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Research Article

Hilly road mapping and holistic management to visualize and plan construction: A case study in Himalayan region

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Abstract:

Traffic conjunction is quite common now a days even in hilly terrain, due to several factors such as increasing tourism/industrialism, blocking of roads due to natural calamities, accidents etc. which tend to seize roads for hours. Such natural or manmade disastrous often results in roads with high traffic densities, prompting road blockage for quite a long time. The solution for such circumstance is often done via road widening or construction of an alternate road. Present case study focuses on construction of an alternate hilly road from Lansdowne to Palkot in Uttarakhand stretching 4.6 Kms in the Himalayan region. Based on the survey performed at the construction site an impactful visualization and mapping is done using surfer software in 3D and 2D. Furthermore, detailed road construction and management of various constructions activities is planned based on well-known construction management principle established by ministry of road transport India and implemented using Primavera and MS-Excel. Such holistic management of construction activities yielded in efficiency of 3 months from total sanctioned schedule time of 18 months for completion of the project. At the end based on latest BOQ as per CPWD, Uttarakhand a financial estimation of the project is also provided.
Keywords: *construction management, road visualization, 3D and 2D plots, road blockage, management of roads, financial estimation*

Introduction:

Roads are one of the most essential commodities required in present day and age to facilitate transportation and access to different places. Any countries overall development majorly depends on the robust road network, which can safely provide passage to high traffic volumes under all circumstances [1-3]. There are a number of types of roads that are being prepared in a country to fulfill different types of requirements according to its width, location, economy, traffic type, rigidity, topography and material. Any good road network has various elements in it, beginning with National Highways (NH) which are constructed to connect all the major cities to the capitol of the country and often are spread throughout the country. State Highways (SH) on the other hand are developed to associate every one of the primary pieces of states inside it. These can be called as second fundamental streets and are finally interface with NH. District Roads are built to interface every one of the little urban communities inside the region to business sectors and to associates the two of them to the public roadways and NH. Village Roads are constructed to connect all the nearby villages to each other and all of them to the district roads. Rural areas have completely different variant of roads to attach farms with their respective town or any city which are sometimes even unpaved. Such roads take farm products produced to city markets and children to school [4].

Figure:1 showing NH, SH, District Road and Village road respectively

However, many a times it is observed that roads are not able to fulfill the traffic demands of certain routes due to rapid industrialization and urbanization. Therefore, governing authorities are taking necessary steps in developing countries like India to avoid high traffic volumes especially of critical pathways. Constructing a new road is modern alternative for this problem, modern because of the enhancement in construction technology now a days has made construction procedure very swift and convenient which was not the case in last decades. New construction not only improves traffic safety but also the capacity which is essential for a nations progress [5-8]. Present study focusses on case study of construction of a State Highway Road from Lansdowne to Palkot region in Uttarakhand. This site is constituted of mountainous terrain type of land amongst the foothill of Himalayas. Paper presents an efficient way to visualize the hilly road from 3D and 2D perspective along with competent construction management and planning which proposes efficiency of 3 months from total sanctioned time. Finally, paper also presents detailed financial breakup of the project as per the latest bill of quantities taken from Central Public Works Department Uttarakhand, Government of India.

Geotechnical review of the site:

The whole length of road being prepared during this project is estimated to be 4.6 Kms long and planned to be black topped on its whole surface.

Topography and soils:

Uttaranchal State is essential for the Western Himalaya and isolated into four zones agreeing height in particular, the Tarai-Bhabar-Shivalik (Sub-Himalayas) with elevation going from 750-1,200meters, Lesser-Himalayas between 1,000 – 3,500 meters, Greater-Himalayas between 3,500-4,800m with snow-line ascending to 5,400m and Trans Himalaya (Tethys) averaging 5,300m. By and large, the district is topographically and pedologically temperamental and inclined to slides and disintegration. Soils of the Uttarakhand Himalayas overall are very shallow, seriously impregnated with un-endured pieces of parent rocks.

Nature of soils of the area have been framed either through paedogenetic measures or they are shipped soils. The paedogenetic soils are the one which have shaped due to long time of exposedness to air offices, physical and synthetic enduring and rock slides

Site overview:

This venture imagines broadening of streets in Pauri Garhwali District of Uttarakhand state. Under this venture single path streets are altered as twofold path streets. The undertaking incorporates the improvement streets associating Jaswantdwar in Lansdowne district to Palkot.

