Enhancing Road Curves Using Geographic Information Systems

Dr. Mulla Alkhuder[1], Nawras Watfa[2], Aws Zuhair Sameen[3]

[1] Department of Civil Engineering, Engineering Collage,Alfurat University, Damascus, Syria
[2]PhD Student, limkokwing University, Selangor, Malaysia
[3]PhD Student, Department of Electrical, Electronics and Systems, Faculty of Engineering, the National University of Malaysia, Selangor, Malaysia

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Abstract - ***When initiating the study and design of a new path for a given road, achieving technical norms and specifications to ensure the safe and smooth movement, is not something complicated, as the freedom to choose the path allows the engineer to achieve all specifications in terms of radiuses and vision distances according to the desired design speed. The real challenge remains is to improve motion conditions at the existing road curves, and actually invested in order to meet (or get close as much as possible) technical norms compatible with the design speed on the road.The importance of GIS lies in the ability of dealing with the road axis points within a three-dimensional environment where the path of the road can be modified (by deleting some points from the path or adding new points) in such a manner that the new path meets the required norms introduced by the engineer.***

Key Words: *Geographic Information Systems (GIS), Global Position Systems (GPS), Universal Transverse Mercator (UTM), KML.*

1. INTRODUCTION

The traffic network in Syria is one of the good traffic networks, but with the increasing intensity in the central roads, it was necessary to raise the level of these roads [1]. One of the methods used is to improve the road curves. Improvement curves process is less expensive and shorter in time than the process of path changing, in order to avoid entering into the issues of land acquisition and payment large costs resulting from this acquisition [2]. Improving curves leads to the mitigation of large human and material loss of traffic accidents.In the old methods that used to improve curves which relies on drawing a circular curve that almost matches the real curved, find two tangents for each curve, and increase the radius based on these tangents [3]. These methods cannot deal with the cascade of horizontal curves, the cascade curves vertical, or the overlay of horizontal curves with vertical curves at the same time [4, 5].This research investigate an accurate computer program that features speed and ease of use in order to improve the curves along the route, particularly for special cases, such as curves cascade and overlay. This program allows the engineer to determine the level of service on the road, curves, radiuses and vision distances.The practical part includes improving traffic conditions on a central road in Al-Sweida'a province; Al-Sweida'a - Salkhad road with 23 km length. This road, like most central roads, was previously local and has been converted to central by conducting some improvements, such as widening the road or adding a traffic lane [6]. However, these roads didn't meet the required technical specifications of the central roads, in terms of radiuses of vertical and horizontal curves. In a step forward to bring traffic conditions of this road to the closest with the technical specifications of the central roads, the new method are applied on this road to improve its curves [7].

2. METHODS

2.1 Research Steps

Creating the axis of the route within the GIS program and directing the map, according to the Syrian stereographic projection system. This path can be drawn in two ways:

1- Google earth Axis.

Using the axis of the plotted route with Google Earth program. The file was saved in .kml format. Thus, a set of projection points is formed according to the global projection system UTM, and then the file will be export to GIS program. If the file with .kml format was opened by word-processing program; Microsoft Word, the points arranged consecutively according to the cascade of path points plotted. Figure 1 shows the file.kml opened in word.

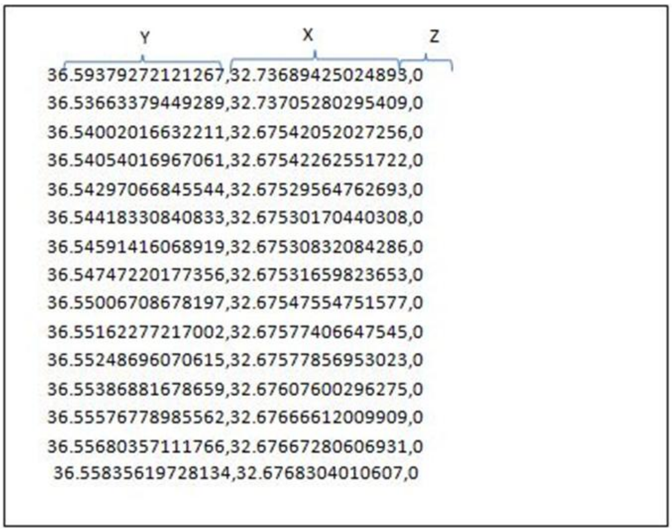

Fig -1: Points Coordinates of plotted route

However, it is noted that point's altitudes were not exported along with the file. Therefore, the subsidiary program designed for dealing with the longitudinal projection plotted in Google Earth program and converting it to values of points' altitudes within GIS environment.Figure 2 shows the longitudinal projection of Points Coordinates of plotted route,which it converts from Google Earth as a points to GIS as a graph.

