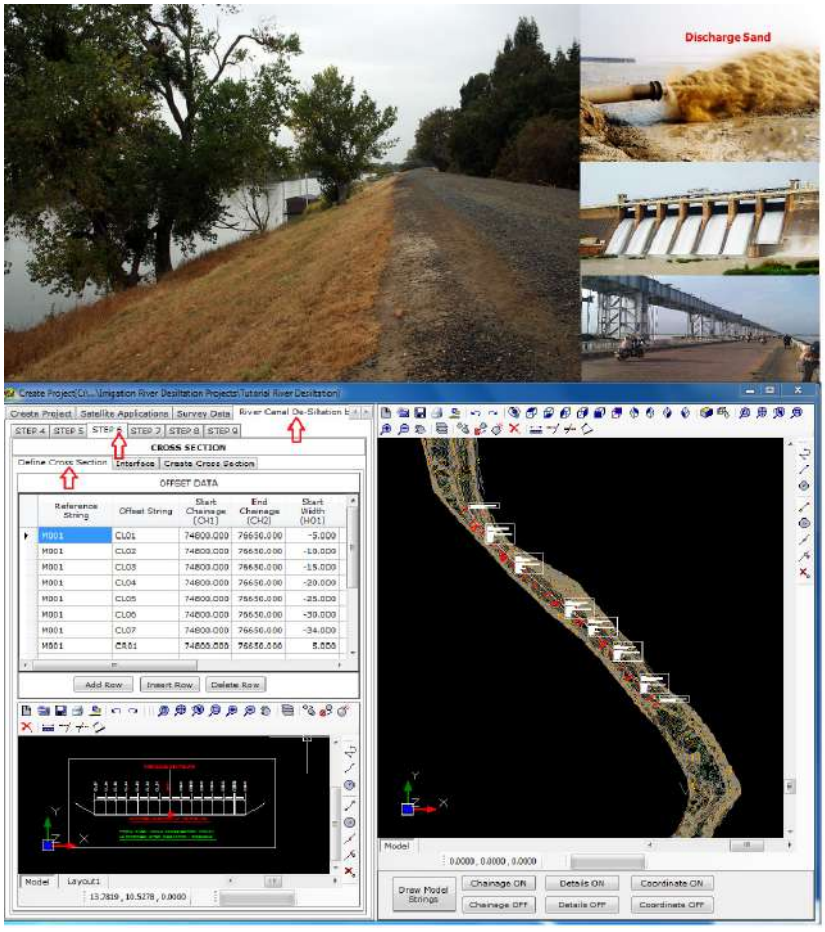
HEADS Site - Irrigation

The largest software system for Water Resources, River Training Works, Stream Hydrology for Flood Control, De-siltation Quantity Estimation, Designing of Hydraulic Structures

HEADS Site is effectively used for constructions of Hydraulic Structures in Irrigation projects, Stream Hydrology, industrial and residential plants with Pipe network for water distribution system etc. The highly powerful software also features for specified water discharge from Dam or Barrage by reading fall of water levels, this uses processing of elevation data as received for satellite.

HEADS Site software has facilitates for various infrastructure development projects by processing Topographical and Spatial Survey Data obtained either from field survey or downloaded from satellite.



Cloud based Process / Storage / Sharing facilities are available as optional. On procuring multiple licenses, say, four licenses, and installing at four different locations anywhere in the country/world, the project name, user name and password may be shared with those four license locations. They all can access cloud server to view the design and drawings, modify, re-process, download, upload the work at the cloud storage 'Techsoft Drive'.

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TechSOFT
web: www.techsoftglobal.com

Introducing HEADS SITE The Versatile Software For Irrigation and Water Resources Project Design

We are pleased to introduce to our versatile software HEADS Site for Irrigation and Water Resources Project applications featuring processing of Survey data, Land Record Management and Site Development and various Irrigation and Water Resources Engineering Applications. The detail Technical Specification is described in following sections for your reference.

HEADS Site is CAD based software and has full range of applications **Survey applications**. It handles various Survey data, DTM, Triangulation, Contour, Satellite images, Conversion from TM (Survey) to UTM (GPS) Coordinates, Communication with Google Earth to plan for Alignments of Canals or Dykes, Use of elevation data for River Bed/Reservoir Bottom/Natural Ground by Online downloading from Shuttle Radar Topography Mission (SRTM) from Internet without any Field Topo Survey, Alignment Geometric design for Road / Canal / Bund / Dyke Traversing with closing error corrections by Bowditch, Transit, Closed Link, EDM, Ground Sections in CAD Drawings.

HEADS Site is also useful for maintaining, retrieving **Land Data Records** with various details useful for Land Acquisition and Information purposes.

HEADS Site has full range of applications for **Site Leveling/Grading projects**, Earthwork quantity estimation for Cut & Fill, Mass Haul Diagram, Design of Construction platforms etc.

HEADS Site has full range of applications in **Irrigation projects** design and Bill of Quantities for Canals, Bunds, Dykes, Guide-Banks, River Bed protection against scour, De-Siltation Dredging work, Measurement of irregular shaped Stock piles for dredged quantity or river bed materials and boulder stock piles to be used for protection of river bed erosion. The Volume of storage and discharged water at a Dam or Barrage Site may be estimated by measuring the fall of water level, creating Digital Terrain Model (DTM) and Contours generated by using SRTM Ground Elevation data of the reservoir bed level, downloaded from satellite without any field survey work.

HEADS Site features for **Slope Stability Analysis**. The analysis is done by Bishop's method using program SSA. Slope stability analysis is performed to assess the safe design of a human-made or natural slopes (e.g. embankments of dam, dyke, road, cuts, open-pit mining, excavations, landfills etc.) and the equilibrium conditions. Slope stability is the resistance of inclined surface to failure by sliding or collapsing.

HEADS Site features for **Stream Hydrology** by measuring ground elevation and river width data on the up stream side for up to 40/50 km and processing the data for plotting **Synthetic Unit Hydrograph (SUH)** by com paring sum of discharge for 1 hour interval of Time and volume of 1 cm direct Runoff. This provides determining the adequacy of the waterway.

HEADS Site has facilities in design for **Water distribution** Pipe Network with output showing Pipe wise Diameter, Discharge, Pressure Heads at nodal points with DisNet program supplied along with.

HEADS Site has facilities in design for **Surfae Drainage** based on storm water duration and hydrological data and by using manning's coefficients the adequacy of the proposed drain section is checked.

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We therefore request you to use HEADS Site in your projects to experience the difference with all other products in this category. We request you to please call us or write to us, in case you want to discuss on any matter, we shall be waiting for your reply, Visit our product web site www.techsoftglobal.com for downloading Installation Setup of the Trial Version, Various Tutorials, Tutorial Videos etc.

HEADS Site Setup and Tutorials are available for download from our web site www.techsoftglobal.com, We suggest you to download 32 Bit PC/Laptop Version for Windows 7 and to download 64 Bit PC/Laptop version for Windows 8/10 which is large in size and requires strong internet connection to download. Before purchase, you may copy each the Design Manual to your PC/Laptop and process the Example data following the steps in the Tutorial guide.

HEADS Sites: Survey and Design Applications

HEADS Site is the effective tool for various needs as one stop solution with latest satellite technology applications by using software Global Maper.

Survey Applications

- Processing of Total Station Survey Data
- Processing of Autolevel Survey Data
- Processing of Bearing Line Data
- Processing of Robotic Total Station Data
- Processing of Drawing File in 3D
- Ground Modeling by Digital Mapping, Triangulation and Contours
- Bowditch method of Closing Error correction of Traverse Survey Data
- Transit method of Closing Error correction of Traverse Survey Data
- Closed Link method of Closing Error correction of Traverse Survey Data
- EDM method of processing Traverse Survey Data

Land Record Management

- Land Record Data Entry
- Land Record Retrieval from Land Map Drawing
- Manual Entry of Land Records
- Saving as CSV file compatible to MS Excel

Site Leveling and Grading

- Design of Vertical Profile of the Control Line
- Design of Construction Platforms at desired levels considering drainage
- Earthwork Volume for Cut & Fill with mass Haul Diagram
- Drawings for Ground Plan, Profile and Cross Sections

Irrigation Applications

River Training Works

- Guide Banks and Earthen Dykes
- Distribution Canals
- Stream Hydrology for adequacy of waterways and Flood Control
- Estimation of water volume from rise or fall of water level

Slope stability analysis

- Analysis of Stability of Slopes by Bishops Method
- Determination of Factor of Safety

Earth Dam or Dyke Design

- Design of Horizontal Alignment of the Control Line
- Design of Vertical Profile of the Control Line
- Design of Cross Section
- Earthwork Volume for Cut & Fill
- Drawings for Plan, Profile and Cross Sections

Concrete Gravity Dam Design

- Safety against Piping
- Stability against Shear Failure, Over Turning and Sliding
- Seepage

Canal Design

- Design of Horizontal Alignment of the Control Line
- Design of Vertical Profile of the Control
- Design of Cross
- Earthwork Estimation for Cut & Fill
- Drawings for Plan, Profile & Cross Sections

River and Canal De-Siltation by Dredging

- Design of Cross Section
- Dredging Quantity Estimation for Cut & Fill
- Drawings for Plan, Profile & Cross Sections

Measurement of Stockpile Quantity

- Ground Modeling, Triangulation and Contours
- Measurement of Stockpile Quantity

Stream Hydrology

- Analysis for Stream Hydrology
- Drawing of Synthetic Unit Hydrograph (SUH) by comparing sum of discharge for 1 hour interval of Time and volume of 1 cm direct Runoff.

Design of Water Distribution Pipe Network

- Process Survey Data
- Ground Modeling, Triangulation and Contours
- Create Pipe Loops, Process to get Pipe Discharges, Node wise Pressure Heads etc.

HEADS SITE SURVEY APPLICATIONS

Processing of Total Station Survey Data

Trimble GPS Receiver R8 with Communications

Trimble GPS Receiver R10 with Advanced

Trimble R8 Model 4 trimble gps receiver

HEADS Site software uses Total Station Survey Data for processing Topographical details most effectively and economically in various Construction Projects for Site Leveling and Grading which is the primary job for Land Development. The developed land is used for platforms for the construction of Housing projects, Industrial plant projects, extension of urban Areas, design of roads, parking lots, planning & design of Airports, Tunnel projects, Irrigation projects, Mining projects, Water Distribution System along with Land Record Management etc.

HEADS Site prepares Survey Base Plan or Ground Model from the ground survey data with Total Station. By selecting drawing feature symbols from CAD Block library, the various texts obtained from the surveyors are also placed correctly in the Base Plan drawing. The drawing is made in CAD layered system and is compatible to AutoCAD and other popular CAD softwares.

HEADS Site develops the Digital Terrain Model (DTM) by using the Total Station survey data by Triangulation and subsequently processed for contouring. The area may be identified by site reconnaissance survey and by using Topographic maps along with satellite imageries. The ground elevation data may be either obtained by Total Station Survey or by downloading from SRTM (Shuttle Radar Topography Mission) by using internet. User may procure the computer program Global Mapper to download ground topography data from internet.

Processing of Autolevel Survey Data

The Autolevel data contains Chainages at a regular / constant interval, the distances on the cross section on either side of the centre point 0.0, left side in '-ve' & right side is '+ve' and the elevations (Z) at all distances on either side of the centre point. The data do not have Easting (X) and Northing (Y) at these points where (Z) is available. So, to get Easting (X) and Northing (Y) at these points an alignment is to be defined, which passes through the centre point at '0.0' of each cross section. Referring to this alignment the program will obtain the X & Y Coordinates of each point on the cross section, this helps in making Triangulation, Digital Terrain Model and finally the Contours of the ground. Only the survey base plan drawing by digital mapping will not be created from ground model, which needs Total Station data for reading various features like Houses, Drains, Electric Poles, Boundary walls etc. on the ground.

Processing of Bearing Line Data

The Bearing Line method of survey is very widely used in the design of hill roads. Every hill road commonly has hill on one side and valley on the other side. In Bearing Line Survey the traverse passes through the foothill side, which changes its side with respect to the road to stick to the hill.

