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on
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Natural Hazards and Disaster management, June 01-03, 2017 Osaka, Japan
http://natural hazards.conferenceseries.com/
Theme: Significance of Early Warning Systems and Risk Management Strategies

Keynote Speech

(Day 2 June 2,2017 Time 10:40-11:20)

Venue: Hotel Hyatt Regency, Osaka, Japan

LANDSLIDES HAZARDS AND DEVELOPMENT OF GLOBAL EARLY WARNING

Speaker

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In-Charge Engineering Geology Laboratory & University Nodal Officer GIS

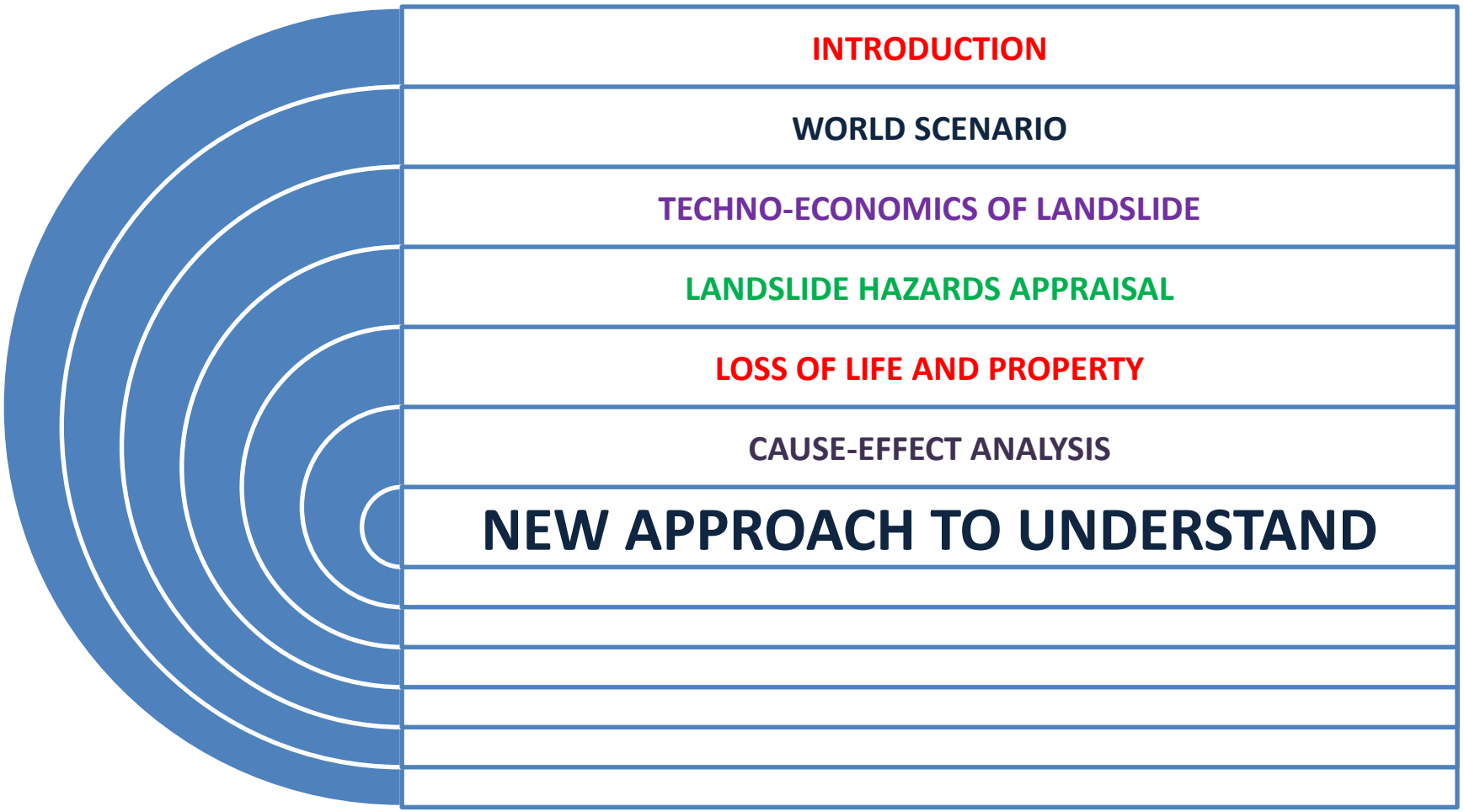
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Summary


INTRODUCTION
WORLD SCENARIO
TECHNO-ECONOMICS OF LANDSLIDE
LANDSLIDE HAZARDS APPRAISAL
LOSS OF LIFE AND PROPERTY
CAUSE-EFFECT ANALYSIS
NEW APPROACH TO UNDERSTAND

Every body knows

- Problem of landslide/ earthquakes frequently occurring
- Global perspective and historical back ground
- Losses incurred and world suffered due to these disastrous phenomena
- Root causes i.e. natural/man made
- Measurement techniques available or yet to explore
- Is it possible to know early/ prior to mis-happenings
- Something concrete done for early warning/ alerts

Landslide: Cause and effect

- A landslide/slope collapses abruptly due to weakened self-retain ability of the earth under the influence of a number of factors
- where rainfall or an earthquake accounts maximum weightage.
- Sudden collapse of slope may results in fatalities and different damages in various ways.
- Such incidents and their number & frequency going higher side day by day.
- The reason is very clear i.e. technological advancements in developments of heavy earth moving machines and speedy excavation, as observed in mining sector, infrastructural developmental activities etc.
- With the increase in size and the stripping ratio of the opencast mines, the amount of overburden generate has also increase considerably

Witnesses insisted upon study

- **The case of the Kawadi opencast coal mine disaster of WCL on 24.6.2000 causing ten fatalities at a time, the DGMS has issued some guidelines for scientific approach towards design of opencast pit slopes.**
- **Cases of slope failure attracted attention of various scientists and they contributed a lot on the slope stability analysis, to find out or evaluate the stability status of existing slopes in mines, natural hills, waste dumps, hilly terrain road and rail network the roadside & railway-line side hill cuts etc.**
- **The landslide of 2014 in village Malin, district Pune state Maharastra, India, Recent 2013 landslides cases of Uttrakhand, consequent upon heavy rains and Nepal landslides consequent upon 25th April2015 earthquake and aftershocks. Hence the slope failures broadly covered under the umbrella of landslides.**

Landslide early warning system

Is it needed ?

- The present paper deals with the need and development of slope failures early warning system
- Purpose is to safeguard environment and consequential damages by issuing alerts or warning announcement in the sensitive area.

Embryonic efforts start with

- Landslide sensitivity models (LSM) suggested by Bhardwaj et al. 2012, clearly envisage the aspect of slope failure.
- The LSM suggests four categories of sensitivity, based on numerical analysis of slope surfaces.
- by using GALENA software version 4.0. The FE analysis carried out using ABAQUS 6.1 and stress concentration distribution pattern simulated for the slope surface depicts the slope failure triggering points. The FE analysis of slope surface incorporated Rock Structure Rating (RSR) and Geological Strength Index (GSI) also for authenticity and to achieve refinement of the precise results (Bhardwaj G.S. et.al. 2010, 2012).
- The ArcGIS and TNTmips geographic information system software analysis carried out for the terrain where slope surfaces existing and a number of parameters obtained in two categories i.e parameters which has direct influence on slope stability and second parameters of indirect influence on slope stability

Global and Indian scenario

Hilly terrain road networking throughout the world are associated with the serious problem of frequently occurring roadside landslides.

Recently developed four lane road network in Aravalli is most prestigious infrastructure development activity of India.

The reason could be the neglect of nature friendly scientific and engineering aspects. Inconveniences consequent upon the landslides are life and financial losses.

Key points

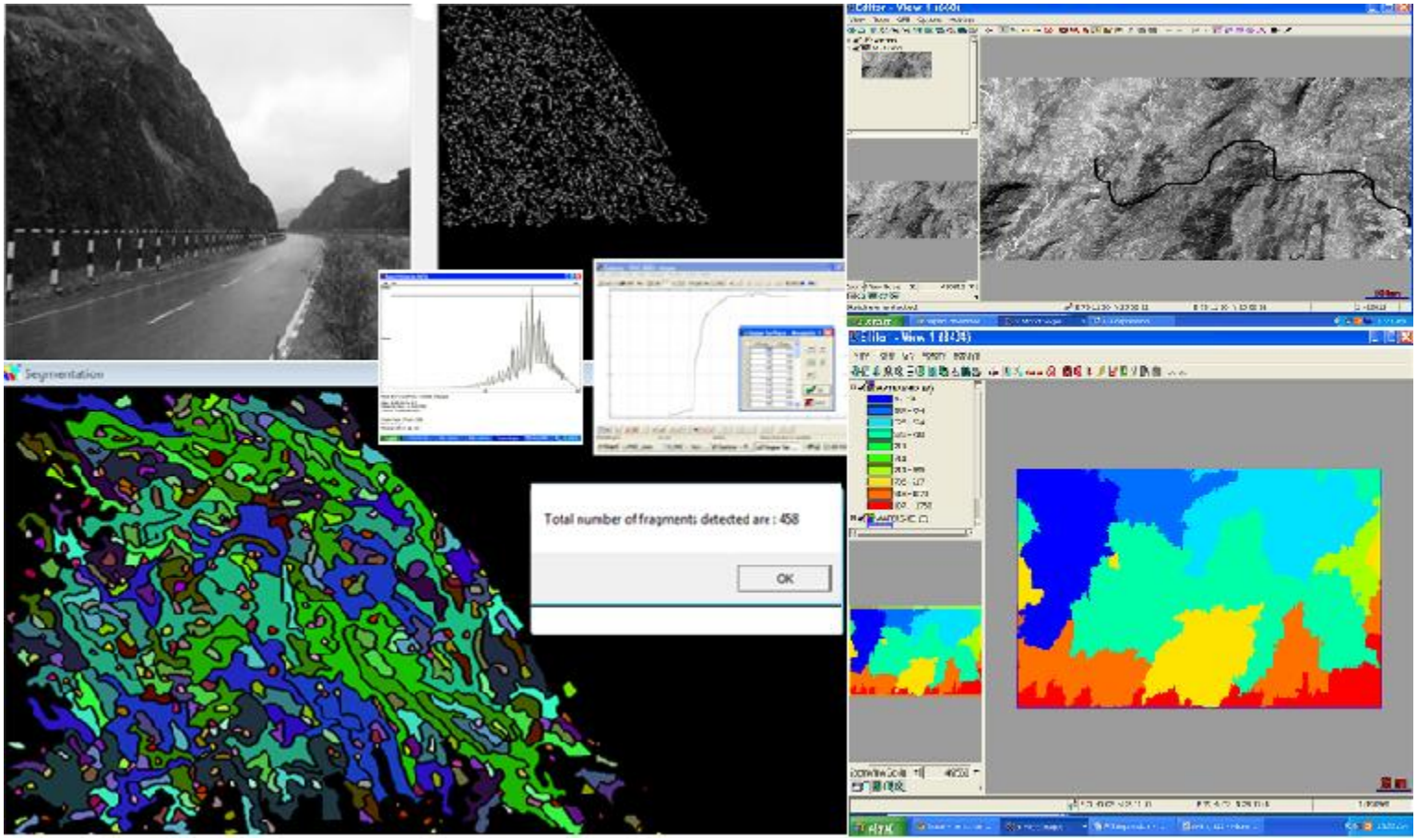
- The above paper is intended to explore dimensions to understand and overcome the problem of landslides.
- **Hill slope geometry, stability analysis and finite elemental analysis help us to understand the disastrous failure of the hills, remedial measures and its suitability analysis.**
- The data collected from hill by putting variables and constants parameters
  - -slope stability analysis,
  - -segmentations analysis of rock mass in the hill cut face
  - -using satellite data
  - - by analyzing with GIS software
- Development of early warning system development.

Key points continued….

- **Collection of rock mass data, rock samples, soil samples, for determination of geo-mechanical properties and slope stability analysis carried out using licensed software GALENA.**

- **Finally computer simulation done with the use of finite elemental analysis by generating computer models of the hill faces likely to fail. Complete data profile generated for selected sensitive hill and measures for controlling the landslides.**
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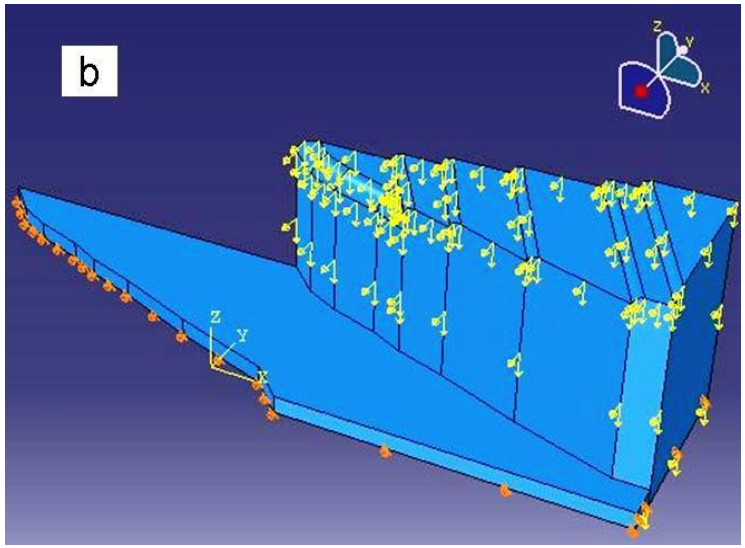
Image showing landslides analysis techniques

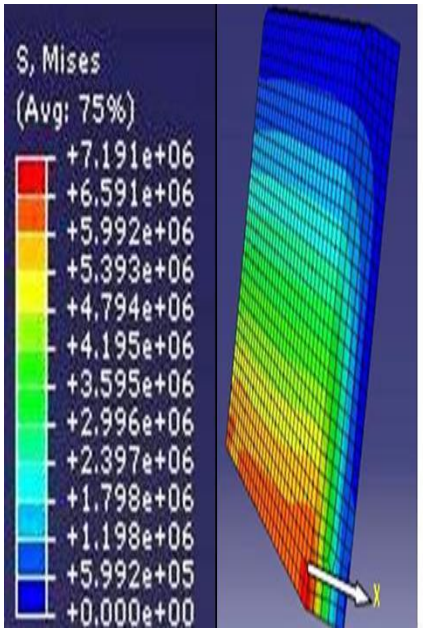


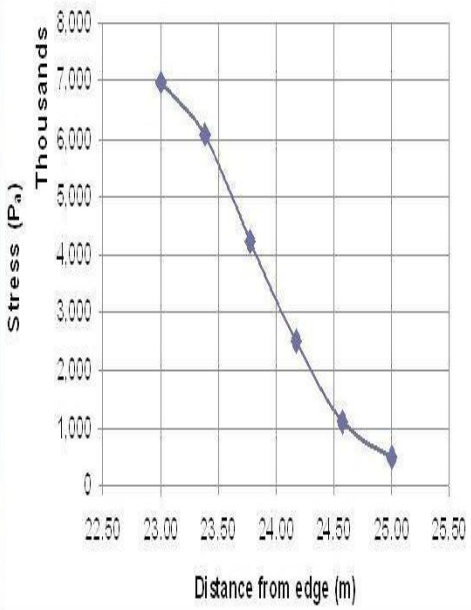
Panoramic view of field study along hilly terrain roads frequently occurring landslides

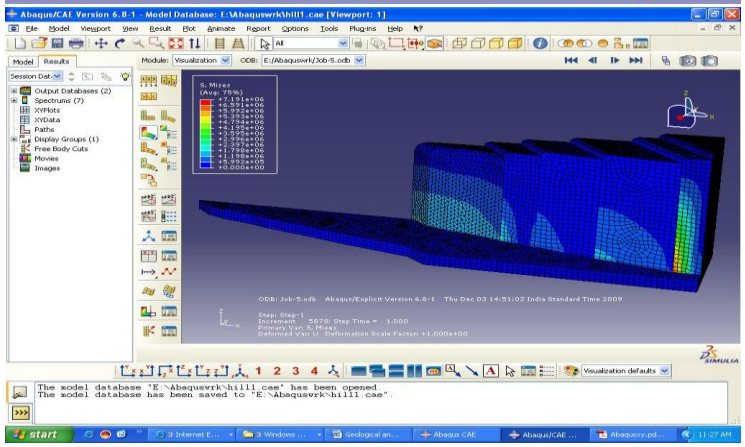


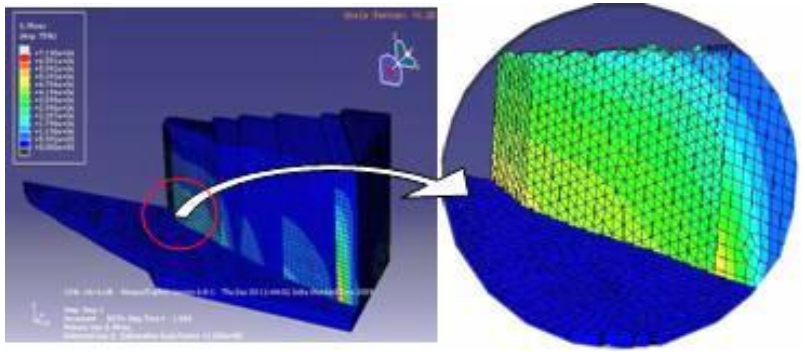
Numerical analysis using FE tool is connected online



