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Traffic Modeling for Hillah-Najaf Highway (Nader Intersection-Babylon Main Gate Segment/Iraq)

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Abstract: Traffic modeling is an abstraction of reality formulation in either conceptacle, physical or mathematical terms and used as mechanism for reproducing the operation of the real world system for analytical purposes. The best fitting and the most significant model that explained the speed density relationship for the roadway section is a linear model like (Green Shield) Model. This represents appropriate and flexible application model. It was been concluded that the linear formula (V_s = 95.962-1.2698*K), show the better correlation between traffic elements in the study area according to regression analysis due to coefficient of correlation (r = 0.9657) when comparing the model with other equations such as log, power and exponential. The study found that the maximum density (K_m) = 38 veh/km/ln, according to maximum flow ($q_{max.}$) = 1824 veh/h, the maximum speed due to stable flow = 48 km/h, also data collection and analysis has been represented that as the speed decreases the traffic density (K) increases and traffic flow change from stable to unstable flow meanwhile the density change from (K_m) to jam density (K_j) which it is equal (76) veh/km/ln. Through observations and data analysis, it was found that the vehicles appear at speed higher than those that have been deduced in Paragraph 3, resulting in many traffic accidents, especially, type (vehicle/pedestrian), this required efforts, studies, activate low and regulations as well as furnishing the roadway section with signs and signal in order to provide safe movement and crossing for pedestrians and road user.

Key words: Traffic modeling intersection, traffic density, flow, observations, pedestrians, regulations

INTRODUCTION

Al-Hillah is a major city in the republic of Iraq which focus of traffic generation. It is drawing significant quantities of traffic from wide speared area for many different purposes. During the last few years an extensive growth, changes and development happened has tack place in the city to stand with extensive scientific and technology rising. In addition, the rapid growth in the level of car ownership led to increase in trip generation and trip distribution, so that, traffic characteristics which include basic traffic elements such as flow, speed and density relationship explained traffic conducted. So, this study seek to the employment of these relationship by building statistical models describe traffic behavior in the study area. The basic principles requirements of modeling are enabling to elevate alternative plus, enabling forecasts to be made investigating the makeup of the system and structure of interactions of operation of system, explaining the principles of operation and improving on decision making based exclusively on intuitive judgment.

MATERIALS AND METHODS

Definition of study area: The study area represented a highway which is classified as multilane highway, begins from Nader interchange to the Babylon University main get of about (7.0) km section length in the South of Al-Hillah city, this highway is a part of Al-Hillah-Al-Najaf highway (Fig. 1). The highway characteristics with four lanes two lanes in each direction, each lane width 3.75 m, divided with median 6.0 m width. The highway section length has many left turn movement and access point for which it conveys various kinds of trips rather for different types of vehicle like (Passenger Car -PC-, Bus -B-, Truck-T). Which has led to many cases of congestion and delay in travel time which is required basic traffic elements in study area in order to find effective solutions to reduce travel time, thus, increasing the safety, efficiently and convenience for road user and goods (Anonymous, 2002; Garber and Hole, 2008; Ministry of Housing & Construction, 2005; Pignataro, 1973; TRB., 2010).

Data collection: Data has been collected according to field survey in order to estimate the traffic elements in the study area included, traffic flow, speed and density as well as roadway characteristics such as number of lanes, lane width, type and width of median. Mechanical count method (video camera) used for this purpose, located to identification number of vehicles that passes 100 m section length, during time period, meanwhile the space mean speed (V_S), conducted according to vehicle individual that pass the section length and time period by

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Table 1: Vehicle classification during peak hour period (In front of university of Babylon gate)

Time	Pc	B	T	Total	Hv (%)	Density (veh./km)	Speed (km/h)
7:45-8:00	472	51	80	603	22	33.33	51.65
8:00-8:15	393	32	74	499	21.24	22.77	68.09
8:15-8:30	296	22	66	384	23	19.09	75.70
8:30-8:45	268	18	63	349	24	10.99	78.98

