Safety Issues and Geometric Design of Highway

(Case Study along Coastal Road West of Tripoli)

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Abstract

This study examine the availability of safety issues and their relationship to the existing geometric design at a segment along a coastal road west of Tripoli were the high number of fatalities has been registered. Many victims of road accidents at the area were reported on this road segment. Even more; the polis employee and residents around the area call this position as" **turning point of death**".

The study area used in this investigation located at rural arterial coastal road about 9.50 Km west of Sabratah City, in other way, it's a superimposing curve (horizontal tangent with a crest vertical curve (Three dimensional alignments).

The numbers of road traffic accidents and casualties were obtained from the office of the Libyan Directorate General of Traffic based in Tripoli.

Survey work has established for this segment and then examined using AutoCAD Civil3d 2012 software. And compare the results with the standards using AASHTO standard as a reference.

The overall results indicated that there is need to reconstruct and replace the segment according to the modern geometric design were the safety factors are taking at the highest priority.

1. Introduction

Today, many cities in the world are facing serious land transport challenges. Increasing traffic congestion has brought with it environmental, social and economic implications. With the proportion of the world's population residing in urban areas projected to increase to more than two-thirds over the next 20 years or so, and with rising car ownership, more cities will find themselves facing the potentially crippling problems of vehicles accidents. Many major cities/Roads in Libya such as Tripoli, Benghazi, Zawia/Coastal road and others are currently facing serious accidents problems as other big cities of the world.

Road accidents claim the lives of 3.1 million people every year and cause injury or disability some 50 million others (Donald Graham, 2012). The incidents leading cause of death among the age group 10 years - 24 years. The majority of these fatalities occur in developing countries.

Libya is considered one of the most suffered country concerning deaths from road accidents where based on the data collected by traffic departments, it can be said that about 40.50 for every 100 thousand inhabitants.

As an example the statistics during the year 2009 indicated that the number of incidents in Libya recorded amounted to (13357) accident, led to the death "16057 "persons (Donald Graham, 2012) .

Each of those people has a network of family, friends, neighbors, colleagues or classmates who are also affected, emotionally and otherwise. Families struggle with poverty when they lose a breadwinner or have the added expense of caring for disabled family members.

The social and economic cost of these accidents is also so high that it would be sufficient to buy the world total production of cereals each year! Furthermore, the number of accidents is in constant increase throughout the world. Although traffic accidents on congested freeways do not usually result in fatal or even very severe injuries, they are responsible for a substantial fraction of the unpredictable delays many of us now regard as unavoidable aspects of urban life. Frequently, such accidents occur when a platoon of vehicles successively brakes and the braking deceleration of at least one vehicle is not sufficient to prevent it from colliding with the vehicle ahead. Reducing the frequency of such collisions, for example by improving the competency of drivers or deploying in-vehicle collision-avoidance technology, could help reduce travel delays without resorting to expensive additions to highway capacity.

Traffic incidents such as stalled vehicles, construction and maintenance activities, adverse weather conditions, or special events such as parades, sporting events, tourist attractions are obstructions or restrictions to the traffic flow

Hypothesis of the study is to examine the availability of safety issues and their relationship to the existing geometric design; this will be carried out through the study of cases along the Highway (west of Tripoli where a large number of accidents have been reported). One of these segments along coastal road west of Tripoli is a location were high number of fatalities are registered, this location at 9.5 KM west of Sabratah City , I was one the suffered people how they lost my brother at the same location.

1.1 Problem statement of study segment

Many victims of road accidents at the area were registered on this road segment. Even more; the police employees and residents around, call this position as" **turning point of death**", although ; according to testimony of the residents that they knew some victim or relative to one of them has known with their wisely behavior and good followers of traffic law.

2. Experimental procedures

In order to demonstrate the application of the study methodology to address the study objectives, databases were collected for the study area of the highways segment. The database was developed from a number separate datasets – the Roadway Inventory Dataset, Route Alignment Dataset, Libyan Crash Dataset, and the Road Sections Dataset, Fig 1 illustrates the relationships between the various components of the database.

