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Comparison of Elevation Data of Unilorin for Designing Road Constructions

S.A. Raji, G. A. Ogunkunbi, A. O. Omiyale, and S. Braimoh

Abstract— Field surveys or raw elevation data for designing roads and the equipment required are not readily available to potential users of a digital elevation model. The availability of accurate elevation data has thus been a challenge for highway engineers in the preliminary phases of road design. The paper deals with utilization of elevation data of the University of Ilorin, Nigeria for the designing of road constructions. It compares the current elevation data of the University of Ilorin obtained via in situ geodetic measurements with the USGS data set collected via Zonums and Google Earth elevation data. The results obtained establish that there are minor discrepancies between the data from the different sources and the in situ geodetic measurements when used in the geometric design of roads.

Index Terms— digital terrain model, elevation data, road construction, Unilorin

1 Introduction

THE geometric design of roads are often done based on digital terrain models (DTM) which are provided by government organizations for surveying, geodesy and photogrammetry. With the important role of elevation models in road design, the availability of sufficiently-accurate elevation data has however remained a perennial and challenging problem for highway engineers in the preliminary phases of road design. Generally, raw elevation data or field surveys and the equipment required to obtain and process these data are not readily available to potential users of a digital elevation model (DEM). Commonly available data sources such as 30-m digital elevation models from government agencies such as United State Geological Survey (USGS) provide a starting point, but more accurate data can yield much better results for a broader range of applications. The basis for designing in 3D space is high quality elevation data and with the advancement in remote sensing methods e.g. laser scanning, even more highly accurate measurements can be made. However, these new surveying techniques have been proved to provide cost benefits only when done over large areas [1], [2].

This paper intends to compare the elevation information of University of Ilorin (Unilorin) made available by different agencies based on photographic and satellite data with geodetic measurements obtained in situ and determine their applicability to geometric design of roads. In this paper, the current elevation data supplied by Index Engineering Consults, Ilorin, Nigeria is compared with the USGS data set made available via Zonums website and Google Earth elevation data.

The University of Ilorin is located in the ancient city of Ilori n, Kwara State, about 500 kilometres from Abuja, the Federal capital. Ilorin, the Capital of Kwara State, is strategically located at the geographical and cultural confluence of the North and South with a land mass of 75,000 (approximate) hectares [3]. For relative ease of access to data, a road currently undergoing construction was selected for the study. The selected road project, as shown in Fig. 1, is part of the ring road project (Abuja Hostel – Trunil Hostel road) which bypasses the main academic area of the institution.

2 Geodetic Data

The elevation data used for the study was obtained from the USGS dataset made available via Zonums website, Google Earth elevation data and geodetic field measurements provided by Index Engineering and Consults, Ilorin, Nigeria. For uniformity, all the data were processed in the Universal Transverse Mercator (UTM) projection system (Zone 31 Northern hemisphere) in the World Geodetic Coordinate System (WGS 84)

2.1 Elevation Data from Zonums

As stated earlier, the data is obtained from the USGS Seamless

Fig. 1. Map showing the study area

Source: Google Maps

- S.A. Raji is a Senior Lecturer in the Department of Civil Engineering, University of Ilorin, Kwara State, Nigeria. E-mail:saraji12000@googlemail.com
- G.A. Ogunkunbi is currently pursuing master's degree program in Civil Engineering in University of Ilorin, Kwara State, Nigeria. E-mail: gaogunkunbi@gmail.com
- A.O. Omiyale is currently pursuing master's degree program in Civil Engineering in University of Ilorin, Kwara State, Nigeria. E-mail: adedoyinomiyale@gmail.com
- S. Braimoh is currently pursuing master's degree program in Civil Engineering in University of Ilorin, Kwara State, Nigeria. E-mail: braimoh.solomon@lmu.edu.ng

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Fig. 2. Zonums' interface

Elevation data sets hosted at USGS/EROS. The interface is shown in Fig. 2. The elevation values returned default to the best-available (highest resolution) data source available at the specified point. The USGS has compiled and published topographic information in many forms and from many sources that are processed to a specification with a consistent resolution, coordinate system, elevation units, and horizontal and vertical datum. The data set provides basic elevation information for earth science studies and mapping applications within and outside the United States [4].

2.2 Google Earth Elevation Data

Google Earth (as displayed in Fig. 3) uses digital elevation model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation models on a near-global scale from 56° S to 60° N, to generate the most complete high-resolution digital topographic database of Earth prior to the release of the ASTER GDEM in 2009 [5].

2.3 In-situ Elevation Data

This data was obtained using geodetic measurement in situ. It was carried out using Total Station by applying basic surveying techniques.

Fig. 3. Google Earth's interface.

3 Elevation Criteria

The proposed road was projected on the digital terrain models. The DTMs were compared on the basis of the existing ground profile and total volume of earthworks.

The road was designed as a two lane crowned undivided two way roadway to the specifications of the Nigerian Highway Manual for a design speed of 60km/h [6]. The structural height of the pavement is 450mm and the total length of the road is 1500m.

