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Comparative Study on Effectiveness of Conventional and Electrical Construction Equipment

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Abstract - *This study looks at several ways of comparative analysis through an examination of electrical and conventional construction machinery. The productivity of the data available from each electrical construction equipment firm was compared to that of conventional equipment, and the list of brands of electrical construction equipment that are now on the market was found, researched, and evaluated. It is envisaged that the findings would serve as a foundation for background information about the selection of electrical construction machinery for on-site construction.*

The purpose of this research study is to examine whether using electrical construction equipment instead of conventional construction equipment might be able to use to understand at site and can achieve sustainability. This can be done by looking at the equipment list and possible methods by analysing the productivity of electrical construction equipment, which was discovered by many brands/companies and can lead to the creation of environments that support construction. This research paper aims to explore the feasibility and potential benefits of electric construction equipment in the construction industry. The study will analyse the performance, energy consumption, and environmental impact of electric equipment compared to conventional equipment, and investigate the barriers to adoption of electric equipment on construction sites. Furthermore, the paper will propose a framework for the implementation of electric construction equipment in construction projects and evaluate the economic feasibility of the transition to electric equipment.

Key Words: *comparative analysis, productivity, construction equipments, electrical construction equipments, environment, sustainable approach.*

1.INTRODUCTION

1.1 Background Study- Construction Machinery

Construction project execution is currently increasingly mechanised and becoming a more significant aspect daily. The success of any building project has always depended heavily on the choice of the appropriate equipment during the construction phase. Since there is now a chance to promote environmental sustainability in the building industry, choosing construction equipment today should take into consideration social and environmental factors in addition to engineering and economic ones. In this situation, choosing the best machinery for a particular building job is a difficult task.

1.2 Aim: To study a comparative analysis on the use of effectiveness of conventional and electrical construction machinery.

1.3 Objectives:

To Identify the electrical construction equipment or machinery availability and their applicability

Comparative Analysis of electrical machinery productivity, cost, SWOT compared to current using construction equipment/machinery.

Identify the aspects or factors which if it leads to environment supportive.

1.4 Scope and Limitations

To check availability of electrical construction equipment of particular companies with study of its productivity for mid-size construction sites, discuss this points on call/survey/interview.

Data is going to be analysed on the basis of availability of information which is provided by respective Electrical machinery producing companies and data available on the online survey.

1.6 Methodology

Finding Problem Statement for Research as problem causing by using of conventional construction equipment and study comparative analysis with respective work productivity of equipments.

Create Research questionnaire (Design-Validate-Distribute-Collect) according to use of construction equipments, find major points to be discuss and validate as per study.

Identify the electrical construction equipment availability and their applicability (Listing out Equipments), Study typology for transitions of using EV Equipments. Study Comparison analysis / SWOT analysis and documented as per understanding at particular points and conclude.

2. LITERATURE REVIEW

2.1 Literature Review 1: A Critical Review and Analysis of Construction equipment emission factors

Factors affecting the construction equipment emissions
There are a large number of factors affecting the exhaust emissions of construction equipment, many are difficult to measure and quantify their degree of impact on the rate of emissions. Overall the factors can be categorized into four groups.

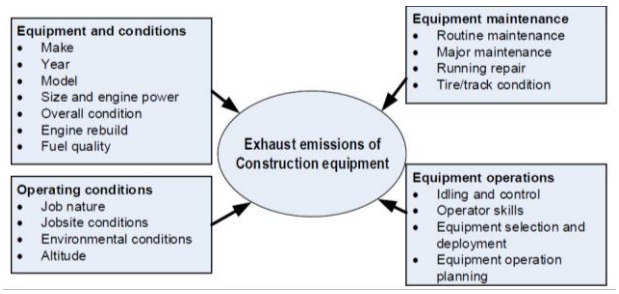


Fig -1: Emission Factors of construction Equipment

2.3 Literature Review 2:

2.3.1 Simon Ofori Ametepey (Corresponding author) Faculty of Technical Education, University of Education, Winneba, P. O. Box 1277, Kumasi, Ghana:

Electric vehicles (EVs) are increasingly being seen on building sites instead than on public roads. The building sector is crucial to the fight against climate change. In total, the building and construction industries are responsible for 38% of global carbon dioxide emissions, according to a research from the UN.

2.3.2 Dr. Ray Gallant, head of product management and productivity at Volvo Construction Equipment, Article 2020

Electric equipment will construct tomorrow's highways, bridges, and utility lines without emitting greenhouse gases (Volvo CE). Early adopters are already employing electric construction equipment successfully, and they are discovering that they can reduce their carbon footprint while maintaining great performance.

