11 Ans 31

APPROVAL SHEET

AN EXPERIMENT TO INVESTIGATE SATURATION

FLOWS AT TRAFFIC SIGNAL JUNCTIONS

by

ASHRAF SAMIR MAGHAWRY

B.Sc. Civil Engineering, Ain Shams University, 1981

--

This thesis for the partial fulfilment of the M. Sc. Degree had been approved by:

25.79 H

Signature

1- Prof. Dr. Ing. Ibrahim El-Dimeery Prof. of Transportation Planning & Traffic Engineering, Faculty of Engineering, Ain Shams University.

25,715

2- Prof. Dr. Eng. Magdi Salah Nour El-Din Prof. of Highway. & Airport Engineering, Faculty of Engineering, Cairo University. Joures -

3- Assoc. Prof. Dr. Eng. Eisa A. Sarhan

Assoc. Prof. of Highway & Airport Engineering,

Faculty of Engineering,

Ain Shams University.

3/ W.

" سُبُعُنَك لَا عِلْمُ لَنَ آلِكُ مَاعَلَىٰنَا اللهُ مَاعَلَىٰنَا اللهُ مَاعَلَىٰنَا اللهُ مَاعَلَىٰنَا المُعَلِينِ مُ اللهُ مَاعَلَىٰنَا المُعَلِينِ مُ اللهُ مَاعَلَىٰنَا المُعَلِينِ مُ اللهُ مَاعَلَىٰنَا المُعَلِينِ مُ اللهُ عَلِينِ مُ اللهُ عَلَيْنِ اللهُ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ اللهُ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ عَلَيْنِ اللهُ الله

صِ اللهُ دَق العَظ مِهُ ا



AN EXPERIMENT TO INVESTIGATE SATURATION FLOWS AT TRAFFIC SIGNAL JUNCTIONS

by

ASHRAF SAMIR MAGHAWRY

B.Sc. Civil Engineering, Ain Shams, University, 1981

Supervised by

Prof. Dr. Ing. Ibrahim El-Dimeery
Prof. of Transportation Planning &
Traffic Engineering,
Faculty of Engineering,
Ain Shams University

Dr. Eng. Aly Salem Heikal
Assist Prof. of Transportation
Planning & Traffic Engineering,
Faculty of Engineering,
Ain Shams University

A Thesis Submitted to FACULTY OF ENGINEERING, AIN SHAMS UNIVERSITY.

for

The Partial Fulfilment Of

The Degree of Master of Science in Civil Engineering CAIRO - EGYPT

1987

TO THOSE WHO LOVE ME AND THOSE WHOM I LOVE

ACKNOWLEDGMENTS

In the name of Allah the most Gracious, most Merciful, and Prayers and Peace upon the **Prophet**, Prayers and Peace from Allah upon him.

The author wishes to express his deep gratitude and sincere appreciation to Professor **Dr. Ibrahim El-Dimeery,** Professor of Transportation Planning and Traffic Engineering, Faculty of Engineering, Ain Shams University, Cairo, for his fatherly guidance, supervision, broad-minded views and continuous encouragement he generously offered during this work. He devoted much of his precious time and effort in order to achieve this work in a successful form.

My special thanks to **Dr. Aly Salem Heikal.** Assistant Professor of Transportation Planning and Traffic Engineering, Faculty of Engineering, Ain Shams University, for his kind encouragement and guidance during the preparation of this thesis.

The author is also grateful to Professor Dr. Gamal Nassar, Professor of Structural Analysis, Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, for his kind help during the implementation of this thesis.

My thanks to Mrs. Karin Ibrahim, Manager in ECOGM Eng. and Consulting Office, for her patience and unending assistance in revising the thesis and my thanks to all friends who offered their help so that this research work could be completed, especially Khaled Fathy.

I am very grateful to my wife who has provided me all the support, encouragement and atmosphere for preparing this work.

My gratitude to my parents who have provided me all encouragement during the implementation of this thesis.

