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Productivity Escalation and Cost Optimisation of Equipment's used in Pavement Construction

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Abstract - *The aim of this work is to highlight the importance of Productivity of Equipment's used in Pavement Construction and its Cost. In construction, some tasks are labour-intensive, some pre-dominantly employ equipment and some use a combination of both, i.e., labour and equipment. In big infrastructure projects like Road or Pavement projects, equipment's and the plants play a crucial role in the production process. While the actual work done and the associated labour is accounted for by the foreman concerned, the equipment productivity control is undertaken to determine its employment time, the output achieved and its productivity at the site. The main purpose of equipment productivity control is to minimize the wastage in utilization and to minimise the Costs.*

Planning and scheduling is an integral part required for efficient execution of construction activities. Project management software's are trending for helping the manager's for better handling of time and other resources. Microsoft Project is one such software aiding in increasing the overall project efficiency.

In Road Construction, Equipment's play a major role as they manage more than 50 % of the work, so their Costs and Productivity play a major role in making the Project profitable to the company.

In this work a Case Study of two Road or Pavement Construction sites is carried out. Efforts are taken to improve the Productivity of Equipment's by using Project Management Techniques which in turn helps to cut down the Costs incurred.

Key Words: **Productivity, Equipment's, Costs**, etc.

1. INTRODUCTION

Rural roads connectivity is prominent in the overall development of rural areas as access to social and economic infrastructure and services are the sine qua non of rural development. In an indirect way, they help in establishing better social and economic relationship between people of nearby areas and also help the country during military emergency.

Rural roads are very essential to:

1. Improve connectivity.
2. Establish better relations with nearby village and cities.
3. Establishing better economy of the village.
4. To get access to Medical, Defence services.
5. To deliver the Agricultural Produce to big markets.

Rural Connectivity has a major role in improving the farmer's economic health in the area. Better roads will lead to better marketing of the produce, easy access to medical, police, political services. Literacy of the people in the area can improved as Educational facilities can be availed easily.

1.1 IRC CLASSIFICATION OF ROADS IN INDIA

1) National Highways (NH):

It has connectivity between major metro cities across India like Delhi, Mumbai, Kolkata, Chennai, Bangalore etc. National Highway play a prominent role in enhancing economic growth of the nation.

2) State Highways (SH):

SH road are connected to District capitals and other important cities of the state and adjacent states. Its connectivity is important in strengthening the state socially and economically.

3) Major District Roads (MDR):

Places and cities important in the District are connected by MDR.

4) Other District Roads (ODR):

These are the roads connecting to the prominent places of economic and social value in the District.

5) Village Roads (VR):

There are the Roads connecting small places of population.

1.2 HIGHWAY CONSTRUCTION EQUIPMENTS

Every task or road layer requires a different equipment compared to other task or layers of the road. Now a days the road work has become an equipment driven job rather than labour driven job.

Below are the equipment's required listed according to the job:

1) Excavation:
It involves shifting the earth from one place to other, it is done by digging, cutting of earth by blades of equipment's etc.
The extensively used equipment's are listed below

Bulldozers are utilised to cut, haul and clear the soil or earth from one place to other. It can be used only for short distances.
Scraper is utilised to excavate, shift, and deliver the soil and earth.
Power shovel is utilised primarily in excavation of boulders, earth etc.
Hoe is utilised for excavation of harder materials. It can excavate below the surface of the chain base.

2) Compaction
Compaction of the pavement is the most important criteria in deciding the quality of a road. Efficient and rigorous compaction ensures greater working life of the read.
Some of the compaction equipment's are listed below.
Smooth wheeled roller {static, vibratory} is used for compaction of road layers. Smooth wheeled rollers are used for vast range of soils, namely granular soils, black cotton soil etc.
Pneumatic rollers are utilised when less granular soil is present as it provides kneading action.
Sheep foot rollers are utilised when clay content in soil is more.
Rammers are utilised for compacting small areas.

3) Crushing
Construction of base course, WMM and other bituminous wearing courses need huge quantities of crushed aggregates.
Jaw crusher is the most familiar type of crusher employed in this regard. The common size of crusher is 400mm x 225mm.
Cone crusher and **roll crushers** are used for secondary and tertiary crushing to produce small size aggregates in large quantities.

4) Batching and Mixing
For the long life of the Pavement it is important that the Mix i.e. BM or SDBC is of best quality.
A **hot mix plant** of best working and design is required to fulfil above requirement
For the production of concrete of good quality, **batching plants** are erected.
This plants can be fully automatic or semi-automatic.

5) Paving
For superior finish, Paver of efficient design is needed. As it is going to lay a wearing course which comes in direct contact with the users of the road. It lays the mix as per the set thickness and is operator driven at speed of 1 to 10 meter per minute.

6) Hauling of Materials
It involves moving of the materials form one place to other. It supports the excavator, hoe, hot mix plant etc to perform efficiently.
It is important to use tippers or dumpers of best quality for best results and efficiency.

1.3 PRODUCTIVITY IN CONSTRUCTION

Productivity means the ability to produce. The term 'productivity', as commonly understood, implies the ratio of output to input. The input and output can be measured in physical quantities, monetary terms or a combination of both. Many link productivity to mean of workers' output capability; they express productivity as work quantity produced per man-hours of input. Productivity is also defined as monitory value of output per man-hour of input. Some consider productivity as performance output in rupees for every rupees of input. In the narrower sense of controlling project resources, the productivity concept is used to measure the performance of resources.

