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Research Article

Assessment of Hire Rate Analysis of Heavy Equipment in Nepal

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A B S T R A C T

The purpose of the study was to analyze the hire rate of heavy equipment used in road construction of Nepal and work out appropriate and standard hire rate. Information about heavy equipment market was identified through a structured questionnaire that was asked to machine owners, Heavy Equipment Entrepreneur's Association of Nepal (HEAN) members and authorized dealers of machines; group discussion with related personnel; and reports and publications of HEAN, Department of Road (DOR) and Department of Transport Management (DOTM). The data analysis was done by using a trend projection for estimation of operating cost. Hire rates of Excavator/ Komatsu PC210, Excavator/ JCB JS205, Excavator/ KomatsuPC130, Grader/ KomatsuGD511, Track Dozer/ KomatsuD39Ex, Backhoe Loader/ JCB 3DX, Loader/ JCB 432ZX and Vibrating Roller/ JCB VM1158 were det ermined on the basis of owning and operating cost method. Hire rates of eight different machines were determined which was found to be nearly 20 percentage higher than hire rate of DOR equipment; this is because DOR did not add profit for operation. Calculated scientific hire rate was recommended to HEAN to practice in market that will make their investment safe and generate more profit all the time. Record keeping of data related to maintenance cost, machine utilization, and revenue generated from hire were found to be very poor with machine owner. So it is proposed to practice standard format which has been developed to suit our condition for better record keeping.

Keywords: Hire Rate, Heavy Equipment, Construction, DOR, DOTM

Introduction

Value management practice is a highly recommended practice for project and production operation management in developed countries as an effective competitive tool also. 'Lack of trained professionals on VM' is the main reason for non-implementation.[23] Performance of construction is not satisfactory in terms of time in Nepal.[15] Contractors don't provide health facilities at the construction site for casual workers. They are compelled to work without proper sanitary facilities, safe drinking water, proper catering service, and other facilities. Employees think that health-related facilities are lacking in the site.[17] In this situation, equipment management is a big issue for the country without value management. Heavy equipment industry is one of those sectors which have a significant share on the national economy. In spite of all these facts, this sector is suffering from lots of irregularities, inequalities, and insufficient support of the related sector. There is no uniformity in hire rate charged by hiring firms, who do not use scientific method to determine hire rate that they charge. They charge hire rate on the basis of hire rate published by department of road, or on their own convenience. Some of the hiring companies lease their

equipment even at a lower price than what it should be, resulting in financial loss. Despite the huge amount of investment in heavy equipment, investor generally did not determine hire rate on the basis of their owning and operating costs during the life of the equipment. The study helps to determine realistic hire rate and helps firms to have hire rate scientifically based and ensure their return on investment.

Rationale of the Study

Good performance of any construction project implies that it is free from defects, right things at right time and the continuous improvement of the project.[20] The study conducted by Maskey and Mishra[13] showed that time spent by skilled and unskilled labor in productive work was 56.92% and 55.74% respectively. It means rest of their time remained unused. So it needs to manage all level of workforce effectively for high performance of the industry. Mishra and Rai[14] also compared different types of buildings and found performance should improve. The results conducted by Mishra and Magar (2017) showed that 72,631 mandays were involved in Financial Year (FY) 2010/11 for four road construction projects and the number increased by 421,863 in FY 2012/13. At the end of Phase-IV (FY 2013/14), in total 790,172 mandays were involved in construction, which means high level of employment generation. NRs. 681,515,657 was spent in Phase-IV and most of the amount went to workers' hands in cash. According to a study conducted by Mishra and Acharya[22] at Salyankot Water Supply Project (SWSP) was found satisfactory (56.81%) and good (95%) based on physical structure index after and before earthquake respectively. The current management system was not found satisfactory. It was having low practice of gender equity and social inclusion (GESI). In Water User and Sanitation Committee (WUSC) meeting and team formation, only the vital persons of the user committee were found active and general assembly meeting had not been held for over 6 years. So, to overcome problem of performs might be improved through the recommendation of this study is expected to helpful not only to HEAN but also to other hiring firms to determine the scientific hire rate. All empirical findings and analyses will be disseminated and made available to the HEAN and private hiring business firms in order to increase the credibility of the research. The recommendation of this study is expected to be helpful to the HEAN and private hiring business firms to apply the scientific hire rate.

Objective of the Study

The overall objective of this study was to analyze the hire rate of heavy equipment used in road construction of Nepal.

Literature Review

Introduction about Hire Rate

A lease is a contract whereby the owner of the capital asset (the lessor) grants to another party (the lessee) the exclusive right to use the asset in return for the payment of rent.[8] Equipment hire rate, also called equipment rental rate, is an agreed sum or rate to be paid by the lessee for the use of the equipment for a limited period of time. It should cover owning cost and operating cost, and also generate profit for the company. Hire rates for a given machine can vary widely because they are influenced by many factors like the type of work the machine does, local prices of fuel and lubricants, shipping costs from the factory, interest rates, etc. Setting a realistic hire rate is a challenging task, particularly in the times of rapid inflation, factors largely outside the control of the company make it almost impossible to forecast the scrap value, the utilization factor, and running cost during the life of the equipment.

Equipment Life

Construction equipment life can be defined in three ways: physical life, profit life, and economic life.[6] Figure 1 shows graphically how these different definitions relate to the life cycle of a typical piece of equipment.