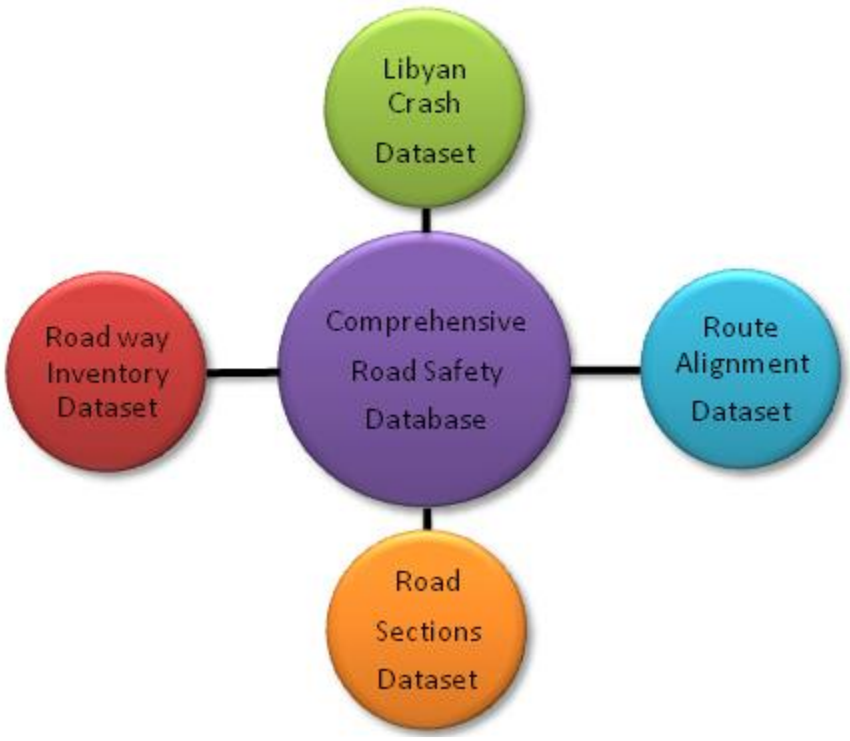

Figure 1 Components of the Comprehensive Road Safety Database

Based on the data collected for the study area the following sequence of activities for identifying the relationship between the existing geometric design and safety aspects, as shown in Fig 2.

Figure 2. Sequence of Activities for Identification of Countermeasures for the study area

2.1 The Libyan crash dataset

Due to the lake of information from the relevant authorities, the crash data maintained by the traffic administration, the Libyan crash database served as the source for crash data. This dataset contains 12 fields along the coastal road west of Tripoli, which providedas a black spots, but it has not provide the comprehensive information of each crash recorded. Each record in the dataset represents crash information such as the crash location (route, township or city), injured or fatal persons, crash severity and pattern, and the primary cause of the crash. The crash database is based on data received annually from the Libyan State Police. For the present study, fig 3 shown black spots along the coastal road west of Tripoli as presented by the police authority.