1.3.1 EQUIPMENT PRODUCTIVITY

In construction, some tasks are labour-intensive, some predominantly employ equipment and some use a combination of both, i.e., labour and equipment. In big infrastructure projects like highway projects, equipment's and the plants play a crucial role in the production process. It becomes important to educate the labours and supervisors to look at equipment productivity as matter of prime importance.

1.3.2 FACTORS AFFECTING THE PRODUCTIVITY OF EQUIPMENTS

The factors affecting equipment's productivity can be broadly categorized into two groups, viz.
a. Job factors and
b. Management factors

a. Job Factors

Job factors refer to those factors, which affect the particular job because of the particularities of that job's physical conditions but not because of the result of some general conditions.
Some of the job factors that affect the productivity of equipment's in case of highway projects are

- The material characteristics like shrinkage, swelling, plasticity, moisture content of the material etc.
- Rolling resistance and condition of the haul roads, which affect the hauling time of the materials.
- Gradients that can be favourable or unfavourable for loading and travel.

- Tractive efficiency, which will determine how much traction can be applied before slippage will occur.
- Reduction of horsepower of engine due to altitude.

b. Management Factors

Management factors refer those factors, which arise due to arrangement and allocation of plants and equipment's at sites and for managing the same in an effective and efficient manner.
The management factors may quantitatively vary from 60% for an average job to 75%-80% for a well-managed job.
With respect to a highway project, the key management factors could be

- Operator efficiency depending on the training and experience of the operator.
- Proper matching of sizes, numbers, capacity etc. of the equipment's mobilized so that the most important production equipment is not kept waiting or idle.
- Time required for on-the-job servicing and maintenance.
- Unavoidable delays in combined operation of all equipment's i.e. delays due to lack of synchronization. In case of earthmoving equipment's, sometimes 50min hour is taken for calculation of production of earthmoving equipment's.
- Availabilities of well-equipped workshops, maintenance facilities, spare parts, stocks etc.
- Management – worker relationship.

If a manufacturer specifies production of his equipment's as P m^3/hr. under ideal condition, then,

Actual Production = P x job factor x management factor.

In case, manufacturers' table / specification is not available, it is possible to calculate the production of equipment by making time study of job calculating the loading time, travel time, delaying time etc.

In assessing the annual production of the equipment, it is necessary to estimate the number of days at work that can be done at site, or the total number of hours that can be achieved in a year. As an average figure, 150 – 200 days per year of production workdays per equipment may be assumed. However, the annual production days will vary from projects to projects on account of climatic conditions. Annual working days for the equipment's used in bituminous work will be shortened by more days for working season constraints.In construction, some tasks are labour-intensive, some pre-dominantly employ equipment and some use a combination of both, i.e., labour and equipment. In big infrastructure projects like highway projects, equipment's and the plants play a crucial role in the production process. It becomes important to educate the labours and supervisors to look at equipment productivity as matter of prime importance.

1.4 EQUIPMENT'S UNDER ANALYSIS

1. **Vibratory Roller**
2. **Hydraulic Excavator**
3. **Bitumen Sprayer**

1. Vibratory Roller

The vibratory rollers (both single and dual drum models) generate three types of compactive forces:
a. Pressure
b. Impact &
c. Vibration
Factors Affecting Roller Efficiency

The major factors that control the productive capacity of the (vibratory) roller are the site and job conditions (job factors) in which the work is being done. The factors are as follows:

- Moisture Content of the Soil
- Lift Thickness of the Soil (or Metal) Layers
- Number of Passes By the Roller
- Amplitude and Frequency of the Vibration
- Travel (Operating) Speed

Production Estimation

The conventional way of measuring the production of the vibratory roller is based on the roller speed, lift thickness and effective width of compaction. The accuracy of the result obtained would depend on the accuracy of speed and lift thickness. Trial operation is advised to determine the production of a particular type of soil (or metal).

Production (cum / hr) = (W x S x L x E) / P
Where,

P = Number of passes required
W = Width compacted per pass (m.)
S = Roller speed (kmph)
L = Compacted lift thickness (mm)
E = Job efficiency

2. Hydraulic Excavator

An excavator can be defined as a power driven digging machine. In 1836, William S. Otis developed a machine that duplicated the motion of a worker digging with a hand shovel. From this machine, evolved a family of cable operated construction machines known as *crane shovels*. Members of this family include shovel, dragline, hoes and clamshell. Later, with the advent of technology, the cable-operated equipments have mostly been replaced by their hydraulic (hydraulically powered) counterparts. In industry, today, the hydraulic excavators are used as the most versatile equipment in the jobs of excavating and lifting. In the construction of highways, hydraulic excavator of this family is the most widely used equipment at site.

The main advantages of the modern hydraulic excavators over the cable-operated old ones are:

- Faster cycle time
- Higher bucket penetrating force
- More precise digging
- Easier operator control

Factors Controlling the Production

a. Job Factors
- Class of material
- Height of cut
- Angle of swing

b. Management Factors
- Condition of the excavator
- Haul-unit exchange
- Size of hauling unit
- Cleanup loading area
- Operator's mental state & efficiency
- Ergonomics

Production Estimation

The basic production formula for excavator is given by:
Production = Materials carried per load x cycles per hour
Elaborating the formula and considering different factors affecting the production, it can be represented by the following expression.

