

A Comparative Study of Actual Productivity and Theoretical Productivity of Construction Equipment and its Remedial Measures.

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Abstract— Construction is the second largest economic activity in India. Poor equipment productivity is a problem faced by the construction industry in developed as well as developing country. In building project, the equipment cost can vary from 5% to 10% of the direct cost whereas in a highway construction project the plant and equipment costs may touch as much as 40% of the project direct costs. Thus, it is essential to improve equipment productivity. Improvement in productivity can be achieved by understanding the factors that adversely affect productivity. The objective of this study is to identify the factors that affect the equipment productivity in the construction projects.

Keywords—Construction Equipment, Cycle Time, Drum Mix Plant, Excavator, Factors Affecting Productivity, Productivity, Overall Equipment Efficiency.

I. INTRODUCTION

The study of equipment productivity and productivity is as old as equipment itself. Construction equipment plays an important role in the execution of high cost time bound construction projects. This equipment produces output at the accelerated speed and enables the completion of task in a limited time. Equipment saves manpower, a source, which is becoming insufficient as per the demand, costly and becoming more demanding day-by-day. Equipment improves productivity, quality and safety. Planning in the construction industries, as is well known plays an important part in the successful outcome of a project. The study outlines the two equipment [Excavator and Drum Mix Plant]. This study concentrates on the type and schedule of presence of the equipment at the project site, since we know that the actual hourly production of the equipment differs from the planned hourly production. Moreover, this study also introduces the factors affecting construction equipment productivity.

Equipment productivity is a key factor that enables contractors to make decisions regarding project scheduling and project costs.

II. OBJECTIVES

The objective of the work is to study and discuss the various factors affecting Construction Equipment productivity (research is limited to Excavator and Drum Mix Plant only).

The production performance ratio compares the volume of work done by each equipment is compared with its planned production (Volume of work to be done) and Actual production (Volume of work done) and, thus, the level of productivity can be justified.

III. DATA COLLECTION

A. Excavator:

In this research work the data collected for Excavator (Hitachi 70) was from current construction project of Saraswati Buildcon, which was available at rehabilitation of Udalpur-Akhaj-Mulsan road. The data collected was for 55 Minutes to compare the Actual productivity with its Theoretical productivity.

TABLE I
EXCAVATOR DATA

No. of Cycle	Cycle Time(second)
1	26
2	23
3	24
4	23
5	25
6	22
7	24
8	23
9	21
10	24
11	23
12	19
13	23
14	21
15	21

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No. of Cycle	Cycle Time(second)
16	24
17	25
18	18
19	23
20	22
21	21
22	24
23	20
24	23
25	22
26	24
27	20
28	19
29	22
30	19
31	21
32	23
33	24
34	25
35	20
36	20
37	21
38	23
39	24
40	20
41	21
42	19
43	23
44	21
45	22
46	22
47	20
48	19
49	21
50	23
51	20
52	22
53	25
54	23
55	21
56	20
57	19
58	21
59	23
60	18
61	25
62	24
63	23
64	24
65	21
66	23

No. of Cycle	Cycle Time(second)
67	25
68	23
69	19
70	23
44	21
45	22
46	22
47	20
48	19
49	21
50	23
51	20
52	22
53	25
54	23
55	21
56	20
57	19
58	21
59	23
60	18
61	25
62	24
63	23
64	24
65	21
66	23
67	25
68	23
69	19
70	23
71	24
72	20
73	22
74	21
75	24
76	22
77	25
78	22
79	24
80	21
81	23
82	20
83	24
84	19
85	22
86	20
87	23
88	21
89	24
90	23

No. of Cycle	Cycle Time(second)
91	21
92	23
93	22
94	20
95	19
96	21
97	23
98	22
99	21
100	19
101	21
102	20
103	23
104	24
105	24
106	22
107	21
108	20
109	24
110	23
111	20
112	22
113	22
114	24
115	19
116	23
117	25
118	22
119	24
120	23
121	25
122	24
123	26
124	24
125	22
126	23
127	20
128	21
129	23
130	21
131	19
132	24
133	23
134	24
135	21
136	22
137	19
138	25
139	23
140	21
141	18