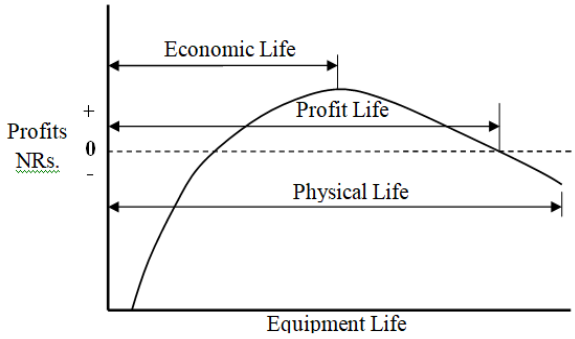


Figure 2.Equipment Life[6]

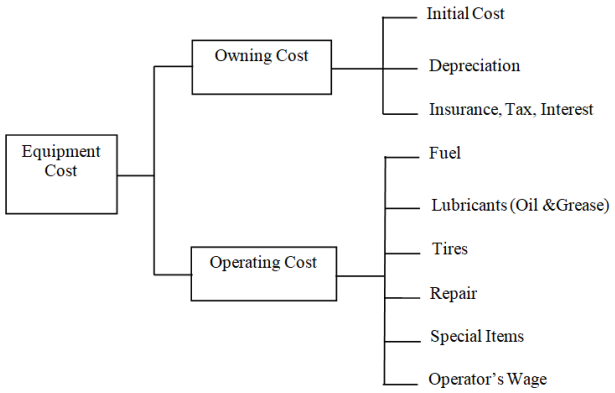
The physical life of equipment will be identified as the service life. This time period ends when equipment can no longer be operated.[5] Profit life is the time period when equipment is generating a profit. This is the most desired stage of the equipment life, because after this point in time the equipment will operate with a loss.[6] Economic life is based on decreasing ownership costs with the increase in operating costs.[10] The time period that these costs are equivalent to is called the economic life. When the operating costs exceed the ownership costs, a piece of equipment is costing more to operate rather than own.

Life Cycle Cost

The Life Cycle Cost (LCC) of equipment is the total cost throughout its life including purchase price, installation, operation, maintenance and any other costs directly attributable to owning and using the asset. Life cycle cost involves identifying and quantifying all costs related to the entire life of a piece of equipment instead of a specified shorter period.[3] The historical record of costs incurred and

the historical record of services obtained from a piece of equipment permit the calculation of the equipment's life cycle cost.[4]

LCC=Operating Cost+Ownership Cost.



Cost of the Machine

Along with the trend for mechanization adopted for economical and satisfactory job accomplishment, equipment costs now occupy a large proportion of the overall construction cost. Therefore, the estimation of the equipment costs has become more important. Success or failure in a contract for a construction job is virtually dependent on the estimates of the equipment costs. In other words, careful consideration of the equipment costs is of prime importance, if a contractor is to fulfill the contract at a profit. Unless estimates are made properly, there will occur cases where a construction job cannot be accomplished at a profit. There are two types of equipment costs: owning costs and operating costs,[9] as shown in Fig. 2. As the equipment ages, the ownership costs decrease and the operating expenses increase as the maintenance and repair requirements grow. Both private and public entities desire to manage this high dollar investment for optimization of a perceived profit.[5]

Owning Cost

The equipment-owning cost is the expense required, as a matter of course, for the purchase and possession of the equipment as a property of its owner.[9] Owning costs refer to the costs incurred even if the machine is not working. Ownership costs are fixed costs and annual in nature.[6] Ownership costs would include initial costs, depreciation, insurance, taxes, storage, and investment costs.[11]

Initial Cost

Initial cost is paid for getting equipment into the contractor's yard, or construction site, and ready for operation. Initial cost consists of the following items: price at factory, extra equipment sales tax, shipping, assembling, and erection.[5] On an average, initial cost makes up about twenty five percent of the total cost that will be invested during the equipment's useful life.[6]

Depreciation

Depreciation is the loss of value resulting from usage or age.[7] A contractor normally recovers this loss by including a sum of money equivalent to the depreciation cost in his rates for doing the work or hiring out the machine. Depreciation is the loss of value of equipment between the time it is retired or replaced. The value of the asset decreases because of such factors as obsolescence and decrease of value of used equipment, or reduced need. In simple terms, depreciation is an allocation of the cost of the equipment over its estimated useful life in systematic and rational manner. When the accumulated depreciation equals the original cost (minus salvage value), no further depreciation is accrued.[1] Among many depreciation methods, the straight-line method, double-declining balance method, and sum-of-years'-digits method are the most commonly used in the construction equipment industry.[6]

Interest

Interest is considered to be the cost of using capital. If borrowed funds are utilized for purchasing a piece of equipment, the equipment cost is simply the interest charged on these funds. However, if the equipment is purchased with company assets, an interest rate that is equal to the rate of return on company investment should be charged.[5] Many owners charge interest as part of hourly owning and operating costs, others consider it as general overhead in their overall operation. When charged to specific machines, interest is usually based on the owner's average annual investment in the unit. If the machine's useful life (N), the average annual investment during the use period, apply the interest rate and expected annual usage are given, then the average hourly base interest charge can be calculated by using following formula:[2]

$$\text{Interest} = \frac{\left[\frac{N+1}{2N} \text{ X Delivered Price}\right] \text{ X Simple Interest \% Rate}}{\text{hours/ Year}}$$