Production = C x S x V x B x E x {1 / (1 + W)}

Where,
C = cycles/hr.
S = swing-depth factor
V = heaped bucket volume
B = bucket fill factor
E = job efficiency
W = swell factor

3. Bitumen Sprayer

Bitumen Sprayer / Distributor is used to apply prime coat, tack coat or a seal coat. It is used in all types of bituminous constructions. The bitumen sprayer is used mainly to provide a uniform rate of coating on to the exposed surface at a steady speed. The asphalt distributors have insulated tanks for maintaining the equipment temperature and are equipped with burners for heating the bitumen to proper application temperature. The heater and the pump are the key instruments and should be well maintained. All gages and measuring devices such as the pump tachometer, measuring stick, thermometer and bitumeter are calibrated prior to the work.

Factors Affecting Bitumen Sprayer Productivity

The production rate of the bitumen sprayer / distributor is affected by the following factors, viz.

- Asphalt Spraying Temperature
- The Liquid Pressure Across Spray Bar Length
- Angle of the Spray Nozzle
- The Nozzle Height Above the Surface
- The Distributor Speed

Production Estimation

The rate of distribution of a bitumen sprayer is usually calculated as the surface area covered (coated with bitumen) per unit of time (hr). It can be calculated from the following equation,

Production (sq. m. / hr) = S x W x T x 1000

Where,
L = Speed of bitumen sprayer (kmph)
W = Width coverage of the sprayer nozzle (m)
T = Time factor (actual minutes of spray in a hour of production)

The main objective of this paper was to measure the Equipment's productivity of a Road project; finding out the factors affecting the productivity of the Equipment's; establishing interrelations of the factors and finally formulation of a system to estimate the productivity of the Equipment's in different environmental and site conditions. For this thesis, relevant data was collected from selected Road project sites of PWP AND IWTD, Chikodi & Panchayat Raj Engineering Department, Chikodi.

During the site visit of Panchayat Raj Engineering Department, relevant data regarding the expenses and production rates of different Equipment's used in the sites was collected. After collecting the data, different factors affecting the production rate of those Equipment's was identified and their effects on the production were found out. Collected data were put under a detailed study. The factors that are expected to be influencing the equipment production rate are geographical factors like height of construction, topography etc, environmental conditions, materials of construction, nature of activity, operator's efficiency etc. On the other hand, the human resource productivity was likely to be affected by working and living conditions, social-economic factors etc.

After studying and analysing the PWD & IWTD work, Ankali Equipment's productivity it was found that the Productivity of the Equipment's was way below the Budgeted Productivity.

For the second Road Work of Examba (PRED, Chikodi) measures were taken to improve the Equipment's

productivity by efficient planning and scheduling of the work by previous experience. Operators and supervisors were educated and motivated to work efficiently.

At last, a comparison of Equipment's productivity between the Panchayat Raj Engineering Department Examba work and PWD & IWTD at Ankali work is established and it is observed that the Examba Road Work of PRED Dept. achieved better Equipment productivity than the PWD & IWTD work at Ankali, as a result of this significant equipment costs were reduced.

2. PRODUCTIVITY DATA ANALYSIS AND INTERPRETATIONS

In case of finding the productivity of a particular activity, stress has been given to determine the production rate of the important and driving equipment's.

2.1 PRODUCTIVITY OF EQUIPMENT'S AT ANKALI WORK

1. Roller

a. Performance of Rollers

Roller under analysis**:**
Model: 1107 EX; **Make:** CASE;
Budgeted Productivity: 50.16 cum/hr.

Table -1: Performance of Vibratory Roller of Ankali Road work

Roller Model	1107 EX
Availability (%)	85 %
Utility (%)	28 %
Net Production (cum/hr)	2.76
Effective Production (cum/hr)	9.69

Observation on Performances

- The net production rate of roller is 2.76 cum/hr and performs quite below the trend (only production hours considered for calculation).
- The average effective production (production quantity / actual deployment hours) of the roller is found to be 9.69 cum/hr. So, the production rate of the Roller is expected to vary in the range from 9 cum/hr to 10 cum/hr under the same conditions. The variation in the production rate can be attributed to the variability in the job conditions, weather condition and variability in the nature of the job.
- The utility of the rollers is expected to vary from 28 % to 30 %, which is quite low with the current management planning procedures.

