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Assessment of Bitumen Paver and HMP Efficiency for a Road Project

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Abstract:

One of the important and dependable sectors of the national economy is the equipment used in highway construction. In the process of building constructions, efficient utilization of labour, supplies, and machinery must be fervently pursued through competent project management. The adoption of innovative procedures and new equipment has resulted in a dramatic advance in construction technology in recent decades. The selection of the right type and size of construction equipment typically affects how productive a project is on the job site. Thus, it is essential that site managers and construction planners understand the primary equipment categories that are most frequently used in construction. Technical aspects and working conditions are taken into consideration in the article's method of calculating the operational productivity and cost of asphalt pavers. This increases the accuracy of decisions made about how to organize and manage highway maintenance activities on Chikhali-Tarsod NH-6.

Keywords: Highway, Construction, Utilization, and Performance.

1. Introduction

The construction sector of the economy depends heavily on the effective use of construction equipment. Thus, one of the most crucial elements influencing the growth of skills to carry out the project efficiently and effectively is equipment. By making better use of the equipment, a substantial amount of work may be completed within the project timetable in less time and with more success. For any project to be successfully completed, an engineer or site supervisor has to be fully aware of the equipment's availability in order to direct it toward a particular purpose. The project's overall progress is significantly influenced by how well the task is accomplished. Because of this, selecting the right equipment necessitates considering every facet of the operating environment at the project site. The correct equipment selection, planning, and administration are essential for maximizing equipment use at the lowest possible cost and with the highest level of output.

Highway construction machinery is one of the most significant and dependable segments of the US economy. Road construction equipment is used for building, maintaining, and repairing highways. The current road and construction equipment system is composed of a complex of high-performance mechanisms and machines that range in capacity and output from large to tiny. The expansion of the paved road network at the local and federal levels, the utilization of resource-saving technologies, the acceleration and improvement of work quality, and the guarantee of highway dependability and durability all have a major influence on the development of road construction equipment. Due to the complexity of imported road and construction equipment, there are certain requirements that must be met in order to comply with international safety and environmental regulations, improve equipment mobility, expand the areas in which it can be used, and ultimately increase 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 equipment's.

2. RESEARCH METHODOLOGY

The research's data set was acquired from the ongoing Chikhali-Tarsod highway construction projects in India, namely NH-6. Technical details, a range of expenses, and equipment owners utilizing these locations were gathered from sellers of construction equipment. Through an examination of the machinery employed in the construction of the Chikhali-Tarsod highway, information was obtained concerning the computation of the productivity of different pieces of equipment, such as the paver parameter, disruption speed, drum insulation, bulldozer hauling speed, hoe capacity of the paver, etc. This study presents the proper findings of the methodologies used to evaluate productivity and various costs.

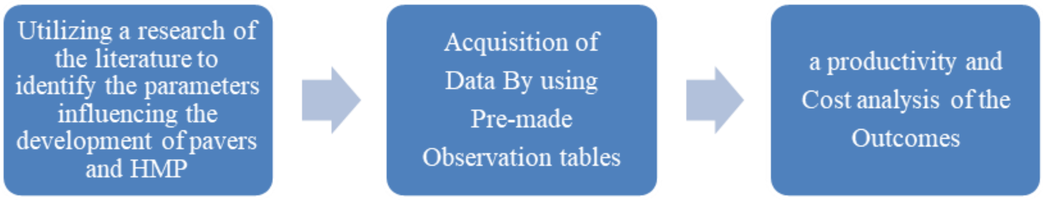

Fig. 1 Research Methodology

3. DATA COLLECTION

The National Highway NH-6 (Package -IIA) case study is the one used to gather data. The project highway's Package-IIA extends 62.7 km, from kilometer 360.000 to km 422.700, starting at Chikhali in the Buldhana district. In the State of Maharashtra, the National Highway Authority of India (NHAI) will implement the project with hybrid annuities, also known as DBOT annuities. This report presents the current state of equipment management.

The process of building bituminous pavement, the operation of asphalt pavers and hot mix plants, and other productivity factors are carefully examined. Information about the amount of asphalt produced by the plants, the average speed of the pavers, and other cost analysis factors, such as the values for landed cost, ownership cost, operating cost, maintenance cost, and so forth, are obtained from construction equipment sellers and equipment operating on project sites. The aforementioned information was acquired between 2020 and 2021.

Bitumen Paver **Hot Mix Plant**

Fig. 2 Specifics of the equipment utilized on the site

4. RESULT ANALYSIS

In highway projects, it is common practice to allocate a single resource, referred to as a dynamic resource, to every task. The end output is what the resource generates, and the equipment's performance dictates the project's total productivity. This section provides a result analysis for cost and production (Theoretical output, Effective production/Practical output, and Net Production) based on factors influencing the manufacture 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:**

- Gradation Curve (easy to deactivate well-organized mixes),
- Heat (hot mixing is easy), and Grin size (very simple mix deformation)
- Stiffness: It is simple to prevent solid mixing.

ii. **Pavement parameters:**

- Thickness of layer (depth cover, bed thickness)
- Width of pavement (greater extension, custom depth)
- Temperature of the environment (heated day, drain)
- Head of object (lower object), deeper

