



إسراء الجامعة

Isra University

Management of Traffic Impact Study of Building

Construction in arterial Street of Amman Area

(Case Study in Jordan)

Prepared by:

Lubna Amireh

Supervised by:

PROF. DR. BASIM K JREW

A Thesis

**Submitted to Faculty of Engineering as a Partial Fulfillment of the
Requirement for Master Degree in Engineering Project Management**

November, 2018

AUTHORIZATION FORM

I, Lubna S. Amireh, authorize Isra University to supply copies of my thesis to libraries or establishments or individuals on request, in accordance to the university regulations.

Signature:

Date:

COMMITTEE DECISION

This thesis (Management of Traffic Impact Study of Building Construction in arterial Street of Amman Area “Case Study”) was successfully defended and approved on 25-November-2018.

Examination Committee

Signature

Prof. Dr. Basim K. Jrew (Supervisor)

Isra University

Amman- Jordan

Assoc. Dr. Ibrahim A. Mohammed (Internal Member)

Isra University

Amman- Jordan

Assoc. Dr. Mohammad A. AboJaradeh(External Member)

Zarqa Private University

Amman-Jordan

Dedication

To the spirit of my father

who was supporting and encouraging me to believe in myself

My Mother

Who taught me to trust in Allah

To My Son, Brothers and Sister

Who always beside me in whole my life

ACKNOWLEDGEMENT

Praise be to Allah alone, and prayer and peace be upon our prophet Muhammad (P.B.U.H).

Allah has commanded us to praise and thank him for his infinite grace, for Allah loves his thankful servant.

Firstly, all my thanks and gratitude are due to Allah (S.W.T) who has granted me the privilege of being able to conduct this study and easing the process of this journey, in which a lifetime of thankfulness will not measure.

I wish to extend my appreciation and gratitude to Prof. Dr. Basim K. Jrew whom was my advisor for this thesis study. Prof. Dr. Basim K. Jrew expertly provided me with guidance, encouragement, and support to complete this study.

In addition, I would like to thank the examination committee, Dr. Ibrahim A. Mohammed and Dr. Mohammad A. AboJradaeh for their valuable comments.

I humbly extend my gratitude to everyone who was concerned about my study, Dr. Imad Ismael, Dr. Nabeel Khalil Salma and E.Issam Balbessy, my colleagues in Great Amman Municipality, and my friends who have supported me throughout my journey of conducting my works.

TABLE OF CONTENTS

Subject	Page
Authorization Form	I
Committee Decision	II
Dedication	III
Acknowledgement	IV
Table of Contents	V
List of Equations	X
List of Tables	XII
List of Figures	XV
List of Appendices	XVII
List of Abbreviations	XVIII
Abstract	XIX
Chapter One: Introduction	1
1.1 Preface	1
1.2 Background	1
1.3 Area of study	2
1.4 Problem statement	2
1.5 Objectives of the study	3
Chapter Two: Review of Literature	5
2.1 Preface	5
2.2 Fundamental Principle of Traffic Flow	8
2.2.1 Uninterrupted Flow Facilities Elements	8
2.2.2 Interrupted Flow	14
1- Saturation Flow Rate	15
2- Signalized Intersection Flow	16
3- Capacity at signalized intersections	18
4- Level of Service at Signalized Intersections (LOS)	19
5- Un-signalized intersections	21

<i>List of contents – continued</i>	
Subject	Page
6- Urban street segments	22
2.3 Traffic Impact Studies- TIS	23
1- Trip Generation	26
2- Trip Distribution	26
3- Traffic Assignment	27
4- Modal Split	27
2.4 Computer Software	28
1- HCM 2010 (Highway Capacity Manual 2010)	28
2- HCS 2010 (Highway Capacity Software)	29
3- Synchro10 Computer Software	29
2.5 Active Traffic Management (ATM)	30
2.6 Previous Studies	31
2.7 Related studies	34
Chapter Three: Methodology	37
3.1 Preface	37
3.2 Study Area	38
3.3 Data Collection	42
3.3.1 Base Year of Traffic Flow	42
3.3.2 Forecast of Traffic Volume	44
3.3.3 Traffic Impact Data	45
1- Trip Generation	45
2-Trip Distribution	46
3-Trip Assignment	47
3.4 Data to be Analyzed	51
3.4.1 Roundabout analysis	51
3.4.2 Urban street segments analysis	53
3.5 Data Analysis	55

