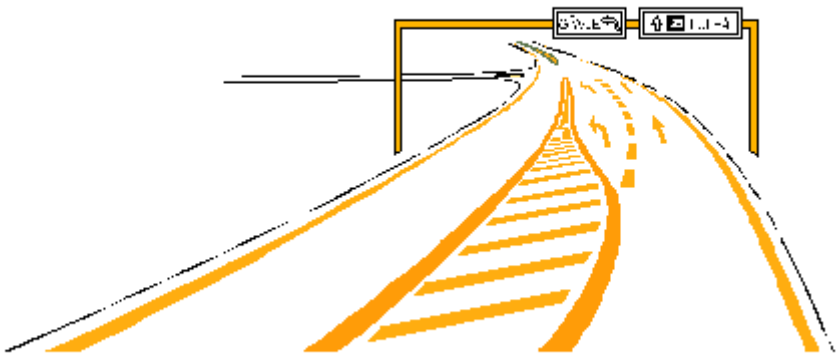
HIGHWAY DESIGN REPORT

Appendix 1

Proposed Principles for Selection of Intersection Type



June 2000

SWEROAD

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1 Introduction

1.1 Purpose

The purpose of this report is to:

- describe a model for selection of intersection type,
- propose measures to adapt the model to the Turkish conditions.

The objective is eventually to incorporate a model for selection of intersection type into new comprehensive Turkish design guidelines. To work out new design guidelines is however a long procedure. Awaiting the new guidelines, it is suggested that the proposed model is adapted to Turkish conditions. This should mainly be done by establishing *preliminary selection criteria* for each step and a *set of standard type intersections* for each intersection category (priority and control intersection).

1.2 Classification of at-grade intersections

At-grade intersections can be classified into two main *intersection categories* depending on the traffic regulations for the main road traffic. For each category, there are a number of different *intersection types*.

Intersection category	Traffic regulation		Intersection types
	Main road	Secondary road	
Priority intersection	Priority	Stop or yield control	Different types depending on the use of separate turning lanes and traffic islands
Control intersection	Stop or yield control		Roundabout Signalized intersection

Classification of at-grade intersections

1.3 Contents

Generally, the selection of intersection type should be made from a socio-economic point of view where, for example, construction costs, accident costs, environmental costs and travel time costs are considered.

However, for some cases, the selection can be based on experiences from other similar intersections. Thus, it is not always necessary to make socio-economic calculations considering all possible types of intersections. The traffic safety aspect is suggested to be the primary criterion. Therefore, the safety should first be checked to see if it meets the requirements. Other effects should then be checked to be acceptable.

In this report the following is presented:

- Proposal for a model for the selection of at-grade intersection type.
- Examples based on Swedish selection criteria.
- Suggestions for continued work to elaborate and revise the model and to adapt it to Turkish conditions.