- The deeper the dent, the longer the stop length.

iii. Paver Parameter:

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

4.2 Factors Affecting HMP Production Rate:

i. Aggregates with Moisture Content:

The moisture content of the aggregates has a big impact on how the hot mix plant is set up, produces, and uses fuel. In the event that the moisture content is really high, say 8–10%, the aggregates won't heat up uniformly and efficiently and shouldn't fall out of flights in a uniform layer. As production decreases and fuel consumption increases with increasing moisture content.

ii. Dust Content:

As bitumen must cover a larger surface area and mix more slowly, productivity decreases as the mixture's dust concentration increases.

iii. Altitude:

Around 3.5% less is produced by the facility for every 300 meters above sea level. When assessing if the plant is necessary in a specific area, this problem should also be taken into account.

iv. Drum Insulation:

Maintaining an exterior and inner shell temperature difference of 60°C can increase plant productivity by 2.5 percent while reducing fuel usage by 4%. The drum shell should be insulated with glass wool or covered with aluminum to stop heat losses. An asphalt mixing plant will operate at full capacity when all the factors listed below are satisfied, including aggregate quality, weather and climate, plant status, and other relevant factors.

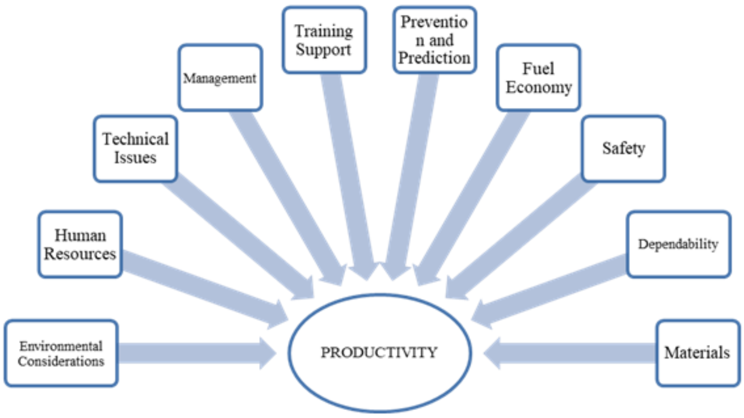

Fig. 3 Factors Affecting Equipment's Productivity

4.3 Performance of Bitumen Paver and its efficiency

Bitumen paver efficiency is typically stated as a ratio of input to output, or as a proportion of actual output to expected output. Conversely, equipment capacity utilization measures how effectively a company makes use of its production capability. It is the correlation between the maximal theoretical output and the real or feasible output of production.

As paver thickness, width, and paving speed rise, so does the volume of material that passes through the paver in a given amount of time, and vice versa. The calculations below can be used to quickly calculate the production required per hour for a given mat width and thickness.

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

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

Table 1 Illustrating Bitumen Paver Performance monthly

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	21-Jan	90	33.4	28.65	13.96	37	31.72
2	21-Feb	90	16.58	21.25	4.00	18.31	23.5
3	21-Mar	90	22.81	31.84	6.87	25.23	35.27
4	21-Apr	90	15.95	35.58	3.76	17.62	39.42
5	21-May	90	15.02	22.57	3.43	16.58	24.97
6	21-June	90	38.07	39.86	17.97	42.19	44.18
7	21-July	90	20.47	22.03	5.68	22.63	24.37
8	21-Aug	90	20.63	21.09	5.76	22.81	23.33

The bitumen pavement has a theoretical output of 90 m3/hr. January 2021 to August 2021 will see a range in net bitumen paver output rates of 4.00 m3/hr to 17.97 m3/hr. The bitumen paver's effective production range is 42.19 m3/hr, with a mean deviation of 25.29 m3/hr. The range of bitumen pavement efficiency is 23.33% to 44.18%.

The variability observed in the production rate can be attributed to multiple factors, such as modifications in the task specifications, upkeep demands, meteorological conditions, and pavement specifications. The several stages of a road project are recognized to be highly dependent on one another. The excavator's performance has decreased and was already below average, as the previously indicated section of the report shows. This prevented the bitumen paver's succeeding stage from operating on a larger scale (range).

Table 2 Showing the Bitumen Paver's Average Total Equipment Cost in Rupees.

Sr. No.	Cost in Rs.	Month & Year							
		21-Jan	**21-Feb**	**21-Mar**	**21-Apr**	**21-May**	**21-June**	**21-July**	**21-Aug**
1	**Landed cost**	115767.12	43027.40	65010.95	72769.86	76002.74	162320.55	88287.67	84408.22
2	**Ownership Cost**	1885382.2	652787.56	918345.60	948127.00	910179.85	1681303.5	774453.78	689735.65
3	**Operating Cost**	191917.47	71163.88	107483.54	120390.64	127205.24	269360.05	146725	139751.29
4	**Maintenance Cost in Rs.**	27685	279000	46334.75	41229	34345	180228	6370	11920
Total Equipment Cost		2220751.79	1045978.83	1137174.86	1182516.51	1147732.8	2293212.1	1015836.5	925815.16

The majority of the cost of performance at the NH-6 project is made up of ownership costs for the two bitumen pavers. The recurring expenditures for the bitumen paver range from Rs. 774453.78 to Rs. 18,85,382.2, with an average of Rs. 10,58,539.39. The second largest contributor to the cost of performance is the bitumen paver's running costs, which range from Rs. 71163.89 to Rs. 2,69,360.05, with an average of Rs. 1,47,749.77/-. Additional costs include landing charges, which range from Rs. 43027.40/- to Rs. 1,62,320.55 and average Rs. 89,449.31/-, and maintenance costs, which range from Rs. 6370/- to Rs. 2,79,000/- and average Rs. 79388.79/-. The costs exhibit a notable variation from March 2021 to May 2021.