Figure 2 shows the broad map of the region in which the road is planned to be constructed and the highlighted blue colored curved line depicts the road described above:

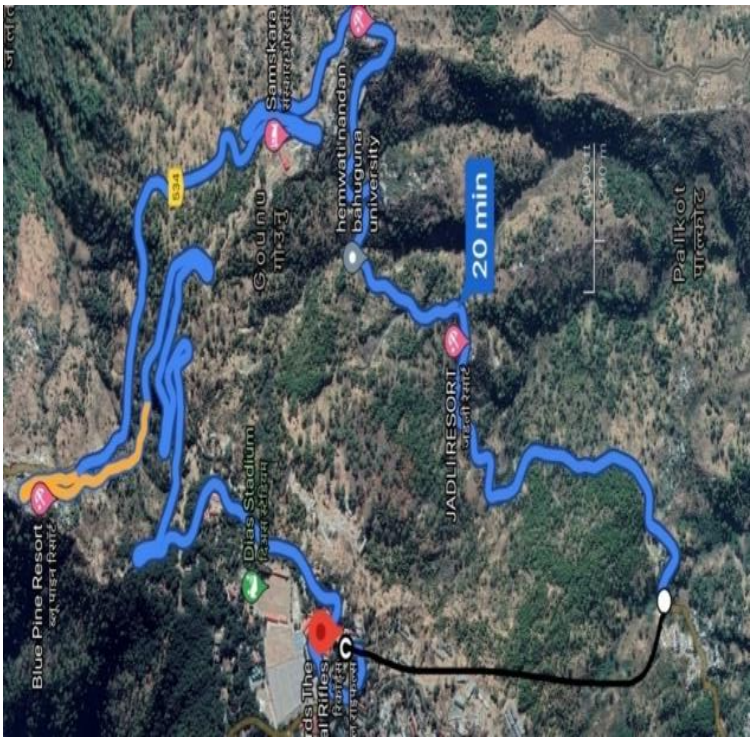


Fig 2- Broad map of the geo-spatial location of the road considered in the case study

Surveying of the Project Site:

Surveying is the science to determine earthbound or 3D places of focuses and moreover points and furthermore the length between these foci. These focuses normally lie on the outside of the earth, and these focuses are regularly familiar with fabricate guides and limits for possession, areas, such as corner building or the surface area of sub-surface alternatives, or totally various capacities needed by Govt. or law, similar to deals of property. Also arranging and execution of most assortments of development need it. It's moreover utilized in transport, correspondences, planning, and furthermore the meaning of legitimate limits for land ownership. A brief overview of survey done for the project is presented below:

Step by step measurements via Total station theodolite:

1. Set up the Total Station at Base point (Jaswantdwar) and leveling it.
2. Now with help of compass see the north direction on total station and input the northing angle as 0.
3. Now using Handy GPS, Northing, Easting and Elevation values of Jaswantdwar inserted in Total Station that are 235975, 235980 and 1508m respectively.
4. As Station coordinates are inserted, now putting Back Sighting Northing, Easting and Elevation as 0, 0 and 0 respectively.
5. Now input the height of instrument and height of prism pole in total station.
6. Now sight the prism that should be around 30m from instrument. Take the readings of Northing, Easting and Elevation at right, left and center of the road, marks those points by Marker and save them.
7. Now replace the Total Station on right/left half of the street and information the station facilitates estimated above and back sights the left/right.

8. Take next arranges of right, left and focus and save them. Rehash the above advances and save the directions.

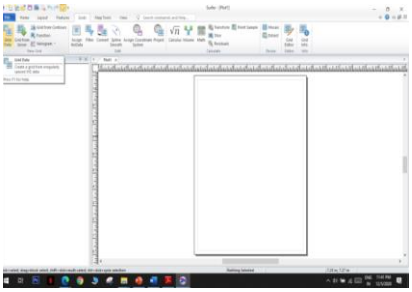
Fig 3- Field surveying via Total Station at Jaswantdwar

3D and 2D Mapping of the Road via Surfer

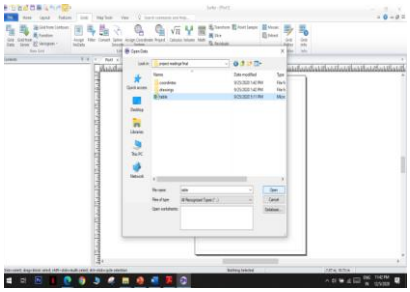
Surfer is an amazing forming, gridding, and surface planning bundle for researchers, architects and academicians to produce maps rapidly without any problem. Present study employs the total station surveying data in form of chainage, easting, nothing and finished road level elevation to produces distribution quality guides. Surfer effectively impart both straight forward and complex spatial information which is extensively used for the present project.

