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Using GPS in Designing Syrian Road Curvesat Speed of 70 km h^{-1}

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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. This is due to the fact that 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 remaining is to improve motion conditions at the existing road curves. This is 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 in 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). This can be done in such a way that the new path meets the required norms introduced by the engineer.

Key words: Geographic Information Systems (GIS), Global Position Systems (GPS), road curves, Syria, path

INTRODUCTION

The traffic network in Syria is among the best traffic networks globally. But with the increasing intensity in the central roads, it became necessary to raise the level of these roads.

One of the methods used is to improve the road curves. Improving curves process is less expensive and takes a shorter time than the process of path changing. This is due to the fact that it avoids entering into the issues of land acquisition and payment of large costs resulting from it (Jiang *et al*., 2013). Improving curves leads to the mitigation of large human and material loss of traffic accidents. The old methods used to improve curves relies on drawing a circular curve that almost matches the real curve, finding two tangents for each curve and increasing the radius based on these tangents (Kumar and Mahajan, 2013). These methods cannot deal with the cascade of horizontal curves, the cascade of vertical curves, or the overlay of horizontal curves with vertical curves at the same time (Zhang *et al*., 2014).

This research investigates 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 (Cai *et al*., 2015). However, these roads didn't meet up with 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 implemented on this road to improve its curves (Elleuch *et al*., 2015).

MATERIALS AND METHODS

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.

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 exported to GIS program. If the file with 1 km format was opened by word-processing program; Microsoft Word, the points are arranged consecutively according to the cascade of path points plotted. Figure 1 shows the file.kml opened in word (Huang and Levinson, 2015).

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

Y X Z

36.59379272121267,32.73689425024893,0
36.53663379449289,32.73705280295409,0
36.54002016632211,32.67542052027256,0
36.54054016967061,32.67542262551722,0
36.54297066845544,32.67529564762693,0
36.54418330840833,32.67530170440308,0
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36.55162277217002,32.67577406647545,0
36.55248696070615,32.67577856953023,0
36.55386881678659,32.67607600296275,0
36.55576778985562,32.67666612009909,0
36.55680357111766,32.67667280606931,0
36.55835619728134,32.6768304010607,0

Fig. 1: Points co-ordinates of plotted route

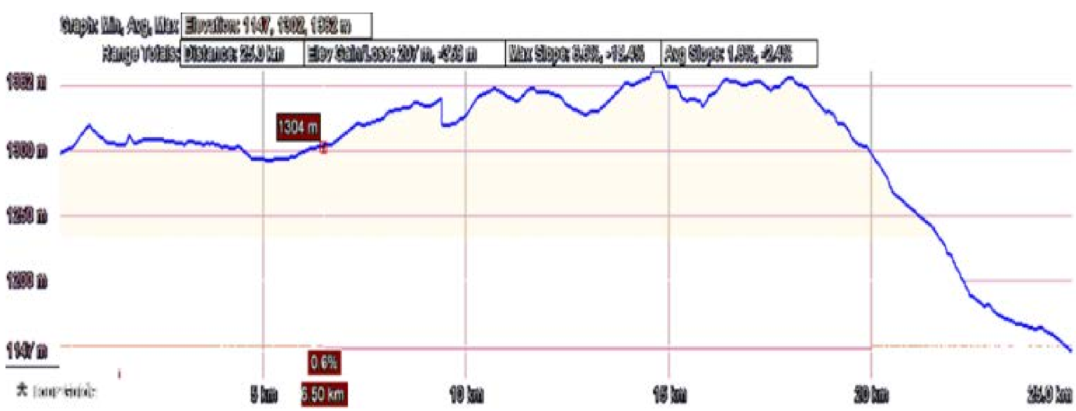

Fig. 2: Plotted route using google earth program

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 increasing 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. Subsequently, the layer will export and create in GIS (which is a path directed according to the Syrian stereographic system), 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. This finally depends on the program 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 is entered to improve the route. Demonstrating the results within the GIS environment and the new path will appear according to the new radiuses.