Processing of Robotic Total Station Data

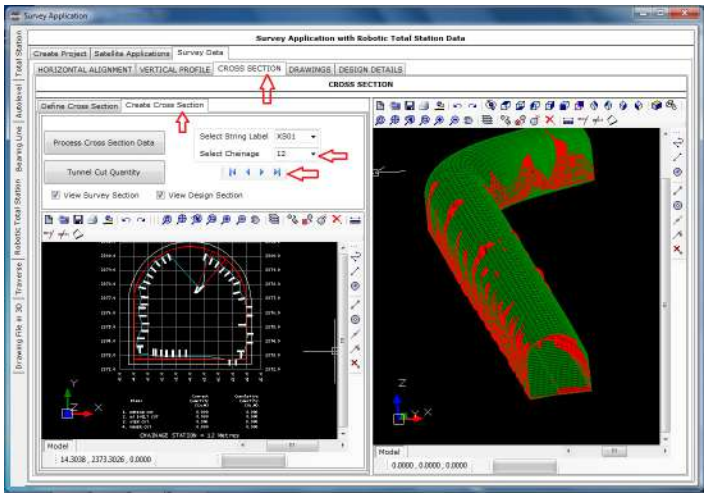
PTS-120R touch screen trimble robotic total station

PTS-120 touch screen trimble robotic total station

TRIMBLE TOTAL STATION robotic total stationRTS-633

US original robotic total station ,trimble robotic total station S6

The Robotic Total Station survey data is very widely used in the construction of Bored Tunnels for Waterway in Hydraulic Power Projects. This is to be noted that the survey is carried out after the boring is done for the tunnel, by following the design horizontal alignment, vertical profile and proposed cross section for the tunnel. The survey data is used to estimate the actual boring against the design cross section of the tunnel. At every chainage the **As-Biult and Design Cross Sections** are plotted. From the cross sections the **'Under Cut'** and **'Over Cut'** quantities are computed by comparing the as-built against the design cross section. Some times in case of excessive overcut the cut quantity is considered up to certain extent outside the design cross section, which is marked as the '**Pay Line**'. Proper measures are to be taken to restore all the over cuts and to remove unwanted soil/rock at the under cuts to match the bored cross sections with the design cross section. All these actions can be done by using the Robotic Total Station survey data and thus processing by HEADS Site to generate cross sections and quantities for Design Cut, As-built Cut (Under Cut & Over Cut) and the Pay Line, also by creating CAD drawings and detail report.



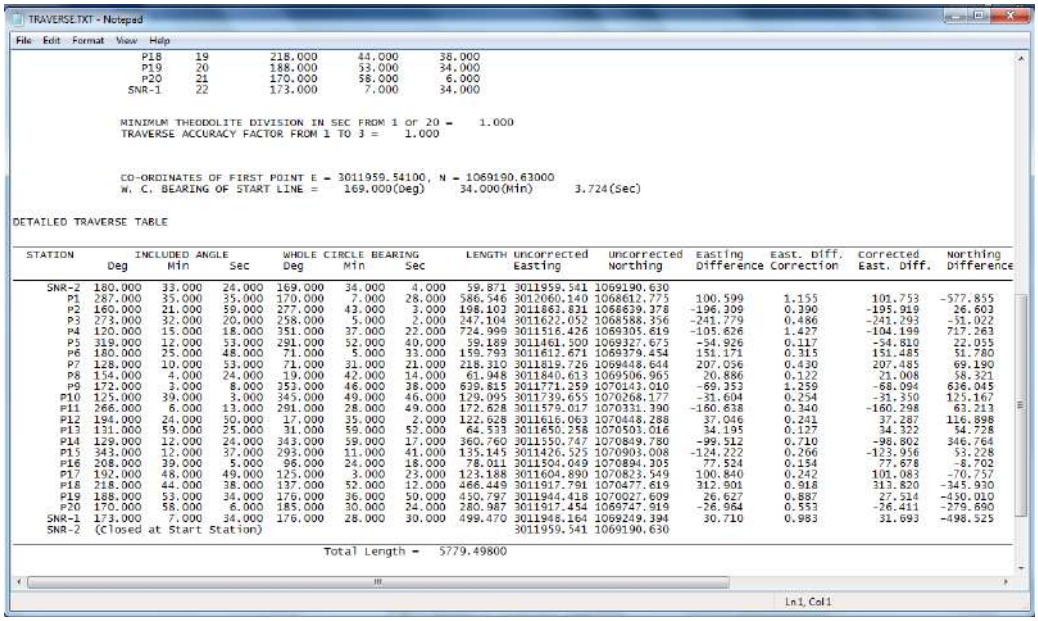
Processing of Traverse Survey Data

Trimble GPS Receiver R8 with Communications

Trimble GPS Receiver R10 with Advanced

Trimble R8 Model 4 trimble gps receiver

HEADS Site generates Traverse Report describing corrected Traverse and its coordinates with closing error corrections by Bowditch, Transit and Closed link, with EDM applications.



TRAVERSE.TXT - Notepad

File Edit Format View Help

P18	19	218.000	44.000	38.000
P19	20	188.000	53.000	34.000
P20	21	170.000	58.000	6.000
SNR-1	22	173.000	7.000	34.000

MINIMUM THEODOLITE DIVISION IN SEC FROM 1 OF 20 = 1.000
TRAVERSE ACCURACY FACTOR FROM 1 TO 3 = 1.000

CO-ORDINATES OF FIRST POINT E = 3011959.54100, N = 1069190.63000
W. C. BEARING OF START LINE = 169.000(Deg) 34.000(Min) 3.724(Sec)

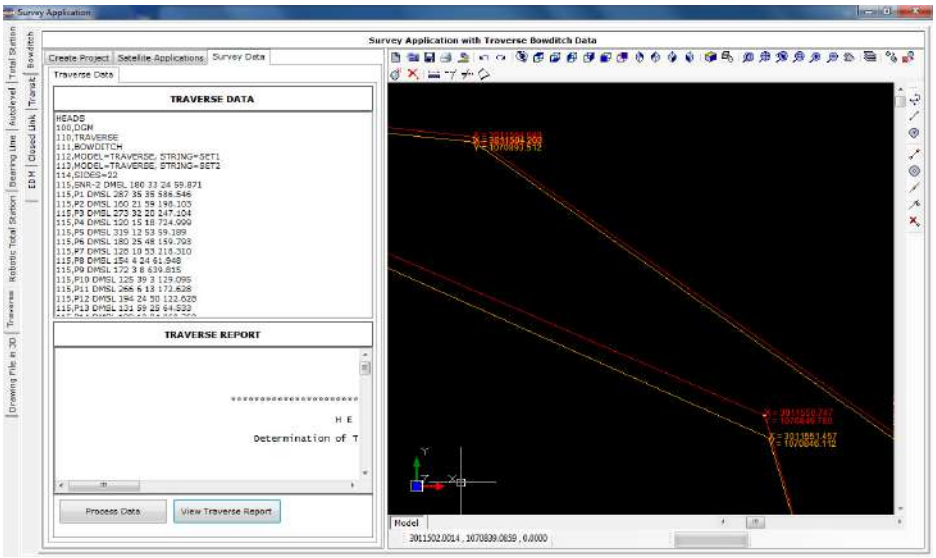
DETAILED TRAVERSE TABLE

STATION	INCLUDED ANGLE Deg	Min	Sec	WHOLE CIRCLE BEARING Deg	Min	Sec	LENGTH	Uncorrected Easting	Uncorrected Northing	Easting Difference	East. Diff. Correction	Corrected East. Diff.	Northing Difference
SNR-2	180.000	33.000	24.000	169.000	34.000	4.000	59.871	3011959.541	1069190.630				
P1	287.000	35.000	35.000	170.000	7.000	28.000	586.546	3012060.140	1068612.775	100.599	1.155	101.753	-577.855
P2	160.000	21.000	59.000	277.000	42.000	3.000	198.103	3011861.831	1068639.378	-196.309	0.390	-195.919	26.603
P3	273.000	32.000	20.000	258.000	5.000	2.000	247.104	3011622.052	1068588.356	-241.779	0.486	-241.293	-51.022
P4	120.000	15.000	18.000	351.000	37.000	22.000	724.999	3011516.426	1069305.619	-105.626	1.427	-104.199	717.263
P5	319.000	12.000	53.000	291.000	52.000	49.000	59.189	3011461.300	1069327.675	-54.926	0.117	-54.810	22.055
P6	180.000	25.000	48.000	71.000	5.000	33.000	159.793	3011612.671	1069379.454	151.171	0.315	151.485	51.780
P7	128.000	10.000	53.000	71.000	31.000	21.000	218.310	3011819.726	1069448.644	207.056	0.430	207.485	69.190
P8	154.000	4.000	24.000	19.000	42.000	14.000	61.948	3011840.613	1069506.965	20.886	0.122	21.008	58.321
P9	172.000	3.000	8.000	353.000	46.000	38.000	639.815	3011771.259	1070143.010	-69.353	1.259	-68.094	636.045
P10	125.000	39.000	3.000	345.000	49.000	46.000	129.095	3011739.655	1070268.177	-31.604	0.254	-31.350	125.167
P11	266.000	6.000	13.000	291.000	28.000	49.000	172.628	3011579.017	1070331.390	-160.638	0.340	-160.298	63.213
P12	194.000	24.000	50.000	17.000	35.000	2.000	122.628	3011616.063	1070448.288	37.046	0.241	37.287	116.898
P13	131.000	59.000	25.000	31.000	59.000	52.000	64.533	3011650.258	1070503.016	34.195	0.127	34.322	54.728
P14	129.000	12.000	24.000	343.000	59.000	17.000	360.760	3011550.747	1070849.780	-99.512	0.710	-98.802	346.764
P15	343.000	12.000	37.000	293.000	11.000	41.000	135.145	3011426.525	1070903.008	-124.222	0.266	-123.956	53.228
P16	208.000	39.000	5.000	96.000	24.000	18.000	78.011	3011504.049	1070894.305	77.524	0.154	77.678	-8.702
P17	192.000	48.000	49.000	125.000	3.000	23.000	123.188	3011604.890	1070823.549	100.840	0.242	101.083	-70.757
P18	218.000	44.000	38.000	137.000	52.000	12.000	466.449	3011917.791	1070477.619	312.901	0.918	313.820	-345.930
P19	188.000	53.000	34.000	176.000	36.000	50.000	430.797	3011944.418	1070027.609	26.627	0.887	27.514	-430.010
P20	170.000	58.000	6.000	185.000	30.000	24.000	280.987	3011917.454	1069747.919	-26.964	0.553	-26.411	-279.690
SNR-1	173.000	7.000	34.000	176.000	28.000	30.000	499.470	3011948.164	1069249.394	30.710	0.983	31.693	-498.525
SNR-2	(Closed at Start Station)							3011959.541	1069190.630				

Total Length = 5779.49800

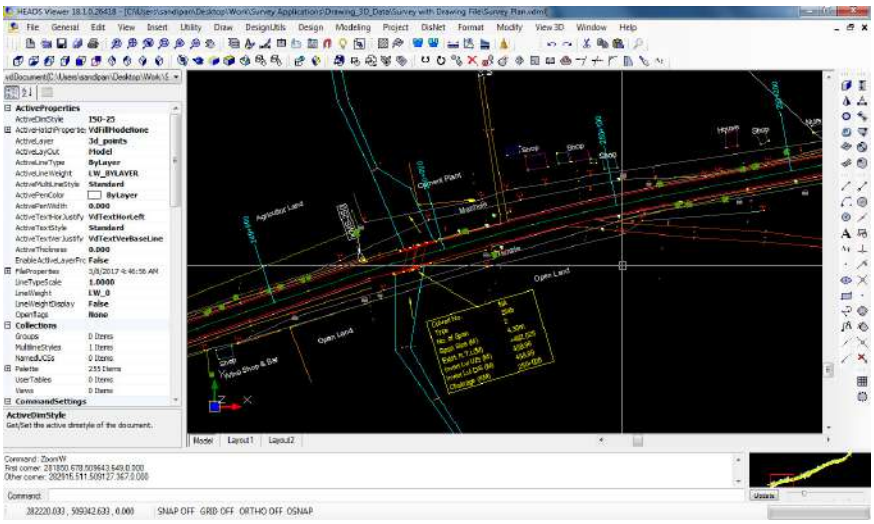
Ln1, Col1

The HEADS Site CAD view of drawing with uncorrected and corrected Traverse and its coordinates.