2 Proposed selection model

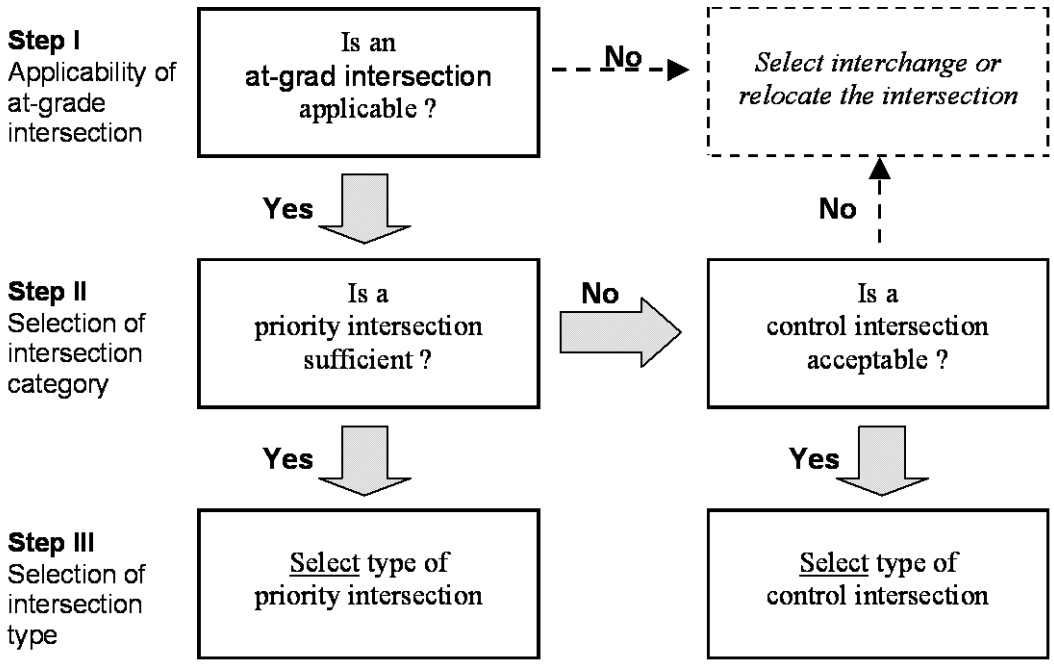
2.1 Model overview

2.1.1 General description

The model is based on the following assumptions concerning different types of at-grade intersections:

- The traffic volumes may be too high to be operated by an at-grade intersection and for certain roads (e.g. national motorways) at-grade intersections may not be acceptable.
- Priority intersections can be safe and give sufficient capacity for certain traffic volumes and speed limits.
- If a priority intersection is not sufficient for safety and capacity, the main road traffic must also be controlled. This may not be acceptable on certain roads.
- Depending on location, traffic conditions and speed limits, different types of priority or control intersection should be selected.

The suggested selection model is divided into three steps according to the figure below.



Intersection selection model

The selection model shows a **suggested procedure** illustrated with selection criteria mainly based on Swedish experiences of intersections on 2-lane roads. The selection model, in order to be suitable in Turkey, must be completed with selection criteria based on Turkish intersection types as well as Turkish accident and capacity data.

2.1.2 Selection criteria

For each step there are a number of selection criteria based on:

- **road and traffic conditions** concerning road classification and location and traffic conditions,
- **standard requirements** concerning safety, speed and capacity/delays,
- **experiences of safety and capacity performances** of different intersection types.

The selection criteria in each step are shown in the table below.

Step	Selection criteria
I. Applicability of at-grade intersection	- Road classification - Capacity
II. Selection of intersection category	
II a. Applicability of priority intersection	- Safety - Capacity
II b. Acceptance of control intersection	- Road classification and location
III. Selection of intersection type	
III a. Priority intersection type	- Safety
III b. Control intersection type	- Safety - Planning conditions - Delays - Economic study

Selection criteria

2.1.3 Required data

Road and traffic conditions

Road classification and location

The acceptability of at-grade intersections and/or traffic control measures (stop or yield control) should be related to the road function. For some important roads, at-grade intersections or traffic control measures might not be accepted.

The acceptability of at-grade intersections and/or traffic control measures should also be depending on whether the road is located in a rural, sub-urban or an urban area.

Traffic conditions

Traffic data is needed mainly on daily traffic volumes (AADT) on the primary and secondary roads. For detailed capacity control and design, traffic data is also needed for hourly traffic and turning traffic streams.

The traffic growth during the *expected service life* of the planned intersection must be considered. Depending on type of project, the service life varies. For small projects in urban areas, it should be shorter than for large projects in rural areas. The official project life for state roads in Turkey is said to be 20 years.

Standard requirements

Safety

Safety is suggested to be the primary selection criterion. The basic safety requirements for intersections, for example, defined as the accepted number of expected accidents or injured per year, must therefore be established.

Speed

Both the safety level and the capacity of different intersection types are depending on the speed limit on the primary road. The speed limit for the main road must thus be decided. The requirements for speed can be based on road classification and location.

