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Use of Satellite Data for Feasibility Study And Preliminary Design Project Report for Urban Development And Highway Cross Drainage Structures

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ABSTRACT: In the developing countries like India, need of infrastructure is very high as compared to the available resources. The various organizations put their demands to state and center government for sanction of their project, government depends upon its various department to provide an approximate cost so that priorities can be assigned. The conventional procedure depends upon the land surveying, collection of data from various departments resulting in delay in necessary decision making or some time shelving due to unreasonable cost estimate due to field data being very old. Survey of India, The National Survey and Mapping Organization single handily taking this responsibility thus up gradation of data is far behind the actual development. From the satellite data, which is available in the form of images and terrains (even in 3d LiDAR points for some areas) is very useful for Feasibility Study, and Preliminary Project Report. In the present study natural drain named 'Chai Nala' meanders through the prime property of Greater Mohali Area Development Authority (GMADA) thus making a big chunk of commercial land inoperative. It was proposed to straighten and channelize to reclaim the land from drain regime. Being the precious land department wanted the most economical and technically sound design without taking any risk. It was decided to counter check the hydraulic data, ground profile, acquired from the Punjab Irrigation Department with the satellite data and Differential Global Positioning System (DGPS). The data from the Google Earth was acquired using Cad Earth software and water shed analysis was carried out using Autodesk Civil 3D software. Comparison of results shows that this technique is quite useful and can be for preliminary feasibility and project preparation. Thus saving huge money and time.

Keywords: LiDAR, DGPS, Cad Earth, Civil 3D, Preliminary Project Report, Feasibility Study.

I. INTRODUCTION

Watersheds area can be categorized as gauged and ungauged catchments [1]. Majority of the basins are either thinly gauged or not gauged at all, where the lack of hydrological and catchment information becomes hurdle in planning [2]. As per Sing et al. [1], hydrological response from each catchment assists in flood routing and in flood modeling and flood forecasting. Schumm [3] apprises that water and sediment discharge are the principal determinants of the dimensions of a river channel and its gradient. Physical characteristics of river channels, such as width/depth ratio, alignment significantly affected by the flow rate and sediment discharge. According to Bhatt and Tiwari [2], channel geometry method is an alternative mode of estimating flood discharge for regional flood frequency analysis. River bed characteristics such s channel width, cross-section area, river bed gradient, and bank side slope are crucial parameters for alternative techniques of discharge estimation.

In hydrology, the term "peak discharge" stands for the highest concentration of runoff from the basin area. The concentrated flow of the basin greatly exaggerated and overtops the natural or artificial bank and this might be called flood [4]. LiDAR - Light detection and ranging, an effective and productive technology used to collect accurate terrain data with the help of unmanned aerial vehicle. LiDAR technology evaluates properties of reflected light to determine type and range of a remote object (Lefsky et al., 2002)[5]. LiDAR systems coupled with accurate positioning and orientation systems can obtain precise 3D measurements of earth surface in the form of point cloud data by using high sampling densities (NOAA, 2012)[6]. LiDAR along with very high-resolution satellite imagery can reduce the time consumption, labor and enhance geographical accessibility to a significant extent. Display of full-resolution images derived from lidar in the Google Earth virtual globe is a powerful way to view and explore these data. Through region-dependent network linked Keyhole Markup Language (KML). Users are able to access LiDAR-derived imagery stored on a remote server from within Google Earth. This method provides seamless, Internet-based access to imagery through the simple download of a small KML-format file from the Open Topography Facility portal. This data can further easily analysed with civil 3D software

II. STUDY AREA AND DATA

Greater Mohali Area Development Authority (GMADA), as the nodal agency set up by the Government of Punjab for implementation and development of infrastructure projects, as per Master Plan in District SAS Nagar, intends to develop I.T City in S.A.S Nagar. Accordingly, the District Town Planner, SAS Nagar, has prepared a layout plan of I.T City consisting of areas for industrial, residential, commercial and mixed use along with areas for public buildings, schools, police stations, community-center, parks etc. A natural drained named "Chai Nala' flows through the proposed layout plan of I.T City and a part of this meanders through part layout where public buildings, residences and institutional area has been planned. GMADA has required that this part of the drain be straightened so as to reclaim the valuable land and utilize it for the ear-marked purpose. The project is located adjoining to the boundary of the IT city towards village Manauli and the location is shown in the Sattelite Plan Fig.1