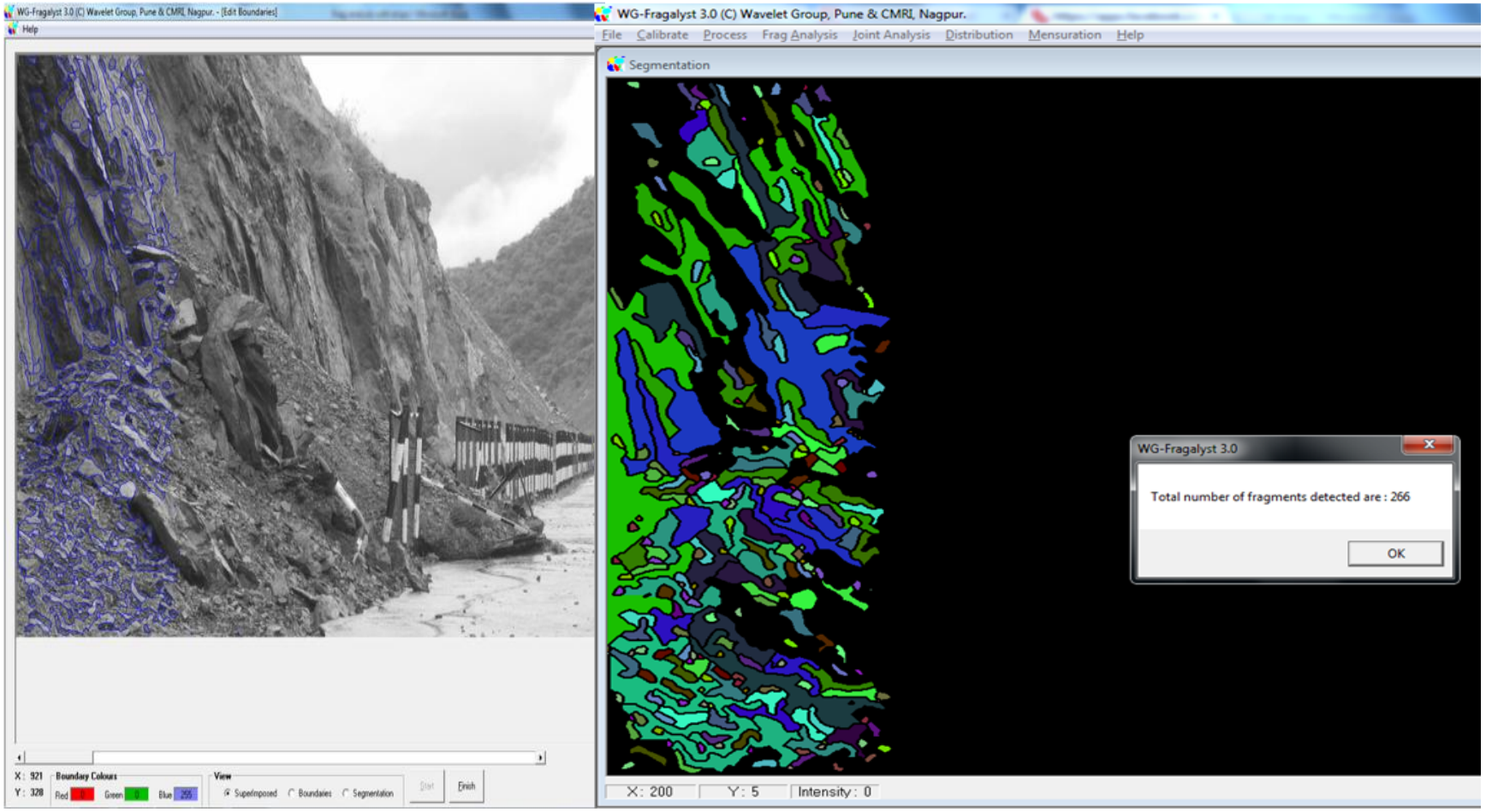








Segmentation analysis

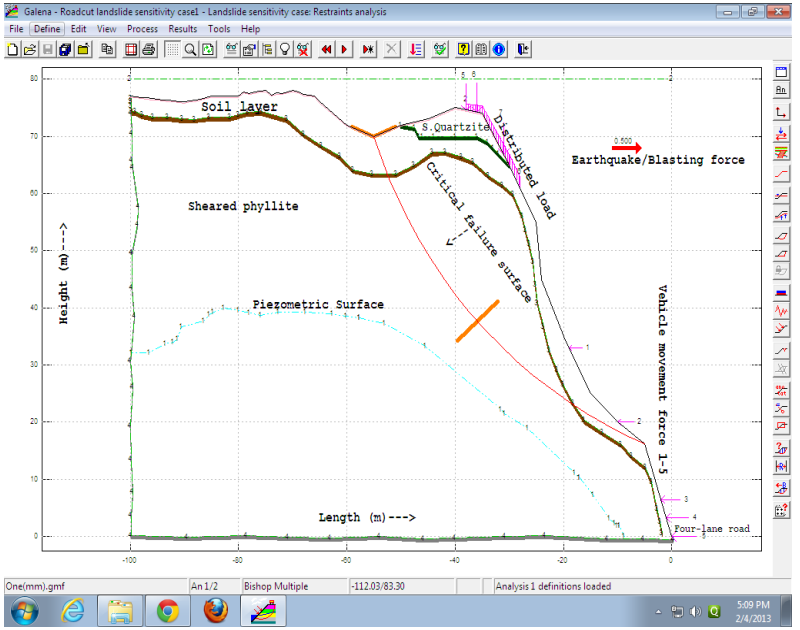


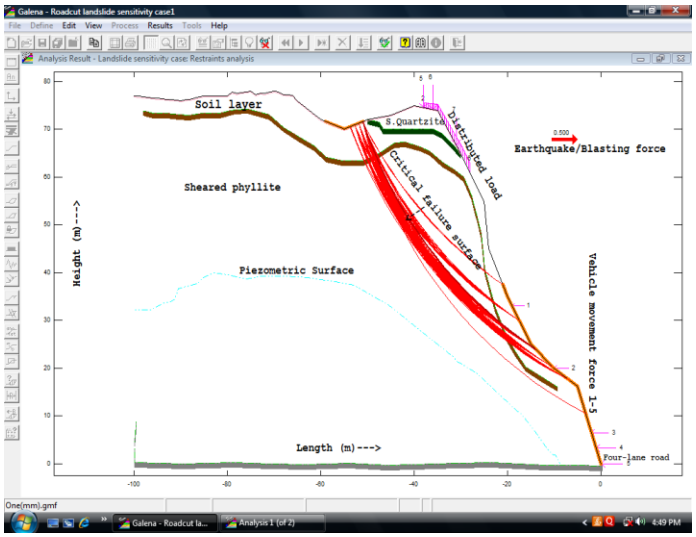
Surface segmentation analysis

- The slope surface segmentation play its important role in slope failures
- The segmentation variables and their mutual relationship may be considered as diagnostic
- Hence the segmentation of analysis authenticated way analyze the slope surface and the material by segmentation pattern using auto uploading of images in software

Failure surface analysis

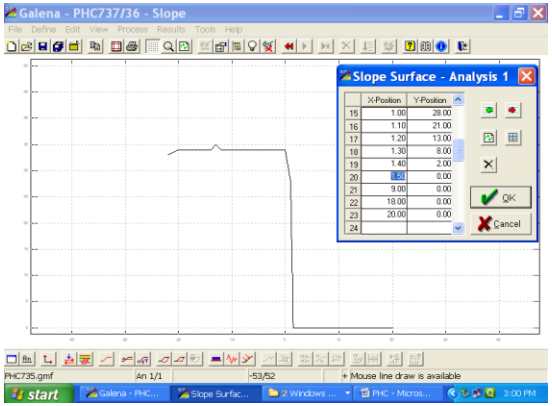


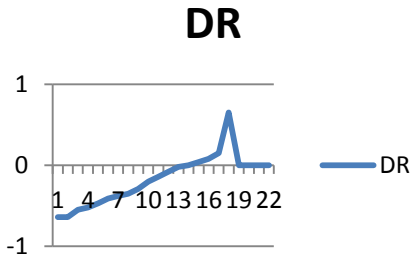


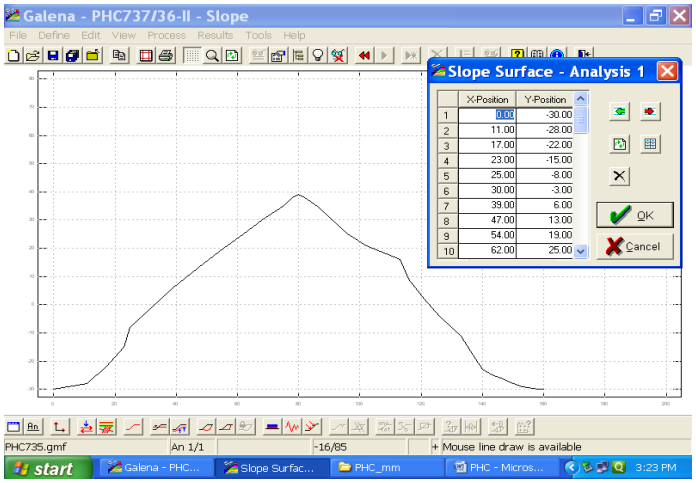


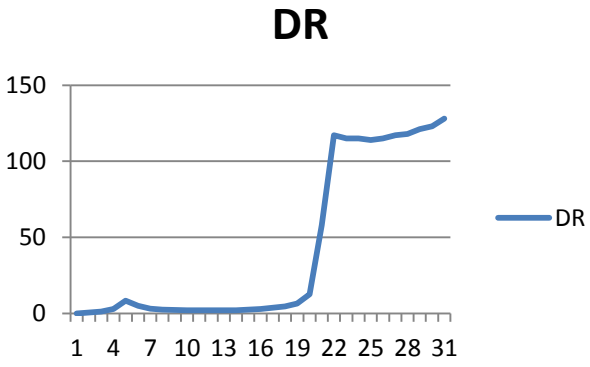
Simulation of hill cut surface profile for road construction: By using GALENA software