Table 1 Step by step modelling in surfer:

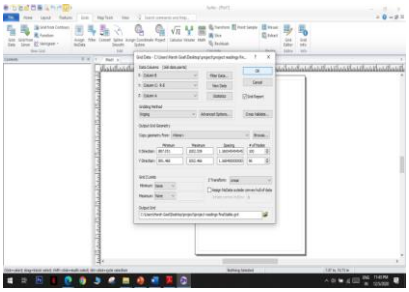
STEP 1: Creation of grid data



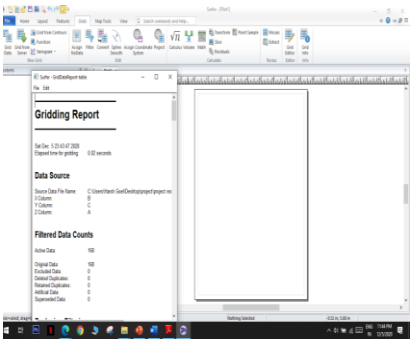
STEP 2: Saving the grid data file to your desired location



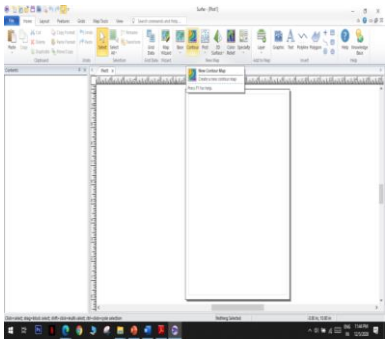
STEP 3: Assigning the data columns for grid data file



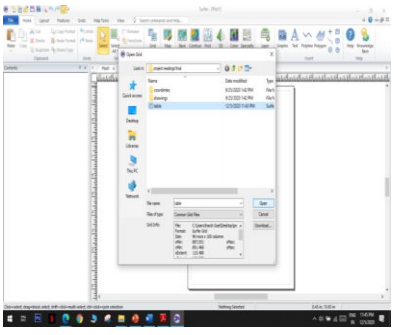
STEP 4: Grid file creation



STEP 5: Choice for a contour map



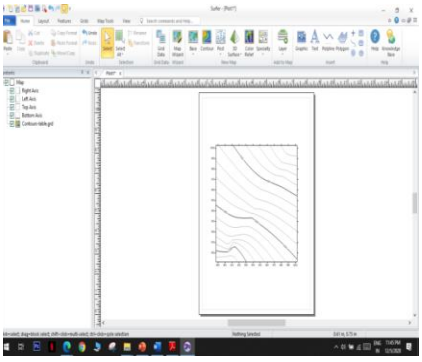
STEP 6: Selecting the grid data for contour map