2.3.3 Ben Benoit, head of the South Coast Air Quality Management District, Article 2020 which is in charge of enhancing air quality in a region that includes Los Angeles

We must also keep in mind the local implications, says Benoit, "since there are unquestionably significant global impacts with electro mobility." "A form of pollution from vehicle exhaust is a risk factor for heart and lung conditions. Therefore, it's crucial that we address this issue for the local population in addition to the global one.

It's not easy to introduce electro mobility to the building sector. Construction equipment has the additional burden of being the machines responsible for developing or maintaining infrastructure, which is an issue for on-road EVs as well. Perhaps the most important of these is building out the charging infrastructure.

The lithium-ion batteries that power many electric vehicles may be recharged using a 220/240-volt electrical outlet, the same kind of outlet that many bigger home appliances require. Additionally, they have fast-charging capabilities that enable them to reach nearly full charge in a matter of hours. In the near future, options like mobile power banks might be accessible for charging in remote regions due to the rapid pace of research and development in this field.

3. DATA COLLECTION

3.1 Process

There were two parts to the data collection process. The first stage involves as study a positive and negative impacts done of using conventional construction equipments on construction site to the surroundings, environment, neighbourhood etc. factors and understand how this impacts can minimize by using alternative to conventional construction equipments.

The middle stage of first phase and second phase is the observations taken and detail out by visit construction sites and take some Semi-structured interviews with select contractors and consultants for the qualitative study of construction equipments, and their views on alternative of shifting from more conventional construction equipments towards environment supportive techniques. The interviews used an attitudinal technique, which is used to evaluate subjectively how one or more individuals feel about a certain attribute, variable, element, or topic.

The second phase entails are to identifying and compiling which electrical construction equipment are readily available or ready to work on construction as per details found by respective manufactures companies, listing out all essentials data of equipments such as work productivity, charging, costing etc. Compare these entails with each other to find out research conclusion.

4. CASE STUDIES

4.1 Case study A. Literature Base Case Study- Mid size construction sites using equipment at Tamil Nadu

Frequency Percentage of Type of Equipment Used for Mid-size construction work Sites

From the above table it highlighted that nearly 40% of the sites use excavator cum loader for their construction work and 35% of them use excavator machines while only 15% of the sites use tractor loader and 10% of them use trenching machines in their construction work.

2.4 FREQUENCY PERCENTAGE OF TYPE OF EQUIPMENT USED

Type of the Equip-ment	Fre-quency	Per-cent	Valid Percent	Cumu-lative Percent
Excavator	7	35.0	35.0	35.0
Excavator cum loader	8	40.0	40.0	75.0
Tractor loader	3	15.0	15.0	90.0
Trenching machine	2	10.0	10.0	100.0
Total	20	100.0	100.0	

Machine Used

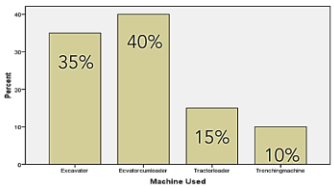


Fig -2: Frequently Percentage of type Equipment used

4.2 Case Study B: Cost and Productivity Analysis of Equipments for Flexible Pavement- A Case Study-Chandigarh, India.

Sr no	Description	Excavator	Backhoe	Loader	Tipper Truck
1	Load Capacity	1.5 cu.m	3 cu.m	0.6 cu.m	10 cu.m
2	Work production rate/hr.	120 cu.m/hr	114 cu.m/hr	75 cu.m/hr	30 km/hr (250 cu.m)
3	Minimum work efficiency	50-60 min	50 min	50 min	43-50 min (30 km single trip)
4	Diesel required (1hr)	13-15 lit (Rs-1425)	10-12 lit (Rs-1140	12 lit (Rs 1140)	10-13 lit (Rs 1235)
5	Working O & O cost (1hr)	1850	1550	1300	1000

4.3 Case Study C: Live Case Study-Pune Business Spaces Pvt ltd, Kharadi-40, Pune.

Location: Rakshak Nagar, Kharadi 40, Pune, Maharashtra.

Integrated business park - Pune is an institution for business and located strategically in Kharadi to foster international trade by providing various services and facilities designed specifically to meet the needs of participants in global commerce.

