

# A CRITICAL LITERATURE REVIEW ON FACTORS AFFECTING IN SELECTION OF CONSTRUCTION EQUIPMENT

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## **ABSTRACT**

*Purchasing with cash, financing through a loan, renting and leasing are four most common ways which are mainly affected by different construction equipment selection factors. For having the best result in profit for a construction industry choosing the best alternative for obtaining equipment is one of the most important issues. The optimum acquisition strategy comes from accurate estimates of revenues and cost and also some non-financial factors that effect on selection of appropriate equipment. The purpose of this paper is to evaluate these factors. The identification of the factors that effect on equipment selection has been carried out using different literatures and by interviewing from experts in construction. This paper has been planned to deal with identification of factors affecting equipment selection, developing a framework for assessing the factors affecting equipment selection. A framework has been developed, which will be used for the future research in this area.*

**Keywords:** *Construction Equipment, Factors Effecting In Selection.*

## **I. INTRODUCTION**

Equipment selection is a critical factor in the execution of many construction projects. This is to be much more critical in heavy construction projects where the equipment fleet plays a vital role in performing the work. In this type of projects, the equipment fleet may represent the largest portion of the bidding price. Consequently, successful contractors and construction managers understand the substantial impacts on their projects when equipment management decisions are not made in a proper and timely manner. Since equipment selection is highly influenced by myriad factors, most contractors tend to rely upon their historical data and experience in similar projects to assist them in determining the optimum fleet. While this is a good approach at the conceptual stages of the project, it is not sufficient to build the equipment fleet benchmark due to the dynamic nature of construction projects. Other approaches such as expert systems could be useful if only integrated with a database of historical data. To overcome this shortcoming, the proposed model is being developed based on integrating manufacture's data for selected pieces of equipment with a comprehensive economical operation analysis for different scopes of earthwork operations. At this stage, however, the developed model includes an optimization of equipment fleet based on simple economical operation analysis.

## II. INVESTIGATION OF LITERATURES FOR CONSTRUCTION EQUIPMENT SELECTION

**Nichols et al. (1976)** proposed a method of estimating repair costs that consisted of multiplying a number of factors times a multiple of the initial purchase price of a machine. These factors took into account type of equipment, total hours of use, years of useful life, temperature, work conditions, maintenance, quality, type of use, operator style, equipment quality, pace of work, and luck. In Nichols's model, repair costs increased with the use of the machine. [1]

**Nunnally et al. (1977)** stated that equipment selection is a critical factor in the execution of many construction projects. This is to be much more critical in heavy construction projects where the equipment fleet plays a vital role in performing the work. In this type of projects, the equipment fleet may represent the largest portion of the bidding price.[2]

**Mayer and Stark et al. (1981)** suggested that unit costs of operations that are affected by factors such as the experience of the operators, condition of equipment, type of soil, and team composition. Therefore, they vary throughout the project, and the use of static values is not consistent with jobsite realities. [3]

**Tavakoli et al. (1985)** described that equipment productivity is a key factor that enables contractors to make a decision regarding the project scheduling, fleet selection, and project costs. Most contractors rely on their historical data and previous projects to obtain the productivity of selected equipment.[4]

**Vorster et al. (1987)** suggested to use failure cost profiles for consequential costs of equipment failures and incorporated into the equipment cost model for equipment replacement.[5]

**Alwood et al. (1989)** stated that equipment selection is a critical factor when trying to complete a project within budget and on schedule. Without the proper working equipment, productivity decreases, delays increase, possible injuries occur, and unnecessary costs are incurred.[6]

**Chan et al. (1989)** has established a database application for the equipment selection. In their spreadsheet, they have used technical criteria for the selection of best backhoes and loaders during earth moving operations.[7]

**Tavakoli et al. (1989)** described that equipment selection is a critical factor in construction projects. Rational selection of equipment leads to profits for contractors. At the same time, miscalculating the proper size and number of fleets required for the project may result in losing the contract or suffering from overhead costs.**Marzouk et al. (2004)** therefore stated that, contractors consider selection of equipment fleet a vital factor for any construction project to be successful.[8][9]

**Amirkhanian et al. (1992)** developed an expert system model for equipment selection in earthmoving operations. As part of developing the expert system, a rule-based expert system was used for selecting earthmoving equipment. The system was developed to interpret data pertaining to soil conditions, operator performance, and volume required for the earthmoving operations.[10]