Insurance and Tax

Insurance cost represents the cost incurred due to fire, theft, accident, and liability insurance for the equipment.[6] Tax cost represents the cost of property tax and licenses for the equipment.[5] Insurance cost and property taxes can be calculated in one of the two ways. If the specific annual cost is known, this figure should be divided by the estimated usage (hours/years) and used. However, when the specific interest and tax costs for each machine are not known, the following formulas can be applied:[2]:

$$\text{Insurance} = \frac{\left[\frac{N+1}{2N} \text{ X Delivered Price}\right] \text{ X Insurance Rate \%}}{\text{hours/ Year}}$$

$$\text{Property Tax} = \frac{\left[\frac{N+1}{2N} \text{ X Delivered Price}\right] \text{ X Tax Rate \%}}{\text{hours/ Year}}$$

Where N=Machine's useful life

Operating Cost

Operating costs are the costs incurred in actually operating the machine. The equipment operating costs are proportional to the time that the equipment works. Operating costs of the equipment are also called "variable" costs because they depend on several factors such as the number of operating hours, the types of equipment used, and the location and working condition of operation.[5] Items considered in this category are fuel, lubricants (oil and grease), filters and periodic maintenance labor, tires, repair cost, special items (ground engaging tools), and wages.[9] The best basis for estimating the cost of operating construction equipment is the use of historical data from the experience of similar equipment under similar conditions. If such data is not available, recommendations from the equipment manufacturer could be used.[6]

Fuel Cost

Fuel consumption is incurred when the equipment is operated. Fuel cost is the cost of fuel consumed during operation of the machine.[2] When operating under standard conditions, a gasoline engine will consume approximately 0.06 gal of fuel per flywheel horsepower hour (fwhp-hr), while a diesel engine will consume approximately 0.04 gal per fwhp-hr.[11]

Fuel consumption can be closely measured in the field. However, if no opportunity exists to do this, consumption can be predicted when the machine application is known. Fuel consumption table in different working conditions can be taken from manufacturer's hand books. The hourly cost of fuel is estimated by multiplying the hourly fuel consumption by the unit cost of fuel:[5]

Hourly Fuel Cost=Hourly fuel consumption*Local unit price of fuel

Lubricant Cost

The quantity of oil required by an engine per change will include the amount added during the change plus the make-up oil between changes. It will vary with the engine size, the capacity of crankcase, the condition of the piston rings, and the number of hours between oil changes.[5] It is a common practice to change oil every 100 to 200 hrs.[11] The consumption data or average cost factors for oil, lubricants, and filters for their equipment under average conditions are available from the equipment manufacturers. Another way to estimate the quantity of the lubricant required per hour can be calculated by using following formula:[9]

$$\text{Hourly fuel consumption} = \frac{\text{Oil replacement amount (liters)}}{\text{Oil change interval (hour)}}$$

Tire

The tire cost represents the cost of tire repair and replacement. The life expectancy of rubber tires is generally far less than the life of the equipment they are used on, so tire cost is taken separately than equipment.[6] Tires are in the category of consumable parts and tires are generally expensive. Therefore, it is better to include the tire cost as an individual item in the operating cost. Tire cost is calculated by the following formula:[9]

$$\text{Hourly tire cost} = \frac{\text{Tire Price}}{\text{Estimated Life}}$$

Repair Cost

To keep a machine in a properly maintained condition, wearing components or parts must be replaced. It is natural for the repair cost of a machine to start from a small amount and gradually increase with time as the machine is operated.[5] Repair costs are more greatly affected by the machine operating conditions than by any other cost items. It depends greatly on the job, operating techniques or operator's skill, proper maintenance, etc. In a specific job application, calculation for repair cost should be made on the basis of the data accumulated in the past. If such data is not available, the calculation should be made with due consideration of experience. Another way to estimate the annual cost of maintenance and repairs may be expressed as a percentage of the annual cost of depreciation or it may be expressed independently of depreciation. The hourly cost of maintenance and repair can be obtained by dividing the annual cost by its operating hours per year.[6]

Special Wear Items

Special items are also referred to as high-wear items such as cutting edges, ripper bits, shanks, teeth, body liners, router bits, etc. and welding costs on booms and sticks.[3] These equipment pieces are typically disposable or expendable and are designed to be replaced as needed. These costs will vary widely depending on applications, materials, and operating techniques.

Operator Allowance

This covers the allowance given to the operator and his helper, if there is one, for the hours the machine actually operates at the construction site.[1] This is an intensive for the operator to be motivated to operate the machine for longer hours in a shift and also work overtime beyond the regular hours of operation. This item should be based on local wage scales and should include the hourly cost of fringe benefits.

Methods of Calculating Ownership and Operating Cost

The most common methods available for calculating ownership and operating costs are as follows:[6]

- Caterpillar method
- Corps of Engineers method
- Associated General Contractors of America (AGC) method
- Peurifoy/ Schexnayder method

Caterpillar Method

- The Caterpillar method is based on the following principles:[2]
- No prices for any items are provided. For reliable estimates, these must always be obtained locally.
- Calculations are based on the complete machine. Separate estimates are not necessary for the basic machine, dozer, control, etc.
- The multiplier factors provided will work equally well in any currency expressed in decimals.
- Because of different standards of comparison, what may seem a severe application to one machine owner may appear only average to another. Therefore, in order to better describe machine use, the operating conditions and applications are defined in zones.