Basic Information
Type of building: commercial office building
Plot Area: 16000 Sq.m nearly 4 Acre.
No of buildings: 1
Total Built up Area: 15,00,000 sq. ft
Type of construction: RCC framing
Building has no. of floors: 3 Basements, 2 Stilt Floors, 17 Floor Commercial

RMC Plant- cement truck mixer
- Distance of site from RMC plant 2.8 km
- 10 min required to reach site from plant

4.3.1 K-40 Case Study Data Analysis- RMC cement truck mixer

Table 2- RMC Truck Mixer Data Analysis

Sr no	Description	M40	M60	M70
1	Density	2517 Kg	2534.4 Kg	2484 Kg
2	Mixing Time Req.	50 second	50 second	100 second
3	Truck Load Capacity	6 cu.m	6 cu.m	6 cu.m
4	Time required to fill 6 Cu.m in Truck	11 Min	14 Min	18 Min
5	Diesel Required (1 Hr) 2 Engine	2.5 Liter (Transport) 2.5 Liter (Rotate)	2.5 Liter (Transport) 3 Liter (Rotate)	2.5 Liter (Transport) 3.5 Liter (Rotate)
6	Average Diesel required for single trip with halt (1hr)	6 Liter (Rs 570)	6.5 Liter (Rs 620)	8 Liter (Rs 760)
7	Cost for per trip with RMC plant to site for 6 Cu.m	40K-50K	50K-60K	70K-80K

4.3.2 Data Analysis: Productivity of Construction Equipment Use for construction at site

Table 3. Productivity of Construction Equipment use on Const. site

Sr no	Description	Excavator	Backhoe	Loader	Transport Truck
1	Load Capacity	1.5 cu.m	3 cu.m	10 cu.m	10 cu.m
2	Work production rate/hr.	90-100 cu.m/hr	120-130 cu.m/hr	70-80 cu.m/hr	30 km/hr
3	Minimum work efficiency	50-60 min	50 min	50 min	43-50 min (30 km single trip)
4	Diesel req. 1hr	8-10 litre (Rs-950)	10-12 lit (Rs1140)	5.5 lit with halt break (Rs 570)	10-13 litre (Rs 1235)
5	Working O & O cost (1hr)	1850	1550	1300	1000

Fig.3 Excavator

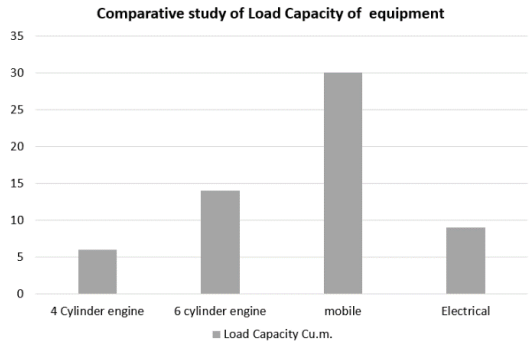
Fig.4 Backhoe

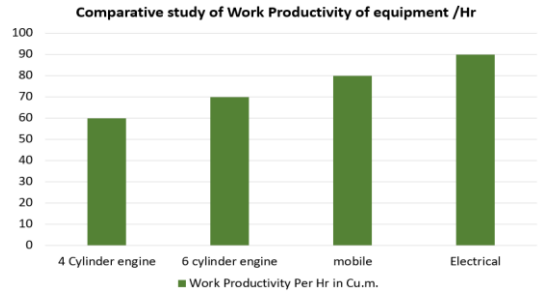
Fig.5 Transport Truck

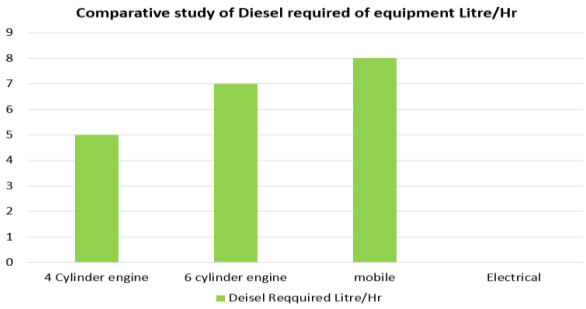
4.3.3 Concrete Boom placer equipment work productivity analysis

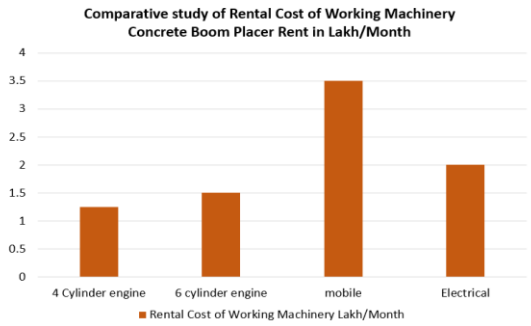
Table 4- Average Work Productivity Analysis Concrete Boom Placer (K40 case study)