<i>List of contents – continued</i>	
Subject	Page
3.5.1 Typical Manual Calculation on Sixth Roundabout	55
Step 1: Converting movement demand volumes to flow rates	55
Step 2: Adjusting flow rates for heavy vehicles	56
Step 3: Determine circulating and exiting flow rates	57
Step 4: Determining entry flow rates by lane	58
Step 5: Determining the capacity of each entry lane and bypass lane as appropriate in passenger car equivalents	58
Step 6: Determining pedestrian impedance to vehicles	60
Step 7: Converting flow rates and capacities into vehicles per hour	61
Step 8: Compute the volume-to-capacity ratio for each lane	62
Step 9: Compute the average control delay for each lane	63
Step 10: Determine LOS for each lane on each approach	64
Step 11: Compute the average control delay and determine lane LOS for each approach and the roundabout as a whole	65
Step 12: Compute 95th percentile queues for each lane	66
3.5.2 Typical Manual Calculation on Urban Street Segment	66
Step 1: Determine traffic demand adjustments	67
Step 2: Determine Running Time	67
Step 3: Determine Through Control delay	69
Step 4: Determine Through Stop Rate	69
Step 5: Determine Travel Speed	70
Step 6: Determine Spatial Stop Rate	70
Step 7: Determine Level of Service:	71
3.6 Data Analysis Using HCS2010 Software	71
3.6.1 Analysis of Existing Condition (year 2018) without TTP	72
3.6.2 Analysis of Existing Condition (year 2018) with TTP	74
1-HCS 2010 Output Results for Existing Conditions (year 2018) with TTP	74
2- Syhncro 10 Output Results for existing (year 2018) with TTP	76

<i>List of contents – continued</i>	
Subject	Page
3.6.3 Analysis of Traffic for Short-Term (year 2023) with TTP	77
1-HCS 2010 output Results for Short-Term (year 2023) with TTP	78
2-Syhncro 10 Output Results for Short-Term (year 2023) with TTP	79
3.6.4 Analysis of Mid-Term Condition (year 2028) with TTP	80
1-HCS 2010 Output Results for Mid-Term (year 2028) with TTP	81
2- Syhncro 10 Output Results for Mid-Term (year 2028) with TTP	82
3.6.5 Analysis Summary	83
Chapter Four: Traffic Active Management	86
4.1 Preface	86
4.1.1 Design modifying strategy	86
4.1.2 Traffic signal strategy	88
4.2 Suggested improvements for existing condition 2018	87
4.2.1 Adding one lane for each segment using HCS2010	87
4.2.2 Adding an exclusive right turn for the Sixth Roundabout using HCS2010	88
4.3 Suggested improvements for short-term 2023	89
4.3.1 Changing the Sixth Roundabout to signalized intersection using HCS2010	90
4.3.2 Segments analysis using HCS2010	91
4.4 Suggested improvements for Mid-term condition 2028	92
4.4.1 Separating the left movement on NB by an overpass on the Sixth signalized intersection using HCS2010	92
4.4.2 Segments analysis using HCS2010	93
4.5 Analysis network using Synchro10	95
4.5.1 Suggested improvements for the existing condition 2018	95
4.5.2 Suggested improvements for short-term condition 2023	96
4.5.3 Suggested improvements for the short-term condition 2023	97
4.6 Summary of ATM program	98