Ownership Cost

These costs are calculated for depreciation, interest, insurance, and taxes. Usually depreciation is done to zero value with the straight line method, which is not based on tax consideration, but resale or residual value at replacement may be included for depreciation or tax incentive purposes. Service life of several types of equipment is given in the Caterpillar Performance Handbook.[2] Acquisition or delivered costs should include costs due to freight, sales tax, delivery, and installation. On rubber-tired machines, tires are considered a wear item and covered as an operating expense. Tire cost is subtracted from the delivered price. The delivered price less the estimated residual value results in the value to be recovered through work, divided by the total usage hours, giving the hourly cost to project the asset's value. The interest on capital used to purchase a machine must be considered, whether the machine is purchased outright or financed. Insurance cost and property taxes can be calculated in one of two ways.[5]

Operating Cost

Operating costs are based on charts and tables in the handbook. They are broken down as fuel; filter, oil, and grease (FOG) costs; tires; repairs; special items; and operator's wages. The factors for fuel, FOG, tires and repairs costs can be obtained for each model from tables and charts given in the Caterpillar Performance Handbook.[2] Tire costs can be estimated from previous records or from local prices. Repairs are estimated on the basis of a repair factor that depends on the type, employment and capital cost of the machine. The operator's wages are the local wages plus the fringe benefits.

Corps of Engineers Method

Corps of Engineers method covers both economic items and geographic conditions. This method generally provides hourly use rates for construction equipment based on a standard 40-hour workweek. The total hourly use rates include all costs of owning and operating equipment except operator wages and overhead expenses. The ownership portion of the rate consists of allowances for depreciation and costs of facilities capital cost of money (FCCM). Operating costs include allowances for fuel, filter, oil, grease, servicing the equipment, repair and maintenance, and tire wear and tire repair.[5]

Ownership Cost

- Depreciation: It is calculated by using the straight-line method. The equipment cost used for depreciation calculation is subtracted by tire cost at the time the equipment was manufactured. Another cost that has to be subtracted is salvage value. It is determined from the Handbook of New and Used Construction Equipment Values (Green Guide), and advertisements of used equipment for sale displayed in current engineering and construction magazines. The expected life span of the equipment is designated from the manufacturers' or equipment associations' recommendations.
- To Facilitate Capital Cost of Money (FCCM), the Department of the Treasury adjusts the cost-of-money rate on or about January 1st and July 1st each year. This cost is computed by multiplying the cost-of-money rate, determined by the Secretary of the Treasury, by the average value of equipment and prorating the result over the annual operating hours. It is normally presented in terms of FCCM per hour.

It should be noted that licenses, taxes, storage and insurance cost are not included in this computation. Instead, they are considered as indirect costs.

Operating Cost

- **Fuel costs:** Fuel costs are calculated from records of equipment consumption, which is done in cost-per-gallon per hour. Fuel consumption varies depending on the machine's requirements. The fuel can be either gasoline or diesel.
- **Filter, Oil and Grease (FOG):** FOG costs are usually computed as percentage of the hourly fuel costs.
- **Maintenance and repair costs:** These are the expenses charged for parts, labor, sale taxes, and so on. Primarily, maintenance and repair cost per hour are computed

by multiplying the repair factor to the new equipment cost, which is subtracted by tire cost, and divided by the number of operating hours.

- **Hourly tire cost:** This is the current cost of new tires plus cost of one recapping and then divided by the expected life of new tires plus the life of recapped tires. It has been determined that the recapping cost is approximately 50% of the new tire cost, and that the life of a new tire plus recapping will equal approximately 1.8 times the "useful life" of a new tire.
- **Tire repair cost:** This cost is assumed to be 15% of the hourly tire wear cost.

Associated General Contractors of America (AGC) Method

This method enables the owner to calculate the owning and operating costs to determine capital recovery. Rather than dealing with the specific makes and models of the machines, the equipment is classified according to capacity or size. For example, this method computes the average annual ownership expense and the average hourly repair and maintenance expense as a percentage of the acquisition costs.[6]

Ownership Cost

The ownership costs considered in this method are the same as described in the Caterpillar method; however, replacement cost escalation is also considered. Depreciation is calculated by the straight-line method, and includes purchase price, sales tax, freight, and erection cost, with an assumed salvage value of ten percent. Average economic life in hours and average annual operating hours are shown for each size range. Replacement cost escalation of 7% is designed to augment the capital recovery, and to offset inflation and machine price increase. Interest on the investment is assumed to be 7%, whereas taxes, insurance, and storage are taken as 4.5%.

Operating Cost

Maintenance and repair costs are calculated based on an hourly percentage rate times the acquisition cost. It is a level rate regardless of the age of the machine. This expense includes field and shop repairs, overhaul, and replacement of tires and tracks, etc. The FOG costs and operator's wages are not considered in this method.

Peurifoy/ Schexnayder Method

R.L. Peurifoy is considered by many to be the father of modern construction engineering. His seminal work on the subject, now in its sixth edition, set the standard for using rigorous engineering principles to develop rational means for developing cost estimates based on equipment fleet production rates.[11]

Ownership Cost

This method assumes the straight-line method for depreciation. The value of the equipment is depreciated to zero at the end of the useful life of the equipment. The ownership costs are based on an average investment cost that is taken as 60% of the initial cost of the equipment. Usually equipment owners charge an annual fixed rate of interest against the full purchase cost of the equipment. This gives an annual interest cost, which is higher than it should be. Since the cost of depreciation has already been claimed, it is more realistic to base the annual cost of investment on the average value of equipment during its useful life. This value can be obtained by taking an average of values at the beginning of each year that the equipment will be used, and this is the major difference between the Peurifoy method and the other methods. The cost of investment is taken as 15 percent of the average investment.[6]

Operating Cost

Since the tire life is different from that of the equipment, its costs are treated differently. The maintenance cost is taken as 50 percent of the annual depreciation, the fuel and the FOG costs are included, whereas the operator wages are not included.