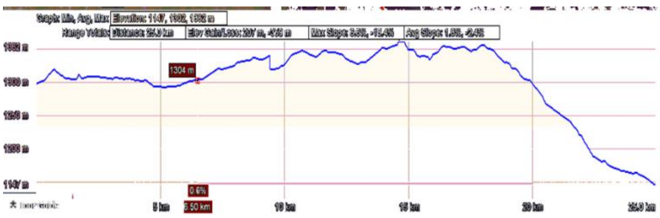

Fig – 2: Plotted route using Google Earth Program

2- GPS technology

The GPS technology requires GPS devices which is currently available in modern mobile devices. Where this technique is operated along the route (in relatively slow speed to increase the number of scanned points, thus increase the accuracy of the path). The device creates a path in a file of .kml format. This file will include values of points' altitudes. There is no need to use a subsidiary program to add altitudes. Then, the file will be exported to GIS environment. Second step, the layer will export and created in GIS, which is a path directed according to the Syrian stereographic system to a shape file by dealing with the path points according to the metric system instead of the grading system. The introduction of radiuses and vision distances will be on metric unit. Finally depending on the program that is already designed and prepared to deal with the shape file. The program improves curves and produces a new shape file according to the criteria that entered to improve the route.Demonstrating the results within the GIS environment, and the new path will appear according to the new radiuses.

2.2 Working with Program

1 –The XY plane.

As aforementioned, the path consists of set of points up, connected with each other by straight lines to make up a track. Each three consecutive points form a certain angle. The program calculates this angle, based on the knowledge of the three points' coordinates in the plane XY. The program draws the circular arch which its radius was introduced according to the requirements of the safe motion. If the angle was smaller than the desired angle of the circular arc, the program will form a number of new points in turn. If the angle was greater, the program will move to the following three points (I, I + 1, I + 2) without omitting point (I). It should be noted that we have to determine the length of the circular arc between each two points. The length of the step which the program will move along the path. The user can control this length as desired, noting that whenever the step was shorter, the curved will be smoother.

2- The ZL plane.

After improving the horizontal curves, a new longitudinal projection of the path is formed in the level ZL. Also, the program formed arcs with the required radius. However, visibility distance and driver's eye were introduced here. Thus, the corresponding radius of the curved vertical is determined.Figure 3 shows how to use visibility distance and driver's eye,to improve horizontal curves.

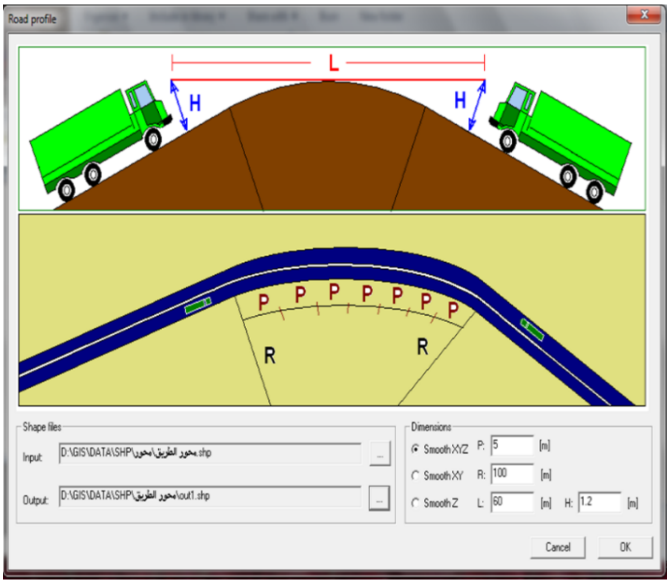

Fig – 3: Improvement of Horizontal Curves

3 RESULTS AND DISCUSSIONS

Curves were improved according to three models of speed design for movement of vehicles. The following forms demonstrate the results of improving some curves on the road by inputs. Each time, improvement was conducted upon horizontal curves only, then upon vertical curves only and, finally, upon both horizontal and vertical curves.

