CAIRO UNIVERSITY
FACULTY OF ENGINEERING
PUBLIC WORKS DEPARTMENT

TRAFFIC ENGINEERING
Third Year Civil

Assignments

2016 / 2017

CASE STUDY

The considered case study is a traffic impact assessment for a a new development (Mall of Egypt) that is currently under construction at El-Wahat Road, in 6th of October city. The corridor currently witnesses considerable traffic volume during the morning and afternoon peaks. The development under construction is expected to significantly impact the level of service of the travel corridor due to the expected increase in traffic volume. A traffic impact study is necessary to quantify the expected impact and propose traffic modification scenarios to mitigate (or limit) this impact.

Study Area Description

Mall of Egypt is a huge shopping/entertainment facility that is currently under construction along the side of a major traffic corridor in 6th of October city, El-Wahat Road. El-Wahat Road is a major 6-lanes divided suburban traffic corridor. El-Wahat Road carries traffic from/to El-Fayoum desert road and the Ring Road to/from 6th of October city and El-Wahat region. Figure 1 presents a map of the study area; El-Wahat road in between the Ring Road and the main corridor carrying traffic to Juhyna square. A total of 5 Entrances/Exits (marked in red) are considered for this study. This stretch of El-Wahat corridor includes one operating U-turn (marked in green).

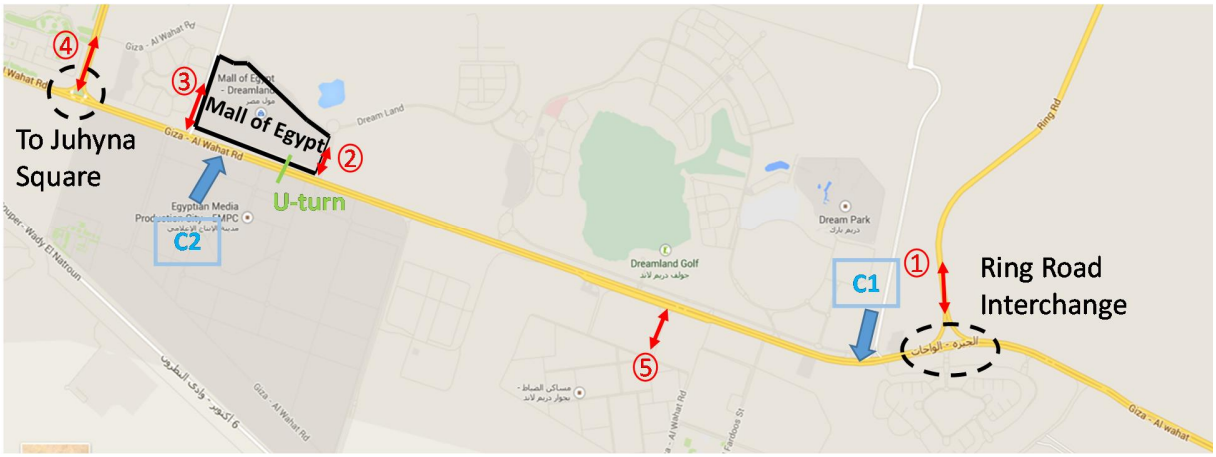


Figure 1: Study Area

Mall of Egypt Land use Data

Mall of Egypt is a huge shopping/entertainment facility that is currently under construction. The mall is scheduled to open in 2017. Figure 2 presents an overall perspective of the intended development. The project main land use incorporates the following land uses on 232,800 sq. meters of GFA:

- Energy Center and substation buildings
- Shopping Facilities with total GFA of 193,800 sq. meters:
    - Retail area of 162,500 sq. meters (Gross Floor Area), around 320 stores
    - Food Court & restaurants (31,300 sq. meters) (Gross Floor Area)
- Entertainment Facilities with total GFA of 39,000 sq. meters:
    - Cinema & Family Entertainment GFA of 23,000 sq. meters
    - Ski Park (16,000 sq. meters)
- 5 Parking Zones (176,500 sq. meters) with capacity of around 4900 parking spaces.

Figure 2: Mall of Egypt ï Model

El-Wahat Road Traffic Data

A classified one-direction 16-hours traffic count and spot speed surveys have been conducted at count stations C1 and C2 (see Figure 1) along El-Wahat corridor. Resulting counts are provided in an Excel format. Table 1 presents a description of the corridorôs main entrances/exits with entering/exiting traffic volume; as a percentage of traffic counts on count stations C1 and C2.

