"STUDY OF PARAMETERS AFFECTING THE HIGHWAY WIDENING PROJECT IN THE HILLY AREAS"

A Thesis

submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

Civil Engineering

with specialization in

Construction Management

under the supervision of

Dr. Gyani Jail Singh
(Assistant Professor)

and

Dr. Ashok Kumar Gupta

(Professor)

by

Aman Thakur
(152607)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
WAKNAGHAT, SOLAN – 173 234
HIMACHAL PRADESH, INDIA
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CERTIFICATE

This is to certify that the work which is being presented in the thesis titled ***"STUDY OF PARAMETERS AFFECTING HIGHWAY WIDENING PROJECT IN HILLY AREAS"*** for partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in **Construction Management** and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Aman Thakur (Enrolment No. 152607) during a period from July 2016 to May 2017 under the supervision of Dr. Gyani Jail Singh **(**Assistant Professor) and Dr. Ashok Kumar Gupta (Professor), Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: ………………………

Co-supervisor	Supervisor	External Examiner
Dr. Ashok Kumar Gupta Professor & Head of Department Department of Civil Engineering JUIT Waknaghat	Dr. Gyani Jail Singh Assistant Professor Department of Civil Engineering JUIT Waknaghat	

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CONTENTS

LIST OF TABLES

Table Name

LIST OF FIGURES

Figure Name

ABSTRACT

Highway construction projects involve huge construction cost depending upon the site conditions, terrain conditions and resources used. In hilly areas construction is difficult due to change in terrain conditions at regular intervals. Due to increase in construction of highways in hilly terrains there is needed to study the parameters which affect cost and duration of construction.

In the present study the cost analysis was done for a stretch of 2 km of NH -22 widening project under execution stage. The parameter affecting costs were identified from interviews with NHAI manager and engineers involved in execution of project. The parameters affecting the cost were cutting, filling and protection works quantity. The Pearson correlation was used to evaluate relation between the quantities of parameters identified. The quantities were taken from estimation of the 2 km stretch. It was also found that there exists a decreasing correlation between hill side and valley side quantities, however, the valley side quantity have an increasing relation with protection works. The scheduling of the stretch was done on MSP to calculate duration.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Construction projects develop through a different stages, starting with the preliminary study or feasibility study followed by some design stages and finally the implementation of the design with the actual construction.

Many parameters affect the cost of the construction project and if these parameters are changed there is cost overrun in the project, this is the most common risk involved in the construction industry. Cost estimates are produced throughout the life of a construction project and are used for different purposes depending on the available information and their expected accuracy. Scheduling of the project is done at the planning stage on the basis of activities require for the completion of the project. Estimating and scheduling is in construction is one of the most important tool in project management. Estimating is done at different stages of project that are preliminary estimate and detailed estimate. At early stages when project budget are not decided and detailed information about the project is not available then parametric cost estimate are helpful in estimation. The preliminary estimates are less accurate because less information is available. But, the estimate developed at early stage of construction process helps the client in decision whether to continue with the proposed project or not. These early estimates are calculated on the basis of parameters which mainly affect the project and its cost of construction. So, manager should have a vast knowledge of the parameters affecting the cost in different conditions as the project is executed in different areas prevailing to different site conditions.

Many studies have been done on the construction projects to find the various parameters which affect the cost and duration of construction projects on the basis of statistical analysis methods. Planning stage plays a vital role in the execution of the project as scheduling done in this stage. Studies have been done to view the importance of scheduling in the construction and concluded that due to huge cost involvement, large construction period, proper planning and scheduling is important for success of these projects. In hilly areas construction period is effected by the terrain condition to a great extent as large amount of cutting and filling is required for the construction of the highway.

National highways form the economic backbone of the country and have often facilitated development along their routes, and many new towns have sprung up along major highways. National highways comprise 1.7% of India's total road network, but carry about 40% of road traffic. Most of them have two lanes. The speed on highway is mostly unregulated and is mostly slowed by heavy trucks in middle lanes. With the increase in traffic and the economic growth the widening of the highways is required.

The widening of highway in hilly areas can be done in four possible ways that are hill side widening, valley side widening, concentric widening and new pavement construction. The widening of highway in hilly terrain is difficult due to the presence of existing structures which are constructed along side of the road and dense forests along the valley side and hill side. The clearance from the forest to cut trees is a time consuming process and a limited number of tress are allowed to cut from a particular area. The three alternatives for widening have different cost of construction for excavation, retaining wall, base coarse and asphalt coarse.

The thesis focuses on studying the parameters which affect the cost of construction in widening of highways in the hilly areas, finding correlation between the quantities of these parameters and scheduling of the work to calculate duration. For the completion of the study a case study is done. The study done on NH 22 (Ambala- Kalka- Shimla- Shipkila) which is 459 km and for this study a stretch of Parwanoo Bye pass to Solan which is 31 km is considered. The widening work of the section considered is under progress client is NHAI and company executing work is GRIL. The data for the thesis will be collected from these agencies and the model for parametric cost estimation will be developed.

1.2 NEED OF STUDY

India has many high altitude motor highways like Manali-Leh. During preliminary stage due to lack of information estimates made are not accurate. The execution of the work is difficult in the hilly areas due to constant change in terrain condition and the road design. A study is needed to find the parameters effecting cost and their relation with each other so that managers can take decisions for the execution of the project. The construction projects are associated with many risks which can occur due to many reasons and one of them being inaccurate scheduling. So, scheduling is important for the execution of the project. This can be done by various methods.

The relation between parameters is identified and scheduling of the project is done in this thesis with regression analysis between the cost parameters to get a best fit model.

1.3 OBJECTIVES OF STUDY

1. Identification of the factors that affect the cost of road widening projects in hilly areas using the previous studies done in this field, the site visits and information from the staff involved in the execution of project. Data for the widening scheme is collected from NHAI office and company execution work.
2. Estimation of the quantities and rate analysis for a stretch of 2 km on the basis of BOQ collected from client office (NHAI) and survey report provided by the contractor executing work (GR Infra.).
3. Correlation and regression analysis of the parameters identified, which affect the cost of construction in hilly areas. The data for the analysis is obtained from the estimation done in the thesis. Regression analysis is also performed to get a best fit quantity and cost data for a stretch of 2 km by dividing the project into multiple stretches of 200 m with different data.
4. Scheduling of stretch of 2 km for widening scheme proposed.

1.4 PRE-REQUISITES FOR THE STUDY

1. MS EXCEL for the tabulation of the data calculated and estimation of the data not available at department office.
2. SPSS software for correlation and regression analysis of the parameters identified effecting cost of construction.
3. AutoCAD 2014 for drawing different sections considered in study.
4. MICROSOFT OFFICE PROJECT (MSP) for the scheduling of the project.
5. ESTIMATION AND COSTING book by B.N DUTTA.

1.5 SCOPE OF THE STUDY

The thesis focuses on estimating the quantities and rate analysis of a stretch of 2 km. The correlation analysis of parameters is done on the basis of quantities so that cause and effect relation studies. The parameters which mainly affect the cost of widening highway roads in hilly areas are identified by considering different stretch of NH 22 from Parwanoo Byepass to Solan in which widening work is under progress. The data for the parameters will be collected from the NHAI Office in Shimla and the site visit. As the project is under construction the data which will not be available is calculated manually by different estimation techniques.. The study is limited only to the earthwork and pavement phase of the widening of the road project bridges, culverts, tunnels and other works are not considered in the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 TYPES OF ESTIMATE

Construction cost estimation can be defined as an effort to forecast the actual cost. Cost estimations can be done in any stage of the project feasibility stage, conceptual stage, engineering stage, procurement stage, construction & turnover.

1. Estimates during conceptual planning:

This estimate is prepared at the very initial stage i.e. during conceptual planning stage of a project. It is based on little information and on broad parameters namely size of the project, location and job site conditions and the expected construction quality of project as a whole. This estimate is prepared to establish the preliminary budget of the project and accordingly project funding can be arranged. The degree of accuracy of this estimate is lowest among all the estimates those are prepared during various stages of a project.

2. Estimates during schematic design:

During this phase of the project, the cost estimate is prepared on the basis of preliminary design information along with required schematic documents. The designer may incorporate different design alternatives and the cost estimate is prepared for these design alternatives by the estimators depending on the available information. The cost estimates of different design alternatives are reviewed keeping in view the project scope and budget and the acceptable alternatives selected in this phase is analyzed in a detailed manner in the next phase of the project. With the improved scope of the project, the expected degree of accuracy in this estimate is more as compared to that in conceptual estimate.

3. During design development phase of the project:

The cost estimate is prepared on the basis of more detailed design information and schematic documents. With the improved level of information, the most of the major project items namely volume of earthwork (m^3), volume of concrete (m^3), weight of steel (tons) etc. can be quantified and the cost estimate is prepared using the known unit prices. Detailed information from subcontractors or material suppliers should be obtained and used in pricing the major project items. With the availability of detailed design information and improved system definition, the expected degree of accuracy in this estimate is higher as compared to that in estimate prepared during schematic design phase of the project.

4. Estimates during procurement :

During this phase of the project, the cost estimate is prepared on the basis of complete set of contract documents that defines the project. The contractors bidding for the project prepare the cost estimate in accordance with contract documents by taking into consideration the estimated project duration. Direct cost includes cost of materials, equipment and labor associated with each item of work and cost of subcontracted works. Indirect costs are the costs which are not attributed to each item of work and are calculated for the entire project and include overhead cost, contingency and profit. As this cost estimate is prepared in accordance with complete set of contract documents of the project, the degree of accuracy of this estimate is extremely high.

2.2 CORRELATION

Correlation is a bivariate analysis that measures the strengths of association between two variables and the direction of the relationship, necessary condition for correlation is there should be cause and effect relationship between the variables. There are four basic methods of correlation which include scatter diagram method, graphical method, Karl Pearson coefficient of correlation (r) and method of least square. The most common method used is karl pearson coefficient.

Correlation coefficient, r:

The quantity r, called the linear correlation coefficient, as a descriptive measure of the strength of a linear association between two variables. The linear correlation coefficient is sometimes referred to as the Pearson product moment correlation coefficient in honor of its developer Karl Pearson. The value of r is $-1 \leq r \leq +1$. The negative and positive sign are used for negative correlation and positive correlation respectively.

Positive correlation: If x and y have a strong positive linear correlation, r is close to +1. An r value of exactly +1 indicates a perfect positive fit. Positive values indicate a relationship between x and y variables such that as values for x increases, values for y also increase.

Negative correlation: If x and y have a strong negative linear correlation, r is close to -1. An r value of exactly -1 indicates a perfect negative fit. Negative values indicate a relationship between x and y such that as values for x increase, values for y decrease.

No correlation: If there is no linear correlation or a weak linear correlation, r is close to 0. A value near zero means that there is a random, nonlinear relationship between the two variables.

A perfect correlation of ± 1 occurs only when the data points all lie exactly on a straight line. If r = +1, the slope of this line is positive. If r = -1, the slope of this line is negative. A correlation greater than 0.8 is generally described as strong, whereas a correlation less than 0.5 is generally described as weak. However, the literatures reviewed in the thesis are as follows:

Augustin Purnus (2014): Augustin Purnus in this paper studied the correlation between parameters of time, resource and cost in the construction projects. The execution of the project is not only analyzed by time and cost individually but also by their effect on each other as they share a cause and effect relationship. This provides a better tool for decision making as it integrates cost, time, resource and other parameters together which effect the project execution. According to the study the project management which studies the cost and time individually rather as a cause and effect parameter is unsuccessful. The change in the design during the execution stage also has impact on the time and cost of the construction project as in correlation with each other. Construction project confronted with delay and causing increase in cost of the project which reduces company profit. The study was done by Monte Carlo stimulation on a data of 50 projects in Romania.

Siraw Yenesew Tesfa (2012): The paper shows factors contributing to time and cost overrun in asphalt pavement construction Ababa City and Ethiopia. For the purpose of the study 47 questionnaires from owner, contractors and consultants were collected on the common factors to contribute for time overrun on asphalt road construction projects completed from 2000-2005 in Addis Ababa city administration by using a purposive sampling technique and analyzed using both descriptive and inferential statistics and a secondary data of asphalt road construction projects completion report was used to know the real extent of time overrun on the projects studied. It was found that 80% of project suffers time overrun. Spearman rank order correlation analysis was used to evaluate relation between groups of respondents i.e owner versus contractor, owner versus consultant and contractor versus consultant The most important causes of time overrun were found to be slow cite clearance, contractors' financial problems, inflation, change in the design due change in the conditions at site, progress payments delay by owner, inaccurate cost estimation, and delay in commencement. The analysis result shows that there was relation between factors contributing to cost overrun in the projects to a moderate and in some cases to a strong level. Less availability of literature was the limitation of study.