3.1 Improving Curves in Accordance with the Design Speed of 70 km/h.

According to the Syrian guide of roads design, the horizontal radius corresponding to the design speed of 70 km/h is 215m and the vision distance to stop is 110m.

1- Horizontal Improvement.

Figure 4 showsthe results of improvement with values of radiuses before and after improvement.

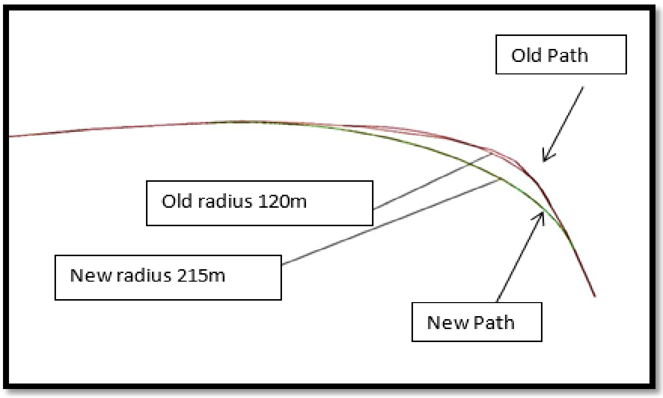

Fig – 4: Horizontal improvement

From figure 4 it can be seen that the small change in curves due to the increase of path radiuses from 120 m to 215 m.

2- Vertical Improvement.

Figure 5 shows the results of the vertical improvement for a portion of the road.

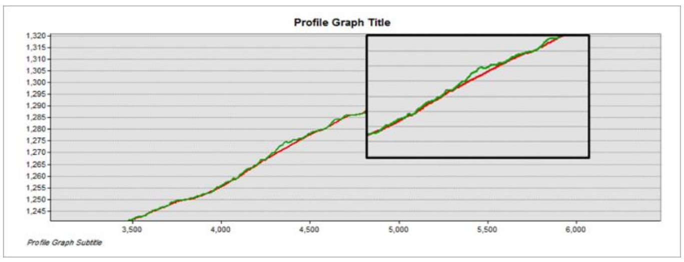

Fig – 5: Vertical improvement

Form figure 5 it is noticed that the vertical curve needs to be cut at the peak by almost 2m to achieve the required vision distance.

3- Overall Improvement.

Figure 6 shows a small change in curves due to overall improvement,because of the change of the road path from its original position due to the vertical and horizontal improvements.

Fig – 6a: Horizontal Section after overall Improvements, Designed Speed 70 Km/h

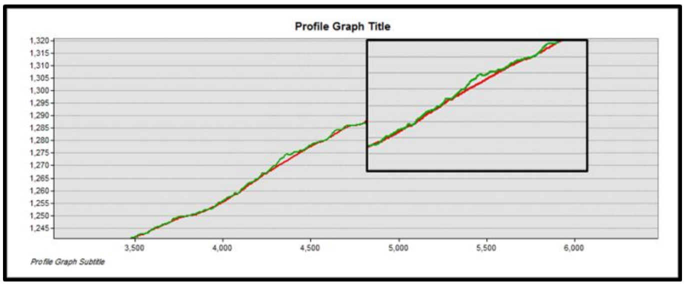

Fig – 6b: Vertical Section after overall Improvements, Designed Speed 70 Km/h

3.2 Improving Curves in Accordance with the Design Speed of 80 km/h.

According to the Syrian guide of roads' design, the horizontal radius corresponding to the design speed of 80 km/h is 280m and the vision distance to stop is 140m.

1- Horizontal Improvement.

Figure 7 shows the process of horizontal improvement only for a certain curve of the studied way. It is also shown how the curve is covered on the ground with a circular arc, the radius of this arc is 159m in order to define the approximate radius of the curve to be improved. The curve after improvement appears to have a radius of 280m, as introduced into the program.

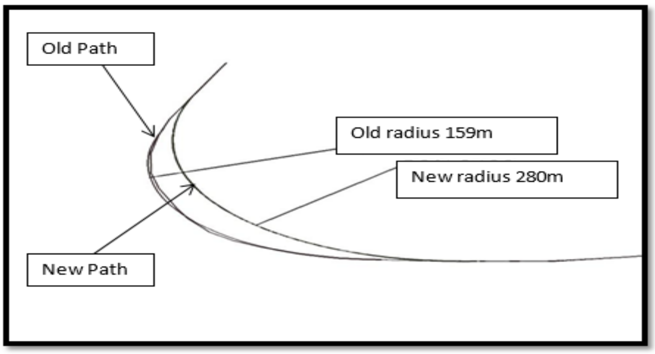

Fig – 7: Horizontal improvementAccordance with the Design Speed of 80 km/h

At a designed speed of 80Km/h the horizontal improvements lead the radius from 159 m to 280 m to create the new road path

2- Vertical Improvement.