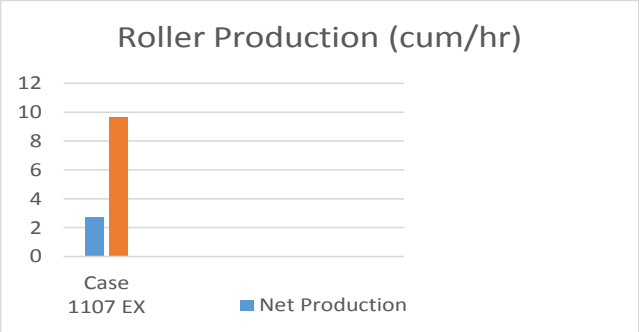

Chart -1: Performance Comparison of Rollers at Ankali Road work

b. Cost Component of Rollers

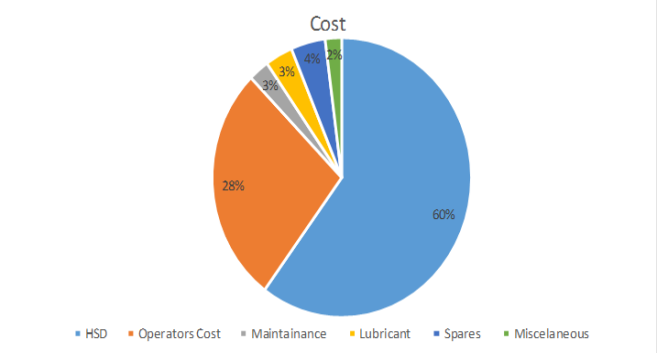

Chart -2: Cost Break-up Roller at Ankali Road work

Observations on Cost Components

- The major cost components of the rollers remain the HSD cost, which varies from 55 to 65 percent of the total cost. On average over all the rollers, the HSD cost amounts to 60%, lubricants 3% & spares 4% while the operators' cost is about 28% of the total cost.

c. Seasonal Variation

Observations on Seasonal Variation

- The cost of production goes down in the months of July and August due to the arrival of monsoon and starts picking up again in September.
- The cost of production reaches the peak at the month of November and December.

2. Hydraulic Excavator

a. Performance of Excavators

Excavator under analysis**:**
Model: M320 D2; **Make:** Caterpillar; **Budgeted Productivity: 28.6** cum/hr.

Table -2: Performance of Excavator at Ankali Road work

Model	M320 D2
Shift Hr.	504
Maintenance Hr.	15
Breakdown Hr.	12
Available Hr.	152
Working Hr.	152
Non Production Hr.	152
Availability (%)	90
Utility (%)	30
Net Production	2.76 cum/hr.
Effective Production	9.18 cum/hr.

Table -3: Performance of Bitumen Sprayer at Ankali Road work

Available Hrs.	144
Maintenance Hrs.	5
Breakdown Hrs.	0
Working Hrs.	48
Idle Hrs.	96
Total Quantity (Sqm)	18620
Production Hrs.	48
Production Rate (MT / Hrs.)	389 sqm/hr.

b. Cost Components of the Excavator

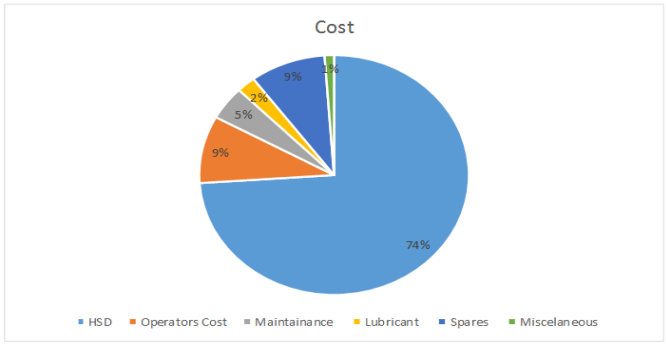

Chart -3: Cost Break-up of Different Excavators at Ankali Road work

Observations on Cost of Performances

- From the performance log of excavator at the Road Site, it is seen that HSD constitute the major cost of the production.
- The Spares and the Cost of operation of the equipment has almost the same percentage of the total cost of production.
- The average percentage of the HSD to total cost of production is 73.92%. Operation cost and Spares have almost the same percentage at around 9%. Lubrication and Maintenance cost takes up the rest of the total cost of production.

c. Seasonal Variations

Observations on Seasonal Variation

- From the seasonal variation graph of the HSD Cost, the HSD cost tends to fall from the July upto October. This is due to the monsoon season, as the equipment might not be used during this period.
- As for the seasonal variation of the total Cost, there is no downfall in the total cost trend during the monsoon period. This is due to the increased in the spending on Spares, General Stores and Maintenance Cost of the equipment.
- During the normal working season of the excavator, the total cost and the HSD cost followed almost the same trend.

3. Bitumen Sprayer

a. Performance of Bitumen Sprayer

Bitumen Sprayer under analysis
Make/Type of Plant: Gujarat/Apollo/Tractor
Mounted Capacity: 1.5 Tonne

b. Cost Components of the Bitumen Sprayer

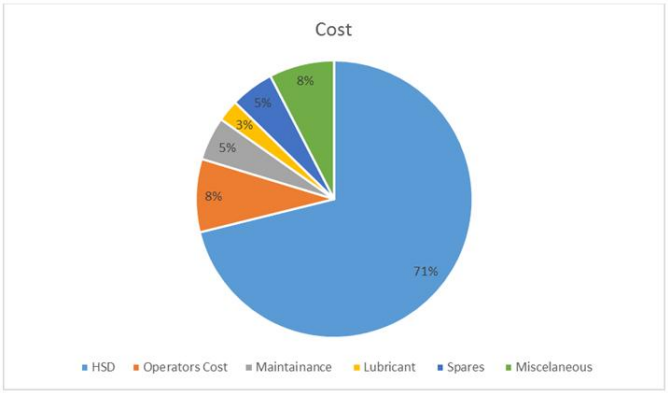

Chart -4: Cost Break-up of O & M of Bitumen Sprayer for Production

Observation on Cost Break-Up of O & M for Production

- The major components of cost O & M for production are energy cost with 49% and aggregate feeding cost with 45% contribution respectively.
- The other cost of O & M for production include spare (3%), Stores cost (2%) and lubricant cost (1%).