2.3 SCHEDULING AND PLANNING

K Swarna Kumari and J Vikranth (2012): K Swarna et.al in their study planned the main resources which are the equipments, plants and manpower deployed at a highway project by using Microsoft Soft Project. The Construction projects, especially the highway construction projects, uses huge amount of resources on and off the field in various forms of resources viz., materials, plants, equipments and human resources along with money, time and space. The change in the conditions of the location makes each project unique and resource planning a tedious job as efficiency of resources dependent on working condition factor. Therefore, a detailed study at the planning stage of project resource planning and productivity can help in the better execution of the project, thus help in good resource planning, better monitoring and overall controlling of the project. In highway projects, the same resource is often used for different activities and the productivity of that resource being different for different activities, it becomes inevitable to know the correct norms for correct estimation, planning and monitoring.

Sunil Sharma, V. K. Bansal, Raman Parti (2014): Sunil Sharma et.al in their paper studied various methods of scheduling and planning discussed in the literature for highways. Highway projects involve huge capital investments and prolonged durations. A number of researchers have developed various computer-based tools and techniques to help planners prepare plans and schedules based on their specific needs. CPM is the predominant scheduling method used in construction industry. However, its inability to efficiently plan and schedule repetitive projects such as highways has widely been recognized. Linear scheduling method on the other hand, was specifically designed and developed for repetitive projects. On the basis of literature study, location based planning utilizing linear scheduling method seems to be the most logical and efficient way of planning highway projects for various reasons discussed in the paper. It is however a new concept and therefore has limited use in practice.

Ashish Singla , Dr. Pardeep Kumar Gupta(2014) :Ashish Singla et.al in their research studied the performance and cost of various equipments used in the construction of the flexible pavement. Equipments being a necessity of any construction project still need major research to improve pre-estimation accuracy for productivity and costs related to equipment. A case study conducted to evaluate per hour owning and operating cost(O&O cost) and per hour productivity of excavator, loader, backhoe loader, grader, paver, hot mix plant , soil compactor, tipper truck and tandem roller used in various projects in Punjab and Chandigarh for construction of flexible pavement with appropriate methods were represented in the paper with appropriate results. The per hour productivity help in time estimation of each activity in flexible pavement construction comprising equipments for planning purposes or we can say time of usage of each equipment can be estimated and managed to prevent idling of equipment on the site hence preventing losses.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The objective of study is to study several parameters that affect the cost and duration of highway widening projects in hilly areas. The widening of highway in hilly terrain is difficult due to the presence of existing structures which are constructed along side of the road and dense forests along the valley side and hill side. In hilly areas widening is done in combination of valley side, hill side, concentric widening and new pavement depending upon the topographic condition and existing structures constructed alongside the road. Due to this some changes are done during the execution of the project to that of proposed work.

For the completion of the objectives of thesis case study of widening of 2 km stretch of NH 22 from Parwanoo to Solan which is at its execution stage is considered. The factors affecting the widening are identified and then data collection is done from NHAI office and GR Infra office, then the estimation of cost of 2 km work is done in MS Excel and relationship between different parameters affecting cost by correlation analysis is done in SPSS, a regression analysis is carried to find the most stretch which best explains the change in cost of the work on the basis of R squared value. The scheduling of the stretch is carried out in MSP.

3.2 WORK DISTRIBUTION

The work is done in different stages which include identification of factors, collection of data, preparation of the BOQ, correlation, regression analysis and scheduling of the work which are described in the flow chart below to fulfill the objectives of the study.

WORK DISTRIBUTION

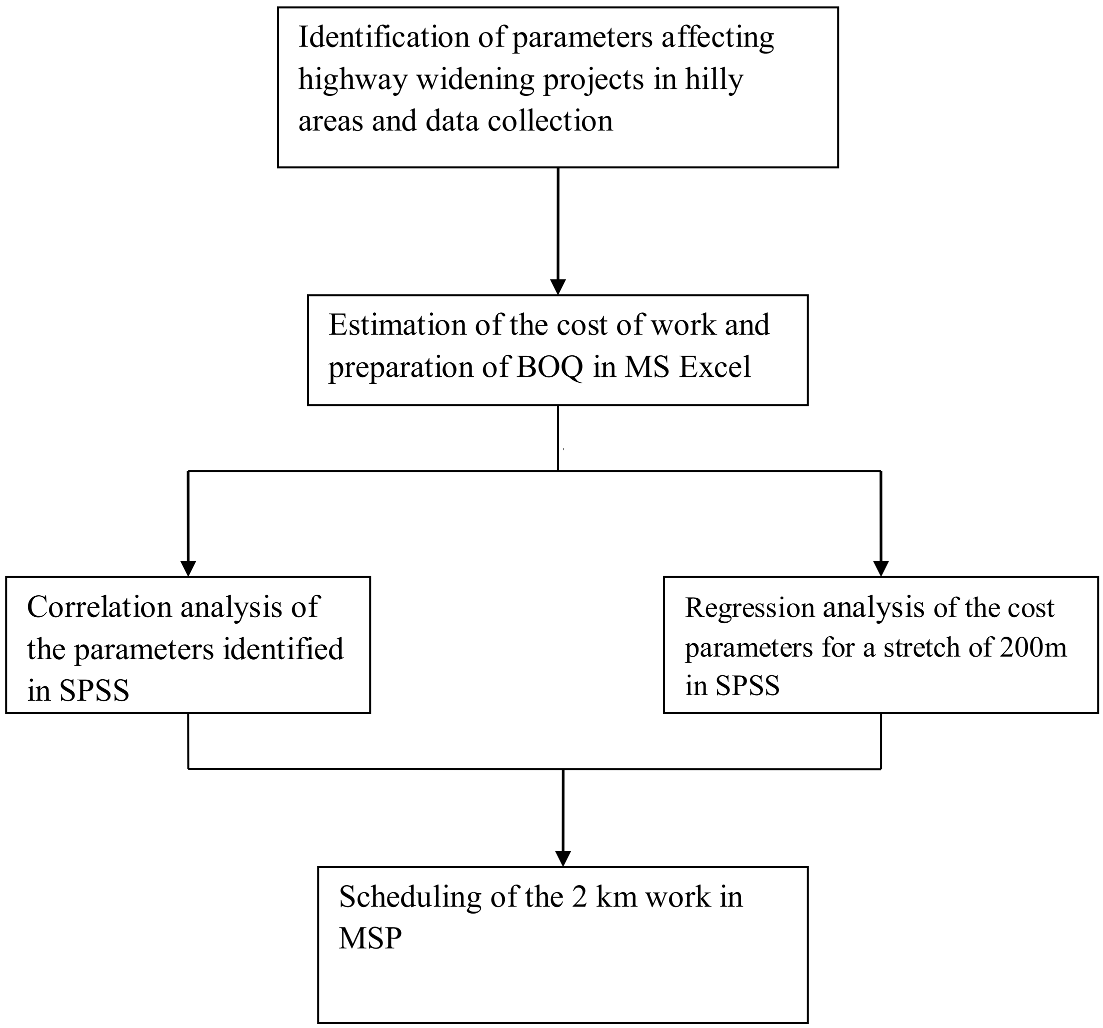

Figure 3.1. Work flowchart

3.3 IDENTIFICATION OF PARAMETERS AFFECTING HIGHWAY WIDENING PROJECTS IN HILLY AREAS AND DATA COLLECTION

The parameters which effect the widening of highway are identified from the literature review, interviews with site engineer of the GR Infra and technical manager of the NHAI and by visiting the site location. The data for a stretch of 2 km is also collected from the office of company and the client which is required for the estimation of the cost of the work, which includes survey report and proposed widening scheme, design of the pavement which includes the thickness of various coarse, BOQ of the proposed work which include cost of earthwork , retaining wall, different coarse in pavement per cubic meter.

3.4 ESTIMATION OF THE COST OF WORK AND PREPARATION OF BOQ IN MS EXCEL

Estimation process includes estimation of the earthwork in embankment which may be cutting or filling, quantities required in different coarse of pavement which includes sub base coarse (WMM and DBM) and base coarse (DBM and BC).The estimation done in MS EXCEL 2013.The estimation is done as per method described in Estimation and Costing book by B.N Dutta. The estimation of a stretch of 2 km work is done.

3.5 CORRELATION ANALYSIS OF THE PARAMETERS IDENTIFIED IN SPSS

The correlation analysis is a statistical technique that shows relationship between variables i.e whether and how strongly variables are related. This thesis focuses on developing correlation between quantities of different activities of project using SPSS. The correlation analysis is done to understand dependency of different activities

3.6 REGRESSION ANALYSIS OF THE COST PARAMETERS

Regression analysis generates equation to describe relationship between variables. Linear regression uses ordinary least square estimation method that derives equation by minimizing sum of squared residual. Regression analysis is proposed which assumes a cause-and-effect relationship between the variables. The overall fit of the regression is given by R^2 that is called the coefficient of determination and is a measure of the explanatory power of the model. The regression analysis is done for a stretch of 200 m for the major cost parameters which affect the total cost of the stretch.

3.7 SCHEDULING OF THE 2 KM WORK IN MSP

MICROSOFT PROJECT is a tool used for scheduling and allocation of resources by the managers and to find the critical path of the project. The scheduling of the project considered is done by assigning the relationship between different tasks to be performed to calculate duration and resource allocation is also done.

CHAPTER 4

DATA COLLECTION

4.1 IDENTIFYING PARAMETERS AFFECTING ROAD WIDENING:

The road widening of highway in hilly areas can be done in four possible ways that are hill side widening, valley side widening, concentric widening and new pavement construction. The parameters which mainly affect the cost and duration of widening scheme are identified from the literature review, interview with site engineer and NHAI technical manager and site visit. The parameters which were identified are:

1. Hill side cutting
2. Valley side filling
3. Protection works construction which include hill side breast wall and valley side retaining wall
4. Sub grade construction

The above listed factors have major effect on the cost, duration and resources to be assigned to the project. The widening scheme of the ongoing project consists of major work on the hill side followed by valley side widening.

4.2 DATA COLLECTION

The data required for the thesis includes survey data of 2 km section which includes survey report and proposed widening scheme, design of the pavement which includes the thickness of various coarse, BOQ of the proposed work which include cost of earthwork, retaining wall, different coarse in pavement per cubic meter. The height and width of cut and fill portion was collected from the site survey as height of cut depends upon the condition of a particular site and width also vary with the height of cut or fill.

The survey data for the thesis is collected from GR Infrastructure site office located in Dharampur. The company has done survey on 20 m interval which includes data of existing centre line and the finished road level.

The design of the pavement was taken from final feasibility report prepared by NHAI for the four laning of the project. This data is collected from NHAI office located in Shimla.The different widening schemes have different design proposal's. The scope of work of four laning the project includes strengthening of existing pavement and construction of new pavement. The drawings of different cross section are also collected from the NHAI office. These cross sections are drawn in AUTO CAD so that the proposed widening schemes can be easily explained and quantities can be calculated easily. The drawings are shown in annexure C.

The BOQ for the proposed project is also collected from the NHAI office which includes cost per unit of different works to be done in the four laning of the project. The data collected shown in annexure A.

CHAPTER 5

ESTIMATION OF QUANTITIES AND RATE ANALYSIS

5.1 ESTIMATION OF QUANTITIES:

Estimation process includes estimation of the earthwork in cutting and filling , embankment construction i.e subgrade, quantities required in different coarse of pavement which includes sub base coarse (WMM and DBM) and base coarse (DBM and BC).The estimation done in MS EXCEL 2013.

Earthwork Estimation for widening of pavement is done by considering the cut and fill areas as triangular portion dimensions of which are taken from site visit which are listed in annexure for a stretch of 20 m. The earthwork volume is calculated by multiplying the area of the cut with the length of the stretch, which is shown in annexure B.

The earthwork for subgrade is estimated from the survey data provided by GR Infra company executing work in the four laning project. The cutting or filling depth of the subgrade level is calculated by subtracting 500 mm from finished road level which is again subtracted from the finished road level which is subtracted from existing centre line level. The length of the section is 20m for each section volume calculation is done. The width of section for earthwork is different from different widening proposals. The area of the cut or fill portion is calculated from the mean of the depth of consecutive chainage and multiplying by length. The volume calculation is done for stretch of 20 m, which is shown shown in annexure A.

Estimation of quantity for different coarses is done by multiplying the length, width and thickness of the respective coarse.

Estimation of quantities of breast wall and retaining wall done by dividing wall into three portion one rectangular and two triangular portions which is explained in drawing attached in annexure C.