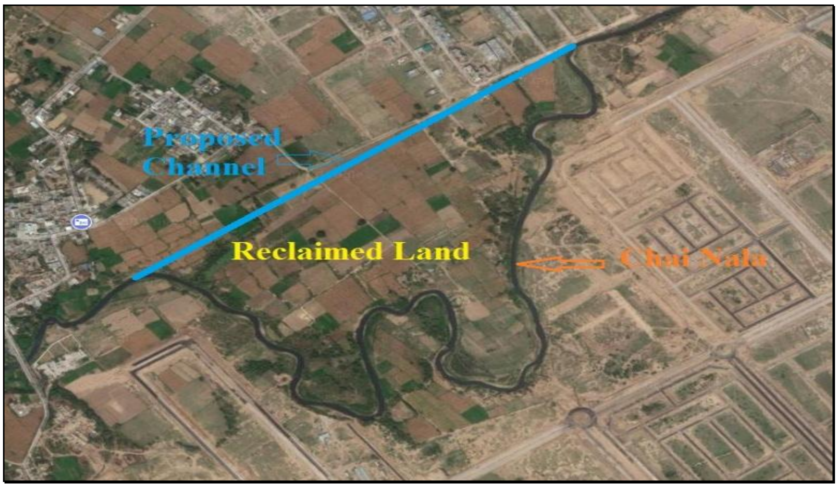

Fig. 1 Sattelite Plan shwoing the Chai Nala (Drain) alignment

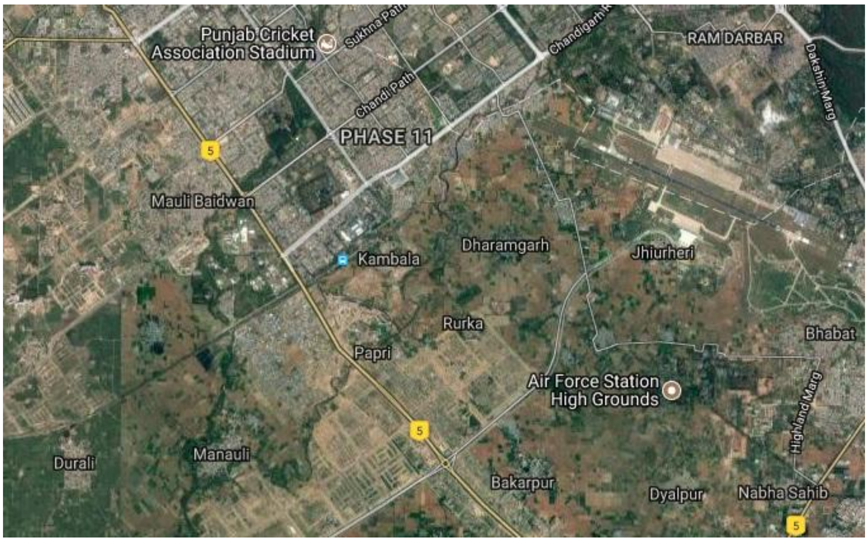

Fig. 2 Sattelite plan of the catchment area of the Chai Nala SAS Nagar, Mohali

The meandering length of the drain about 1800 m whereas the proposed length of realigned channel is 910 meter. With bed width as 90 m side slopes 1.5:1 (H:V) with side pitching to cater the design discharge of 3600 cfs. The research problem is to study the possibility of verification of design discharge, bed slope and average runoff coefficient using satellite data.

METHODOLOGY

The surface run-off resulting after precipitation contributes to the storm water. The quantity of storm water reaching to the sewers or drains is very large as compared with sanitary sewage. The factors affecting the quantity of storm water flow are as below:

i. Area of the catchment

ii. Slope and shape of the catchment area
iii. Porosity of the soil
iv. Obstruction in the flow of water as trees, fields, gardens, etc.
v. Initial state of catchment area with respect to wetness.
vi. Intensity and duration of rainfall
vii. Atmospheric temperature and humidity
viii. Number and size of ditches present in the area

Methods for Estimation of Quantity of Storm Water

1. Rational Method
2. Empirical formulae method

In both the above methods, the quantity of storm water is considered as function of intensity of rainfall, coefficient of runoff and area of catchment. Time of Concentration: The period after which the entire catchment area will start contributing to the runoff is called as the time of concentration. The runoff will be maximum when the duration of rainfall is equal to the time of concentration and is called as critical rainfall duration.

Time of concentration = Inlet time + time of travel

Inlet Time: The time required for the rain in falling on the most remote point of the tributary area to flow across the ground surface along the natural drains or gutters up to inlet of sewer is called inlet time (Figure 6.1). The inlet time 'Ti' can be estimated using relationships similar to following. These coefficients will have different values for different catchments.

Where,

Ti = [0.885 L3/H]0.385 (1)

Ti = Time of inlet, minute

L = Length of overland flow in Kilometer from critical point to mouth of drain H = Total fall of level from the critical point to mouth of drain, meter

Time of Travel: The time required by the water to flow in the drain channel from the mouth to the point under consideration or the point of concentration is called as time of travel.