Sr	Description	Diesel based 4 cylinder engine	Diesel based 6 cylinder engine	Diesel based mobile	Electrical
1	Space required for equipment (Area for work)	18 Sq.m	28 Sq.m	32 Sq.m	6 Sq.m
2	Equipment Working range (Height/Length)	100 Meter	100-120 Meter	40 Meter	36 Meter (360^0)
3	Load Capacity	6-7 Cu.m	14-15 Cu.m	30 Cu.m	8-9 Cu.m
4	Equipment work productivity	60 Cu.m	70 Cu.m	80 Cu.m	80-90 Cu.m
5	Diesel required (1hr)	4-5 litre (Rs-475)	6-8 Litre (Rs-760)	6-8 Litre (Rs-760)	No
6	Electricity Required	No	No	No	125 Amp Battery full charge 9 hr or Plug to power source directly Electrical Power consumption 13 kWh=120 Rs/hr
7	Working cost rent of Equipments	1-1.25 Lakh/Month	1.5 Lakh/Month	3-4 Lakh / Month Or 15-20K single day shift work	2 Lakh/Month







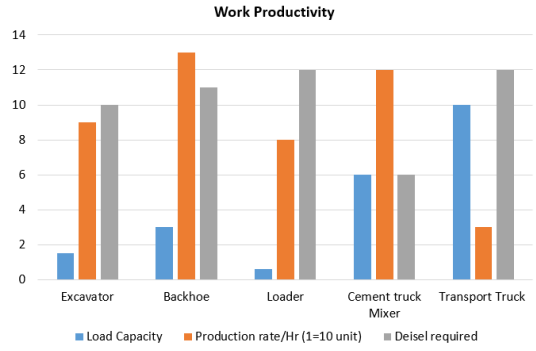


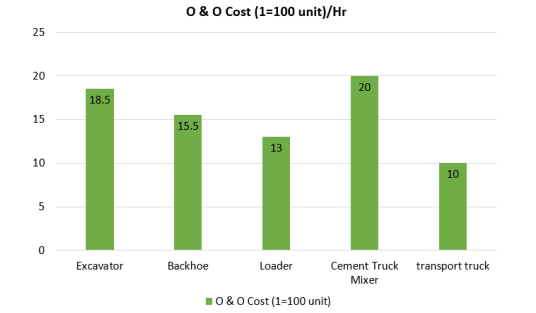
5. DATA ANALYSIS:

5.1 Average Productivity of Construction Equipment Use for construction at site

Table 5. Average Productivity Analysis of Construction Equipment

no	Description	Excavator	Back hoe	Loader	Cement Truck Mixer	Transport Truck
1	Load Capacity	1.5 cu.m	3 cu.m	0.6 cu.m	6 cu.m	10 cu.m
2	Work production rate/ hr.	90-100 cu.m/hr	120-130 cu.m /hr	70-80 cu.m/hr	12 cu./Hr	30 km/hr
3	Minimum work efficiency	50-60 min	50 min	50 min	40-50 min	43-50 min (30 km single trip)
4	Diesel required (1hr)	8-10 litre	10-12 litre	12 litre	6 Litre	10-13 litre
5	Working O & O cost (1hr)	1850	1550	1300	2000	1000



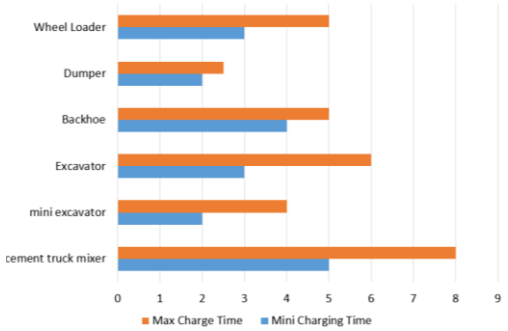


5.2 Analysis: Average work productivity of Electrical Construction Equipment Product List Available for comparative study.

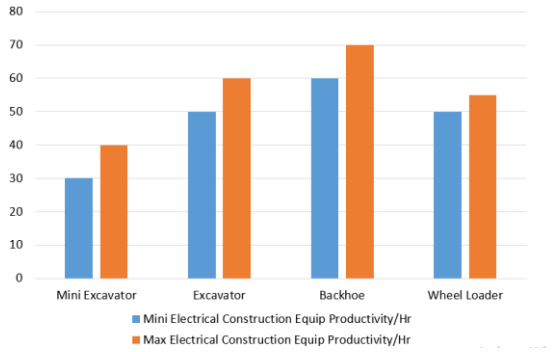
Table 6. List of Average Productivity Analysis of Electrical Construction Equipment