DOR Model for Calculation of Equipment Hire Rates

DOR's model for the calculation of equipment hire rate, which is similar to Caterpillar method, is given below. It is based on the assumption that the fuel and lubricant topping up is done by the equipment users.

1. Estimated ownership period (year) $N=H/h$
   Where: H=estimated ownership period (hours)
   h=estimated annual usage (hours)
2. Equipment cost (Rs) $C=C_0\times E(1+r)^n(d_1+d_2)(1+S)+t(1+r)^n$
   Where: C_0=cost price of equipment in foreign currency
   E=Exchange rate (buying)
   r=inflation rate (decimal)
   n=no. of year through which C_0 has to be updated to get present CIF price
   d_1=custom duty (decimal)
   d2=additional custom duty (decimal)
   s=sales tax (decimal)
   t=transportation cost (Rs.)
3. C=current unit base price $(d_1+d_2)(1+s)+t(1+r)^n$
   Equipment cost to be recovered (Rs.) $C_1=C-(P_t\times N_t+W\times P_s)$
   Where: P_t=estimated present price of tire
   N_t=number of tires
   W=weight of equipment (kg)
   P_s=price of scrap (Rs. /kg)
4. Depreciation cost/hour $C_d=C_1/h$
5. Interest cost/hour $C_i=[(N+1)/2N]\times(c\times i)/h$
   Where: i=interest rate (decimal)

6. Owning cost/hour=(C_d+C_i)
7. Tire cost/hour C_t=(Pt×N)/Lt
   Where: Lt=life of the tire (hour)
8. Overhaul cost/hour C_0=(F_0×C)/H
   Where: F_0=overall cost factor
9. Maintenance and minor repair cost/hour Cm=(F_m×C)/H
   Where: Fm=maintenance and minor repair cost factor
10. Operator cost/hour C_{01}=(13×1.1×S)/h
    Where: S=total monthly salary of for operator
11. Supervision and overhead cost/hour Cs=(F_s×C)/h
    Where: Fs=supervision and overhead cost factor
12. Operating cost/hour=C_t+C_0+C_m+C_{01}+C_s
13. Hire rate/idle hour=C_d+C_i
14. Hire rate/normal hour=C_d+C_i+C_t+C_0+C_m+C_{01}+C_s

Source: DOR, 2015

Department of Road purchases equipment through international competitive bidding and hence purchase prices are in foreign currency. So in DOR model, foreign prices are converted into Nepalese rupees. DOR calculates the hire rate of each type of machine that it purchases by using above model and then publishes hire rates on its website.

Research Work Related to Hire Rate of Equipment

Research work on Major Equipment Life-cycle Cost Analysis was done by Gransberg D.D. and O'Connor P. E. at Minnesota Department of Transportation Research Services & Library, Ireland in 2015. In this study, equipment Life-Cycle Cost Analysis (LCCA) is used as one component of the equipment fleet management process and allows the fleet manager to make equipment repair, replacement and retention decisions on the basis of a given piece of equipment's economic life. To repair, overhaul, or replace a piece of equipment in a public agency's fleet is a function of ownership and operating costs Equipment replacement decisions are critical to the success of public agency fleet management.

Similarly another research work on The Replace/Repair Decision for Heavy Equipment was done by Gillespie J.S. and Hyde A.S. at Virginia Transportation Research Council, Virginia in 2004. This study has focus on the optimal equipment replacement strategy, generally speaking, is to keep and operate a piece of equipment as long as the expected marginal cost of operating it is less than or equal to the expected average total cost of a new piece over its lifetime.

Research work on Profitability Versus Construction Equipment Maintenance was done by Craig, A.C., at Purdue University, Indiana in 2010. Construction equipment is a high cost of capital investment and the highest impact cost factor other than the initial purchase investment is the expenses related to maintenance and repair. As the equipment ages, the ownership costs decrease and the operating expenses increase as the maintenance and repair requirements grow; hence company should desire to manage this high-dollar investment for optimization of a perceived profit.

Plant Hire Unit

Public Work Department (PWD) was established in 2007 B.S. for construction and maintenance of road in Nepal. A Few major road projects were started like Tribhuvan Rajpath, Mugniln-Naubise, and Hetauda-Naryangadh projects. Numbers of heavy equipment owned by PWD started to increase. So, heavy equipment divisions were established for maintenance of equipment and hiring them.

In 2045 B.S, Mugling-Malekhu Road Reconstruction Project (MMRRP) was started by contractor Crown Agent Care International (CACI) which was financed by Overseas Development Agency of United Kingdom. All heavy equipment used in this project was bought from aboard. So to manage that equipment, a separate Plant Hire Unit (PHU) was established under CACI. The functions of PHU were as follows.