Time of Travel (Tt) = Length of drain/ velocity in drain (2)

Runoff Coefficient: The total precipitation falling on any area is dispersed as percolation, evaporation, storage in ponds or reservoir and surface runoff. The runoff coefficient can be defined as a fraction, which is multiplied with the quantity of total rainfall to determine the quantity of rain water, which will reach the sewers. The runoff coefficient depends upon the porosity of soil cover, wetness and ground cover. The overall runoff coefficient for the catchment area can be worked out as follows:

Overall runoff coefficient, C = [A1.C1 + A2.C2 + ….+ An.Cn] / [A1 + A2 + …+ An] (3)

Where, A1, A2,.An are types of area with C1, C2, …Cn as their coefficient of runoff, respectively.

The range of Coefficient of runoff is normally as under

Type of Cover	Coefficient of runoff
Business areas	0.70 – 0.90
Apartment areas	0.50 – 0.70
Single family area	0.30 – 0.50
Parks, Playgrounds, Lawns	0.10 – 0.25
Paved Streets	0.80 –0.90
Water tight roofs	0.70 – 0.95

Storm water quantity can be estimated by rational method as below:

Storm water quantity, Q = C.I.A / 360 (4)

Where,

Q = Quantity of storm water, m3/sec C = Coefficient of runoff

I = intensity of rainfall (mm/hour) for the duration equal to time of concentration, and

A = Drainage area in hectares

For the verification of the design data and its sufficiency to cater the future needs for at least 50 years, study is conducted as described below.

1) Collection of Satellite Data:

The satellite from Google Earth is collected through as per detail procedure described in the Google Earth Manual, 2007 and Cad Earth Software using Cad Earth 2013 manual, after geo-referencing the drawing.

2) Processing of data:

The downloaded data is exported into any suitable software Mx Road, Civil 3D or Auto Plotter are various option available in this study Autodesk Civil 3D is used. The data is checked for any discontinuity or any flaw while transposing from one format to another. The 3D terrain is randomly checked for ground truthiness, (Rick Ellis 2012) [7]

3) Generating the Catchment Area and Water Drop using Civil 3D software.

The catchment area and water drop analysis with terrain slope and surface runoff coefficient gives the basic input for calculation of surface runoff if rainfall data is available. The detail procedure is described in Manual for (Civil 3D 2013) [7].

4) Creating Channel profile using Civil 3D

The channel cross section and longitudinal section are drawn using civil 3D [7] inbuilt features, to find the channel slope cut and fill depth stability of side slopes can be performed as per the standard procedure.

5) Calculation of Design Discharge and Section Requirement

Fig. 3 (a) Effective catchment area of Chai Nala

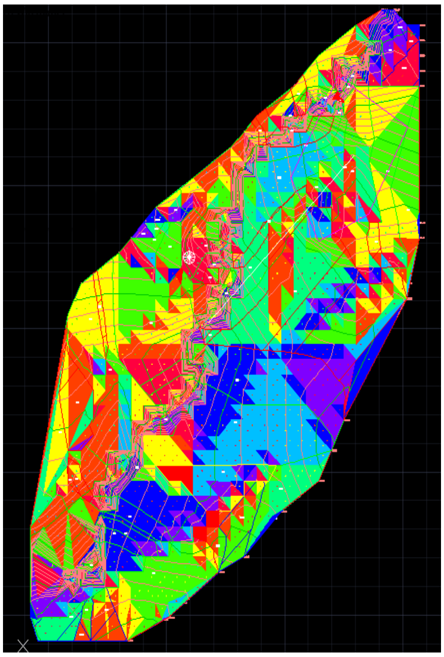

Fig. 3 (b) Watershed analysis showing water basins

The intensity of rainfall for one hour-storm duration for various return periods was indicated as under:

a. 2 years return period: 43.7 mm/hr. (1.72 inch/hr.)
b. 5 years return period: 58.2 mm/hr. (2.29 inch/hr.)
c. 10 years return period: 63.2 mm/hr. (2.73 inch/hr.)
d. 25 years return period: 83.8 mm/hr. (3.30 inch/hr.)

The characteristics of urban areas are different from rural areas. Due to high concentration of population and economic activities in urban area the loss to life and property is much higher compare to rural area. This necessitates a different approach for design of storm water drains in urban areas (NCR Report, 2016) [8]. The Indian Roads Congress (IRC) brought out guidelines on urban drainage (IRC SP:50 1999) [9]. This provides guidance for drainage design for roads, but does not provide design information on rainfall intensities to be adopted for various cities. For example, it mentions that Mumbai drains are being designed for 50 mm/h and Chennai for 25 mm/h, but does not provide guidelines for future planning for other Indian cities. This will take into account current international practices, the locations specific factors and rainfall pattern of the cities and future needs. The adjoining Punjab and Haryana capital city is designed for ½" /hour intensity and presently the need for up gradation is cropping up. Hence in this study the surface run of 1"/hour is considered. The hydraulic data is processed using Microsoft Excel Spreadsheets. The peak discharge verses time is shown in Fig.4.