TABLE OF CONTENTS

		Page
Chapter	1	
1.	Introduction	1
Chapter :	2	
Literatu	re Review	
2.1	Introduction	5
2.2	Greater Cairo Urban Development Improvements to Cairo Corridors Project (ICC)	5
2.3	Cairo Urban Transport Project	6
2.4	Saturation Flow Measurements in Cairo	10
2.5	Saturation Flow According to Webster in England	13
2.6	Some Factors Affecting the Capacity of Signalized Intersections	23
2.7	An Experiment to Investigate Saturation Flows at Traffic Signal Junctions	25
2.8	Australian Road Capacity Guide	35
2.9	Swedish Transport Research Commission	40
2.10	Signalized Intersection Capacity According to the HCM	48
2.11	Estimation of Left Turn Saturation Flow	52
2.12	Highway Capacity Manual, Saturation Flow Module	53
2.13	Lost Time Calculation2.13.1 Initial Lost Time Calculation for	54
	the Case of Cairo	55
	Intersection	55
	in England	58
2.14	Summary	5.8

	2.14.1 2.14.2	Saturation Flow Lost Time	5 6
Chapter 3			
Field Mea	surements		
3.1	Introduct	ion	61
3.2	Selection	of Intersections	62
3.3	Data Coll	ection Methods	68
3.4	Field Mea. 3.4.1	surement Problems	68
	3.4.2 3.4.3	Direction	69
2 -	C4		70
3.5	3.5.1 3.5.2 3.5.3	Data Collection	70 72 72
		Units	74
3.6	Data Anal	ysis	75
Chapter 4			
Results a	nd Analysis	s of Saturation Flow Measurements	
4.1	Introduct	ion	80
4.2	Results of	f Saturation Flow	80
	4.2.2	Traffic Movements	80
	, - 2 - 2	Traffic Movements	88
4.3	Flow	Representation of Saturation Histograms of Saturation Flow	91
		During Saturated Time	92
4.4	Saturation	Flow Variations	92
4.5	Analysis o	Saturation Flow Data Saturation Flow as a Function of Effective Movement Width During Saturated Time for Through Traffic Movements	97 98

	4.5.2	Saturation Flow as a Function of Effective Movement Width During Green Time for Through Traffic Movements	101
	4.5.3	Effect of the Extended Green Time on Saturation Flow	101
4.6	Effect of Flow Durin	Turning Movements on Saturation ng Saturated Time	104
4.7	Comparisor Saturated	n of Saturation Flow During Time at Different Day Times	108
4.8	Summary		109
Chapter :	5		
Results a	and Analysis	of Lost Time Measurements	
5.1	Introducti	on	112
5.2	Results of (Through T	Initial and Final Lost Times	112
5.3	Results of (Combined	Initial and Final Lost Times Traffic Movements)	119
5.4	3.4.1	f Lost Time Data	119
	3.4.2	Through Traffic Movements Effect of Site Characteristics and Traffic Condition on Initial	123
	3.4.3 (Lost Times	127
	5.4.4	Irailic Movements Effect of Extended Green Time	129
	5.4.5 [on Initial Lost Time	132
	·	Ihrough Movement	133
5.5	Effect of T Time During	Turning Movements on Initial Lost Saturated Time	136
5.6	Effect of Time During	Turning Movements on Final Lost	138

5.7	Comparison of Initial Lost Time During Saturated Time at Different Day Times 14	2
5.8	Summary 14	4
Chapter 6		
Summary a	d Conclusions	
6.1	Thesis Objectives	7
6.2	Field Measurements 14	8
6.3	Results	2 4
List of Re	ferences	9
APPENDIX A	: Sketches of the 16 Approaches Selected for Measuring Saturation Flow and Lost Times	4
APPENDIX H	: Saturation Flow Histograms of the Considered 33 Movements at the 16 Chosen Approaches	
APPENDIX C	Both Traffic Volumes and Composition (%) of the Considered 33 Movements at the 16 Chosen Approaches	5
APPENDIX D	: Variation of Saturation Flow and Lost Times of the Considered 33 Movements at the 16 Chosen Approaches to Each Cycle)

LIST OF FIGURES

Figure	Description	Page
3.1	Intersection Description Form	65
3.2	Tabulation of Field Data	. 73
3.3	Analysis Data Sheet	. 76
4.la	Saturation Flow Versus Effective Movement Width During Saturated Time for Through Traffic Movements at Different Times of the Days	. 83
4.1b	Saturation Flow Versus Effective Movement Width During Green Time for Through Traffic Movements AM - Period	. 84
4.2	Rate of Saturation Flow Versus Unopposed Turns Percentage During Saturated Time for Combined Traffic Movements AM - Period	. 85
4.3a	Saturation Flow Rate Histogram During Saturated Time (Movement 11.2)	. 89
4.3b	Saturation Flow Rate Histogram During Green Time (Movement 11.2)	90
4.4	Saturation Flow Rate Increasing considerably during Saturated Time (Movement 1)	93
4.5	Saturation Flow Rate Decreasing Considerably During Saturated Time (Movement 10)	. 94
4.6	Saturation Flow Rate Decreasing Steadily During Saturated Time (Movement 16.2)	95
4.7	Saturation Flow Rate Changing Uniformly During Saturated Time (Movement 11)	.96
4.8	Effect of Effective Movement Width on Saturation Flow During Saturated Time for Through Traffic Movements - AM Period	
4.9	Effect of Effective Movement Width on Saturation Flow During Green Time for Through Traffic Movements - AM Period	102
4.10	Effect of Unopposed Turns on Rate of Saturation Flow During Saturated Time	

