Figure (5): On site picture for Mohmad Al-Qasim highway showing the gap acceptance process between two adjacent lanes.

Figure (6): On site picture for Mohmad Al-Qasim highway showing the gap acceptance process for on ramp vehicle to the second lane directly.

For this purpose the Real Player Time Recorder software, is used. A virtual line was fixed on the monitor to locate the position of the rear bumper of the leader vehicle. The location of this line on the monitor is varied for each time depending on the new position for the selected vehicles. The time needed for the front bumper of the follower vehicle to reach this position represents the acceptable gap. This method is repeated for each successive event try to perform lane change process during the tested session. Because in a weaving maneuver it is important to ensure that the crossing streams can find a sufficient number of acceptable gaps within the opposing stream and can do without being delayed or stopped, the possible observed gap or lag is only the accepted one. Gap acceptance results for all observed cases are shown in the Table (2) in a frequency form.

Gap Acceptance Data Analysis and Results

Following the abstraction, the data were analyzed statistically to calculate the mean, standard deviation, maximum and the minimum values. These are descriptive statistical quantities. In addition to that the mathematical distribution is determined, which can be used to represent the observed data. The observed frequencies are presented in the form of a histogram as shown in Figure (7).

The observed data are assumed to follow normal distribution. This is to be expected in any action that is dependent on human reaction. The parameters of the normal distribution were calculated using the method of transformation of cumulative normal distribution to linear relationship using the probit method of analysis. The calculated probit values were regressed against the class width. Linear regression is used to find the best fit line which represents the data.

The coefficients of the linear regression model are presented in equation below.

$$Y=0.501\ X\ +2.438$$

This equation is used to calculate the mean and standard deviation of the normal distribution. Setting Y equal to 5 results in X value, which represent the mean. The reciprocal of the coefficient of X result in the standard deviation of the normal distribution. Their values are presented in Table (3). The method is represented graphically in Figure (8).