Table I: Details of the catchment area derived using Autodesk Civil 3D software

⊟ General	
Revision number	0
Number of points	1106
Minimum X coordinate	665387.170m
Minimum Y coordinate	3390342.980m
Maximum X coordinate	670530.420m
Maximum Y coordinate	3397232.400m
Minimum elevation	278.810m
Maximum elevation	317.740m
Mean elevation	298.119m
⊟ Extended	
2D surface area	20900517.55sq.m
3D surface area	20912372.98sq.m
Minimum grade/slope	0.00%
Maximum grade/slope	539.40%
Mean grade/slope	1.52%

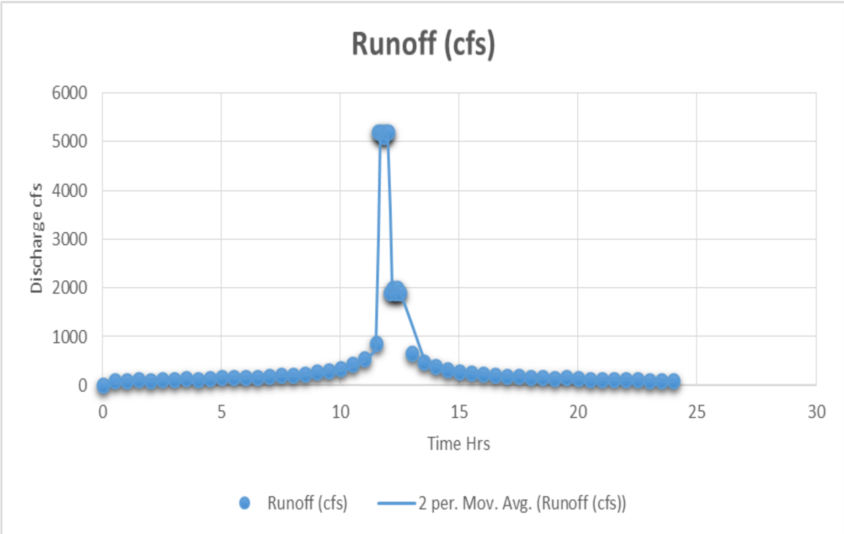

Fig. 4 Graph shwing the peak runoff with respect to time.

III. COMPARISON OF DISCHARGE CALCULATIONS

Discharge is the volume of water moving down a stream or river per unit of time, commonly expressed in cubic feet per second or gallons per day. In general, river discharge is computed by multiplying the area of water in a channel cross section by the average velocity of the water in that cross section. As the open channels don’t have definite cross-section profile. Calculation of discharge in plain areas is always challenging job. This site being in foothills of Shivalik Hills have relative steep slope and well-formed cross section hence the comparison of results could be very useful for future works of highway cross drainage design and calculation of discharge for bridge structures. The results obtained from the satellite data and that provided by irrigation are given in Table 2.

Table 2: Comparison of conventional and satellite data based results

Design parameter of open channel with side slope 1.5H: 1V with side pitching				
Design Parameter	**based upon old office data**		**based upon current satellite data**	
Peak Discharge	3600	cfs	5195	cfs
Velocity	6	ft/sec	6	ft/sec
Designed Bed Width	90	ft	133	ft
Depth of Water at FSL	6	ft	6	ft

IV. DISCUSSION

The variation in peak runoff and subsequently wider design section of the drain is due to change in the surface porosity of the catchment area. The weighted average porosity can easily be calculated from the satellite imagery data. That clearly differentiate between buildings, roads, cultivated farms and green cover of trees and shrubs thus better calculation of surface runoff is possible. Google earth data can serve good purpose for preliminary design report and feasibility study of any large scale land development and infrastructures. The areas where LiDAR enabled satellite data is available, it can be confidently used for detailed project reports also. The major advantage of this technique that various development agencies can put their future planning in the form KMZ on Google earth so that other planning agencies can incorporate their implication on project by simply merging all data in a single platform.

V. CONCLUSION

From the above study the following conclusions are drawn.

1. Satellite data is very useful for preparation of preliminary project report, conducting preliminary feasibility study, as it involves a fractional time cost as compared to conventional procedure.
2. The data collected are almost current data and brings the higher level of confidence when all the design data is available from horse's mouth.
3. The seamless connectivity of satellite data with other data collected during initial investigations during project implementation and operations can easily be superimposed on the drawings.
4. The verification of data is very easy as the hand held GPS and even the mobile phone applications are capable to trace the point on ground very easily.
5. The locations where high accuracy LiDAR enable satellite data is available the accuracy can further be enhanced to the normal working level.

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