# INFLUENCE OF GEOMETRIC FEATURES ON CAPACITY AND CAPACITY LOSS FOR TWO-LANE TWO-WAY RURAL ROADS

**By**

**Eng. Amr Ali Shalkamy Mohammed**

**A Thesis Submitted to the**
**Faculty of Engineering at Cairo University**
**In Partial Fulfillment of The**
**Requirements for the Degree of**
**MASTER OF SCIENCE**
**in**
**CIVIL ENGINEERING - PUBLIC WORKS**

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY**
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**Title of Thesis**

Influence of Geometric Features on Capacity and Capacity Loss for Two-Lane Two-way Rural Roads

**Key Words:**
Two-lane Two-way highway; capacity; capacity loss; geometry data; traffic data; passenger car unit; regression analysis.

**Summary:**

Studying the relation between different geometric features and roadway capacity is very important and can lead to significant improvements in the planning and design stages. The main objective of this research is to model the relation between the different geometric features of the horizontal alignment with the capacity of tangent and curved elements of two-lane two-way highways and, more specifically, to model the capacity loss between tangent and curved elements. Traffic and geometry data were collected from six rural two-lane two-way sites on Benisuif - Assiut Agricultural Road in Egypt. Regression analysis was performed to show the relation between different geometric features with capacity and capacity loss between tangents and curves. In addition, analysis was done to relate passenger car unit (PCU) values with the different geometric features. The resulting models are useful for optimizing geometric design on two-lane two-way highways from the capacity point of view to provide a consistent and flowing highway at a suitable level of service, avoiding significant capacity loss on sharp horizontal curves.

## ACKNOWLEDGEMENTS

The author would like to express his sincere appreciation to Prof. Dr. Laila Radwan, Professor of Traffic, Highway and Airport Engineering, Cairo University for her guidance and help in completing this study. Her valuable support and guidance throughout the completion of this research has been invaluable. Her wise recommendation always resulted in the enhancement of the quality of this thesis. Her time, efforts, and patience are highly appreciated. The author is wishing her all pleasure and good health.

The author highly appreciates the role of Dr. Dalia Said, Assistant Professor of Traffic, Highway and Airport Engineering, Cairo University. Without her support and encouragement, the fulfillment of this dissertation was certainly not possible. She not only served the thesis as a supervisor but also encouraged and challenged the author throughout his academic program. Dr.Dalia is not just a supervisor, but also a model for a successful researcher. She stood behind each progress in the study by valuable advice, encouragement and endless efforts. The author wishes her the all happiness and success.

The author would also like to thank all teamwork especially his friends Ahmed Mohammed and Mohammed Ragab for their efforts during the research.

## DEDICATION

*My mother, you are my mother and my friend. You are everything. All thanks to you. You are the symbol of endless giving. Without your loyal prayers, I cannot achieve anything during my life.*

*To the person who supported me with unconditional giving and love. My beloved fiancé Samaa Ali, I dedicate this thesis to you, only to you. No words can describe your appreciation. Allah rewards you as far as you deserve. We will success together.*

*I can't forget to thank my father, my lovely sisters Samar, Omnia, Dina and my Lovely brother Mostafa.*

*Thank you,*

*Amr Shalkamy*

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# ABSTRACT

Capacity is a central concept in design and operation of roadways. Estimation of capacity is an important issue for planning and design of highway facilities. Studying the relation between different geometric features and roadway capacity is very important and can lead to significant improvements in the planning and design stages. The main objective of this research is to model the relation between the different geometric features of the horizontal alignment with the capacity of tangent and curved elements of two-lane two-way highways and to model the capacity loss between tangent and curved elements. Another objective is to study the impact of carriageway width on passenger car unit (PCU) values.

Traffic and geometry data were collected from six sites which are located on Benisuif-Assiut Agricultural Road, Egypt. Each site is composed of two elements; a straight element (tangent) and a succeeding horizontal curve. Traffic volumes and speeds were collected at each element from the study sites. Then, the traffic volumes of vehicles which were classified into six categories were transformed into passenger car unit. The capacity for each element was estimated using extrapolation from a fundamental diagram which represented the relationship between traffic flow and density.