Sr	Product	Charging time	Capacity	Productivity (per/hr)	Operation Time	Manufactures
1.	Mini Excavator	2-4 hours	0.6 cu.m	30-40 cu.m/hr	6-8 hours (Full day shift work)	Bobcat(US), Green Machine, Hitachi, Hyundai, Komatsu, Takeuchi, Volvo
2.	Excavator	3-6 hours	1.5 cu.m	50-60 cu.m/hr	4-9 hours	Hitachi, JCB, Kubota, Nasta, PonCat, Volvo, Wacker Nueson
3.	Backhoe	4 hours	3 cu.m	60-70 cu.m/hr	8 hours	John Dheere
4.	Wheel Loader	3-5 hours	1 cu.m	50 cu.m/hr	5hours-Full Day work shift	Wacker Nueson, Caterpillar, Kramer, Volvo, Wiedmann
5.	Cement Truck Mixer	5-8 hours	6 cu.m	25-30 km/hr	250 km (Range)	CIFA, Futuricum
6.	Dumper	3-5 hours	6-7 cu.m	20-25 km/hr	Full day shift	JCB, SANY

Graph: Average Charging Time in hours required for Electrical Construction Equipment



Graph: Average Productivity of Electrical Construction Equipment cu.m/Hr

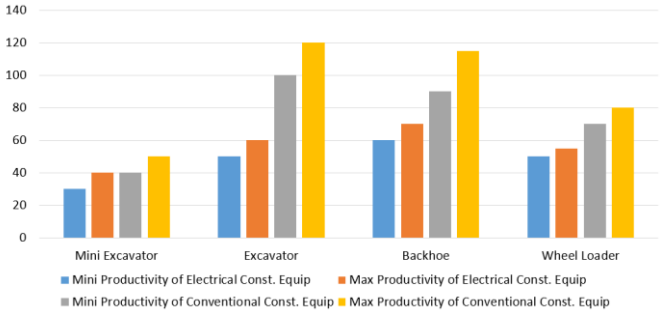


5.3 Comparative Analysis: Average Productivity of Conventional and Electrical Construction Equipment/ Hr

Table 7. Comparative Productivity between construction Equipments

Ssr. no	Product	Capacity	Electrical Construction Equipment		Conventional Construction Equipment	
			Productivity (per/hr)	Full Charging time	Productivity (per/h	Diesel Req. (per/
11	Mini Excavator	0.6 cu.m	30-40 cu.m/hr	2-4 hr	40-50 cu.m/hr	7-8 litre
22	Excavator	1.5 cu.m	50-60 cu.m/hr	3-6 hr	100-120 cu.m/hr	13-15 litre
33	Backhoe	3 cu.m	60-70 cu.m/hr	4 hr	90-115 cu.m/hr	10-12 litre
44	Wheel loader	1 cu.m	50 cu.m/hr	3-5 hr	70-80 cu.m/hr	11-12 litre
55	Cement Truck Mixer	6 cu.m	25-30 km/hr	5-8 hr	25-30 km/hr	10-13 litre
66	Dumper	6-7 cu.m	20-25 km/hr	3-5 hr	20-25 km/hr	10-12 litre

Graph: Average Productivity of Conventional and Electrical Construction Equipment/Hr



5.4 Findings

Table 8. Comparative analysis: consideration points between conventional and electrical construction equipment

Description	Conventional Construction Equipment	Electrical construction Equipment
Availability	Easily Available to reach site	Yet to be check if available due to limited production
Work Productivity	High Working Capacity/Hr	20% less working capacity/Hr
Power Base Required	Diesel	Electric Charging
Daily Shift Work Load	Full Daily Shift	Limited on charging which is up to 8-10 hours
Use of Equipment as per construction site	Project cost-nearly 350-450 Cr	Can use from low cost to medium cost project nearly 300cr
Rental cost	Minimum- 1 lakh Maximum- 4 Lakh/month	Limited to 2-2.5 Lakh/month

6. CONCLUSIONS

As all points of productivity of work has been done on consideration for comparative analysis between electrical and conventional construction equipment at site in this study. As far now limited electrical construction equipment are available for construction at construction site and also some of these are not started using in India yet. As taking consideration of working sites and Manufacturing companies of construction equipments stated that, there is a chance to promote environmental sustainability in the building industry, choosing construction equipment today should take into consideration social and environmental factors in addition to engineering and economic ones.

This comparative study concludes conventional construction equipment has more productivity data than compare to electrical one as now electrical construction equipment need to more develop. This study concludes as in upcoming 5 year/Decade span time electrical construction equipment will start to take place as huge alternative to conventional construction equipment since there is some consideration points such as limit to diesel availability and cost increasing factor. Electrical will be more environmental support and increasing sustainability factor for construction.

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