2.2 PRODUCTIVITY OF EQUIPMENT'S AT EXAMBA WORK

1. Roller

a. Performance of Rollers

Roller under analysis:
Model: 1107 EX; **Make:** CASE;
Budgeted Productivity: 50.16 cum/hr.

Table -4: Performance of Vibratory Roller of Examba Road work

Roller Model	1107 EX
Availability (%)	100 %
Utility (%)	33 %
Net Production (cum/hr)	6.48
Effective Production (cum/hr)	19.44

Observation on Performances

- The net production rate of roller is 6.48 cum/hr and performs quite below the trend (only production hours considered for calculation).
- The average effective production (production quantity / actual deployment hours) of the roller is found to be 19.44 cum/hr. So, the production rate of the Roller is expected to vary in the range from 19 cum/hr to 20 cum/hr under the same conditions. The variation in the production rate can be attributed to the variability in the job conditions, weather condition and variability in the nature of the job.
- The utility of the rollers is expected to vary from 32 % to 34 %, which is improved compared to Ankali work with the current management planning procedures.

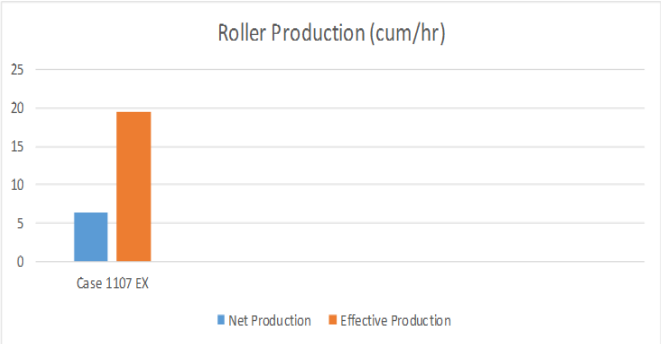

Chart -5: Performance Comparison of Rollers at Examba Road work

b. Cost Component of Rollers

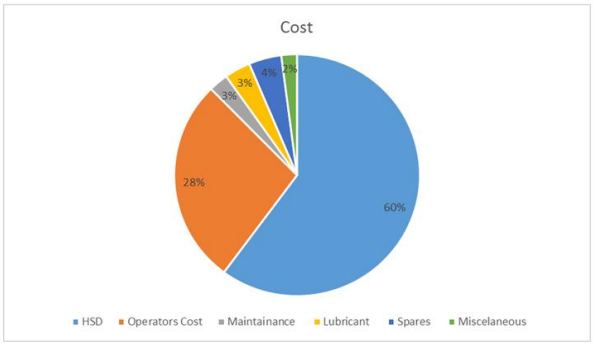

Chart -6: Cost Break-up Roller at Examba Road work

Observations on Cost Components

- The major cost components of the rollers remain the HSD cost, which varies from 55 to 65 percent of the total cost. On average over all the rollers, the HSD cost amounts to 60%, lubricants 3% & spares 4% while the operators' cost is about 28% of the total cost.

c. Seasonal Variation

Observations on Seasonal Variation

- The cost of production goes down in the months of July and August due to the arrival of monsoon and starts picking up again in September.
- The cost of production reaches the peak at the month of November and December.

2. Hydraulic Excavator

a. Performance of Excavators

Excavator under analysis:
Model: M320 D2; **Make:** Caterpillar;
Budgeted Productivity: 28.6 cum/hr.

Table -5: Performance of Excavator at Examba Road work

Model	M320 D2
Shift Hr.	768
Maintenance Hr.	10
Breakdown Hr.	04
Available Hr.	754
Working Hr.	320
Non Production Hr.	434
Availability (%)	100
Utility (%)	41.66
Net Production	6.48
Effective Production	19

b. Cost Components of the Excavator

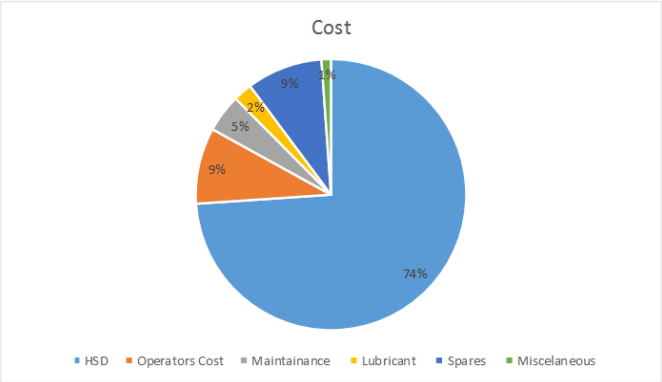

Chart -7: Cost Break-up different Excavators at Examba Road work

Observations on Cost of Performances

- From the performance log of excavator at the Road Site, it is seen that HSD constitute the major cost of the production.
- The Spares and the Cost of operation of the equipment has almost the same percentage of the total cost of production.
- The average percentage of the HSD to total cost of production is 73.92%. Operation cost and Spares have almost the same percentage at around 9%. Lubrication and Maintenance cost takes up the rest of the total cost of production.

c. Seasonal Variations

Observations on Seasonal Variation

- From the seasonal variation graph of the HSD Cost, the HSD cost tends to fall from the July upto October. This is due to the monsoon season, as the equipment might not be used during this period.
- As for the seasonal variation of the total Cost, there is no downfall in the total cost trend during the monsoon period. This is due to the increased in the spending on Spares, General Stores and Maintenance Cost of the equipment.
- During the normal working season of the excavator, the total cost and the HSD cost followed almost the same trend.