**Norris et al. (1995)** found that the characterization of the equipment selection process as an essentially multifaceted problem involving numerous, variegated considerations, often with complex trade-offs among them, implied that a suitable solution method might be found among the family of multiattribute-decision-analysis MADA methods.[11]

**O'Brien et al. (1996); Schaufelberger et al. (1999); Nunnally et al. (2000); Harris et al. (2001); Peurifoy et al. (2006)** described that selecting the right equipment has always been a key factor in the success of any construction project; this is even more so in today's complex, highly industrialized projects.[12][13][14][15][16]

**Haidar et al. (1999)** split the equipment selection process into knowledge based and optimization genetic algorithms. The former part involves procedures that screen the desired equipment from the list based on subject knowledge whereas the later one refines the selection on the basis of criteria. These criteria include production rate, ownership cost, operating cost, equipment characteristics along with manufacturer, model, number and operating life.[17]

**Schaufelberger et al. (1999)** stated two general factors that should be considered in the process of selection of equipment fleet: (a) cost effectiveness; which involves considering the size of equipment besides the proper type; and (b) versatility; which involves selecting equipment that can perform multiple tasks at the site work.[13]

**Schaufelberger et al. (1999)** stated that with the growing industrialization and mechanization, this is getting even more important and complex for companies to assess and make the best decision from the pool of many alternatives.[13]

**Lotker et al. (2000)** stated that there are varieties of factors that a good manager should consider in acquiring the equipment. These factors are both financial and non-financial. A good construction manager should identify these factors and by evaluating them decision making is possible.[18]

**Chan et al. (2001)** have developed evaluation criteria for the selection of material handling equipment. Their research work identified performance measure, technical, economic and strategic aspects as the evaluation criteria.[19]

**Schenayder et al. (2002); John et al. (2009)** stated that construction firms are often faced with problems related to high rate of equipment failure or breakdown and accident resulting from unskilled operator's abuse. Poor training of equipment operators is often claimed as a major cause of equipment related accidents.[20][21]

**Bascetin et al. (2003)** has established a decision support system by using qualitative and quantitative factors for the selection of open pit mining equipment. He classified the selection criteria into cost and operational technical requirements.[22]

**Shapira et al. (2005)** described that conclusions were further supported by findings of a field survey conducted among successful project managers with experience in the construction of sizable, complex projects.[23]

**Shapira et al. (2005)** studied that, a list of tangible (hard) and intangible (soft) factors were identified. The tangible factors include technical specifications, site conditions and cost consideration. The intangible factors are qualitative and include safety considerations, company policies regarding equipment acquisition, market conditions and environmental constraints. It is an important aspect that this research work raises the issue of soft consideration in the selection of construction equipment in building projects.[23]

**Vorester et al. (2005)** found out that during the execution phase, construction equipment and machineries worth is approximately 30% of the total company assets.[24]

According to **Gransberg et al. (2006)**, the first factor to consider would be matching the right equipment to the proper type of activity. Another factor would be the availability of the right equipment with proper service, maintenance, and repair reserves.[25]

**Gransberg et al. (2006)** proposed two factors that can be considered when selecting proper equipment: (i) type and condition of the site work; which includes the distance to be traveled; and (ii) desired productivity; which is a critical factor that affects equipment selection.[25]

**Gransberg et al. (2006)** stated that selection of equipment is typically made by matching equipment in a fleet with tasks. Such matching accounts for equipment productivity, equipment capacity, and cost.[25]

**Gransberg et al. (2006)** stated that industrial and heavy construction projects required intense and high utilization of machinery for carrying out mass excavation, stabilizing, compacting, asphalt paving and finishing, pipelines, railroads and many other special activities.[25]

**Peurifoy et al. (2006)** stated that the complexity of today's building projects makes it harder to evaluate equipment alternatives and make the right selection from many alternatives.[26]

**Tatari et al. (2006)** stated that the primary agenda of equipment selection process is to achieve higher productivity, more operational flexibility and viable economic considerations. The past research shows that the appropriate selection of equipment has always been considered as a strategic decision during the construction phase of any project.[27]

**Tatum et al. (2006)** found that proper use of appropriate equipment contributes to economy, quality, safety, speed and timely completion of the project.[28]

**Yeo et al. (2006)** shows in past research that the acquisition of heavy equipment constitutes 36% of the total project cost and possesses high risk and uncertainties for the owners.[29]

**Schexnayder et al. (2009)** concluded that the cost and time that exceed the designated budget or schedule on projects are often resulted from poor equipment maintenance practice.[30]

