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Research Paper

Premature Failure of District Road Construction Equipment: Case of Northern Uganda

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ABSTRACT

This study examined possible factors that led to premature failure of Road Construction Equipment supplied to various districts of Uganda in 2012. In this case, the Northern Uganda Districts were selected *viz*: Kitgum, Lira, Gulu, Arua and Adjumani. The method for data collection included physical observation, library research, oral interviews and discussions with various stakeholders. In some aspects of the study, Gulu Regional Mechanical Workshops (GRMW) for Northern Uganda was used as a case study to map regional failure of the equipment.
It was established that, the specifications of equipment supplied were consistent with contractual specifications. It was also found that from the districts, many of the equipment were subjected to heavier task than their designed tasks. No record of repairs, periodic inspections and maintenance was available above all, the clock hour instruments that guides the maintenance schedule for most of these machines were found not working. The study also found that there is inadequate staffing in all the districts where the study was conducted. Additionally, the few staff at the districts are not qualified and lacked frequent refresher trainings. Standard operating procedures, (SOPs) were also not available in the mechanical workshops at districts. These multiple management weaknesses contributed to their premature failures. Measures proposed to help prevent early failures in these equipment includes; development of SOPs and close monitoring/supervision by MoWT, inclusion of mandatory after sales services and operator trainings on suppliers of various road equipment.

Keywords: *premature failure, maintenance, technical specifications*

INTRODUCTION

In the year 2011, the Government of the Republic of Uganda through the Ministry of Local Government, procured 1,405 pieces of road equipment from FAW a Chinese firm. By their design the equipment were meant to operate for over 10 years without major repairs. Within three years, the ministry of Works and Transport (MoWT) received multiple complaints from various Districts about premature failures of the equipment supplied to them (Letters from Chief Administrative Officers of Local Government, 2014. Various factors are associated to premature failures in equipment these include; poor maintenance, misuse and design faults among others (Luiz, 2007).

Failures in equipment/engineering plants can be categorized into various types depending on the nature of failures whether it's attributed to management and human errors or materials failures. There are generally four types of machine failures *viz*: design failure, catastrophic failure, compounding failures and human error failures (Gary and Bill, 2019, Luiz, 2006). There are routine practices that cause equipment failures/breakdown and these include: improper operation, failure to

perform preventive maintenance, failure to Continuously Monitor Equipment, Not Reading the Operator's Manual, Overrunning Machines, Misaligned Tighteners, Improper Storage, and Ignoring Warning Signals among others. To prevent equipment failures, maintenance engineers have adopted the following strategies: Establish a Maintenance Schedule, Utilize Equipment Monitoring system, Train and Empower Employees, Undertake a Risk Audit, calculate the Cost of Downtime, Prepare Proper Documentation and Change of Thinking from Reactive to Proactive. The key practice to be adopted is machine maintenance.

Maintenance is the actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable conditions to achieve its maximum useful life. Various researches have yielded to the establishment of six types of maintenance namely: Corrective maintenance, Preventive Maintenance, Predictive Maintenance, Zero Hours Maintenance (Overhaul), Periodic maintenance, Total productive maintenance (Bamiro *et al*, 2011, Vankatesh, 2007).

The study aimed at determining factors that caused premature failures of the road construction equipment referred to above so that mitigation measures to premature failures are developed.

METHODOLOGY

The Study Area

Northern districts selected as for the study includes: Gulu, Kitgum Lira, Adjumani and Arua. The Regional Mechanical Workshops for Northern Uganda is located in Gulu and therefore, many aspects of the study were conducted from Gulu District.

Case study research design was adopted and the methods used in data acquisition included; discussions, interviews, observations and archival research. Discussions were inclined to the topical issues i.e. the road construction equipment supplied to districts and municipalities. Interview questions were designed and administered to various respondents. Observations were made on the selected equipment to establish their selected technical specifications and present status. Archival research was done to establish facts about history of breakdowns, service, repair and maintenance records. Each task had independent approach appropriate for data collection.