Using correlation and regression analysis, different models were developed. For tangent elements, the results showed that as the carriageway width increases, the capacity also increases. In addition, for paved shoulders the capacity increases by257 pc/hr. For curved elements, as the carriageway width and horizontal curve radius increases, the capacity also increases. In addition, for paved shoulders the capacity increases by 362.82 pc/hr. The models related to capacity loss showed that, as horizontal curve radius and carriageway width of curved elements increases, the capacity loss decreases. It was noticed that at horizontal curve radius of 903m, there is no loss in capacity between tangent and curved elements. In addition, the results showed that the PCU values for vehicle categories increases linearly with increasing of carriageway width. The resulting models are useful for optimizing geometric design on two-lane two-way highways from the capacity point of view to provide a consistent and flowing highway at a suitable level of service, avoiding significant capacity loss on sharp horizontal curves.

# CHAPTER 1. INTRODUCTION

## 1.1 GENERAL INTRODUCTION

Two-lane two-way highways are defined in the Highway Capacity Manual (HCM 2010) as “Roads having one lane for the use of traffic in each direction”. These facilities are considered a key element in the highway system in Egypt and most other countries, as they serve a wide range of vehicle types and provide a variety of transportation functions. Two-lane two-way highways represent the vast majority of the highway system in Egypt, as they constitute about 75% of all paved rural highways (Hashim 2011).

Two-lane two-way highways are an example of uninterrupted flow. This type of highways has unique characteristics as it has a single lane in each direction of travel. Therefore, the traffic operations differ from other facilities due to the significant interaction between vehicles maneuver in the same direction and in the opposing direction of travel due to passing maneuvers and lane changing.

Passing maneuver, where the faster vehicle pass a slower vehicle ahead, is a complex maneuver performed only on two-lane two-way highways. It is limited by sight distance, gaps between vehicles in the opposing direction, road geometry, traffic volume and traffic composition. For this reason two-lane two-way highway capacity is affected to a great extent by the interaction between the two directions of flow.

## 1.2 PROBLEM STATEMENT AND RESEARCH OBJECTIVE

Estimation of roadway capacity is an important issue for determining the traffic demand for roadways when these facilities are designed. Capacity is defined in the HCM (2010) as “the maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic, and control conditions”.

Two-lane geometric characteristics, especially horizontal alignment characteristic are one of the most important factors which affect road capacity, operation and safety of roads. On sharp curves, vehicles may reduce their speed or increase the longitudinal gaps, and thus the flow is reduced (Shawky and Hashim 2010).

A poor design for roadway leads to reduction in speed and performance of the facility which appears obviously in safety and comfort. Moreover, it may cause reduction in roadway capacity and increase the operation and maintenance cost of vehicles. It may also increase the probability of collisions. Designers should consider horizontal curve aspects in the design stage like curve radius, superelevation, widening and provide transition curves between tangent elements and curve elements instead of using simple curves. This provides a more comfortable drive and improves the appearance of the roads with smooth operational conditions.

Horizontal alignment is composed of two elements, straight elements (tangents), and curved elements (curves). The geometric features of tangents that affect roadway capacity are lane width, shoulder width, and tangent length. The geometric features of horizontal curves that affect roadway capacity are mainly horizontal curve radius, lane width, and shoulder width. As a result, the maximum flow served by each element varies and thus, affects the roadway capacity.

Few research has been done on the influence of highways geometric features on capacity and capacity loss. Studying the capacity loss between tangent and curved elements is significant to be considered in the design stage. It provides for a consistent design that reduces speed reductions and thus loss of capacity on horizontal curves. In addition, no further models were found to describe the capacity loss between tangents and curved sections. Therefore there is a need to research the relation between the different geometric features of the horizontal alignment with the road capacity for two-lane two-way highways. In addition, the relation between capacity loss between tangent and curved elements and geometric elements is investigated. Therefore, the main objective of this research is to model the relation between the different geometric features of the horizontal alignment with the road capacity for two-lane two-way highways. Another important objective is to model the capacity loss between tangent and curved elements.

To realize the main objective, two types of models were developed. First, models between the different geometric features of the horizontal alignment and the road capacity for two-lane two-way highways were developed. Second, models between the capacity loss between tangent and curved elements were developed. The latter type of model shows the range of horizontal curve radii that result in significant capacity loss and would help in design with consistent and flowing traffic flow in mind and thus improve the operation of the highway specifically for roads with high