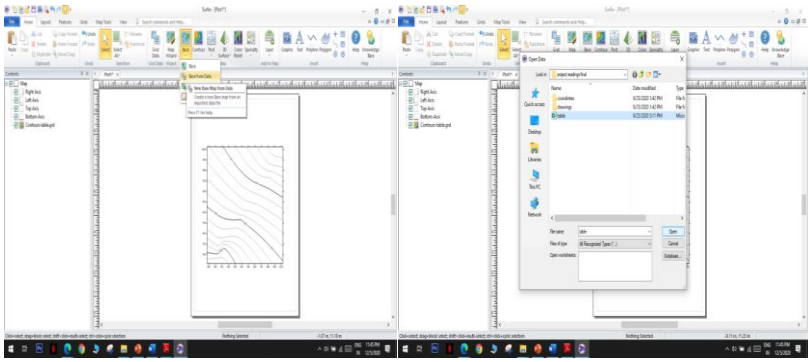
STEP 7: Creation of Contour Map

STEP 8: Selection of base map option

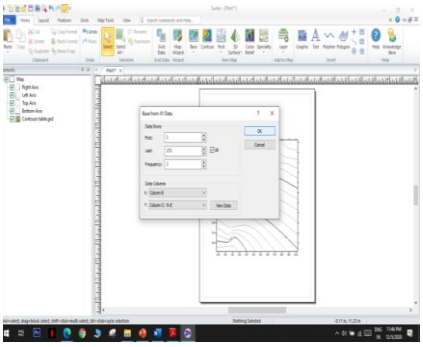
STEP 9: Grid file date selection

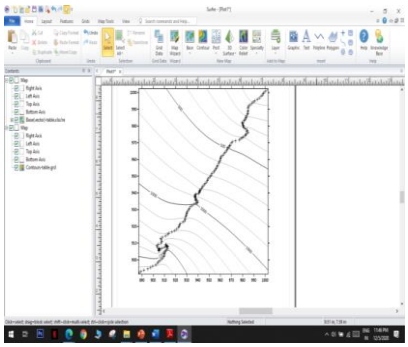


STEP 10: Assigning the data columns from data



STEP 11: Map is created





For the present project, the roads visualization along with the surrounding topology can be visualized in high quality 3D and 2D contour plots as shown in Figure 4 and Figure 5 respectively along with the elevation. A plot showing the location of retaining walls (in red color), breast walls (in green color) and toe wall (in blue color) is also generated via Surfer and is shown in Figure 6.

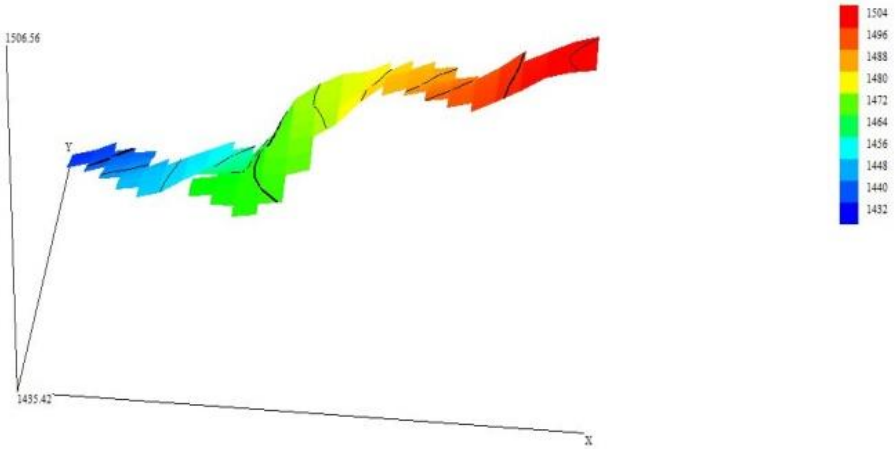


Fig 3- 3D geometry plot of the hilly road under investigation obtained via surfer

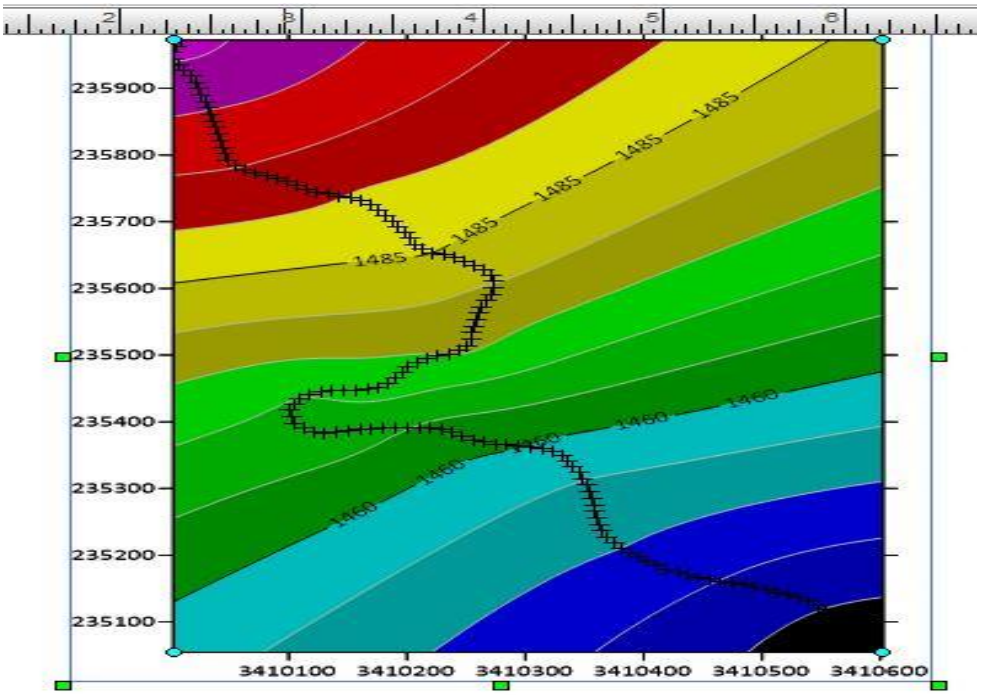


Fig 5- 2D geometry plot of the hilly road under investigation obtained via surfer