PC = Passenger Car; B = Bus; T = Truck; HV% = Percentage of Heavy Vehicles

50 observation each 5 min. Speed is one of the most important traffic operation. Its measurement is a frequent necessary in traffic engineering studies. According to the observation of running time of different type of vehicles which are traversing a section length of study area space mean speed was calculated by using the following Eq. 3:

$$SMS = \frac{D}{\frac{t_i}{n}} \quad (1)$$

Where:

SMS = Space Mean Speed (m/sec)
t_i = Travel time or running time (sec)
D = Section length of observation (m)

then convert (m/sec) to (km/h)

Data was collected during Peak Hour Volume (PHV). Two sections were selected to collect traffic elements, the selection of this site is based on the following reasons:

- The variation of traffic volume elements
- Availability of the best required conditions for study data collection and measuring
- The pavement surface condition
- Level, straight and midblock location

There was no shielding to reduce the number of variables that might affect accuracy of the field data collection. Field measurement of traffic density is one of the purposes of this research, the measurement has been done along significant section and then more than 50 random of observation different types of vehicles each 5 min was recorded. Density was determined using the following Eq. 2:

$$\text{Density} = \frac{\text{No. of vehicles occuping at any time period}}{\text{Distance (m)}} \quad (2)$$

However, density can be determined from space mean speed and traffic flow as following:

$$K = \frac{q}{V_s} \quad (3)$$

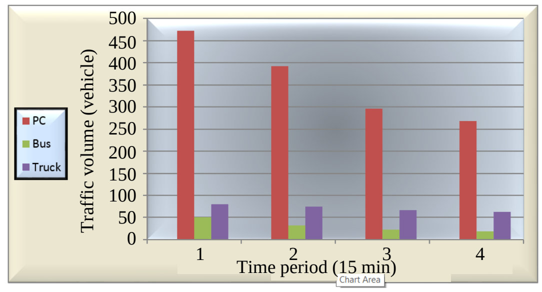

Fig. 1: Variation of traffic flow during peak hour period (In front of university of Babylon gate)

Where:

K = Density (veh/km/ln)
q = Traffic flow (veh/h)
V_S = Space mean speed (km/h)

Data was represented in Table 1 and Fig. 1.

RESULTS AND DISCUSSION

Speed-density model: As shown in Fig. 2-8 and Table 2, it was clear that the traffic volumes are at their peak in the first quarter of peak hour, therefore the behavior of space mean speed (V_s) and density (K) as following when:

- K = 0
- V_s = 95.962 km/h

When: $V_s = 0$; $K = K_j$

K_j = the density at which the speed = 0 and the flow is equal to zero too, so, the vehicles in the highway section completely stop. According to statistical model which is describe the speed density relationship, the coefficient of determination (R^2) indicates, the independent variable (K), may select a rate of (0.9326%) from the total variation in the depended variable (V_s) while the coefficient of correlation (r) illustrates good relationship between variables which is demonstrated by the value of (r = 0.965).

Mathematical model

Speed-density relationship: According to Green Shield Model:

Table 2: Speed-density model due to regression analysis (In front of university of Babylon gate) section

Dependent variable	Independent variable	R^2	r	Relation type	Equation
Space mean speed (V_s)	Density (K)	0.9326	0.965	Linear	$V_s = 95.962-1.2698*K$
		0.8190	0.904	Log	$V_s = 140.23-23.92\ln.K$
		0.7890	0.888	Power	$V_s = 203.86K^{-0.368}$
		0.9153	0.956	Exponential	$V_s = 103.55.e^{-0.02k}$

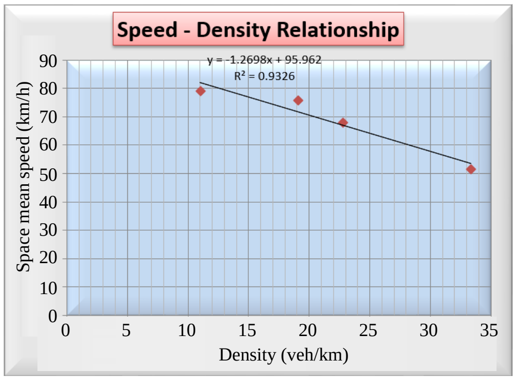

Fig. 2: Speed density relationship according to linear equation (In front of university of Babylon gate)