4.4 Performance of Hot Mix Plant and its efficiency:

Hot mix asphalt is transported by trucks from a central plant to the paving site. An asphalt factory is a high-tech complex of machinery designed to continuously mix, heat, and combine aggregates and asphalt cement to create asphalt concrete. The process of producing an HMP is.

Production (cum / hr.) = (N x C x T) / t

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

Table 3 Showing Hot Mix Plant's Monthly Performance

Sr. No.	Month & Year	Theoretical Output (m3/hr.)	Effective Production / Practical Output (m3/hr.)	Net Production m3/hr.	Output Efficiency of Plant in %
1	Jan-21	64	18.99	6.43	29.31
2	Feb-21	64	14.85	4.42	22.84
3	Mar-21	64	20.15	7.33	31.12
4	Apr-21	64	26.95	12.99	41.74
5	May-21	64	22.65	9.28	35.03
6	Jun-21	64	61.05	79.63	95.03
7	Jul-21	64	25.96	13.99	40.20
8	Aug-21	64	30.12	18.45	46.70

For HMP, the theoretical output is 64 m3/hr. From January 2021 to March 2021, the net production rates of HMP range from 3.77 m3/hr to 79.63 m3/hr. Because HMP depends on the demand for pavers, there was a significant drop between January 2020 and March 2021 as a result of the decreased effective output of pavers. It is discovered that the HMP has an effective production range of 61.05 m3/hr and a standard deviation of 27.59 m3/hr. The efficiency of the HMP varies from 22.84% to 95.03%.

Numerous variables, such as shifting job conditions, dampness, maintenance problems, weather, and task-specific variances, can be blamed for the change in output rate.

Table 4 Showing Total Average Equipment Cost Components of HMP in Rs.

Sr. No.	Cost in Rs.	Month & Year							
		21-Jan	**21-Feb**	**21-Mar**	**21-Apr**	**21-May**	**21-Jun**	**21-July**	**21-Aug**
1	**Landed cost**	60514.76	51000.23	65637.98	89790.26	75152.51	249341.7	100768.57	115406.32
2	**Ownership Cost**	890719	738003.52	933244.04	1246016.63	1019910.8	3178033.6	1248615	1390987
3	**Operating Cost**	632913.98	533141.67	686900.54	941408.6	789482.14	2622704.3	1058063.90	1211341.4
4	**Maintenance Cost in Rs.**	850	1550	8821	6800	33766	112765	43991	112765
Total Equipment Cost		1584647.74	1322645.42	1694603.56	2284015.49	1918311.4	6162844.6	2451438.5	2830499.7

Ownership expenses, which range from Rs. 8,90,719 to Rs. 31,78,033.6, with an average of Rs. 13,31191.18, make up the majority of the NH-6 project's cost of performance. The second-largest component of cost of performance is the operational expenses of the HMP, with an average of Rs. 1059994.56/- and a range of Rs. 5,33,141.67/- to Rs. 10,58,063.9/-. Landing charges are an additional expense that vary from Rs. 51000.23 to Rs. 249341.70, with an average of Rs. 1,01,451.54; maintenance costs are another expense that vary from Rs. 850.00 to Rs. 1,12,765.00, with an average of Rs. 4,04,488.50. Costs vary the most in May and June of 2021.

5. CONCLUSIONS

When it comes to highway construction sites, driving and non-driving equipment are frequently divided into two categories.

1. Although the bitumen paver has a theoretical output rate of 90 m3/hr, real production rates on project sites are often closer to 25.29 m3/hr.

2. Similar to this, given the plant's 64 m3/hr capacity, the average effective production rate of the Hot Mix Plant at the project location has to be very near to 27.59 m3/hr.

3. When evaluating the equipment's availability and utility criteria, differences in performance are evident.

4. The average equipment utilization percentage, which falls between 20 and 50%, is comparatively low, suggesting that the equipment is either not being maintained on the site or is not operating at peak efficiency.

5. The influence of COVID 19 on the construction industry has been ongoing, with a noticeable difference between January 2021 and August 2021. This has led to a lack of workers and delays in scheduled activities. Equipment performance has thus been below average within the same time period.

6. The most unfortunate aspect is that we were not ready for the second COVID-19 wave at all, and we were almost praying it wouldn't arrive. The overall cost of the equipment is mostly determined by the landed cost, while ownership, operating, and maintenance expenditures are more variable according to working hours.

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