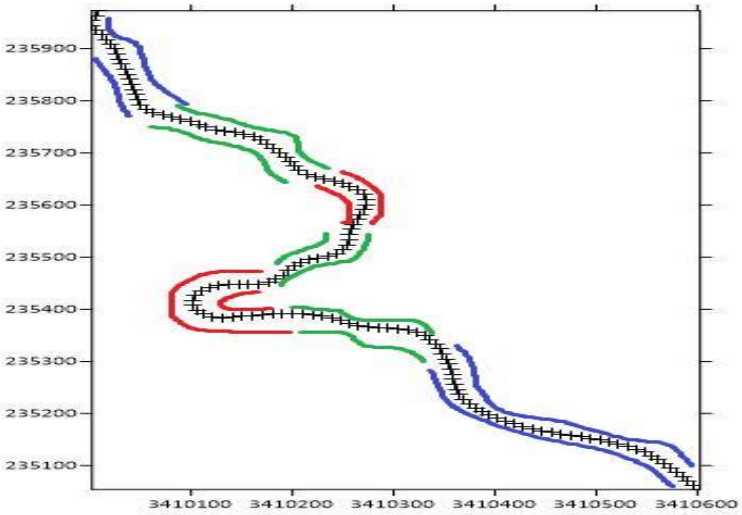


Fig 6- Location of Retaining walls (Red), Breast walls (Green) and Toe walls (Blue) along the road plotted in Surfer

Road Construction Management and Estimation:

The estimation of whole construction was done on the basis of latest BOQ and SOR of Uttarakhand using MS-Excel. Various parameters considered and associated cost are depicted in Table 2.

Table 2 Cost estimation as per later BOQ and SOR of Uttarakhand, India for the investigated hilly road:

S.no	Description	Labour Unit	Labour type	Per Quantity	Units	Area to cover	Available labour	Days to complete	Cost of 1 labour per day INR	Total cost in INR
1.0	Jungle clearance including cutting	30	labour man	2000	sq m	27161.9	28	14.55	750	305571.71

1	down trees					3				
1.02	Rough excavation in soil/soil mixed with small boulders using mechanical means	1	excavator	1000	cu m	23328.77	1	23.32	5000	116643.85
1.03	Rough excavation in soft rock requiring blasting	15	labour man including supervisor	1000	cu m	61881.87	35	26.52	900	835405.24
	disposal of excavated material by any means to dumping location	1	Truck	2000	cu m	61881.87	2	15.47	2000	61881.87
1.04	Rough Excavation in hard rock by drilling with compressor	2	Compressor	800	cu m	4372.56	1	10.93	4000	43725.6
	Rough excavation in soft rock requiring blasting	15	labour man including supervisor	1000	cu m	4372.56	30	2.18	900	59029.56
	disposal of excavated material by any means to dumping location	1	Truck	2000	cu m	4372.56	3	0.72	2000	4372.56
1.05	compaction by mechanical means	1	compactor	2000	cu m	49817.98	1	24.90	4500	112090.45
	Earthwork in embankment by filling with earth	30	labour man	1000	cu m	49817.98	30	49.81	750	1120904.55
										2659625.40
2.01	Construction of Kerb and Channel type road side Drain	30	labour man	1000	r/mtr	4494.03	45	2.99	1000	134820.9
2.02	Construction of Culvert 2 Mtr Span	30	labour man	3	nos.	17	39	4.35	1000	170000
2.03	Construction of Culvert 3 Mtr Span	30	labour man	2.5	nos.	8	30	3.2	1000	96000
2.04	Construction of Culvert 6 Mtr span	30	labour man	1	nos.	4	40	3	1000	120000
2.05	Construction of RRM Breast Wall 2.00 Mtr height	30	labour man	100	R/Mtr	680	50	4.08	1000	204000
2.06	Construction of RRM Breast Wall 3.00 Mtr height	30	labour man	75	R/Mtr	280	35	3.2	1000	112000
2.07	Construction of RRM Retaining Wall 2.00 Mtr height	30	labour man	100	R/Mtr	440	40	3.3	1000	132000
2.08	Construction of RRM Retaining Wall 4.00 Mtr height	30	labour man	60	R/Mtr	1200	45	13.33	1000	600000
2.09	Construction of RRM Toe Wall 1.00 Mtr Height	30	labour man	100	R/Mtr	800	43	5.58	1000	240000
2.1	Construction of RRM Toe Wall 2.00 Mtr Height	30	labour man	50	R/Mtr	700	40	10.5	1000	420000
2.11	Construction of RRM Parapet Wall	30	labour man	500	R/Mtr	1372	44	1.87	1000	82320
	Plastering	30	labour man	400	R/Mtr	1372	45	2.28	1000	102900
2.12	Providing & Fixing ordinary KM stone	30	labour man	2	nos.	5	45	1.66	1000	75000
2.13	Providing & Fixing sub KM stone	30	labour man	10	nos.	18	45	1.2	1000	54000
2.14	Providing/Fixing of delineator (900 mm)	30	labour man	50	nos.	144	46	1.87	1000	86400
										2629440.9