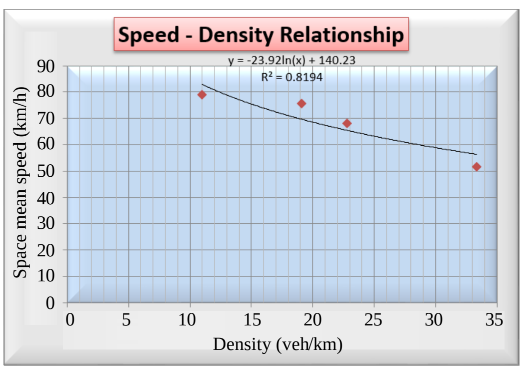

Fig. 3: Speed density relationship according to log. equation (In front of university of Babylon gate)

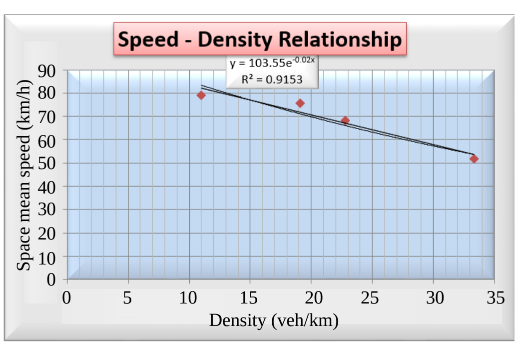

Fig. 4: Speed density relationship according to exponential equation (In front of university of Babylon gate)

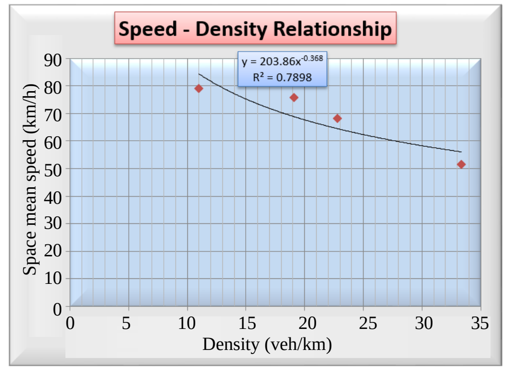

Fig. 5: Speed density relationship according to power equation (In front of university of Babylon gate)

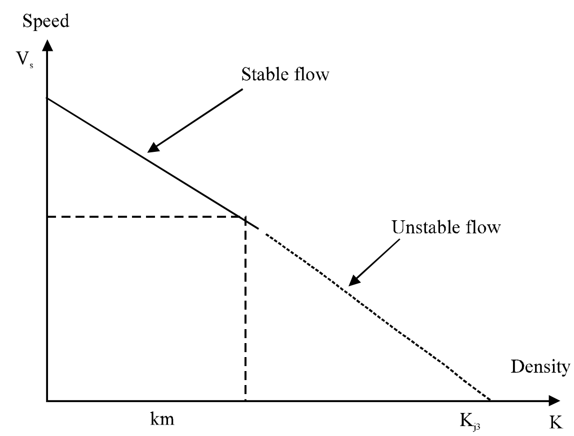

Fig. 6: Speed-density relationship in study area

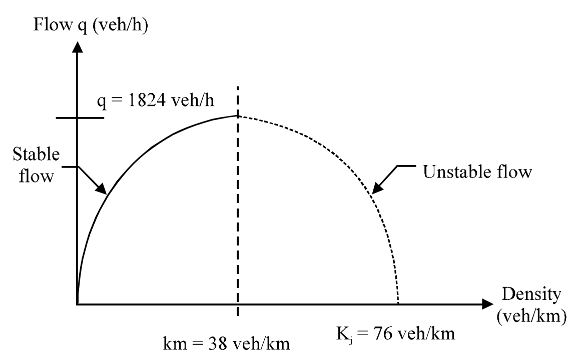

Fig. 7: Flow-density relationship in the study area

$$V_S = V_f - \frac{V_f}{K_j}.K$$

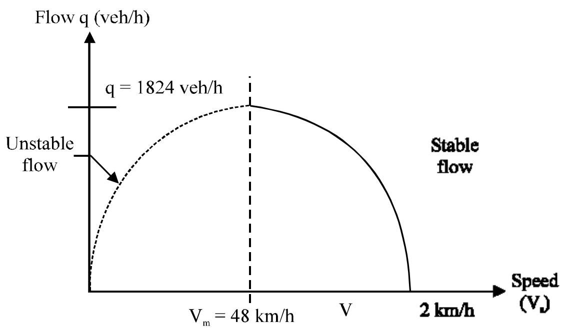

Fig. 8: Flow-speed relationship in the study area

Where:
V_S = Space mean speed (km/h)
V_f = Free flow speed (km/h)
K = Density (veh/km)