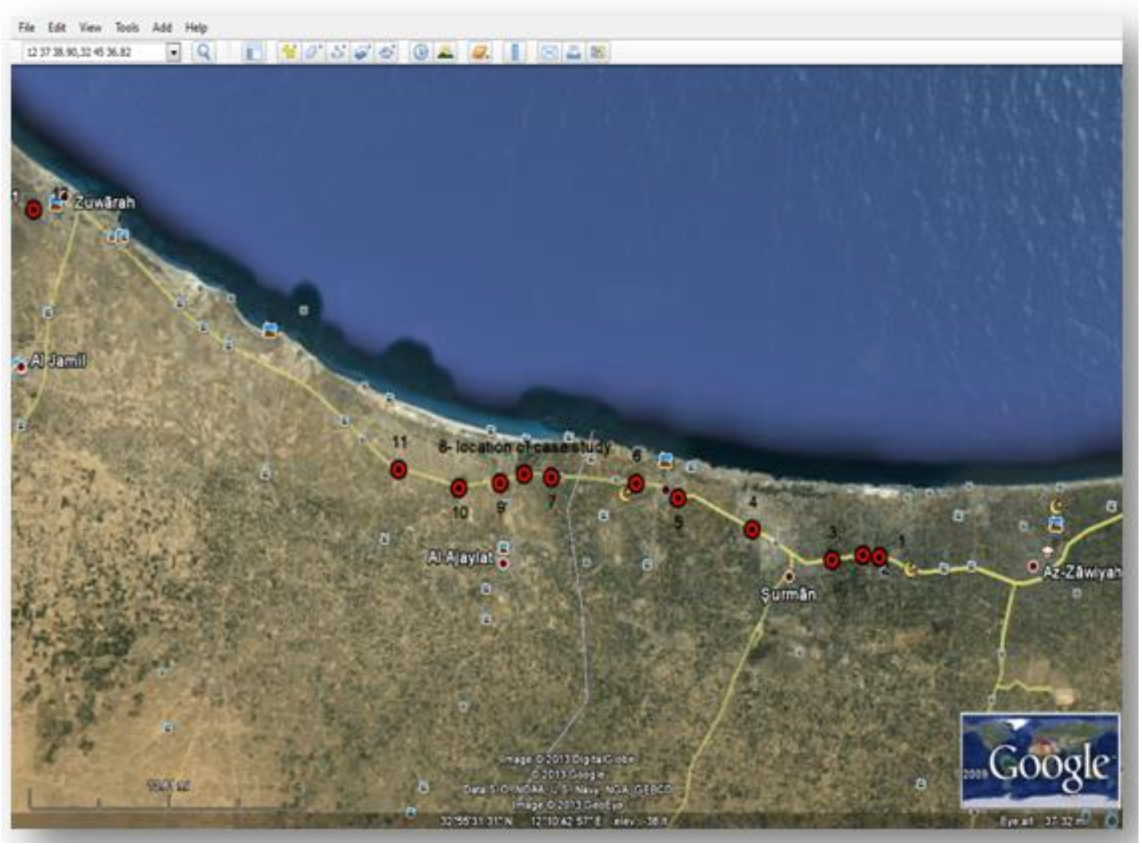

Figure 3. Illustrate the location of black spots along the coastal road-west of Tripoli

The route alignment dataset, obtained by land surveying using AUTO CAD CIVIL3D software, the dataset contains existing information on the alignment characteristics of roads at the location of the case study. The horizontal alignment information contains information such as the length, radius and degree of curvature for the curve while the vertical alignment file contains information such as the length, start and end grades and K-values (which reflect degree of curvature) vertical curve.

2.2 The Roadway Inventory Dataset

The roadway inventory dataset for the rural two-lane at the area of the study which provide detailed information on the location, cross sectional elements, and pavement condition, land marking status, lighting condition, signs availability, side features status, over all clear zone condition.

2.3Segment Section Dataset

The segment section dataset provides the existing section of the road at the location of studied area, which has compared with the recommended standards (lane width, shoulder width, clear zone width).

2.4 Study Area and Data Set

The study area used in this investigation located at rural arterial coastal road about 9.50 Km west of Sabratah City, and located at the coordinate.

N 32°48'01.56", E 12°23'29.32" According to LGD 2006

Figure 4. Shown the location of the studied segment

In other way, it’s a superimposing curve (horizontal tangent with a crest vertical curve (Three dimensional alignments)

2.5 Problem statement of this segment

Many victims of road accidents at the area were registered on this road segment. Even more; the police employees and residents around, call this position as" **turning point of death**", although ; according to testimony of the residents that they knew some victim or relative to one of them has known with their wisely behavior and good followers of traffic law.

2,6visual investigations of the road segments

During the heading driving west – east direction with operating speed 80 km/h, I discovered that the vision of the opposite direction almost does not exist before the curve as that appears in fig 5; and the combination of horizontal and vertical curve with crossing by sub-residential road might lead to increase the accidents risk, fig 6.

Figure 5. Shown the lack of vision condition of the studied segment

Figure 6. Shown the risk at the studied segment

And, by using AutoCAD Civil 3D to simulate the visibility of any assumed objects which was noted with Blue X sign on fig 7 inside the combined curve with height = 600mm (AASHTO 2004)Will find the following visibility:

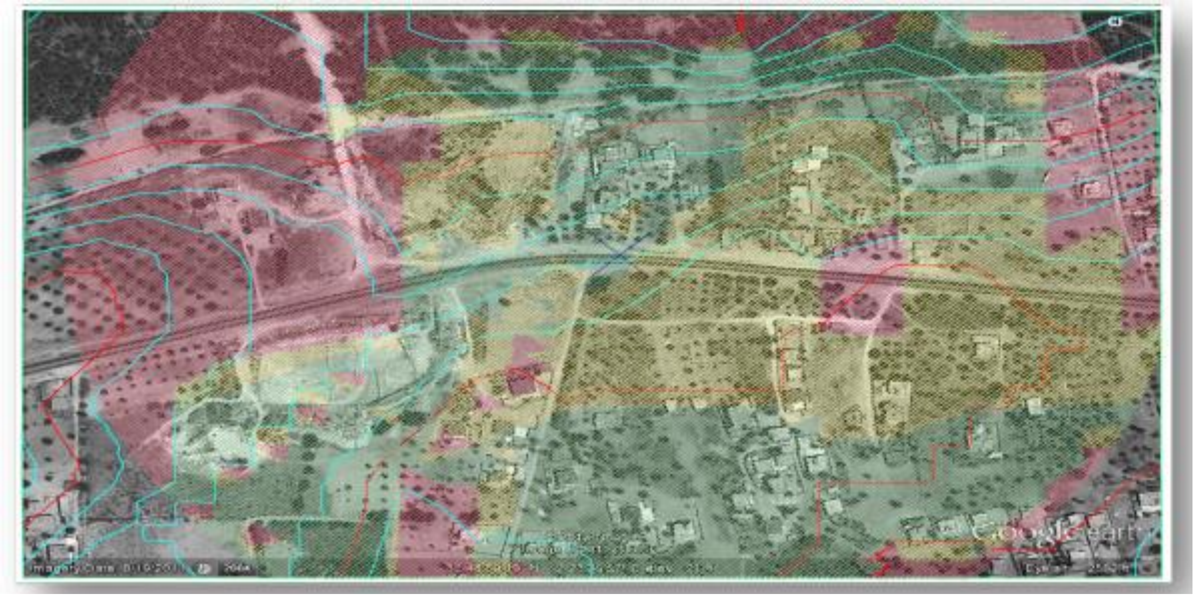

Figure 7. Shown the visibility of 600mm height object inside the combined curve

Where:

Table 1 Distribution of the three types of visibility using AutoCAD Civil 3D 2012

Color	Visibility
Green	**The object is visible**
Yellow	**The object is partially visible**
Red	**The object is not visible**

2.7 Methodology of Evaluation of the existing Geometric design of the segment:

Many researches showed that there are over 50 highway design elements for different highway classes and these elements are related with traffic accidents in one way or the other. In order to reach more healthy results in evaluation studies about this subject, it is necessary to make a simpler classification.

A design elements' classification with units, used in a study evaluating the effects of safety in highway projects are given as below:

- Roadway
    - Number of Lanes (Lane)
    - Lane Width (m)
    - Surface Condition (Good/Bad)
- Vertical Alignment
    - Grade on Tangent (%)
    - Grade on Curve (%)
    - Sight Distance (m)
- Horizontal Alignment
    - Degree on Curve (Degree)
- Shoulder
    - Width (m)
    - Surface Condition (Good/Bad)
- Traffic Control

Delineator (Yes or No)

Guide Sign (Yes or No)

Lighting (Yes or No)

Marking (Yes or No)

2.7.1 Geometric characteristics evaluation:

- Road way has classified as a rural arterial with 2 lane highway.

  Lane width = 4m

  Surface condition = not good

- Traffic control:

  Delineator of the road is invisible

  Guide signs = not exist

  Lighting = doesn’t active

  Marking =not good as shown in fig 8

Figure 8.Geometric characteristics of the studied segment

Risk of serious crashes within horizontal curves is a function not only of the curve geometry but also Presence of intersections and driveways Roadside features and clear zone, as shown in fig 9.

Figure 9. Geometric characteristics of the studied segment

- **Horizontal and Vertical Alignments**

The study begun with the survey work for the segment by using the total station (Lica TCR 408) with using the UTM system coordinates; and the results were attempted with AutoCAD civil3D 2012 and using criteria of AASHTO 2004 in the software as shown on the fig 10,11.

Noted that the speed on the study used was 100 Km/h,this is the operating speed that used for most drivers with unsent of the traffic control

The report of the curve for the attempted data shown in the table inside fig 12.

