Evaluation of Road Networks Based on Traffic Accidents in Erbil City

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Abstract. The traffic accidents threatens humans live and its increases during the time. For this reason, this paper tries to analysis the traffic accidents by assessment of accident situations. Also, study the effect of road design elements and regulations coincide with case study in two methods applied first the five parameters individually tested. Then effective parameters tested together, correlation between accidents and the parameter, the roads and streets must design carefully and according to specifications and criteria. In this paper trying to indicate the weak points of road network and fixing this points to avoid them in the future. The ring road have a negative aspect because it extends the path and collecting local roads more than the straight paths. Also, restriction of sight distance occurs, the topographic of Erbil city is helpful in avoiding vertical curves, but the horizontal curves presented with concentric ring roads.

Keywords: Traffic Accident, Intersection, Criteria

1. Introduction
The road network as well as the human factor and vehicle effecting at the traffic accidents so in this study applied to analysis road design elements and find the correlations between this elements and the number of accidents in the intersection is the area where two or more streets join or cross at-grade. The Pedestrians crossings and motor vehicles and bicycles turning and crossing movements are typically concentrated at intersections. The planning of traffic must be before the implementation of blocks and buildings and unique plan excluded the conflict of deferent local plans when this face together. The road design contains a lot of elements and details, many of them excludes the vehicle characteristics, like volume, friction factor of tires, speed, weight etc. This study tries to improve the planning and road, street designs in the near future plan.

2. Case Study
Erbil city location is between longitude E 43° 57' 00" to 44° 3' 37" E, Latitude N 36° 8' 00" to N 36° 14' 40". It’s an old city it is the capital of Kurdistan region and have a rapid growth and development in last 20 years, the road planning was not developed due to this abnormal growth and implemented not depending on sustainable plans. Therefore, there is many traffic problem in the city and road network in Erbil city is at generally two types radial and concentric ring roads.
2.1. Traffic Accidents
Traffic accidents have three main resources 1- The Human 2- The Vehicle 3- The road conditions. This study searches only the road and street effects on traffic accidents. Inside Erbil city the statistics of five years obtained (Source: the Directory of Erbil Traffic/Statistics Department year 2018) and arranged the data that belongs to this study in the following table 1.
Table 1. Traffic accidents for five years (2014-2018) [2]

| Month | 2014 | 2015 | 2016 | 2017 | 2018 |
|-------|------|------|------|------|------|
| 1     | 59   | 39   | 50   | 30   | 55   |
| 2     | 48   | 43   | 42   | 47   | 45   |
| 3     | 35   | 61   | 43   | 44   | 69   |
| 4     | 37   | 63   | 41   | 53   | 40   |
| 5     | 35   | 61   | 56   | 33   | 42   |
| 6     | 35   | 53   | 76   | 42   | 40   |
| 7     | 36   | 55   | 43   | 45   | 46   |
| 8     | 34   | 44   | 49   | 41   | 60   |
| 9     | 37   | 44   | 29   | 62   | 50   |
| 10    | 48   | 43   | 57   | 48   | 41   |
| 11    | 39   | 41   | 56   | 47   | 44   |
| 12    | 51   | 46   | 42   | 33   | 40   |
| Average | 41.2 | 49.4 | 48.7 | 43.8 | 47.7 |
| Total  | 494  | 593  | 584  | 525  | 572  |

Average number of accidents monthly=46.2, Total number of accidents =2768

For this study noted that the determination of accident location is for three last years (2016,2017,2018) and this determination is approximately not exactly. Then arranged the space and the number of accidents in a new table. For the study purpose selected the locations with the maximum number of accidents, noted the intersections have the maximum events and there are 14 intersection inside the city they are between the radial and rig roads, more critical than others, and this intersections and number of accidents are as in the following table:

Table 2. Case Study, intersection area accidents for years (2016-2017-2018) [2]

| No. | Intersection Location   | Type of Intersection     | No. of Accidents |
|-----|-------------------------|--------------------------|------------------|
| 1   | 40 m -Shorsh             | Signalized T Shape       | 13               |
| 2   | 60 m-Shorsh              | Signalized Overpass      | 10               |
| 3   | 60 m- Bahrka             | T Shape                  | 11               |
| 4   | 60 m -Alban              | Signalized Crossroads    | 10               |
| 5   | 60 m- Mosul              | Signalized T Shape       | 15               |
| 6   | 100 m -Makhmor           | Signalized Crossroads    | 15               |
| 7   | 100m -Kirkuk             | Signalized Overpass -Underpass | 17               |
| 8   | 100m -Akar Fuel Station  | Signalized Crossroads    | 10               |
| 9   | 100 m -Badawa police Center | T Shape               | 33               |
| 10  | 100m- -Rigary hospital    | Interchange              | 13               |
| 11  | 100m – Permam            | Underpass                | 26               |
| 12  | 100m- Airport            | Signalized Crossroads    | 12               |
| 13  | 100 m – MRF flats        | T Shape                  | 10               |
| 14  | 100m- Musol              | Signalized Underpass     | 12               |
2.2. Practical Part

For this study, a surveying for checking the distances, block dimensions, and road width for the critical needed space are done. For traffic flow in narrow streets and roads, the flow of vehicles especially during the peak hour (7-9 AM) and data of average flow of roads taken from traffic directory. For any intersection of 14 taken the data of only the required critical road for comparing with criteria. These places selected depending on the study radius of turning curve. The flow range of vehicles in bottlenecks (flow) measured and these dimensions checked with an update map (Source: Directory of Erbil Municipality and Directory of Urban planning).

3. Methodology

For analysis and find the probability parameters effecting at the accident, five selected parameters were applied after the field survey and interviews with related authorities and the experience certainly with the theoretically concepts also help the idea of the choosing and summarizing the parameters to five elements they are:

1- Radius of Turning in Intersections
2- The spacing between driveway and intersections
3- The Flow of vehicle per road width
4- The minimum block width adjacent to the major road (clearance from access way to the major road)
5- Have service roads in two lanes

(Source: Policy of the geometric design of streets and highways, AASHTO, 2014)

1- The radius of turning computed from formula

\[ R = \frac{v^2}{15 (0.01 E + F)} \]  

(1)

R= Radius of centerline turning curve
V= Speed (Velocity) in miles per hour (mph)
E= Super – elevation, this assumed to be zero in urban condition
F = Side friction factor
In case study we have two fixed speeds 60 Km/h internal the 100 m ring road, its equals 37 mph, and 80 Km/h equal to 49 mph.

For 60 Km/h \[ R = \frac{(60)^2}{15 (0.01 (0)+37)} = 6.5 \text{ ft} = 1.9812 \text{ m} \] (2)

For 80 Km/h \[ R = \frac{(80)^2}{15 (0.01 (0)+49)} = 8.7 \text{ ft} = 2.6518 \text{ m} \] (3)

2- The Spacing of local road from intersection depended 90 m
3- The Average flow of vehicles per minute, depend on passenger car per hour per lane its 800-1000, because the lane and road width s in critical access haven’t a unique width in case study depended on average 15 vehicle per minute per lane as standard.
4- The minimum block width adjacent major road, also it is the spacing between the intersection and the local road r clearances of access depending on 75 m. for 60 km/h road, and 100 m for 100km/h road.
5- The service road is necessary created in major roads and highways in both directions .here comparing the case study all roads must have service roads.

Table 3. The Parameters of case study compared with the standard, Source: Researcher’s work

| No. | Location          | R as built m | R standard m | D1 | Spacing As built m | Spacing Standard d m | D2 | P/m/ L As built | P/m/ L Standard |
|-----|------------------|--------------|--------------|----|-------------------|----------------------|----|----------------|-----------------|
| 1   | 40 m - Shorsh     | 3.5          | 6.5          | 3  | 45                | 60                    | 15 | 15            | 15              |
| 2   | 60 m - Shorsh     | 4.4          | 6.5          | 2.1| 51                | 60                    | 9  | 16            | 15              |
| 3   | 60 m - Bahrka     | 4            | 6.5          | 2.5| 45                | 60                    | 15 | 15            | 15              |
| 4   | 60 m - Alabn      | 4.5          | 6.5          | 2  | 52                | 60                    | 8  | 16            | 15              |
| 5   | 60 m - Mosul      | 3.5          | 6.5          | 3  | 43                | 60                    | 17 | 15            | 15              |
| 6   | 100 m - Makhmor   | 5.6          | 8.7          | 3.1| 53                | 80                    | 27 | 17            | 15              |
| 7   | 100 m - Kirkuk    | 5.4          | 8.7          | 3.3| 62                | 80                    | 18 | 17            | 15              |
| 8   | 100 m - Akar      | 7.5          | 8.7          | 1.2| 54                | 80                    | 26 | 17            | 15              |
| 9   | 100 m - Badawa police Center | 2.7 | 8.7 | 3.8 | 72 | 80 | 8 | 17 | 15 |
| 10  | 100 m - Rigary hospital | 5.7 | 8.7 | 3 | 65 | 80 | 15 | 17 | 15 |
| 11  | 100 m - Permam    | 5.3          | 8.7          | 3.4| 75                | 80                    | 5  | 18            | 15              |
| 12  | 100 m - Airport   | 6            | 8.7          | 2.7| 77                | 80                    | 3  | 16            | 15              |
| 13  | 100 m - MRF flats | 6.9          | 8.7          | 1.8| 66                | 80                    | 14 | 16            | 15              |
| 14  | 100 m - Musol     | 5.9          | 8.7          | 2.8| 65                | 80                    | 15 | 16            | 15              |
Table 4. The parameter of case study compared with the standard, Source: Researcher’s work

