ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume3, Special Issue 6, February 2014

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

A 3D Scanner Based Technology for Land Levelling

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ABSTRACT: In modern and intensive agriculture conditions, the importance of soil levelling is high.. It's effects are found in providing optimal and equal conditions to the crops, during yielding and growing. In areas with water excess, the soil levelling provides an appropriate water runoff, ensuring a better water management. The levelling works design is based on land surveying performed for surface units which are going to be ameliorated. Based on the survey plans, the following issues are settled: - the alignments which need levelling and the necessary optimal slopes from the efficient runoff point of view; - the areas of digging/filling, depending on optimal slopes, to minimize the volume and transport distance of the ground. The calculations are performed using "Least-squares method" or other approximate methods. Unfortunately, the use of these methods needs long time and their accuracy and effectiveness are limited. The paper gives a more effective technology to perform levelling works, which is based on the newest technology used in environmental engineering. The method is tested in Land Recovery and Environmental Engineering Faculty, and consists in using the following 3 elements of high novelty: -replacement of the classical survey with modern scanning methods using LASER technology devices; - use of modern GIS applications, developed by ESRI International, for data processing, combined with efficient CAD applications, developed by Autodesk Inc., world widely utilized; - generation of a 3D model, based on the information collected and processed in accordance with the above mentioned steps. Then The model is sent to dirt mover machine, by the aid of an operating device, using LASER technology. This way, the ground work machine can model the land with high accuracy, low costs and minimum fuel use.

I. INTRODUCTION

As water is a precious resource for agriculture, more and more producers are turning to care land-leveling to help preserve and expand their water resources. Effective land levelling optimizes water-use, improves crop establishment, reduces the irrigation time and also the required effort to manage the crop.

There are perhaps two land levelling ideas:

- to give a slope which fits a water supply;
- to level the field to its best condition with minimal earth movement and then vary the water supply for the field condition.

Land levelling design methods are the following:

- Plane method - is a simple least squares method fit of field elevations to a two-dimensional plane;
- Profile method - Essentially it consists of a trial and error method of adjusting grades on plotted profiles until the levelling criteria are met with and the earthwork balance is attained.
- Plan inspection method - The grid point elevations are noted on the plan, and the design grade elevations are determined by inspection by studying topography. It is largely a trial and error procedure.
- Contour adjustment method - The contour adjustment method of land levelling designs consists of trial and error adjustments of the contour lines on a plan map. The method is specially used for the smoothening of steep lands that have to be irrigated.

Unfortunately, these methods needs long time and their accuracy are limited. Once the surface design has been determined, a land levelling operation begins. This is usually a private contractor utilizing his equipment to move the earth into the new position on the field, and the adequacy of the land levelling depends on

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the skill of the equipment operator. The paper presents a more effective technology to perform levelling works, which is
based on the newest technology used in environmental engineering.

II. MATERIAL AND TECHNIQUES

The new technology consists of using the following 3 elements:

- replacement of the classical survey with modern scanning methods using LASER technology devices;
- use of modern GIS applications, developed by ESRI International, for data processing, combined with efficient CAD applications, developed by Autodesk Inc., world widely utilized;
- generation of a 3D model, based on the information collected and processed in accordance with the above mentioned steps.
- laser land leveling according to the generated 3D model, by the aid of a laser guided system mounted on scrapers.

A.LASER SCAN STATION

It is shown in figure 1. The main features of laser scan station are:

- measuring horizontal and vertical angles.
- measuring distances.
- recording measurements.
- computing by software.
- target search..
- visualizing the aiming direction and vertical axis.
- remote control of surveying products.
- data communication.