- Hire the equipment to MMRRP projects
- Maintenance equipment and vehicles running under MMRRP projects
- Deposit hire amount in its own account
- Analyzing cost and benefit of revenue and expenditure occurred in machine operations
- Purchase of spare parts

All equipment was handed over to Heavy Equipment Division, Butwal, after successful completion of this project. British agency had recommended to apply PHU concept to others projects too but it could not be implemented in others projects even after successful completion of MMRRP project.

Methodology

Study Design

A cross-sectional study descriptive analytical in nature was conducted to explore the existing hire rate determination practices of private hiring firms. It is a type of observational study that involves the analysis of data collected from a population and compression of hire rate made at a single point in time. This is a qualitative and quantitative study.

Study Area

The study was conducted in Nepal in coordination with Heavy Equipment Entrepreneur's Association of Nepal, which is a professional body, to standardize hire rates for private sector. The study was more focused on private sector rather than government organizations.

Population and Sample size

There are 26 types of heavy equipment generally used in construction works in Nepal (Parajuli, 2013). Analyzing all types of equipment available in Nepalese construction industry will not be practically possible within the given time frame. From the survey, it is found that right different equipment (six types) were most in demand and used extensively compared to others and its study will be more relevant as well as its result will be more useful and beneficial. So eight units of equipment (six types), out of 26 types, which are most demanded were considered for hire rate determination. Based on sample size calculation, questionnaires were collected from 60 persons who are involved in the hiring business of heavy equipment. Most demanded equipment was determined on the basis of the questionnaire and feedback from key personnel interviews.

Calculation of Sample Size for Questionnaire

Sample Size for finite population is given by:

$$\text{Sample Size} = \frac{Z^2 * p(1-p)/e^2}{1 + \frac{Z^2 * p(1-p)}{e^2 N}}$$

Where, N=Population size

e=Margin of error
z=z-score for confidence level
p=Proportion of success

For this study, the values of N, e, Z and p were taken as

N=500, e=10%, z=1.65 for 90%confidence level and p=0.5

Then, sample size=59.9
So, sample size for the study=60

Method of Data Collection

The study was based on secondary data.

Secondary Data: The secondary data for this study was collected from HEAN, private hiring companies, DOR, Department of Transport Management, and from websites.

Literature Review: To be familiar with the concepts, international practices of hire rate calculation of equipment; articles and journals, user hands book of different manufacturers were reviewed.

Working Procedure and Data Analysis

To fulfill the objective, i.e., to analyze the hire rate determination practices of heavy equipment in Nepal, following analyses were done:

- Hire rate determination practices in Nepal
- Role of HEAN in hire rate determination
- Acceptability of hire rate
- Uniformity of hire rates in Nepal.

Information was collected through focused group discussion with HEAN's members, interviews with entrepreneurs involved in heavy equipment market, questionnaire, and reports and publications of HEAN.

Last phase of the study was focused on determination of hire rate of most-demand equipment on the basis of owning and operating cost and its comparison with Department of Road's hire rate.

Method for Calculating Hire Rate of Machine

Method used to calculate the hire rate of selected equipment is Caterpillar method. Caterpillar method for calculation of hire rate is selected due to following reasons:

- Information required calculating hire rate will be available in Nepalese market.
- Simple and practical method.
- Similar method has been given in Komatsu Specification and Application Handbook and Caterpillar Performance Handbook that indicate the acceptability of this method by manufacturers of heavy equipment.
- Most common method to calculate the owning and operating cost.

The frame work to calculate hire rate is given below:

Machine & Model: Estimated Ownership Period (Years):
Estimated Usage (Hours/year): Ownership Usage (Total Hours)

	Owning Cost			
1	A	Delivery Price (including attachments)	***	
	B	Less tire replacement cost if desire	(***)	
	C	Delivery price less tire	***	
2	Less residual value at replacement		(***)	
3	A	Value to be recovered through work		
	B	Cost per hour	***	
4	Interest Cost		***	
5	Insurance Cost		***	
6	Property Tax		***	

7	Total Hourly Owning Cost (Sum of line 3b, 4, 5 & 6)		***
	Operating Cost		
8	Lubricants (Lube oils, filter & grease)	***	
9	Tire	***	
10	Repairs cost	***	
11	Special wear items	***	
12	Operator's hourly cost	***	
13	Total Operating Cost (sum of line 8,9,10,11 & 12)		***
14	**Total Hourly Owning and Operating Costs (sum of line 7 & 13)**		****
15	Profit as per risk		****
	Total Hourly Hire Rate (sum of 14 & 15)		****

Note: Fuel cost is not included in hire rate

Source: Caterpillar[2]

Owning costs are generally fixed in nature but operating costs are variable. Operating costs (from line no. 8, 9, 10 and 11) were taken from maintenance record of the hiring company. A profit margin is considered in determination of hire rate.

Results and Discussions

In this section, hire rate of selected equipment is determined based on operating and owning cost method and then compared with DOR's hire rate as well as market rate.

Hire Rate Determination of Heavy Equipment

Fixed Cost of Machines

Different types of fixed costs are involved in owning the machine. Fixed costs for the selected machine were collected from machine manufacture authorized dealers and insurance company. Fixed cost required to calculate the owning costs of the machine are summarized in Table 1.

Variable Cost of Machines

Different types of variable costs are involved in operating the machine. Variables cost were determined on the basis of survey, records of machine owner and manufacturing standard. Variable costs used in calculation of hire rate for selected machine is shown in Table 2.