Processing of Drawing File in 3D to extract ground data

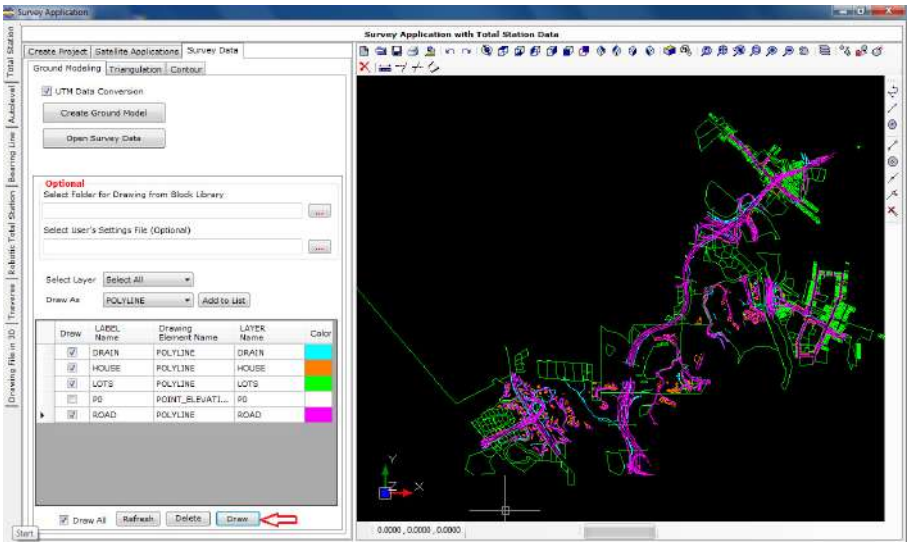
The survey plan drawing is made in 3 Dimension and the processing is done to extract the Layer wise x,y,z data of various features of the drawing. The data is saved as Text data in Total Station format and created model with string labels taking from the layer names by saving in the model files.



Ground Modeling

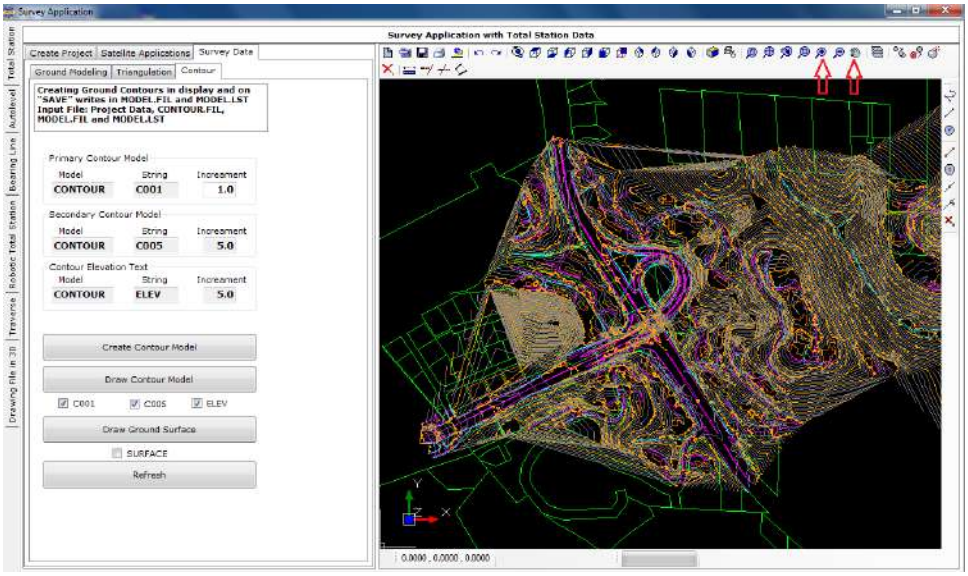
The data in the Total Station survey data file must be made available in the following format and saved as a text file (for example SURVEY.TXT) which can be opened in 'Notepad'. It has five columns of data, when a data record with Serial No. '0' is met (as after Serial No. 5) then it discontinues the last feature and reads a new feature (from Serial No. 1) in the Ground Model.

Serial No:	Easting (Mtres)	Northing (Metres)	Elevation (Metre)	Feature Code
1	281566.03732	509117.65525	469.71900	Weigh_Bridge
2	281563.26666	509126.27648	469.74200	Weigh_Bridge
3	281566.15874	509127.20005	469.72900	Weigh_Bridge
4	281568.92941	509118.57880	469.72900	Weigh_Bridge
5	281566.03732	509117.65525	469.71900	Weigh_Bridge
0	0.00000	0.00000	469.71900	Weigh_Bridge
1	282088.56147	509335.67693	461.27800	3d_Canal
2	282088.40215	509293.76817	459.56500	3d_Canal
3	282140.91930	509218.62702	460.41900	3d_Canal



Triangulation and Contours

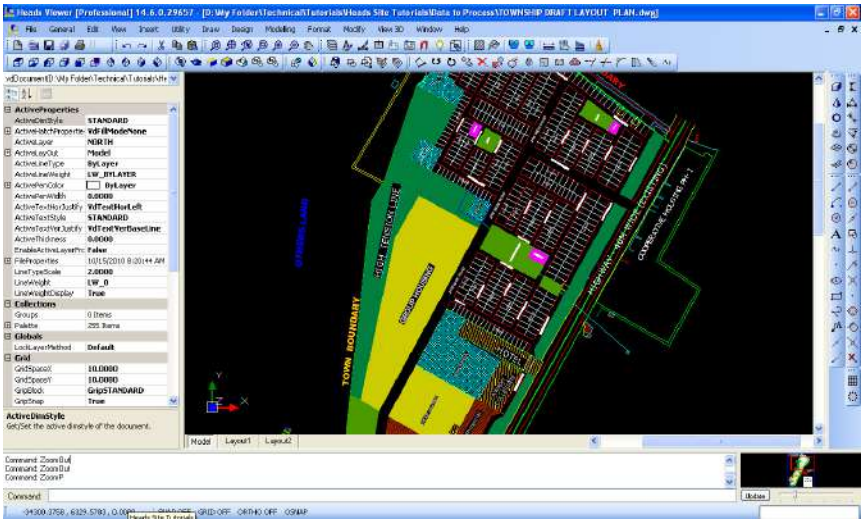
The model Name, String Label and increments for primary, secondary and Text are set with default names & values. If the ground is of flat nature then user has to reduce the primary contour increment as 0.5 or 0.1 to get contours for the relatively flat ground. The secondary contour increment is always five times of increment of the primary contours. Texts for contour elevations are displayed on the secondary contours.



LAND RECORD MANAGEMENT SYSTEM

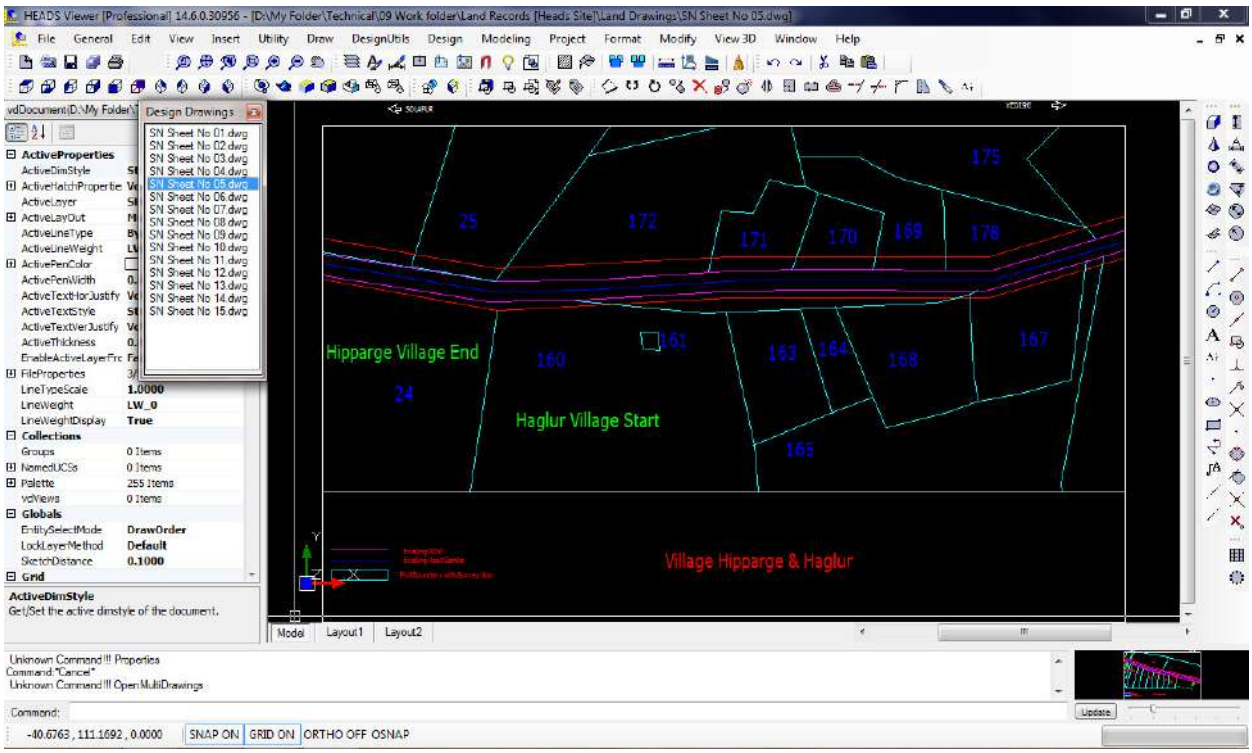
Relational Data Base Management System (RDBMS with MS Access) is used with HEADS Site CAD Viewer

For any construction project the Acquisition of Land for the site is the next job for preparing for construction. The list of names of the land owners, Land category, Land Plot ID, Plot Number, reference District and State in the country. The owners of the acquired land plots are paid by the project authorities. A proper storage of the details along with land maps are therefore essential for the project. The record details are maintained in Relational Data Base Management Systems (RDBMS) with MS-Access and all the land maps as CAD Drawings. The built-in CAD engine is highly powerful with complete drafting and editing facilities. The drawings are compatible to AutoCAD and all other popular CAD softwares.

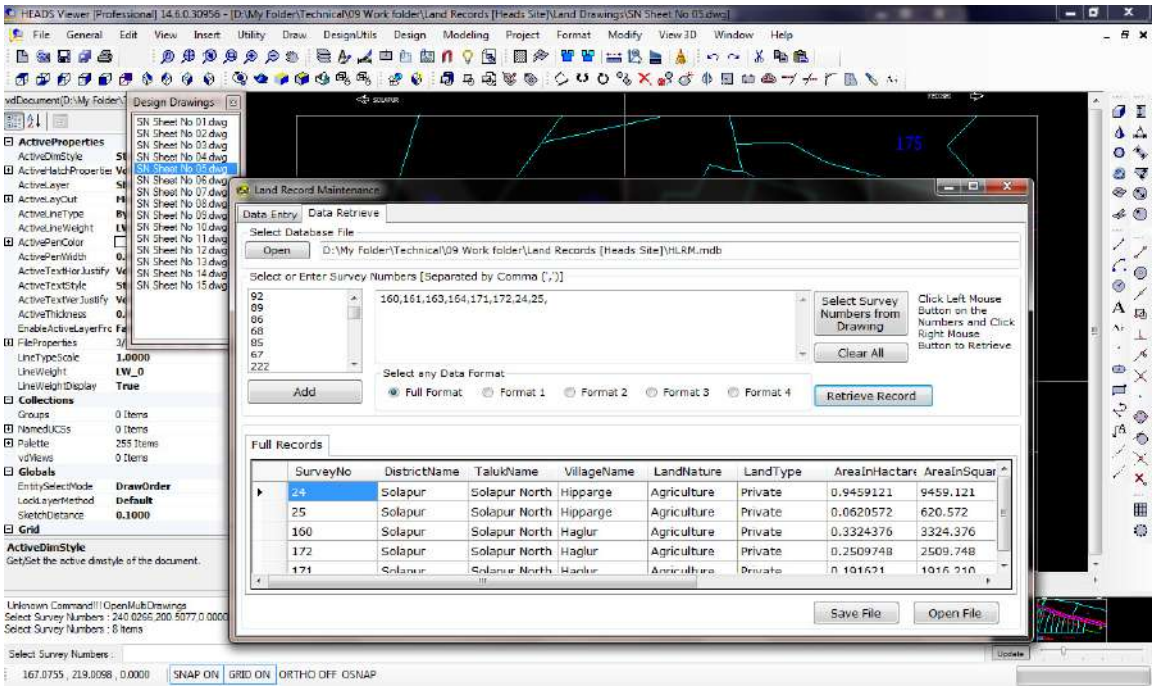


Land records may be Entered and stored in MS Access Database format and CAD Drawings

For any Site preparation the land records and land maps in the existing ground are most essential and properly coordinated by HEADS Site. The establishment of correlation between the database records and the related drawings are extremely useful facilities for maintaining the land records by the users.