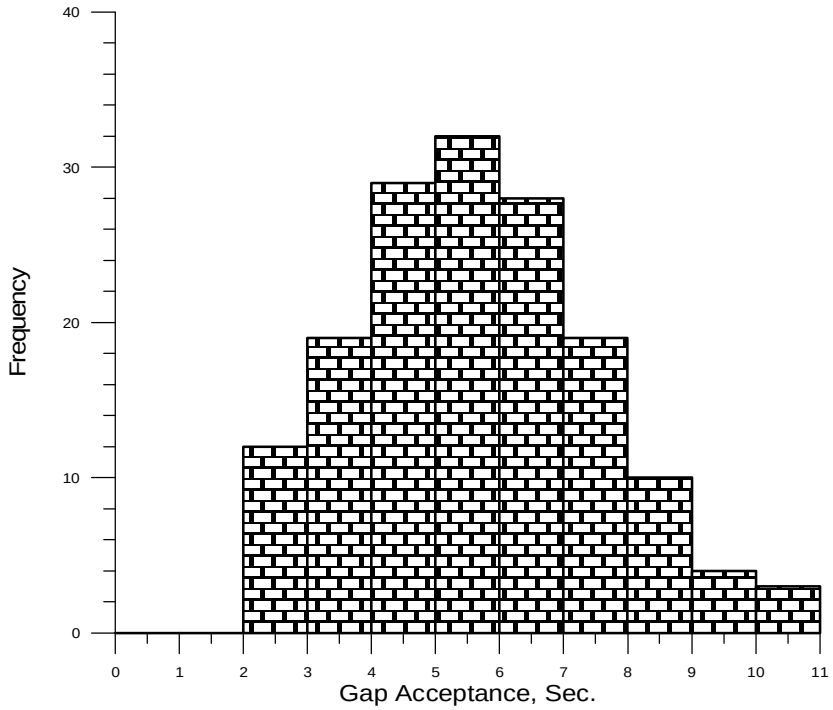

Figure 7: Observed distribution of vehicular acceptable gap data

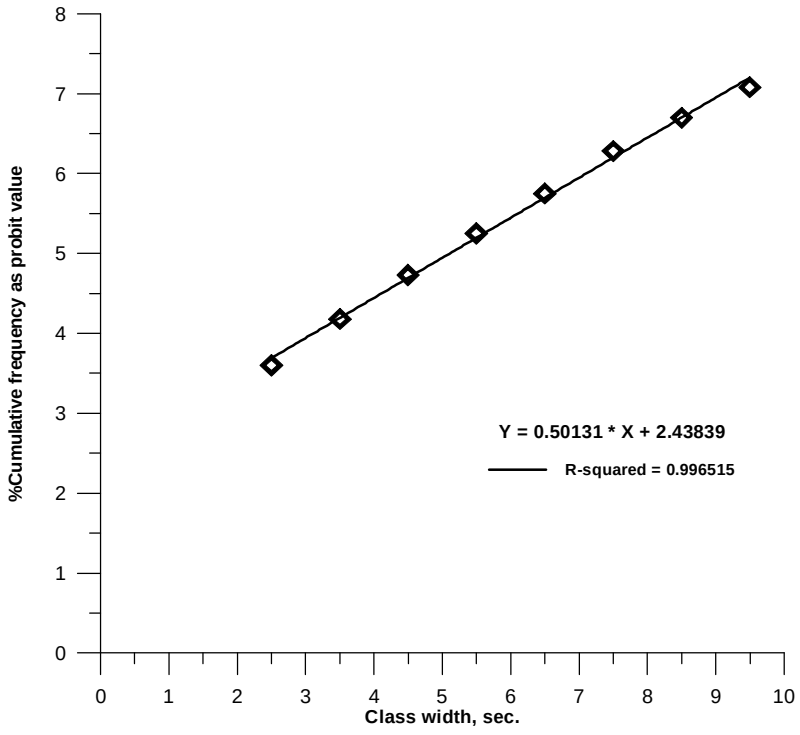

Figure 8; Transformation of cumulative normal distribution of observed acceptable gap data to linear relationship using probit method

Table (2): Statistical test results of observed acceptable gap distribution

lass width Sec.	Observed Frequency	Theoretical Frequency
1	0	2.80
2	12	5.77
3	19	15.28
4	29	20.59
5	32	29.49
6	28	30.10
7	19	24.33
8	10	15.44
9	4	7.33
10	3	2.96
Calculated chi-square value =10.19 Tabulated chi-square value (5%) =11.1 Degree of freedom=5		

The Chi-square test was used to test the validity of the assumption that the observed data follows the normal distribution. Theoretical frequencies were calculated and presented in Table (2). The Table contains also results of the Chi-square test performed. At the 5% level of significance and at (5) degrees of freedom the tabulated value of 11.1 was higher than the calculated value of 10.19. This has the implication that there is no reason to reject the hypothesis that the observed data may be represented by a normal distribution with mean and standard deviation of 5.11 and 1.99 seconds respectively.

Table (3): Results of statistical analysis of observed gap acceptance

Function, Sec	Average for all values, Sec.
Mean	5.11
Standard deviation	1.99
Max. value	10
Min. value	2.0

Determination of Critical Gap

HCM2000 defines the critical gap as the "minimum time interval acceptable to a minor street driver executing a maneuver". The critical gap is defined as the minimum gap in the major traffic stream needed by a minor stream vehicle to merge into or travel through the major stream gap [7].

According to the above two definitions, the concluded critical gap for this research is (2.0 seconds), which is the minimum observed value. These definitions may seem simple but are vague and difficult to apply in practice. The critical gap values measured by different people may be inconsistent. It is generally assumed in gap acceptance theory that drivers are both consistent and homogenous. Where gap size is likely to depend on many factors as described above, therefore, this assumption is not entirely correct. The 1985 and 1994 HCM contained different critical gap values which recognize the effects of turning movement, speed, and number of lanes on major roadway.

Gerlough, et. al., [10] stated that the probit analysis is a statistical technique used to treat the percentages of a population making all-or-nothing (binomial) responses to increasingly severe values of a stimulus. In the context of gap acceptance studies, the value of stimulus is the size of gap. This allows the plotting of data based on the transformation of the percentage of acceptance and gap size. A fitted linear line can then be plotted on the chart to identify the value of gap that produces probit of 5.0. This value is considered as the median value of the stimulus, i. e., the critical gap.

Regarding the probit technique which is used to determine the mean and standard deviation of the observed gap acceptance data, the value that produce probit of 5.0 is 5.11 seconds. This critical gap value may be consistent with the critical gap definition according to Miller. Miller [11] define the critical gaps are

those gaps that 50% of people will accept, or the median of the gap acceptance distribution.

Results Discussion and Conclusion

1. The observed acceptable gap distribution for the traffic flow in the highway merging area was found to follow the normal distribution. This result is consistent with other studies and to be expected in any action that is dependent on human reaction.

2. The observed minimum acceptable gap was 2.0 seconds. However, it is likely that the minimum acceptable gap size is related both to the geometric of the highway and the weaving section length in addition to the factors listed herein above which affect on its size. The observed short lag size is due to the queue of vehicles trying to make lane change and in this case the follow up time can be seen.

3. The observed average mean gap value was agreed reasonably well with that observed elsewhere. Their average value was 5.11 seconds with a standard deviation of 1.99.

4. The critical gap for the observed data may be considered 5.11 seconds. This is according to the definitions which consider the critical gap is the median of the observed acceptable gaps.

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