Working with program

The XY plane: As aforementioned, the path consists of a 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 point's coordinates in the plane XY. The program draws the circular arch in which its radius was introduced according to the

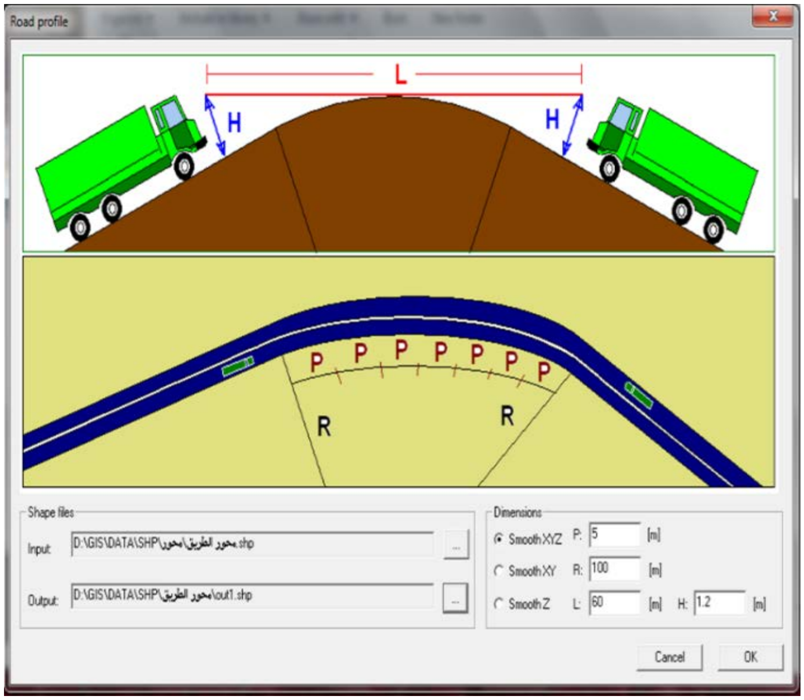

Fig. 3: Improvement of horizontal curves

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 a point (I). It should be noted that we have to determine the length of the circular arc between each two points, i.e., the length of the step in which the program will move along the path. The user can control this length as desired, noting that whenever the step was shorter, the curve will be smoother.

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 vertical curve is determined. Figure 3 shows how to use visibility distance and driver's eye, to improve horizontal curves.

RESULTS AND DISCUSSION

Curves were improved according to the speed design of 70 km h^{-1} 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.

Improving curves in accordance with the design speed of 70 km h^{-1}: According to the Syrian guide of roads design, the horizontal radius corresponding to the design speed of 70 km h^{-1} is 215 m and the vision distance to stop is 110 m.

Horizontal improvement: Figure 4 shows the results of improvement with values of radiuses before and after improvement. From Fig. 4, it can be seen that the small change in curves is due to the increase of path radiuses from 120-215 m.

Vertical improvement: Figure 5 shows the results of the vertical improvement for a portion of the road. In Fig. 5, it is noticed that the vertical curve needs to be cut at the peak by almost 2 m to achieve the required vision distance.

Overall improvement: Figure 6 and 7 shows a small change in curves due to overall improvement because of the change in the road path from its original position due to the vertical and horizontal improvements.