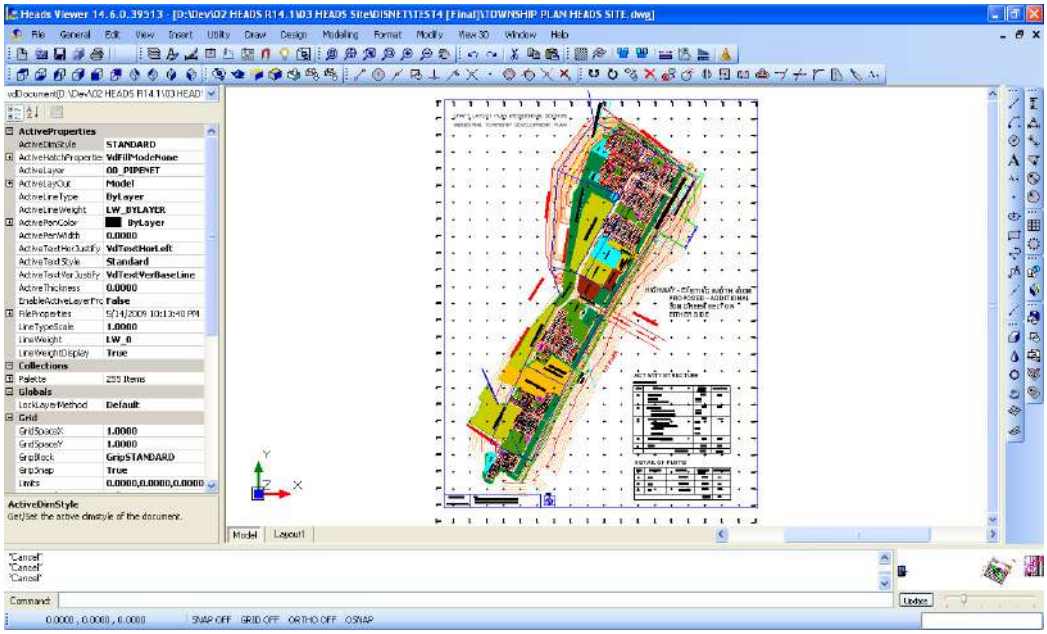
Land records may be retrieved in various specified formats from database or drawings. The relationship between the land map drawings and related records in database management system is highly useful for land record maintenance.



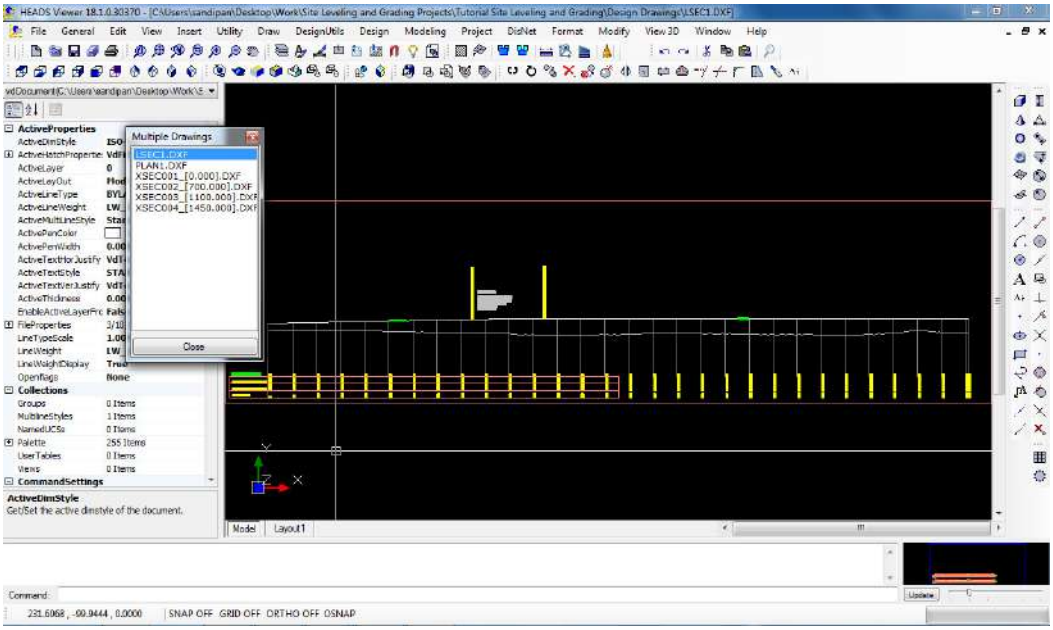
SITE LEVELING AND GRADING

For any site development project for construction the Levelling Grading of the site is the next job for preparing construction platforms at various elevations and maintaining desired slopes in 3 Dimensional perspectives. The estimation of Earthwork in Cut & Fill is computed accurately by software HEADS Site in well formatted Tabular format following Stations defined along the reference Line. Along with the Digital Terrain Model (DTM) it generates Contours, Elevations on Grids, 3D Surface etc. and all as CAD Drawings. The built-in CAD engine is highly powerful with complete drafting and editing facilities. The drawings are compatible to AutoCAD and all other popular CAD softwares.

For any Site preparation by Leveling & Grading, the existing ground is compared with the Proposed Leveled Ground and the Earthwork is estimated in terms of Cut & Fill.

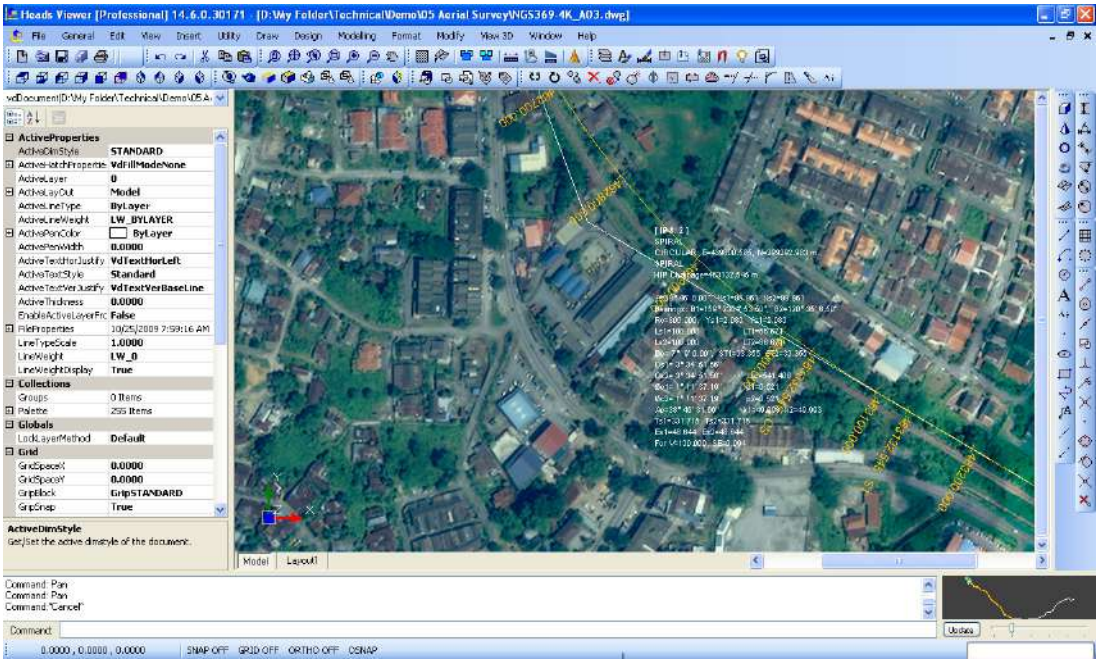


HEADS Site computes Earthwork for cut and fill as the result of grading of the original uneven ground to construct leveled platforms with roads, drains, slopes etc.

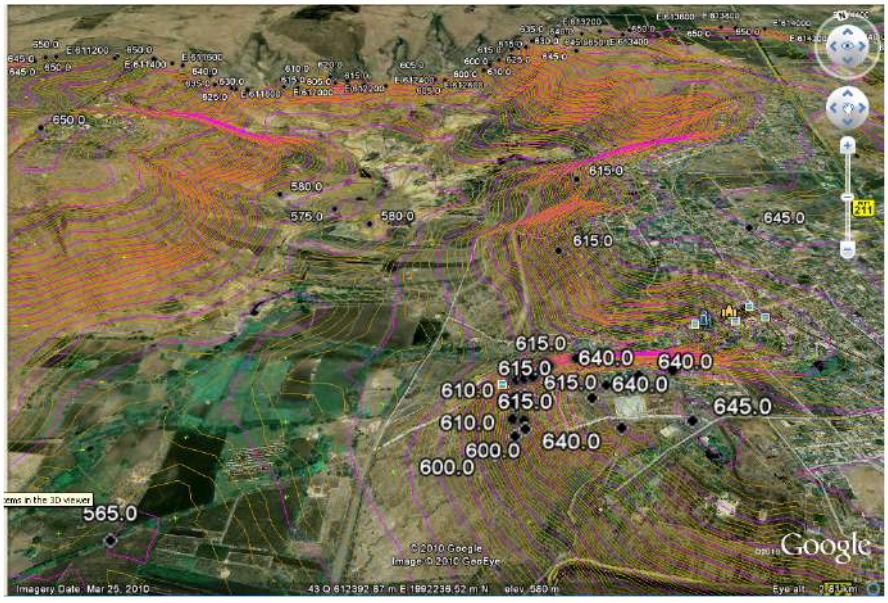


SITE PLANNING

A site planning is done for the finalization of the project, say for the route of the canal. In recent past the Total Station Survey data was used to record the existing condition and the land use of the site. By using the present advancement of technology in respect of satellite facilities, the various projects are better planned. In HEADS Site the site planning is effectively done with the in-built CAD engine by opening the satellite imagery and enabling the users to make various site planning on the satellite imagery.



By using Global Mapper the ground elevation data by Shuttle Radar Topography Mission (SRTM) may be downloaded from Internet, without any field survey. This ground data is processed in HEADS Site to develop the Digital Terrain Model (DTM) by Delauney Triangulation and the Ground Contours are created. Next, for site levelling and grading the various construction platforms are planned and for each construction platform the horizontal and vertical alignments for the reference axis is designed. Finally cross sections of the platforms are processed to estimate the cut & fill quantities in respect of the existing ground. A well formatted Text Report for quantity estimation and Mass Haul diagram are generated.



IRRIGATION APPLICATIONS

Earth Dam or Dyke Design

When the dam is completed floods are designed to be discharged through the spillway without damaging the dam. The diversion of the river and construction of the dam in the lowest, river bed area of the dam site is always timed to be carried out during the driest time of the year based on available rainfall records, when floods are least likely to occur; in the event that a flood does occur and the partially completed dam wall is overtopped the downstream face of the dam is covered in protective steel mesh which is designed to prevent flood waters that flow over the top of the dam from washing away the rock and soil which form the dam wall.

FILL or EMBANKMENT DAMS

- Earth Dams
- Earth and Rock Fill Dams
- Concrete Faced Rock Fill Dams

Earth and Rock Fill Dams have a relatively narrow, impermeable earth or clay core inside the dam but most of the dam is constructed of permeable rock fill which, by itself, would be incapable of retaining water. The impermeable membrane in these dams is the clay core. Most commonly the Dams or Dykes have roads on the top, which are used by the inspection and service vehicles of Irrigation department and also by the public in case of non-availability of alternative roads. So, Horizontal and vertical alignment of the earth dams or dykes are designed in respect of standards for the construction of roads over it, although the alignment must primarily follow the route of the river or canal. The design is done for the proposed dam cross section to be fitted with the horizontal alignment and vertical profile of the dyke axis or dyke centre line. The side slopes of the dam or dyke cross section may be checked of their stability based on the 'C-ϕ' values of the soil material, for which the Bishop's method is commonly used. The process produces construction drawings for Plan, Profile and Cross sections and by computing the earthwork which is estimated in terms of Cut & Fill.