List of contents – continued

Subject	Page
Chapter Five: Conclusion and Recommendations	102
5.1 Preface	102
5.2 Conclusions	102
5.3 Recommendations	104
5.4 Limitation s, Strength and obstacles of the research	106
5.5 Future Research	106
References	110

LIST OF EQUATIONS

Number	Page
Equation 2- 1	9
Equation 2- 2	9
Equation 2- 3	9
Equation 2- 4	10
Equation 2- 5	10
Equation 2- 6	11
Equation 2- 7	12
Equation 2- 8	12
Equation 2- 9	15
Equation 2- 10	18
Equation 2- 11	18
Equation 2- 12	20
Equation 2- 13	20
Equation 3- 1	55
Equation 3- 2	56
Equation 3- 3	56
Equation 3- 4	57
Equation 3- 5	57
Equation 3- 6	58
Equation 3- 7	59
Equation 3- 8	59
Equation 3- 9	61
Equation 3- 10	61
Equation 3- 11	61
Equation 3- 12	62
Equation 3- 13	62
Equation 3- 14	65

<i>List of Equations – continued</i>	
Number	Page
Equation 3- 15	65
Equation 3- 16	66
Equation 3- 17	67
Equation 3- 18	68
Equation 3- 19	68
Equation 3- 20	69
Equation 3- 21	69
Equation 3- 22	70
Equation 3- 23	70
Equation 3- 24	77

LIST OF TABLES

Number	Table Caption	Page
Table 2-1	Time control delay per vehicle for each Level of Service (HCM 2010)	21
Table 2-2	LOS for un-signalized intersection (HCS 2010)	22
Table 2-3	LOS thresholds for urban streets (segments)	23
Table 3-1	Traffic Volumes on Sixth Roundabout (vph)	42
Table 3- 2	Traffic volumes on the two segments (vph)	43
Table 3- 3	Overall Peak Hour Trips Generated from TTP during a Typical Weekday (vph)	46
Table 3- 4	Trip distribution pattern	46
Table 3- 5	The percentage of traffic volume on the Sixth Roundabout	48
Table 3- 6	The percentage of traffic volume on the First & Second segments of Zahran street	48
Table 3- 7	Upstream trip assignment on the Sixth Roundabout (vph)	48
Table 3- 8	Trip assignment on the First & Second segments of Zahran street	49
Table 3- 9	Flow rates at the Sixth Roundabout (veh/hr)	56
Table 3- 10	Adjusted flow rates for heavy vehicles at Sixth Roundabout (pc/hr)	57
Table 3- 11	Circulating and exiting flows at Sixth Roundabout	58
Table 3- 12	Entry flow rate for each lane	58
Table 3- 13	Capacity of each entry lane at Sixth Roundabout	60
Table 3- 14	Lane flow rates and capacities (veh/hr)	62
Table 3- 15	Volume-to-capacity ratio for each lane	63
Table 3- 16	Average control delay for each lane	64
Table 3- 17	LOS for each lane on each approach	64
Table 3- 18	Control delay for each approach and a whole intersection with LOS of the intersection	65
Table 3- 19	The 95th percentile queues for each lane	66
Table 3- 20	A comparison result between manual calculation and the HCS2010- output result	72