5.2 RATE ANALYSIS

Rate analysis done by multiplying quantities by rate as per BOQ provided by NHAI which is shown below:

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
1	67000-67020	477360	61920	716528	10382	463343	1729533	Hill side
2	67020-67040	397800	67080	617534	24578	463343	1570335	Hill side
3	67040-67060	609840	56760	669388	27165	463343	1826496	Hill side
4	67060-67080	548625	59340	617534	23284	463343	1712126	Hill side
5	67080-67100	660660	51600	716528	25872	463343	1918003	Hill side
6	67100-67120	660660	46440	570394	29752	463343	1770589	Hill side
7	67120-67140	656640	51600	503219	24578	463343	1699380	Hill side
8	67140-67160	908960	72240	711814	13173	463343	2169530	Hill side
9	67160-67180	318240	350880	2248066	30261	469720	3417167	concentric
10	67180-67200	351900	325080	1815088	26183	469720	2987971	concentric
11	67200-67220	296820	337980	2248066	54060	469720	3406646	concentric
12	67220-67240	565440	325080	487899	17247	469720	1865386	concentric
13	67240-67260	397320	304440	2239348	35574	469720	3446402	concentric
14	67260-67280	325125	309600	1055936	18009	469720	2178390	concentric
15	67280-67300	620160	67080	503219	24558	463343	1678360	Hill side
16	67300-67320	780780	72240	476114	25857	463343	1818334	Hill side
17	67320-67340	369495	56760	428974	20790	463343	1339362	Hill side
18	67340-67360	147186	696600	1950374	7276	463343	3264779	Valley side

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
19	67360-67380	180540	638550	1809664	11174	463343	3103271	Valley side
20	67380-67400	189720	522450	1586459	16816	463343	2778788	Valley side
21	67400-67420	293760	46440	456079	23284	463343	1282906	Hill side
22	67420-67440	570570	54180	617534	24578	463343	1730205	Hill side
23	67440-67460	317625	61920	617534	19015	463343	1479437	Hill side
24	67460-67480	554400	49020	456079	10478	463343	1533320	Hill side
25	67480-67500	584430	67080	716528	17334	463343	1848715	Hill side
26	67500-67520	531300	72240	711814	13554	463343	1792251	Hill side
27	67520-67540	498960	61920	716528	25225	463343	1765976	Hill side
28	67540-67560	596700	51600	810808	25872	463343	1948323	Hill side
29	67560-67580	637560	36120	570394	21991	463343	1729408	Hill side
30	67580-67600	632320	56760	617534	8652	463343	1778609	Hill side
31	67600-67620	434720	72240	503219	26329	463343	1499851	Hill side
32	67620-67640	554400	624360	3138500	17903	679800	5014963	New pavement
33	67640-67660	351900	283800	1411814	25276	679800	2752590	New pavement
34	67660-67680	802560	487620	1908658	37493	679800	3916131	New pavement
35	67680-67700	173250	667575	1695349	16570	463343	3016087	Valley side
36	67700-67720	194040	580500	1836059	27286	463343	3101228	Valley side

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
37	67720-67740	184800	609525	2284599	31185	463343	3573452	Valley side
38	67740-67760	138600	551475	1884619	19698	463343	3057735	Valley side
39	67760-67780	450450	371520	1908658	50332	469720	3250680	concentric
40	67780-67800	355740	294120	2362500	23828	469720	3505908	concentric
41	67800-67820	273600	253098	1858520	51264	469720	2906202	concentric
42	67820-67840	300300	252840	1891100	49711	469720	2963671	concentric
43	67840-67860	465300	239037	1787514	44706	463343	2999900	Hill side
44	67860-67880	646000	41280	503219	21087	463343	1674929	Hill side
45	67880-67900	750750	49020	711814	45276	463343	2020203	Hill side
46	67900-67920	846000	61920	716528	27941	463343	2115732	Hill side
47	67920-67940	319200	239940	833199	23799	469720	1885858	concentric
48	67940-67960	171360	211560	1046508	22587	469720	1921735	concentric
49	67960-67980	355680	196080	2284599	22494	469720	3328573	concentric
50	67980-68000	286650	154670	497219	24948	469720	1433207	concentric
51	69000-69020	85995	667575	1809664	33783	463343	3060360	Valley side
52	69020-69040	235620	406350	597499	17960	463343	1720772	Valley side
53	69040-69060	129360	609525	1695349	22271	463343	2919848	Valley side
54	69060-69080	224960	551475	1884619	13955	463343	3138352	Valley side

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
55	69080-69100	191520	377325	597499	26767	463343	1656454	Valley side
56	69100-69120	197600	493425	833199	15063	463343	2002630	Valley side
57	69120-69140	212940	464400	597499	15295	463343	1753477	Valley side
58	69140-69160	45517.5	696600	1836059	24837	463343	3066356.5	Valley side
59	69160-69180	440640	38700	716528	13401	463343	1672612	Hill side
60	69180-69200	554400	36120	570394	12366	463343	1636623	Hill side
61	69200-69220	291060	206400	1691814	17088	463343	2669705	Hill side
62	69220-69240	191646	126420	974619	20195	469720	1782600	concentric
63	69240-69260	138180	98040	456079	21748	469720	1183767	concentric
64	69260-69280	40698	725625	1454959	14291	463343	2698916	Valley side
65	69280-69300	124215	522450	827799	10654	463343	1948461	Valley side
66	69300-69320	186120	580500	2279199	14293	463343	3523455	Valley side
67	69320-69340	48195	783675	1773250	17671	463343	3086134	Valley side
68	69340-69360	58905	754650	2610334	34569	463343	3921801	Valley side
69	69360-69380	790400	539220	1814619	30780	463343	3638362	Valley side
70	69380-69400	609840	330240	1060394	33148	679800	2713422	New pavement
71	69400-69420	454480	563730	874659	42619	679800	2615288	New pavement
72	69420-69440	377910	325080	1928934	41672	679800	3353396	New pavement

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
73	69440-69460	395010	425700	711814	28413	679800	2240737	New pavement
74	69460-69480	791700	234780	550359	12407	679800	2269046	New pavement
75	69480-69500	498960	283800	428974	7813	679800	1899347	New pavement
76	69500-69520	306000	220590	928658	16953	679800	2152001	New pavement
77	69520-69540	565440	325080	361799	11744	679800	1943863	New pavement
78	69540-69560	328020	216720	428974	7718	679800	1661232	New pavement
79	69560-69580	496860	180600	314659	15627	679800	1687546	New pavement
80	69580-69600	582120	144480	664674	8997	679800	2080071	New pavement
81	69600-69620	434280	255420	314659	1657	679800	1685816	New pavement
82	69620-69640	478170	278640	617534	20125	679800	2074269	New pavement
83	69640-69660	425880	288960	597499	24340	679800	2016479	New pavement
84	69660-69680	651420	387000	711814	7529	679800	2437563	New pavement
85	69680-69700	953160	67080	716528	4708	463343	2204819	Hill side
86	69700-69720	420750	51600	570394	7425	463343	1513512	Hill side
87	69720-69740	606375	72240	716528	13582	463343	1872068	Hill side
88	69740-69760	693000	56760	617534	16170	463343	1846807	Hill side
89	69760-69780	450450	46440	597499	15212	463343	1572944	Hill side
90	69780-69800	570570	51600	617534	17411	463343	1720458	Hill side

S.NO	Chainage	Cutting cost (INR)	Filling cost (INR)	Protection work cost (INR)	Subgrade cost(INR)	Pavement cost (INR)	Total Cost (INR)	Widening Scheme
91	69800-69820	710640	56760	597499	15212	463343	1843454	Hill side
92	69820-69840	869440	46440	570394	14928	463343	1964545	Hill side
93	69840-69860	810810	51600	669388	19015	463343	2014156	Hill side
94	69860-69880	637560	61920	617534	18912	463343	1799269	Hill side
95	69880-69900	517040	41280	716528	13556	463343	1751747	Hill side
96	69900-69920	583680	36210	456079	16480	463343	1555792	Hill side
97	69920-69940	367840	46440	597499	16894	463343	1492016	Hill side
98	69940-69960	637560	41280	617534	13194	463343	1772911	Hill side
99	69960-69980	532350	46440	503219	14462	463343	1559814	Hill side
100	69980-70000	570570	51600	711814	15393	463343	1812720	Hill side

Table 5.1 Rate analysis of 2 km

Activity	Cost (INR)
Cutting	44252052.5
Filling	25238165
Protection Works	104737063
Subgrade	2156588
Pavement construction (GSBC to BC)	50332558

Table 5.2 Abstract of cost of 2 km

Total Cost for 2 km =INR 2, 26,716,400

CHAPTER 6

CORRELATION AND REGRESSION ANALYSIS

6.1 CORRELATION ANALYSIS

The correlation studies the cause and effect relationship between the variables, it is one of the most common and most useful statistics. A correlation is a single number that describes the degree of relationship between two variables. It is a bivariate analysis that measures the strengths of dependency between two variables and the direction of the relationship. The value of the correlation coefficient varies between +1 and -1. When the value of the correlation coefficient lies around ± 1, then it is said to be a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. The direction of the relationship is simply the +ve sign indicating a positive relationship between the variables and –ve sign indicating a negative relationship between the variables of the correlation. There are four types of correlations which are Pearson correlation, Kendall rank correlation, Spearman correlation, and the Point-Biserial correlation.

In this thesis Pearson correlation analysis is done which is the most widely used method of correlation analysis. The relationship between parameters quantities (i.e cutting ,filling, protection works and subgrade quantity) which effect the cost and duration is developed. The correlation analysis is done in this thesis to study the cause and effect relationship among parameters which will help in studying their effect on duration of the project if one of the variables is changed. As in actual site conditions quantities vary from as calculated at the design stage of the project, this can cause delay in the completion of the project.

The correlation analysis is done on SPSS software and quantities are taken from annexure for different works. It is done in two steps:

Scatter plot is first drawn to show a linear relationship between the variables. This is done by selecting graph icon in SPSS and a scatter plot is selected and a graph is obtained for the variables selected which shows relationship between the variables which is shown in figure 6.1 below. Following inferences were drawn from the graph:

1. The graph shows negative linear relation of hill side quantity with valley side quantity and protection works.
2. The graph shows linear negative relation of valley side quantity hill side, positive relation with protection works and subgrade.
3. The graph shows positive linear relation of protection works with valley side quantity and subgrade quantity.
4. The graph shows positive linear relation with valley side quantity and protection works.

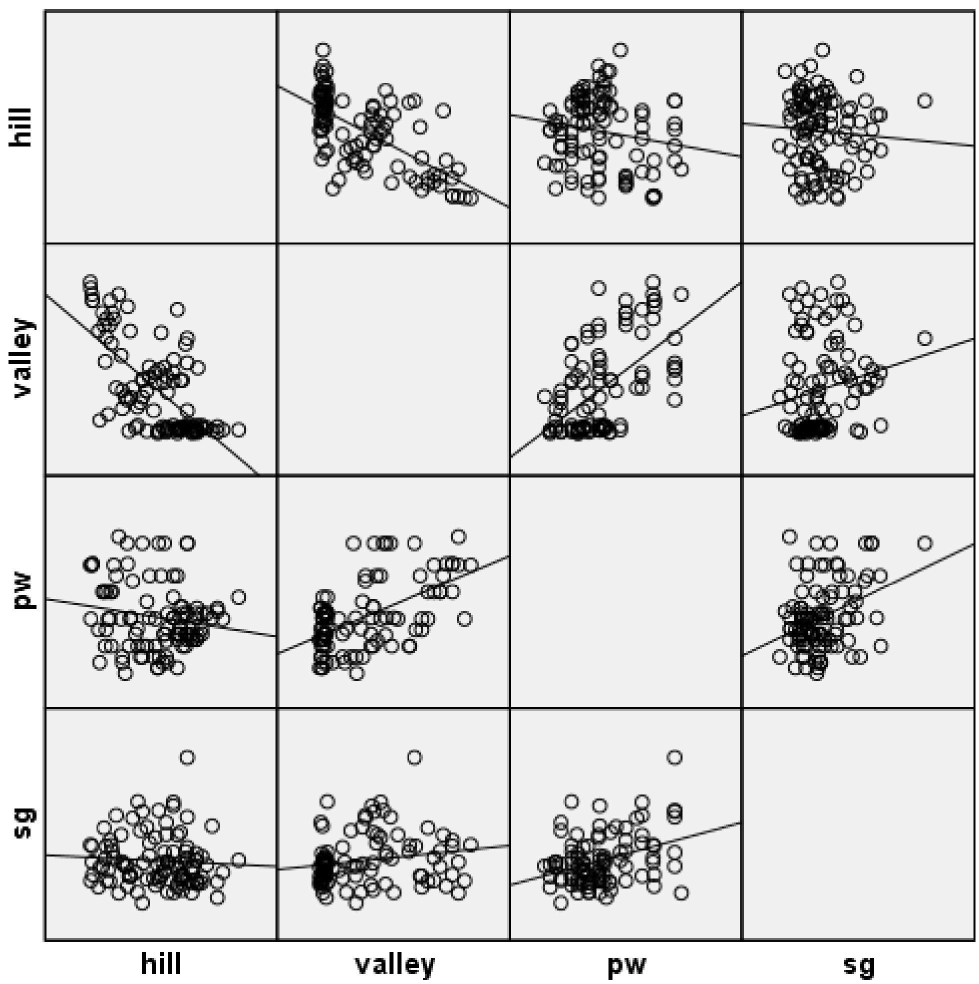

Figure 6.1. Scatter Plot for variables showing relationship

Where,

hill represents hill side quantity,

valley represents valley side quantity,

pw represents protection works quantity,

sg represents subgrade quantity.