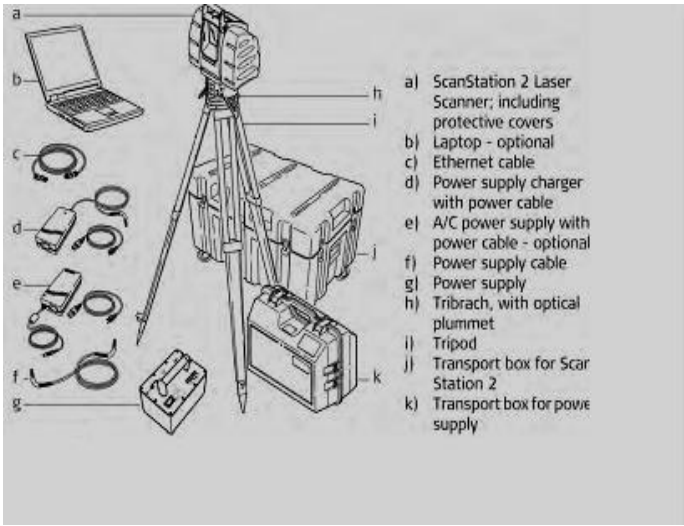

Fig.1

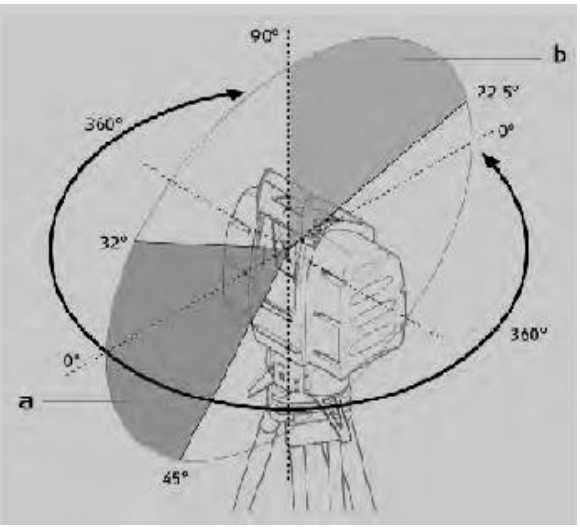

Fig.2

The scanning principle consists in selecting a scanning region that uses both the main and upper windows, the instrument automatically uses the following steps (as an example a vertical extent of -20 to 45 degrees – figure 2):

1. The instrument starts scanning using the main window and scans from -20 to 32 degrees.
2. It then makes a 180 degrees horizontal rotation.
3. It finishes the scan (32 to 45 degrees) using the upper window.

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The general technical data of the instrument are:

- pulsed, dual-axis compensated, high-speed laser scanner, with survey-grade accuracy, range, and field-of-view;
- notebook or tablet PC;
- servo motor;
- integrated high-resolution digital camera.

B.DATA PROCESSING USING SCANNER OUTPUT AND GIS APPLICATIONS, COMBINED WITH EFFICIENT CAD APPLICATIONS

AutoCAD® Civil 3D® software gives a range of features which help engineering project teams complete environmental projects and land development faster and with improved accuracy.

AutoCAD® Civil 3D®software perform the following operations:

- Supports GPS Machine Control by exporting design models with Land XML.
- uses coordinate geometry (COGO) to create, import, and manage plan metric data. Transparent commands give the flexibility to create more accurate objects from coordinate geometry.
- makes coordinate system transformations, by converting local northing and easting to defined coordinate systems; it uses sea-level scale factors and grid scale factors to more quickly and easily transforms local coordinates to projected coordinate systems;
- has extended properties for survey data, allowing surveyors to collect multiple elevations for a single point.
- Harness the power of points and manage them by using description keys, styles, and point groups.
- Set Coordinate Systems, working with more than 4,000 real-world coordinate systems more accurately.
-

C.3D MODEL GENERATION

AutoCAD® Civil 3D® software, helps engineers to analyze what-if scenarios and optimize land levelling project performance with its built-in tools for 3D model generation.

Followings are the steps to generate a 3D model and to design the land leveling :

- pull in aerial imagery and terrain models delivered by the laser scan station, importing surveying information data, making least-squares adjustment, editing of survey observations, and automated creating the survey figures and surfaces.
- build surfaces from traditional survey data, such as points and break lines. Utilize large data sets from aerial photogrammetry, and digital elevation models by taking advantage of the surface reduction tools; view the surface as contours or triangles, or create powerful elevation and slope banding analysis.
- generate parcels by converting existing AutoCAD ® entities or by using flexible layout tools to automate the process.
- perform earthwork calculations processing earth volumes between the existing and proposed surfaces using composite volume or average end area methods .
- make quantity takeoff analysis, run reports, or utilize built-in pay item lists to generate bid-ready contract documents.

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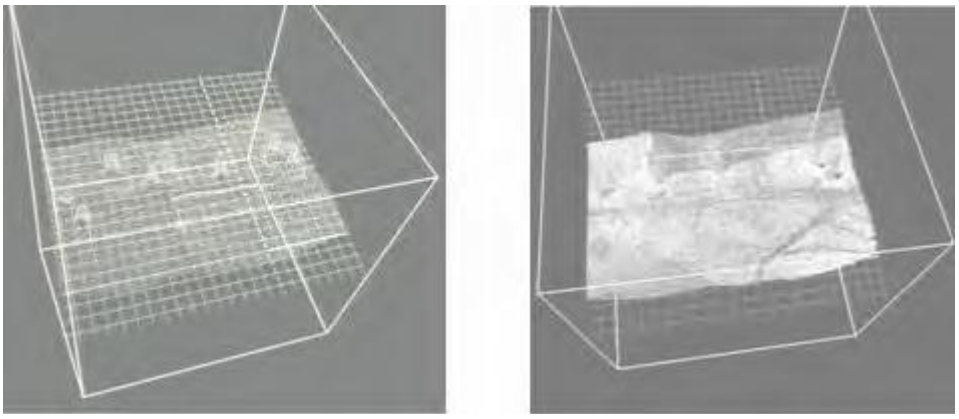

Fig 3: Building surfaces in AutoCAD Civil 3D

D. LASER LAND LEVELLING

It is a process for smoothening the land surface (± 2 cm) from its average elevation using laser equipped drag buckets to achieve accuracy in land leveling. Precision land leveling involves altering the fields in such a way as to create a constant slope of 0 to 0.2%. Large horsepower tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser-guided instrumentation are used in this method, so that the soil can be moved either by cutting or filling to create the desired slope/level . The following figure shows the principle of laser & land levelling.