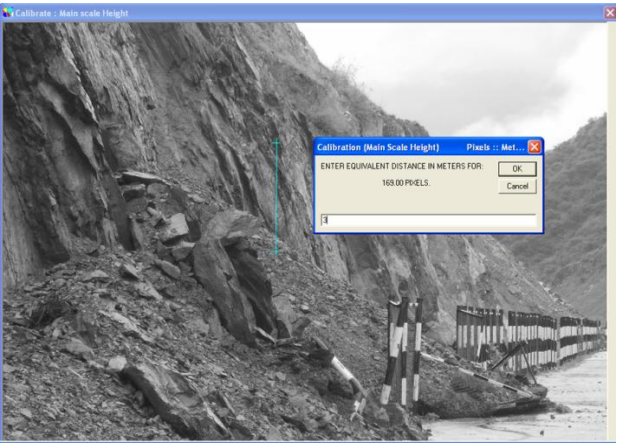


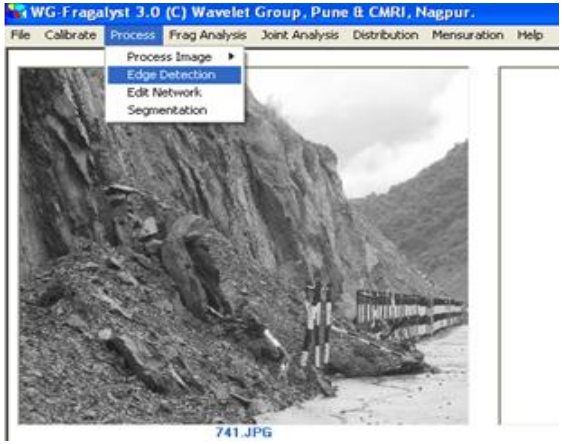


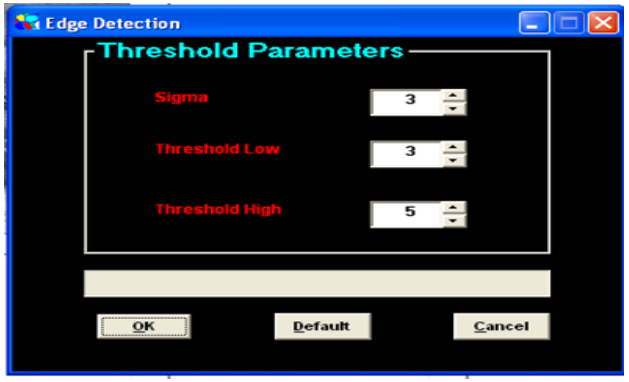


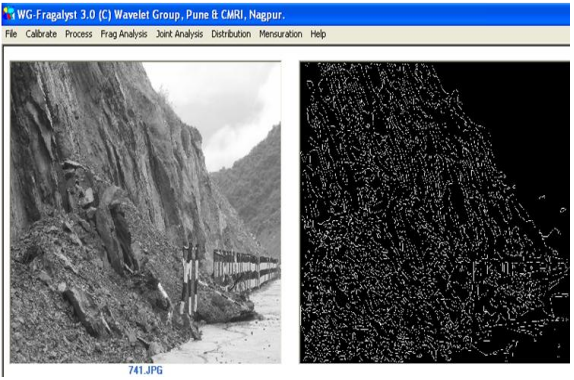


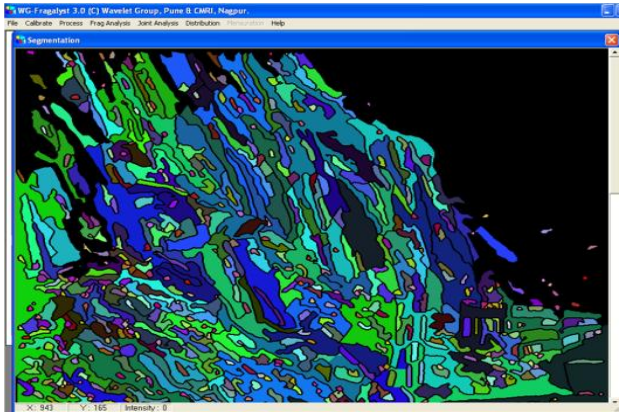
Hill cut rock segmentation analysis

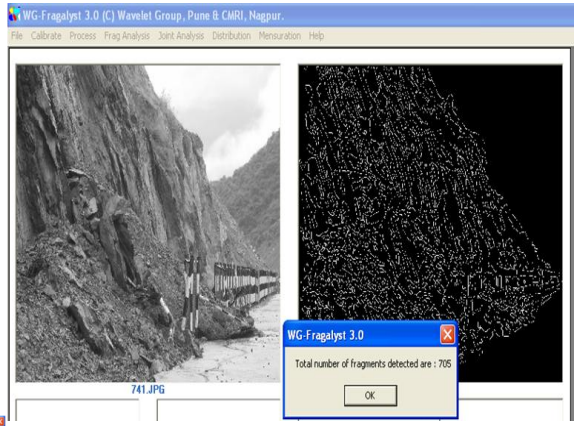


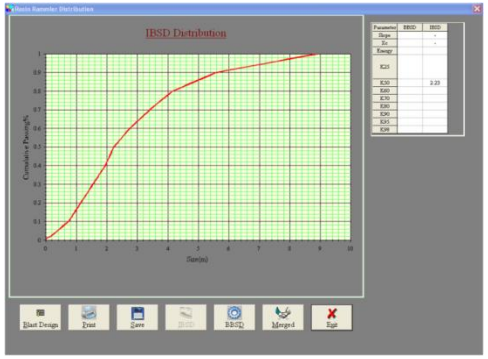


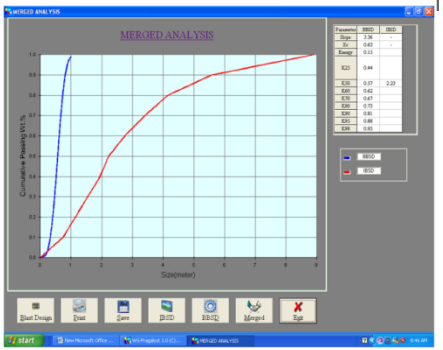








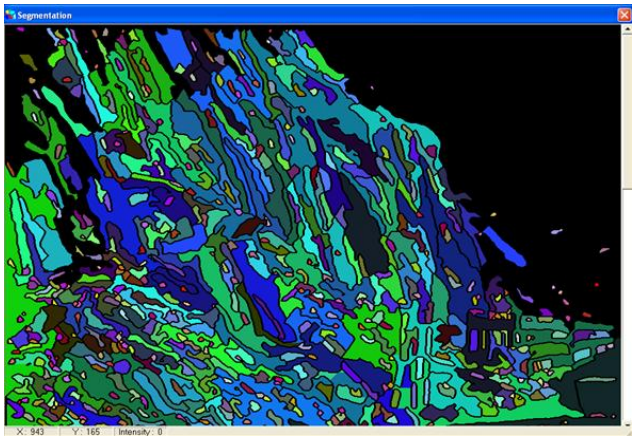


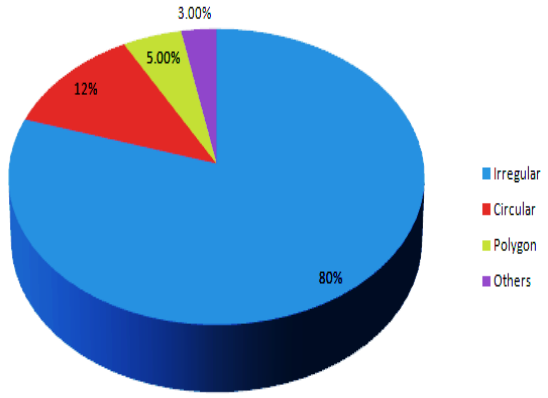


Using software
WG fragylist 3.0

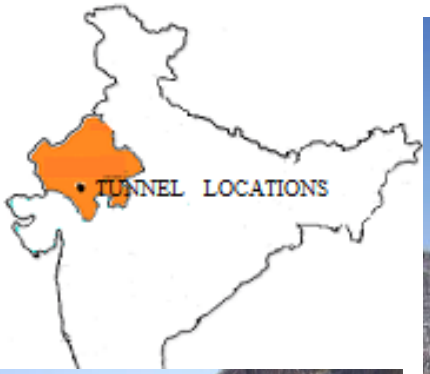
Surface image and its segmentation

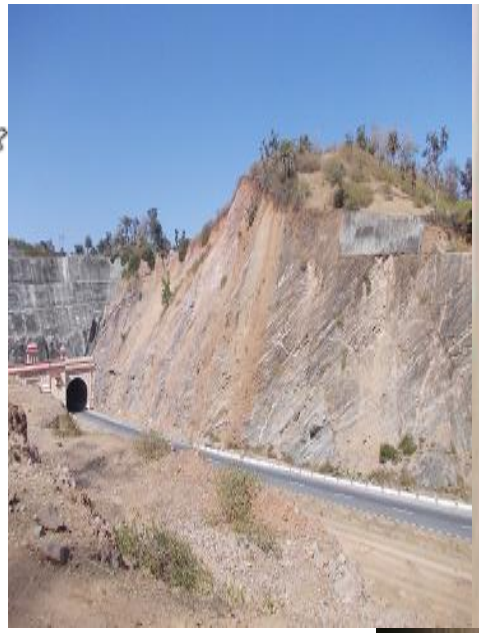




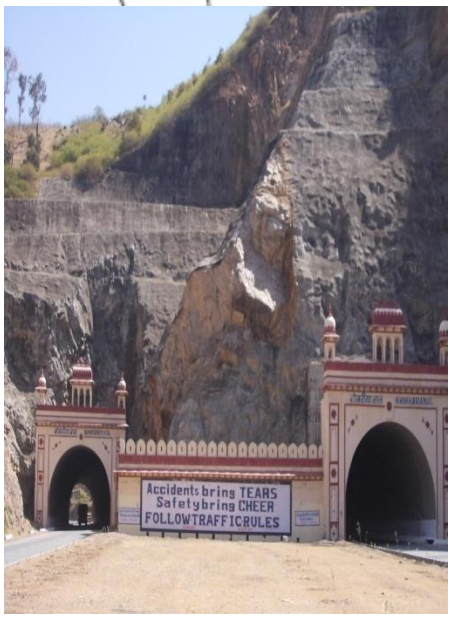


Roadways tunnel failure



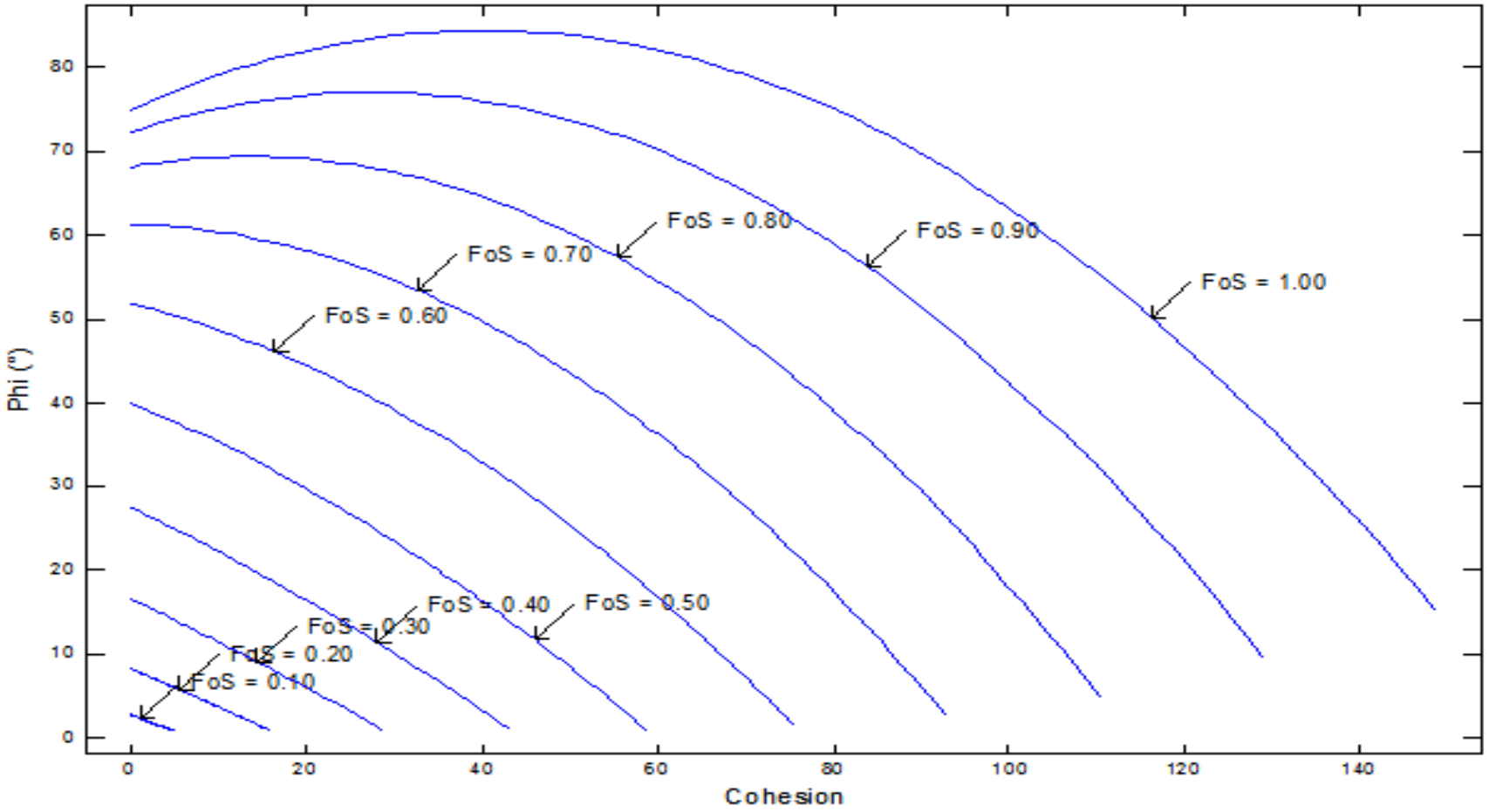




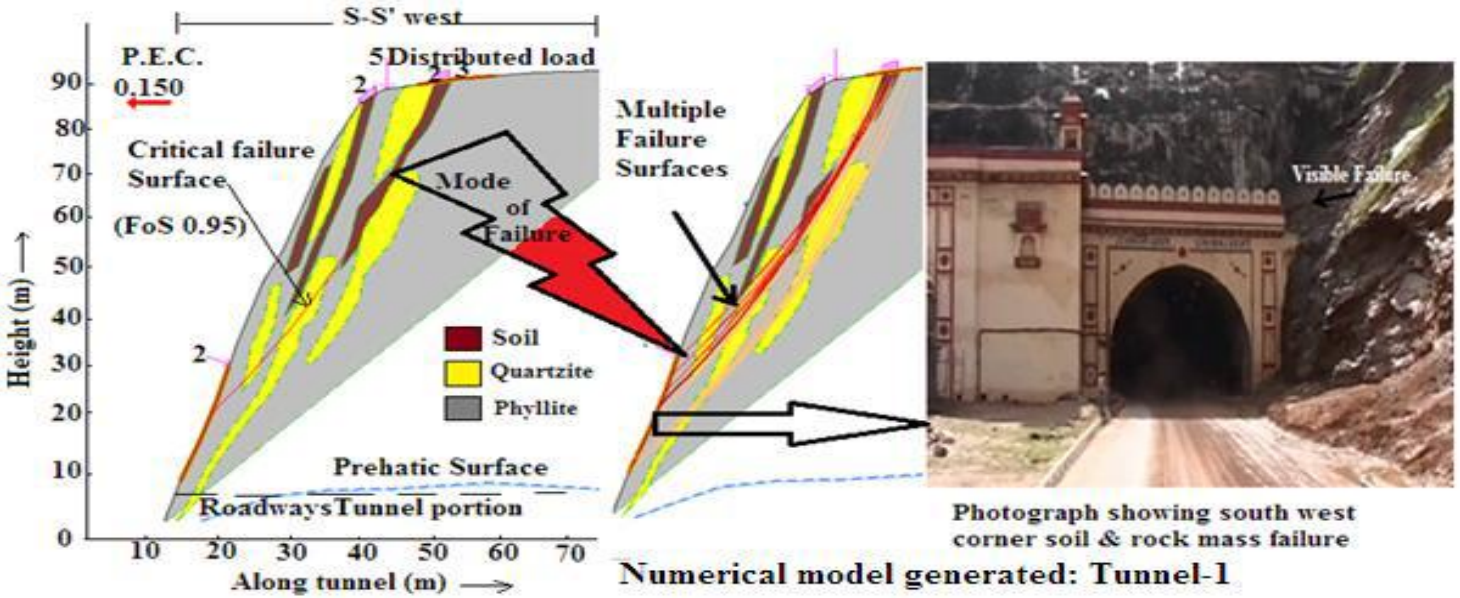




Tunnel-Back analysis multiple

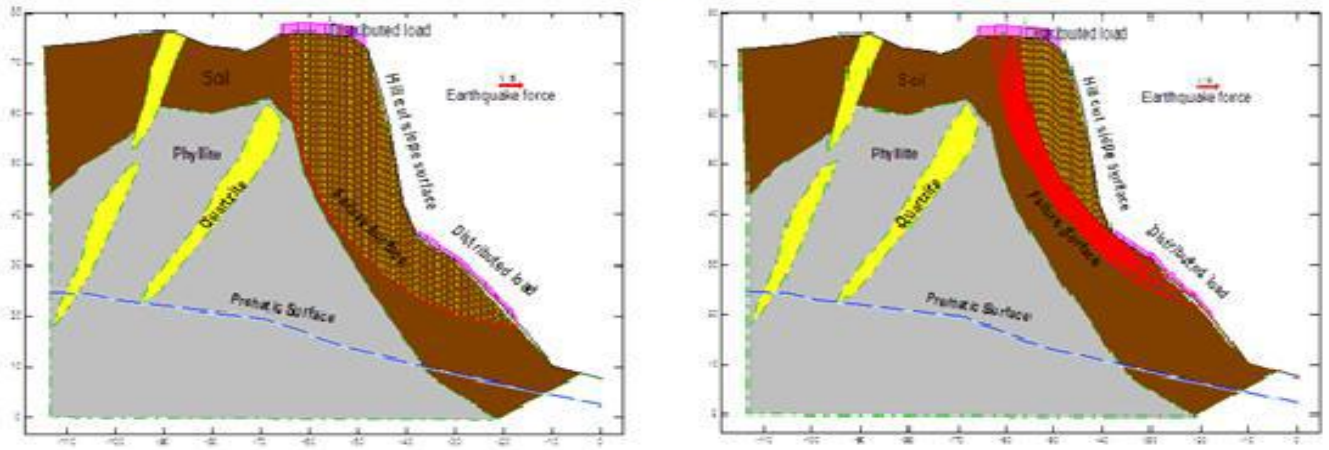


Tunnel failure numerical analysis



Photograph showing south west corner soil & rock mass failure

Numerical model generated: Tunnel-1



Numerical model generated: Tunnel-2

Various forces acting on the tunnel

Induced Forces on the Soil & rock mass	Distributed load (2-Loads)				Pseudo-static earthquake coefficient	External Force (Vehicle movement induced)		
	X-Left	Pressure	X-Right	Pressure	0.150	Value	X-Pos'n	Angle
1	29.56	2.0	32.05	3.0	0.150	2.0	10.12	335.0
2	40.53	3.0	43.02	4.0	0.150	5.0	33.71	270.0

Tunnel failure surface for critical search

Particulars	XC		YC	
Circle centre(C)	-135.82		142.80	
Intersections value assigned	**XL**	**YL**	**XR**	**YR**
	6.45	18.37	44.02	84.66
Generated Failure surface (X,Y Coordinates)	(6.45, 18.37) (9.08, 21.44) (11.63, 24.56) (14.13, 27.74) (16.55, 30.97) (18.90, 34.25) (21.19, 37.58) (23.40, 40.96) (25.54, 44.38) (27.61, 47.85) (29.60, 51.36) (31.51, 54.92) (33.35, 58.51) (35.11, 62.15) (36.80, 65.81) (38.40, 69.52) (39.93,73.26) (41.37, 77.03) (42.74, 80.83) (44.02, 84.66)			
Variable restraints	Parameter descriptor and value assigned			
	XL	**XR**	**R**	
Range of variation	7.00	11.00	9.00	
Trial positions within ranges	9	9	9	

Selection of Variables used for the analysis

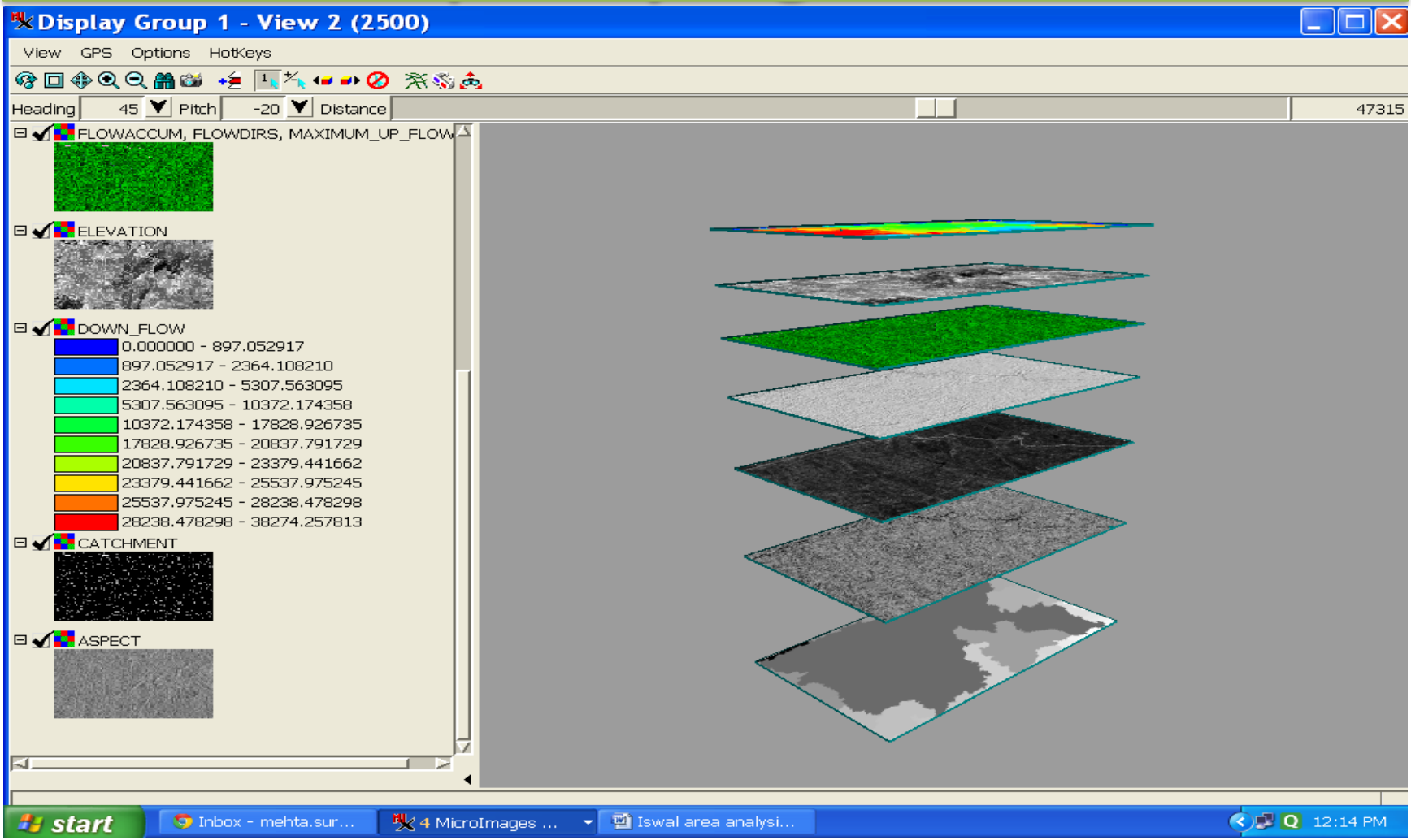
- **Most commonly used and well tested sensor networkings are zigbee, crossbow, imote etc.**

- **These sensors are software embedded hardware for RFID communication.**
- **Optical fiber sensors is the sensing of deformation occurred in the fiber arm. The fiber sensor placed underground is deformed by the movement of landmass and thereby exhibit light loss in the transmission. T**
- **his perturbation of fiber axis results in redistribution of guided power between modes of the fiber and those results in the effect of coupling network (Stephen Evanczuk, 2012).**
- **The Global Positioning System (GPS) is a major tool for automated continuous monitoring of slope surface.**
- **This system is being increasingly used for detection of displacement of land masses even for the order of millimeter.**
- **This is done with the help of more than one GPS satellite data with their relative displacement. In GPS based monitoring systems, the accuracy, availability, reliability and integrity of the positioning solutions heavily depend on the number and geometrical distribution of satellite being tracked i.e. almanac, ephemeris and atomic clock aboard on satellites in networking.**
- **The importance of GPS system is that it can be used in all the weathers and inter-station visibility is not required. Moreover, the station relative positioning can be achieved up to millimeter accuracy**

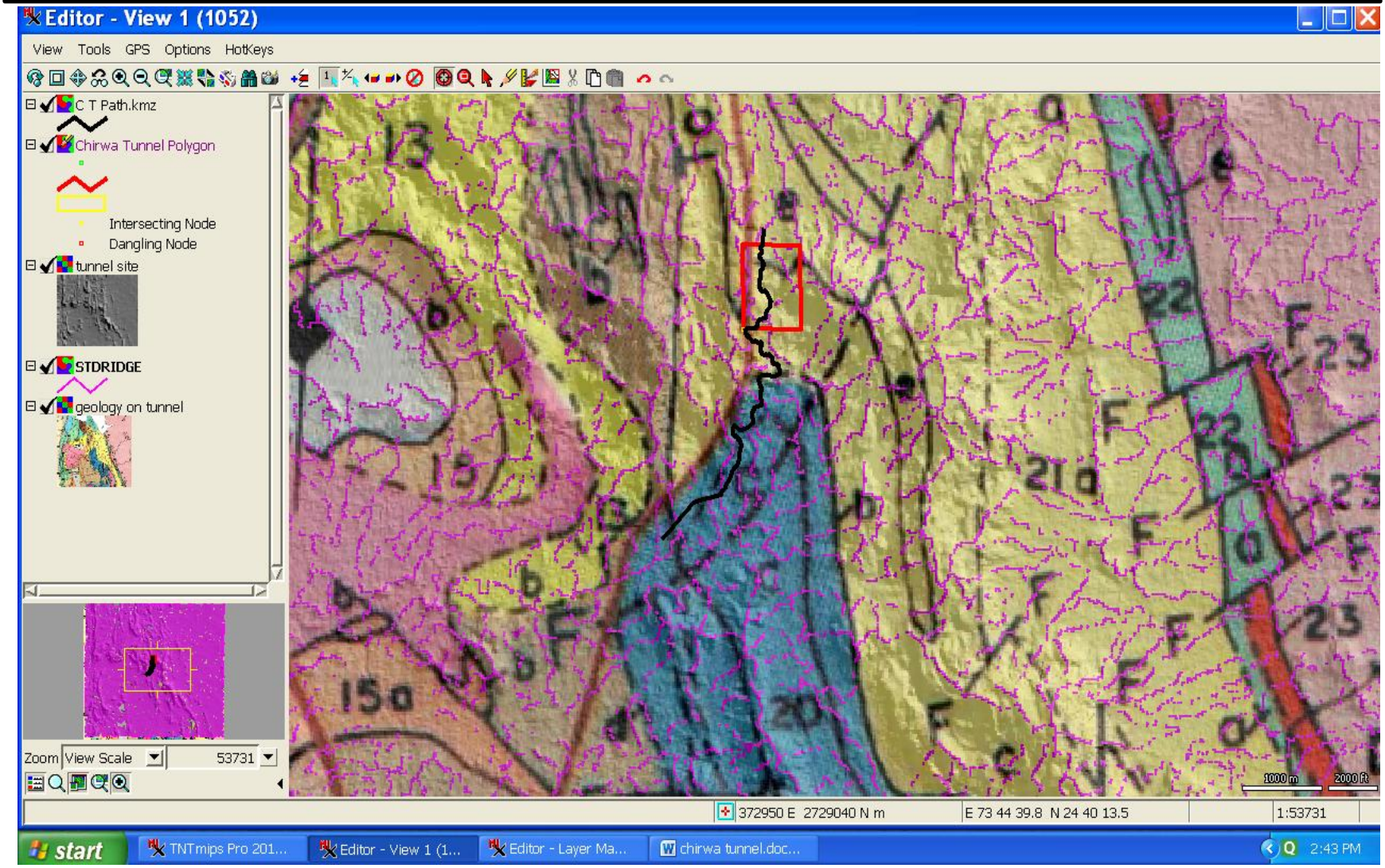
Architecture Development

- Simulation of slope geometry, slope surface angle, slope surface and subsurface material properties, structural planar and structural features, Vegetative index of slope surface, location in water shed, standard stream number and order, relief, rainfall precipitation or intensity per unit time, pseudo static earthquake coefficient etc of slope surface. Slope description, Slope parameters, Slope failures and Slope stability.

