotary Island depends upon the number and layout of the intersecting roads. There are various shapes for Central Island like circular, elliptical, tangent, turbine. But for our design we provide circular shape for Central Island because all the radiating roads are symmetrical also in circular shape there is a proper speed control.

2. Design Speed

The design speed for national highways is 80kmph. In urban areas at plains, the speed at the rotary is restricted to 30 kmph. So it is found that in plains, the speed of vehicles at the rotary is reduced by 37.5% of the design speed.

According to IRC-52:2001, the minimum design speed for national highways at mountainous terrain is 30 kmph and the ruling speed is 40 kmph. So, to obtain the speeds at rotary, we decrease these minimum and ruling speeds for mountainous terrain by 37.5% which gives speed values of 15 kmph and 18.75 kmph respectively. Hence the speed range obtained is between 15 kmph to 18.75kmph.

But reducing the speeds to such low values would increase the travel time and moreover the guidelines issued by Public Works Department, Solan and a thorough analysis has indicated these speeds to be a quite low value which is not justified. Hence we increase the ruling speed at rotary by 33.33% to obtain a value of 25 kmph.

3. Minimum radius of horizontal curve

The minimum radius of horizontal curve is calculated from the formula given in the design table step 3. But in this formula the superelevation (e) is taken zero because in a rotary it is not possible to provide adequate superelevation so it is safer to neglect the superelevation and consider only friction factor.

4. Value of friction coefficient

The value of friction coefficient 'f' are taken as 0.43 and 0.47 in rotary intersection for the speeds 40 kmph (for rural area) and 30 kmph (for urban area). But in our design the speed is 25 kmph so we have to extrapolate the values of these two speeds to determine the value of 'f' for speed of 25 kmph.

5. Radius of Central Island

The radius of Central Island is 1.33 times of entry radius as per IRC. But for our design the radius comes out to be very high which is not possible due to space restrictions in hilly regions. So, we have taken slightly less radius as calculated from the given formula.

6. Radius of entry curve

Entry radius depends on various factors like design speed, super-elevation, and coefficient of friction. Entry to the rotary is not straight, but a small curvature is introduced, this will force the driver to reduce the speed. The IRC has given the radius of entry curve to be 20-35 m for speed of 40 kmph and a radius of 15-25m for speed of 30 kmph. But for our design speed of 25 kmph we have extrapolate these values to determine entry radius which comes out be 12.5 m.

7. Radius of exit curve

Exit radius should be higher than the entry radius so that the vehicles will leave from the rotary at a higher speed. As per IRC guidelines the exit radius is to be kept as 1.5 to 2 times the entry radius.

8. Width of entry (e_1)

The width at entrance and exit of a rotary is depend on the amount of traffic entering and leaving the rotary. The IRC-65:1976 has given the values of width of carriageway at entry given in the following table:

R_{entry}	e_1
30 m	8 m
20 m	10 m
12.5 m	11.5 m

Table 3.9: Width of entry

9. Width of non-weaving section (e_2)

The width of non-weaving section should be equal to the width of entry and should generally be less than the width of weaving section (W). So, generally $\mathbf{e_2 = e_1}$ **and** $\mathbf{e_2 < W}$

Note: -The design parameters from step 10 to step 14 are calculated by substituting the respective values of parameters calculated above.