Analysis of Hire Rate

Hire rate calculated under actual cost method and theoretical cost method is shown in Table 3. In theoretical cost method, operating costs are taken as a fraction of purchase cost of machine. Calculated hire rate is based upon following assumptions:

Table 1.Fixed Costs of Machines

S.No.	Machine Type	Make/Model	Price NRs.	Annual Insurance NRs.	Property Tax NRs.
1	Excavator	Komatsu/PC210	10,500,000	150,000	30450
2	Excavator	JCB/JS205	76,25,000	109,000	30450
3	Excavator	Komatsu/PC-130	9,500,000	140,000	30450
4	Backhoe Loader	JCB/3Dx Supper	39,50,000	65,000	30450
5	Grader	Komatsu/GD511A	12,800,000	170,000	30450
6	Dozer	Komatsu/D39ex	11,000,000	160,000	30450
7	Loader	JCB/432zx	62,00,000	63,000	30450
8	Vibrating Roller	JCB/VM115	41,50,000	62,000	30450

Source: Field Survey, 2016

Table 2.Annual Variable Costs of Machines

S. No.	Machine Type	Model	Lubricants NRs.	Repair with parts NRs.	Wear Item NRs.	Tire NRs.
1	Excavator	PC210	3,86,889	4,25,775	2,63,386	-
2	Excavator	JS205	3,33,265	3,59,025	2,91,913	-

3	Excavator	PC-130	2,17,282	3,78,875	2,48,489	-
4	Backhoe Loader	3Dx Supper	2,50,891	249,225	1,39,200	1,60,000
5	Grader	GD511A	2,99,158	4,12,525	2,23,617	1,75,000
6	Dozer	D39EX	2,76,289	4,41,300	2,78,690	-
7	Loader	432ZX	3,24,181	2,86,625	1,87,561	3,60,000
8	Vibrating Roller	VM115	2,25,063	2,82,400	1,06,461	1,80,000

Source: Field Survey, 2016

- It does not include fuel cost.
- Transportation cost of machine should be borne by the user.
- Operator field allowance should be paid by user of machine.
- Oils top-up on site should be done by user.
- Minor repair works should be done by user.
- User has all the liabilities of machine till handover of the machine after use.

rate of Komatsu excavator of model PC130 is Rs. 2055 per hour; hire rate of Komatsu grader GD511 is Rs. 2751 per hour; hire rate of Komatsu dozer D39EX is Rs. 2359 per hour; hire rate of JCB backhoe loader 3DX supper is Rs. 1107 per hour; hire rate of JCB wheel loader 432ZX is Rs. 1625 per hour; and hire rate of JCB vibrating roller is Rs. 1138 per hour.

Hire rate calculated under actual cost method is higher

Table 3.Calculated Hire Rate of Selected Machine

S. No.	Machine Type	Make/Model	Hire Rate under Actual cost method NRs.	Hire Rate under Theoretical cost method NRs.
1	Excavator	Komatsu/PC210	2335	2230
2	Excavator	JCB/JS205	1990	1829
3	Excavator	Komatsu/PC-130	2103	2055
4	Grader	Komatsu/GD511A	2604	2751
5	Dozer	Komatsu/D39ex	2380	2359
6	Backhoe Loader	JCB/3Dx Supper	1290	1107
7	Loader	JCB/432zx	1755	1625
8	Vibrating Roller	JCB/VM115	1285	1138

Table 3 shows that hire rates of machines vary according to their prices and different type of cost incurred during their operation. Hire rate under actual operating cost method of Komatsu excavator of model PC210 is Rs. 2335 per hour; hire rate of JCB excavator of model JS205 is Rs. 1990 per hour; hire rate of Komatsu excavator of model PC130 is Rs. 2103 per hour; hire rate of Komatsu grader GD511 is Rs. 2604 per hour; hire rate of Komatsu dozer D39EX is Rs. 2380 per hour; hire rate of JCB backhoe loader 3DX supper is Rs. 1290 per hour; hire rate of JCB wheel loader 432ZX is Rs. 1755 per hour; and hire rate of JCB vibrating roller is Rs. 1285 per hour.

Hire rate under theoretical cost method of Komatsu excavator of model PC210 is Rs. 2230 per hour; hire rate of JCB excavator of model JS205 is Rs. 1829 per hour; hire

than the theoretical cost method because in theoretical cost method, operating costs are taken as a fraction of purchase cost of machine while in actual cost method; operating costs are calculated based upon the actual cost incurred in machine during the life of the machine. At the beginning of machine, repair costs are low but increases as machine became older and older. The average cost during the whole life of machine may represent true figure that why actual cost method gives more acceptable result in context of local market.

Comparison of Hire Rates

Hire rate practices in market, DOR's hire rates and calculated hire rates of selected machines are shown in Table 4. Market hire rates are not fixed, so these are given in range.

Table 4.Comparison of Hire Rates

S. No.	Machines	Calculated Hire Rate per hour NRs.	Market Hire Rate per hour NRs.	DOR's Hire Rate per hour NRs.
1	Excavator/ PC210	2335	1800–2500	1800

2	Excavator/ JS205	1990	1800–2500	1800
3	Excavator/ PC130	2103	1200–1500	1800
4	Grader/ GD511	2604	1500–2000	1600
5	Dozer/ D39Ex	2380	1500–2000	1800
6	Backhoe/ 3DX Supper	1290	1000–1200	1050
7	Loader/ 432ZX	1755	1250–1500	N/A
8	Vibrating Roller/ VM115	1285	800–1250	1200

Source: Field Survey, 2016

Table 4 shows the calculated hire rate is nearly 20 percent ages higher than DOR's hire rate due to following reasons:

- Calculated hire rate is more scientific and is based on owning and operating cost method.
- Operating costs like lubricant cost, repair cost and special wear items cost are consider over whole life of the machine which gives better result.
- A 15% profit margin is included in total hourly hire rate.
- DOR's hire rates are calculated at breakeven so it does not include profit margin.
- Privet hiring firm generally did not determine their own hire rate.