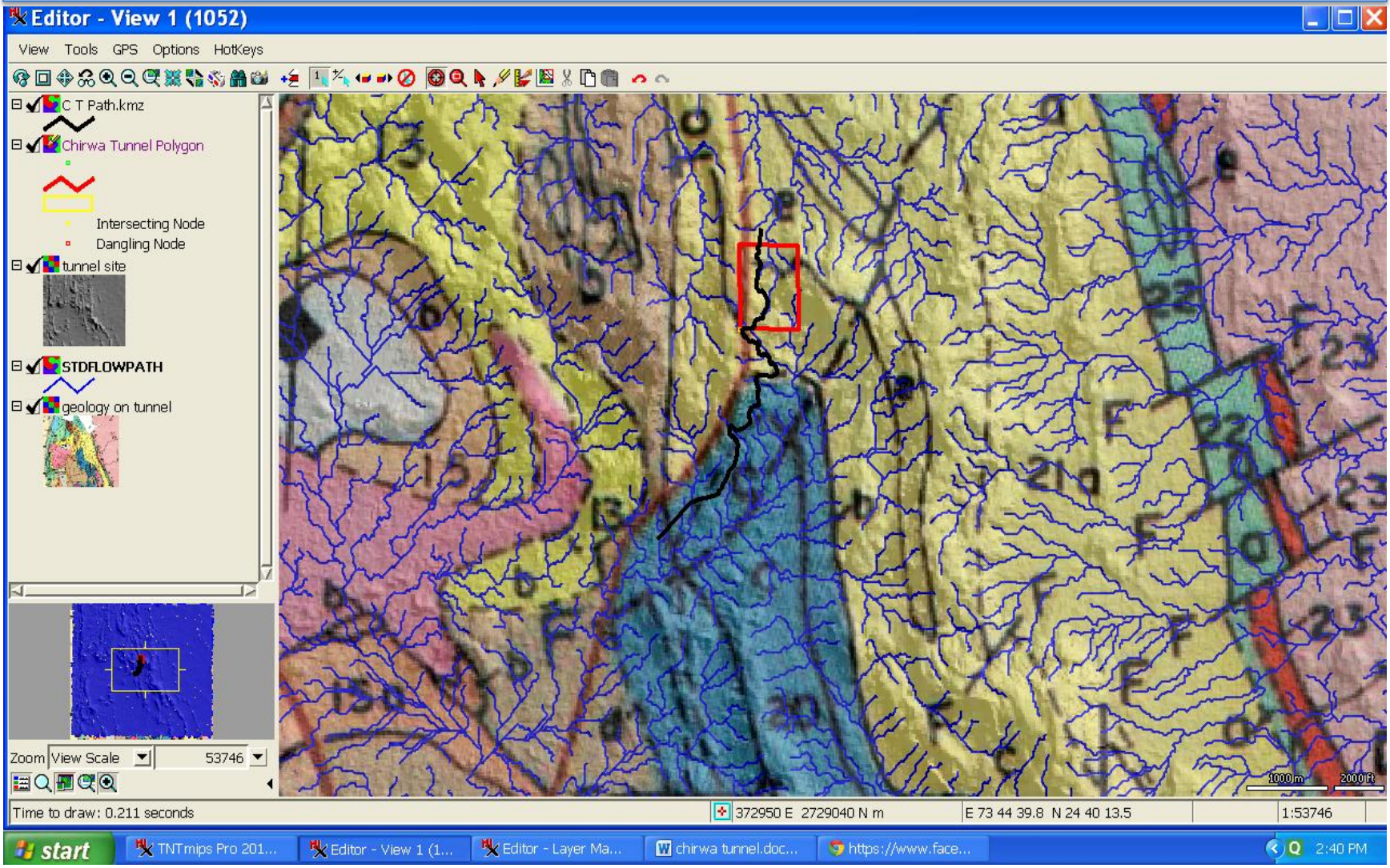
Coordinate/ Grid-wise Multiple layer generation



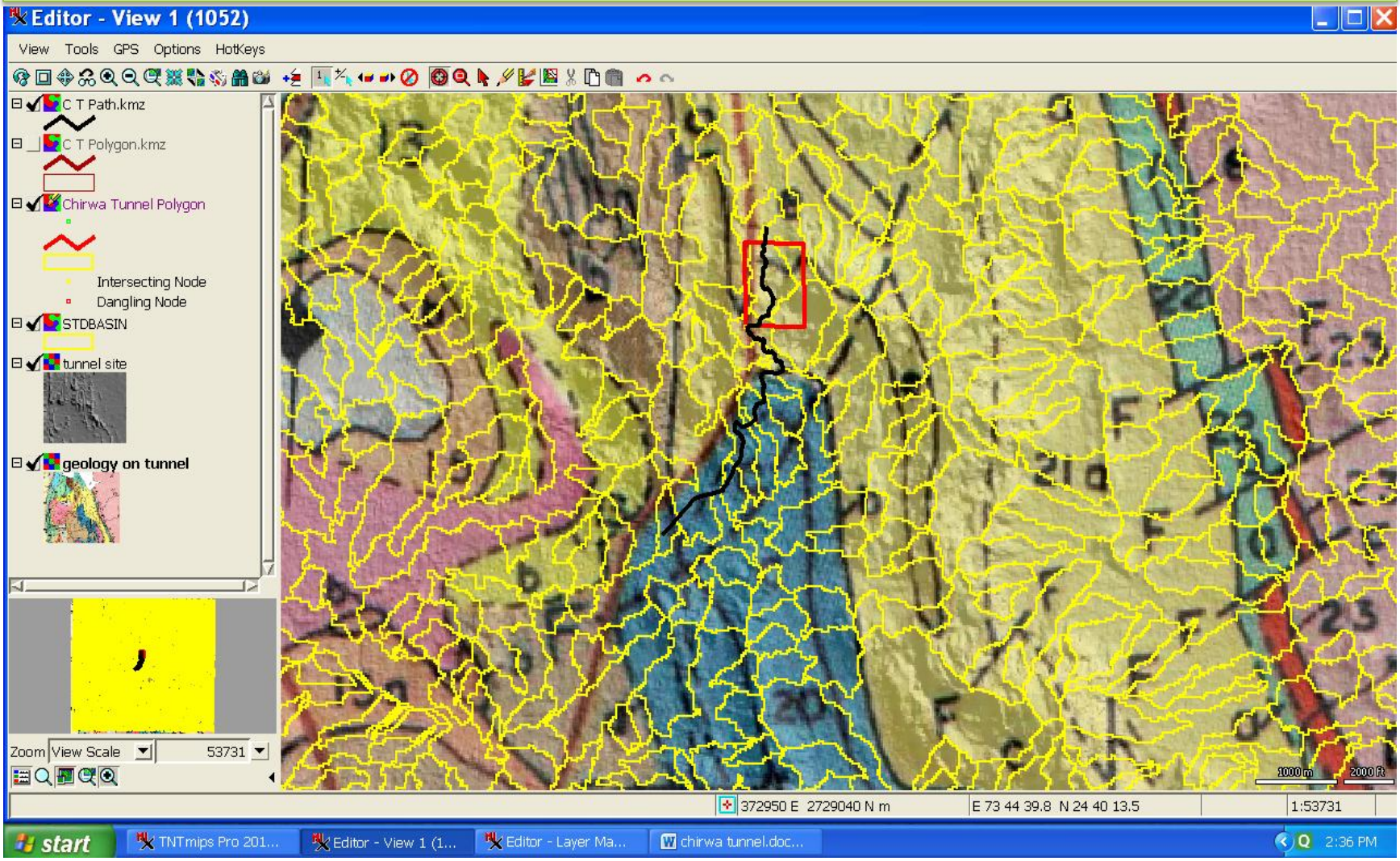
Auto-geo-referencing brings Geology with ridges