Table 1: El-Wahaat Corridor Main Entrances/Exits

Entrance/ Exit number	**To/From**	**Entering/Existing Traffic Volume Percentages**	**Base Count Station**
1	From Ring Road	Entering 50%	C1
4	To Juhyna Square	Exiting 35%	C1
	From Juhyna Square	Entering 25%	C2

SHEET (1)
TRAFFIC STUDIES

To evaluate the existing conditions prior to opening the Mall; two studies were conducted along El-Wahat Road at count station C1.

1) **Spot Speed Study:** during the speed study, the observer measures and marks a section of the road; and starts a stopwatch when a vehicle enters that section and stops it when the vehicle exits the section. In this study, a 100 m section of the road was measured and marked. The recorded times in seconds are listed below for a sample of only 30 vehicles of all vehicles between 3 pm and 4 pm: 4.3, 4.0, 4.1, 5.3, 5.1, 4.7, 3.8, 4.0, 4.0, 3.7, 4.7, 4.6, 5.2, 5.0, 4.1, 4.0, 5.0, 5.3, 3.9, 3.6, 4.0, 4.4, 4.0, 4.7, 4.5, 5.5, 3.7, 3.5, 4.1, 4.5. Assume a free flow speed of 120 km/h.
   a) Calculate the Time Mean Speed, and the Modal Speed (km/h) for this roadway section. Comment on your results from theoretical and practical perspectives.
   b) Calculate the Speed Index and the Buffer Time Index for this roadway section. Comment on the travel time reliability of El-Wahat Road.

2) **Traffic Volume Study:** during the traffic volume study, the following traffic counts were recorded between 6 am and 10 pm with a 15 min interval.
   a) Plot the time of day vs. volume diagram.
   b) Determine the am and pm peak hourly traffic volumes.
   c) Determine the peak hour factor (PHF)

Interval			Count
6:00 AM	-	6:15 AM	256
6:15 AM	-	6:30 AM	266
6:30 AM	-	6:45 AM	336
6:45 AM	-	7:00 AM	442
7:00 AM	-	7:15 AM	370
7:15 AM	-	7:30 AM	385
7:30 AM	-	7:45 AM	486
7:45 AM	-	8:00 AM	639
8:00 AM	-	8:15 AM	481
8:15 AM	-	8:30 AM	489
8:30 AM	-	8:45 AM	496
8:45 AM	-	9:00 AM	467
9:00 AM	-	9:15 AM	401
9:15 AM	-	9:30 AM	411
9:30 AM	-	9:45 AM	374
9:45 AM	-	10:00 AM	403
10:00 AM	-	10:15 AM	415
10:15 AM	-	10:30 AM	422
10:30 AM	-	10:45 AM	383
10:45 AM	-	11:00 AM	367
11:00 AM	-	11:15 AM	351
11:15 AM	-	11:30 AM	398
11:30 AM	-	11:45 AM	318
11:45 AM	-	12:00 PM	332
12:00 PM	-	12:15 PM	333
12:15 PM	-	12:30 PM	346
12:30 PM	-	12:45 PM	332
12:45 PM	-	1:00 PM	290
1:00 PM	-	1:15 PM	357
1:15 PM	-	1:30 PM	319
1:30 PM	-	1:45 PM	497
1:45 PM	-	2:00 PM	227
2:00 PM	-	2:15 PM	432
2:15 PM	-	2:30 PM	506
2:30 PM	-	2:45 PM	512
2:45 PM	-	3:00 PM	449
3:00 PM	-	3:15 PM	546
3:15 PM	-	3:30 PM	529
3:30 PM	-	3:45 PM	382
3:45 PM	-	4:00 PM	344
4:00 PM	-	4:15 PM	329
4:15 PM	-	4:30 PM	344