From survey, it was found that only 55% of machine owner are making profit or significant profit while 45% are at breakeven or in loss. From the study, following reasons were identified for breakeven or loss of hiring company:

- Hire rate of private hiring company is not fixed. Some time they lease the machine at very lower rate that did not cover their owning and operating cost.
- Machine owner did not keep proper record of their revenue and expense so it very difficult to say about profitability.
- Unhealthy competition
- Default of hire charge
- Poor utilization of machine

To know the preference of machine user for selection of hire source, respondents were asked, "If you required machine for construction work, which source will you prefer?" and response received is depicted in Fig. 1.

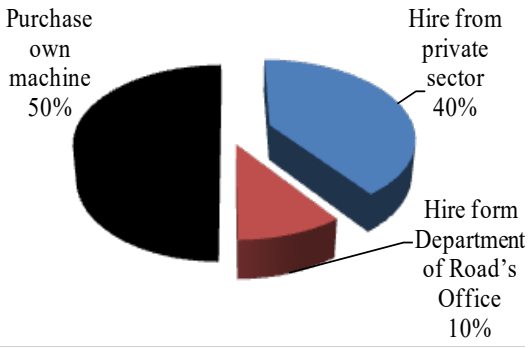


Figure 1.Preference of Hire Source by Machine User

Figure 1 depicts that at 50% of machine users preferred to buy machine when required for construction; 40% of machine users preferred to lease from private hiring company, and remaining 10% preferred to take on rent from DOR's office. So from above result, it was found that most of the users preferred to buy and then use the machine. From discussion with machine owners and contractors, it was found that contractors will prefer to buy the machine when they have a big project due to easy availability of bank financing, long utilization period, and use on lease for small projects. The contractor gives less importance to DOR's machine because of availability of equipment with private sector and simplicity of hiring process as compared to DOR.

Proposed Record Keeping for Equipment

From field visits and discussion with machine owners, it was found that record keeping of machine utilization as well as maintenance was very poor. Data was not easily available with owners. It is very important that the equipment is used optimally to get maximum productivity. Machine maintenance, transfer from one place to another, etc., should be closely monitored and controlled. Three record keeping standard formats are proposed that should be used for performance monitoring, maintenance record keeping, and to keep track of equipment deployed at construction site. These three record keeping standard formats are discussed in sub topic for proper record keeping of machine utilization and maintenance.

Maintenance Cost Record

Maintenance cost record is important to track the cost incurred in regular maintenance and repair of the equipment. A sample of maintenance cost record card to record the expenditure incurred in repair and maintenance of the machine during its lifetime is shown in Appendix J. This record will assist the organization in:

- Tracking down equipment maintenance cost trends
- Tracking down equipment life cycle cost
- Assessing the effectiveness of maintenance programs
- Equipment replacements analysis
- Planning and controlling of spares and materials required for maintenance

Equipment Productivity Card

Equipment productivity card should be used to record the productivity of a particular machine. It will be very helpful for financial analysis of the machine. A sample of equipment productivity card to record the utilization of the machine is shown in Appendix K. This record will assist the organization in:

- Tracking down the equipment utilization
- Determination of hire revenue over life of equipment
- Planning and controlling of equipment utilization

Equipment Utilization Record Card

Equipment needs to be transferred from one user to another or one working place to another working place. Mobilization of machine should be closely monitored. A sample of equipment utilization record card to record the utilization of the machine is shown in Appendix L. This record will assist the organization in:

- Assessing in maintenance planning, especially periodic maintenance
- Planning and controlling of equipment mobilization
- Analyzing the causes of idle time of equipment

Conclusion

The calculated hire rate is based on owning and operating cost method which is not done by machine owner. Hire rates of 8 machines were calculated which were found to be nearly 20% higher than DOR's hire rates. Calculated hire rate for Komatsu excavator of model PC210 is Rs. 2335 per hour; hire rate of JCB excavator of model JS205 is Rs. 1990 per hour; hire rate of Komatsu excavator of model PC130 is Rs. 2103 per hour; hire rate of Komatsu grader GD511 is Rs. 2604 per hour; hire rate of Komatsu dozer D39EX is Rs. 2380 per hour; hire rate of JCB backhoe loader 3DX supper is Rs. 1290 per hour; hire rate of JCB wheel loader 432ZX is Rs. 1755 per hour; and hire rate of JCB vibrating roller is Rs. 1285 per hour. Determining hire rate based on scientific method is most essential. This rate when applied helps the investors to recover their investment in estimated time and to have cash flow for maintenance. Methods used in the study will work as a guideline for determination of hire rate of other machines whose hire rate is not covered in this study and sticking to the rates will ensure smooth operation of machine and cost recovery in pre-determined time.

Availability of data related to maintenance cost, machine utilization, revenue generated from hire is very poor with machine owners. So it is recommended to apply the developed standard format which is in Appendix for better record keeping.

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