Capacity

In addition to safety, the capacity (or delays) is an important selection criterion. Capacity requirements, for instance, defined as level of service (e.g. according to HCM) or load factor (actual traffic volume/maximum traffic volume) for intersections, should thus be established.

2.2 Step I - Applicability of at-grade intersection

To determine if an at-grade intersection is applicable two checks should be made:

- Is an at-grade intersection acceptable on this road?
- Is the capacity of an at-grade intersection sufficient?

Road classification

At-grade intersections can generally be accepted on all roads except motorways and four lane divided highways. However, for intersections between some important roads, the goal could be to avoid at-grade intersections. Based on a functional road classification, a table showing the acceptance of at-grade intersections can be worked out. An example of such a table is shown below.

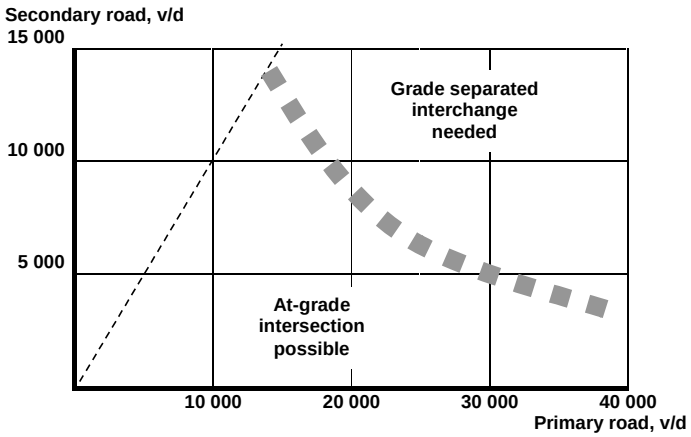
	Intersecting/adjoining road			
Main Road	*State road type I*	*State road type II*	*Provincial roads*	*Village, municipality and forest roads*
State road, type I	Yes/No [1)]	Yes / No[1)]	Yes	Yes
State road, type II		Yes	Yes	Yes
Provincial road			Yes	Yes

1) For roads with very low traffic volumes, at-grade intersections could be accepted

Example of table for acceptance of at-grade intersections

Capacity evaluation
The traffic volumes an at-grade intersection can handle with reasonable delays depend on many factors. Thus, the first check if an at-grade intersection is sufficient can be a rather rough estimate. It can be done by using a diagram where the traffic volumes on the primary and secondary roads are considered.

The figure below shows an example of such a diagram based on experiences from the UK (Roads and Traffic in Urban Areas, 1987).



Example of a diagram for checking the capacity of an at-grade intersection

2.3 Step II - Selection of intersection category

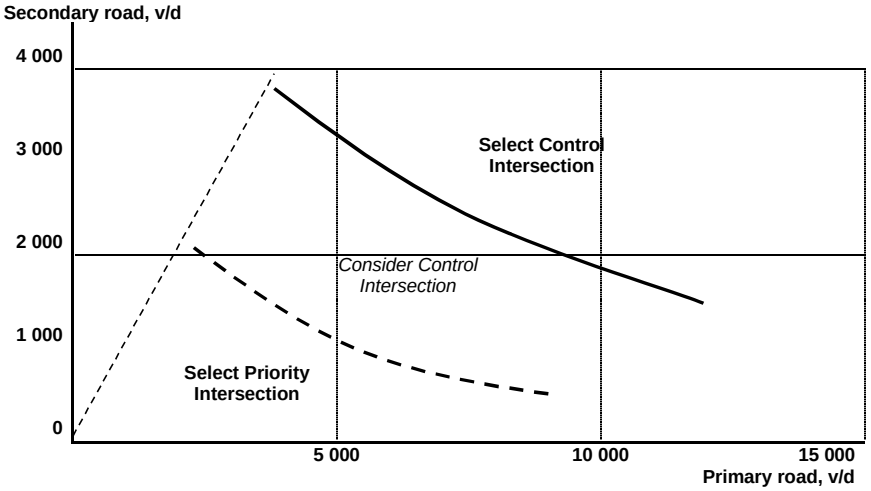
The selection of intersection category can be made in two steps:

- Is a priority intersection sufficient as to safety and capacity?
- If not, can a control intersection be accepted?