	- AM Period105
5.la	Initial Lost Time Versus Effective Movement Width During Saturated Time for Through Traffic Movements at Different Times of the Day
5.1b	Initial Lost Time Versus Effective Movement Width During Green Time for Through Traffic Movements - AM Period116
5.2	Final Lost Time Versus Effective Movement Width During Saturated Cycle for Through Traffic Movements - AM Period117
5.3	Rate of Initial Lost Time Versus Unopposed Turns Percentage During Saturated Time for Combined Traffic Movements - AM Period
5.4	Rate of Final Lost Time Versus Unopposed Turns Percentage During Saturated Cycle For Combined Traffic Movements - AM Period
5.5	Effect of Effective Movement Width on Initial Lost Time During Saturated Time for Through Traffic Movements - AM Period
5.6	Modified Linear Equation of Initial Lost Time as a Function of Effective Movement Width During Saturated Time for Through Traffic Movements - AM Period
5.7	Effect of Effective Movement Width on Initial Lost Time During Green Time for Through Traffic Movements - AM Period130
5.8	Effect of Effective Movement Width on Final Lost Time During Saturated Cycle for Through Traffic Movements - AM Period
5.9	Effect of Unopposed Turns on Rate of Initial Lost Time During Saturated Time - AM Period
5.10	Effect of Unopposed Turns on Rate of Final Lost Time During Saturated Cycle - AM Period

LIST OF TABLES

Table	Description	age
3.1	Characteristics of All Selected Approaches	66
3.2	Approaches with Two Movements	67
3.3	Passenger Car Equivalent Units	75
4.1	Measured Saturation Flow Values for Through Traffic Movements - AM Period	81
4.2	Measured Saturation Flow Values During Saturated Time for Through Traffic Movements at Different Times of the Day	86
4.3	Measured Saturation Flow Values During Saturated Time for Combined Traffic Movements - AM Period	87
4.4	Correction Factor "FS" for Saturation Flow due to Turning Movements - AM Periodl	.08
4.5	Adjustment Factor for the Effect of the Day Times on Saturation Flow During Saturated Time	.09
5.1	Measured Initial and Final Lost Time Values for Through Traffic Movements - AM Periodl	13
5.2	Measured Initial Lost Time Values During Saturated Time for Through Traffic Movements at Different Times of the Dayl	18
5.3	Measured Initial and Final Lost Time Values During Saturated Time and Saturated Cycle for Combined Traffic Movements - AM Period	20
5.4	Comparison Between Observed and Calculated Initial Lost Timel	26
5.5	Correction Factor "FITC" of Initial Lost Time due to Site Characteristics and Traffic Conditionsl	29
5.6	Effect of Extended Green Time on Initial	

viii

	Lost Time132
5.7	Comparison Between Initial and Final Lost Time
5.8	Correction Factor "FIT" for Initial Lost Time due to Turning Movements - AM Period139
5.9	Correction Factor "FFT" for Final Lost Time due to Turning Movements - AM Period143
5.10	Adjustment Factor for the Effect of the Day Times on Initial Lost Time During Saturated Time

LIST OF SYMBOLS

The following Symbols are used in this Thesis.

Other Symbols not listed below are defined where they are used.

Symbol	Description
С	Length of Cycle Time in Seconds
_Σ PCUG	Total Number of Vehicles in PCU Crossing the Stop
	Line During the Green Time of a Given Phase
_Σ PCUgs	Total Number of Vehicles Waiting in Queue in PCU
	Crossing the Stop Line from the Start of the Green
	Time to the End of the Saturation Flow (End of
	Queue) "gs"
FT	Final Lost Time of Vehicles Waiting in Queue
	during Saturated Cycle for Through Traffic
	Movements in Seconds
ft	Rate of Final Lost Time of Vehicles Waiting in
	Queue during Saturated Cycle for Through Traffic
	Movement in Seconds per Meter
FTO	Final Lost Time of Vehicles Waiting in Queue
	during Saturated Cycle for Combined Traffic
	Movements in Seconds
fto	Rate of Final Lost Time of Vehicles Waiting in
	Queue during Saturated Cycle for Combined Traffic
	Movements in Seconds per Meter
FS	Reduction Factor for Saturation Flow for
	Percentage of Unopposed Turns