Knowing the volumes of excavation and backfill to be implemented by knowing the depth and distance must happen along the part of path to be improved through the following vertical projection. Horizontal axis shows the cumulative distance. Vertical axis shows the amount of points altitudes for each of old and improved path. Through the difference between the values of point's altitudes for two paths,the amount required amount of excavation and backfill could be got easily. Figure 8 shows continue here who we can determine of amount of excavation and backfill between the two road paths.

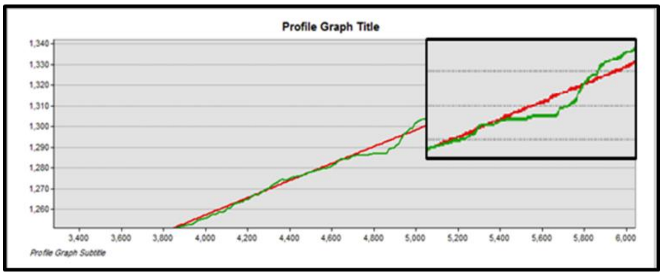

Fig – 8: Vertical improvementAccordance with the Design Speed of 80 km/h

3- Overall Improvement.

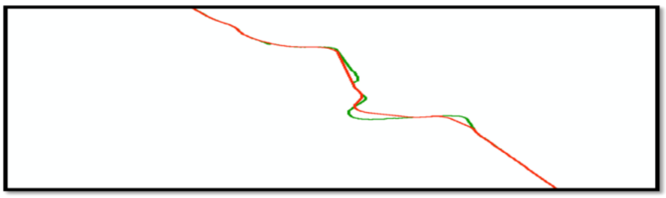

Fig – 9a: Horizontal Section after overall Improvements, Designed Speed 80 Km/h

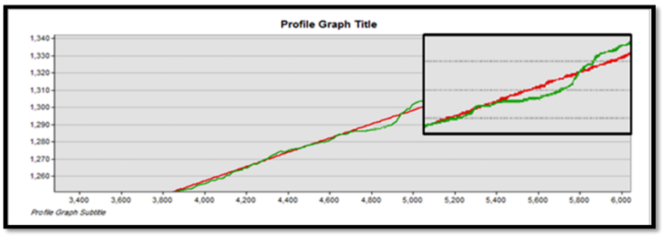

Fig – 9b: Vertical Section after overall Improvements, Designed Speed 80 Km/h

Figure 9 shows a medium change in curves due to overall improvement, becauseof the change of the road path fromits original position due to the vertical and horizontal improvements.

3.3 Improving Curves in Accordance with the Design Speed of 90 km/h.

According to the Syrian guide of roads' design, the horizontal radius corresponding to the design speed of 90 km/h is 375m and the vision distance to stop is 170m.

1- Horizontal Improvement.

Figure 9 shows the horizontal improvement for a portion of the road is noted. The horizontal improvement included two consecutive horizontal curves with small radiuses. The program integrated these curves in one horizontal curve with a radius corresponding to the design speed of 90 km/h.

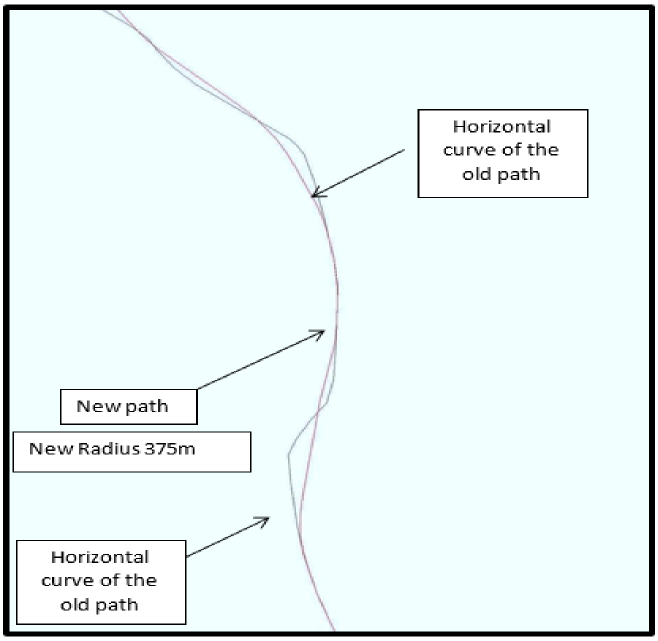

Fig – 9: Horizontal improvement Accordance with the Design Speed of 90 km/h

2- Vertical Improvement.