3.6 Drawing Layout

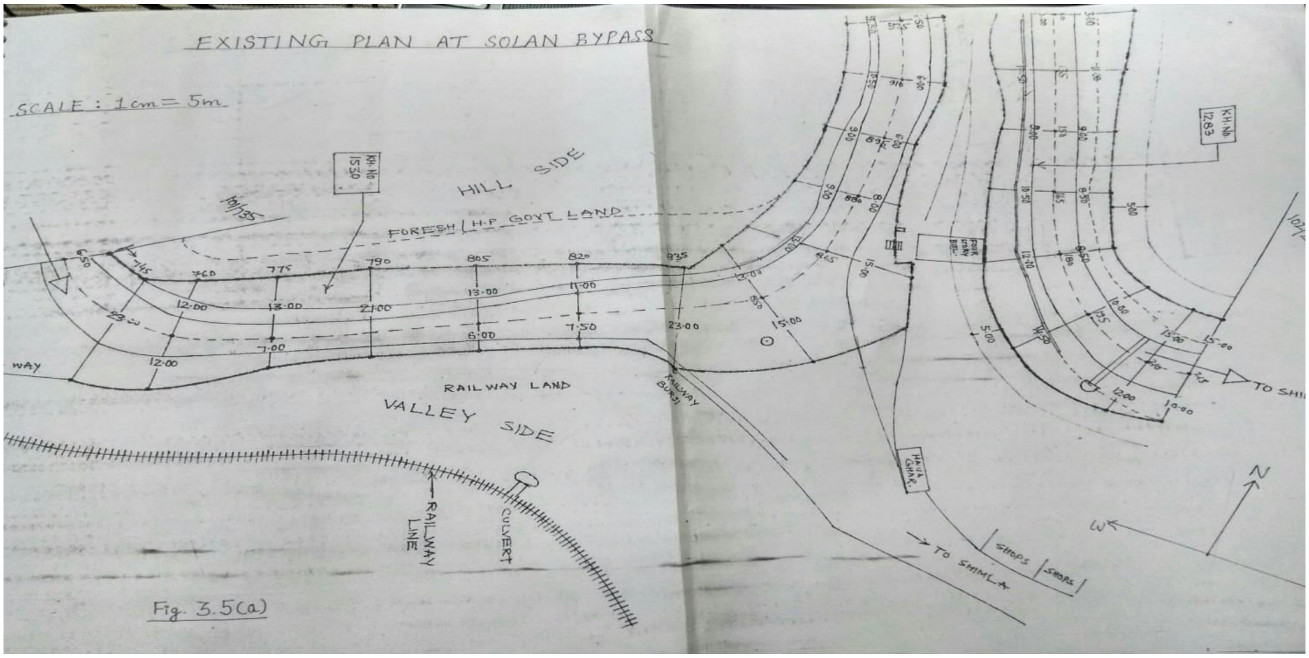


Fig. 3.6(a) Existing plan at Solan bypass