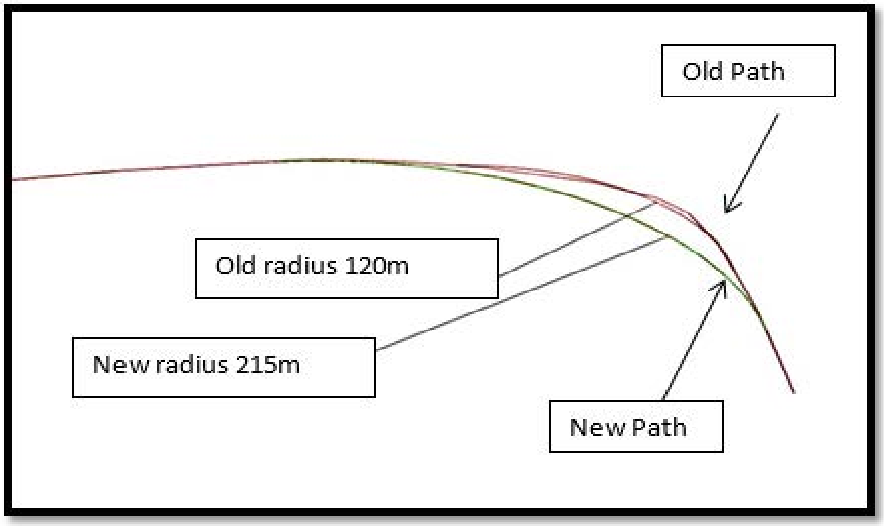

Fig. 4: Horizontal improvement

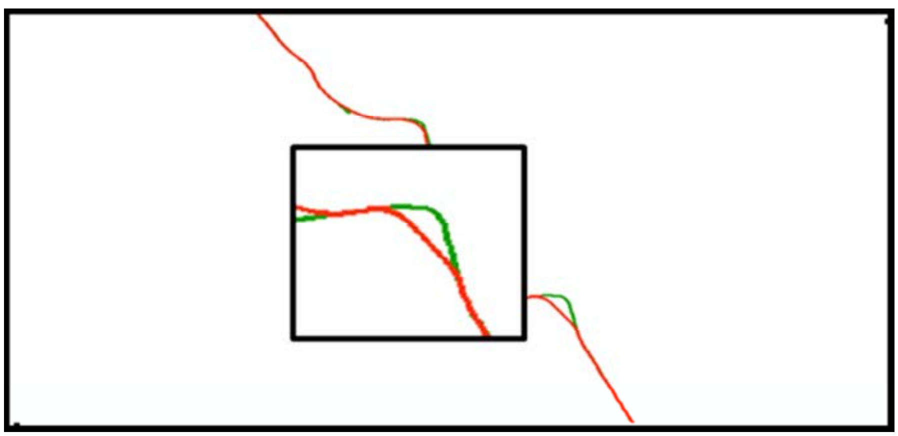

Fig. 5: Vertical improvement

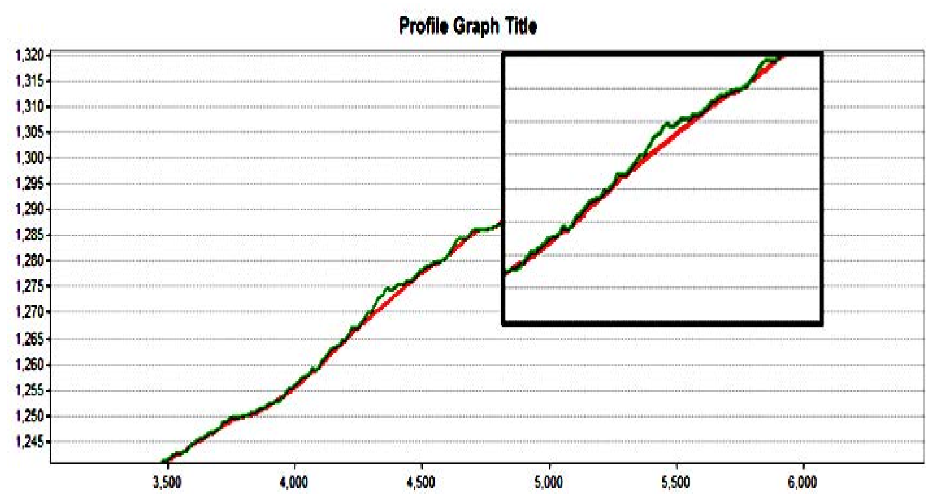

Fig. 6: Horizontal section after overall improvements, designed speed 70 km h^{-1}

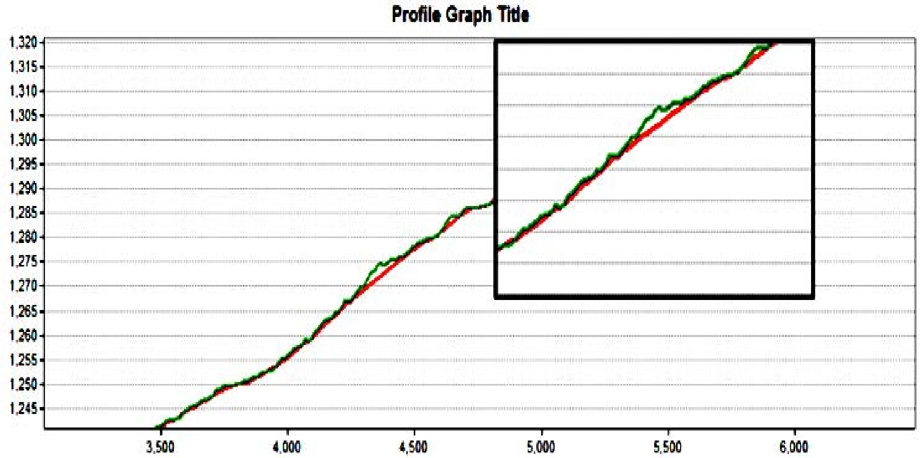

Fig. 7: Vertical Section after overall Improvements, designed speed 70 km h^{-1}

CONCLUSION

The harnessing 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. Thus activating its role and preparing trained technical staff who are 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: the conducting of periodic survey and inventory of the components of the roads and its conditions by road institutions in order to create and update databases that will enable the prediction of 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 wide 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.

RECOMMENDATIONS

While, this study contributed to further understanding relevant to designing curve roads at the speed of 70 km h^{-1}, there is still need for further future investigations. First, there can be an extension of this research to another speeds like 80 and 90 km h^{-1}. Second, there is a need to investigate additional factors that may influence designing curve roads using GPS like the equipment's and engineers qualifications.

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