Earthwork verification system and improvement in presentation of geometric design of roads

Objective **— How we can control anomalies in earthwork estimates of roads/canals projects and reduce corruption level.**

INTRODUCTION

Roads are constructed in all over the world and mostly existing roads have to be improved. In BOQ's of road construction projects majority of items are well defined and can be easily verified on site. One unique item which cannot be easily verified is an earthwork volume. For earthwork volume computations survey team collects site data two times one before starting earthworks and secondly after work is completed. Due to the presence of large data sets and involvement of geometric calculations, values for earthwork volume cannot be fully verified. Commonly this item is verified by random checks. So this random check and partial verification of earthworks, opens door for introducing anomalies in documents submitted as a proof along with bills. Main objective of this paper is to present a full proof earthwork verification system as well as new improvements in presentation of geometric design of roads/canals using CivilStrips application.

DEVELOPER'S BACKGROUND

AMS Animation Lab (amslab) is a private organization, which is serving in the field of civil engineering related to Geometric Design of roads, Earthwork volume calculations and digital topographic mapping, facilitating both Govt. and private sectors since 1993. In 2007 amslab realized the need of computer software for professionals specially engaged in highways construction, who have sufficient knowledge & experience of their profession but lack of programming skills in order to automate their routine and upcoming technical problems. Amslab started to integrate their 14 years professional experience in the form of civil engineering software. After multiple beta tests, successful use of application in their own and in some client's offices, in 2008 amslab launched Pakistan's first civil engineering application CivilStrips V01.0.0.1

APPLICATION BACKGROUND

CivilStrips is a research product of amslab which include 20 years of amslab's professional experience in relevant field. Its whole development and testing is based on projects success fully completed in amslab's office since 2007. As we have experience that each civil engineering project brings new challenges in technical side so CivilStrips is an open interface application i.e. new automation tools can be easily plugged in any time on user demand. CivilStrips is a complete solution for geometric design of roads/canals and computation/verification of earthworks. It has also support for topographic mapping. CivilStrips can be effectively used in roads, railways, runways, and water streams like canals, irrigation channels, drains, and water reservoir projects. CivilStrips can be used for new and old alignments, plane and hilly sites as well as during design and construction phases.

EARTHWORK VERIFICATION SYSTEM STAGE 1

In geometric design of road this is common practice that first of all topographic survey of project area is conducted, with the help of total station and data is collected in NXYZC format i.e. Serial No, Easting, Northing, Elevation, Code. This data is imported in civil engineering application. After drawing basic details like road center line, edges, shoulders, buildings and water channels, points are triangulated and NSL data for cross sections is extracted from triangulation. As shown in figure 1. With the help of this NSL data and finished vertical alignment data, design engineer prepares cross section, computes different cut\fill area and prepares estimates of earthwork.

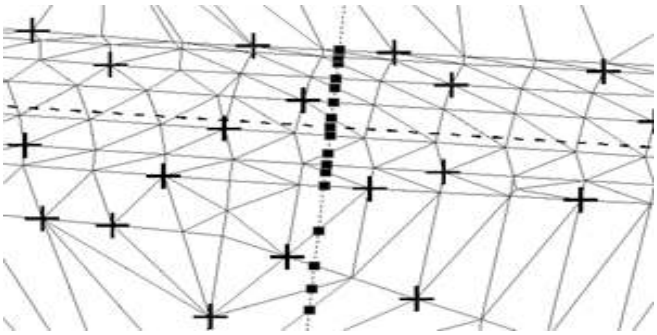

Figure 1. Data extraction for cross section at design stage

After tendering process contractor before starting construction conducts survey in the supervision of consultant. Contractor conducts cross sectional survey with level machine, and collects data in level/offset format, commonly at 25 meter intervals. As shown in figure 2. With the help of this NSL data and design data provided by client, contractor prepares cross sections, computes different cut/fill area's at each cross section and prepare measurement sheet. If earthwork quantities computed by contractor are near to the quantities mentioned in BOQ, it's OK but if computed values are less than his expectation, then at this stage he thinks to adopt such options which lead him to words introducing anomalies in submitted documents.

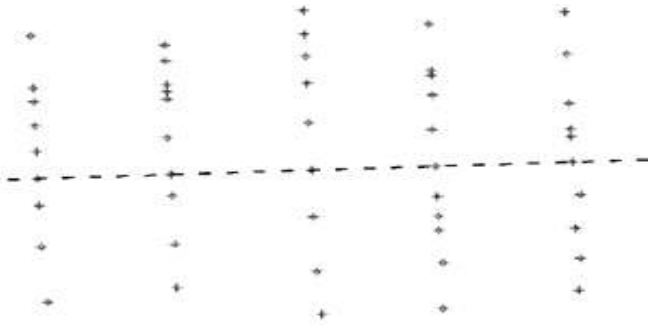

Figure 2. Cross sectional survey at construction stage

At this stage question arises that which thing is leading contractor to words introducing anomalies. So the basic thing is unexpected difference between quantities calculated by designer and contractor.