Interval			Count
4:30 PM	-	4:45 PM	320
4:45 PM	-	5:00 PM	308
5:00 PM	-	5:15 PM	309
5:15 PM	-	5:30 PM	309
5:30 PM	-	5:45 PM	255
5:45 PM	-	6:00 PM	368
6:00 PM	-	6:15 PM	224
6:15 PM	-	6:30 PM	262
6:30 PM	-	6:45 PM	340
6:45 PM	-	7:00 PM	292
7:00 PM	-	7:15 PM	168
7:15 PM	-	7:30 PM	241
7:30 PM	-	7:45 PM	194
7:45 PM	-	8:00 PM	397
8:00 PM	-	8:15 PM	228
8:15 PM	-	8:30 PM	243
8:30 PM	-	8:45 PM	223
8:45 PM	-	9:00 PM	206
9:00 PM	-	9:15 PM	230
9:15 PM	-	9:30 PM	220
9:30 PM	-	9:45 PM	218
9:45 PM	-	10:00 PM	232

3) A rural Road "R1" has a traffic volume distribution of ADT through the year as shown below:

Month	***ADT***
January	4150
February	4580
March	3720
April	2600
May	1880
June	1620

Month	***ADT***
July	1390
August	1200
September	1440
October	1550
November	2070
December	2840

a) Calculate monthly (seasonal) expansion factors.

b) Another Road "R2" is considered similar to Road "R1" in term of traffic seasonal variations. Daily counts of 2200 vehicles were recorded during the month of April.

i- Estimate the AADT of Road "R2"

ii- Estimate the ADT on Road "R2" during month of August.

SHEET (2)

TRAFFIC FLOW MODELS

While the preceding studies and definitions provided the basis for the measurement and calculation of the traffic stream parameters (speed, volume) at a specific location, for a certain duration along El-Wahat Road; it is essential to understand the interaction of the individual macroscopic measures to fully analyze the performance of the existing conditions of El-Wahat road prior to opening the Mall. To study the relationship between the traffic stream parameters, the following speeds and corresponding densities were measured along one lane of El-Wahat Road across several hours of the day.

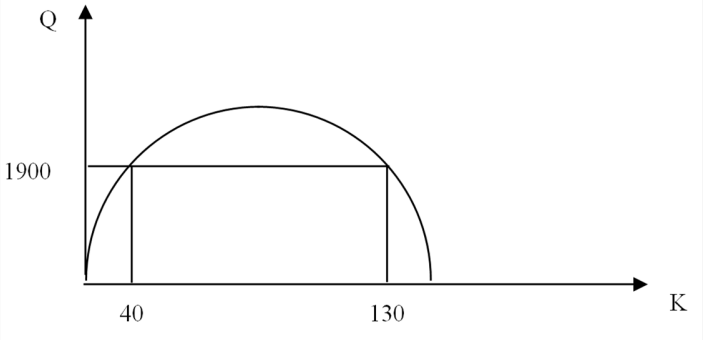
1) Fit the speed-density data to the Greenshield and Greenberg traffic flow models; and

   a) Comment on which model better represents the collected field data?
   b) Estimate the capacity of the freeway, critical speed, and critical density under both traffic flow models.
   c) Find the free-flow speed and jam density, and comment on the results.
   d) Derive equations describing flow versus speed and flow versus density.
   e) Sketch the speed-density, flow-speed, and flow-density curves.

Speed (kph)	Density (vpkm/lane)
113	1
110	2
105	5
104	6
100	7
89	14
85	14
83	15
77	21

Speed (kph)	Density (vpkm/lane)
56	34
37	42
29	48
28	48
20	52
17	57
16	54
10	58
4	64

2) The speed-density relationship is linear and the Q-K curve is as depicted in the figure below. Show how you can express the average speed in terms of the traffic density only.



SHEET (3)

SHOCKWAVES & QUEUING ANALYSIS

1. After mall opening, the traffic volume (demand) in El-Wahat Road at the peak hour is forecasted to be 5200 vph. An accident blocks 1 lane of the highway. It took 15 minutes till the accident is cleared and capacity is fully restored. Use the speed-density relationship of El-Wahat Road (refer to Sheet 2) to answer the following questions:
    a) Sketch the above incident in a flow-density as well as time-space diagrams.
    b) Using shockwave analysis:
        i. Estimate the maximum queue
        ii. How long will it take for the queue to completely clear?
        iii. How far will the queue reach?

2. Shipping trucks begin to arrive at the gate of the mall at 6:45 A.M. with a deterministic rate of 2 trucks/min. At the mall gate, the security attendants start working at 7:00 A.M. Each truck takes a deterministic process/service time of 20 seconds at the gate for security checks.
    a) Calculate the maximum queue at the gate?
    b) When will the queue cleared?
    c) Calculate the average truck delay?