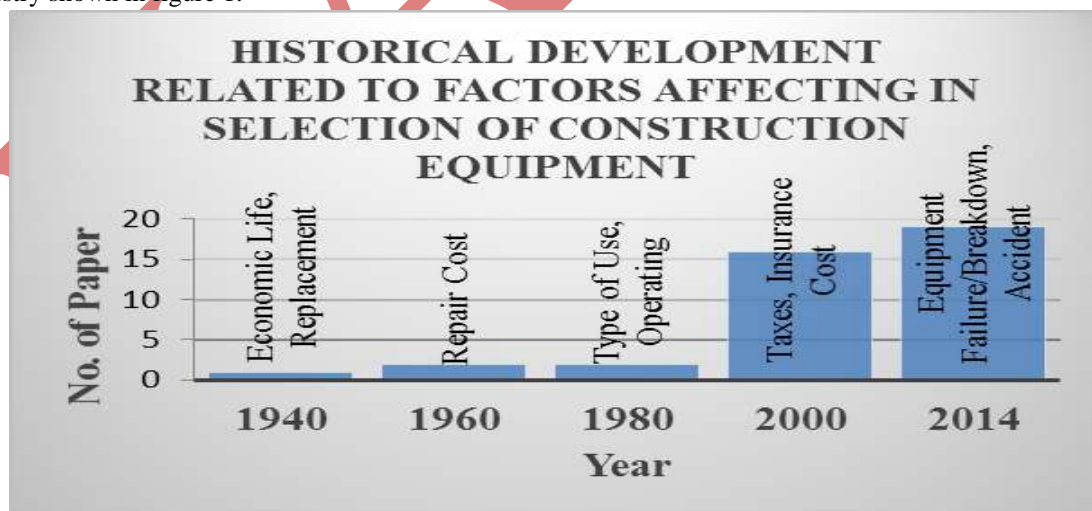
**Schexnayder et al. (2009)** found that, equipment maintenance has not been given appropriate attention and this contributes to about 40% of total construction project cost overrun.[30]

**Avetisyan et al. (2012)** stated that equipment categorization, age and horsepower and as well as type of fuel used, can greatly affect rates of emissions .[31]

**Chamzini et al. (2012)** have identified the nine point criteria and classified them into two broad categories i.e. benefit criteria based on technical performance and cost criteria.[32]

**Chinchore et al. (2014)** stated that selection is a process in which the equipment that is most suitable for a particular job is found out. And decision is made regarding the make of the equipment to be procured.[33]

Based on previous research review, historical development related to Selection of Equipment for construction industry shown in figure 1.



**Fig. 1: Historical Development Related To Factors Affecting In Selection of Construction Equipment**

After identifying these factors, an integrated framework for assessing the factors affecting the equipment selection was developed, which contained main 2 groups containing 10 sub-groups which containing 53 factors. This framework, shown in figure 2(Financial factors) & figure 3(Non-financial factors) shall be used for future research work.