3. Bitumen Sprayer

a. Performance of Bitumen Sprayer

Bitumen Sprayer under analysis:
Make/Type of Plant: Gujarat/Apollo/Tractor Mounted
Capacity: 1.5 Tonne.

Table -6: Performance of Bitumen Sprayer at Examba Road work

Available Hrs.	480
Maintenance Hrs.	5
Breakdown Hrs.	0
Working Hrs.	100
Idle Hrs.	375
Total Quantity (Sqm)	18600
Production Rate (Sqm / Hrs.)	310

b. Cost Components of the Bitumen Sprayer

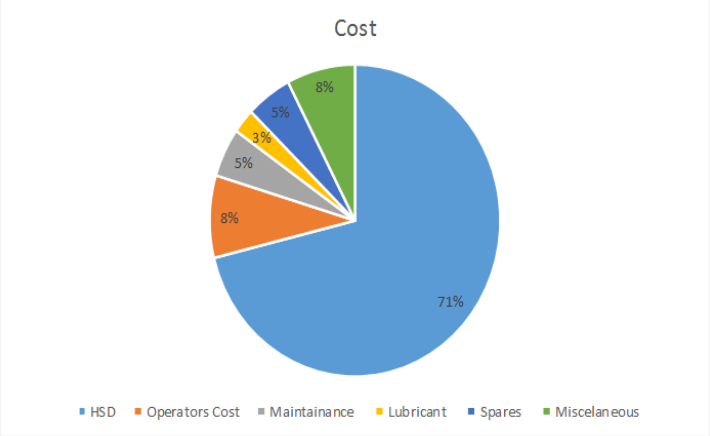

Chart -7: Cost Break-up of O & M for Production

Observation on Cost Break-Up of O & M for Production

- The major components of cost O & M for production are energy cost with 49% and aggregate feeding cost with 45% contribution respectively.
- The other cost of O & M for production include spare (3%), Stores cost (2%) and lubricant cost (1%).

Table-7: Total Equipment Cost – Budgeted and Incurred Cost

SL. NO.	EQUIPMENT	BUDGETED COST (Rs.)	INCURRED COST (Rs.)
1	Roller	1,41,120	1,52,409
2	Hydraulic Excavator	1,22,304	1,32,088
3	Tipper	2,06,080	2,22,566
4	Bitumen Sprayer	56,000	60,480
5	Hot Mix Plant	4,03,200	4,35,456

Total Budgeted Cost- Rs. 9,28,704 /-
Incurred Cost- Rs. 10,02,519 /-
Percentage Increase in Cost- 7.39 %

2.3 MICROSOFT PROJECT SOFTWARE

In this project, Microsoft Project software is used for planning and scheduling of the project undertaken. A calendar is created and assigned to the project. It shows the work timings and the working as well as non-working days. Duration required for each task is fed which gives the total duration required for project completion as an output. By assigning task relationships, critical activities are obtained. Different resources are applied according to their work profile. These resources are allocated based on the quantity of work, unit rate for resources are assigned and the total amount for each work is obtained.

Microsoft Project is a contemporary tool for Project Management that assists in overcoming the hindrances faced owed to the traditional approach. It promotes optimum and efficient grouping of activities which provides a vision to finish the project according to the scheduled duration and within the budget.

It is a project managing software which is developed and traded by Microsoft. It is designed to help the project manager in planning, allocating resources to tasks, tracing progress, managing expenses and analysing the workloads. Project generates budgets upon the work assignment and cost of resources. As the resources are allotted to the task, the software determines the cost which is equal to the work times the rate, which moves up to the task level, then to the summary task level and lastly to project level.

Resources are well-defined (Work, Material and Cost), they are shared among projects via a shared resource option. Each individual resource can have its own peculiar calendar, which outlines resource work time. Resource assignment costs are obtained using resource rates. Single resource can be allocated to several tasks in various projects also every task can be given abundant resources.

Execution of the scheduled works depending on the availability of resource as defined already in resource calendar.

The software crafts a critical path. Resource can be levelled and Gantt chart depicts the task linkages. Furthermore, Microsoft Project identifies deviating classes of users. These users of different classes can have different levels access to projects, views and other data. Personalisation of facets in Microsoft Project like views, calendars, filters, tables and fields are stored in a global enterprise which can be accessed by all the users.

2.3.1 FEATURES OF MICROSOFT PROJECT SOFTWARE

Following are the features of the software:

1. Tracking of the project.
2. Tasks can be linked to costs.
3. Report generation.
4. Create baselines.
5. It is an industry standard tool.

2.3.2 BENEFITS OF MICROSOFT PROJECT SOFTWARE

Microsoft Project is an established, valued, and robust Project Management software. The following are its advantages:

1. This software helps in dramatically improving project productivity.
2. Detailed scheduling can be attained. Projects can be updated for any changes occurring in the tasks or resources after scheduling has been done.
3. Cost control and management.
4. Resource allocation.
5. Quality management.
6. Tracking the progress and critical path.