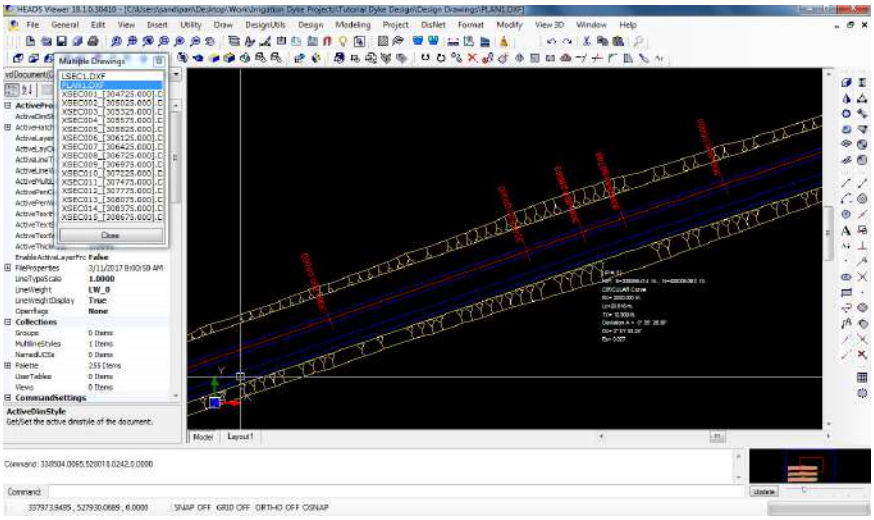
Concrete Gravity Dam Design

The design considers that technically a concrete gravity dam derives its stability from the force of gravity of the materials in the section and hence the name. The gravity dam has sufficient weight so as to withstand the forces and the overturning moment caused by the water impounded in the reservoir behind it. It transfers the loads to the foundations by cantilever action and hence good foundations are pre requisite for the gravity dam. The design is also checked for leakage of water from the reservoir to the downstream side.

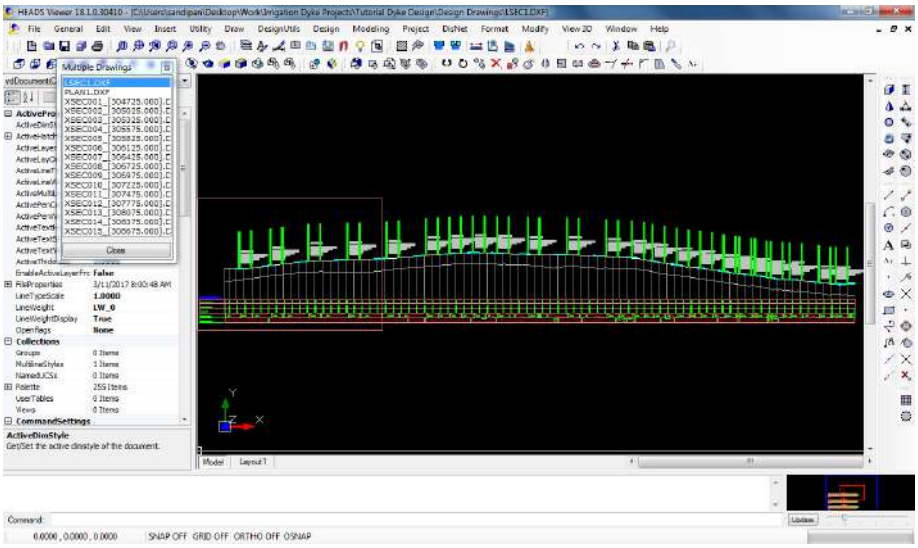
Earth Dam / Dyke

Concrete Gravity Dam

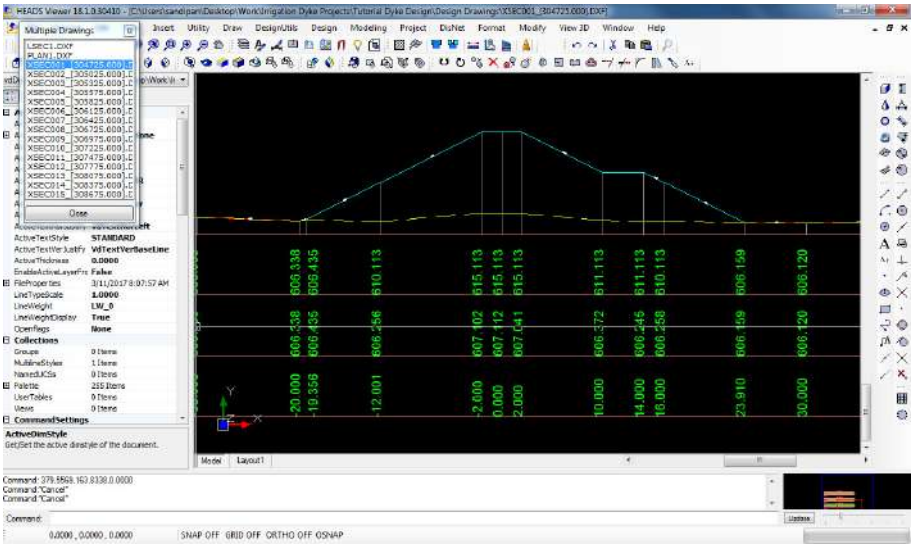
The Plan drawing



The Vertical profile drawing



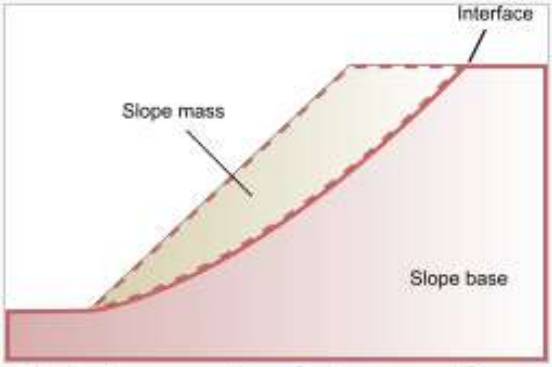
The Cross Section drawing



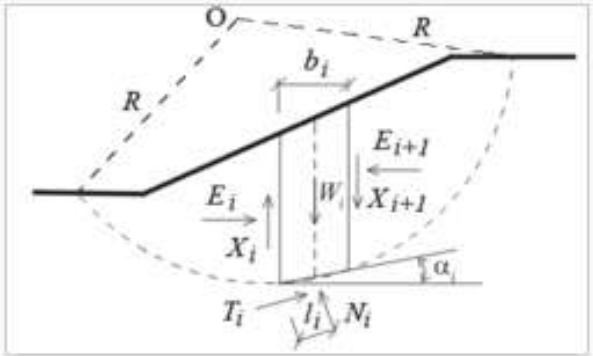
Analysis for Stability of Slopes

Slope stability analysis is performed to assess the safe design of a human-made or natural slopes (e.g. embankments of dam, dyke, road, cuts, open-pit mining, excavations, landfills etc.) and the equilibrium conditions. Slope stability is the resistance of inclined surface to failure by sliding or collapsing. The main objectives of slope stability analysis are finding endangered areas, investigation of potential failure mechanisms, determination of the slope sensitivity to different triggering mechanisms, designing of optimal slopes with regard to safety, reliability and economics, designing possible remedial measures, e.g. barriers and stabilization.

Successful design of the slope requires geological information and site characteristics, e.g. properties of soil/rock mass, slope geometry, groundwater conditions, alternation of materials by faulting, joint or discontinuity systems, movements and tension in joints, earthquake activity etc. The presence of water has a detrimental effect on slope stability. Water pressure acting in the pore spaces, fractures or other discontinuities in the materials that make up the pit slope will reduce the strength of those materials. Choice of correct analysis technique depends on both site conditions and the potential mode of failure, with careful consideration being given to the varying strengths, weaknesses and limitations inherent in each methodology.



A typical cross-section of a slope used in two-dimensional analyses.



Schematic of the method of slices showing rotation center.

Modified Bishop's Method of Analysis

The Modified Bishop's method is slightly different from the ordinary method of slices in that normal interaction forces between adjacent slices are assumed to be collinear and the resultant interslice shear force is zero. The approach was proposed by Alan W. Bishop of Imperial College.The constraint introduced by the normal forces between slices makes the problem statically indeterminate. As a result, iterative methods have to be used to solve for the factor of safety. The method has been shown to produce factor of safety values within a few percent of the "correct" values.

The factor of safety for moment equilibrium in Bishop's method can be expressed as

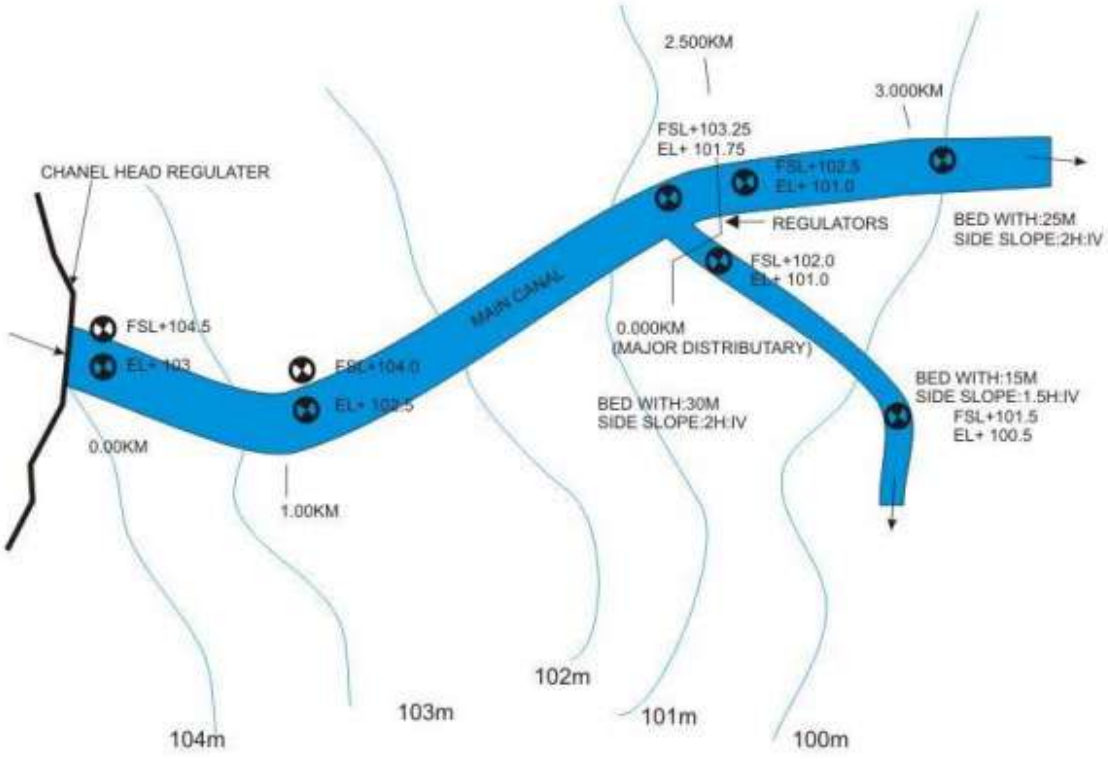
$$F = \frac{\sum_j \frac{[c' l_j + (W_j - u_j l_j) \tan \phi']}{\psi_j}}{\sum_j W_j \sin \alpha_j}$$

where

$$\psi_j = \cos \alpha_j + \frac{\sin \alpha_j \tan \phi'}{F}$$

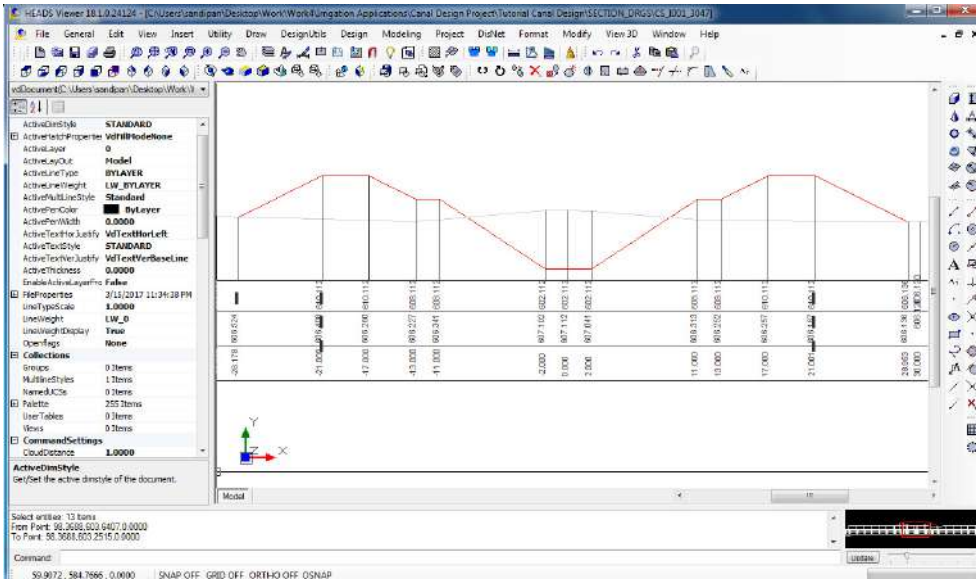
where, as before, j is the slice index, c' is the effective cohesion, ϕ' is the effective angle of internal friction, l is the width of each slice, W is the weight of each slice, and u is the water pressure at the base of each slice. An iterative method has to be used to solve for F because the factor of safety appears both on the left and right hand sides of the equation.