From Table 2 and Fig. 2; $V_S = 95.962\text{-}1.2698*K$:

$$V_f = 95.962 \text{ km/h}$$

$$\frac{V_f}{K_j} = 1.2698$$

$$V_s K = K_j\left(V_S - \frac{V_s^2}{V_f}\right) \quad K_j = 76 \text{ veh/km}$$

Flow-density relationship:

$$V_S = V_f - \frac{V_f}{K_j}.K$$

$$V_S = V_f\left(1 - \frac{K}{K_j}\right)$$

Multiply by K:

$$V_s.K = V_f\left(K - \frac{K^2}{K_j}\right)$$

$$q = V_f\left(K - \frac{K^2}{K_j}\right)$$

$$\frac{dq}{dk} = V_f\left(1 - \frac{2K}{K_j}\right)$$

@ Max. flow: dq/dk = 0

$$0 = V_f\left(1 - \frac{2K}{K_j}\right)$$

Since:
V_f = 0
$1\text{-}2K/K_j$ = 0

@ Max. Flow, = K_m:

$$K_m = \frac{K_j}{2}$$

$$K_m = \frac{K_j}{2}$$

K_m = 38 veh/km:

$$q = V_f.K - \frac{V_f}{K_j}.K^2$$

Where:
q = $95.962*K\text{-}1.2698*K^2$
K_m = Max. density in the stable flow (veh/km)

Flow-speed model:

$$V_S = V_f\left(1 - \frac{K}{K_j}\right)$$

$$K = K_j\left(1 - \frac{V_S}{V_f}\right)$$

$$V_S.K = K_j\left(V_S - \frac{V_s^2}{V_f}\right)$$

$q = V_s.K$:

$$q = K_j\left(V_S - \frac{V_s^2}{V_f}\right)$$

$$\frac{dq}{dV_S} = K_j\left(1 - \frac{2V_S}{V_f}\right)$$

@ Max. flow:
dq/dV_s = 0
V = V_m
V_s = 0
K_j = 0

Thus:

$$1 - \frac{2V_s}{V_f} = 0$$

$$V_m = \frac{V_f}{2} = \frac{95.962}{2}$$

$$V_m = 48 \text{ km/h}$$

$$q_{max.} = \frac{V_f}{2} * \frac{K_j}{2}$$

$$q_{max.} = V_m * k_m$$

$$q_{max.} = 48*38$$

$$q_{max.} = 1824 \text{ veh/h}$$

$$q = 96*V_s - 1.2698*V_s^2$$

Where:

V_m = Max. speed in the stable flow (km/h)
$q_{max.}$ = Max. flow in the stable flow (veh/h)

Thus, the same method followed in the second section of highway in the study area.

CONCLUSION

The best fitting and the most significant model that explained the speed density relationship for the roadway section is a linear model like (Green Shield) Model. This represents appropriate and flexible application model.

The linear formula (V_s = 95.962-1.2698*K), show the better correlation between traffic elements in the study area according to regression analysis due to coefficient of correlation (r = 0.9657) when comparing the model with other equations such as log, power and exponential.

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Data collection and analysis has been represents that as the speed decreases the traffic density (K) increases and traffic flow change from stable to unstable flow meanwhile the density change from (K_m) to jam density (K_j) which it is equal (76) veh/km/ln.

Through observations and data analysis, it was found that the vehicles appear at speed higher than those that have been deduced in Paragraph 3, resulting in many traffic accidents, especially, type (vehicle/pedestrian), this required efforts, studies, activate low and regulations as well as furnishing the roadway section with signs and signal in order to provide safe movement and crossing for pedestrians and road user.

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