How we will decide who is wrong, designer or contractor. At this stage need of some civil engineering automation tool arises so that we can super impose NSL submitted by contractor on NSL used by designer and can easily check difference between them. Selected tool should be so efficient and user friendly that for 60KM road having 2400 cross sections it can analyze data quickly and easily.

But this is not solution. Why we blame to design engineer or to contractor. We will blame to system. Designer and contractor are using two different systems for taking natural surface levels (NSL). Designer's NSL are based on random shots at changing features and contractor's NSL are based on linear shots commonly at 25M intervals perpendicular to the alignment of road. Designer's NSL are based on interpolation while contractor's NSL are exact site observations. Neither we can divert design engineer to words cross sectional survey nor we can divert contractor to words topographic survey.

Human behaviors also play an important role at this occasion. Designers surveyor while surveying knows that during construction phase nobody is able to verify random shots, and

contractors surveyors knows that there is no such tool is in use with designers to check my 2400 cross sections thoroughly so what is the solution.

The best solution is that when designer complete designing of horizontal and vertical alignments of road, on his finished designed alignment he should conduct cross sectional survey at points where in future contractor will do survey. For preparing earthwork estimates, instead of topographic survey data he should use cross sectional survey data. With the help of cross sectional survey, designer should produce cross sections showing all necessary features for the satisfaction and construction need of contractor like super elevation, road edges, shoulder edges, existing drains, proposed drains, walls and catch points etc.

After tendering process when contract is awarded to contractor he should conduct cross sectional survey in the supervision of consultant and instead of making any new cross sections his NSL should be simply super imposed on designers cross sections for cross checking. As NSL of designer's cross sections and contractors cross sections are taken from the same system and same center line point so there will be minimum and negligible difference between offsets and levels of cross sections. In this case client, consultant, and contractor all the three parties will be satisfied on earthwork quantities mentioned in BOQ. This process shuts the door for introducing any anomaly. Consultant's QS is also a human being. For getting desired quantities contractors try to develop soft corner in his heart, by giving the job of preparing cross sections to him. As in this process contractor does not have to prepare cross sections so consultant QS will also concentrate on his responsibility only. This practice saves the time and money of contractor. Contractor will not have to prepare cross sections again and again till the satisfaction of consultant. He will fill contract documents with full confidence. Designer will also feel ease, because in this way he will not have to change design again and again.

CivilStrips have tools through which we can super impose NSL submitted by contractor on NSL used by design engineer and verification process can be done in minutes. So for getting above goal design engineer must have to prepare cross sections in CivilStrips. In future for any work done bill, when ever contractor submit cross section, his NSL can be quickly checked against already verified NSL of Joint survey. For this contractor also have to prepare cross sections in CivilStrips. What we can do when

- Designer refuses for additional cross sectional survey.
- Design has been done, contract is awarded to contractor and we are at the stage of joint survey.
- Quantities calculated from Joint survey are accepted, and we are at the stage of work done bills.
- Road construction is completed, but contractor is demanding additional quantities.

In the above mentioned situations we have to keep loin's eye on documents submitted as a proof of quantities along with bills. For the full verification and transparency of claimed quantities we have to adopt following methods. Look at stage 2 of earthwork verification system.

EARTHWORK VERIFICATION SYSTEM STAGE 2

- How we will verify that volume computation worksheet is correct and cut/fill area values labeled on cross section sheets are same as shown in volume computation worksheet. If we have 60 Km road then either we have to check cut/fill area labels of at least 2400 cross sections against volume computation worksheet or we have to random check. Full checking is more tedious and time consuming process, while random check may lead to words anomalies. If contractor have prepared cross sections in CivilStrips then through volume computation module, we can recalculate cut/fill volume within minutes. So measurement sheets can be quickly and fully verified. Here direct use of CivilStrips application shuts the door for anomalies in work done bills.

- How we will verify that area values labeled on cross sections are correct and cut/fill area computed against NSL and Design lines is the same as shown on cross section. This item is also important to check. On each cross section multiple cut/fill area are summed up and labeled on corner of cross section. We have two options either we use random check on selected sections which may lead to word anomalies because in this way whole document will not be verified but partially verified. Another way is to recalculate all the area values manually for each cross section, which is extremely laborious time consuming and some time practically impossible. So CivilStrips have an area verification tools. As shown in figure 3. With the help of which we can verify cut and fill area values of 2400 cross section with single click and with in minimum time.