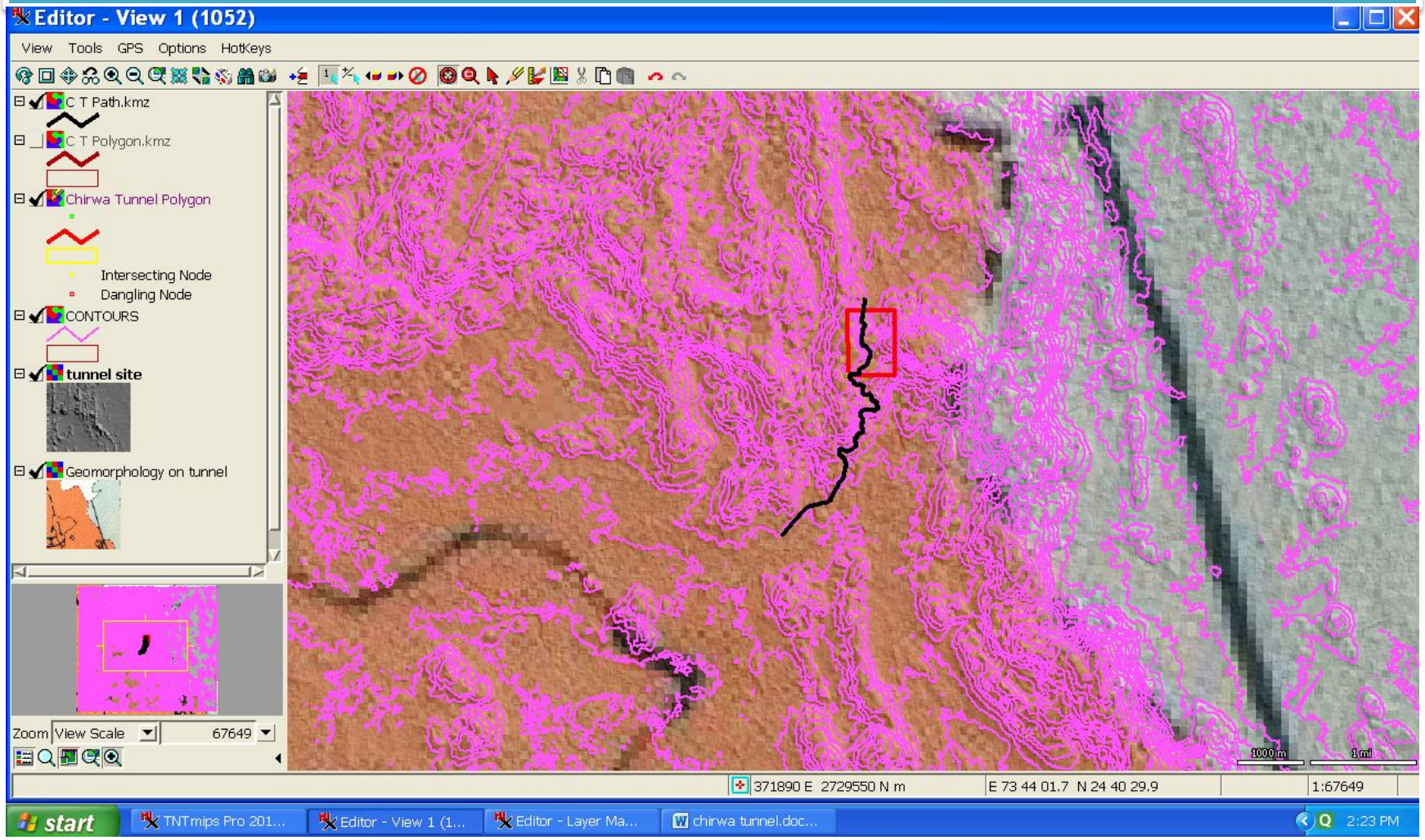
Auto-Super-imposition of flow-paths



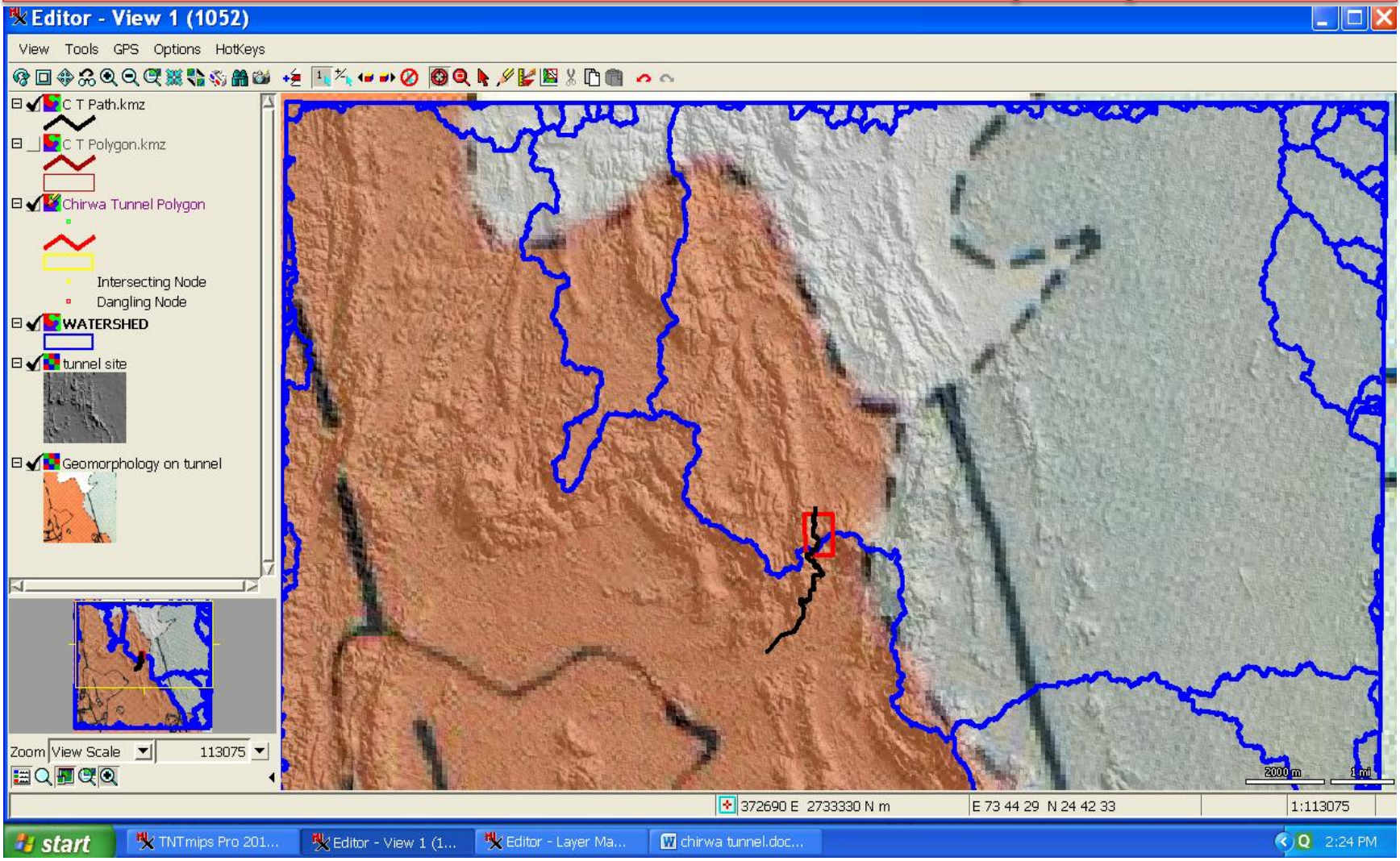
Auto-display of micro-basins



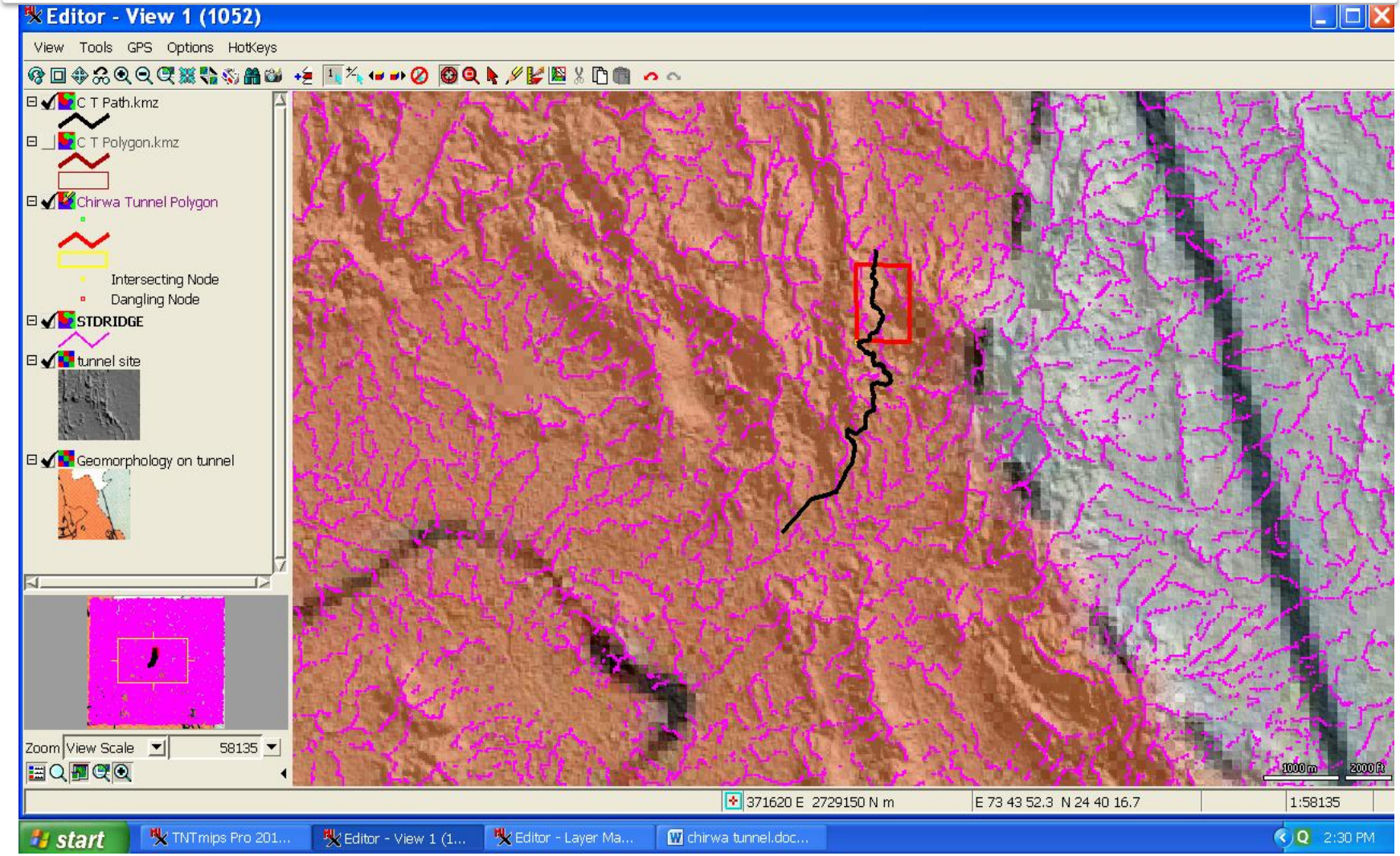
Computer generated Geomorphology with contours



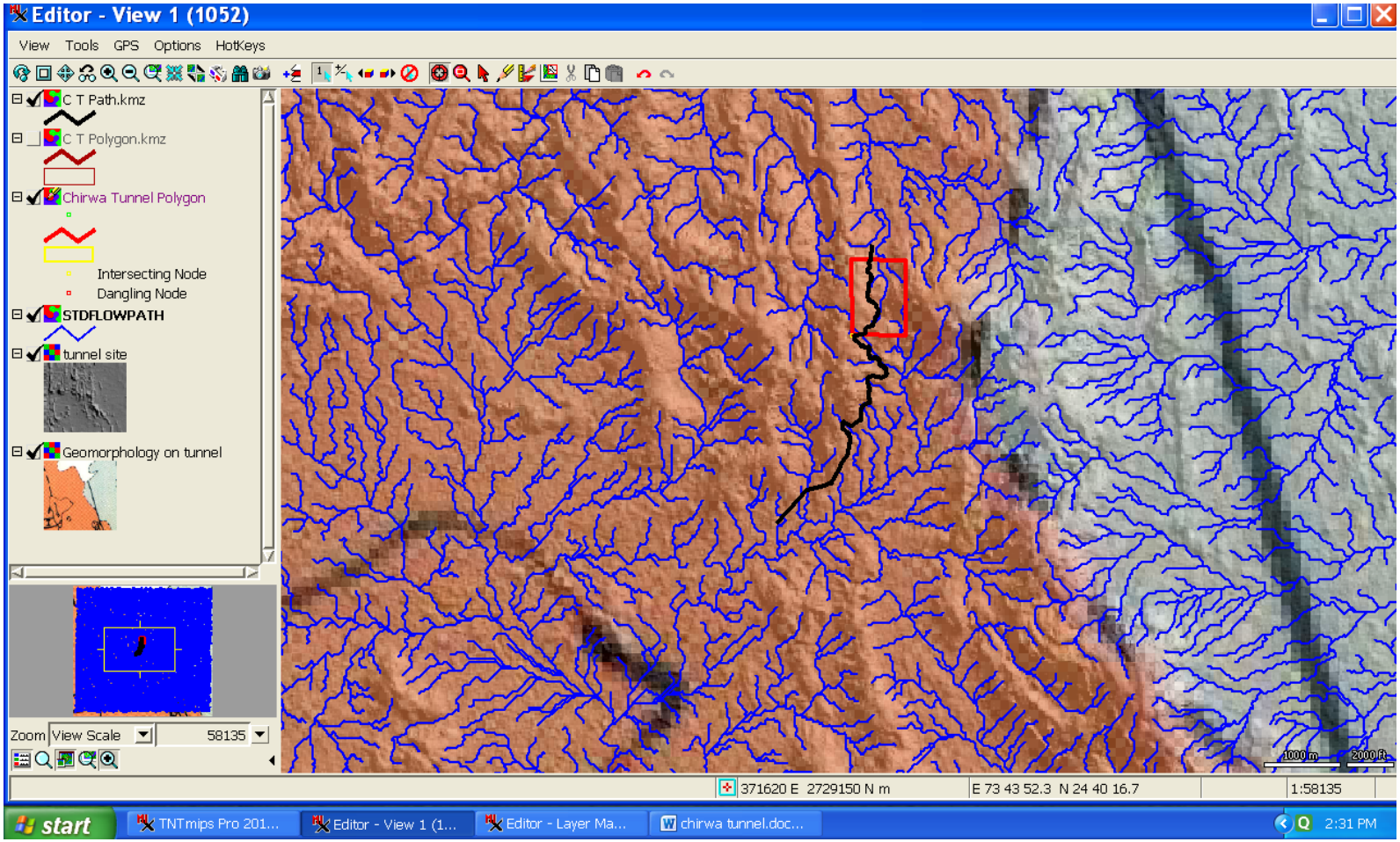
Geomorphology, watershed and buffer Zones auto-display