4 Data Processing

The ring road was designed using Autodesk's software, .AutoCAD Civil 3D (2017 version). AutoCAD Civil 3D software is a civil engineering design and documentation solution that supports building information modelling workflows. AutoCAD Civil 3D offers a better understanding of project performance while more consistent data and processes can be maintained with a faster response to change [7]. The software was used for the generation of the DTMs from survey data, corridor modelling which combines vertical and horizontal geometry with flexible cross sectional components to create a parametrically defined dynamic 3D model of the roads and also the computation of volume of earthworks.

The DTMs were created from text files which contained the coordinates and elevation of points using the point creation tool and the points were added to a surface using Triangulated Irregular Network (TIN). The road alignments were then designed and modelled as shown in Fig. 4 and the volume of earthworks was computed using the average end area method.

5 Results

5.1 Elevation Profile

The DTMs were compared according to the existing ground elevation profile generated on AutoCAD Civil 3D as displayed in Fig. 5 using the minimum, maximum and average elevations as points of comparison as shown in Table 1.

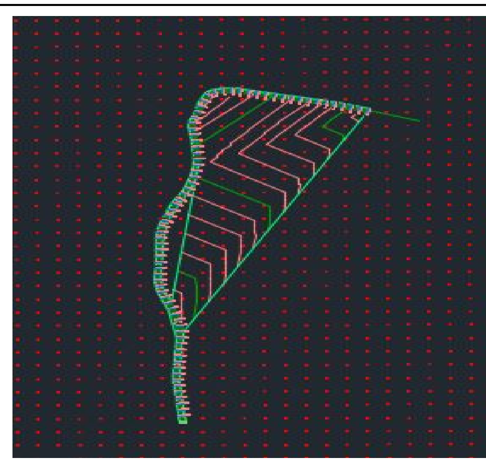

Fig. 4. Modelled corridor (2D) of the proposed road.

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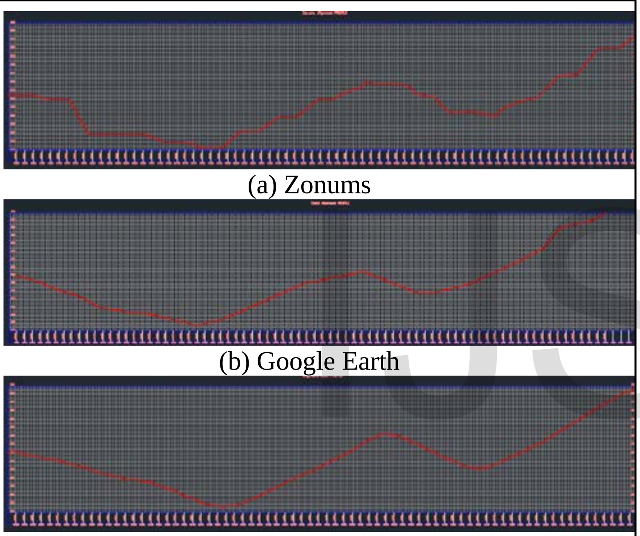
The results show that although the three data sources produced a similar curve pattern in the elevation profiles, the in situ geodetic measurements established that the spot elevations are higher than portrayed by Zonums and Google Earth.

TABLE 1
COMPARISON OF ELEVATION PROFILE

Elevation	Zonums	Google Earth	In situ
Minimum (m)	327.00	329.00	331.00
Average (m)	339.80	339.74	342.61
Maximum (m)	354.00	363.00	360.00

5.2 Volume of Earthworks



(a) Zonums

(b) Google Earth

(c) In situ

Fig. 5. Existing Ground Elevation Profile.

The volume of earthwork which is the second criterion of comparison shows that there a similar trend among all three DTMs that were analyzed. The results as shown in Table 2 establishes that for the proposed road, a larger volume of excavation will be done than embankment. This is partly a result of the intersection which is at a lower altitude. However, the DTM generated from Google Earth data has a better agreement with the DTM generated from in situ measurements while the DTM generated from Zonums exhibits a much greater discrepancy with the other two. The adjudged differences between the in situ DTM and the other two DTMs can be said to be connected and in agreement with the declared total mean error of an elevation obtained from satellite imagery and photogrammetry.

TABLE 2
TOTAL VOLUME FOR EARTHWORKS

Surface	Cut (m^3)	Fill (m^3)
Zonums	19373.58	2035.80
Google Earth	12081.30	1311.14
In situ	11797.80	716.26

6 CONCLUSION

The results of the study has established that elevation data from different authoritative sources are usually sufficient for preliminary and general alignment studies as their differences when compared with elevation data obtained from conventional field geodetic measurements are within acceptable limits. There is nevertheless a need for the national agencies and private geoinformatics firms in Nigeria to explore the benefits of the advancement in remote sensing techniques as this will provide even more accurate elevation data.

However, before a road is actually built, the importance of the conventional terrestrial field survey within the vicinity of the construction site cannot be over-emphasized as this produces more accurate information for construction costs estimation and planning.

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