List of Tables - continued

Number	Table Caption	Page
Table 3- 21	The results of the Sixth Roundabout- without TTP-2017	73
Table 3- 22	The results of the two segments of Zahran Street- without TTP – 2017	74
Table 3- 23	The results of the Sixth Roundabout with TTP- 2017	75
Table 3- 24	The results of the two segments of the Zahran Street- with TTP-2017	75
Table 3- 25	Network level of service - with TTP - 2017	76
Table 3- 26	Traffic volumes on the Sixth Roundabout- without TTP- short-term 2023	77
Table 3- 27	Traffic volume on the two segments- without TTP –short-term 2023	77
Table 3- 28	Traffic volumes on the Sixth Roundabout- with TTP –short-term2023	78
Table 3- 29	Traffic volumes on the two segments - with TTP –short-term2023	78
Table 3- 30	The results of the Sixth Roundabout- with TTP- 2023	78
Table 3- 31	Level of service of the two segments of the -Zahran street.-	79
Table 3- 32	Network level of service-with TTP- 2023	79
Table 3- 33	Traffic volumes on the Sixth Roundabout- without TTP- 2028	80
Table 3- 34	Traffic volumes on the two Segments- without TTP – 2028	81
Table 3- 35	Traffic volumes on the Sixth Roundabout- with TTP- 2028	81
Table 3- 36	Traffic volume on the two Segments- with TTP- 2028	81
Table 3- 37	The results of Sixth Roundabout- with generated TTP- 2028	82
Table 3- 38	The results of the two segments of Zahran street- with TTP- 2028	82
Table 3- 39	Network level of service- with generated TTP – 2028	83
Table 3- 40	Comparing results of existing condition with and without TTP- 2017	84
Table 3- 41	Comparison table between three periods with TTP	84
Table 3- 42	Comparison table between three periods as a network with TTP	85
Table 4- 1	Comparison of the first segment results before and after improvement for Existing condition 2018 using HSC 2010	88
Table 4- 2	Comparison of the second segment results before and after improvement for Existing condition 2018 using HCS 2010	88

List of Tables - continued

Number	Table Caption	Page
Table 4- 3	Comparison results before and after improvement for the Sixth Roundabout for existing condition 2018 using HCS2010	89
Table 4- 4	Comparison results before and after improvement for the Sixth Roundabout for short-term 2023 using HCS2010	91
Table 4- 5	Comparison results of First segment before and after improvement for short-term 2023	91
Table 4- 6	Comparison results of the Second segment before and after improvement for short-term 2023	92
Table 4- 7	Comparison of the results before and after improvement for the Sixth signalized intersection for Mid-term 2028-using HCS2010	93
Table 4- 8	Comparison of the results of the First segment before and after improvement for Mid-term condition 2028	94
Table 4-9	Comparison of the results of the Second segment before and after improvement for Mid-term condition 2028	95
Table 4- 10	Comparison of the results for the network between, before and after the improvement for the existing condition 2018	96
Table 4-11	Comparison results for network between before and after the improvement for the short-term condition 2023	97
Table 4- 12	Comparison results for network between before and after the improvement for Mid-term condition 2028	98
Table 4-13	Management improvement of the Sixth Roundabout in control delay	99
Table 4- 14	Management improvement of First segment in control delay	100
Table 4- 15	ATM Management improvement of the Second segment in control control-delay	100
Table 4- 16	ATM Management improvement of network in control delay	101

LIST OF FIGURES

Number	Figure Caption	Page
Figure 2-1	Points, Segments, and Corridors in urban system (HCM, 2010)	6
Figure 2-2	Corridors, Areas, Systems (HCM, 2010)	6
Figure 2-3	Space Mean Speed versus Time Mean Speed (HCM,2010)	11
Figure 2-4	Fundamental Diagrams of Traffic Flow (HCM, 2010)	13
Figure 2-5	Headways at a Signalized Intersection, (HCN, 2010)	17
Figure 2-6	Concept of Saturation Flow Rate and Lost Time (HCN, 2010)	17
Figure 2-7	Flow chart of transportation analysis techniques	25
Figure 3-1	Aerial Photograph of the Study Area in Amman (Um-Uthinah District)	39
Figure 3-2	Total area of impact study	40
Figure 3-3	Selected study Area that Affected by Twin Tower Project (Case Study)	41
Figure 3-4	Traffic flow volume of the movements on Sixth Roundabout (vph)	43
Figure 3-5	Traffic volumes on the two segments (vph)	44
Figure 3-6	Trip assignment TTP generated traffic on the network (Sixth Roundabout and the two segments of Zahran street)	47
Figure 3-7	Upstream trip assignment of TTP on the Sixth Roundabout (vph)	49
Figure 3-8	Trip assignment of TTP on the First & Second segment of Zahran street	50
Figure 3-9	Traffic volumes on the Sixth roundabout with TTP impact (vph)	50
Figure 3-10	Traffic volumes on the two segments with TTP impact (vph)	51
Figure 3-11	Roundabout analysis methodology	52
Figure 3-12	Methodology for analysis urban street segments,	54
Figure 3-13	Types of flow at roundabout (HCM,2010)	60
Figure 3-14	Sixth geometry input (HCS2010)	73
Figure 3-15	Network level of service- with TTP- 2018	76
Figure 3-16	Network level of service- with TTP- 2023	80
Figure 3-17	Network level of service- with generated (TTP) – 2028	83
Figure 4-1	Ariel photograph of the improvement on the Sixth Roundabout for the existing condition 2018	89

