



Identification and Analysis of Factors Affecting Machinery in the Construction Industry of Pakistan

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Abstract

This research has been carried out to explore the current practices of machinery used in the construction industry of building projects of Pakistan. Management of construction equipment varies from project to project and organization. Small to medium contractors normally purchase used equipment required for their projects, because smaller equipment can be purchased and managed more easily. On the other hand, larger contractors often subcontract equipment/ machines to perform the specific tasks of the project. This research work revealed different factors of machinery management. Factors causing cost overrun in the construction projects were ranked on the basis of Relative Importance Index (RII). Top five significant factors identified were frequent equipment breakdowns, maintenance of equipment, insufficient number of equipment, performance / efficiency of equipment and inadequate modern equipment.

Keywords: Construction equipment; machinery management and Relative importance index.

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1. Introduction

Machinery or equipment is as an item that is portable or mobile ranging from small hand tools through tractors, cranes, and trucks. Author studied different mechanisms of equipment technology for labor productivity and identified five different factors to describe changes in technology [1].

Different authors measured the changes in equipment and labor costs per unit of physical output for various construction activities from 1920 to 1970. They revealed that advancement in technology and increased usage were the two primary causes and due to advancement in technology capital costs of many activities has increased while the relative labor costs declined. They also revealed that the capital to labor ratio is used with the assumption that lesser labors are required due to technological advancement i.e. consider a project that uses four units of machinery and eighty workers produces forty units of output. An up-to-date version of the machinery uses eight units of machinery but only thirty workers produces the same amount of output. These improvements represents a relative increase in capital to labor requirements [2].

First part of the research paper presents literature review of machinery management. The next section shows research methodology. The third section gives the results and analysis. In the last section conclusion and recommendations are shown.

2. Literature review:

2.1. Equipment Planning

Man-power is cheaply and easily available in India. So, most of the activities can be easily carried out by the manpower. However, a combination of machines and manual labor is preferred. The purpose of equipment planning is to separate different type and size of required equipment on rent, lease or complete purchase for the construction projects. While planning a project the extent of use of a construction equipment to be very carefully decided. Middle and minor construction projects comprise between manual and mechanical means whereas mechanization of major construction projects is indispensable. Measurement of the standby repair unit's size and availability of the machinery is necessary for the operation failure cost [3,4].

2.2. Selection of Equipment

Managers of the construction equipment have to decide that how, when and which machine is to be acquired, operated and disposed off [5]. Contractor's large investments of the equipment managing system and policy have great impact on the profit. Innovations in the construction equipment act as a catalyst for the advancement of a construction industry [6].

Since the 18th century, the discoveries and their expanded and improved applications were more dramatic. Primary causes of poor productivity, delay in schedule, and cost overrun on many projects is the forbear of new technology [7].

Construction equipment industry is mature industry, in which rapid developments of equipment are observed

with the passage of time. These developments are due to market competition, process and incremental innovations[8].

2.3. Equipment Cost

Generally, contractor rely on the output, useful life, fuel cost, depreciation cost, repair and maintenance cost, salvage value, interest rate and taxes of the machinery. Author developed a regression model from quadratic function for the repair cost of the machine age from field data [9]. As machinery life changes with every repair work, so whenever it requires repair, decision to be made to estimate the life earned due to repair.

Finance of the construction equipment is related to the owner and operating cost includes repair, purchase, life, maintenance and its availability. Another approach would be to have standby equipment in case of failure. This redundant equipment could be older equipment performing less important activities or could be rented.

Machinery of any construction firm constitutes major investment and policy of the equipment has a great impact on the income/ profitability of the project [4].

2.4. Training Equipment Operators

Sharma (1997) said that without a competent operator best equipment of the world is valueless. To survive job in private organizations especially in construction sector one should have multiple skills. Most of the equipment operators acquired their skills by self-instruction or from other operators by trial and errors, which results in damaging of the equipment. It is responsibility of the organization to ensure proper training of the operators.

2.5. Equipment Technology Factors

Construction productivity is influenced by different mechanisms of construction machinery. Following five factors are identified to characterize technology changes [1].

2.5.1 Human energy amplification

Amplification of human energy is technology designed to make an activity physically easier to carry out. Simply, an output can be increased by transferring energy requirements from human to machine.

2.5.2 Control level

Level of control is related to advancement in hand tools and machinery in which control is transferred from the human to the machine.

2.5.3 Functional range

Machine's range of capabilities is expanded in equipment's functional range.

2.5.4 Ergonomics

Ergonomics is technology that lessens physical stress imposed on the human and assists the worker to handle the work environment.