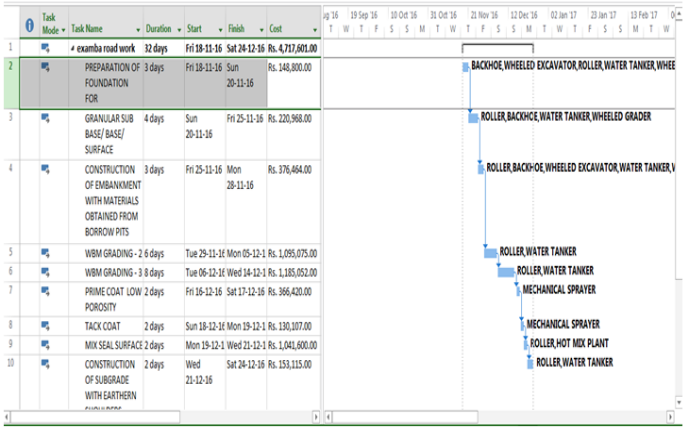

Fig -1: Screenshot of MS Project Task Sheet and Gantt Chart

3 RESULTS AND DISCUSSIONS

It includes the comparison of Productivity of the Equipment's at Ankali Road work and Examba Road work. The improved Productivity of Equipment's at Examba Road work is discussed here.

a. Performance comparison of Equipment's at Ankali and Examba Road work

1. Roller

The results of the Productivity are given table site wise and a comparative graph is plotted for better understanding.

Table-8: Performance of Vibratory Roller of Ankali Road work

Roller Model	1107 EX
Availability (%)	85 %
Utility (%)	28 %
Net Production (cum/hr)	2.76
Effective Production (cum/hr)	9.69

Table-9: Performance of Vibratory Roller of Examba Road work

Roller Model	1107 EX
Availability (%)	100 %
Utility (%)	33 %
Net Production (cum/hr)	6.48
Effective Production (cum/hr)	19.44

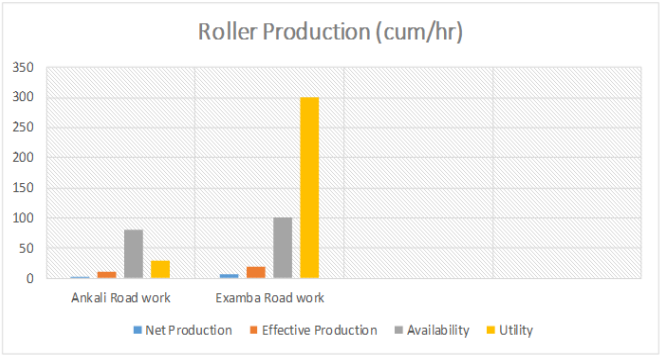

Chart -9: Graphical representation and comparison of the results achieved

It is observed that the Productivity of Examba Road Work is increased with the help of Efficient Planning and Scheduling with the help of MS Project software, increasing the working hours in a day, motivating the operators and timely maintenance of the Equipment's.

2. Hydraulic Excavator

The results of the Productivity are given table site wise and a comparative graph is plotted for better understanding.

Table-10: Performance of Excavator at Ankali Road work

Model	M320 D2
Shift Hr.	504
Maintenance Hr.	15
Breakdown Hr.	12
Available Hr.	152
Working Hr.	152
Non Production Hr.	152
Availability (%)	90
Utility (%)	30
Net Production	2.76 cum/hr.
Effective Production	9.18 cum/hr.

Table-11: Performance of Excavator at Examba Road work

Model	M320 D2
Shift Hr.	768
Maintenance Hr.	10
Breakdown Hr.	04
Available Hr.	754
Working Hr.	320
Non Production Hr.	434
Availability (%)	100
Utility (%)	41.66
Net Production	6.48
Effective Production	19

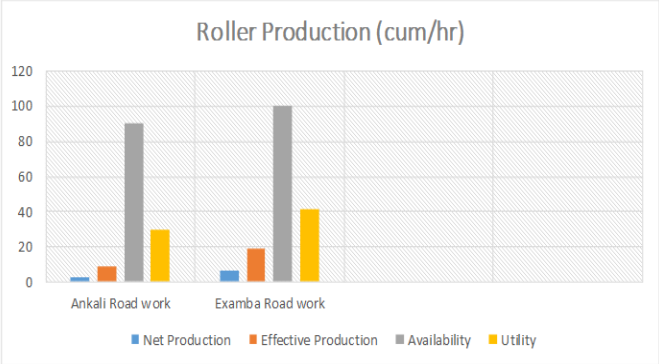

Chart -10: Graphical representation and comparison of the results achieved

It is observed that the Productivity of Examba Road Work is increased with the help of Efficient Planning and Scheduling with the help of MS Project software, increasing the working hours in a day, motivating the operators and timely maintenance of the Equipment's.

3. Bitumen Sprayer

The results of the Productivity are given table site wise and a comparative graph is plotted for better understanding.

Table-12: Performance of Bitumen Sprayer at Ankali Road work

Available Hrs.	480
Maintenance Hrs.	5
Breakdown Hrs.	0
Working Hrs.	100
Idle Hrs.	375
Total Quantity (Sq.m)	18600
Production Rate (Sq.m / Hrs.)	310

Table-13: Performance of Bitumen Sprayer at Examba Road work

Available Hrs.	144
Maintenance Hrs.	5
Breakdown Hrs.	0
Working Hrs.	48
Idle Hrs.	96
Total Quantity (Sqm)	18620
Production Hrs.	48
Production Rate (MT / Hrs.)	280 sqm/hr.