Canal Design



Layout of Canal showing bed level and full supply levels

The entire water conveyance system for irrigation, comprising of the main canal, branch canals, major and minor distributaries, field channels and water courses have to be properly designed. The design process comprises of finding out the longitudinal slope of the channels and fixing the cross sections. The channels themselves may be made up of different construction materials. For example, the main and branch canals may be lined and the smaller ones unlined. Even for the unlined canals, there could be some passing through soils which are erodible due to high water velocity, while some others may pass through stiff soils or rock, which may be relatively less prone to erosion. Further, the bank slopes of canals would be different for canals passing through loose or stiff soils or rock.

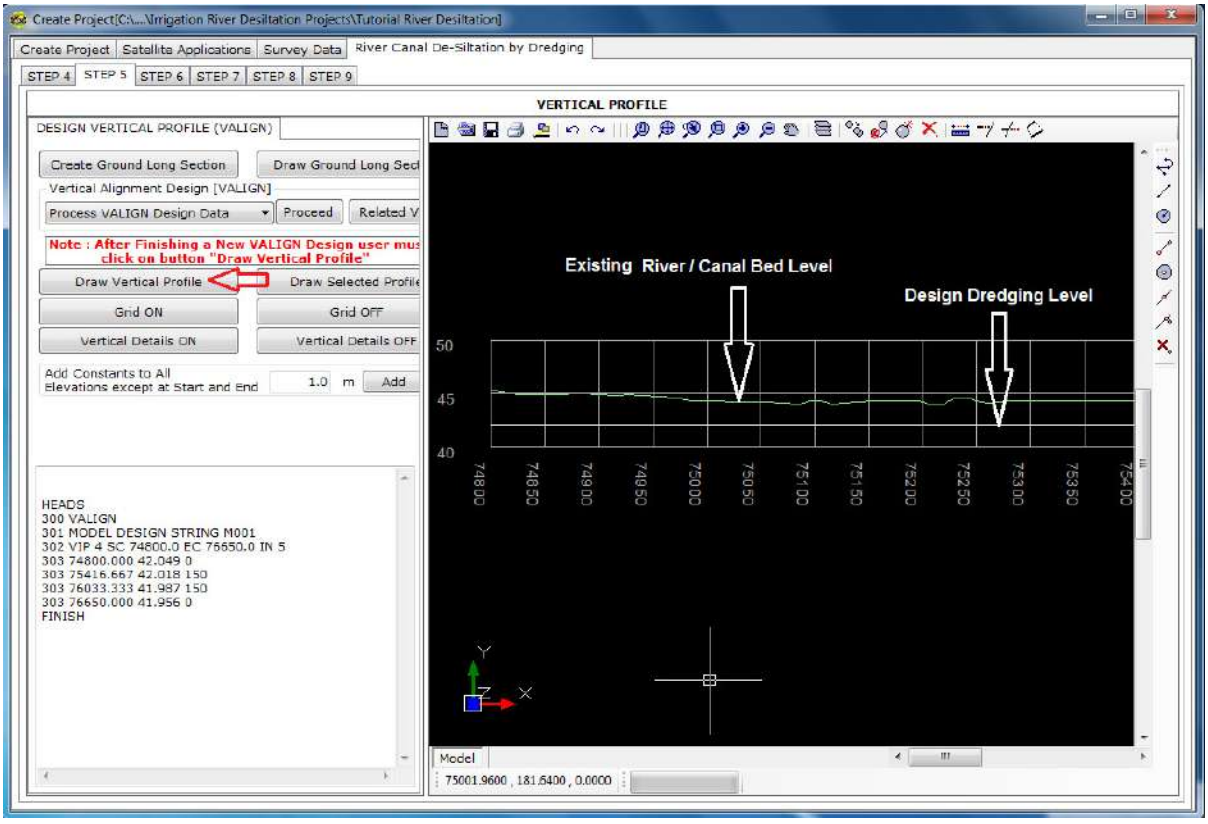


River & Canal De-Siltation by Dredging

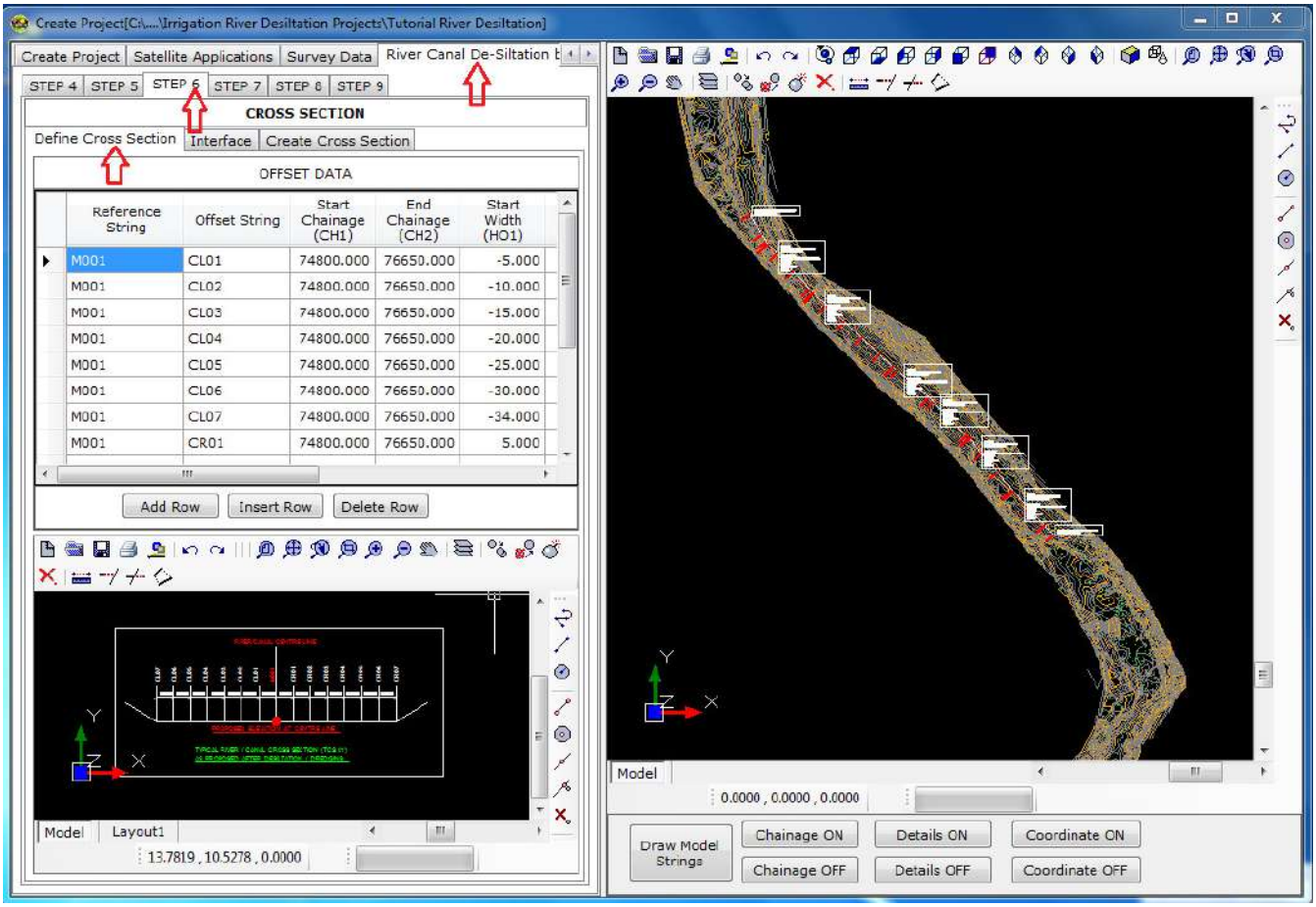
As the siltation is inevitable in rivers and canals, the water depth is reduced over certain period of time. This causes flood in the adjoining areas. So it is essential to maintain the desired depth in the rivers and canals as required for the estimated discharge. The desiltation is most commonly done by dredging of river or canal bed soil to a certain depth. It helps maintain the desired cross section of river or canal for the estimated water flow. This not only prevents flood but also enables navigation by steamers and vessels for transportation purposes.

Before the dredging a cross section survey is carried out along the length of the river or canal to obtain the existing bed levels at certain distances across the width of the river or canal, on either side of the river or canal centre line. This is done either as X,Y,Z by Total station survey or as Chainage, Offset-distances, Z by Autolevel/Digital level survey. The elevations (Z) at regular chainage interval are plotted as Existing Ground Long Section.

The alignment traverse of the river centre line is collected by using Total Station and GPS as the list of the intersection points with easting (X) and northing (Y) of points at all turns and bends along the river or canal centre line and is used to set curves at each intersection point. This enables to define the horizontal alignment of the river or canal centre line. The desired vertical profile of the centre line of the river or canal bed is designed over the plotting of existing ground long section of the river or canal bed centre line.



Finally, the cross section for water flow for river or canal is defined, along with side slopes and proposed desiltation quantity is computed as cut quantity and the deposit at the locations of excessive erosions as fill quantity. The design bed is derived by horizontal alignment, vertical profile and cross section of the river or canal bed centre line. The design drawings for Plan, Profile and Cross Sections of the river or canal along with estimated quantities for Cut & Fill are produced as the output of the process by HEADS Site.



During the dredging the soil removed from the river or canal bed is dumped on the bank as stock piles, which is to be measured at a regular periodic interval and to be compared against the design Cut-Quantity. Once the dredging is completed, then either the material from De-Siltation or brought from out side sources are stacked at site as stockpiles, which are to used for filling in the excessive erosion location. The stock piles are to be measured and compared against the design Fill-Quantity. Once the whole job for Cut & Fill is over, a post work cross section survey of the river or canal bed is to be done to check about the accuracy of the work against the design cross sections chainage wise.

Stock Piles which are formed by Dredging & De-siltation or Boulder Stacks are computed by processing Total Station elevation survey data. Area and Volume of any Irregular Stock Piles can be measured in 3 Dimensional CAD System. It is also possible to produce Long Section and Cross section drawings of the stock piles with the Built-in CAD system. The Total Station Data by collecting the elevations on and around the stock pile of Earth/Silt Dumps at the site may be processed and the Storage quantity calculations may be produced as Tabular Text Report at various intervals of elevations from Top to Bottom of the stock pile storage.

Quantity estimation of Stockpiles of irregular shape is done by measuring the volume. Stockpiles formed by Dredging and De-siltation or Boulder Stacks are computed by processing Total Station elevation survey data. Area and Volume of any Irregular Stockpiles can be measured in 3 Dimensional CAD System. It is also possible to produce Long Section and Cross section drawings of the stockpiles with the Built-in CAD system. The Total Station Data collecting the elevations on and around the stockpile of Earth/Silt Dumps at the site may be processed and the Storage quantity calculations may be produced as Tabular Text Report at various intervals of elevations from Top to Bottom of the stockpile storage.