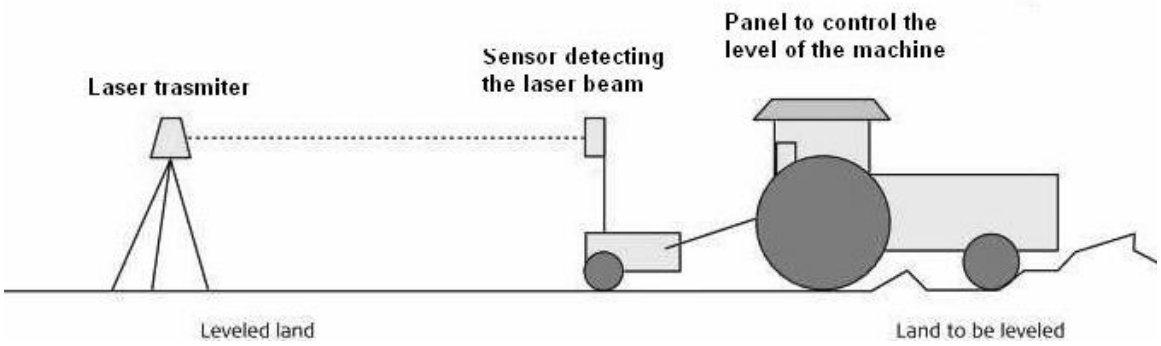

Fig 4: Laser land levelling process

Laser(transmitter) is used in the laser leveler. It emits a rapidly rotating beam parallel to the required field plane, which is picked up by a sensor (receiving unit) fitted to a tractor towards the scraper unit. The signal received is converted into cut and fill level adjustment and the corresponding changes in the scraper level are carried out automatically by a hydraulic control system. The scraper guidance is fully automatic; the elements of operator error are removed to achieve accurate land leveling. There are two units in the setup. The Laser transmitter is mounted on a high platform. Like a light house the laser transmitter rapidly rotates & sends the laser light in a circle, so it remains in a very narrow beam. The mounting has an automatic leveler built into it, so when it's set to all zeros, the laser's circle of light is perfectly leveled.

III. RESULTS AND DISCUSSIONS

The method may be tested in a Laboratory equipped with a laser scanner 3D - HDS Leica Geosystems consisting in a laser scanner, a laptop and the corresponding software for scanning, transfer and data processing. The system captures in 3D the surface geometry, structures and sites. The complete scanning process can be captured as dense and precise 3D points, called "point clouds" which forms the digital image.

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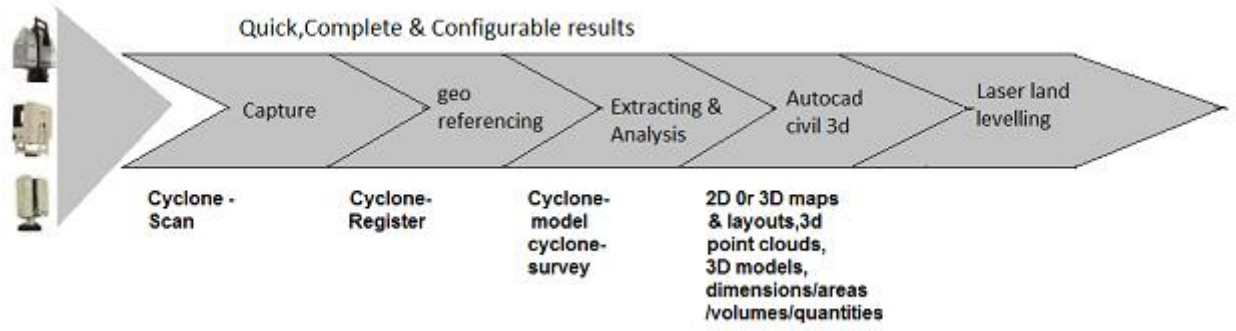

Fig 5: Land leveling modern technology chart

IV. CONCLUSIONS

These are the advantages of the new technology:

- The costs for survey measurements are low;
- It is also a safe process for the people performing the measurements;
- Reduction or elimination of the cases when is necessary to redo the measurements;
- The accuracy is high in real situation capturing on site;
- It also requires shorter time & low cost also;
- The obtained information and the resulted 3D models can be utilize by more users, improving the project management;
- better decisions about the cost of the project earlier in the design process with accurate quantity takeoff analysis
- It's accuracy is also higher in case of land levelling.

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