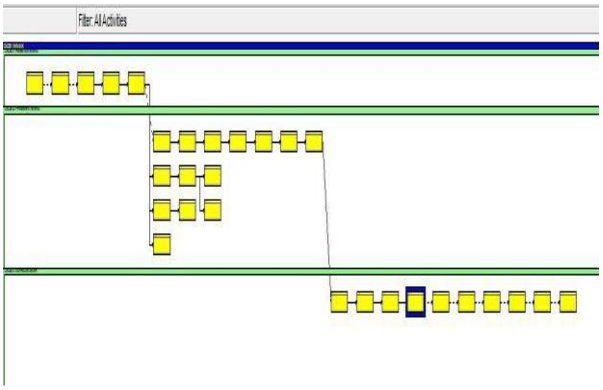
3.01	Preparation of sub-grade in SMB by excavating upto 20 cm avg depth	30	labour man	1000	Sqm	5278.32	50	3.16	900	142514.64
	consolidating with power roller	1	power roller	1000	Sqm	5278.32	2	2.63	12000	63339.84
	Watering	30	labour man	1000	Sqm	5278.32	45	3.51	900	142514.64
3.02	Preparation of sub-grade in SR by excavating upto 20 cm avg depth	30	labour man	500	Sqm	13150	45	17.53	900	710100
	consolidating with power roller	1	power roller	1000	Sqm	13150	2	6.57	12000	157800
	disposal of surplus material by any mean to dumping location	1	Truck	2000	cu m	13150	4	1.64	2000	13150
3.03	Preparation of sub-grade in HR by excavating upto 20 cm avg depth	30	labour man	500	Sqm	1962.84	44	2.67	900	105993.36
	consolidating with power roller	1	power roller	1000	Sqm	1962.84	2	0.98	12000	23554.08
	disposal of surplus material by any mean to dumping location	1	Truck	2000	cu m	1962.84	4	0.24	2000	1962.84
3.04	GSB 15 cm thick (compacted) with stone aggregate including disposal of surplus material by any mean to dumping location	1	Truck	2000	cu m	19978.34	4	2.49	2000	19978.34
	Watering	30	labour man	1000	Sqm	19978.34	44	13.62	900	539415.18
	Compaction with power vibratory roller	1	power roller	1000	Sqm	19978.34	2	9.98	12000	239740.08
3.05	Providing, laying, spreading stone aggregate grading as per Table-400-13	30	labour man	600	Sqm	18635.35	45	20.70	900	838590.75
	compacting graded stone aggregate with power vibratory roller	1	power roller	1000	Sqm	18635.35	2	9.31	12000	149082.8
	premixing the material with water to OMC in mechanical mix (Pug Mill)	1	pug mill	1500	Sqm	18635.35	2	6.21	10000	124235.66
	laying in uniform layers in sub base/base course on a well prepared base	30	labour man	600	Sqm	18635.35	45	20.70	900	838590.75
3.06	premixing the material with water to OMC in mechanical mix (Pug Mill)	1	pug mill	1500	Sqm	37270.71	2	12.42	10000	248471.4
	laying in uniform layers in sub base/base course on a well prepared base	30	labour man	600	Sqm	37270.71	44	42.35	900	1677181.95
	compacting graded stone aggregate with power vibratory roller	1	power roller	1000	Sqm	37270.71	2	18.63	12000	447248.52
3.07	Providing and laying 50 mm thick DBM layer	30	labour man	500	Sqm	17623.86	45	23.49	800	845945.28
	Rolled to the required specification	1	power roller	1000	Sqm	17623.86	2	8.81	12000	211486.32
	mix composition requirement as per Table - 500-8/9/10	1	pug mill	700	Sqm	17623.86	2	12.58	10000	251769.42
3.08	Providing and laying 30 mm thick BC on bituminous concrete layer	30	labour man	500	Sqm	17623.86	45	23.49	900	951688.44
	mix composition requirement as	1	pug mill	700	Sqm	17623.8	2	12.58	10000	251769.42