The target population used in the study included; District Local Council (v) Chairpersons (LCV), Chief Administrative Officers (CAO), District and Municipal Engineers, staff from mechanical sections. A one stage stratified sampling technique was used to get data from the target population. The strata used are mechanics, operators, administrative staff and political officers. Road construction equipment was sampled using a random method for sampling i.e. cluster sampling technique. Clusters used includes: bulldozers, wheel loaders, excavators, motor graders and rollers. A two stage sampling technique was adopted where all members in a cluster had equal chance of being selected for the study. Exceptions were made for Bulldozers and Excavators which were all studied at the regional workshops due to their limited number.

Data Analysis and Interpretation

Data obtained were non numeric and the analysis method used includes: Narrative and discourse analysis. Where stories were reformulated as presented by respondents taking into account context of each case and different experiences of each respondent. All naturally occurring talks as in discussions and all types of written texts from the archival search were taken into consideration for respect of discourse analysis.

Data Quality Control was based on clarity and appropriateness of the research questions, appropriateness for sampling, data collection and data analysis.

Reliability and Validity of the Report

Constant data comparison, comprehensive data use, inclusion of the

deviant case and use of tables were used to achieve reliability. As data were extracted from the original sources, accuracy was verified in terms of form and context with constant comparison alone and with peers (a form of triangulation). Validity of Report was achieved by including 1st tier triangulation (of researchers) and 2nd tier triangulation (of resources and theories) including well-documented audit trail of materials and processes.

RESULT

Table 1. Equipment use/applications at district level

S/No.	Equipment type	Intended use			Actual use (at district)			Variance
1	Bulldozer			H			H	Compliance
2	Wheel Loader		M				H	M to H
3	Motor Grader	L					H	L to H
4	Excavator		M				M	M to H
5	Vibro Roller		M				M	M to H

Key: Intended use; use of machine as prescribed by the MOWT, Actual use: Task done by machines by the district, L: light work, M: Medium work/task, H: heavy duty

Table 2. Maintenance modes practiced on various equipment at district levels

District	Equipment & maintenance mode				
	Bulldozer	Excavator	Motor grader	Wheel loader	Vibro roller
Gulu/GRMWs	Corrective Periodic	Corrective Periodic	Corrective Periodic	Corrective Periodic	Corrective Periodic
Kitgum			Corrective	Corrective	Corrective
Lira			Corrective	Corrective	Corrective
Adjumani			Corrective	Corrective	Corrective
Arua			Corrective	Corrective	Corrective

Table 3. Status of staffing in mechanical section at selected districts

Staff	Number of staff at District				
	Gulu	Lira	Kitgum	Arua	Adjumani
OC Mechanics	1	1	1	1	1
Mechanics	0	0	0	0	0
Operators	3	2	2	3	2

Table 4. Qualification of staff in mechanical section at selected districts

Staff	Qualification of staff at District				
	Gulu	Lira	Kitgum	Arua	Adjumani
OC Mechanics	HDM	ODM	ODM	ODM	ODM
Mechanics	N/A	N/A	N/A	N/A	N/A
Operators	BOL	BOL	BOL	BOL	BOL

Key: HDM: Higher Diploma in Mechanical Engineering, ODM: Ordinary Diploma in Mechanical Engineering, N/A: Not Applicable (No provision for mechanics at District), BOL: Below Ordinary Level of Education

DISCUSSION

Through a thorough library search and observation of the road equipment at various sites, it was established that the contractual specifications are consistent with specifications of the equipment supplied. It is hoped that, contractual technical specifications for the other road equipment not included in the study also tally with the specifications of equipment supplied. Some technical specifications like materials specifications for various components of the equipment were not included in the study yet, this have a fundamental impact on equipment performance. It is evident from this segment of the study that, the premature equipment failure of these road construction equipment was not a result of the wrong specifications of supplied equipment. No doubt failures of parts of the road equipment could have resulted from specifications other than those in the contractual e.g. component materials specifications.

From Table 1 above, it can be noted that wheel loaders, vibro roller, motor grader and excavator were designed to handle light to medium duties like loading murram and debris, soil/murram spreading, road molding among others. But, at the districts they were subjected to both medium and heavy duty like excavation in opening of new roads mining murram and bush clearing. This inconsistency in designed use and actual duties is one of the factors that explain why the equipment experienced premature failures. However, this does not explain why bulldozers also experience premature failures yet they were subjected to their designed use.