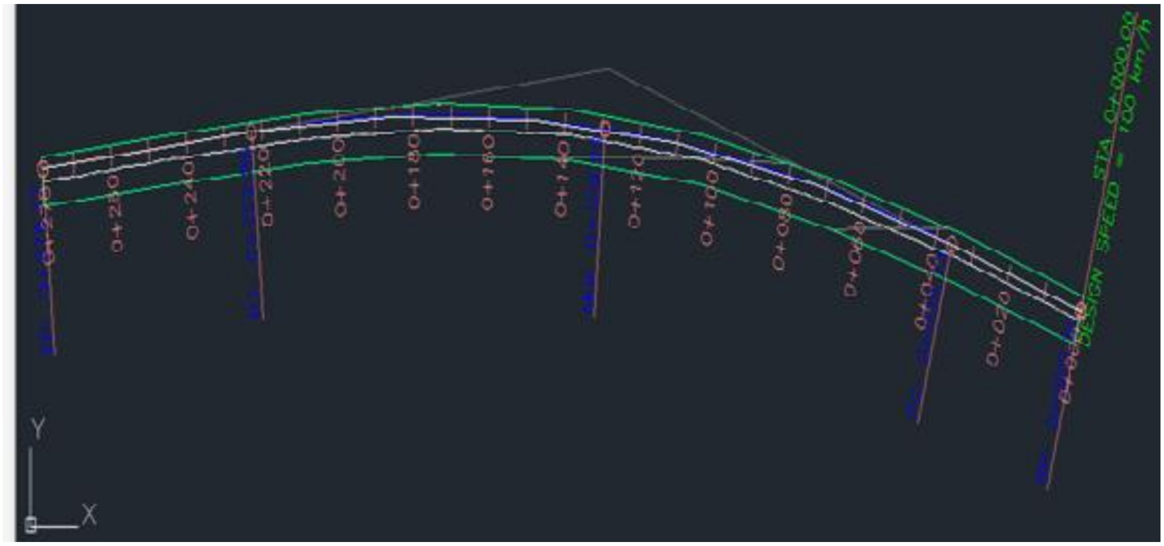

Figure 10. Data analysis of the studied horizontal curve

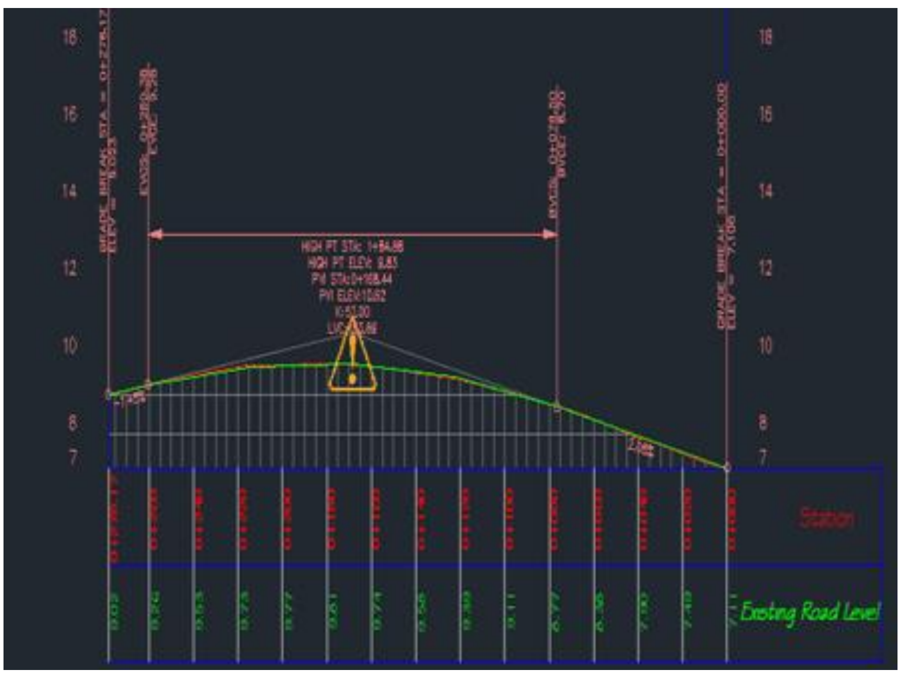

Figure 11. Data analysis of the studied vertical curve

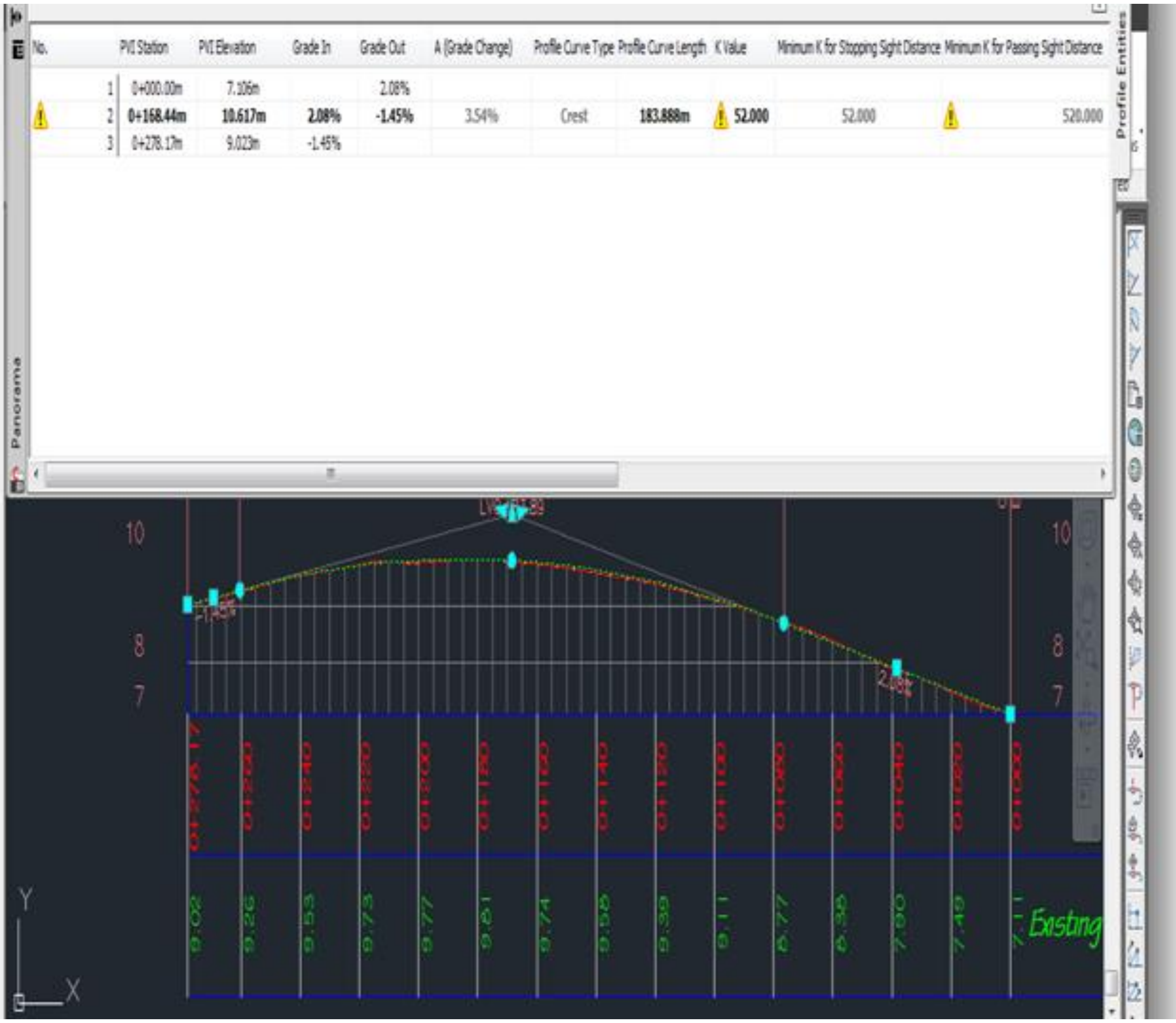

Figure 12. Report of analysis the data of the combined curves

2.8 Analysis of Results and Discussion

- For the horizontal curve:

  Existing design criteria:

  - Design speed (V)=100 km/hr
  - From AASHTO 2004:use the minimum radius table and

    e_{exist} =10%.

From AASHTO, By V=100 Km/hr., e_{exist} =10%.

→ R_{min} =360 m

From the drawings Δ= delta angle=25.964(g).

