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Feasibility Study of LiDAR over Total Station for Topographic survey of road projects

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Abstract

Highway surveying is a specialized type of land surveying generally conducted for government or private agencies during the planning stages of a highway development project. In which topographic survey is the most basic and vital elements in road construction project for which conventionally Total stations are being used. LiDAR is now rising as a much less time consuming substitute of Total station for the topographic surveys of road projects. This article specializes in feasibility evaluation of each these techniques which have been used for topographic survey of road projects. Study is done for 2 kms of span on which both LiDAR and Total station survey performed. By comparing documents, input and output data and manpower involved in topographic survey we have considered time, cost and accuracy as parameters for feasibility study.

Keywords- LiDAR, Topographic survey, Total stations.

1. Introduction: -

Highway surveying is a specialized type of land surveying generally conducted for government or private agencies during the planning stages of a highway development project. After the highway is built, a highway survey can be used to provide an accurate layout of roadways, utilities, storm drainage systems, overhead wires, nearby buildings, and other features of the landscape.

A Topographic Survey is a survey that gathers data about the elevation of points on a piece of land and presents them as contour lines on a plot. The purpose of a topographic survey is to collect survey data about the natural and man-made features of the land, as well as its elevations. Topographic maps are used to show elevations and grading features for architects, engineers, and building and road contractors.

Mostly topographic survey is done by conventional method i.e Total Station. The instrument gives its output data with great accuracy. In which a lot of human efforts and skills are involved. Total stations are mainly used by land

surveyors and civil engineers, either to record features as in topographic surveying or to set out features (such as roads, houses or boundaries). They are also used by archaeologists to record excavations and by police in crime scene investigations, private accident reconstructions and insurance companies to take measurements of scenes.

Total stations combine electronic theodolites and EDM into a single unit. They digitally observe and record horizontal directions, vertical directions, and slope distances. These digital data observations can be adjusted and transformed to local X-Y-Z coordinates using an internal or external microprocessor. Various atmospheric corrections, grid and geodetic corrections, and elevation factors can also be input and applied. The total station may internally perform and save the observations or (more commonly) these data may be downloaded to an external data collector. With the addition of a data collector, the total station interfaces directly with onboard microprocessors, external PCs, and software.

Nowadays, LiDAR (Light Detecting and Ranging) is more and more frequently used in all kinds of fields, such as forest measurement, transportation and power transmission fields[1].

LiDAR may prove to be an alternative technology to obtain terrain information in a more expedient manner since it does not face the same limitations as traditional data collection methods. LiDAR data can be collected under variety of environmental conditions, including low sun angle, cloudy conditions, and even darkness, resulting in expanded windows for data collection[2].

Many of the nations are currently using LiDAR technology for different types of surveys. This technology nowadays also emerging in India rapidly. The NHAI made it mandatory to use LiDAR for feasibility study of all highway projects as it takes a day to complete survey of 100-200 kms. On the other hand by total station only 2 kms of survey can be done.

There are different platforms with which LiDAR can be used are as follows:

a) Airborne LiDAR(mounted below aircraft)
b) Terrestrial LiDAR(mounted above Vehicle)
c) Bag pack(A person walks or runs with bag pack in which small LiDAR instrument is fixed)

In this study terrestrial LiDAR was used. LiDAR survey performed with an instrument placed above the roof of Mahindra Xylo. Height of instrument was 2185mm above the ground surface. LiDAR data was captured with varying speed with as per present condition of road.

2. Feasibility Study:-

For every project transient and also in development phase the feasibility may consider as an important steps for the investor or the organization to make sure that their mission is officially feasible, gainful for the organization and beneficial for society. The methodical study may also provide the exact respond earlier. Feasibility evaluation mainly classify in five types or categories.

A. Technical Feasibility

Technical feasibility mainly associated with the technologically evolutes the project. In this subject area generally a group of engineers or technical expert studies the whole projects and technical aspects. This study facilitates said organizations to proper assess. The industrial possessions may assemble capability. Based on the results it decides whether the technical team is able to convert the idea into real [8].