Water Discharge Quantity by Measuring Water Level

Discharge from the Dam

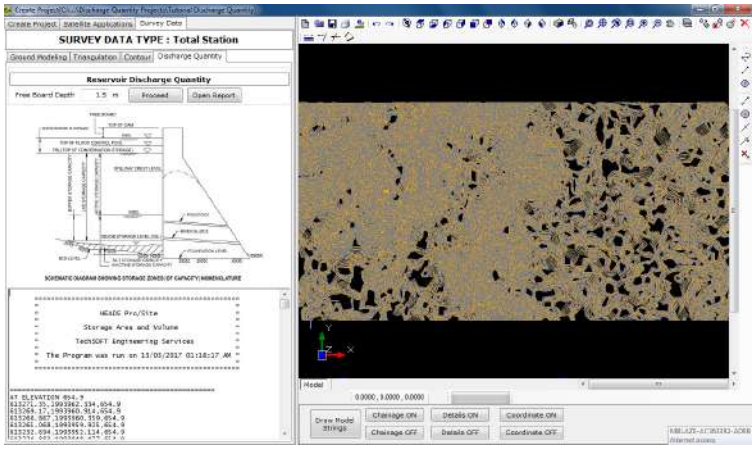
Discharge from the Barrage

The process is to estimate the stored water quantity by obtaining the elevations of the bed of storage reservoir of irregular shape at the Dam or Barrage. The elevation data may be processed and the Storage quantity calculations may be produced as Tabular Text Report at desired interval of elevations from Top to Bottom of the water in the reservoir.

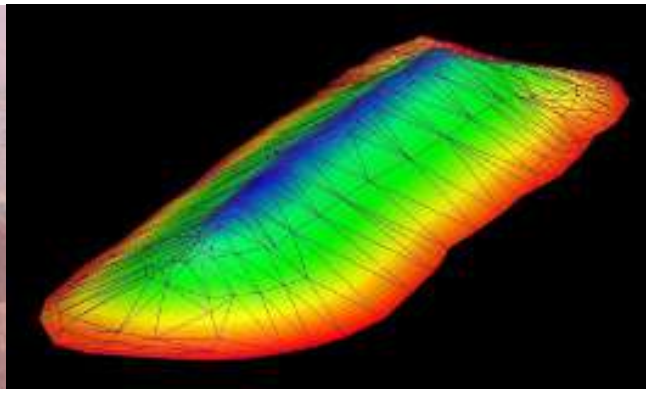
To ensure define quantum of discharge of water either from a Dam or Barrage the procedure available with HEADS Site is to get the elevations at different levels of the storage basin on the upstream side. The Global Mapper based elevation capturing is most suitable way by using the latest satellite based technology. Next, from the current water level, the quantity of water under storage area is computed height wise in HEADS Site. This enables the user to get the quantum of water in the storage at different elevations which are at lower levels with respect to the current top water surface. In case some definite quantity of water is to be discharged then reduction of elevation of water surface from the current elevation to reach an elevation to give the desired discharge quantity, will be the linear measure for the desired discharge of stored water.

According to the World Commission on Dams, a key difference between a barrage and a dam is that a dam is built for water storage in a reservoir, which raises the level of water significantly. A barrage is built for diverting water, and raises the water level only a few feet, they are generally built on flat terrain across wide, often meandering rivers. In a Dam that forms a reservoir for the storage of water during the annual flood period of the river in order to supplement the natural flow of the river during the low-water period. A Barrage merely raises the river or canal level, when necessary, to the height required for adequate flow into the canals which take off above it. Barrages are usually larger than the headworks of irrigation and navigation canals, with which they are associated.

A Barrage is a type of low-head, diversion Dam which consists of a number of large gates that can be opened or closed to control the amount of water passing through the structure, and thus regulate and stabilize river water elevation upstream for use in irrigation and other systems. The gates are set between flanking piers which are responsible for supporting the water load of the pool created.



Measurement of Stockpile Quantity



Sometimes stone boulders are taken from their stock piles on the river side and are dropped in the river bed to protect the river bed from erosion. The work is therefore estimated by measuring the stock piles on the river bank.

Sometimes river beds are dredged to remove siltation from the river bed, which is essential to maintain the required depth of water to facilitate the flow of water in the river and navigation. The dredged siltation are discharged on the bank of the river in the form of stock piles of irregular shapes. This work is also estimated by measuring the stock piles on the river bank.

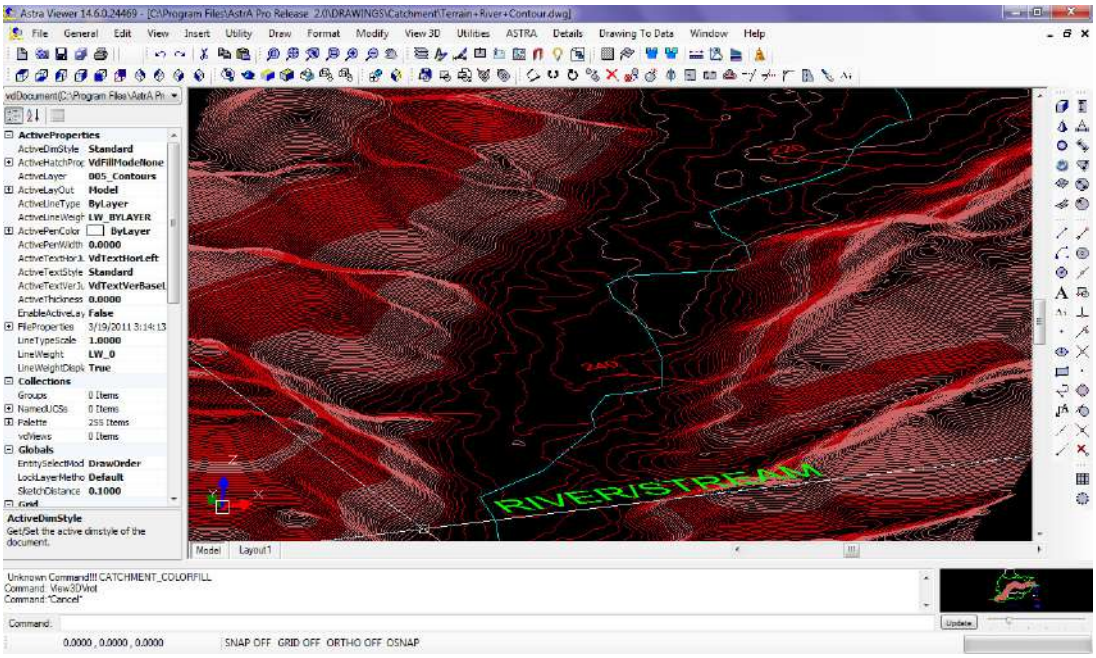
The estimation of quantity in the irregular shaped stock piles may be done either by taking satellite elevation data by using software Global Mapper or by using total station survey data. The estimation is done by creating contours in HEADS Site and by computing the volumes between each two contours surfaces.

The area of horizontal plane is computed at top most elevation, and there is no quantity is estimated at this top most elevation. Next, the area is computed for the horizontal plane at next lower elevation, and the quantity is estimated as the average of the previous and the current areas and by multiplying by their difference of elevations. Every time the current volume and the cumulative volume are computed and written in the report.

This process is continued up to the lowest elevation of the Open Cast Pit, at this lowest point the cumulative volume gives the volume for the excavated pit under consideration. The report is also opened in ‘Notepad’ this helps in taking printout of the report. The difference between two volumes made by obtaining survey data (or satellite downloaded data) at certain interval of time gives the current volume of excavation during that period.

STREAM HYDROLOGY

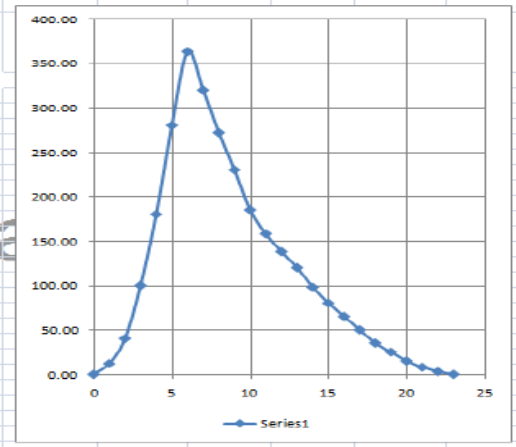
Stream Hydrology is computed in details from Terrain Topography by transforming Transverse marcator data to Universal Tranverse marcator (UTM) data, Referring to WGS84 origin and directly downloaded from Shuttle Radar Topography Mission (SRTM) without Topo maps. Discharge Location at Bridge is measured from farthest point of the River for water discharge at the Bridge location. The environment is 3D CAD, fully compatible to other CAD softwares.



Synthetic Unit Hydrograph (SUH) is plotted by comparing sum of discharge for 1 hour interval of Time and volume of 1 cm direct Runoff.

Estimated parameter of Unitgraph in step-2 were plotted to scale. The plotted points were joined to draw synthetic unitgraph. The discharge ordinates of unitgraph at ti=tr=1 hr interval were summed up and compared with the volume of 1.00 cm direct runoff as calculated below

Time (in hrs)	1-hr Synthetic U.G. ordinates
0.0	0.00
1.0	12.00
2.0	40.00
3.0	100.00
4.0	180.00
5.0	260.00
6.0	363.00
7.0	320.00
8.0	272.00
9.0	230.00
10.0	185.00
11.0	158.00
12.0	138.00
13.0	120.00
14.0	98.00
15.0	80.00
16.0	65.00
17.0	50.00
18.0	35.00
19.0	25.00
20.0	15.00
21.0	8.00
22.0	3.00
23.0	0.00
Sum	2777.00



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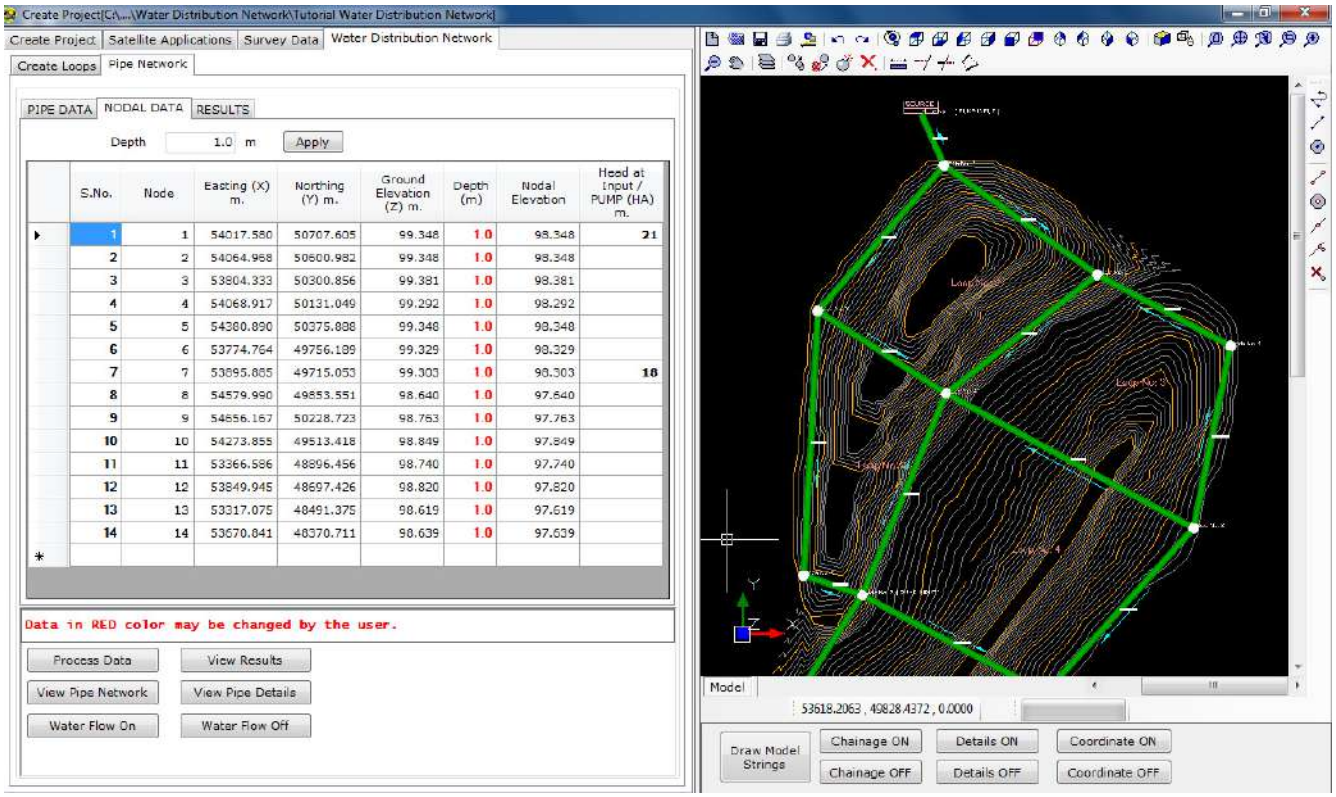
WATER DISTRIBUTION PIPE NETWORK

Pipe Network Analysis

A pipe network is analyzed for the determination of the nodal pressure heads and the link discharges. As the discharges withdrawn from the network vary with time, it results in a continuous change in the nodal pressure heads and the link discharges. The network is analyzed for the worst combination of discharge withdrawals that may result in low-pressure heads in some areas. The network analysis is also carried out to find deficiencies of a network for remedial measures. It is also required to identify pipe links that would be closed in an emergency to meet fire fighting demand in some localities due to limited capacity of the network. The effect of closure of pipelines on account of repair work is also studied by analyzing a network. Thus, network analysis is critical for proper operation and maintenance of a water supply system.