The extensive survey on the record of maintenance at the different mechanical workshops at the selected districts revealed that all the district used corrective maintenance on the equipment whose management falls under their docket as detailed in Table 2 above. At the GRMWs, both corrective and periodic maintenance were used however, periodic maintenance was use only on the bulldozers and excavators.

Considering the role of maintenance, the development of efficient maintenance system is critical in enhancing the life time value that an organization will obtain from its assets (Kelly A. 2006). Corrective maintenance is the most basic model, and includes, in addition to visual inspections and lubrication, the arising breakdowns repair. Simply, corrective maintenance can be the result of a deliberate run-to-failure strategy (Eric, 2018). In our case, corrective maintenance was solely used on wheel loaders, vibro rollers and motor graders at the districts. This equipment has heavy capital investment in their procurement and the laxity of leaving them at the mercy of simple corrective maintenance which is run down to failure approach laid a heavy cost burden to the Government of Uganda. Periodic maintenance is a type of maintenance that is done at a regular interval while the equipment is still functioning with the aim of preventing failure or reducing the likelihood of failure (Rock, 2017). Preventive maintenance can be time based i.e. every week, every month or every three months. But preventive maintenance can also be based on usage e.g. every 150 cycles, every 10,000hrs or like your car: service every 10,000km. At the GRMWs, this type of maintenance was used on Excavators and Bull dozers with the aim of reducing failures. This approach is most suitable when used alongside other types of maintenance like the total productive maintenance (Eric, 2018), condition based maintenance. This is the maintenance concept that depends on real time equipment condition checks. This method requires specialized tools to monitor critical parts of equipment. Data on the condition of the equipment can be collected either periodically or on continuous basis and must be used in such a way that decisions are taken proficiently. Reliability centered maintenance (RCM) this is defined as a structured and logical process for developing or maximizing the maintenance requirement of a physical resource in its operating context to realize its inherent reliability (Samanta *et al*, 2001). Given the amount of investments put in the road construction equipment, these three maintenance modes are preferred to be blended for the equipment to realize their full lifespan.

In practice and standard guideline by the MoWT, every district and municipality is meant to have one OC mechanic, two mechanics and at least five operators. It has been established that all the selected districts have no mechanics and just a few operators, leaving the mechanical sections under staff as detailed in Table 3 above. Most of the existing staff especially operators do not have the minimum qualifications required details of that is captured in Table 4 above. The standing order from MoWT says that every machine operator must have a minimum of ordinary level certificate or its equivalent.

The poor staffing in mechanical sections came because of the boom in the road construction industry which is largely taken up by Chinese firms. This left a thin mechanical crew at the districts. The inadequate staffing leaves the few staff at the stations with heavy work burden and hence general inefficiency. This frustrates general record keeping and planning for repair and maintenance among others.

Training effects on performance may be subtle (though measurable). In a qualitative study involving mechanics in Northern India, Barber (2004) found that on-the-job training led to greater innovation and tacit skills. Tacit skills are behaviors acquired through informal learning that are useful for effective performance. We take

the point of view that training leads to important benefits for individuals and teams, organizations, and society. With rapidly changing technology, there is growing need for frequent training for mechanics and machine operators. However, this has not always been the case with government departments with the mechanical sections inclusive. The on-job training when encouraged with systematic approaches would help alleviate problems associated to lack of trainings and inadequate staffing. The big gap cited in training, makes it difficult for mechanics to trouble shoot mechanical problems and conduct general repairs. Operators also find difficulty or wrongly operate equipment hence leading to failures of various parts. Furthermore, the staffing gap, staff training and qualifications impact negatively on the general use of these machines leading to low performance and total breakdowns within designed life.

CONCLUSION

The study established a number of factors that favored the premature failures of the road construction equipment and these include factors here stated. Some of these equipments were used for heavier duties than their designed/ intended duties. Inadequate staffing and lack of refresher training in mechanical sections denied the equipment the needed attention in terms of planned repairs, maintenance and work records. Most of the staff in mechanical sections especially operators do not have the minimum qualifications required. The unqualified personnel are not easy to train since they are not in position to read manuals for various equipment leading them to operate equipment wrongly. These factors resulted to lack of adequate maintenance, lack of trouble shooting and general improper operations. Standard operational procedures/guidelines (SOPs) were found lacking in all districts.

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