B. Economic Feasibility

Economic feasibility study related with price, and all kind of expenditure related with the scheme before the project start. This study also improves project reliability [9]. It is also helpful for the decision-makers to decide the planned scheme processed latter or now, depending financial condition of the organization [10]. This evaluation process also studies the price benefits of the proposed scheme.

C. Operational Feasibility

Operational Feasibility may employ the responsibility to examine and also decide whether the proposed methods fulfill all kind of business requirements [11]. It actions forecast all possible schemes to recognized and resolves troubles [12]. This studies may also examine and verify how the project planed guarantee the method development is feasible or not.

D. Scheduling Feasibility

A very significant part of feasibility study is scheduling Feasibility. It is also play an important roles to complete the project in its schedule time [17]. Project some time not be unsuccessful if it is not finished in its bounded time frame. Here we may predict the time requirement to complete various task of the entire project.

Here considered factors for feasibility Study are Time, cost and accuracy. With this factors all type of feasibilities have examined.

1) Time-

For time LiDAR is a clear winner. With one total station maximum 2kms of highway topographic survey can be carried out per day. On the other hand LiDAR completes 70-80 kms of topographic survey per day. LiDAR completes survey with vehicle's speed in kmph.

For processing LiDAR takes quite more time than that of TS data. Actual output data comes after the LiDAR survey is of size 1GB per km. So this data takes quite more time for processing. It approximately takes equal time as that of it takes for survey i.e. 70-80 kms per day. In case of TS data comes directly in excel format along with Northing, easting and elevation of every pre-defined points. This data actually needs to join.

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But in LiDAR first extraction and cropping of data takes place then selected point cloud data is joined with the help of photographs. In spite of that LiDAR is actually consumes less than 1/10 th time required for Total Station.

2) Cost-

- According to leica officials LiDAR technology is only feasible for any organization only if they can have continuous frequency of projects of more than at least 250kms otherwise the instrument can become white elephant.
- Initial cost of latest and mostaccurate LiDAR system is 3,50,00,000 INR.
- Operation cost LiDAR vendors charges approximately 25,000/km. LiDAR is made compulsory for NH DPR project.
- Other factors to be considered for cost.
  - o Skilled office staff is required because to give final output of survey first LiDAR data comes in size as 1km=1GB.
  - o GIS professionals are very important for processing of data.
  - o On site there is very few requirement of manpower as compared to TS survey.

Mobile LiDAR Technology with higher Return Of Investment (ROI) :

- ROI with the Mobile LiDAR Technology for 1000 Km :
- Cost of the System in Rs = 3,50,00,000/-
- (Pegasus Hardware & Software)
- Returns Generated in Rs = 2,50,00,000/-
- (Assuming rate of Rs 25,000/- per Km)
- Actual Expenses for execution in Rs = 1,50,00,000/-
- Net Returns in the above = Rs 1,00,00,000/-
- Number of days required = 26 days (13 + 13).
- (Assuming average survey of 75 Km / day)
- Profit or Return per day = Rs 4,34,783/-
- Profit or Return in 85 days = Rs 3,69,56,555/-
- **ROI** = 3,69,56,555 / 3,50,00,000 x 100 = **105 %**
- i.e. The cost of the LiDAR system is already recovered in 85 days of continuous work in different projects & thereby achieving more work experience & three times the turnover compared to Total Stations.

- ROI with the primitive Total Station for 1000 Km :
- Cost of the Total Station in Rs = 70,00,000/-
- (10 Total Station Hardware & Software)
- Returns Generated in Rs = 2,00,00,000/-
- (Assuming rate of Rs 20,000/- per Km)
- Actual Expenses for execution in Rs = 1,60,00,000/-
- Net Returns in the above = Rs 40,00,000/-
- Number of days required = 85 days (80 + 5).
- (Assuming average survey of 1.25 Km / day x 10 TS)
- Profit or Return per day = Rs 47,058/-
- Profit or Return in 85 days = Rs 40,00,000/-
- **ROI** = 40,00,000 / 70,00,000 x 100 = **57 %**
- i.e. The cost of the Total Stations is just 57 % recovered in 85 days of continuous work in one project only thereby achieving lesser work experience and three times lesser turnover compared to LiDAR.