3. As shown in Figure (1) a traffic signal operating at an intersection inside the mall with effective green and red times of 40 and 50 seconds respectively. Vehicles arrive at the intersection at a rate of 700 vph. The traffic stream model that will be used inside the mall is given such that u = 70 ï 0.71k (u is speed in kph and k is density in vpkm/lane). Determine the following:
    a) Max queue length
    b) How long will take for the queue to completely clear?
    c) Will the queue formed during the red time block the service road entrance?

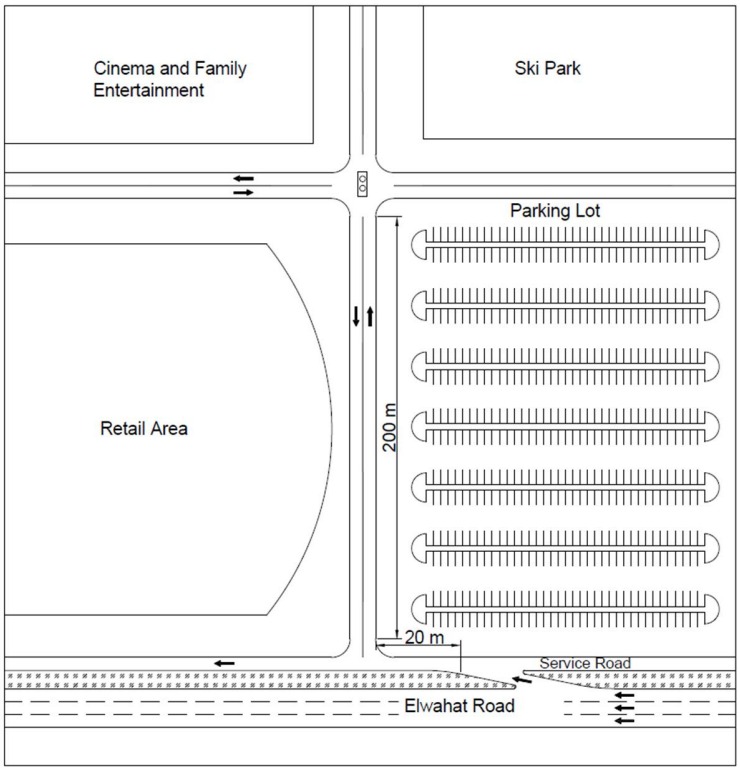


Figure (1)

4. A highway has a capacity of 3000 vph per direction and a constant traffic flow rate of 2000 vph per direction. At 10:00 am, a traffic accident closed the highway (i.e., no vehicles can pass through the accident site). At 10:15 am, the highway was partially opened to traffic with a capacity of 1500 vph. At 10:30 am, the accident was completely removed and the highway was cleared and restored to its full capacity (i.e., 3000 vph per direction).
    a) Sketch the cumulative arrival and departure curves.
    b) Determine the maximum queue length
    c) Calculate total delay and average delay due to this accident.
    d) When will the queue be cleared?
    e) What was the queue length at 11:00 am?

SHEET (5)

CAPACITY ANALYSIS OF UNINTERRUPTED FLOW

1. Determine the LOS for a 5-mile two-lane highway in rolling terrain. The existing data for this road are as follows:

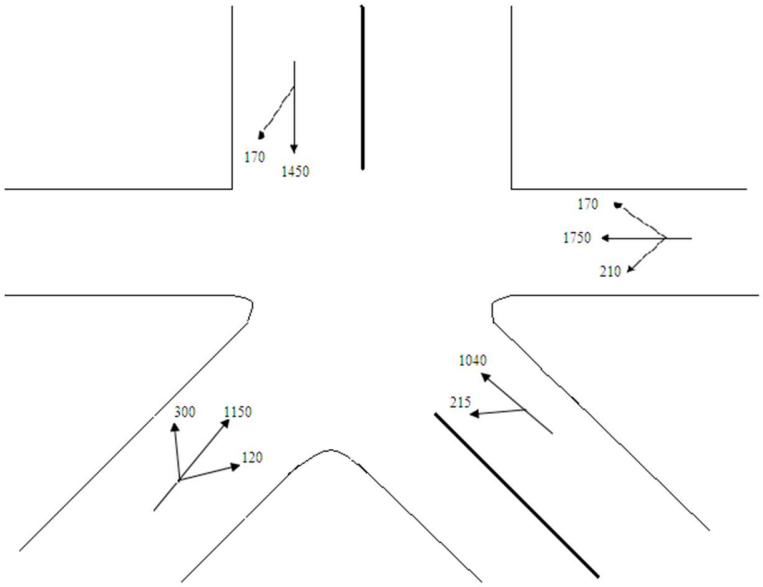
- Volume = 1050 veh/h (two-way)
- Percent trucks = 8
- Percent RVôs = 4
- Peak hour factor = 0.95
- Percent directional split = 60 ï 40
- Percent no-passing zone = 40
- BFFS = 60 mi/h
- Lane width = 10 ft
- Shoulder width = 5 ft
- No. of access points = 15 point/mi