When conducting improvement vertical according to a relatively large design speed, an increase in the excavation and backfill is noted significantly. Depth of backfill is around 3 - 4m. Therefore, it is preferable to conduct the study of the road according to a certain speed then reduce the value of this speed at some critical parts and curves. Figure 10 shows a vertical projection for an area of the road that needs large amounts of backfilling to achieve the motion conditions in accordance with the design speed of 90 km/h.

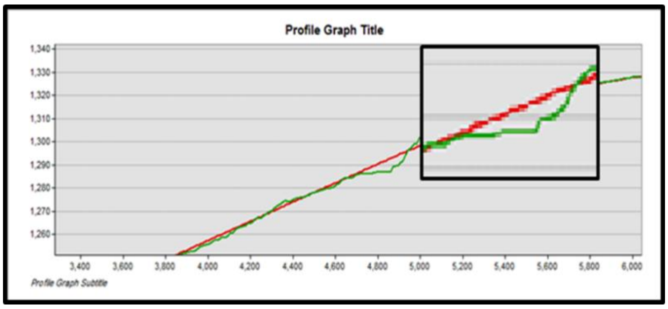

Fig – 10: Vertical improvementAccordance with the Design Speed of 90 km/h

3- Overall Improvement.

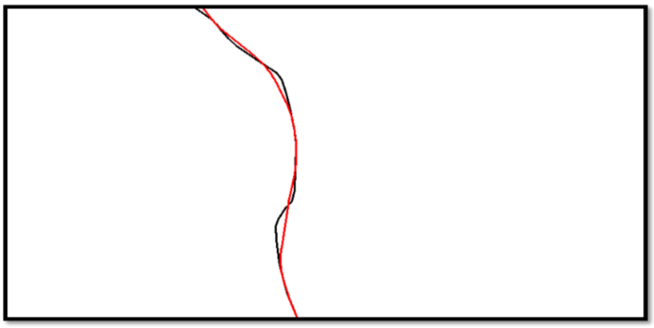

Fig – 11a: Horizontal Section after overall Improvements, Designed Speed 90 Km/h

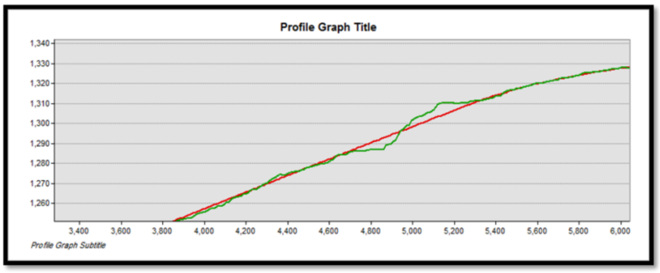

Fig – 11b: Vertical Section after overall Improvements, Designed Speed 90 Km/h

Figure 9 shows a high change in curves due to overall improvement, because of the change of the road path fromits original position due to the vertical and horizontal improvements.

4 CONCLUSION

The harness of the technical possibilities and modern software for the purpose of business development and road studies is an available option in practice that requires only the provision of these technologies on the road institutions level, activating its role and preparing trained technical staff who is able to move forward towards the development of the traffic matrix in Syria and upgrading the performance in all areas. There are some other recommendations such as:Road institutions should conduct periodic survey and inventory of the components of roads and its condition in order to create and update databases so that enable to predict the performance of roads.Moving towards the exploitation of Google Earth maps and GPS devices in surveying road conditions and its elements, as these techniques give a full concept of the data and performance of the road network in such a manner that is completely lifelike.Moving towards the widely use of geographic information systems in road institutions and for all the required work, in addition to training available staff on the use of these systems.This research ensures identifying many effective features of using geographic information systems and programming languages in the field of maintenance and rehabilitation.

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