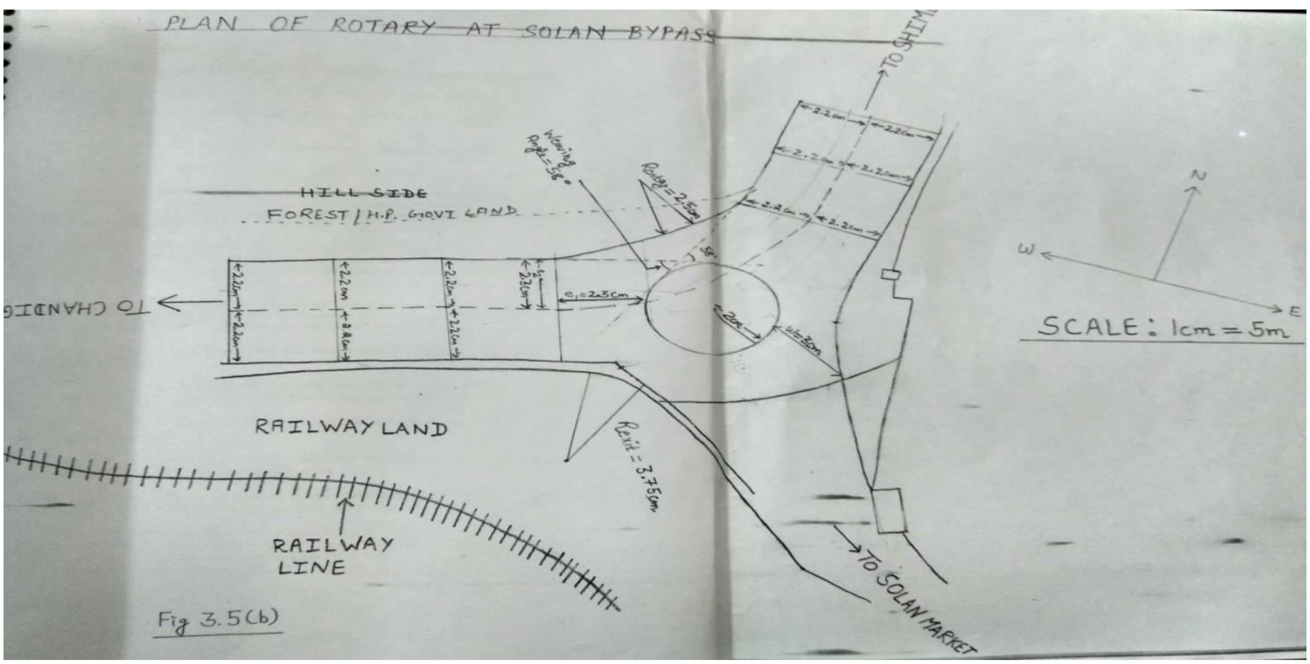
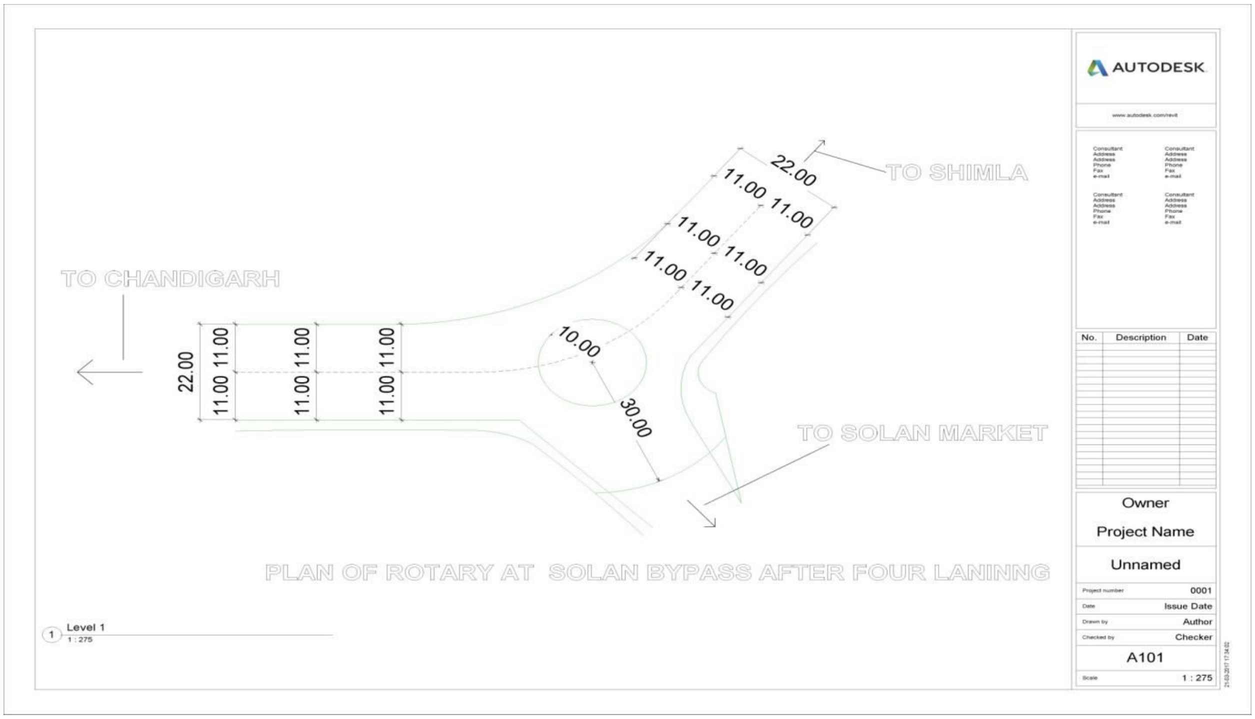


