Evaluation of Bitumen Paver & HMP Performance for a Highway Project

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Abstract: -
Highway construction equipment is one of the major and reliable segments of national economy. The effective use of labour, materials, and equipment must be strongly pursued through good project management in highway construction. Construction technology has undergone radical development in recent decades because to the employment of new equipments and creative techniques. The productivity of a project on the job site is frequently influenced by the choice of the appropriate kind and size of construction equipment. Therefore, it is crucial that site managers and construction planners are aware about the main categories of equipment that are employed in construction the most. The approach used in the article to calculate the operational productivity and cost of asphalt pavers takes into account technical factors and working conditions, which improves the accuracy of decisions regarding the organisation and management of highway maintenance activities on Chikhali-Tarsod NH-6.

Keywords:- *Construction, Highway, Performance, Utilization, India.*

1. Introduction

The efficient utilization of construction equipment is crucial to the economy's construction industry. Equipment is therefore one of the most important factors impacting the development of abilities to conduct the project effectively and productively. A significant amount of work may be finished in less time and more successfully within the project timeline by improving equipment utilization. An engineer or site supervisor must have thorough awareness of the equipment's availability in order to guide it to a specific task and ensure the successful completion of any project. The efficiency with which the task is completed has a significant impact on the project's overall progress. As a result, choosing the appropriate equipment requires taking into account all aspects of the project site's operational environment. To use equipment successfully at the lowest cost and with the most productivity, it is crucial to provide the right selection, planning, and management of equipment.

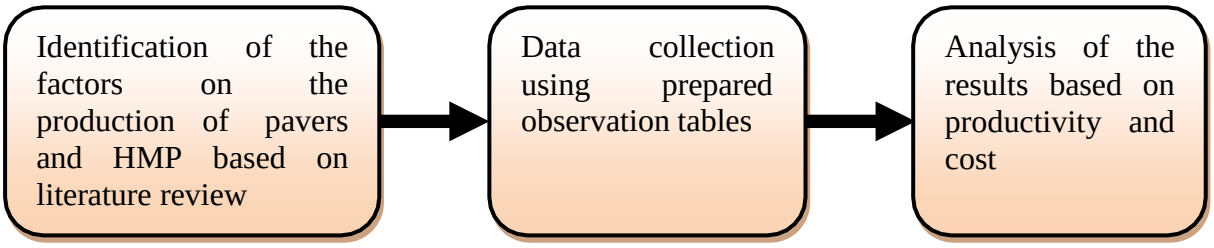
One of the most important and reliable subsectors of the national economy is highway construction machinery. Highway construction, maintenance, and repair are all done with the use of road construction equipment. A complex of high-performance mechanisms and machines, both large and small in capacity and productivity, make up the modern road and building machinery system. The development of road construction machinery is significantly impacted by the growth of the network of paved roads on both the federal and local levels, the use of resource-saving technologies, an increase in the pace and quality of work, and the assurance of the dependability and durability of highways. The complexity of foreign road and construction equipment raises difficult demands for adherence to global safety and

environmental standards, improving equipment mobility, broadening its useful application regions, and, ultimately, boosting its capacity and productivity.

Even though equipment is a necessary for each construction project, significant study is still needed to increase the accuracy of pre-estimations for productivity and equipment-related expenses. The objective of this research paper is to evaluate the productivity and cost of various bitumen paver & HMP among others highway construction equipments.

2. RESEARCH METHODOLOGY

The information required for the research was gathered from the ongoing NH-6 Chikhali-Tarsod highway construction projects in India. Technical specifications of equipment, various costs were collected from equipment owners using these sites and retailers of construction equipment. By observing the equipment used in the Chikhali-Tarsod highway construction project, data regarding the calculation of the productivity of various items of machinery, including the paver parameter, disruption speed, insulation of the drum, hauling speed of the bulldozer, hoe capacity of the paver, etc., were gathered. Productivity and various costs were evaluated by appropriate methods, which are presented in this paper with appropriate results.