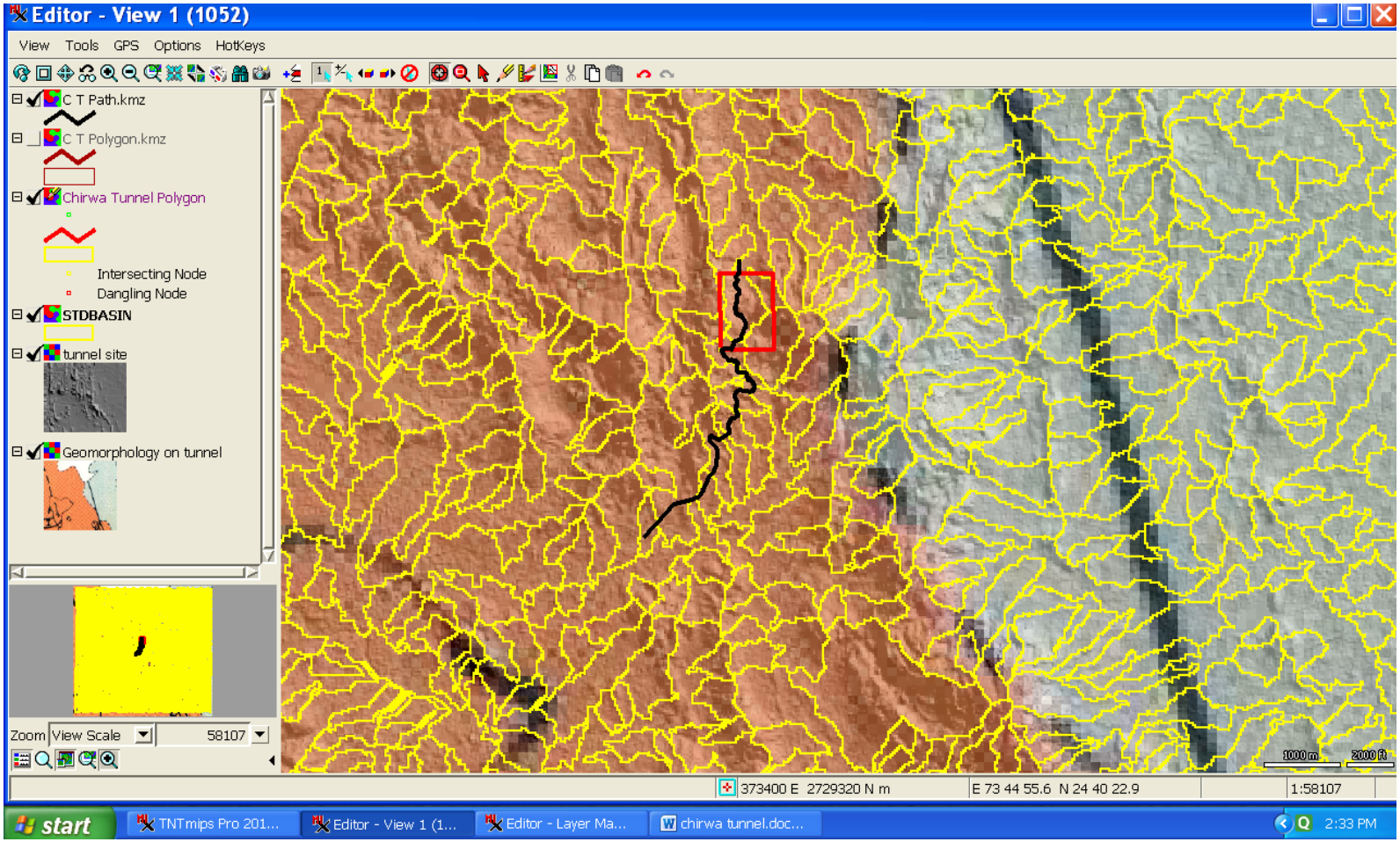
Geomorphology with standard ridges



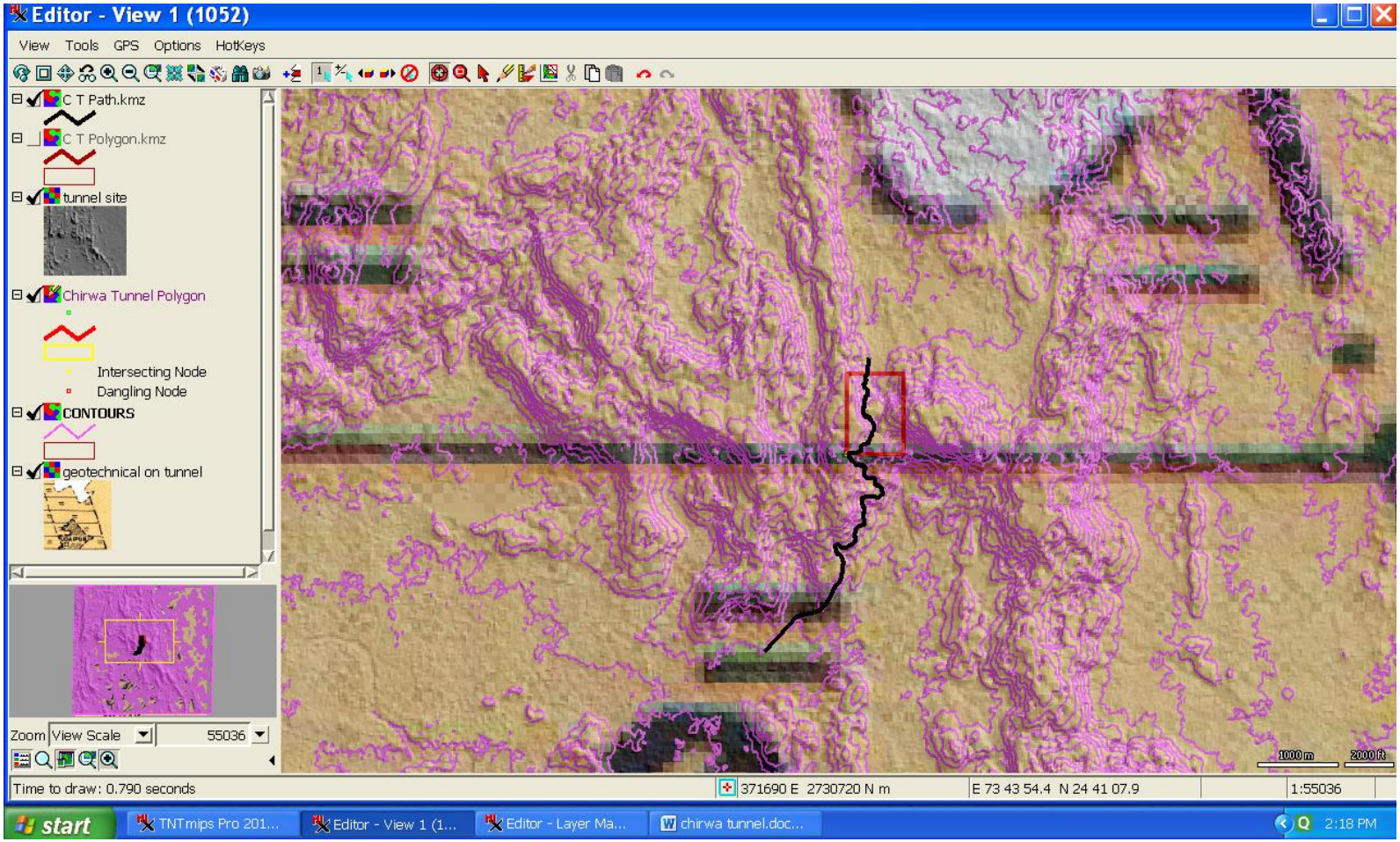
Geomorphology with standard flow-path



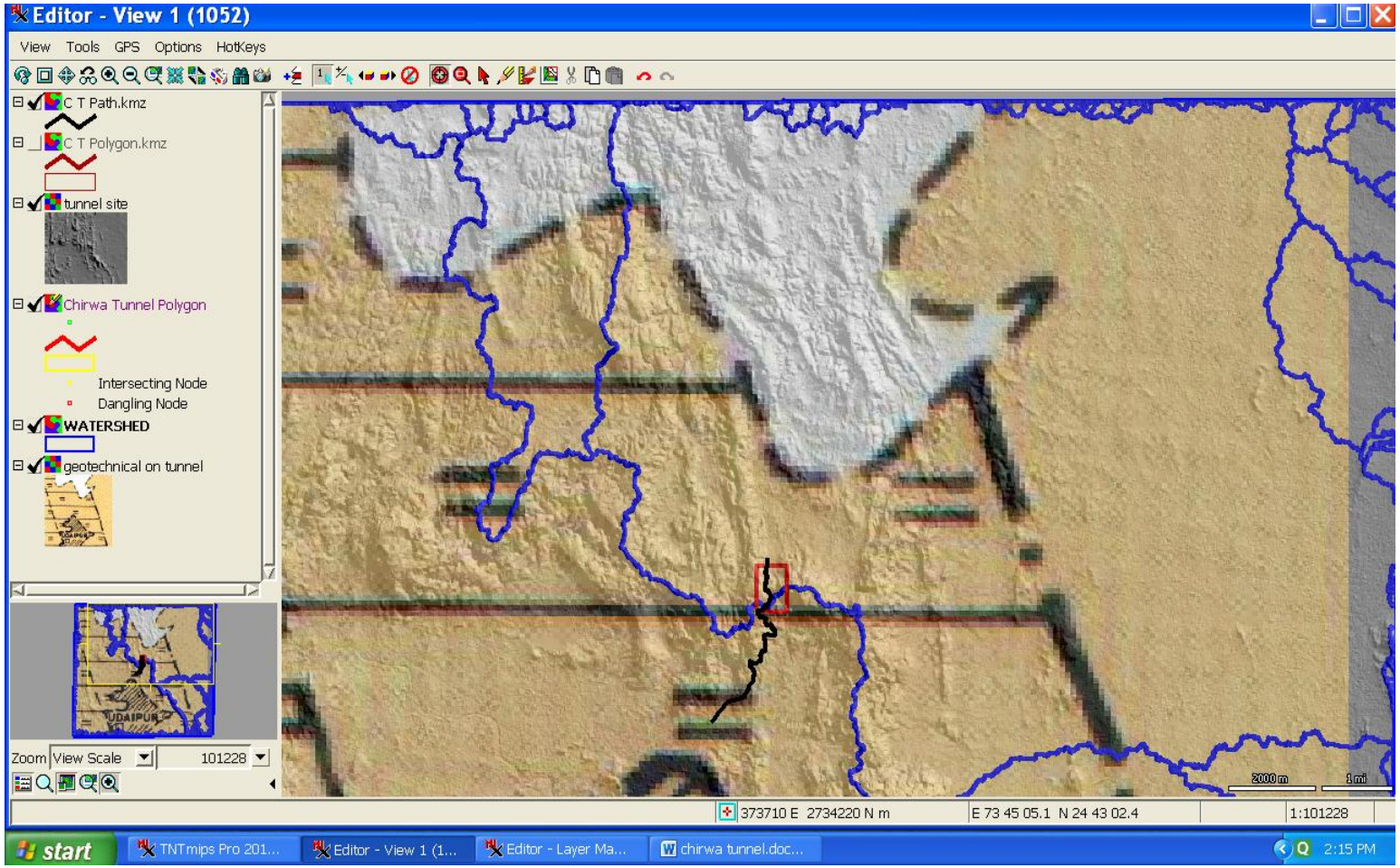
Geomorphology with standard basin



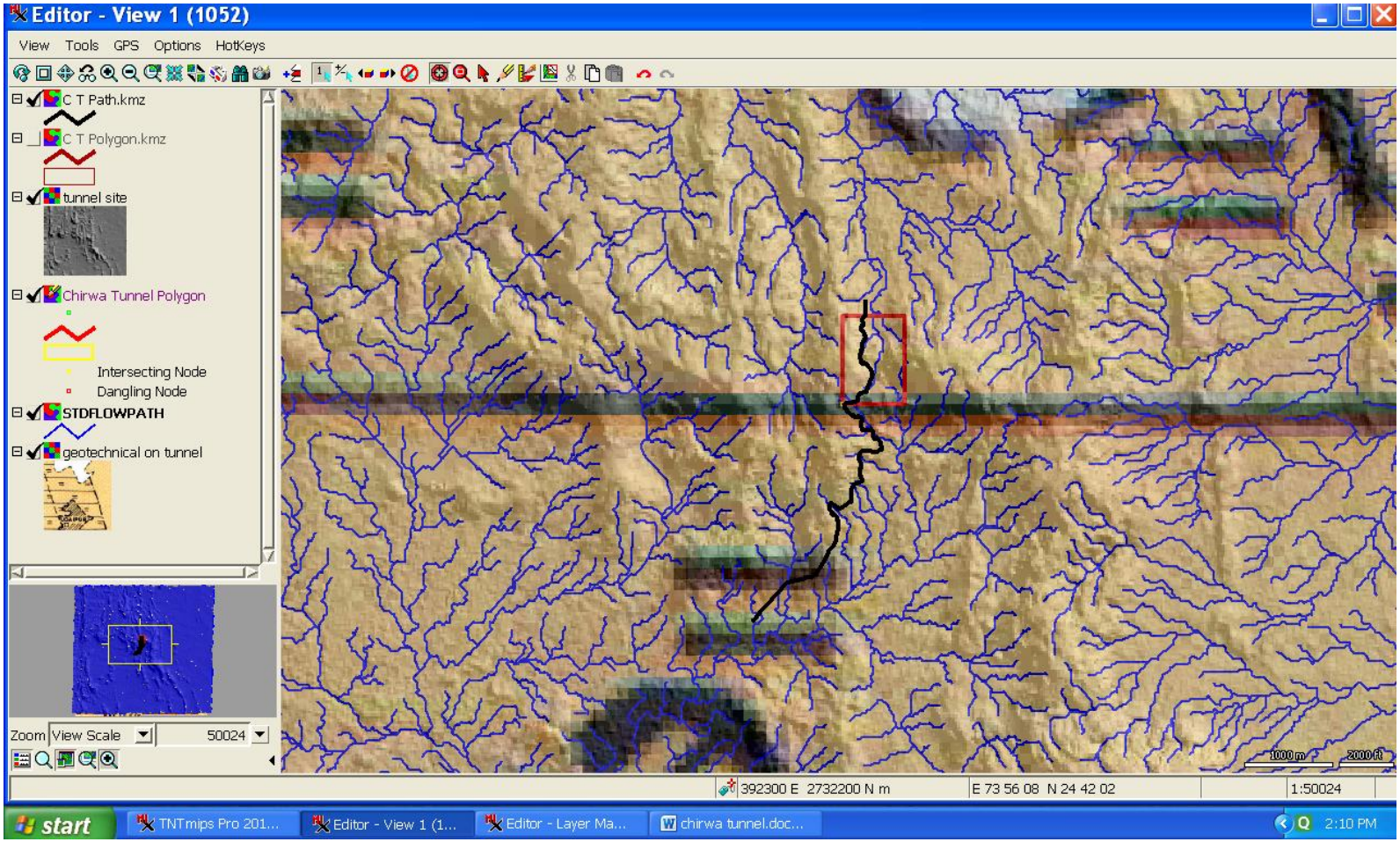
Geotechnical categorization with contours



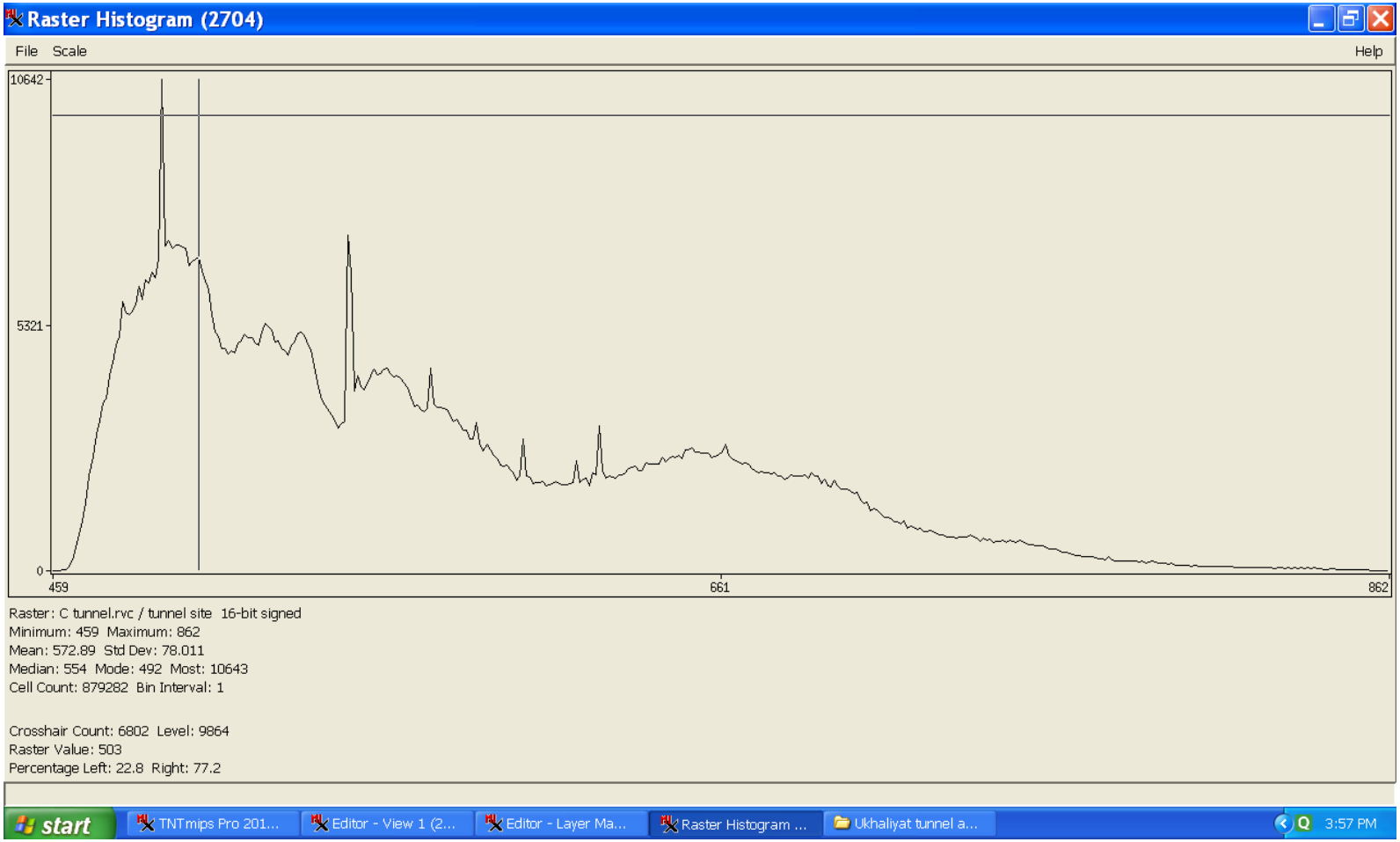
Geotechnical with watershed



Geotechnical with standard flow-paths



Raster histogram with meta data



Enhance contrast for further refinement of coordinate details

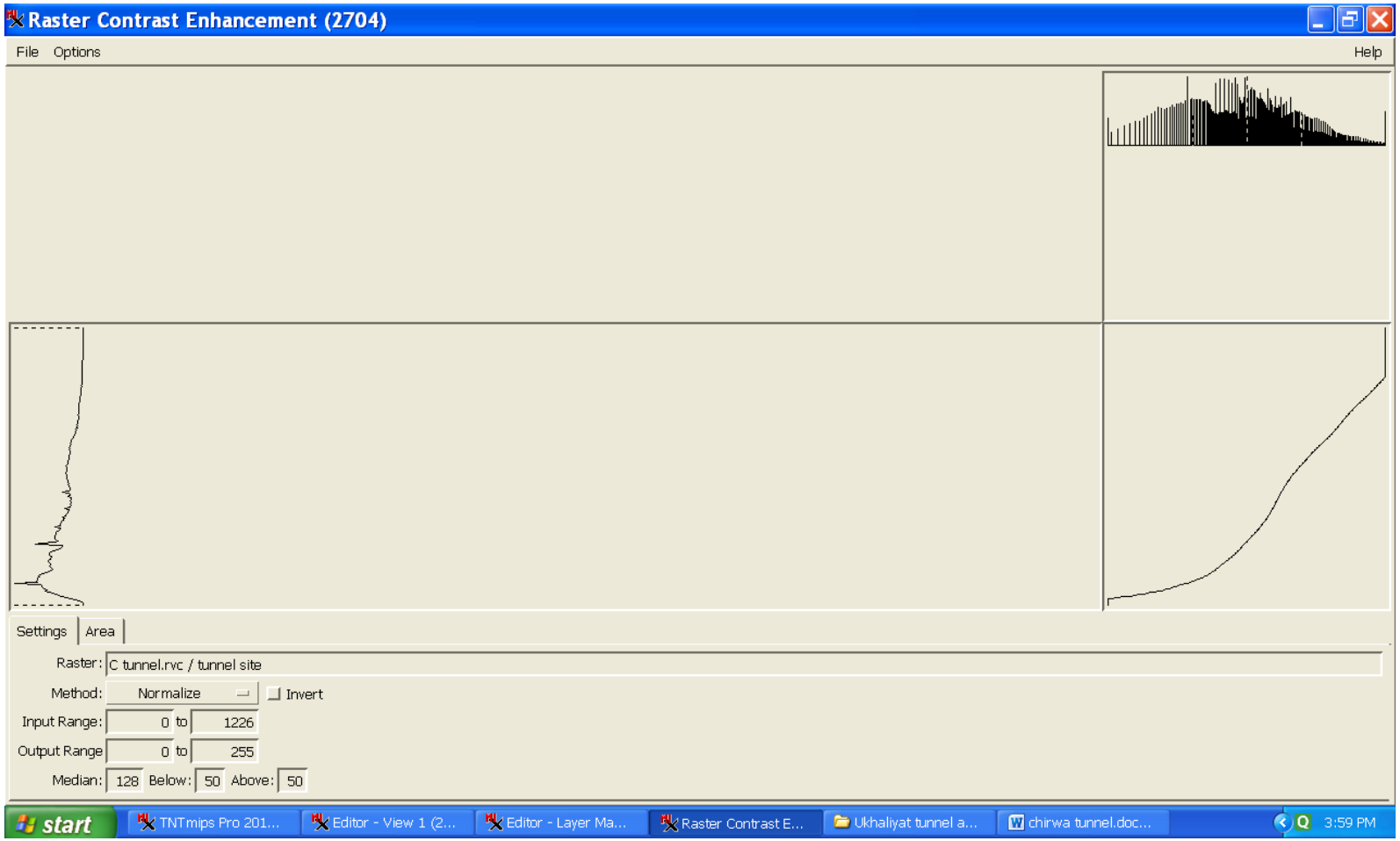
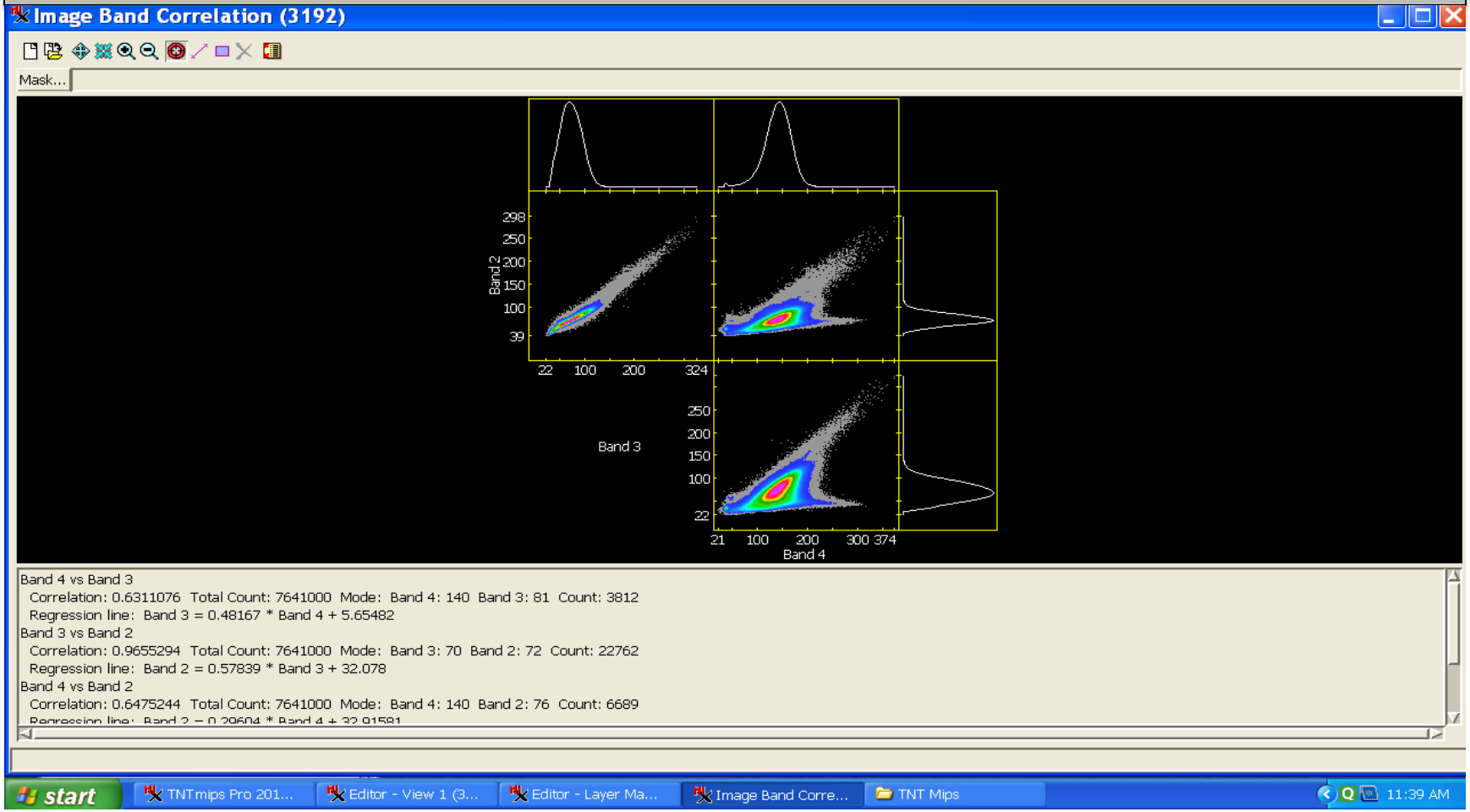


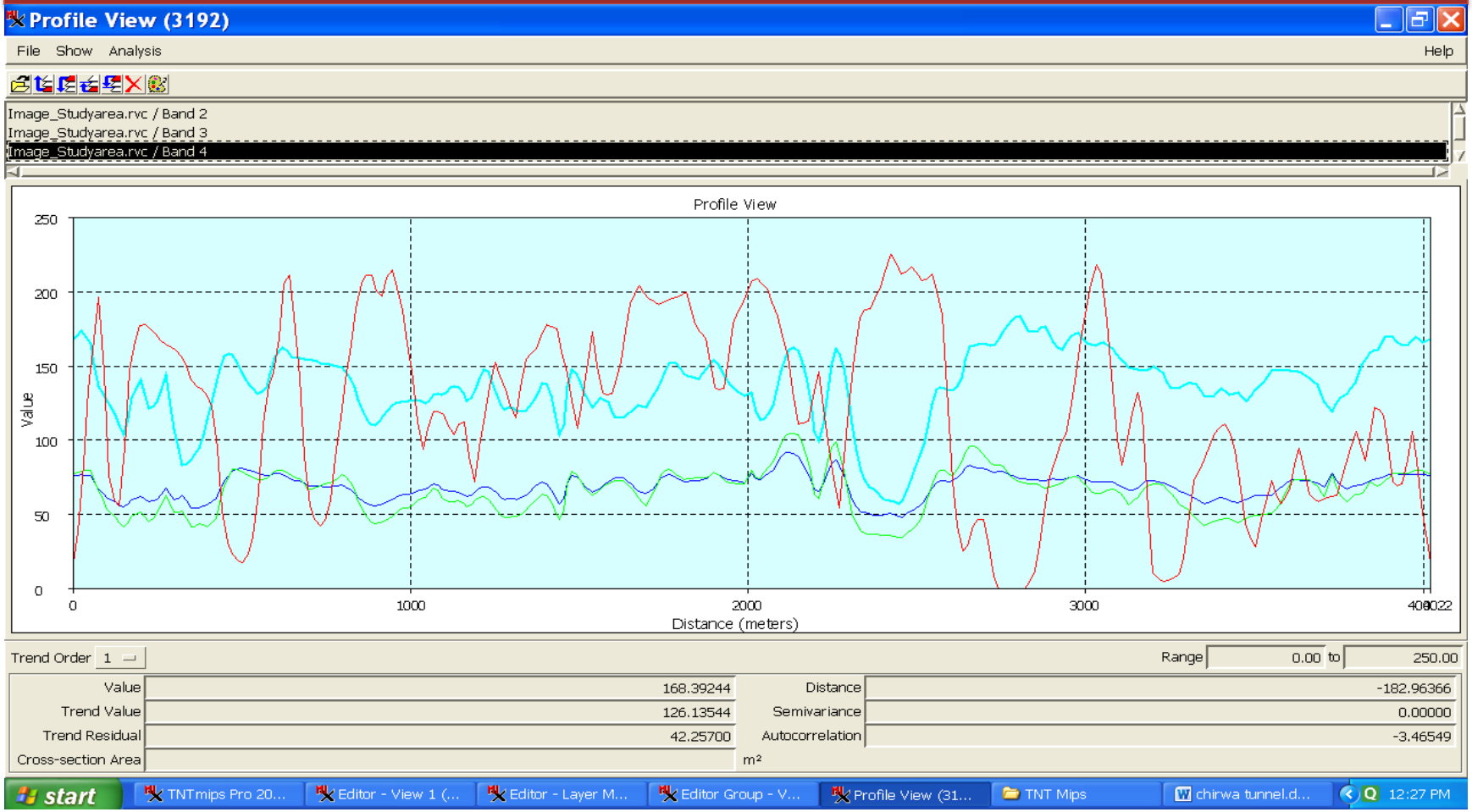
Image band correlation helps in pin pointing the scar line of likely to be landslides