Fig. 3.6(b) Rotary intersection after extension of NH-22

3.7 Software Simulation



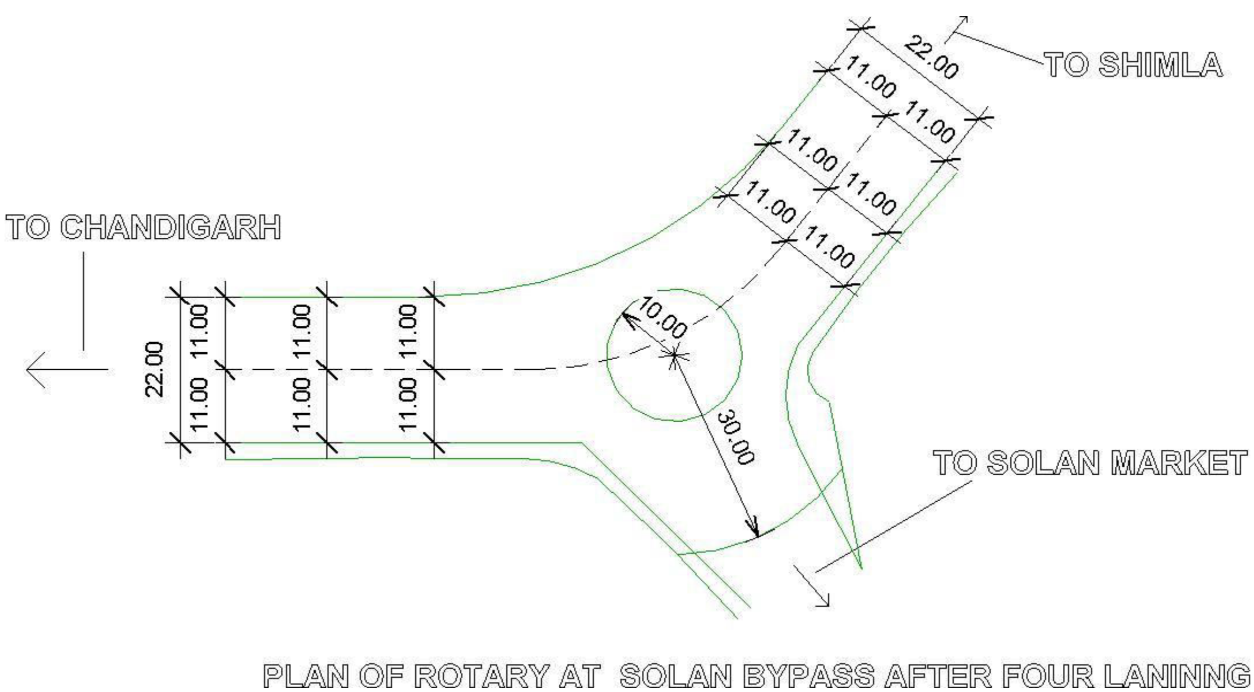


Fig. 3.7(a) Software Simulation

3.8 Cost Estimation of Central Island

S.NO	Description	Unit	Quantity	Rate	Amount
				Rs	Rs
1.	Details for cost of 1cum concrete				
(a)	MATERIAL				
I	Stone Aggregates 20mm nominal size	cum	0.67	1175	787.25
ii	Stone Aggregates 10mm nominal size	cum	0.21	1175	246.75
iii	Carriage of stone aggregates	cum	0.88	106.49	93.7112
iv	Coarse sand (Zone III)	cum	0.44	1200	528
V	Carriage of coarse sand	cum	0.44	106.49	46.8556
vi	Portland Cement (0.22 cum)	bags	6.4	320	40320
vii	Carriage of cement	tonnes	0.32	94.65	30.29
(b)	LABOUR				
I	Mason (average)	day	0.1	417	41.7
ii	Beldar	day	1.63	329	536.27
iii	Bhisti	day	0.7	363	254.1
iv	Hire charges for concrete mixer with hopper	day	0.07	800	56
V	Vibrator	day	0.07	350	24.5
vi	Sundries	L.S.	14.3	1.78	25.45
	TOTAL				42990.88
	Add water charges @ 1%				429.9088
	TOTAL				43420.79
	Add CPOH @ 15%				6513.118
	Cost of 1cum concreting				49933.9
2.	Details for earthwork				
	Volume of soil	cum	177.355		
	Carriage of soil	tonnes	354.71	94.65	33573.3
	TOTAL COST				**83507.2**

Table 3.10: Abstract for cost estimation

1.	The radius of central island obtained is 10.0m
2.	Assuming the height of central island be 60cm
3.	Assuming the thickness of central island be 30cm
4.	Volume of outer cylinder = $\prod * r^2 h$
	= 3.14*10*10*0.70
	V_1= 219.911 cum
	*Height is taken as 0.70m because concreting in the outer wall is started from 10cm below the ground.
5.	Volume of inner cylinder = $\prod * r^2 h$
	= $3.14*(10-0.3)^2*0.60$
	V_2= 177.355 cum = volume of soil
6.	Volume of concrete = V_1 - V_2 = 219.911 - 177.355 = 42.556 cum
7.	M15 grade of concrete is used in central island with C:FA:CA ratio of 1:2:4
8.	Dry concrete mix is taken to be 1.54 times equivalent to the wet concrete mix quantities
9.	Quantity of cement = (1/1+2+4)*1.54 = 0.22 cum
	= 0.22*28.8
	= 6.4 bags
	Considering 1 cum of cement requires 28.8 bags
10.	Quantity of fine aggregates = (2/1+2+4)*1.54 = 0.44 cum
11.	Quantity of coarse aggregates = (4/1+2+4)*1.54 = 0.88 cum
	Taking 0.670 cum of 20mm CA & 0.210 cum of 10mm CA
12.	Considering density of soil = 2000 kg/m^3 = 2 t/m^3
13.	Weight of soil = 2*177.355 = 354.71 tonnes