A correlation analysis is carried out by selecting analyze tab in SPSS then select correlate and bivariate analysis is performed. Scatter matrix is obtained as follow in table 6.1

Correlations

		Cutting	filling	Pw	Sg
Cutting	Pearson Correlation	1	-.665**	-.171	-.069
	Sig. (2-tailed)		.000	.090	.498
	N	100	100	100	100
Filling	Pearson Correlation	-.665**	1	.565**	.185
	Sig. (2-tailed)	.000		.000	.066
	N	100	100	100	100
Pw	Pearson Correlation	-.171	.565**	1	.361**
	Sig. (2-tailed)	.090	.000		.000
	N	100	100	100	100
Sg	Pearson Correlation	-.069	.185	.361**	1
	Sig. (2-tailed)	.498	.066	.000	
	N	100	100	100	100

Table 6.1. Pearson correlation

Where,

Cutting represents cutting quantity,

Filling represents filling quantity,

pw represents protection work quantity of retaining wall and breast wall,

sg represents subgrade quantity,

Sig.(2-tailed) represents p-value which defines significance of relation. If p-value<.05 relation is significant and if p-value>.05 relation is not significant.

Pearson correlation represents relationship between variables closer the value to -1 and +1 more strong relation

The results obtained from the Table 6.1:

1. The cutting quantity has a significant relation with filling quantity but with –ve sign indicating a decreasing correlation, when cutting is increased filling is decreased. The cutting quantity has a poor relation with protection work and subgrade quantity.
2. The valley side quantity has a significant relation with filling quantity but with –ve sign indicating a decreasing correlation, when cutting is increased filling is decreased. The filling quantity also has a significant relation with protection work quantity with +ve sign indicating a increasing correlation, when filling is increased protection work also increases. There is no significant relation with subgrade quantity.
3. The protection work quantity has a weak relation with subgrade quantity and not a significant relation with cutting and filling quantity.
4. The subgrade quantity has a weak positive relation with protection work quantity and not a significant relation with cutting and filling quantity.

6.2 REGRESSION ANALYSIS

In statistical modeling regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (predictors).

Regression analysis is used in this study to find best fit line of quantities with the cost and to locate the stretch which best explains the variation in the cost with quantity. The quantities are taken as independent variable and cost as dependent variable. The regression analysis was done considering 200m stretch of the highway widening and ten models were taken for 2 km data. The analysis was performed on these models, r^2 value represent the relationship between independent and dependent variable and higher the r^2 value more strong relationship between variables. The regression table obtained for different models is shown in annexure and best fit model is discussed below:

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	pw, hill, valley[b]	.	Enter

a. Dependent Variable: cost

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.967[a]	.935	.903	203081.60565

a. Predictors: (Constant), pw, hill, valley

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3587911882769.745	3	1195970627589.915	28.999	.001[b]
	Residual	247452831320.754	6	41242138553.459		
	Total	3835364714090.500	9			

a. Dependent Variable: cost
b. Predictors: (Constant), pw, hill, valley

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-295967.518	462547.670		-.640	.546
	Hill	140.911	155.343	.184	.907	.399
	Valley	899.950	406.563	.468	2.214	.069
	Pw	6422.528	947.519	.791	6.778	.001

a. Dependent Variable: cost

Table 6.2. Regression Analysis Results

The above table shows the R square value is .935 and R value is .96 which shows us that 93% of change in cost is explained by change in hill, valley and protection works quantity.

CHAPTER 7

SCHEDULING OF THE PROJECT

7.1 INTRODUCTION

The planning of the project is major event at the planning stage of project which defines the duration of the project, resources required for the different tasks, cost estimate of the project and finding critical activities of the project. Thus Estimates of costs and duration for the various activities are to be prepared in this phase. Scheduling is the evaluation of the time period required for events in the project that is when and which task will be performed. Therefore Scheduling can also be defined as the detailed plan of the project work tasks with respect to time period The duration of project is calculated on the basis of tasks defined for the project whose duration are known and their relationship with each other. The scheduling can be done in MSP or PRIMEVERA software.

The duration of the tasks/ activities is calculated on the basis of quantity of work and productivity of resource associated with that work for e.g to get duration of earthwork quantity of earthwork is divided productivity of excavator. The MSP scheduling in the thesis is done for a stretch of 2 km considering manpower and machinery rates on the basis of CPWD schedule of rates.

7.2 WORK SEQUENCE :

The work for all the widening schemes is done in the following sequence:

1. Site clearance
2. Hill side cutting
3. Breast wall construction
4. Retaining wall construction
5. Valley side filling
6. Subgrade construction as per design
7. Laying of GSBC (Granular sub base coarse) as per design
8. Laying of WMM (Water mix macadam) as per design

9. Laying of DBM (Dense bitumen macadam) as per design
10. Laying of BC (Base coarse) as per design

The work for four widening schemes is conducted in the above sequence and relationship between activities is defined to calculate actual duration.

7.3 PRODUCTIVITY ANALYSIS OF MACHINES:

The productivity of different machines to be used in the execution is calculated

1. Excavator:

The productivity of excavator calculated as

$$\text{Production Rate} = c * f * \eta * 3600/t_s$$

where,

c is capacity of bucket in m^3,

f is fill factor (80%)

t_s swing time in sec.

η is the efficiency of machine in different soil conditions, which is taken as 80% for soil and 70% for rock

S.NO	Specification	Excavator Soil	Excavator rock
1	Capacity of bucket	3 m^3	3 m^3
2	Time of swing	30 sec	30 sec
3	Efficiency	80 %	70 %
4	Productivity	230 m^3/hr	202 m^3/hr

Table 7.1 Excavator Specifications

2. Compactor :

The productivity of compactor calculated as

$$\text{Production Rate} = w * s * t * \eta/N$$

where,

w is width of compactor drum in m,

s is speed of compactor in km/hr,

t is lift thickness in mm,

N is number of passes for compaction.

Soil and asphalt compactor are required for the execution of the work whose details are tabulated as:

S.No	Specification	Soil Compactor	Asphalt Compactor
1	Width	2.1 m	1.7 m
2	Speed	2 km/hr	2 km/hr
3	Lift thickness	150 mm	150 mm
4	No. of passes	4	4
5	Productivity	126 m^3/hr	102 m^3/hr

Table 7.2 Compactor specifications

3. Grader:

The productivity of grader calculated as:

$$\text{Production Rate} = s * l * d * \eta / N$$

Where,

s is speed of grader,

l is blade length of grader,4.3 m

d is distance of grading, taken as 100 m

η is efficiency of grader,80%

N is number of passes

Productivity of grader 344 sqm/hr

4. Asphalt Paver:

The production rate for paver calculated as:

Density of material	= 2.2 ton/m^3
Paving width	= 3.5 m
Thickness of coarse	= 110 mm
Volume of material /km	= 3.5*.11*1000
	= 385 m^3/hr
Weight of material	= 847 ton/km
Speed of paver	= 90/847 90 TPH is capacity of hot mix plant
	= .106 km/hr

i.e 106 km in 1 hr maintain balance between plant and paver.

Productivity = 106*.11*3.5

= 40 m^3/hr

7.4 DURATION OF DIFFERENT ACTIVITIES:

The duration of activities are calculated on the basis of productivity of machines and quantity which is tabulated as below and calculation shown in annexure:

1. Hill side widening:

S.No	Activity	Duration (days)
1	Cutting	25
2	Breast wall	120
3	Retaining wall	90
4	Filling	22
5	Subgrade	2
6	GSBC	1.5
7	WMM	2
8	DBM	1
9	BC	.25

Table 7.3 Duration hill side

2. Valley side widening:

S.No	Activity	Duration (days)
1	Cutting	5
2	Breast wall	75
3	Retaining wall	120
4	Filling	32
5	Subgrade	3
6	GSBC	1.7
7	WMM	2
8	DBM	.30
9	BC	.104

Table 7.4 Duration valley side

3. Concentric widening:

S.No	Activity	Duration (days)
1	Cutting	5
2	Breast wall	60
3	Retaining wall	90
4	Filling	30
5	Subgrade	1.4
6	GSBC	1
7	WMM	1
8	DBM	.39
9	BC	.2

Table 7.5 Duration concentric widening

4. New Pavement :

S.No	Activity	Duration (days)
1	Cutting	7.2
2	Breast wall	60
3	Retaining wall	90
4	Filling	38
5	Subgrade	8.3
6	GSBC	1.5
7	WMM	2
8	DBM	.8
9	BC	.26

Table 7.6 Duration new pavement

7.5 MICROSOFT PROJECT:

Microsoft Project is project management software which enables project manager in planning the project by calculation of duration, assigning resources to tasks, tracking progress, managing the budget and analyzing workloads in a construction project. The scheduling of the project will be done from BOQ and productivity. The BOQ is obtained from the estimation of quantities. Resource definitions (Labour, equipment and materials) can be shared between projects and each resource can have its individual calendar, which defines what days and time is resource present for the specified task of a project.

MSP defines critical path of the project on the basis of relation between different events and the events in the critical path are called as critical activities such that any delay in the execution of these activities resulting to the delay of the project. This helps the manager to allocate the resources without affecting the critical path Schedules can be resource leveled, and task networks are visualized in a Gantt chart in the micro-soft project and also the critical path obtained can be seen.

Many additional features such as calendar, working hour, days etc makes MSP a better tool for estimation of duration and cost. The durations of activities are taken from the tables shown above. The relationship between different activities is defined on the basis of their work sequence. The relationship between variables and results obtained from MSP for critical path and activities are shown in annexure D.

The total duration of 2 km stretch from MSP is 142 days and the duration for completion of each widening scheme proposed is as follows:

1. Hill side Widening is 81.93 days
2. Valley side widening is 86.56 days
3. Concentric widening 72.31 days
4. New construction 87.3 days

CHAPTER 8

CONCLUSION

6.1 CONCLUSIONS FROM THE PRESENT STUDY

The 2km stretch of the NH 22 widening project (in between Dativar to Chakki Mod) was considered for cost analysis and estimation. The scheduling of this stretch was also performed in MSP and corresponding duration was 142 day. The following conclusions were drawn:

(1) The identified parameters which affect the highway widening projects in hilly areas are hill side cutting; valley side filling and construction protection work.

(2) There exists a correlation between all the parameters affecting cost which was concluded from the correlation analysis. The hill side quantity have a dependency with valley side filling in decreasing order and valley side filling have a dependency with hill side cutting in decreasing order and dependency with protection works in increasing order.

6.2 LIMITATIONS OF THE STUDY

The study was limited to a stretch of 2 km and construction of culverts, bridges, tunnels were not considered in the study.