| No. | Location          | Block depth As built m | Block depth Standard m | D4 As built | Service Standard D4 | D5 |
|-----|-------------------|-------------------------|-------------------------|-------------|----------------------|----|
| 1   | 40 m -Shorsh      | 60                      | 75                      | 15          | 4                    | 4  |
| 2   | 60 m-Shorsh       | 60                      | 75                      | 15          | 4                    | 3  |
| 3   | 60 m- Bahrka      | 60                      | 75                      | 15          | 0                    | 4  |
| 4   | 60 m -Alban       | 60                      | 75                      | 15          | 0                    | 4  |
| 5   | 60 m -Mosul       | 60                      | 75                      | 15          | 0                    | 4  |
| 6   | 100m Makhmor      | 80                      | 100                     | 20          | 1                    | 4  |
| 7   | 100m -Kirkuk      | 85                      | 100                     | 20          | 1                    | 4  |
| 8   | 100m -Akar Fuel Station | 80                  | 100                     | 15          | 0                    | 4  |
| 9   | 100 m -Badawa police Center | 85              | 100                     | 20          | 0                    | 4  |
| 10  | 100m -Rigary hospital | 85                      | 100                     | 15          | 0                    | 4  |
| 11  | 100m – Permam     | 80                      | 100                     | 20          | 0                    | 4  |
| 12  | 100m- Airport     | 85                      | 100                     | 15          | 0                    | 4  |
| 13  | 100 m – MRF flats | 85                      | 100                     | 15          | 1                    | 4  |
| 14  | 100m- Musol       | 85                      | 100                     | 15          | 1                    | 4  |

To know the correlation between any of the parameters separately because there isn’t any links between this parameters and accidents applied Spearman rule (Chi square )

\[
r = \frac{n\sum(xy) - (\sum x)(\sum y)}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}
\]

and a arranged in a new table.

Table 5. data of case study compared with the standard in the table, Source: Researcher’s work

| No. | Location          | D1 | D2 | D3 | D4 | D5 | No. of Accidents |
|-----|-------------------|----|----|----|----|----|------------------|
| 1   | 40 m -Shorsh      | 3  | 45 | 31 | 15 | 4  | 13               |
| 2   | 60 m-Shorsh       | 2.1| 38 | 30 | 15 | 3  | 10               |
| 3   | 60 m- Bahrka      | 2.5| 38 | 32 | 15 | 4  | 11               |
| 4   | 60 m -Alban       | 2  | 36 | 28 | 15 | 4  | 10               |
| 5   | 60 m -Mosul       | 3  | 47 | 32 | 15 | 4  | 15               |
| 6   | 100m Makhmor      | 3.1| 48 | 32 | 20 | 3  | 15               |
| 7   | 100m -Kirkuk      | 3.3| 50 | 33 | 20 | 3  | 17               |
| 8   | 100m -Akar Fuel Station | 1.2  | 35 | 27 | 15 | 4  | 10               |
| 9   | 100 m -Badawa police Center | 3.8 | 56 | 37 | 20 | 4  | 33               |
| 10  | 100m -Rigary hospital | 3  | 41 | 30 | 15 | 4  | 13               |
| 11  | 100m – Permam     | 3.4| 54 | 35 | 20 | 4  | 26               |
| 12  | 100m- Airport     | 2.7| 41 | 31 | 15 | 4  | 12               |
| 13  | 100 m – MRF flats | 1.8| 34 | 26 | 15 | 3  | 10               |
| 14  | 100m- Musol       | 2.8| 42 | 29 | 15 | 3  | 12               |
Table 6. Correlation factor (r) between parameters and No. of Accidents, Source: Researcher’s work