It is observed that the Productivity of Examba Road Work for Bitumen sprayer is increased with the help of Efficient Planning and Scheduling with the help of MS Project software, increasing the working hours in a day, motivating the operators and timely maintenance of the Equipment's.

b. Cost comparison of Equipment's at Ankali and Examba Road work

At Ankali Road Work, equipment's were deployed as per the conventional method i.e. without Scheduling and Planning. Due to lack of Planning and Scheduling, Operators of Equipment's and Supervisors were less motivated and had no idea of Productivity of Equipment, which led to increase in time of Task which in turn escalated the Costs by 26.45%. At Examba Road Work, Equipment's were deployed by proper Planning and Scheduling of Tasks and by motivating the Operators and Supervisors. Productivity of the Equipment's was given priority and instructions were given to complete the Task for the day.

This led to increase in Productivity at Examba work and in turn decreased the Cost Escalation of Equipment's by 19.06% compared to Ankali work.

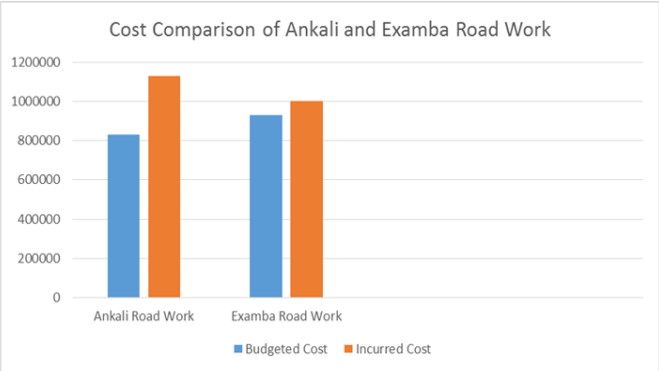

Chart -11: Cost Comparison of Ankali and Examba work

ANKALI ROAD WORK:

Total budgeted cost- Rs. 8,29,200 /-
Incurred cost- Rs. 11,27,500 /-
Percentage increase in Cost- 26.45 %

EXAMBA ROAD WORK:

Total budgeted cost- Rs. 9,28,704 /-
Incurred cost- Rs. 10,02,519 /-
Percentage increase in Cost- 7.39 %

4 CONCLUSIONS

The visits to different Road project sites and study of the available data in the Road sites reveal that the Construction Companies in India have not realised the necessity of study of their own equipment's.

The problem of not maintaining proper database is partially attributed to temporary and ephemeral nature of the job, which brings unwillingness to the site management to keep proper and detailed record and database for further analysis. In the process, the company loses its opportunity to examine its own strengths and weaknesses. This attitude of lack of concern about self-improvement among the big companies has further been enhanced due to absence of too many equally competitive competitors.

The companies should not only concentrate on activity oriented planning, but also at the same time should plan the mobilization and usage of the equipment's well before the execution work is started.

Project management plays a key role in making a project successful. This work mainly deals with improving Productivity of the Equipment's used for the Road work and Planning and Scheduling the work using MS Project software.

The following conclusions can be drawn from the work carried. They are:

1. Study and use of proper equipment for a particular job is of prime importance.
2. A database of Equipment's Productivity for every site must be maintained and studied.
3. It was observed that the Productivity of Ankali Road Work was low because of improper planning and scheduling.
4. Use of Project Management software's like MS Project play a vital role in improving the Productivity of tasks by proper Planning and Scheduling of Projects.
5. It was observed that, use of MS Project software and Management techniques for Examba Road Work helped in reduction of excess Costs of Equipment's by 19.06% compared to that of Ankali Road Work.

5 FUTURE SCOPE

1. A study of all equipment's can be carried out for achieving higher efficiency.
2. A study with respect to material management for Road work can be carried.
3. A study on Optimum utilisation of Human Resource which is major resource in Road work can be carried.
4. Productivity analysis considering all the variables can be studied.
5. Study of effect of training, experience, age and ergonomics on the operator's performance and productivity.

REFERENCES

[1] Abramson, Robert, Halset, Walter, "Planning for improved enterprise performance – A guide for mangers and Consultants", ILO, Geneva, 1979.

[2] Barnes, Ralph M., "Motion and Time Study", New York, John Willey & Sons Inc., 1961.

[3] Chitkara, K K., "Construction Project Management", Tata McGraw Hill, New Delhi, 2004.

[4] Drewin, F J, "Construction Productivity", Elsevier Science, New York, 1982.

[5] Horner, Malcolm. Duff, Roy. MORE for LESS: A Contractor's Guide to Improving Productivity in Construction.

[6] Julian E. and Daniel Quinn Mills, "The Construction Industry", Lexington Books, 1979.

[7] McCullough, David, "The Path Between the Seas", Simon and Schuster, 1977.

[8] Nunnaly S.W, "Construction Methods and Management", Pearson Prentice Hall, New Jersey, 2004.

[9] Peurifoy Robert L, Schexnayder C.J, "Construction Planning, Equipment & Methodology ", Tata Mc Graw Hill, New Delhi, 2003.

[10] Prokopenda, Joseph. "Productivity Management – A practical Handbook", ILO, Geneva, 1992.

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