2.5.5 Processing information

Overtime construction equipment has been designed for greater and more accurate internal and external process information.

Various factors were identified from the Literature review. Source of each factor is explained in Table 1:

Table 1. Factors affecting Machinery

Sr. No	Code	Machinery Related Factor	Source
1	EQ1	High cost of equipment	[10 & 11]
2	EQ2	Maintenance of equipment	[11]
3	EQ3	Inadequate modern equipment	[12]
4	EQ4	Lack of new technologies / methodologies	[12]
5	EQ5	Performance/ efficiency of equipment	[12]
6	EQ6	Frequent equipment breakdowns	[12]
7	EQ7	Delivery of equipment	[13 & 14]
8	EQ8	Insufficient number of equipment	[12]
9	EQ9	Equipment availability	[12]
10	EQ10	Equipment allocation problem	[12]

3. Methodology

Data was collected through 48 questionnaires, 19 interviews and 10 site visits. The collected data was analyzed using MS Excel 2013, and SPSS software. The choice of sample size depends upon:

- The confidence required for the data i.e. the level of certainty that the characteristics of the data gathered will represent true population.
- The margin of error that can be tolerated i.e. accuracy required for the estimates made from the sample.
- Size of the Population

In this research the sample size is calculated by empirical formula [15]:

$$Ns = (Np \times P \times (1-P)) / ((Np-1) (B/C)^2 + P \times (1-P))$$

Where

N_s =Sample size

N_p =Population size

P =Proportion of the population that is expected to choose one of the response categories; $P = 0.5$

B =acceptable sampling error; ($\pm 10\%$ or ± 0.10)

C =Z statistic associated with the confidence level

(1.645 corresponds to 90% confidence level)

Questionnaire and site based survey carried out through structured questionnaire from the professionals' of construction industry of Pakistan. A total of 170 questionnaire sets were distributed to professionals as the targeted population for the research, containing 32 Employer personnel, 53 Consultants and 75 Contractors working on various construction projects in Pakistan. Out of 160 respondents, 77 of them filled the questionnaire survey which was considered valid for the analysis. Table 2 shows a response rate of 48%.

All these respondents were amply qualified and experienced in the Pakistan construction industry. Around 45% of the respondents had accumulated over 15 years of relevant experience, about 30% having 10-15 years' experience, about 15% having 5-10 years' experience and 10% having less than 5 years' experience in the construction industry. Therefore the information provided by these professionals was considered were authentic and reliable. The category wise distribution is shown in Table 2.

Table 2: Responses to the questionnaire

Respondent	Questionnaires sent	Questionnaires received	Response rate (%)
Employer	32	19	59
Consultants	53	26	49
Contractors	75	32	43
Total(Overall)	160	77	48

There were 77 questionnaires returned out of 160 showing a response rate of 48%. Owen and Jones (1994) revealed that an average of 20% of questionnaires returned is considered satisfactory. Thus, the response rate in this research is highly acceptable.

3.1. Respondent's Background

The population targeted was professional working on construction projects in the national and multi-national

organizations belonging to different ages in Pakistan. It is obvious that Eighty percent (80%) of the respondents were having experience ten (10) years or more, shown in Figure 1

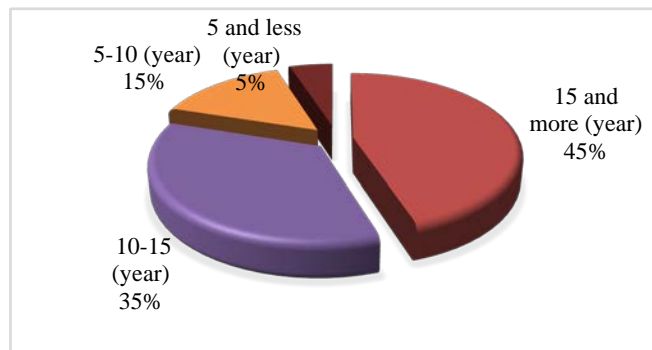


Figure 1: Respondent's experience (years)

The respondents were approached over the internet and personal meetings depending upon the availability and location of the projects. These respondents were belonged to all the three parties i.e. client, consultant and contractor. The occupational background of the respondents is shown in the Figure 2.