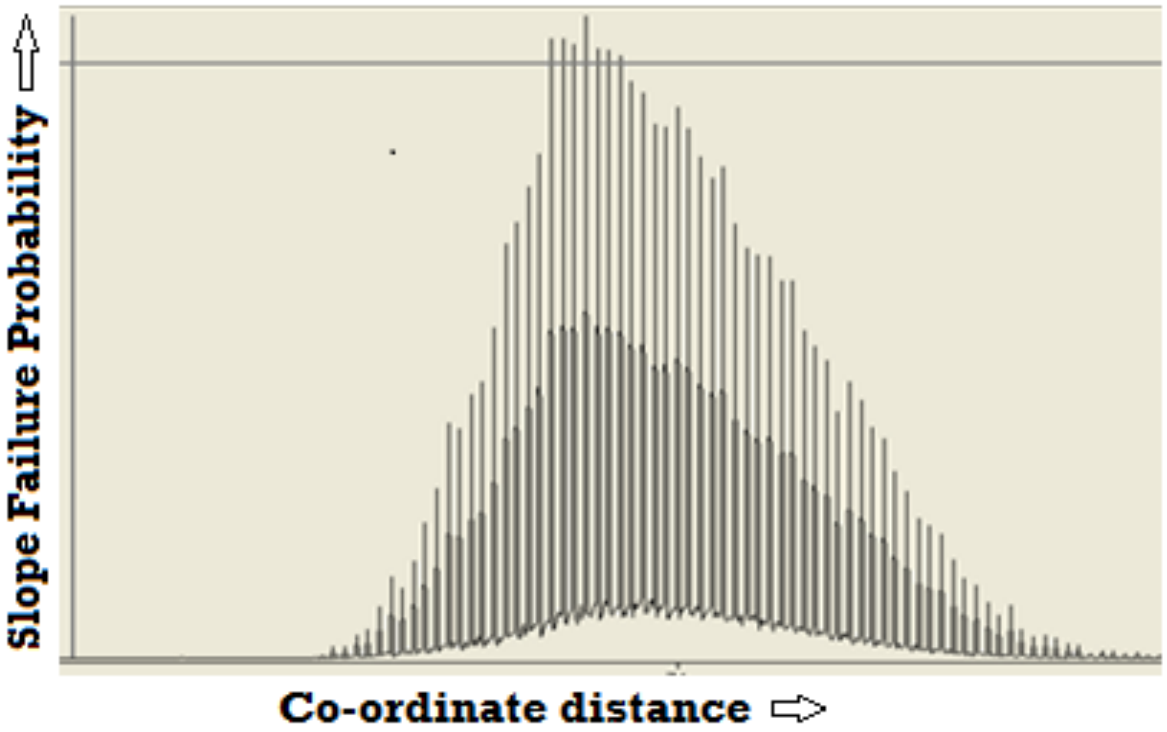
Satellite Data Sample

- Band 4 vs Band 3
- Correlation: 0.6311076 Total Count: 7641000 Mode: Band 4: 140 Band 3: 81 Count: 3812
- Regression line: Band 3 = 0.48167 * Band 4 + 5.65482
- Band 3 vs Band 2
- Correlation: 0.9655294 Total Count: 7641000 Mode: Band 3: 70 Band 2: 72 Count: 22762
- Regression line: Band 2 = 0.57839 * Band 3 + 32.078
- Band 4 vs Band 2
- Correlation: 0.6475244 Total Count: 7641000 Mode: Band 4: 140 Band 2: 76 Count: 6689
- Regression line: Band 2 = 0.29604 * Band 4 + 32.91581
- Band 4: Range: 21 to 374 Mean: 139.41 StdDev: 26.3 Median: 141 Mode: 145 Most: 127941
- Band 3: Range: 22 to 324 Mean: 72.8 StdDev: 20.07 Median: 72 Mode: 68 Most: 142536
- Band 2: Range: 39 to 298 Mean: 74.19 StdDev: 12.02 Median: 74 Mode: 71 Most: 266322

Profile view for likely to be landslide & its pattern diagnosis



Failure Probability Extrema peaks



Meta Data Sub-folder Auto-saved and interlinked with numerical analysis

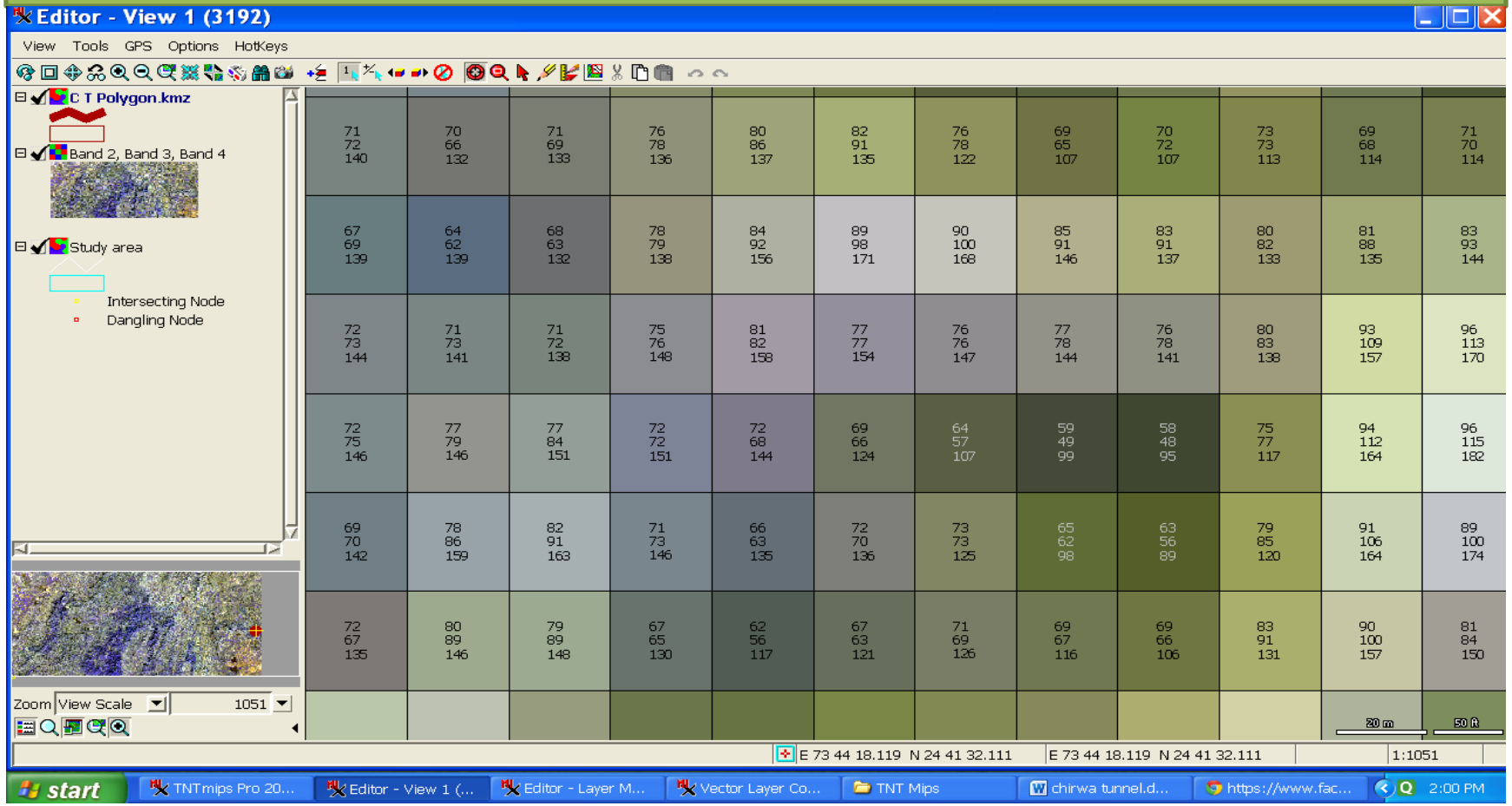
Perimeter	4021.81224 m
Major Axis	1539.62050 m
Minor Axis	471.25949 m
Area	728634.3032 6 m²
X Extent	471.28563 m
Y Extent	1539.62050 m
Angle	0.00000 deg
Center X	E 73 44 12.512
Center Y	N 24 41 07.450

_C_T_Polygon_km	
Type	Vector
Minimum X	73.73448
Centroid X	73.73681
Maximum X	73.73914
X Extent	0.00466
Minimum Y	24.67845
Centroid Y	24.68540
Maximum Y	24.69235
Y Extent	0.01390

Line measurement statistics	
Length	2075.14034 m
Angle	-90.00000 deg
Heading	180.00000
Start X	E 73 44 11.315
Start Y	N 24 41 36.821
End X	E 73 44 11.315
End Y	N 24 40 29.378
Centroid X	E 73 44 11.315
Centroid Y	N 24 41 03.099

C_T_Polygon_km	
Type	Vector
Minimum X	73.73648
Centroid X	73.73648
Maximum X	73.73648
X Extent	0.00000
Minimum Y	24.67483
Centroid Y	24.68419
Maximum Y	24.69356
Y Extent	0.01873

Coordinate-wise spectral reflectance database for likely to be landslides



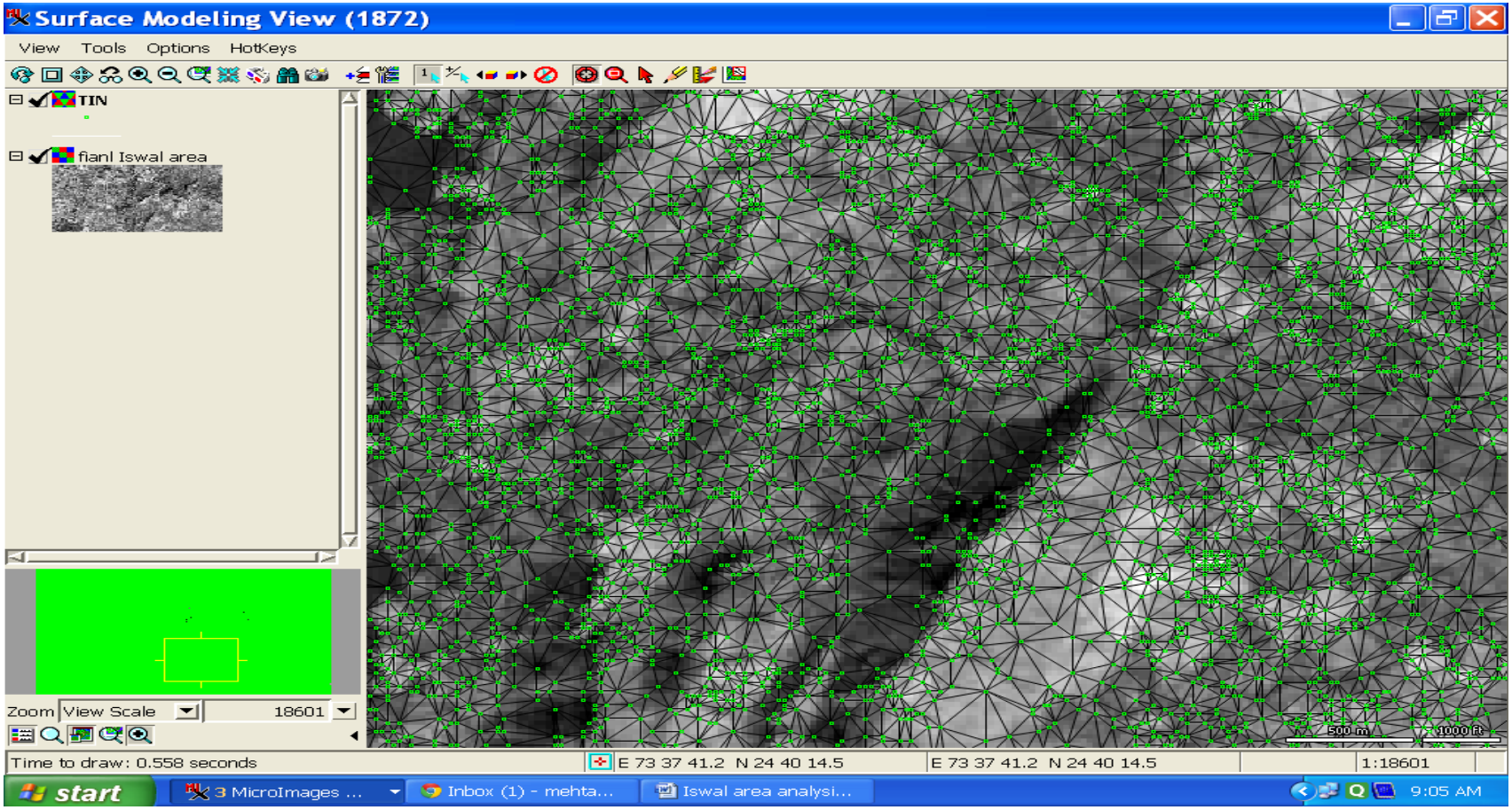
Spectral reflectance shadow categorization for early warning



Node patterns

- This node change patterns continuous monitoring by software computations online for a desired period feed to input option of SFEW diagnose and pin point slope areas likely to fail and early warning may be made.
- Nodes pattern change vs. time gives the trend of slope failure.