The Pipe details and Nodal details, are displayed in the CAD Window along with animated direction wise water flow



Design Considerations

The design considerations involve topographic features of terrain, economic parameters, and fluid properties. The essential parameters for network sizing are the projection of residential, commercial, and industrial water demand; per capita water consumption; peak flow factors; minimum and maximum pipe sizes; pipe material; and reliability considerations.

Another important design parameter is the selection of an optimal design period of a water distribution system. The water systems are designed for a pre-decided time horizon generally called design period. For a static population, the system can be designed either for a design period equal to the life of the pipes sharing the maximum cost of the system or for the perpetual existence of the water supply system. On the other hand, for a growing population or water demand, it is always economic to design the system in stages and re-strengthen the system after the end of every staging period. The design period should be based on the useful life of the component sharing maximum cost, pattern of the population growth or increase in water demand, and discount rate. The reliability Considerations are also important for the design of a water distribution system as there is a trade-off between cost of the system and system reliability.

In general, water distribution systems can be divided into four main components: (1) water sources and intake works, (2) treatment works and storage, (3) transmission mains, and (4) distribution network. The common sources for the untreated or raw water are surface water sources such as rivers, lakes, springs, and man-made reservoirs and groundwater sources such as bores and wells. The intake structures and pumping stations are constructed to extract water from these sources. The raw water is transported to the treatment plants for processing through transmission mains and is stored in clear water reservoirs after treatment. The degree of treatment depends upon the raw water quality and finished water quality requirements. Sometimes, groundwater quality is so good that only disinfection is required before supplying to consumers. The clear water reservoir provides a buffer for water demand variation as treatment plants are generally designed for average daily demand.

Water is carried over long distances through transmission mains. If the flow of water in a transmission main is maintained by creating a pressure head by pumping, it is called a pumping main. On the other hand, if the flow in a transmission main is maintained by gravitational potential available on account of elevation difference, it is called a gravity main. There are no intermediate withdrawals in a water transmission main. Similar to transmission mains, the flow in water distribution networks is maintained either by pumping or by gravitational potential. Generally, in a flat terrain, the water pressure in a large water distribution network is maintained by pumping; however, in steep terrain, gravitational potential maintains a pressure head in the water distribution system.

A distribution network delivers water to consumers through service connections. Such a distribution network may have different configurations depending upon the layout of the area. Generally, water distribution networks have a **looped** (as available in HEADS Site) and branched configuration of pipelines, but sometimes either looped or branched configurations are also provided depending upon the general layout plan of the city roads and streets. Urban water networks have mostly looped configurations, whereas rural water networks have branched configurations. On account of the high-reliability requirement of water services, looped configurations are preferred over branched configurations.

The cost of a water distribution network depends upon proper selection of the geometry of the network. The selection of street layout adopted in the planning of a city is important to provide a minimum-cost water supply system. The two most common water supply configurations of looped water supply systems are the gridiron pattern and the ring and radial pattern; however, it is not possible to find an optimal geometric pattern that minimizes the cost.

Flow Hydraulics And Network Analysis

The flow hydraulics covers the basic principles of flow such as continuity equation, equations of motion, and Bernoulli's equation for close conduit. Another important area of pipe flows is to understand and calculate resistance losses and form losses due to pipe fittings (i.e., bends, elbows, valves, enlargers and reducers), which are the essential parts of a pipe network. Suitable equations for form-losses calculations are required for total head-loss computation as fittings can contribute significant head loss to the system.

The flow hydraulics of fluid transporting sediments in suspension and of capsule transport through a pipeline is complex in nature and needs specific consideration in head-loss computation. Such an area of fluid flow is of special interest to industrial engineers/designers engaged in such fluid transportation projects. The basics of sediment and capsule transport through pipes are important for computation of flow through pipes.

Analysis of a pipe network is essential to understand or evaluate a physical system, thus making it an integral part of the synthesis process of a network. In case of a **single input system**, the input discharge is equal to the sum of withdrawals (As available in module DisNet). The known parameters in a system are the pipe sizes and the nodal withdrawals. The system has to be analyzed to obtain input point discharges, pipe discharges, and nodal pressure heads. In case of a branched system, starting from a dead-end node and successively applying the node flow continuity relationship, all pipe discharges can be easily estimated. Once the pipe discharges are known, the nodal pressure heads can be calculated by applying the pipe head-loss relationship starting from an input source node with known input head. In a looped network, the pipe discharges are derived using loop head-loss relationship for known pipe sizes and nodal continuity equations for known nodal withdrawals.

Darcy–Weisbach and Hazen–Williams provided the equations for the head loss computation through pipes. Liou (1998) pointed out the limitations of the Hazen–Williams equation, and in conclusion he strongly discouraged the use of the Hazen–Williams equation. He also recommended the use of the Darcy–Weisbach equation with the Colebrook–White equation. The Hazen–Williams equation was not only inaccurate but also was conceptually incorrect. Brown (2002) examined the historical development of the Darcy–Weisbach equation for pipe flow resistance and stated that the most notable advance in the application of this equation was the publication of an explicit equation for friction factor. He concluded that due to the general accuracy and complete range of application, the Darcy–Weisbach equation should be considered the standard and the others should be left for the historians. Considering the above investigations, only the Darcy–Weisbach equation for pipe flow has been identified as acceptable for pipe network analysis.

Based on the application of an analysis method for water distribution system analysis, the information about pipes forming primary loops can be an essential part of the data. The loop data do not constitute information independent of the link-node information, and theoretically it is possible to generate loop data from this information. The information about the loop-forming pipes can be developed by combining flow paths. These pipe flow paths, which are the set of pipes connecting a demand (withdrawals) node to the supply (input) node, can be identified by moving opposite to the direction of flow in pipes. Unlike branched systems, the flow directions in looped networks are not unique and depend upon a number of factors, mainly topography, nodal demand, layout, and location and number of input (supply) points. The pipe flow patterns will vary based on these factors. Hence, combining flow paths, the flow pattern map of a water distribution network can also be generated, which is important information for an operator/manager of a water system for its efficient operation and maintenance.

The analysis of a network is also important to make decisions about the network augmentation requirements due to increase in water demand or expansion of a water servicing area. The understanding of pipe network flows and pressures is important for making such decisions for a water supply system.

Generally, the water service connections (withdrawals) are made at an arbitrary spacing from a pipeline of a water supply network. Such a network is difficult to analyze until simplified assumptions are made regarding the withdrawal spacing. The current practice is to lump the withdrawals at the nodal points; however, a distributed approach for withdrawals should also be considered. A methodology is required to calculate flow and head losses in the pipeline due to lumped and distributed withdrawals.

Pipe Network Analysis

A pipe network is analyzed for the determination of the nodal pressure heads and the link discharges. As the discharges withdrawn from the network vary with time, it results in a continuous change in the nodal pressure heads and the link discharges. The network is analyzed for the worst combination of discharge withdrawals that may result in low-pressure heads in some areas. The network analysis is also carried out to find deficiencies of a network for remedial measures. It is also required to identify pipe links that would be closed in an emergency to meet firefighting demand in some localities due to limited capacity of the network. The effect of closure of pipelines on account of repair work should also be studied by analyzing a network. Thus, network analysis is critical for proper operation and maintenance of a water supply system.

Hardy Cross Method

Analysis of a pipe network is essential to understand or evaluate a pipe network system. In a branched pipe network, the pipe discharges are unique and can be obtained simply by applying discharge continuity equations at all the nodes. However, in case of a looped pipe network, the number of pipes is too large to find the pipe discharges by merely applying discharge continuity equations at nodes. The analysis of looped network is carried out by using additional equations found from the fact that while traversing along a loop, as one reaches at the starting node, the net head loss is zero. Here, the analysis of looped network is involved, as the loop equations are nonlinear in discharge.

Hardy Cross (1885–1951), who was professor of civil engineering at the University of Illinois, Urbana-Champaign, presented in 1936 a method for the analysis of looped pipe network with specified inflow and outflows (Fair et al., 1981). The method is based on the following basic equations of continuity of flow and head loss that should be satisfied:

1. The sum of inflow and outflow at a node should be equal:
$\sum Q_i = q_j$ for all nodes j = 1, 2, 3, . . . , j_L

where Q_i is the discharge in pipe i meeting at node (junction) j, and q_j is nodal withdrawal at node j.

2. The algebraic sum of the head loss in a loop must be equal to zero:
$\sum_{\text{loop k}} K_i Q_i |Q_i| = 0$ for all loops k = 1, 2, 3, . . . , k_L

where
$Ki = 8 f_i L_i / \pi^2 \times g \times D^5$

where i = pipe link number to be summed up in the loop k.

In general, with the initially assumed pipe discharges satisfying nodal continuity equation the discharges are modified it is not possible to satisfy equation, So that equation becomes closer to zero in comparison with initially assumed discharges. The modified pipe discharges are determined by applying a correction Qk to the initially assumed pipe flows. Thus,

$$\sum_{\text{loop k}} K_i (Q_i + \Delta Q_k)|(Q_i + \Delta Q_k)| = 0$$

Expanding the above equation and neglecting second power of ΔQ_k and simplifying equation 3.16 the following equation is obtained:

$$\Delta Qk = - \sum_{\text{loop k}} K_i Q_i |Q_i| \Big/ 2 \sum_{\text{loop k}} K_i |Q_i|$$

Knowing Qk, the corrections are applied as

$Q_i \text{ new} = Q_{i \text{ old}} + \Delta Q_k$ for all k

The overall procedure for the looped network analysis can be summarized in the following steps:

1. Number all the nodes and pipe links. Also number the loops. For clarity, pipe numbers are to be enclosed as circled and the loop numbers are to be put in square brackets, in the drawing.

2. Adopt a sign convention that a pipe discharge is positive if it flows from a lower node number to a higher node number, otherwise negative.

3. Apply nodal continuity equation at all the nodes to obtain pipe discharges. Starting from nodes having two pipes with unknown discharges, assume an arbitrary discharge (say 0.1 m^3/s) in one of the pipes and apply continuity equation above to obtain discharge in the other pipe. Repeat the procedure until all the pipe flows are known. If there exist more than two pipes having unknown discharges, assume arbitrary discharges in all the pipes except one and apply continuity equation to get discharge in the other pipe. The total number of pipes having arbitrary discharges should be equal to the total number of primary loops in the network.

4. Assume friction factors $f_i = 0.02$ in all pipe links and compute corresponding Ki using above equation. However, f_i can be calculated iteratively using equation above.

5. Assume loop pipe flow sign convention to apply loop discharge corrections, generally, clockwise flows positive and counterclockwise flows negative are considered.

6. Calculate ΔQk for the existing pipe flows and apply pipe corrections algebraically.

7. Apply the similar procedure in all the loops of a pipe network.

Repeat steps 6 and 7 until the discharge corrections in all the loops are relatively very small.

Analysis of a pipe network is essential to understand or evaluate a physical system, thus making it an integral part of the synthesis process of a network.

DRAINAGE DESIGN

HEADS Site has highly effective module for design of drainage for roads and ground surface, based on storm water duration and hydrological data and by using manning's coefficients the adequacy of the proposed drain section is checked.

The section of drain is considered based upon vertical profile of the surface to consider for drainage and the location of discharge points. The design is difficult in plain terrain as the natural slope is not available so planning is to be done carefully.

Provision for adequate drainage is of paramount importance in road and other surface design and cannot be overemphasized. The presence of excess water or moisture within the roadway or ground surface will adversely affect the engineering properties of the materials with which it was constructed. Cut or fill failures, surface erosion, and weakened sub grades followed by a mass failure are all products of inadequate or poorly designed drainage. As has been stated previously, many drainage problems can be avoided in the location and design of the road and ground surface. Drainage design requires most appropriate considerations of alignment and gradient planning.

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