2.3.1 Step IIa - Applicability of priority intersection

Safety evaluation
The safety requirement for intersections can be defined as an interval where a desired level ought to be satisfied and a definite maximum/minimum level must be satisfied. If the expected number of accidents does not exceed the desired level, a priority intersection should be selected. If the number exceeds the definite level, a control intersection should be selected. Between the two defined levels, a control intersection should be considered.

The selection can be made by using diagrams with the relationships between the safety levels and the traffic volumes on the primary and secondary roads. Below a diagram is shown for a 3-leg intersection (T-intersection) with 70 km/h speed limit on the main road, based on Swedish accident statistics.

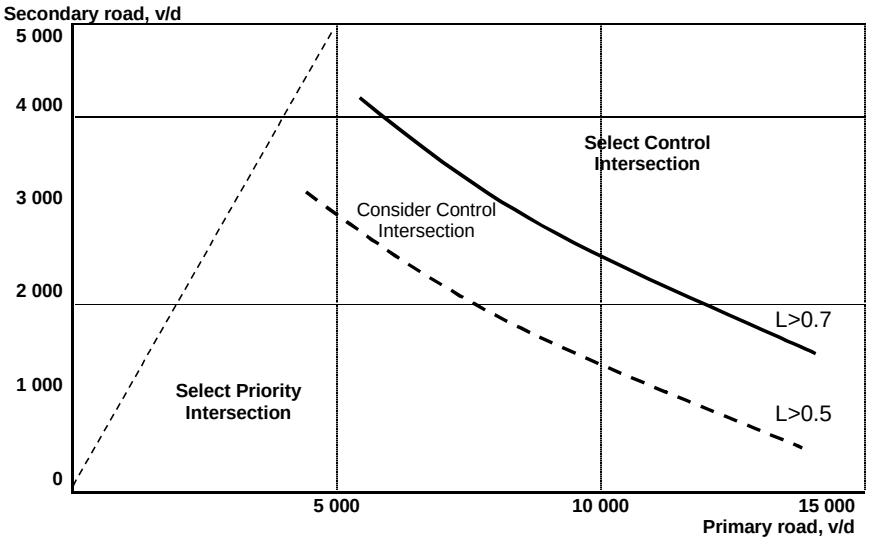


Example of diagram for safety evaluation of priority intersections (T-intersection, 70 km/h)

Capacity evaluation

If a priority intersection should be selected or considered for safety reasons, the capacity must be checked. This can be done in the same way as for safety. The capacity requirement (defined as level of service or load factor) can be defined as one desired level that ought to be satisfied and one definite maximum/minimum level that must be satisfied.

The selection can be made by using diagrams with the relationships between the capacity levels and the traffic volumes on the primary and secondary roads. Below a diagram is shown for a 3-leg intersection (T-intersection) with 70 km/h speed limit on the main road.



Example of diagram for capacity evaluation of priority intersections (T-intersection, 70 km/h)
L = Load factor (actual traffic volume / maximum capacity)

2.3.2 Step II b - Acceptance of control intersection

Road classification and location
Traffic control measures (e.g., local speed limit and stop or yield control) may not be acceptable on the primary road. The table below shows an example of the road standard requirements depending on road classification and location.