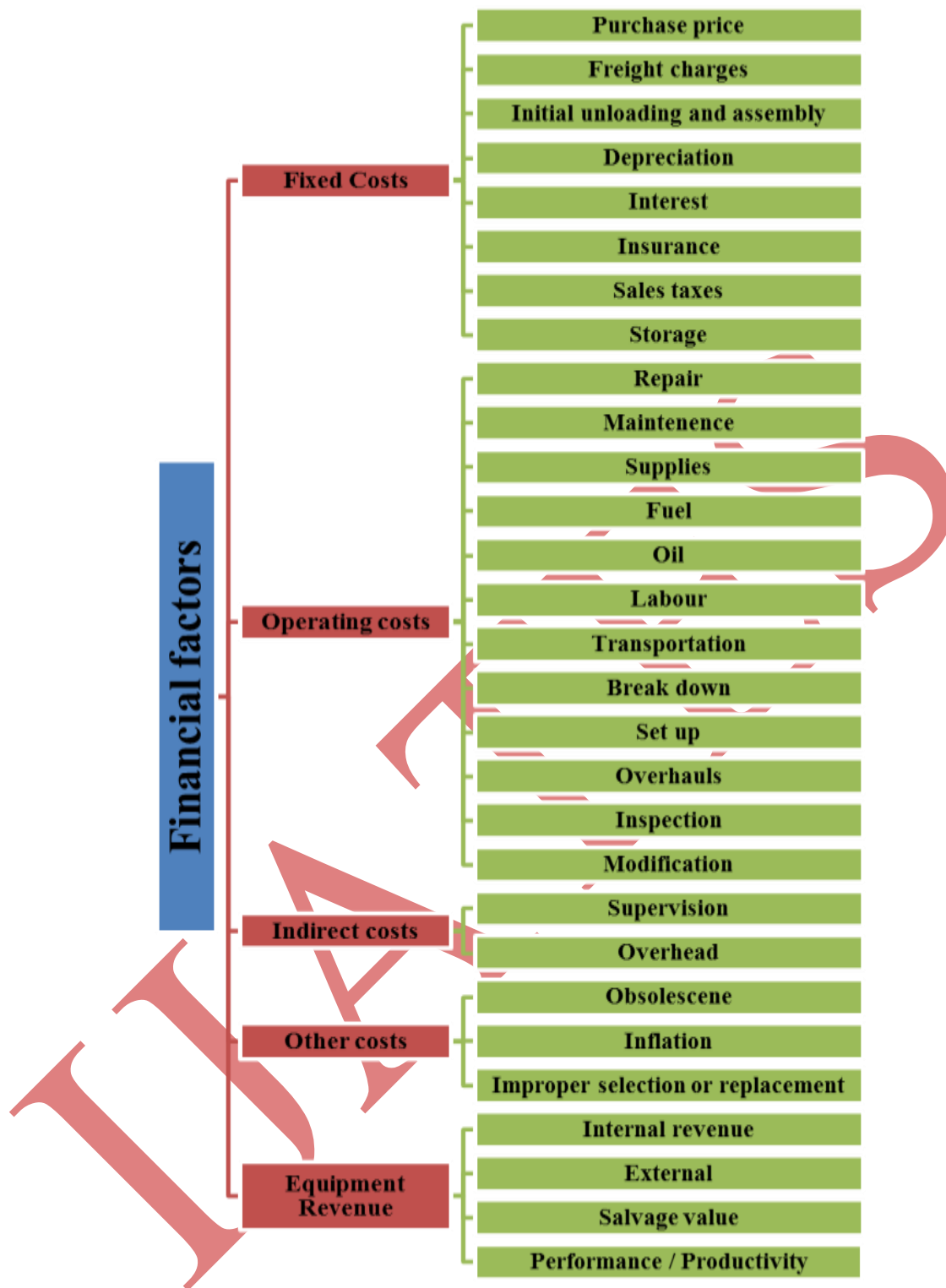


Fig. 2: Integrated Framework for Assessing Financial Factors Affecting Equipment Selection