3. DATA COLLECTION

The case study of National Highway NH-6 (Package -IIA) is chosen for data collection. The project highway's Package-IIA begins in Chikhali in Buldhana district and runs for 62.7 km, from kilometre 360.000 to km 422.700. The project will be carried out by the National Highway Authority of India in the State of Maharashtra using hybrid annuities (DBOT annuities) (NHAI). This study reveals the situation of equipment management at the moment.

The process of constructing bituminous pavement and the operation of asphalt pavers and hot mix plants are thoroughly investigated, and further productivity such as quantity of asphalt produced by plants, average speed of paver to be evaluated and cost analysis, such as values for landed cost, ownership cost, operating cost, maintenance cost, and so on, are gathered from equipment working on project sites and construction equipment sellers. The data mentioned above was gathered between 2020 and 2021.


Bitumen Paver **Hot Mix Plant**

Figure No.01 Details of equipment work on site

4. RESULT ANALYSIS

One resource, known as a dynamic resource, is often assigned to each activity in highway projects. The equipment's performance determines the project's overall productivity, and the final output is what the resource produces. This section offers a result analysis for production (Theoretical output, Effective production/Practical output & Net Production) & cost based on variables impacting the production of two pieces of equipment, Bitumen Paver & HMP.

4.1 Factors Affecting the Production of Bitumen Pavers:

Several aspects are influenced by the settlement's depth;

i. Mix parameters:

- ✓ Heat (hot mixing is easy)
- ✓ Grain size (very simple mix deform)
- ✓ Gradation Curve (well-organized mixes are easily disabled)
- ✓ Stiffness (solid mixing is easily disabled)

ii. Paving Parameter:

- ✓ Layer thickness (bed thickness, depth cover)
- ✓ Paving Width (more extension, custom depth)
- ✓ Ambient Temperature (hot day, drain)
- ✓ Object head (lower object), deepen
- ✓ Stopping length (longer the stop, deeper the dent)

iii. Paver Parameter:

- ✓ Speed (acceleration, maximum stay)
- ✓ Disruption of magnitude (increase in magnitude, decrease in concentration)
- ✓ Disruption speed (acceleration, deceleration)
- ✓ Screed Setting (raises attack angle, maximum stay)

4.2 Factors Affecting HMP Production Rate:

i. Aggregates with Moisture Content:

The preparation, creation, and fuel usage of the hot mix plant are all significantly influenced by the moisture level of the aggregates. If the moisture content is really high, say 8–10%, the aggregates shouldn't fall out of flights in a uniform veil and won't be heated evenly and effectively. Therefore, as moisture content rises, output declines and fuel usage rise as well.

ii. The Mix's Dust Content:

Because more surface area needs to be covered with bitumen, which takes longer time to mix, production drops as dust content in the mixture rises.

iii. Altitude

Every 300 metres above sea level, the plant's production decreases by around 3.5%. This issue should also be taken into consideration while determining the need for the plant in a particular location.

iv. Drum Insulation

By maintaining a 60°C temperature differential between the drum's outer and inner shells, the plant's production may be enhanced by 2.5% while its fuel consumption is cut by 4%. To prevent heat losses, the drum shell should be coated with aluminum or insulated with glass wool. When all conditions are favorable, including the quality of the aggregate, the climate and weather, the status of the mixing plant, and the following additional parameters, an asphalt mixing plant will produce at its maximum capacity;