	Road class		
Location	State road type I	State road type II	Provincial road type I and II
Rural	No	Yes / No	Yes
Sub-urban	Yes / No	Yes	Yes
Urban	Yes	Yes	Yes

Example of acceptance of traffic control measures for different road classes

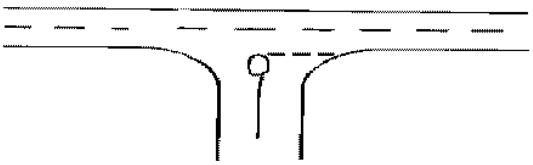
2.4 Step III – Selection of intersection type

Depending on if a priority or a control intersection is chosen in step II, the selection of intersection type can be made in one of the two following ways:

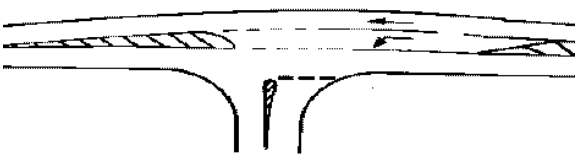
- Selection of priority intersection type – Step II a
- Selection of control intersection type – Step II b

2.4.1 Step II a - Selection of priority intersection type

Priority intersection types
Suggested types of priority intersections are shown in the figure below:

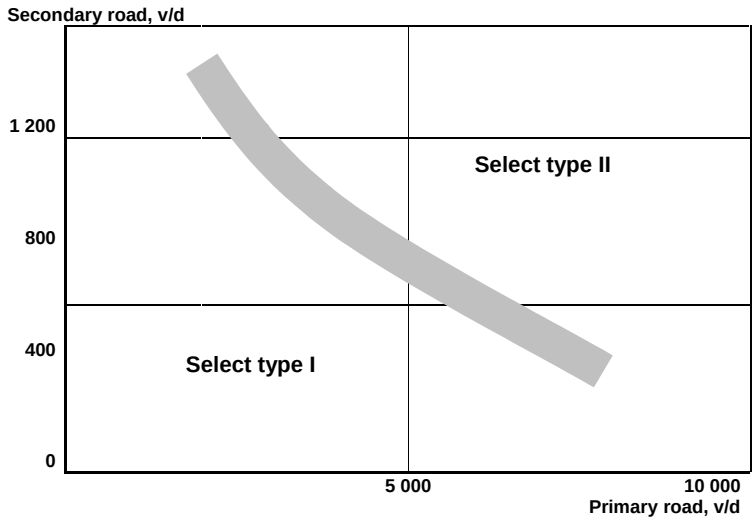


Priority intersection Type I



Priority intersection Type II

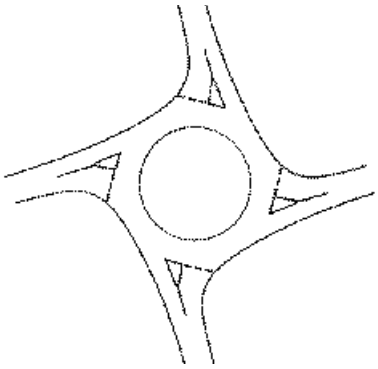
Safety evaluation
The selection of the priority intersection type is based on the safety performance only, since a safe intersection generally also gives enough capacity. The selection can be made using the same kind of diagram as in earlier steps.



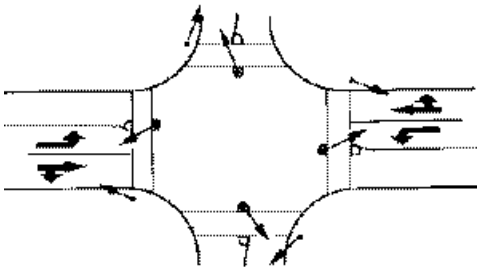
Example of diagram for selection of priority intersection type

2.4.2 Step III b - Selection of control intersection type

Control intersection types
Suggested types of control intersections are shown in the figure below:



Roundabout



Signalized intersection

Safety evaluation
According to recent studies, roundabouts are found to be safer than signalized intersections. Also roundabouts, but not signalized intersections, can normally be accepted on roads and in locations where a control intersection is accepted. For safety reasons, a roundabout should therefore be selected unless:

- the planning conditions are such that a signalized intersection ought to be selected,
- a signalized intersection is more favorable from a socioeconomic point of view.

Evaluation of planning conditions

A roundabout may not be possible to use, for example, depending on the available space or the alignment of the connecting roads. This can be checked by a preliminary lay-out of a roundabout with standard dimensions.