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ANNEXURE

Annexure A

Data Collected and Subgrade calculation

S. No	Chainage	Existing Centre Line	Finished Centre Line	Subgrade thickness (mm)	Depth (m)	Width (m)	Sectional area(m^2)	Length(m)	Quantity(m^3)	Rate (INR)	Total cost(INR)	Remarks
1	67000	872.082	871.98	500	0.50	11.2						cutting
2	67020	873.262	873.275	500	0.40	11.2	5.04	20	100.8	103	10382.4	cutting
3	67040	874.365	874.313	500	0.55	11.2	5.32	20	106.4	231	24578.4	cutting
4	67060	875.155	875.091	500	0.50	11.2	5.88	20	117.6	231	27165.6	cutting
5	67080	875.605	875.609	500	0.40	11.2	5.04	20	100.8	231	23284.8	cutting
6	67100	876.275	875.868	500	0.60	11.2	5.60	20	112	231	25872	cutting
7	67120	875.95	875.895	500	0.55	11.2	6.44	20	128.8	231	29752.8	cutting
8	67140	875.99	876.056	500	0.40	11.2	5.32	20	106.4	231	24578.4	cutting
9	67160	875.953	876.477	500	0.02	13.45	2.85	20	57.028	231	13173.468	cutting
10	67180	875.685	877.157	500	0.95	13.45	6.55	20	131.003	231	30261.693	cutting
11	67200	876.657	878.097	500	0.94	13.45	12.71	20	254.205	103	26183.115	cutting
12	67220	878.581	879.986	500	0.80	13.45	11.70	20	234.03	231	54060.93	cutting
13	67240	879.114	880.686	500	0.45	13.45	8.37	20	167.4525	103	17247.6075	cutting
14	67260	880.739	882.086	500	0.70	13.45	7.70	20	154.0025	231	35574.5775	cutting
15	67280	882.259	883.486	500	0.60	13.45	8.74	20	174.85	103	18009.55	cutting
16	67300	883.038	883.886	500	0.35	11.25	5.32	20	106.3125	231	24558.1875	cutting
17	67320	882.1	883.285	500	0.65	11.25	5.60	20	111.9375	231	25857.5625	cutting
18	67340	886.989	887.668	500	0.15	11.25	4.50	20	90	231	20790	filling
19	67360	888.659	889.029	500	0.13	11.25	1.58	20	31.5	231	7276.5	filling
20	67380	890.446	890.369	500	0.30	11.25	2.42	20	48.375	231	11174.625	filling

21	6740 0	891.7 33	891.6 89	500	0.35	11.2	3.64	20	72.8	231	16816. 8	fillin g
22	6742 0	893.0 13	892.7 86	500	0.55	11.2	5.04	20	100.8	231	23284. 8	cuttin g
23	6744 0	894.1 8	894.2 79	500	0.40	11.2	5.32	20	106.4	231	24578. 4	cuttin g
24	6746 0	895.4 1	895.5 72	500	0.34	11.2	4.12	20	82.32	231	19015. 92	cuttin g
25	6748 0	896.2 91	896.8 65	500	0.07	11.2	2.27	20	45.36	231	10478. 16	cuttin g
26	6750 0	898.2 49	898.1 58	500	0.60	11.2	3.75	20	75.04	231	17334. 24	cuttin g
27	6752 0	899.5 28	899.4 51	500	0.58	11.2	6.58	20	131.6	103	13554. 8	cuttin g
28	6754 0	900.7 63	900.7 34	500	0.40	11.2	5.46	20	109.2	231	25225. 2	cuttin g
29	6756 0	902.1 43	902	500	0.60	11.2	5.60	20	112	231	25872	cuttin g
30	6758 0	903.2 18	903.2 5	500	0.25	11.2	4.76	20	95.2	231	21991. 2	cuttin g
31	6760 0	904.5 94	904.4 84	500	0.50	11.2	4.20	20	84	103	8652	cuttin g
32	6762 0	905.2 72	905.7 03	500	0.75	20.45	12.78	20	255.625	103	26329. 375	fillin g
33	6764 0	906.3 3	906.9 04	500	0.10	20.45	8.69	20	173.825	103	17903. 975	fillin g
34	6766 0	909.0 25	908.0 9	500	1.10	20.45	12.27	20	245.4	103	25276. 2	cuttin g
35	6768 0	909.5 58	909.2 71	500	0.68	20.45	18.20	20	364.01	103	37493. 03	cuttin g
36	6770 0	910.7 25	910.4 51	500	0.75	11.25	8.04	20	160.875	103	16570. 125	cuttin g
37	6772 0	911.4 4	911.6 31	500	0.30	11.25	5.91	20	118.125	231	27286. 875	cuttin g
38	6774 0	913.2 52	912.8 11	500	0.90	11.25	6.75	20	135	231	31185	cuttin g
39	6776 0	914.2 31	913.9 92	500	0.80	11.25	9.56	20	191.25	103	19698. 75	cuttin g
40	6778 0	915.4 91	915.1 72	500	0.82	13.45	10.89	20	217.89	231	50332. 59	cuttin g
41	6780 0	917.0 59	916.6 52	500	0.90	13.45	11.57	20	231.34	103	23828. 02	cuttin g
42	6782 0	917.8 21	917.5 32	500	0.75	13.45	11.10	20	221.925	231	51264. 675	cuttin g
43	6784 0	919.0 93	918.7 13	500	0.85	13.45	10.76	20	215.2	231	49711. 2	cuttin g
44	6786 0	920.2 65	919.8 87	500	0.88	11.2	9.68	20	193.536	231	44706. 816	cuttin g
45	67880	920.3 45	919.8 87	500	0.95	11.2	10.24	20	204.736	103	21087.8 08	cuttin g
46	67900	922.7 01	922.3 98	500	0.80	11.2	9.80	20	196	231	45276	cuttin g
47	67920	923.1 13	923.3 33	500	0.28	11.2	6.05	20	120.96	231	27941.7 6	cuttin g
48	67940	924.4	924.4	500	0.49	13.45	5.15	20	103.027	231	23799.2	cuttin

		88	62								37	g
49	67960	925.332	925.591	500	0.24	13.45	4.89	20	97.7815	231	22587.5265	cutting
50	67980	926.702	926.719	500	0.48	13.45	4.87	20	97.378	231	22494.318	cutting
51	68000	929.569	927.848	500	0.32	13.45	5.40	20	108.0035	231	24948.8085	cutting
52	69000	979.592	980.642	500	0.50	11.25	4.61	20	92.25	231	21309.75	filling
53	69020	980.306	981.638	500	0.80	11.25	7.31	20	146.25	231	33783.75	filling
54	69040	981.378	982.634	500	0.75	11.25	8.72	20	174.375	103	17960.625	filling
55	69060	983.023	983.63	500	0.11	11.25	4.82	20	96.4125	231	22271.2875	filling
56	69080	984.551	984.608	500	0.43	11.25	3.02	20	60.4125	231	13955.2875	filling
57	69100	985.605	985.475	500	0.60	11.25	5.79	20	115.875	231	26767.125	cutting
58	69120	986.55	986.342	500	0.70	11.25	7.31	20	146.25	103	15063.75	cutting
59	69140	987.337	987.209	500	0.62	11.25	7.43	20	148.5	103	15295.5	cutting
60	69160	987.946	988.077	500	0.34	11.2	5.38	20	107.52	231	24837.12	cutting
61	69180	988.622	988.944	500	0.18	11.2	2.90	20	58.016	231	13401.696	cutting
62	69200	989.612	989.811	500	0.30	11.2	2.68	20	53.536	231	12366.816	cutting
63	69220	990.434	990.678	500	0.25	13.45	3.70	20	73.975	231	17088.225	cutting
64	69240	991.453	991.545	500	0.40	13.45	4.37	20	87.425	231	20195.175	cutting
65	69260	992.229	992.412	500	0.30	13.45	4.71	20	94.15	231	21748.65	cutting
66	69280	993.003	993.34	500	0.16	13.45	3.09	20	61.87	231	14291.97	cutting
67	69300	994.186	994.429	500	0.25	11.25	2.31	20	46.125	231	10654.875	cutting
68	69320	995.371	995.557	500	0.30	11.25	3.09	20	61.875	231	14293.125	cutting
69	69340	996.525	996.631	500	0.38	11.25	3.83	20	76.5	231	17671.5	cutting
70	69360	997.414	997.531	500	0.35	20.5	7.48	20	149.65	231	34569.15	cutting
71	69380	998.194	998.381	500	0.30	20.5	6.66	20	133.25	231	30780.75	cutting
72	69400	999.175	999.231	500	0.40	20.5	7.18	20	143.5	231	33148.5	cutting
73	69420	1000.104	1000.082	500	0.50	20.5	9.23	20	184.5	231	42619.5	cutting
74	69440	1000.831	1000.932	500	0.38	20.5	9.02	20	180.4	231	41672.4	cutting
75	69460	1001.503	1001.782	500	0.22	20.5	6.15	20	123	231	28413	cutting

76	69480	1002.09	1002.632	500	0.04	20.5	2.69	20	53.71	231	12407.01	cutting
77	69500	1002.859	1003.482	500	0.12	20.5	1.69	20	33.825	231	7813.575	cutting
78	69520	1003.698	1004.433	500	0.24	20.5	3.67	20	73.39	231	16953.09	cutting
79	69540	1004.696	1005.183	500	0.01	20.5	2.54	20	50.84	231	11744.04	cutting
80	69560	1005.712	1006.033	500	0.15	20.5	1.67	20	33.415	231	7718.865	cutting
81	69580	1006.564	1006.883	500	0.18	20.5	3.38	20	67.65	231	15627.15	cutting
82	69600	1007.219	1007.733	500	0.01	20.5	1.95	20	38.95	231	8997.45	cutting
83	69620	1008.059	1008.584	500	0.03	20.5	0.36	20	7.175	231	1657.425	cutting
84	69640	1008.954	1009.898	500	0.40	20.5	4.36	20	87.125	231	20125.875	cutting
85	69660	1009.898	1010.284	500	0.11	20.5	5.27	20	105.37	231	24340.47	cutting
86	69680	1010.679	1011.134	500	0.05	20.5	1.63	20	32.595	231	7529.445	cutting
87	69700	1011.477	1011.984	500	0.14	11.2	1.02	20	20.384	231	4708.704	cutting
88	69720	1012.485	1012.835	500	0.15	11.2	1.61	20	32.144	231	7425.264	cutting
89	69740	1013.524	1013.649	500	0.38	11.2	2.94	20	58.8	231	13582.8	cutting
90	69760	1014.124	1014.348	500	0.25	11.2	3.50	20	70	231	16170	cutting
91	69780	1014.851	1015.013	500	0.34	11.2	3.29	20	65.856	231	15212.736	cutting
92	69800	1015.516	1015.679	500	0.34	11.2	3.77	20	75.376	231	17411.856	cutting
93	69820	1016.098	1016.345	500	0.25	11.2	3.29	20	65.856	231	15212.736	cutting
94	69840	1016.759	1017.011	500	0.32	11.2	3.23	20	64.624	231	14928.144	cutting
95	69860	1017.494	1017.583	500	0.41	11.2	4.12	20	82.32	231	19015.92	cutting
96	69880	1017.95	1018.127	500	0.32	11.2	4.09	20	81.872	231	18912.432	cutting
97	69900	1018.374	1018.67	500	0.20	11.2	2.93	20	58.688	231	13556.928	cutting
98	69920	1018.823	1019.756	500	0.43	11.2	3.57	20	71.344	231	16480.464	cutting
99	69940	1019.482	1019.756	500	0.22	11.2	3.66	20	73.136	231	16894.416	cutting
100	69960	1020.021	1020.229	500	0.29	11.2	2.86	20	57.12	231	13194.72	cutting
101	69980	1020.611	1020.842	500	0.27	11.2	3.13	20	62.608	231	14462.448	cutting

Annexure B

Earthwork Calculation

Hill side cutting

Chainage	Width of cut (m)	Height of cut (m)	Area of crossection (m^2)	Volume (m^3)	Rate /m^3	Cost (INR)
67000-67020	12	26	156	3120	153	477360
67020-67040	13	20	130	2600	153	397800
67040-67060	11	24	132	2640	231	609840
67060-67080	12.5	19	118.75	2375	231	548625
67080-67100	13	22	143	2860	231	660660
67100-67120	13	22	143	2860	231	660660
67120-67140	12	18	108	2160	304	656640
67140-67160	13	23	149.5	2990	304	908960
67160-67180	8	26	104	2080	153	318240
67180-67200	8.5	22	115	2300	153	351900
67200-67220	7.75	23	97	1940	153	296820
67220-67240	7.5	13	93	1860	304	565440
67240-67260	8	21.5	86	1720	231	397320
67260-67280	8.5	25	106.25	2125	153	325125
67140-67160	13	23	149.5	2990	304	908960
67280-67300	12	17	102	2040	304	620160
67300-67320	13	22	143	2860	273	780780
67320-67340	11.5	21	120.75	2415	153	369495
67340-67360	3.7	13	48.1	962	153	147186
67360-67380	3.5	12.5	59	1180	153	180540
67380-67400	3.25	11	62	1240	153	189720
67400-	12	16	96	1920	153	293760