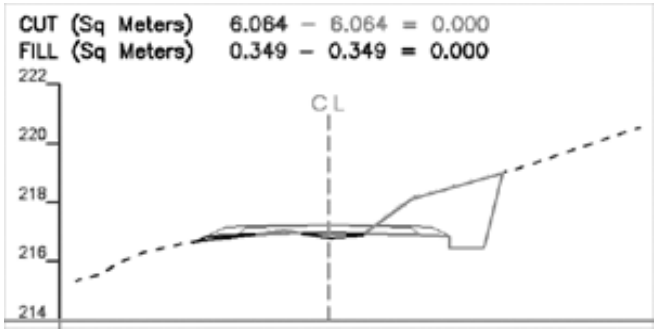

Figure 3. Verification of area labels mentioned

- How we will verify the consistency between NSL Line and levels labeled on cross sections. If we have verified NSL of Joint Survey, through CivilStrips we can supper impose Verified NSL on work done cross sections. When we plot both NSL on each other and check them then there is no need of Levels and Offsets Verification. If currently we have not NSL of Joint Survey and we want to check that Levels are of the same NSL Line we can re plot NSL Line from Mentioned Levels. So this tool also closes the door for manually changing the levels of NSL line and keeping NSL Labels UN touch.

By implementing above mentioned suggestions every client can easily control the anomalies in earthwork estimates and can reduce corruption level.

IMPROVEMENTS IN PRESENTATION OF GEOMETRIC DESIGN OF ROADS

As we have mentioned earlier that CivilStrips is a research and project based product of AMS Animation Lab. Majority of the tools are added in application on user demand. We have tried to maximize the automation process of geometric design of road so that design reviews can be done with less effort and minimum time. Following are some new additions in presentation of geometric design. One can find some features already present in other applications. After study of that applications we have also enhance that features. User can find maximum tools under one umbrella.

1. It is common practice that only finished road levels (FRL) of center line are mentioned on plan/profile sheets. With CivilStrips we can mention complete FRL i.e. Center, Both Edges and shoulders on plan/profile sheets. As shown in figure 4.

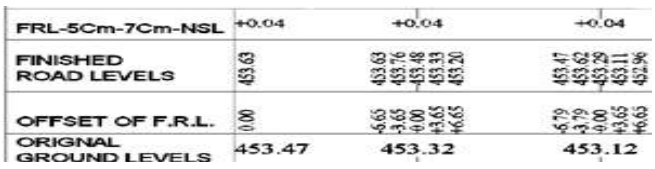

Figure 4. Full FRL and Vertical Differences

2. Graphical representation of earthwork can also be shown in profile data fields. As shown in figure 5.

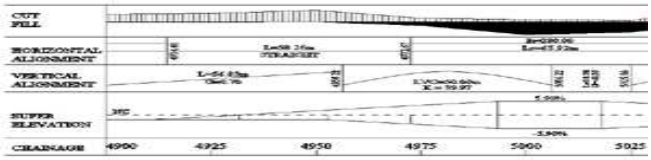

Figure 5. Area graph, linear plan of horizontal and vertical alignment and super elevation

3. Now we can project finished horizontal alignment on NSL line in profile graphical area.

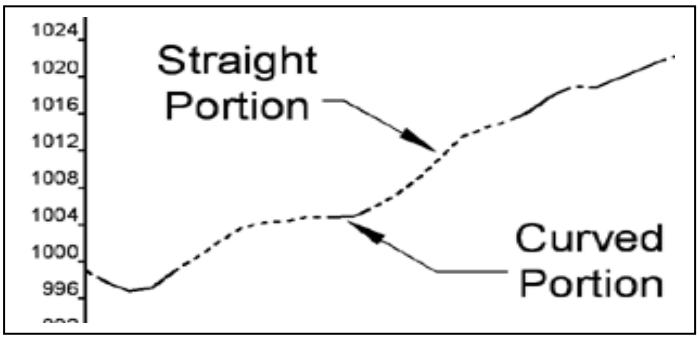

Figure 6. Finished horizontal alignment in long section for easy establishment of coordination between horizontal and vertical alignment.

4. Remarks in the form of labels or dimensions can be shown in profile data fields
5. Conditional earthwork calculations can also be done easily.
6. Full support for labeling sections and profile, having no of options
7. Cross sections for work done bills can also be prepared
8. You can visually design and tune both alignments for accepted earth work estimates.
9. Graphical representation of super elevation and linear representation of horizontal and vertical alignments are easy to plot. As shown in figure 5.
10. Automatic vertical distribution of profiles in case of extreme grades.

More detail and advance features of CivilStrips application can be watched on Birds' eye view section of www.civilstrips.com. CivilStrips is a world most light weight application, Net executable size is less than 5 MB. So far we know, it's a Muslims world first civil engineering application for geometric design of roads and canals. Its documentation and video tutorials are complete learning guide for civil engineering students. Its fully visual interface make it more user friendly. We hope that suggestions and solutions regarding anomalies in earthwork quantities will help to reduce corruption levels in department of transportation.

Thanks
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