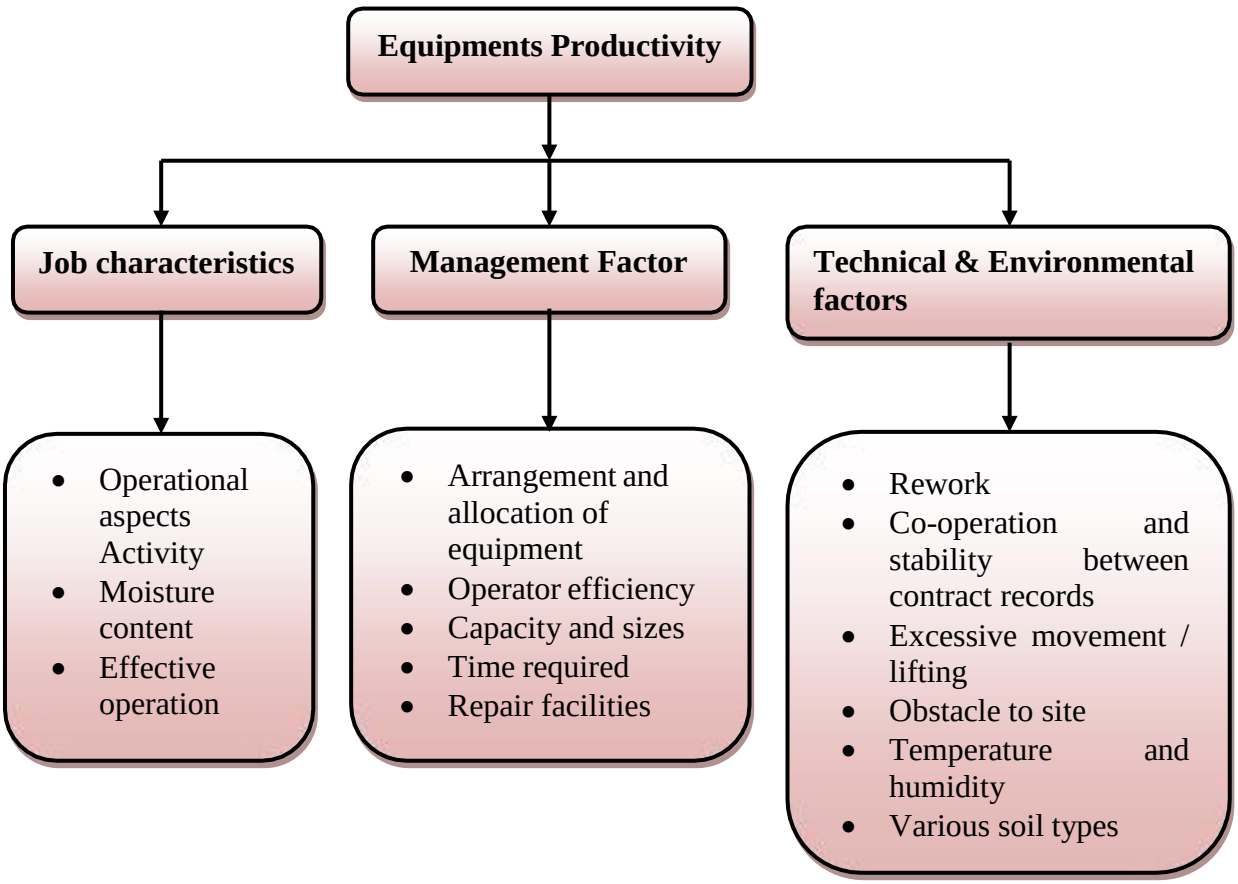


Figure No. 1 Factors Affecting Equipments Productivity

4.3 Performance of Bitumen Paver and its efficiency

Efficiency of Bitumen Paver is usually expressed as a percentage of the actual output to the expected output (it is a ratio of input to output). Equipment capacity utilization, on the

other hand, is a compute of how well an organization uses its productive capacity. It's the relationship between theoretical maximum output and the actual/practical production output.

The amount of material moving through the paver in a given period will increase with increasing thickness, breadth, and paving speed, and vice versa. For a particular width and thickness of mat, the production needed per hour may be quickly calculated using the formulas below.