| No. | Parameter                                           | R     |
|-----|-----------------------------------------------------|-------|
| 1   | Radius of Turning in Intersections                  | 0.73  |
| 2   | The spacing between driveway and intersections      | 0.13  |
| 3   | The Flow of vehicle per hour per lane               | 0.61  |
| 4   | The clearance from access way to the major road     | 0.77  |
| 5   | The U turn spacing from the intersection            | 0.23  |

Figure 4. Spacing between local road and Signalized Intersection

From the results we find that D1 which is the Standard Radius for turning right side in intersections the correlation factor r was 0.73 that means there is an influence of radius of turning at accidents. For vehicles per hour per lane D3 seen the correlation factor is 0.61 that mean have less effect on the accidents. Correlation for the block depth D4 which means the distance from the crossroads inter the local road with major road is 0.77 also have a strong effect on the accidents. The minimum spacing of local road or driveway from intersection D2 and U turn D5 spacing from intersections there is a week correlation 0.13 and 0.23 therefore there is no effect of these two parameters on accidents.

4. Combined parameters

In this method applied to choose three effective parameters together combined area inter the intersection zone contains more than one effected parameters, and computed the shortage area in any intersection using G.I.S version 10.4.1 to find the deference area between the as built and the theorical standards. Then applying the correlation test of these areas with the numbers of accidents to find the probability of effective on the problem.

The Shortage area = The standard area – The as built area (Table7)
Table 7. Intersections and shortage area and No. of accidents, Source: Researcher’s work

| No. | Intersection               | As built block area m² | Standard Block area m² | The Shortage area m² | No. of Accidents |
|-----|---------------------------|------------------------|------------------------|----------------------|------------------|
| 1   | 40 m -Shorsh              | 6153                   | 7709                   | 1556                 | 13               |
| 2   | 60 m-Shorsh               | 5025                   | 6562                   | 1537                 | 10               |
| 3   | 60 m- Bahrka              | 1108                   | 2418                   | 1310                 | 11               |
| 4   | 60 m -Alban               | 1577                   | 2692                   | 1115                 | 10               |
| 5   | 60 m- Mosul               | 575                    | 2502                   | 1927                 | 15               |
| 6   | 100m Makhmor              | 4618                   | 6532                   | 1914                 | 15               |
| 7   | 100m -Kirkuk              | 1764                   | 3480                   | 1716                 | 17               |
| 8   | 100m -Akar Fuel Station   | 1900                   | 2772                   | 872                  | 10               |
| 9   | 100 m -Badawa police Center | 5087               | 7540                   | 2453                 | 33               |
| 10  | 100m- -Rzgary Hospital    | 3580                   | 5069                   | 1489                 | 13               |
| 11  | 100m – Permam             | 2308                   | 4535                   | 2227                 | 26               |
| 12  | 100m- Airport             | 3375                   | 4436                   | 1061                 | 12               |
| 13  | 100 m – MRF flats         | 684                    | 1682                   | 998                  | 10               |
| 14  | 100m- Musol               | 1852                   | 3071                   | 1219                 | 12               |

After applying the chi square between the shortage area and number of accidents appear there is a strong correlation between these two variables $r = 0.86$. Therefore, the combined parameters effecting more than the separate effect of each of them.

The Figures of (14) Intersections and critical spaces according to the Spatial Analysis

60 m Shorsh overpass
40 m Shorsh T shape intersection
5. Conclusion

There isn't a sustainable plan to implement the roads, the turning curve inert the intersection due to bottleneck. There isn't enough cooperation between the municipality directory and traffic directory to overcome this problem by a participating committee. There isn't any planning for parking in crowded heavy traffic areas and there are attractive buildings and compasses don’t have enough withdrawal from the highway or major street. The overpass and under pass and other interchanges executed only in one direction and no regarded the turning curve between the other crossroad and changed road actually not to design before the road constructions they are made later to overcome the conflicts and not.

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