Where: c=chord length= 185.828m

R=$\frac{c}{2\sin\frac{\Delta}{2}}$ = 458.811 m >R_{min}

But for the operating speed 120Km/hr , from the table,

R_{min} = 359 m

R = 458.811m <R_{min}

- For vertical curve:

Generally, it is impractical to design crest vertical curves to provide for passing sight distance particularly for high-speed roads. Passing sight distance on crest vertical curves may be practical on roads with unusual combinations of low design speeds and gentle grades or higher design speeds with very small algebraic differences in grades. Ordinarily, passing sight distance is provided only at locations where combinations of alignment and profile do not need the use of crest vertical curves.

From AASHTO 2004 and table control for crest vertical curve for K Value:

Where: $K_{exist}=\frac{L}{A}=\frac{183.89}{2.08-(-1.45)}=52$

Table2 Control for crest vertical curve for K Value

Metric			US Customary		
Design speed (km/h)	Passing sight distance (m)	Rate of vertical curvature, K* design	Design speed (mph)	Passing sight distance (ft)	Rate of vertical curvature, K* design
30	200	46	20	710	180
40	270	84	25	900	289
50	345	138	30	1090	424
60	410	195	35	1280	585
70	485	272	40	1470	772
80	540	338	45	1625	943
90	615	438	50	1835	1203
100	670	520	55	1985	1407
110	730	617	60	2135	1628
120	775	695	65	2285	1865
130	815	769	70	2480	2197
			75	2580	2377
			80	2680	2565

Note: *Rate of vertical curvature, K, is the length of curve per percent algebraic difference in intersecting grades (A). K=L/A

It's very clear that the proper design speed to achieve $K_{exist}>K_{min}$value should be 30 Km/h, which is counterfactual that minimum operating speed is 100 km/h.

In other hand; Due to a short length 183.88m of a crest vertical curve which leaded to insufficient sight distances.

So, this was leading to critical driving maneuvers because of visual misconceptions, since portions of the alignments become hidden from the drive´s view, which may, in turn, mislead the driver about the course of the roadway and opposing traffic. These visual misconceptions are especially dangerous in the case of passing maneuvers. And because the completion of the both curves horizontal and vertical alignments was not placed at approximately the same location and have not the same length, the insufficient perspective view of the drivers which is lead the driving speeds to be excessive for the available sight distance. Driver speeds appeared to be influenced more by the level of discomfort experienced while driving around a curve, than by the sight distance restriction.

When a vehicle travels slowly around a curve with high superelevation, negative lateral forces develop and the vehicle is held in the proper Path only when the driver steers up the slope or against the direction of the horizontal curve. This direction of steering is an unnatural movement on the part of the driver and possibly explains the difficulty of driving on roads where the superelevation is in excess of that required for normal speeds.

Also, some vehicles, such as large trucks, may have a high center of gravity or may be loosely suspended on their axles. When these vehicles travel slowly on steep cross slopes, a high percentage of the mass is carried by the inner tires.

And, due to the insufficient superimposing crest vertical curve with horizontal curve, With respect to crest vertical curves, the sight Distances for design are determined such that drivers are not able to see over the top of the hill and therefore objects at the other side will not be discerned.

So, the insufficient balancing between the vertical and horizontal curve at the same location, the elements of vertical alignment that cause crashes include steepness, length of grade, and vertical curve design has been hypothesized that Geometric countermeasures for vertical alignment include minimizing the effects of insufficient perspective view and excessive speed than the pass sight distance on the curve by providing opportunities to pass, and increasing the sight distance on vertical curve.

3. Conclusion and recommendation

The following conclusion can be derived from the research:

- The safety problems at the studied segment cannot be ignored. Current geometric deficiencies at this segment would lead to increased fatalities, injuries and property damage crashes, vehicle operating costs, delays and inconveniences which may translate into driver frustration and lost time and these may in turn exacerbate existing safety problems that already exist due to inadequate geometry.
- The standards were not updated or evaluated and the coastal road were designed and built many years ago.
- Lack of Information as a data base that give you high intensive figure of the type of accident and statistic fatal and injuries at any certain location of such black spots.

So, from the resulst of the research; It is recommend that there is need to reconstruct and replace the segment according to the modern geometric design were the safety factors should be taken at the highest priority.

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