67420						
67420-67440	13	19	123.5	2470	231	570570
67400-67420	12	16	96	1920	153	293760
67420-67440	13	19	123.5	2470	231	570570
67440-67460	12.5	11	68.75	1375	231	317625
67460-67480	12	20	120	2400	231	554400
67480-67500	11	23	126.5	2530	231	584430
67500-67520	11.5	20	115	2300	231	531300
67520-67540	12	18	108	2160	231	498960
67580-67600	13	16	104	2080	304	632320
67600-67620	11	13	71.5	1430	304	434720
67620 -67640	9.5	22	120	2400	231	554400
67640-67660	10	23	115	2300	153	351900
67660-67680	11	24	132	2640	304	802560
67680-67700	3.75	10	37.5	750	231	173250
67700-69720	3.8	9	42	840	231	194040
67720-69740	3.85	8.5	40	800	231	184800
67740-69760	3	10	30	600	231	138600
69760-69780	11	15	82.5	20	273	1650
69780-69800	13	19	123.5	20	231	2470
67800-67820	7.5	12	45	900	304	273600
67820-67840	7.2	16	65	1300	231	300300
67840-67860	7.5	22	82.5	1650	282	465300
67860-67880	12.5	17	106.25	20	2125	304
67880-67900	13	25	162.5	20	231	2350
67900-67920	12	25	150	3000	282	846000
67920-67940	7	15	52.5	1050	304	319200
67940-	7.5	23	56	1120	153	171360

67960						
67960-67980	7.3	14	58.5	1170	304	355680
67980-68000	7.5	14	52.5	1050	273	286650
69000-69020	3.5	9	15.75	315	273	85995
69020-69040	3.65	12	51	1020	231	235620
69040-69060	3.5	8	28	560	231	129360
69060-69080	3.25	7.5	37	740	304	224960
69080-69100	3.5	9	31.5	630	304	191520
69100-69120	3.6	7	32.5	650	304	197600
69120-69140	3	8.5	39	780	273	212940
69140-69160	3.5	8.5	14.875	297.5	153	45517.5
69160-69180	12	24	144	20	2880	153
69180-69200	12	20	120	20	2400	231
69200-67220	7	18	63	1260	231	291060
69220-67240	7.8	9	35.1	702	273	191646
69240-67260	7	7	24.5	490	282	138180
69260-69280	3.8	7	13.3	266	153	40698
69280-69300	3.25	7	22.75	455	273	124215
69300-69320	3.5	7.5	33	660	282	186120
69320-69340	3.5	9	15.75	315	153	48195
69340-69360	3	8.5	12.75	255	231	58905
69360-69380	9.5	17	130	2600	304	790400
69380-69400	12	22	132	2640	231	609840
69400-69420	11.5	13	74.75	1495	304	454480
69420-69440	13	19	123.5	2470	153	377910
69440-69460	9.5	18	85.5	1710	231	395010
69460-69480	12.5	16	145	2900	273	791700
69480-	10	19.5	108	2160	231	498960

69500						
69500-69520	10.5	25.5	100	2000	153	306000
69520-69540	11	15	93	1860	304	565440
69540-69560	9.5	20	71	1420	231	328020
69560-69580	13	14	91	1820	273	496860
69580-69600	12	21	126	2520	231	582120
69600-69620	11	14	77	1540	282	434280
69620-69640	11.5	18	103.5	2070	231	478170
69640-69660	12	13	78	1560	273	425880
69660-69680	11	21	115.5	2310	282	651420
69680-69700	13	26	169	3380	282	953160
69700-69720	11	25	137.5	2750	153	420750
69720-69740	12.5	21	131.25	2625	231	606375
69740-69760	12	25	150	3000	231	693000
69760-69780	11	15	82.5	20	1650	273
69780-69800	13	19	123.5	20	2470	231
69800-69820	14	18	126	20	2520	282
69820-69840	13	22	143	2860	304	869440
69840-69860	13.5	26	175.5	3510	231	810810
69860-69880	12	23	138	2760	231	637560
69880-69900	13	26	169	20	3380	153
69900-69920	12	16	96	20	1920	304
69920-69940	11	11	60.5	20	1210	304
69940-69960	12	23	138	20	2760	231
69960-69980	13	15	97.5	20	1950	273
69980-70000	13	19	123.5	20	2470	231

Valley side filling

Chainage	width of cut (m)	Height (m)	Area (m^2)	Quantity(m^3)	Rate(INR)	Total Cost (INR)
67000-67020	2	12	12	240	258	61920
67020-67040	2	13	13	260	258	67080
67040-67060	2	11	11	220	258	56760
67060-67080	2	11.5	11.5	230	258	59340
67080-67100	2	10	10	200	258	51600
67100-67120	2	9	9	180	258	46440
67120-67140	2	10	10	200	258	51600
67140-67160	2	14	14	280	258	72240
67160-67180	5.45	23	68	1360	258	350880
67180-67200	5.45	19	63	1260	258	325080
67200-67220	5.45	22	65.5	1310	258	337980
67220-67240	5.45	12	63	1260	258	325080
67240-67260	5.45	19.5	59	1180	258	304440
67260-67280	5.45	7	60	1200	258	309600
67280-67300	2	13	13	260	258	67080
67300-67320	2	14	14	280	258	72240
67320-67340	2	11	11	220	258	56760
67340-67360	11.25	24	135	2700	258	696600
67360-67380	11.25	22	123.75	2475	258	638550
67380-67400	11.25	18	101.25	2025	258	522450
67400-67420	2	9	9	180	258	46440
67420-67440	2	10.5	10.5	210	258	54180
67440-67460	2	12	12	240	258	61920
67460-67480	2	9.5	9.5	190	258	49020

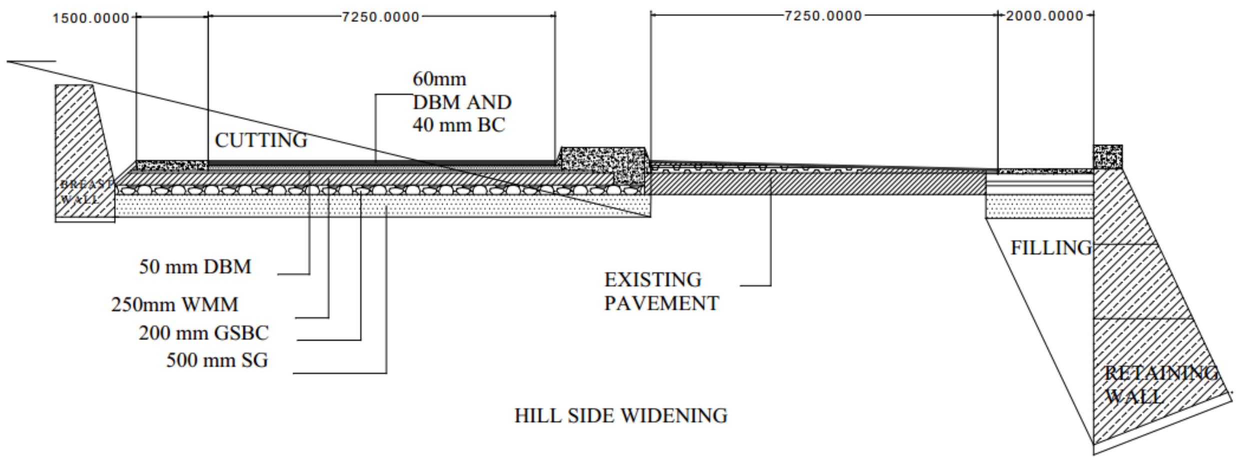
67480-67500	2	13	13	260	258	67080
67500-67520	2	14	14	280	258	72240
67520-67540	2	12	12	240	258	61920
67540-67560	2	10	10	20	200	51600
67560-67580	2	7	7	20	140	36120
67580-67600	2	11	11	220	258	56760
67600-67620	2	14	14	280	258	72240
67620 - 67640	11.5	20	115	2420	258	624360
67640-67660	10	11	55	1100	258	283800
67660-67680	9	21	94.5	1890	258	487620
67680-67700	11.25	23	129.375	2587.5	258	667575
67700-67720	11.25	20	112.5	2250	258	580500
67720-67740	11.25	21	118.125	2362.5	258	609525
67740-67760	11.25	19	106.875	2137.5	258	551475
67780-67800	5.45	21	57	1140	258	294120
67800-67820	5.45	18	49.05	981	258	253098
67820-67840	5.45	16	49	980	258	252840
67840-67860	5.45	17	46.325	926.5	258	239037
67860-67880	2	8	8	20	258	66564
67880-67900	2	9.5	9.5	20	258	66564
67900-67920	2	12	12	240	258	61920
67920-67940	5.45	15	46.5	930	258	239940
67940-67960	5.45	13	41	820	258	211560
67960-67980	5.45	21	38	760	258	196080
67980-68000	5.45	11	29.975	599.5	258	154671
69000-69020	11.25	23	129.375	2587.5	258	667575
69020-69040	11.25	14	78.75	1575	258	406350

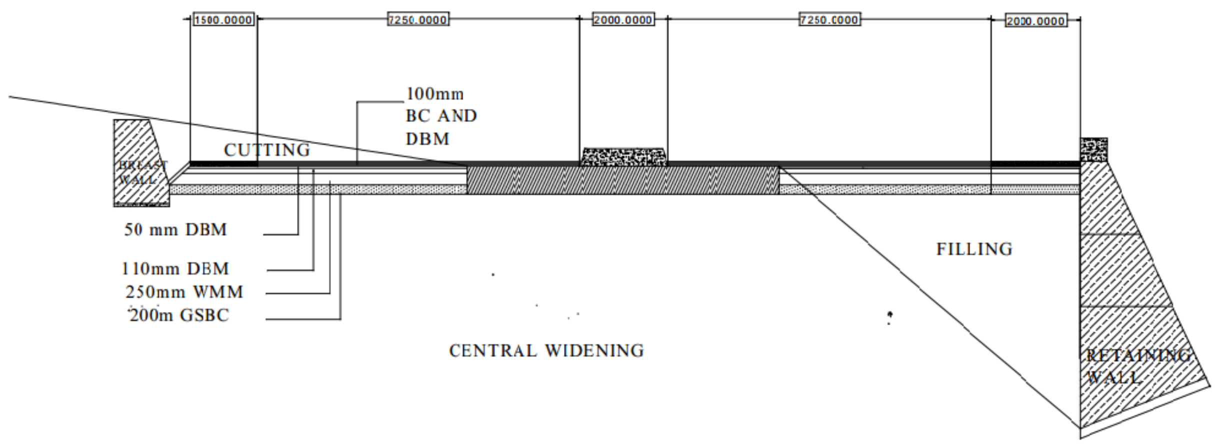
69040-69060	11.25	21	118.125	2362.5	258	609525
69060-69080	11.25	19	106.875	2137.5	258	551475
69080-69100	11.25	13	73.125	1462.5	258	377325
69100-69120	11.25	17	95.625	1912.5	258	493425
69120-69140	11.25	16	90	1800	258	464400
69140-69160	11.25	24	135	2700	258	696600
69160-69180	2	7.5	7.5	20	258	66564
69180-69200	2	7	7	20	258	66560
69200-67220	5.45	10	40	800	258	206400
69220-67240	5.45	20	24.5	490	258	126420
69240-67260	5.45	7	19	380	258	98040
69260-69280	11.25	25	140.625	2812.5	258	725625
69280-69300	11.25	18	101.25	2025	258	522450
69300-69320	11.25	20	112.5	2250	258	580500
69320-69340	11.25	23	129.375	2587.5	258	667575
69340-69360	11.25	26	146.25	2925	258	754650
69360-69380	10.5	17	89.25	1785	258	460530
69380-69400	8	7	28	560	258	144480
69400-69420	9.5	7.5	35.625	712.5	258	183825
69420-69440	7	16	56	1120	258	288960
69440-69460	10.5	13	68.25	1365	258	352170
69460-69480	7.5	18	67.5	1350	258	348300
69480-69500	10	9	45	900	258	232200
69500-69520	9.5	21	99.75	1995	258	514710
69520-69540	9	12	54	1080	258	278640
69540-69560	10.5	6	31.5	630	258	162540
69560-69580	7	8	28	560	258	144480