Table 3.11: Calculation of quantities for Central Island

Chapter 4: OBSERVATIONS & CONCLUSIONS

1. For the efficient functioning of the intersection, the observations and conclusions are as follows:

2. The design speed at the Solan bypass intersection is found to be 25kmph.

3. The value of the coefficient of friction is found to be 0.49.

4. The radius of Central Island comes out to be 10.0 m.

5. The total cost for constructing the central island comes out to be around Rs. 83,507.

6. The peak hour traffic volume of the three legged intersection was found out to be 2300 PCU per hour and 2645 PCU per hour. The corresponding values of the capacity of the rotary in terms of traffic volume are 4595 PCU per hour and 4318 PCU per hour respectively which are greater than the present traffic volume.

7. The maximum volume that a traffic rotary can handle efficiently can be taken as about 3000 vehicles per hour entering from all intersection legs. If the traffic volume exceeds this value then, the rotary has to be redesigned as a signalized intersection or a grade separated intersection needs to be designed.

8. Channelizing islands reduces the area of conflict between intersecting traffic streams and promotes orderly and safe movement. To streamline the vehicular traffic and to provide refuge to the pedestrians crossing the road, channelizing islands are provided.

9. The intersections should be provided with necessary widening on all the legs of the intersection.

10. As far as possible the intersections should be located on level ground. A rotary intersection may be sited to lie on a plane which is inclined to the horizontal at not more than 1 in 50.

11. Encroachment on all the 3 legs of the intersections ought to be removed which would enhance the capability of the junction.

12. The parking or stopping of vehicles should not be allowed at the intersections because the intersections are always treated as No Stopping- No Standing Zone.

13. The construction of rotary at the junction would not delay the movement or the travel time because of the following two reasons:
    i) Absence of traffic signals.
    ii) The actual speed for design is greater than the theoretically obtained value (which is quite less).

REFERENCES

1. Analysis of Rates for Delhi (Vol-1 & Vol-2) 2014, Central Public Works Department, Government of India, New Delhi, 2014.

2. Code of practice for road signs, IRC: 67-2001, Indian Road Congress, New Delhi, 2001.

3. Debasish Das, Dr. M Ali Ahmed, "Performance Analysis of Rotary Intersection", International Conference on Transportation Planning & Implementation Methodologies for Developing Countries (11th TPMDC), Case Study, Silchar, Assam.

4. Guidelines for the design of at-grade intersections in rural & urban areas, Special Publication 41, IRC: SP-41, Indian Road Congress, New Delhi, 1994.

5. Guidelines for Design of Traffic Rotaries, IRC: 65-1976, Indian Road Congress, New Delhi, 1976.

6. Guidelines for regulation and control of mixed traffic in urban areas, IRC: 70-1977, Indian Road Congress, New Delhi, 1997.

7. Hill Road Manual, Special Publication 48, IRC: SP-48, Indian Road Congress, New Delhi, 1998.

8. Junaid Yaqoob, Er. Amir Lone (2016), "Design of Rotary at Janglatmandi, Anantnag to reduce traffic congestion at the intersection", International Journal of Advanced Research in Education & Technology, Volume 3 Issue 2, April-June 2016.

9. Recommendations about the alignment survey and geometric design of hill roads, IRC: 52-2001, Indian Road Congress, New Delhi, 2001.

10. Road Accident Forms A-1 and 4, IRC: 53-1982, Indian Road Congress, New Delhi, 1982.

11. Rokade S, Jain M, Goyal P & Sharma V (2014), "Analysis and Design of Intersections on Approach Road of Birla Mandir, Bhopal", International Journal of Innovative Engineering Research, Volume 1 Issue 1, July 2014.

12. S.K. Khanna, C.E.G Justo, "Highway Engineering", Nem Chand & Bros., Roorkee (Revised 10^{th} Edition, 2015).

.