Production (cum / hr.) = (L x W x T x S)

Where, L = Length of Road in m
W = Width of Road in m
T = Thickness of Asphalt in mm
S = Working Speed in m/hours

$$\textbf{Output efficiency of the Paver} = \frac{\textbf{Average output per hour x 100}}{\textbf{Theoretical Output per hour}}$$

Table No. 4.3.1: - Showing Monthly Performance of Bitumen Paver

Sr. No.	Month & Year	Theoretical Output (m3/hr.)	Effective Production / Practical Output (m3/hr.)	Avg. Effective Production / Practical Output (m3/hr.)	Net Production m3/hr.	Output Efficiency of Equipment in %	Average Output Efficiency of Equipment in %
1	20-Oct	90	32.4	**27.65**	12.96	**36**	**30.72**
2	20-Nov	90	15.58	**20.25**	3.0	**17.31**	**22.5**
3	20-Dec	90	21.81	**30.84**	5.87	**24.23**	**34.27**
4	21-Jan	90	14.95	**34.58**	2.76	**16.62**	**38.42**
5	21-Feb	90	14.02	**21.57**	2.43	**15.58**	**23.97**
6	21-Mar	90	37.07	**38.86**	16.97	**41.19**	**43.18**
7	21-Apr	90	19.47	**21.03**	4.68	**21.63**	**23.37**
8	21-May	90	19.63	**20.09**	4.76	**21.81**	**22.33**

The theoretical Output for Bitumen Paver is 90 m3/hr. The net Bitumen Paver output rates from October 2020 to May 2021 vary from 4.98 m3/hr. to 18.65 m3/hr. The effective production range of the bitumen paver is 38.86 m3/hr, with a typical deviation of 20.09 m3/hr. Efficiency for Bitumen Pavers varies from 22.33% to 43.18%.

The volatility in production rate may be caused by a variety of factors, including changes in the task's requirements, maintenance requirements, weather, and paving standards. It is a well-known fact that there is a strong interdependence between the various phases of a road project. As we can see from the report's aforementioned part, the excavator's performance has declined and was already subpar, which served as a barrier to the bitumen paver's subsequent stage not functioning on a greater scale (range).

Table No. 4.3.2: - Showing Total Average Equipment Cost Components of Bitumen Paver in Rs.

Sr. No.	Cost in Rs.	Month & Year							
		20-Oct	20-Nov	20-Dec	21-Jan	21-Feb	21-Mar	21-Apr	21-May
1	Landed cost	114767.12	42027.3973	64010.9589	71769.863	75002.7397	161320.548	87287.6712	83408.2192
2	Ownership Cost	1884382.2	651787.545	917345.603	947127.005	909179.852	1680303.46	773453.78	688735.647
3	Operating Cost	190917.47	70163.8889	106483.548	119390.645	126205.238	268360.054	145725	138751.29
4	Maintenance Cost in Rs.	26685	278000	45334.75	40229	33345	179228	5370	10920
Total Equipment Cost		2216751.8	1041978.83	1133174.86	1178516.51	1143732.83	2289212.07	1011836.45	921815.156

The ownership expenses for the two bitumen pavers at the NH-6 project account for the majority of the cost of performance. These costs vary from Rs. 7,73,453.77 to Rs. 18,84,382.23/-, with an average of Rs. 10,56,539.39/- for the bitumen paver's ongoing work. The running cost of the bitumen paver, with an average of Rs. 1,45,749.64 and a range of Rs. 70,163.89 to Rs. 2,68,360.05, is the second highest contribution to the cost of performance. Other expenses include maintenance expenditures, which vary from Rs. 5370.00 to Rs. 2,78,000.00 and average Rs. 77,388.97, as well as landing charges, which range from Rs. 42,027.40 to Rs. 161320.55 and average Rs. 87449.32. Costs show a significant fluctuation between March 2021 and May 2021.

4.4 Performance of Hot Mix Plant and its efficiency:

Trucks deliver hot mix asphalt to the paving location from a central plant. In order to constantly mix, heat, and combine aggregates and asphalt cement to generate asphalt concrete, a high-tech complex of equipment is called an asphalt factory. An HMP's production procedure is.

$$\textbf{Production (cum / hr.)} = \textbf{(N x C x T) / t}$$

Where, N = No. of trucks
C = Capacity of trucks unit m3
T = No. of Trips per trucks units
t = Effective Production Hours

$$\textbf{Output efficiency of the plant} = \frac{\textbf{Avg. output per hrs. x 100}}{\textbf{Capacity of the Ideal Production Plant}}$$