Fig. 1. Return on Investment LiDAR vs Total station

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In fig. 1. Return on investment is shown from the vendor's point of view. LiDAR is giving return on investment as 105% and on the other hand 10 total station compared giving return on investment of 57%.

Again from clients point of view it seems a better deal. It takes only 5000 INR more for the LiDAR survey than TS with saving of tremendous time which will result in benefits.

3) Accuracy:-

Currently, LiDAR is used for topographic survey in so many highway projects because it is very less time consuming than conventional method. But, there are some issue regarding its accuracy. In India vehicle mounted LiDAR is mostly used. As LiDAR is operated with moving platform so it is unable to give that much accuracy as that of traditional method. In case of Topographic survey there are three applications of LiDAR must be considered i.e. DEM (Digital Elevation Model), Line Mapping and DTM (Digital Terrain Model). In DEM there is elevation of ground is measured by making use of reflection of LASER point clouds. Formulas used to measure ground elevation are as follows,

$$\text{Distance between machine and ground} = [(\text{Travel Time}) * (\text{Speed of Light})] / 2$$

To find ground elevation we have to subtract this occurred distance from the altitude of machine as follows,

$$\textbf{Ground Elevation} = \text{Altitude of machine} - \text{Distance between machine and ground}$$

By using these formulas, we can actually calculate ground elevations and this we get very rapidly by using simple computer programming. Here in these formulas we can factors which can affect the accuracy of LiDAR. Another factor is GPS observations of particular control points. It is very important to match GPS data with the topographic survey. So, on site what adjustment can be done that is needed to be studied. Final and main factor which affects the accuracy is processing of data taken by LiDAR. In this process Line mapping and DEM needs to be join if we achieve more perfection in this process more accuracy we can give in output data.
In this observed difference between Total Station and LiDAR is as follows,

X=0.129592

Y=0.207756

Z=0.137097

As survey depends on the phenomenon of relative accuracy within the points, this much difference is permissible.

3. Results and Conclusions

Here, questionnaire surveys were conducted in Industry among the people involved in highway topographic survey i.e. surveyors, highway designers, engineers, vendors.

Feasibility Criteria	Wt.	LiDAR	Total Station
Operational Feasibility	**40%**	**60%**	**40%**
		LiDAR can work in extreame weather and social scenarios.	There are limitations for total stations as a large manpower is involved.
Technical Feasibility	**20%**	**50%**	**50%**
		Highly skilled and qualified technocrats are required for processing of data. Data collected very easily at the speed of vehicle.	Throughout the survey more skilled and unskilled manpower is required. Data collection reqiures accuracy and precision.
Economic Feasibility	**30%**	**70%**	**30%**
		As it gives ROI of 105%. But it needs a large investment. Initial investment is 30 times greater than that of TS.	It gives Return on investment of 57%. But it costs much lesser than that of LiDAR.
Schedule Feasibility	**10%**	**90%**	**10%**
		It is less time consuming than Total station. Very less possibility to disturb schedule.	It is more time consuming than LiDAR. Schedule could get disturbed due to various reasons.
Total Points	**100%**	**64%**	**36%**
Ranking		**1**	**2**

Table No. 1. Feasibility Analysis

From all the data from questionnaire survey and studies related accuracy, cost and time fesibility matrix is prepared which is shown in Table No. 1. Here four types of feasibilities are considered. In all aspects LiDAR is getting edge but accuracy of LiDAR is an issue which could be adjusted during design and construction stages in road projects.

So, it is found that LiDAR is having edge in all the factors considered in feasibility study. In all aspects LiDAR is more feasible than Total Station.

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