	per Table - 500-8/9/10					6				
3.09	Providing and applying Prime Coat with bitumen emulsion	30	labour man	500	Sqm	17292.36	45	23.05	900	933787.44
	g clearing of road surface & spraying primer using mechanical means	1	sprayer	2000	Sqm	17292.36	2	4.32	7000	60523.26
3.1	Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor	1	emulsion pressure distributor	5000	Sqm	35247.73	2	3.52	8000	56396.36
	surface cleaning	1	mechanical broom	5000	Sqm	35247.73	2	3.52	5000	35247.73
3.12	Provisioning and Providing road marking with thermoplastic paint	30	labour man	1000	Sqm	1643.41	45	1.09	800	39441.84
										10121520.37

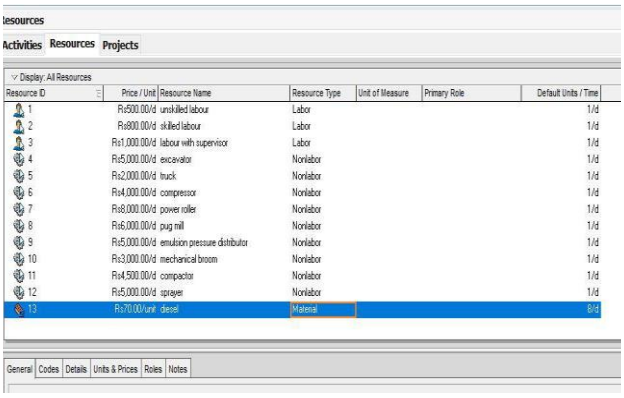
Furthermore, in order to do efficient scheduling and management of the whole construction phase Primavera software was employed which helps in planning and control of project schedule from cost to time. For current project, construction phases can be presented using above mentioned activities and costs in Primavera as follows:

Table 3 Step by step Road construction management and estimation in Primavera

Network diagram creation

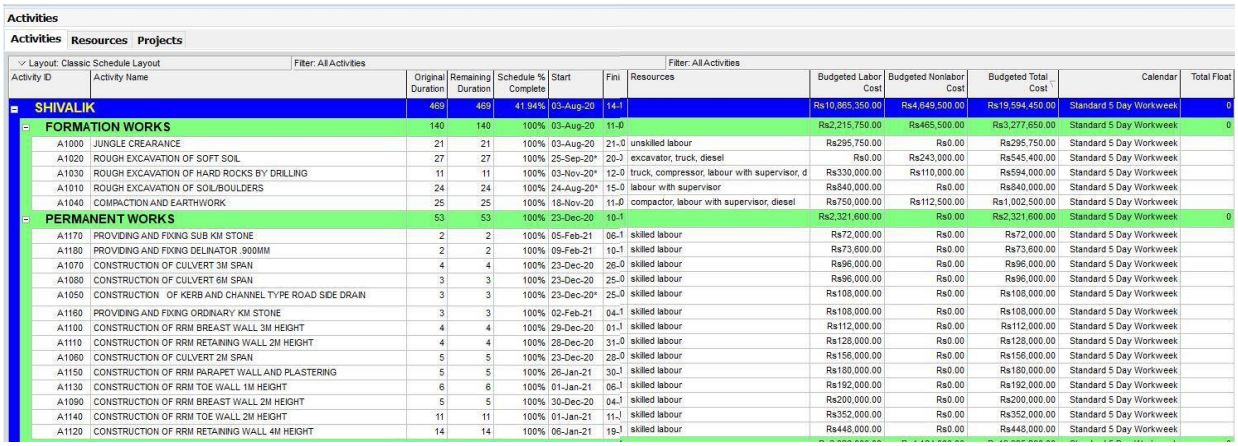


Resource allocation

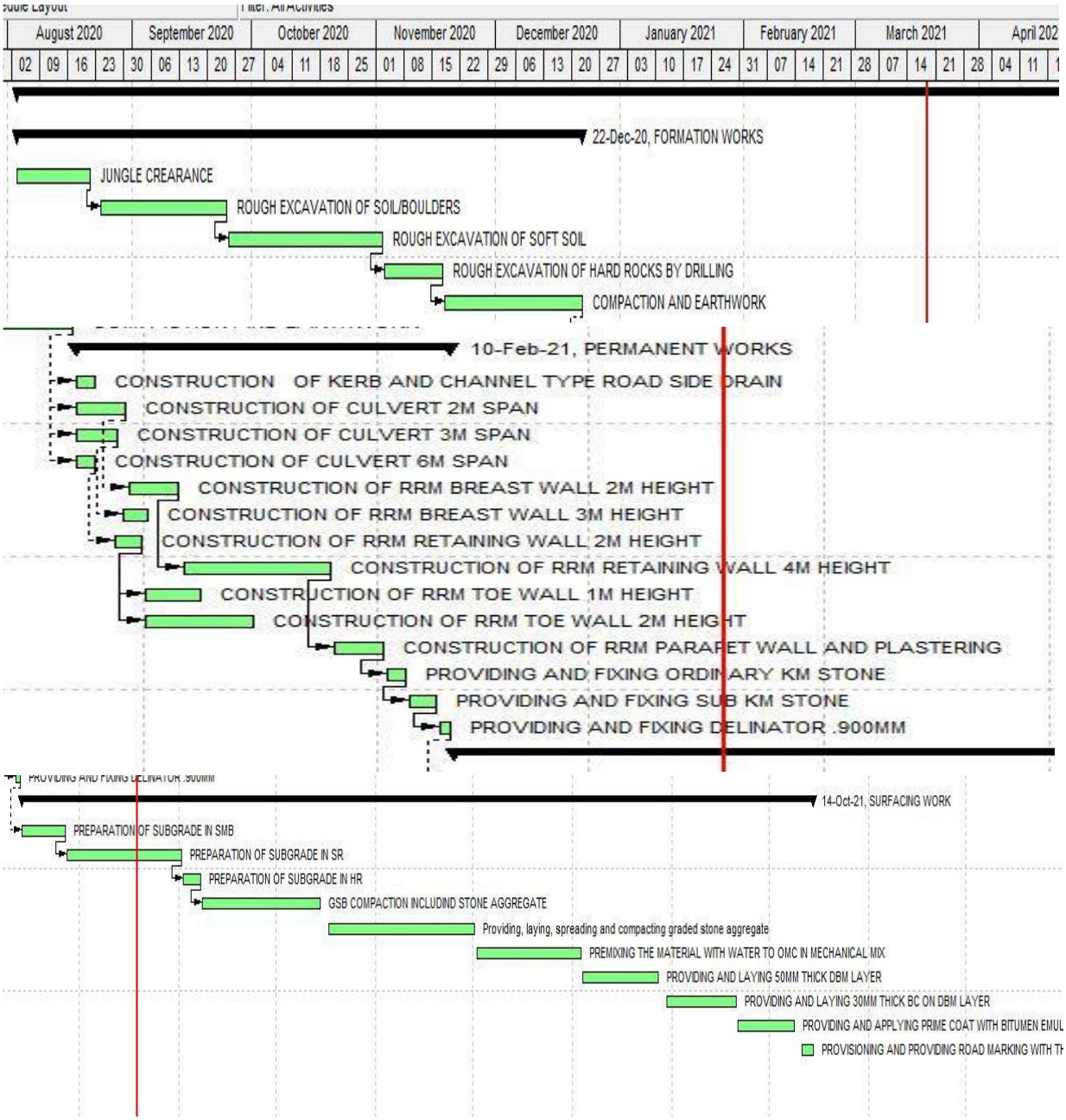


Project Layout

Project Cost



Bar Representation of Scheduled activities



Conclusions:

In this Paper a case study upon a newly planned hilly road located in Uttarakhand state amongst the Himalayan region of India is discussed. Using modern surveying equipment the data is collected from the field, which is further reproduced in 3D and 2D terrain maps of different configuration via Surfer software. Estimation of the whole project considering various aspects of constructions as per the guidelines of Ministry of road transport India and BOQ CPWD Uttarakhand are generated via Excel and Primavera software. Results published here of the case study not only establishes the construction management principles but also present a statistical data for further study. The current project is performed assuming the static coordinates whereas real– time coordinates must be considered as input in total station for more accuracy.

Surveying done for construction of roadway is not just about the preparation of the road, but also about the design of the roadway. Land surveys help one to determine the roadway design, materials required and the construction method to be applied for that particular project. The field data presented in the paper provides a

necessary platform to facilitate decision making and management of road construction. Efficiently done scheduling of the road construction yields a 3-month faster construction time as compared to 18 months sanctioned time of the project. Total estimated cost of the project is based on the current rates provided by govt authorities and is subjected to change; however author believes furnishing of cost data will help designers a great deal to optimize the cost of their running projects.

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