No. of Cycle	Cycle Time(second)
142	22
143	24
144	19
145	21
146	23
147	21
148	24
149	23
150	21
TOTAL	3309 Second (55 minutes)
AVG	22 Second

B. Drum Mix Plant:

In this research work the data collected for Drum Mix Plant (Owned by Saraswati Buildcon) is situated at Timba. The data collected was for 3 Hours to compare the Actual productivity with its Theoretical productivity.

**TABLE II
PLANT DATA**

Date	Total weight of the truck	Empty weight of truck	Net weight	Total weight of quantity	Time
15/12/16	37.21	11.18	26.03	26.03	7:10
15/12/16	40.68	11.79	28.89	54.92	7:40
15/12/16	44.35	12.12	32.23	87.15	8:10
15/12/16	38.25	11.3	26.95	114.1	8:30
15/12/16	42.53	11.33	31.2	145.3	9:10
15/12/16	40.04	11.28	28.76	174.06	9:40
15/12/16	34.46	11.12	23.34	197.4	10:00
ALL WEIGHTS ARE IN TONNE.					

IV. METHODOLOGY

A. Excavator:

In every construction project, excavation is the key activity.

Excavators are heavy construction equipment consisting of boom, stick, bucket and cab on a rotating platform. Excavators are also called diggers. Excavators are widely used in construction work, such as digging trenches, holes and foundations, as well as for handling materials, moving earth, demolition, dredging, etc.

Procedure:

Step 1. Obtain bucket capacity from the manufacturers' data sheet.

Step 2. Consider the efficiency based the type of material being excavated.

Step 3. Calculate Net Capacity.

Step 4. Calculate the time of swing.

Step 5. Calculate the production rate.

Calculation:

1. Bucket Capacity = 0.3 m³.

2. Assume efficiency = 75% (This may vary depending on the type of material to be excavated).

3. Thus, Net capacity = (Bucket Capacity * 75%)
= 0.3*75%
= **0.225m³**.

4. Time per swing (swing, fill, swing, unload)
= 22 seconds.

∴ Time per swing /60 = 22/60
= **0.36 minutes**.

5. Consider 5 minutes of rest time taken by the operator every one hour

∴ Number of swing cycles per hour = (60 min – Rest Time) / Time per swing in min.
= (60 – 5) / 0.36
= 152.77
≅ **152 cycles**.

Per hour Capacity of Excavator = Number of swing cycles per hour * Net capacity
= 152 * 0.225
= **34.2 m³/hour**.

B. Drum Mix Plant:

In many of the construction projects, Drum Mix Plants are widely used to produce hot mix asphalt. The purpose of a Drum Mix Plant is to blend together aggregates and binder, to produce a hot mixed homogeneous asphalt paving mixture.

Procedure:

For determining Efficiency of Plant, OEE (Overall Equipment Efficiency) approach is used.

OEE measures the efficiency of the equipment. OEE is a function of the three factors mentioned below.

1) Availability = Actual Production Time / Potential Production Time

Where,

Actual Production Time = Potential Production Time – Stop Time

2) Performance = Actual Output / Theoretical Output

3) Quality = Good Product / Actual Output

Where,

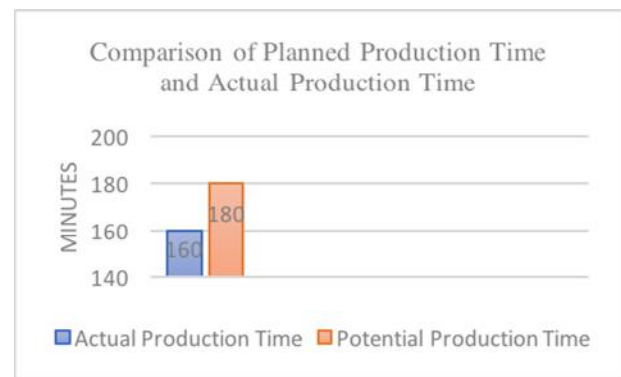
Good Product = Actual Output – Losses

Thus, OEE = A * P * Q * 100

Calculation:

Availability	A	Potential production time => 180 Minutes	
	B	Actual production time => 180 - 20 = 160 Minutes	Availability losses: 20 min - breakdowns - waiting/changeover
Performance	C	Theoretical output => 225 TONNE	= 60 - 90 TPH Avg=75 TPH
	D	Actual output => 198 TONNE	
Quality	E	Actual output => 198 TONNE	<i>Effectiveness loss</i>
	F	Good product 193	

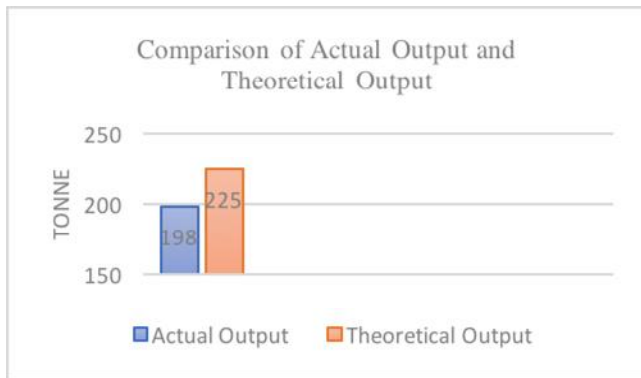
1) Availability A, = (180 Minutes - 20 Minutes) / 180
= **0.88**



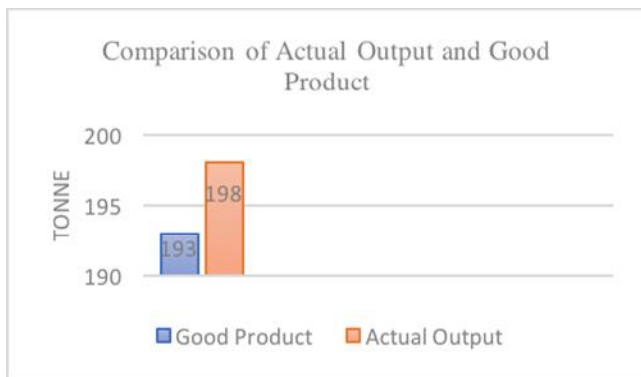
$$2) \text{ Performance } P, = 198 \text{ Tonne} / (75 \text{ Tonne} * 3 \text{ Hours}) \\ = \mathbf{0.88}$$

Where,

75 Tonne is the average Theoretical Output



$$3) \text{ Quality } Q, = (198 \text{ Tonne} - 5 \text{ Tonne}) / 198 \text{ Tonne} \\ = \mathbf{0.97}$$



$$\therefore \text{OEE} = A * P * Q * 100 \\ = 0.88 * 0.88 * 0.97 * 100 \\ = \mathbf{75.11\%}$$

V. CONCLUSION / RECOMMENDATIONS

Aim of this research work was to improve the equipment productivity and to find the factors affecting it. This research work also provided remedies/suggestion for improving productivity of equipment.

The Equipment on which research work was done were Excavator and Drum Mix Plant, it will be discussed one after another.

Excavator:

- 1) To reduce the cycle time and time required for excavation, Maximum Capacity of Bucket should be used.
- 2) Dumping Site should be near to the Excavating Site can save time and the vehicles used for carrying excavated materials.
- 3) Reducing the angle of swing can reduce the cycle time and work can be done more efficiently.
- 4) Operator should be skilled as a skilled operator can handle the equipment more effectively providing maximum output from machine.

Drum Mix Plant:

- 1) To avoid breakdown, proper and timely maintenance of plant should be done.
- 2) Minor Stoppages can be saved by keeping sufficient material transport vehicle on site.
- 3) Losses can be reduced by scrapping the stucked material and reusing them.

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