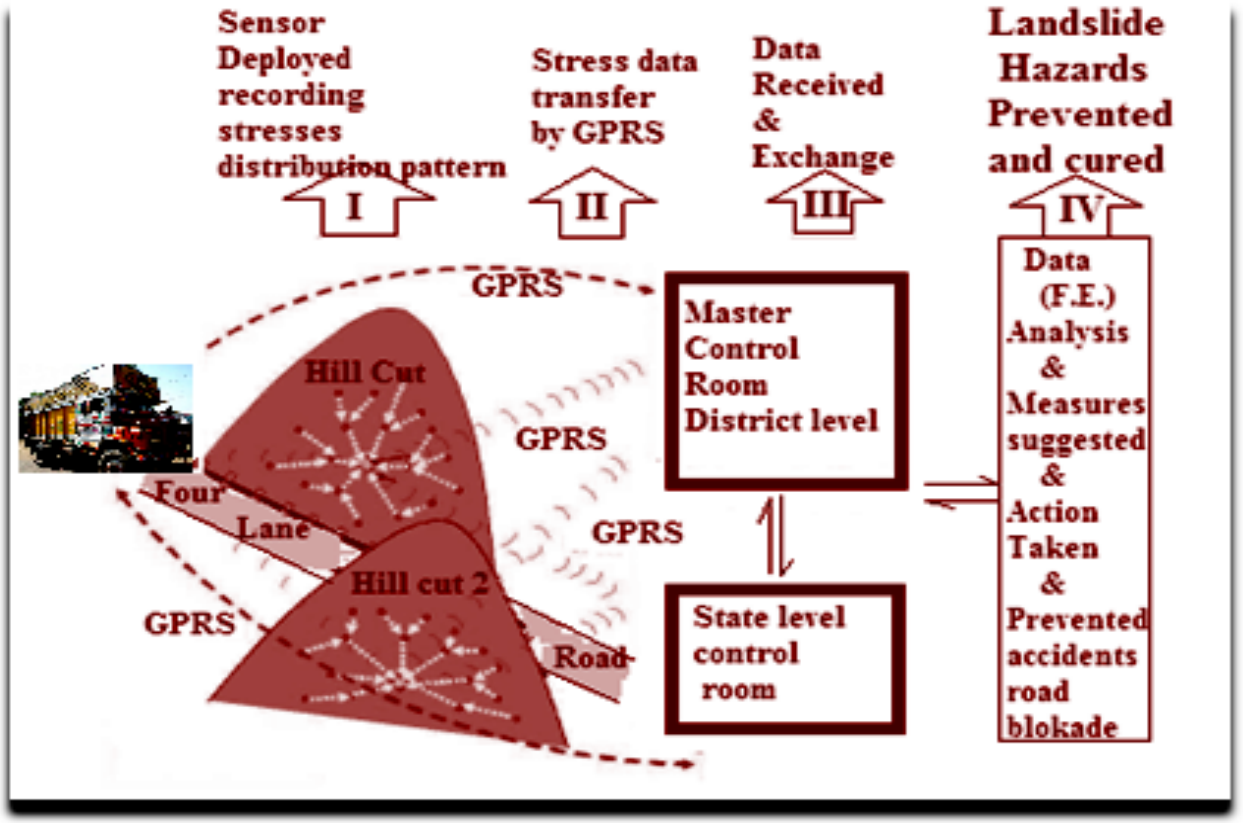
Landslides Nodes Generated



Validation and detailing

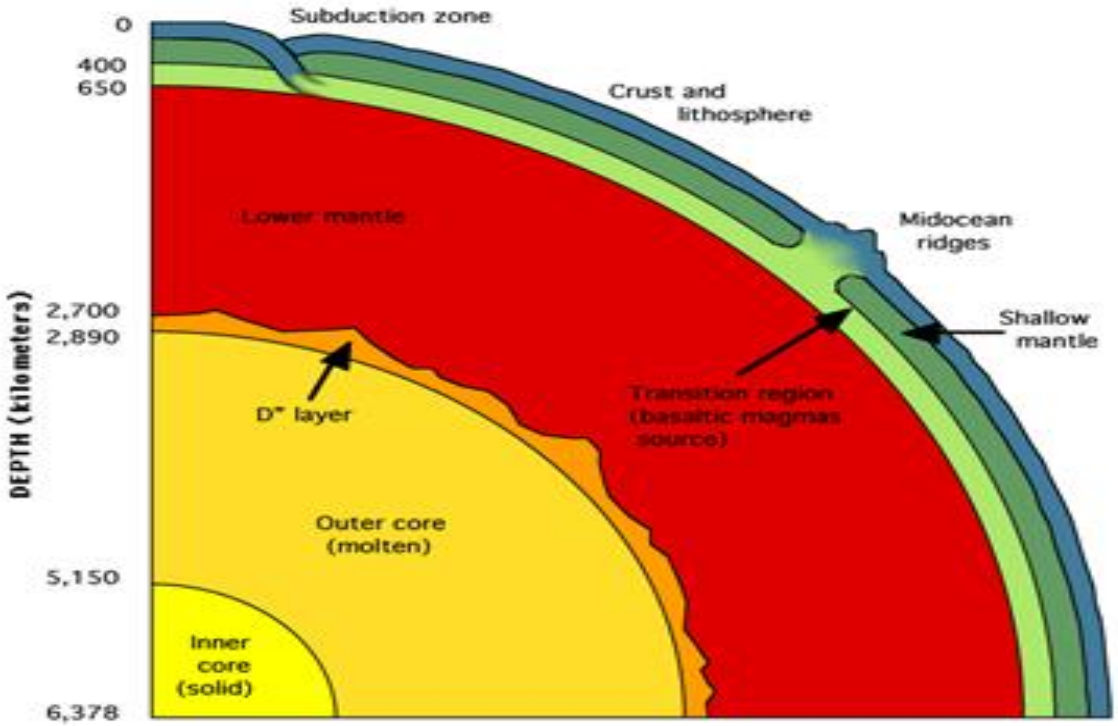
- **For validation and detailing of the area to be selected for early warning may be decided by its extent component in terms of size of data as bytes, X: 0.5 to 783.5, Y: 0.5 to 429.5, Z: 0 to 158 Scale (meters): X: 22.7717033664326 Y: 24.92409673695834**
- **and latitude departure as N 24 44 26.023 -N 24 44 26.023 & E 73 31 46.860 - E 73 42 21.137 and N 24 41 32.270- E 73 37 03.998 & N 24 38 38.516 - N 24 38 38.516 - E 73 31 46.860 to E 73 42 21.137, suggests Coordinate Reference System may be WGS84 / Geographic,**
- **Datum: World Geodetic System 1984 (WGS84), Type: Geodetic, Epoch: 1984, Ellipsoid: WGS 1984, Semi-major axis 6378137, Inverse flattening: 298.257224, Prime Meridian: Greenwich, Valid Area World Coordinate System, Type: Ellipsoidal, Axis 1: Geodetic longitude, Unit: degree, Symbols: E(+) W(-), Axis 2: Geodetic latitude, Unit: degree, Symbols: N(+) S(-), Valid Area World.**

Architecture for Landslide prediction along hilly terrain four lane road side



Effort has been made to record , simulate landslides likely to be with Subsurface crustal blocks energy transformations recorded

Everybody knows but one must get best out of it



Online Data Analysis Flow Chart levels & Global Landslide Early Warning

	Data Analysis Stage I	Data Analysis Stage II	Data Analysis Stage III	Data Analysis Final Stage IV
Initial	-Satellite data entire globe Coordinate wise - Advancements in space technology and data acquisition - wireless monitoring - optical fiber sensing	Slope surface Height; Radius of curvature, its number and value gap in XYZ, Diagonal Ratio; Path length, Ground length, Heading in Degree,	Data exchange networking	Warning for provincial level on the various parts of the Globe. This may be disclosing in awareness campaign and preparedness. This alert can be issued month-wise and globally as published document online.

	Data Analysis Stage I	Data Analysis Stage II	Data Analysis Stage III	Data Analysis Final Stage IV
Progressive	**Sequential changes observed in time and space by coordinate wise data of any part of the Globe. Recent methods of sensing & monitoring updated and fraction of time whatever changes, are automatically recorded and advance data filters provided to diagnose the slope failure prone data trends**	**Data indicative of slope failure prone or sensitive, further zoom in and with the provisions made in the soft computation or numerical analysis, the trace of the scar line along which the likely failure may occurs are obtained as marker line.**	**Within the scar line of slope failure the finite elemental analysis of the area ZOOM IN stress distribution pattern changes in time and space. Further using automated options of standard methods of slope failure already established as used in various slope stability analysis software, for obtaining FoS estimations.**	**Warning for regional level for more refined alert in terms of limited area of several thousand square kilometers for alert at advance level preparedness. It should be made available online every 15 days.**

	Data Analysis Stage I	Data Analysis Stage II	Data Analysis Stage III	Data Analysis Final Stage IV
Final	Globally slope failure regions identified in initial and progressive slope failure early warnings are automatically direct the satellites and sensors deployed in the wireless network etc. to open and activate advanced technical filters to record finite elemental level changes in the area.	Automatically estimations done for the mechanics and kinematics of the slope failure mass & volume	Slope failure portions dynamics estimation	Warning for pin pointing the slope failure areas. It should be made available online 24 hourly.

Data flow sequencing

Data variables imported to different analysis options available in GIS software for finding interrelated links with stability of slope surface by using software commands.

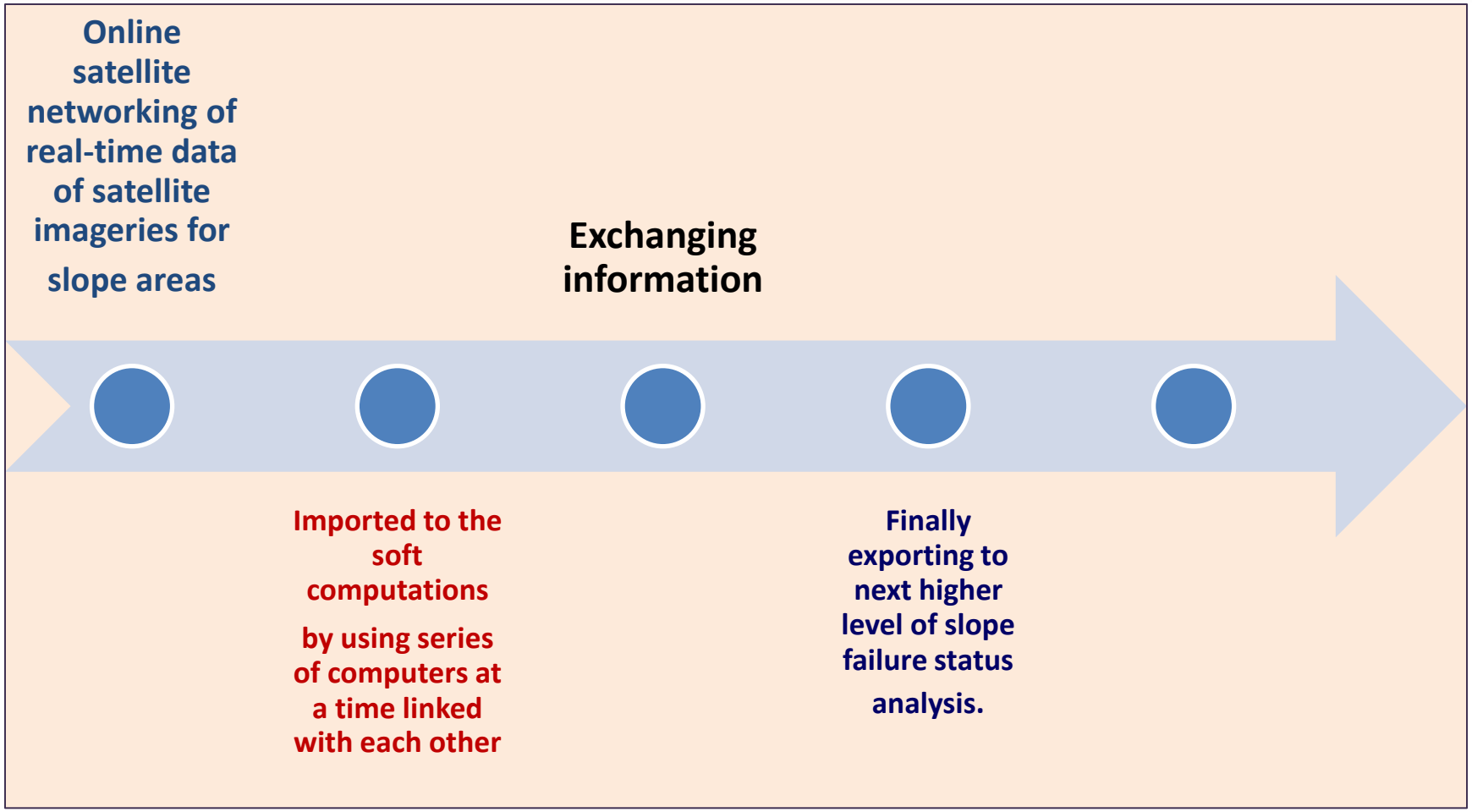
Google earth online images of slope surface belonging terrain also carried out and using analysis options available a set of data dealing number of aspects related to stability of slope surface has been done

it is an alternate tool by which one can identify sensitive places prone to fail within the slope surface

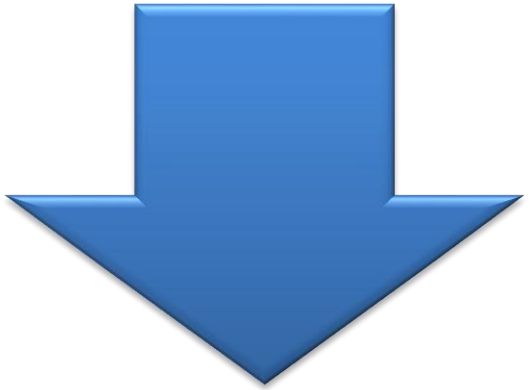
The slope surface segmentation pattern analysis carried out by using FRGYLST software and it is found useful in further refinement of the evaluation of status of slope failure.

The MATLAB used to establish neural network link between slope failure as output and input data variables and found that this shows encouraging results.

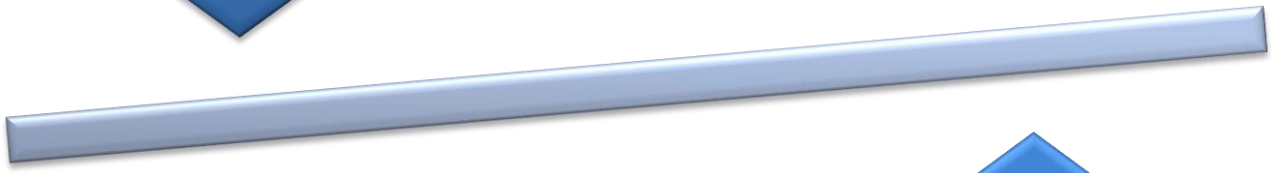
Advance steps to reach Bottom level of landslides early warning



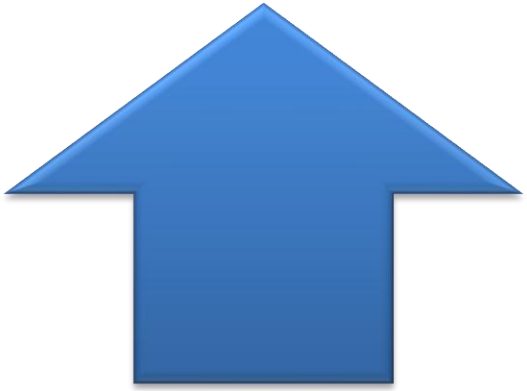
Considerations



Single, multiple slope surfaces and sloping terrain are taken in to consideration for extensive and intensive, in-depth work



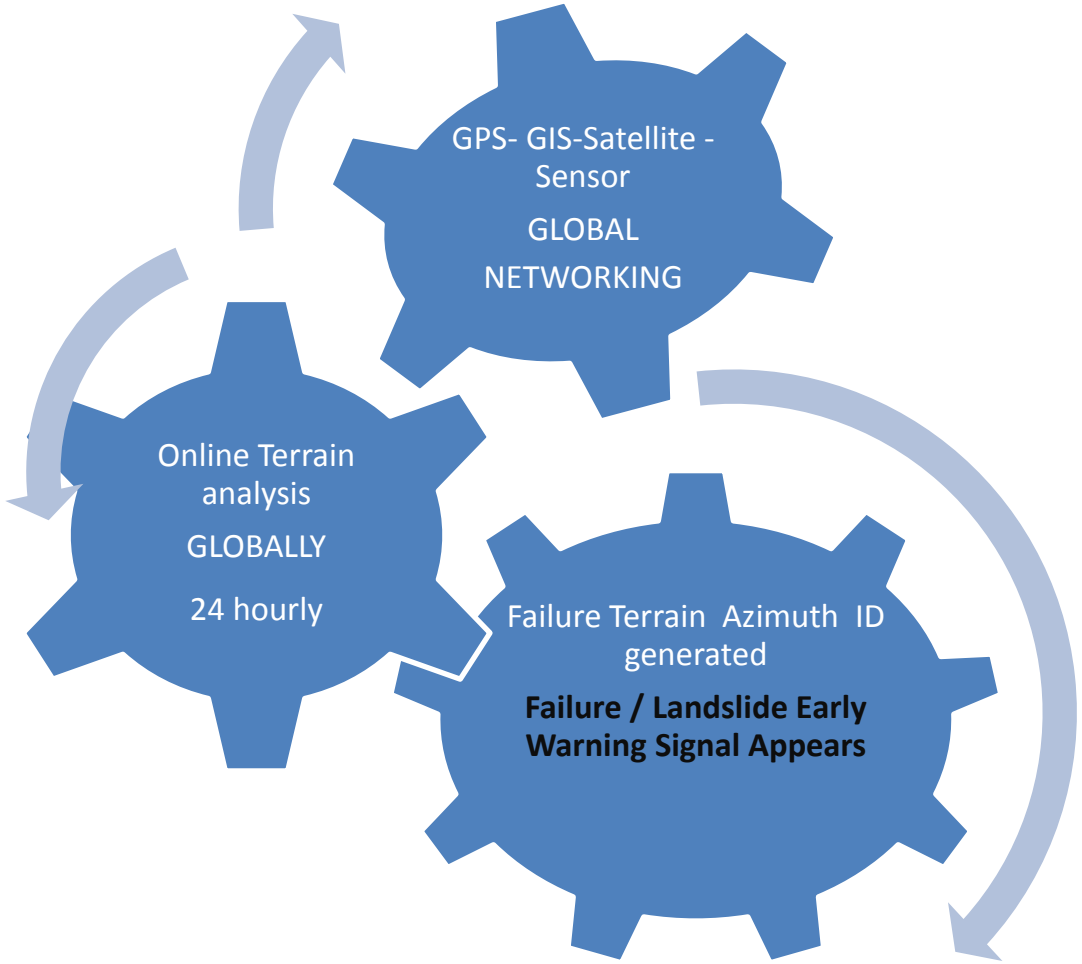
According to established international and national standard practices / methods



Gearing Mechanism

- Slope Failure Early Warning (SFEW) gearing mechanism is given in next slide mentioning schematic representation,
- FIRST Data gear as GPS-GIS-Sensor- Global networking in functional mode 24 hourly,
- SECOND gear of Online terrain analysis globally 24 hourly
- and THIRD gear of slope failure early warning ID generated for final appearance of warning signals.

Three gear system for early warning of landslide



Glad to inform

- **The multi-dimensional analysis using different approaches and involvement of variety of software**
- **it has been realized to put some sincere efforts for the development of slope failure early warning system**
- **For prevention measures to minimize consequent upon losses i.e. hill, mine pit slope failures, life, property, infrastructure, buildings, rail and road network.**
- **Initial piece of work is encouraging for the development of Slope Failure Early Warning System (SFEW), although lot of scope for more dedicated work inputs are still needed.**
- **The SFEW is initiated in two types looking to the world scenario of slope failures and landslide cases may be caused by natural or man intervention in natures creations not by virtue of developmental activities.**

Concrete shape emerging

- Efforts done in the field of development of landslide/earthquake-early warning system, categorized as
- i.e. Global & Local warnings and data analysis stages
- Next slides showing stages of advancements

Hopeful to succeed- Begins with

- On the basis of extensive and intensive field and laboratory work for geo-mechanical engineering study of hill cuts along four lane road network in Aravalli Mountain based, insight in to the early warning of slope failures could possible.
- Present study is based on interdisciplinary research work and coordinated interlinking of data could be a strong base for slope failure early warning systems development (SFEW).

Derived -complete sense

- Initial study establishes that the net working could be established online multilevel, multi-disciplinary analysis, for the development of slope failure early warning system(SFEW). The azimuthally recorded satellite and sensor data of terrain exported to high tech computer networking with automated analysis options using different filters data.

Continued……

- The SFEW is urgent need of the time to safe guard the slope failure hazards and losses and if efforts are made it can be developed at feasible and viable way.
- Sincere efforts and team of interdisciplinary expertise with proper coordination is desired under single networking.
- Satellite data availability to the centre of SFEW at global and national level may be developed and modus operandi for the same should be discussed at international platform.

Continued…..

- Information about slope failure early warning made available to entire world on payment basis and a corporate fund should be raised to do more researches and improvement in the early warning field.
- The global level joint research program may be launched undertaken for further refinement of SFEW and software development.

THANKS FOR SHARING

AND THINKING IN THE DIRECTION

TO FIND MITIGATE AND PREVENTIVE MEASURES

.....To minimize losses

Do justice and fulfill expectations of THE society AS A scientists

- DEDICATED WORK FOR ….

STRONG BONDS OF
Universal Scientific programs
WITH COMMITTMENT TO SAFEGUARD
unique creation of nature

- **HUMAN BEINGS & life**
- **and mother earth.**

THANKS

FOR BRAIN STORMING SESSION