Table No. 4.4.1: - Showing Monthly Performance of Hot Mix Plant

Sr. No.	Month & Year	Theoretical Output (m3/hr.)	Effective Production / Practical Output (m3/hr.)	Net Production m3/hr.	Output Efficiency of Plant in %
1	Oct-20	64.00	18.34	5.78	**28.66**
2	Nov-20	64.00	14.20	3.77	**22.19**
3	Dec-20	64.00	19.50	6.68	**30.47**
4	Jan-21	64.00	26.30	12.34	**41.09**
5	Feb-21	64.00	22.00	8.63	**34.38**
6	Mar-21	64.00	60.40	78.98	**94.38**
7	Apr-21	64.00	25.31	13.34	**39.55**
8	May-21	64.00	29.47	17.80	**46.05**

The theoretical Output for HMP is 64 m3/hr. The net production rates of HMP vary from 3.77 m3/hr from October 2020 to 78.98 m3/hr till May 2021. HMP relies on the demand for pavers, and the decreased effective output of pavers in particular resulted in a large decline between October 2020 and February 2021. The range of effective production of the HMP is found to be 60.40 m3/hr. with a standard divergence of 14.20 m3/hr. The HMP has an efficiency that ranges from 22.19% to 94.38%.

The fluctuation in production rate can be attributed to a variety of factors, including fluctuating job circumstances, the presence of moisture, maintenance issues, climatic conditions, and variations in the nature of the task.

Table No. 4.4.2: - Showing Total Average Equipment Cost Components of HMP in Rs.

Sr. No.	Cost in Rs.	Month & Year							
		20-Oct	20-Nov	20-Dec	21-Jan	21-Feb	21-Mar	21-Apr	21-May
1	**Landed cost**	60014.76	50500.23	65137.98	89290.26	74652.51	248841.7	100268.57	114906.32
2	**Ownership Cost**	890219	737503.52	932744.04	1245516.63	1019410.77	3177533.57	1248115	1390486.95
3	**Operating Cost**	632413.98	532641.67	686400.54	940908.6	788982.14	2622204.3	1057563.89	1210841.4
4	**Maintenance Cost in Rs.**	0	0	8321	6300	33266	112265	43491	112265
Total Equipment Cost		1582647.7	1320645.42	1692603.55	2282015.49	1916311.43	6160844.57	2449438.46	2828499.66

The majority of the cost of performance for the NH-6 project is comprised of ownership expenses, which vary from Rs. 7,37,503.52 to Rs. 31,77,533.57/- with an average of Rs. 13,30,191.18/-.

With an average of Rs. 10,58,994.56 and a range of Rs. 532641.67 to Rs. 2622204.30, the HMP's operational expenses are the second-largest component of cost of performance. Additional expenses include landed charges, which range from Rs. 50500.23 to Rs. 248841.70, with an average of Rs. 1,00,451.54; and maintenance expenditures, which vary

from Rs. 0.00 to Rs. 1,12,265.00, with an average of Rs. 39,488.50. Between March and May 2021, costs show the most range.

5. CONCLUSIONS

Driving and non-driving equipment are often separated into two groups when it comes to construction sites for highways.

1. The theoretical production of the bitumen paver is 90 m3/hr, while the average actual production rate on a project site is estimated to be close to 49.85 m3/hr.
2. Similarly, at the project location, the Hot Mix Plant's average effective production rate must be close to 21.41 m3/hr. as the plant has a 64 m3/hr capability.
3. The performance discrepancy is seen when comparing the equipments' availability and utility factors. The average percentage of equipment utilisation, which ranges from (20 to 60%), is relatively low, indicating that the equipment is not functioning well or being maintained on the site.
4. The effect of COVID 19 on the construction sector has been continuous, resulting in workforce shortages and delays in planned operations, with a pronounced impact between October 2020 and May 2021. As a result, over the same time period, equipment performance has been below average.
5. The worst part is that we were in no way prepared for the second wave of COVID 19, and we were actually hoping it wouldn't come. As a result, owing to working hours, ownership, operating, and maintenance expenses are more erratic than the overall cost of the equipment, which is mostly tied to the landed cost.

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