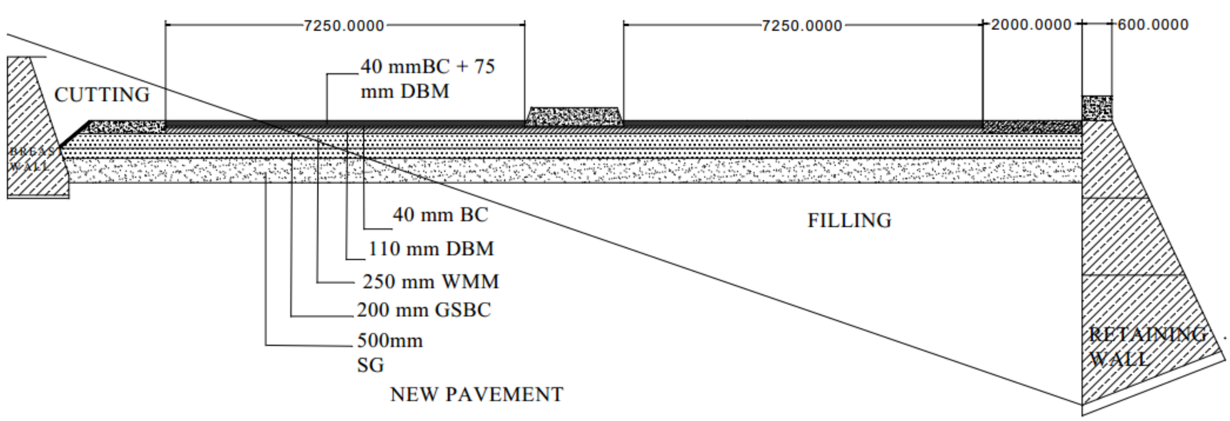
69580-69600	8	14	56	1120	258	288960
69600-69620	9	9	40.5	810	258	208980
69620-69640	9	12	54	1080	258	278640
69640-69660	8	14	56	1120	258	288960
69660-69680	10	15	75	1500	258	387000
69680-69700	2	13	13	260	258	67080
69700-69720	2	10	10	200	258	51600
69720-69740	2	14	14	280	258	72240
69740-69760	2	11	11	220	258	56760
69760-69780	2	9	9	20	180	46440
69780-69800	2	10	10	20	200	51600
69800-69820	2	11	11	20	220	56760
69820-69840	2	9	9	180	258	46440
69840-69860	2	10	10	200	258	51600
69860-69880	2	12	12	240	258	61920
69880-69900	2	8	8	20	258	66564
69900-69920	2	7	7	20	258	66564
69920-69940	2	9	9	20	258	66564
69940-69960	2	8	8	20	258	66564
69960-69980	2	9	9	20	258	66564
69980-70000	2	10	10	20	258	66564