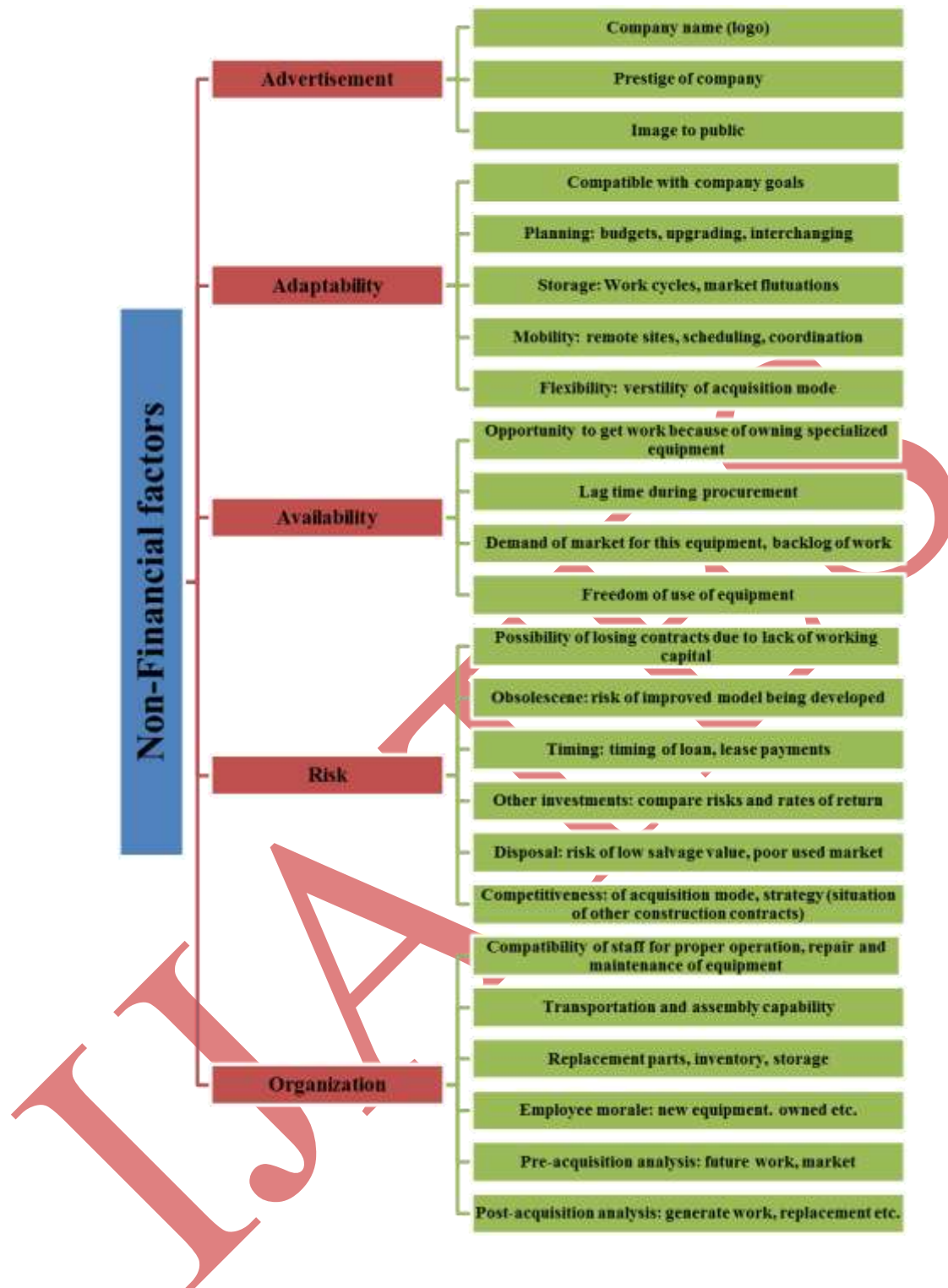


Fig. 3: Integrated Framework for Assessing Non-Financial Factors Affecting Equipment Selection

### III. CONCLUSION

1. Repair costs are affected by type of equipment, total hours of use, years of useful life, temperature, work conditions, maintenance quality, type of use, operator style, equipment quality, pace of work, and luck. In Nichols’s model, repair costs increased with the use of the machine.[1]

2. Equipment selection is a much more critical in heavy construction projects where the equipment fleet plays a vital role in performing the work. In this type of projects, the equipment fleet may represent the largest portion of the bidding price.[2]
3. Equipment productivity is a key factor that enables contractors to make a decision regarding the project scheduling, equipment selection, and project costs.[4]
4. Equipment selection is a critical factor when trying to complete a project within budget and on schedule. Without the proper working equipment, productivity decreases, delays increase, possible injuries occur, and unnecessary costs are incurred.[6]
5. Technical criteria should be used in the selection of proper equipment.[7]
6. Equipment selection is a critical factor in construction projects. Rational selection of equipment leads to profits for contractors. At the same time, miscalculating the proper size and number of fleets required for the project may result in losing the contract or suffering from overhead costs.[8]
7. Equipment selection criteria include production rate, ownership cost, operating cost, equipment characteristics along with manufacturer, model, number and operating life.[17]
8. Two general factors that should be considered in the process of selection of equipment fleet: (a) cost effectiveness; which involves considering the size of equipment besides the proper type; and (b) versatility; which involves selecting equipment that can perform multiple tasks at the site work.[13]
9. There are varieties of factors that a good manager should consider in acquiring the equipment. These factors are both financial and non-financial.[18]
10. A decision support system should be used qualitative and quantitative factors for the selection of equipment.[22]
11. Construction equipment and machineries worth is approximately 30% of the total company assets.[24]
12. First factor to consider would be matching the right equipment to the proper type of activity. Another factor would be the availability of the right equipment with proper service, maintenance, and repair reserves.[25]
13. Two factors that can be considered when selecting proper equipment: (i) type and condition of the site work; which includes the distance to be travelled; and (ii) desired productivity; which is a critical factor that affects equipment selection.[25]
14. The Primary agenda of the equipment selection process is to achieve higher productivity, more operational flexibility and viable economic considerations.[27]
15. Proper use of appropriate equipment contributes to the economy, quality, safety, speed and timely completion of the project.[28]
16. Cost and time that exceed the designated budget or schedule on projects have often resulted from poor equipment maintenance practice.[30]
17. If equipment maintenance has not been given appropriate attention and this contributes to about 40% of total construction project cost overrun.[30]

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