<i>List of Figures - continued</i>		
Number	Figure Caption	Page
Figure 4- 2	Ariel photograph of thFfig improvements of the Sixth Roundabout for short-term 2023	90
Figure 4- 3	Ariel photograph of the improvement of the Sixth signalized intersection for Mid-term condition 2028	93
Figure 4- 4	Network level of service after improvement Sixth Roundabout for existing condition 2018	95
Figure 4- 5	Network LOS after improvement the Sixth Roundabout for short-term condition 2023	96
Figure 4- 6	Network LOS after improvement the Sixth signalized intersection for Mid-term condition 2028	97

LIST OF APENDICES

Number	Appendix Name	Page
Appendix A	HCS 2010 Software Results	A-1
Appendix B	Synchro 10 Software Results	B-1
Appendix C	HCS 2010 Software Results-with improvements	C-1
Appendix D	Synchro 10 Software Results- with improvements	D-1

LIST OF ABBREVIATIONS

Abbreviation	Meaning
EPM	Engineering Project Management
LOS	Level of Service
TIS	Traffic Impact Studies
TSM	Transportation System Management
TDM	Transportation Demand Management
TMS	Traffic Management System
TNMS	Traffic Network Management System
QoS	Quality of Service
AS	Autonomous System
DTA	Dynamic Traffic Assignment
DRIP	Dynamic Route Information Panel
ITE	The Institute of Transportation Engineers
PHF	Peak Hour Factor
PHV	Peak Hour Volume
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
AADT	Annual Average Daily Traffic
ITS	Intelligent Transportation System
PCE	Passenger Car Equivalent
TRB	Transportation Research Board

Management of Traffic Impact Study of Building Construction in Arterial Street of Amman Area (Case Study)

By: Lubna S. Amireh

Supervisor: Prof. Dr. Basim K. Jrew

Abstract

This research presents the management of traffic impact study (TIS) through a case study for the Twin Tower Project (TTP), especially on the arterial urban street and the Sixth roundabout. The traffic impact is analyzed for the existing condition (2017), the short-term condition (2023) and the mid-term condition (2028) using Highway Capacity Manual (HCM 2010) and Highway Capacity Software (HCS 2010). The results of the analysis show a low level of service (LOS) for the Sixth roundabout and the two segments of the urban arterial street in all study periods, which represents a congestion in the network with a low quality of service. HCS 2010 and Synchro 10 are used to improve both traffic flow and network geometry, the results of the improvement show increment in the level of service (LOS) and the capacity of the network, and reduction in the control delay time. The study recommendations for the existing condition are to improve the network geometry by adding one lane for both directions of urban arterial street with exclusive right turn on the Sixth roundabout. For the short-term condition, it is recommended to redesign the roundabout to a signalized intersection. While for the mid-term condition, it is recommended to separate the high volume on the intersection by constructing an overpass.

Keywords: Traffic Impact Study, Traffic Congestion, Traffic Control delay, Level of Service, Trip Generation, Trip Distribution, Active Traffic Management (ATM), Improvements, Capacity, Roundabout, Segment, Updating software (Synchro10, HCS 2010).