ANNEXURE C

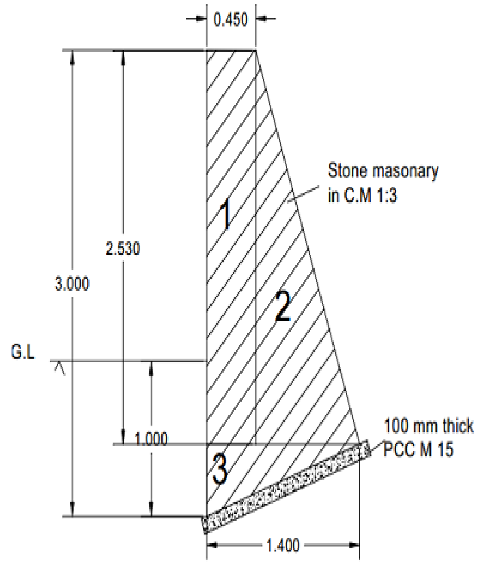
Drawings



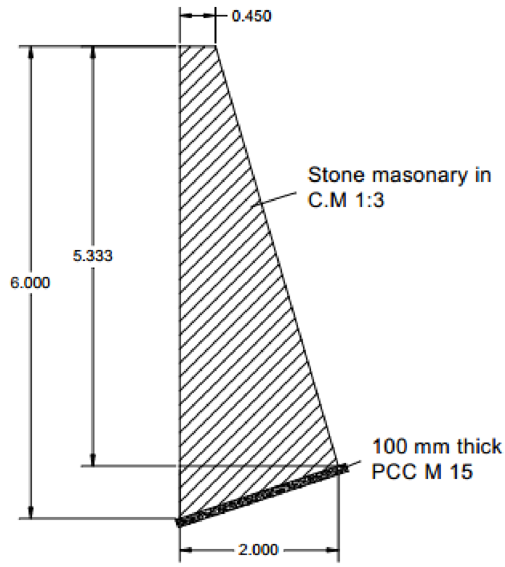




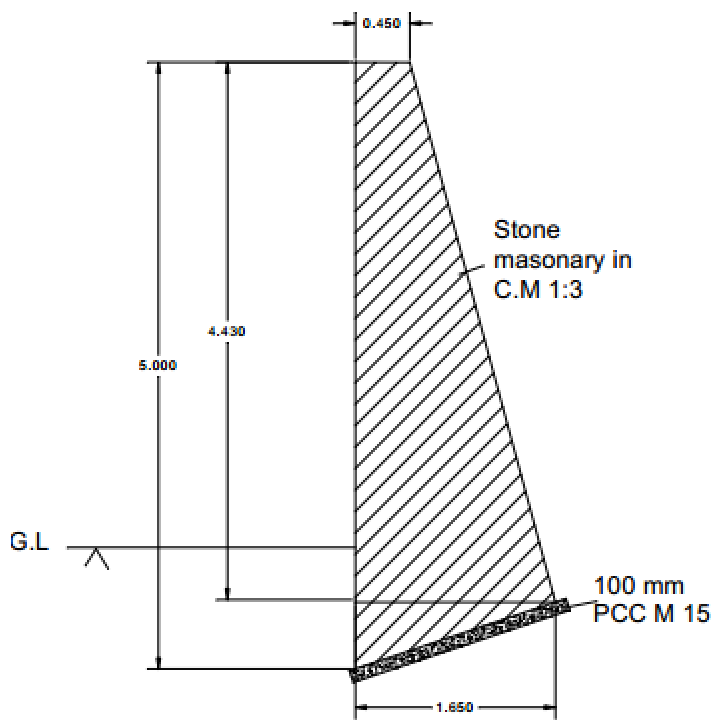
Breast Wall



Breast Wall

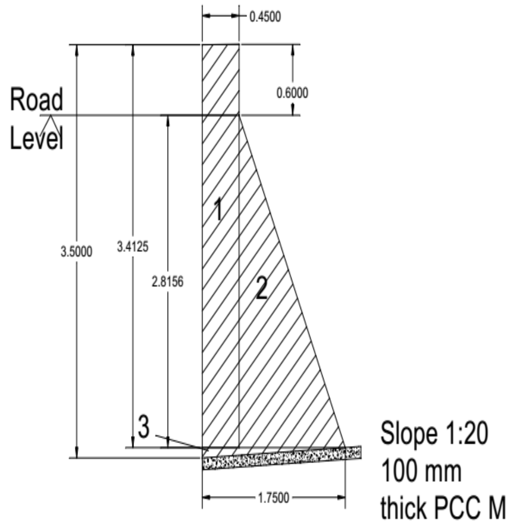


Breast wall 5
to 6 m

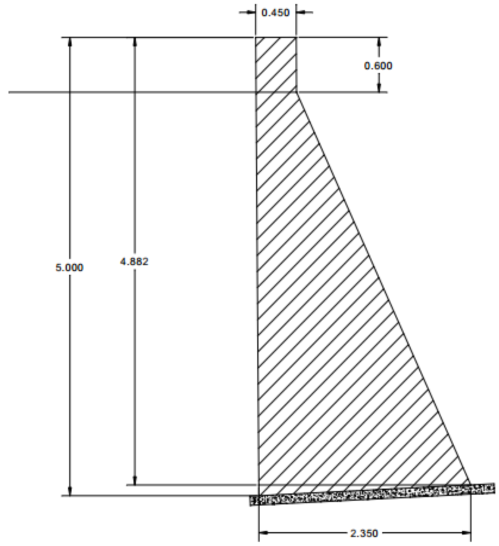


Breast Wall 3
to 5 m

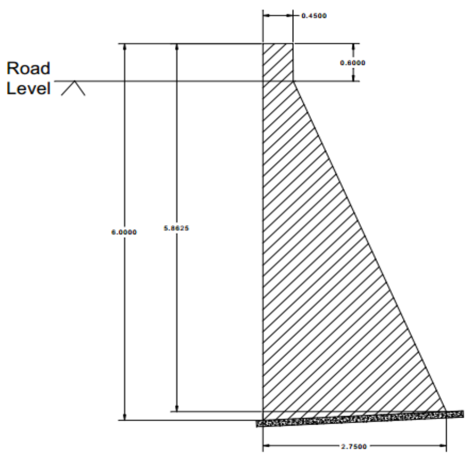
Retaining wall



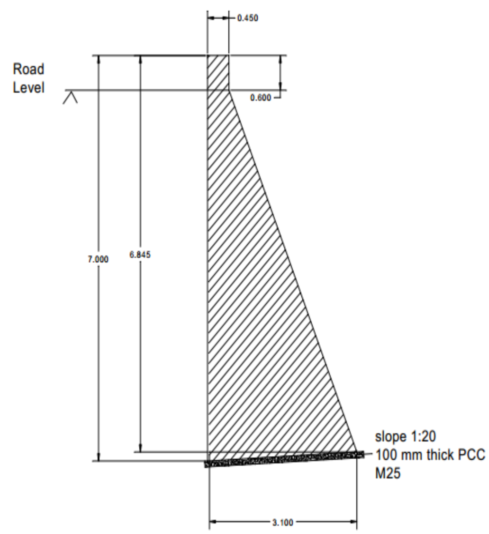
Retaining Wall 3.5 m



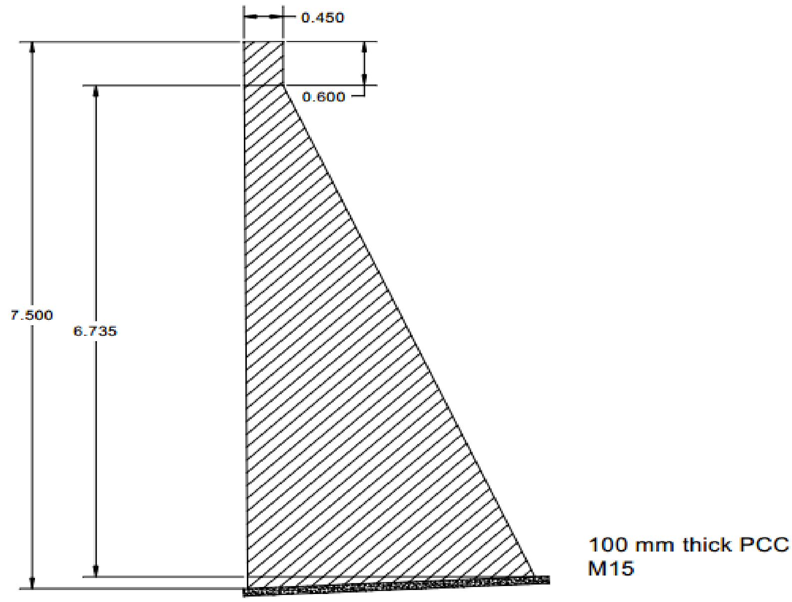
Retaining Wall 5 m



Retaining wall 6 m



Retaining wall 7 m



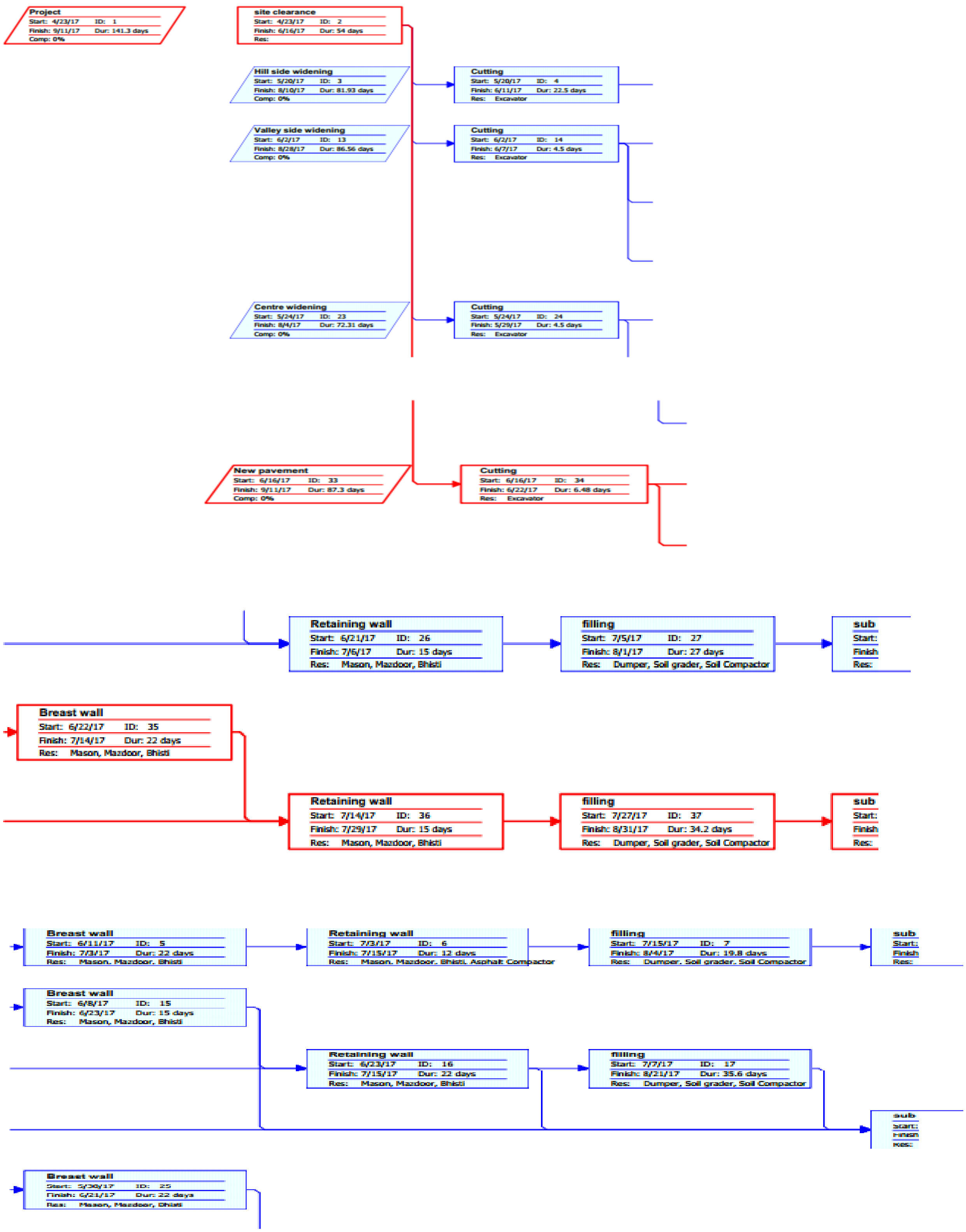
Retaining wall height 7.5 m

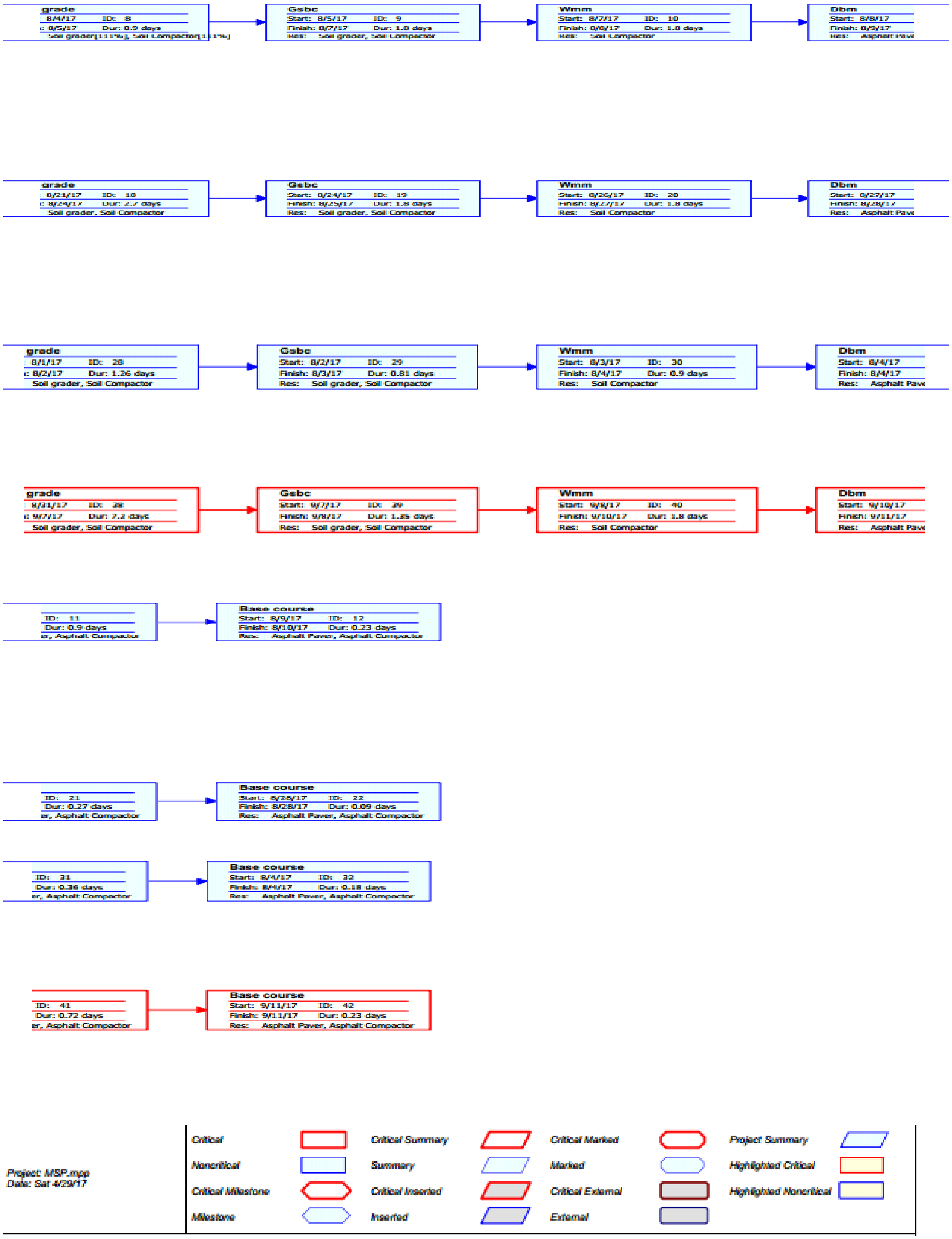
ANNEXURE D

MSP Scheduling

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**Project**	**141.3 days**	**Sun 4/23/17**	**Mon 9/11/17**		
2		site clearance	54 days	Sun 4/23/17	Fri 6/16/17		
3		**Hill side widening**	**81.93 days**	**Sat 5/20/17**	**Thu 8/10/17**		
4		Cutting	22.5 days	Sat 5/20/17	Sun 6/11/17	2SS+27 days	Excavator
5		Breast wall	22 days	Sun 6/11/17	Mon 7/3/17	4	Mason,Mazdoor,Bhisti
6		Retaining wall	12 days	Mon 7/3/17	Sat 7/15/17	5	Mason,Mazdoor,Bhisti,Asphalt Compacto
7		filling	19.8 days	Sat 7/15/17	Fri 8/4/17	6	Dumper,Soil grader,Soil Compactor
8		sub grade	0.9 days	Fri 8/4/17	Sat 8/5/17	7	Soil grader[111%],Soil Compactor[111%]
9		Gabc	1.8 days	Sat 8/5/17	Mon 8/7/17	8	Soil grader,Soil Compactor
10		Wmm	1.8 days	Mon 8/7/17	Tue 8/8/17	9	Soil Compactor
11		Dbm	0.9 days	Tue 8/8/17	Wed 8/9/17	10	Asphalt Paver,Asphalt Compactor
12		Base course	0.23 days	Wed 8/9/17	Thu 8/10/17	11	Asphalt Paver,Asphalt Compactor
13		**Valley side widening**	**86.56 days**	**Fri 6/2/17**	**Mon 8/28/17**		
14		Cutting	4.5 days	Fri 6/2/17	Wed 6/7/17	2SS+40.5 days	Excavator
15		Breast wall	15 days	Thu 6/8/17	Fri 6/23/17	14SS+6.3 days	Mason,Mazdoor,Bhisti
16		Retaining wall	22 days	Fri 6/23/17	Sat 7/15/17	14SS+1.8 days,15	Mason,Mazdoor,Bhisti
17		filling	35.6 days	Fri 7/7/17	Mon 8/21/17	16SS+13.5 days	Dumper,Soil grader,Soil Compactor
18		sub grade	2.7 days	Mon 8/21/17	Thu 8/24/17	14,15,16,17	Soil grader,Soil Compactor
19		Gabc	1.8 days	Thu 8/24/17	Fri 8/25/17	18	Soil grader,Soil Compactor
20		Wmm	1.8 days	Sat 8/26/17	Sun 8/27/17	19	Soil Compactor
21		Dbm	0.27 days	Sun 8/27/17	Mon 8/28/17	20	Asphalt Paver,Asphalt Compactor
22		Base course	0.09 days	Mon 8/28/17	Mon 8/28/17	21	Asphalt Paver,Asphalt Compactor
23		**Centre widening**	**72.31 days**	**Wed 5/24/17**	**Fri 8/4/17**		
24		Cutting	4.5 days	Wed 5/24/17	Mon 5/29/17	2SS+31.5 days	Excavator
25		Breast wall	22 days	Tue 5/30/17	Wed 6/21/17	24SS+6.3 days	Mason,Mazdoor,Bhisti
26		Retaining wall	15 days	Wed 6/21/17	Thu 7/6/17	24SS+1.8 days,25	Mason,Mazdoor,Bhisti
27		filling	27 days	Wed 7/5/17	Tue 8/1/17	26SS+13.5 days	Dumper,Soil grader,Soil Compactor
28		sub grade	1.26 days	Tue 8/1/17	Wed 8/2/17	27	Soil grader,Soil Compactor
29		Gabc	0.81 days	Wed 8/2/17	Thu 8/3/17	28	Soil grader,Soil Compactor
30		Wmm	0.9 days	Thu 8/3/17	Fri 8/4/17	29	Soil Compactor
31		Dbm	0.36 days	Fri 8/4/17	Fri 8/4/17	30	Asphalt Paver,Asphalt Compactor
32		Base course	0.18 days	Fri 8/4/17	Fri 8/4/17	31	Asphalt Paver,Asphalt Compactor
33		**New pavement**	**87.3 days**	**Fri 6/16/17**	**Mon 9/11/17**		
34		Cutting	6.48 days	Fri 6/16/17	Thu 6/22/17	2	Excavator
35		Breast wall	22 days	Thu 6/22/17	Fri 7/14/17	34SS+6.3 days	Mason,Mazdoor,Bhisti
36		Retaining wall	15 days	Fri 7/14/17	Sat 7/29/17	34SS+1.8 days,35	Mason,Mazdoor,Bhisti
37		filling	34.2 days	Thu 7/27/17	Thu 8/31/17	36SS+13.5 days	Dumper,Soil grader,Soil Compactor
38		sub grade	7.2 days	Thu 8/31/17	Thu 9/7/17	37	Soil grader,Soil Compactor
39		Gabc	1.35 days	Thu 9/7/17	Fri 9/8/17	38	Soil grader,Soil Compactor
40		Wmm	1.8 days	Fri 9/8/17	Sun 9/10/17	39	Soil Compactor
41		Dbm	0.72 days	Sun 9/10/17	Mon 9/11/17	40	Asphalt Paver,Asphalt Compactor
42		Base course	0.23 days	Mon 9/11/17	Mon 9/11/17	41	Asphalt Paver,Asphalt Compactor

Critical Activities




grade
Gsbc
Wmm
Dbm
Start: 8/5/17 ID: 9
Start: 8/7/17 ID: 10
Start: 8/8/17
Res: Soil grader, Soil Compactor
Res: Soil Compactor
Start: 8/24/17 ID: 19
Start: 8/26/17 ID: 20
Start: 8/27/17
Res: Asphalt Pave
8/1/17 ID: 28
Soil grader, Soil Compactor
Start: 8/2/17 ID: 29
Finish: 8/3/17 Dur: 0.81 days
Start: 8/3/17 ID: 30
Finish: 8/4/17 Dur: 0.9 days
Start: 8/4/17
Finish: 8/4/17
8/31/17 ID: 38
Start: 9/7/17 ID: 39
Finish: 9/8/17 Dur: 1.35 days
Start: 9/8/17 ID: 40
Finish: 9/10/17 Dur: 1.8 days
Start: 9/10/17
Finish: 9/11/17
Base course
ID: 11
Dur: 0.9 days
Start: 8/9/17 ID: 12
Finish: 8/10/17 Dur: 0.23 days
ID: 21
Dur: 0.27 days
Finish: 8/28/17 Dur: 0.09 days
Res: Asphalt Paver, Asphalt Compactor
ID: 31
Dur: 0.36 days
Start: 8/4/17 ID: 32
Finish: 8/4/17 Dur: 0.18 days
ID: 41
Dur: 0.72 days
Start: 9/11/17 ID: 42
Finish: 9/11/17 Dur: 0.23 days
Project: MSP.mpp
Date: Sat 4/29/17
Critical
Noncritical
Critical Milestone
Milestone
Critical Summary
Summary
Critical Inserted
Inserted
Critical Marked
Marked
Critical External
External
Project Summary
Highlighted Critical
Highlighted Noncritical