2. El-Wahat Multi-lane highway has a level terrain with 20 access points per mile and has 11 ft lanes, with a 5-ft shoulder on the right side and a 3-ft shoulder on the left side. There are 7% large trucks, 3% buses, and 2% recreational vehicles. Assume the base free flow speed is 55 mph. Determine the level of service before and after the mall opening if the peak hour is forecasted to be 4200 vph with a peak hour factor of 0.82.
3. Based on the results of Question 2 above, determine the additional number of 12-ft lanes required in each direction if the road is to operate El-Wahat highway at level of service C.

SHEET (6)

INTERSECTION CONTROL AND ANALYSIS

1. Find the number of conflict points for the following intersection:



2. As shown in Figure 1, the left turns on approaches (1) and (2) move in protected phasing. The following additional data are given.

   - % Trucks = 15% -grade = 2%

   - Number of parking maneuvers per hour = 20

   - Number of buses stopping per hour = 30

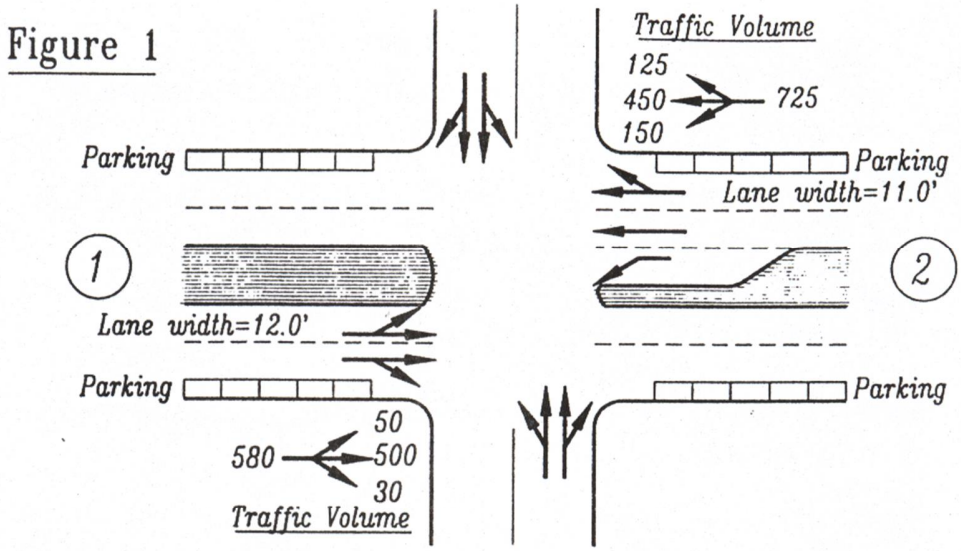
   For each approach, determine the following:

   a. Adjusted saturation flow rate.
   b. Capacity.
   c. Level of service.

3. The peak-hour volumes for a major intersection on an expressway are shown in the figure 2. Using the Webster method, determine suitable signal timing for the intersection using the suggested phasing system shown in figure 2. The following data is given:

- -PHF = 0.95
- Left-turn factor = 1.4
- PCE for buses and trucks =1.6
- Truck percentage = 2 percent for south approach traffic and zero otherwise.
- Saturation flow:
  - Through and through lanes 2000 veh/h/ln
  - Left lanes 1500 veh/h/ln
- Each phase has a 3.5 seconds total lost time and 3.0 seconds yellow interval.

Figure 1



PHASING SEQUENCE				
(C + Y) , sec	30	25	20	15

Figure 2