A signalized intersection should be considered if the intersection is part of a coordinated signalized network or located in an area where signalized intersections are common and well known to the road users.

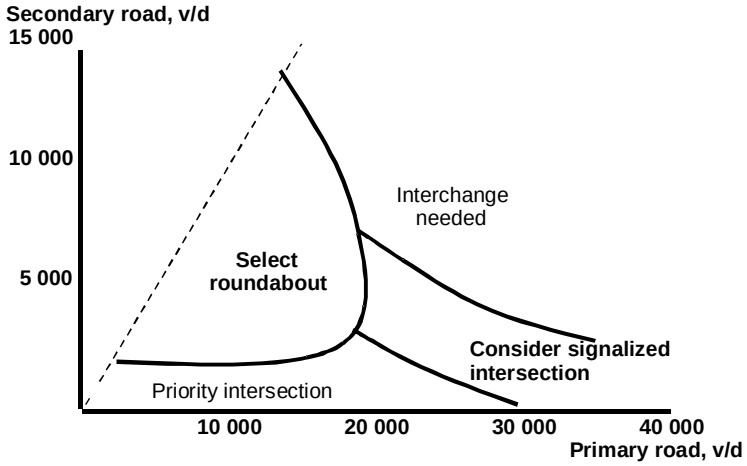
Signalized intersections generally cannot be accepted for all road classes and locations. The following table shows an example of how the acceptance of signalized intersections can be determined.

	Road class		
Location	State road type I	State road type II	Provincial road type I and II
Rural	-	-	-
Suburban	-	Accepted	Accepted
Urban	Accepted	Accepted	Accepted

Example of acceptance of signalized intersection for different road classes and locations

Evaluation of delays

For high traffic volumes on the primary road, delays are normally shorter in a signalized intersection than in roundabouts. Consequently, a signalized intersection can give lower total socio-economic costs. The diagram below shows for which traffic volumes signalized intersections should be considered from an economic point of view.



Example of diagram for when to select roundabout and when to consider signalized intersection

Economic study
If a signalized intersection is considered due to planning conditions or traffic volumes, a socio-economic analysis should be made. This analysis should include road construction and maintenance costs, accident costs, travel time costs, vehicle operating costs and environmental costs.

3 Example

The following example is based on suggested road classification for Turkey, while other prerequisites (standard requirements, intersection types and safety and capacity performances) are based on Swedish conditions.

Road and traffic data

Primary road:	State road, type II
Secondary road:	Provincial road, type II
Number of legs:	3
Location:	Rural
Traffic volumes:	Primary road 5 000 vehicles/day
	Secondary road 1 000 vehicle/day

Standard requirements

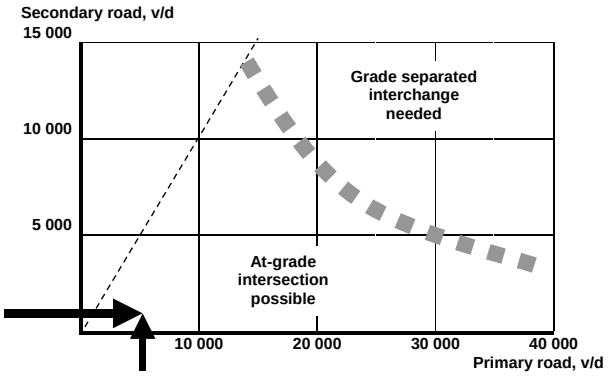
Safety requirement:	0.5 expected accidents per year
Speed limit:	70 km/h
Capacity requirement:	Load factor < 0.5

Step I - Applicability of at-grade intersection
Road classification

	Intersecting/adjoining road			
Main Road	*State road type I*	*State road type II*	*Provincial road type I and II*	*Village, municipality and forest roads*
State road, type I	No	Yes / No	Yes	Yes
State road, type II		Yes	Yes	Yes
Provincial road, type I and II			Yes	Yes