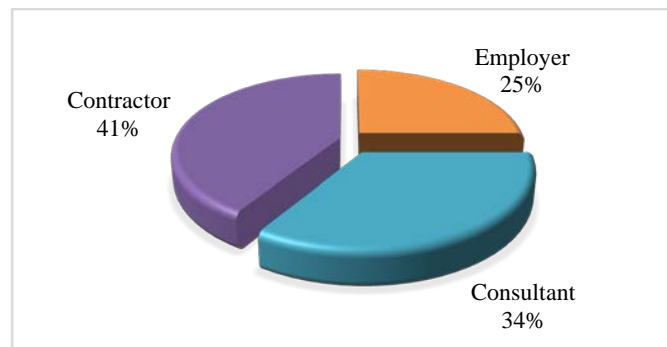


Figure 2: Occupational background of respondents (%)

4. Results and Discussion

4.1. Reliability:

Reliable measurement is the repetition of any measurement that produces the same result. Cronbach's Alpha value range from 0 to 1 with 0.75 being considered the most sensible value [16]. Guide line provided by them to assess the reliability of any data as shown in the Table 3.

Table 3: Guideline for assessing reliability results

S. No	Range	Reliability
1	0.9 and above	Excellent
2	0.7 – 0.9	High
3	0.5 - 0.7	Moderate
4	0.5 and below	Low

Since the data collected was based on Likert-scale; therefore to check reliability of the research Cronbach’s Alpha method was used. Its value was found to be 0.812 which showed high reliability of the data.

4.2. Ranking:

To assess the likelihood of each identified factor in the construction projects five point likert-scale of 1-5 was used, where scale of 1= strongly disagree, 2= disagree, 3 = neutral, 4= agree and 5 = strongly agree. All the respondents were asked to rank each factor as per degree of importance. The identified factors were then ranked on the basis of Relative Importance Index (RII). The equation used for RII is

$$RII = \frac{\sum(P_i * U_i)}{N * n} \quad [17]$$

Where,

P_i = Respondent’s rating

U_i = Number of respondents placing identical rating

N = Sample size

n = Highest value on Likert scale

The RII for all factors was calculated by above formula. One hundred sixty (160) construction professionals were approached for this research work. Out of one hundred sixty (160), seventy seven (77) valid responses were collected. Overall ranking of machinery management factors are shown in the Table 4.

There are total ten factors identified from literature review for machinery management group as shown in Table 1. A frequent equipment breakdown (EQ6) was ranked first among ten machinery management factors, with relative importance index of 0.90. Maintenance of equipment (EQ2) and was ranked second, with RII of 0.86, Insufficient number of equipment (EQ8) was ranked 3rd with RII value of 0.85, Performance of Equipment was ranked 4th (EQ5) while inadequate modern equipment was ranked 5th (EQ3) with RII value of 0.73 among all 10 factors of machinery management.

Table 4: Overall ranking of 10 Factors

Sr. No	Code	Machinery Related Factor	RII Value
1	EQ6	Frequent equipment breakdowns	0.90
2	EQ2	Maintenance of equipment	0.86
3	EQ8	Insufficient number of equipment	0.85
4	EQ5	Performance/ efficiency of equipment	0.83
5	EQ3	Inadequate modern equipment	0.73
6	EQ9	Equipment availability	0.71
7	EQ7	Delivery of equipment	0.69
8	EQ1	High cost of equipment	0.67
9	EQ4	Lack of new technologies / methodologies	0.65
10	EQ10	Equipment allocation problem	0.61

5. Conclusions / Recommendations:

Aim of this research work to identify factors affecting, machinery of resource management and to recommend measures for improvement / better utilization of machinery in construction industry of Pakistan. Based on results and conclusion / proffered recommendations of this study are as under:

- Frequent Equipment Breakdown was the top most critical factor identified, it is recommended that condition of equipment should be thoroughly checked up before the mobilization of Equipment on site so that it may not disrupt the progress of work.
- 2nd top ranked factor was related to the maintenance of Equipment. In Pakistan no special care is given to the maintenance of Equipment and it is run badly without regular checkups. Equipment maintenance should be done on regular basis and after one month it should be checked from High specialized workshop in order to maintain and increase the life of equipment.
- Based on results 3rd most important factor was insufficient number of Equipment available with the Contractor. It is recommended that before award of Contract, qualification criteria should be setup strictly with the project requirements and sufficient number of equipment must be ensure then Project should be awarded to that Contractor which found satisfactory with project requirements.
- Performance / efficiency was also ranked higher among the top factors. Equipment efficiency should be calculated before bringing the Equipment on site. Results of Equipment efficiency should be thoroughly checked up by Employer and those Equipment whose average frequency is less than 70% should not be recommended for the projects.

- It is also recommended that all the old and outdated Equipment should be disposed off and modern equipment must be purchased by the Contractor in order to smoothly run the Projects.

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