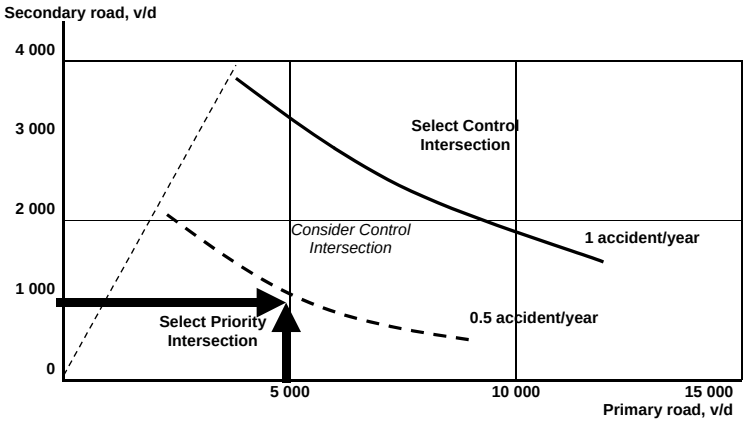
An at-grade intersection can be accepted for this intersection.

Capacity evaluation



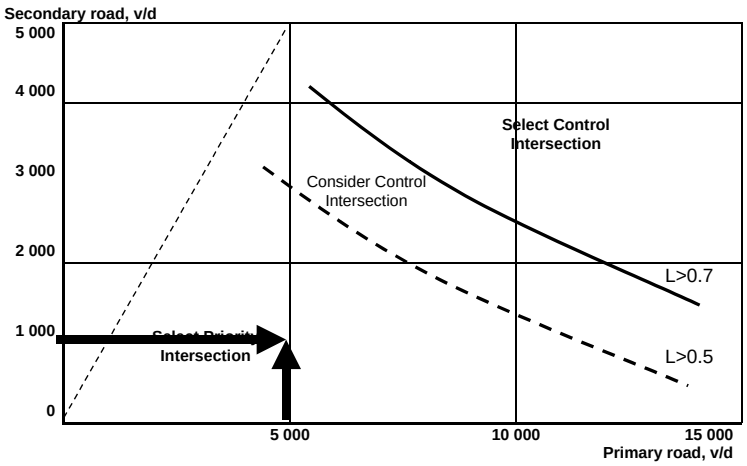
The capacity of an at-grade intersection is quite sufficient.

Step II a - Applicability of priority intersection
Safety evaluation



The expected number of accidents is approximately 0.5 a year.
Priority intersection satisfies the safety requirement.

Capacity evaluation



The load factor is less then 0.5.

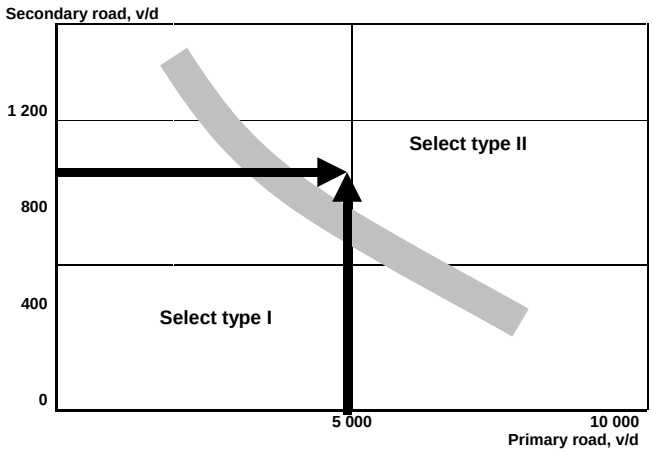
A priority intersection satisfies the capacity requirement.

Conclusion

Since it is sufficient for both safety and capacity, priority intersection can be selected.

Step II b - Acceptance of control intersection
Since priority intersection is selected, the check of acceptance of control intersection is not necessary.

Step III a - Selection of priority intersection type
Safety



Priority intersection type II, with separate left turn lane in the primary road, should be selected for safety reasons.