Using Computerized Maintenance Management System (CMMS) in Roads Maintenance Operations

HESHAM ALMOMANI [a], ABDURAHMAN HAMAD ALDAIHANI [b]

[a] Department of Industrial Engineering, Faculty of Engineering, The Hashemite University,
[b]MPW, Kuwait
E-mail: heshamalmomani@hu.edu.jo

Abstract:- Roads maintenance is a very important issue for roads sustainable and for their importance in transportation of passengers and goods. The continuity of roads work is very important for economy in any country, and so as the repair of such roads is fast as the economy progressed. Keep roads under continuous monitoring and inspection is very important to locate areas of failure and segments of the road need maintenance can be achieved by using CMMS. Roads suffering from many defects like cracks, different of roads slope, wear, debris and others, the need for continuous inspections and maintenance is very important.

Objectives: This paper aim to apply computerized maintenance management system (CMMS) on roads maintenance management operations and to compare the maintenance management effectiveness or performance without CMMS and with CMMS by using appropriate metrics like MTTR and MTBF. The other objectives of this paper is to increase the Knowledge about CMMS: its requirements, how to inter the data its output and its role in improving maintenance operations in roads maintenance. . This paper discusses these new factors which are making the use of CMMS a business imperative.

Methods: The data is collected from literature and experts and MPW-Kuwait. The data collected are examined and tested and classified. It is found that the CMMS improves road maintenance operations by decreasing MTTR increasing MTBF, reducing downtime and number of failures by a considerable ratios.

Results: The benefits of adopting a CMMS are well documented, industry analysts report that 70% of businesses are yet to adopt a CMMS to manage their maintenance; this is particularly prevalent in small and medium manufacturing sites. However, recent industry commentators argue that factors are now at play which look set to change this phenomenon Using CMMS in roads maintenance management operations will reduce workers efforts, reducing time required and costs. Continuous monitoring and maintenance can be offered for roads by using CMMS. MTTR and MTBF values are improved after applying CMMS.

Conclusion: Performance and effectiveness of applying CMMS in roads maintenance operations are measured by MTTR, Number of total failures, Downtime reduction, and MTBF. It is clear that the CMMS improves road maintenance operations by decreasing MTTR increasing MTBF, reducing downtime and number of failures by a considerable ratios.

Keywords: CMMS, Maintenance, Cost, Mean time to failure, Mean time between failures.

1. Introduction

Facilities operations and maintenance envelop a wide range of administrations, abilities, procedures, and instruments required to guarantee the fabricated condition will play out the capacities for which an office was structured and developed. Tasks and support normally incorporates the everyday exercises vital for the structure/constructed structure, its frameworks and hardware, and tenants/clients to play out their expected capacity. Activities and support are consolidated into the normal term O&M in light of the fact that an office can't work at top productivity without being kept up; in this manner the two are genuine property stock which Provides a review on the sort of framework expected to keep up a stock of an association's physical resources and deal with those benefits [1].

There are numerous new programming's applications utilized in overseeing upkeep activities like: Computerized support the board framework — Contains depictions of techniques and practices used to follow the support of an association's advantages and related expenses. PC supported offices the executives which is initially alluded to space arranging advances, in any case, isn't utilized all the more conventionally to portray an assortment of advances tending to any or all parts of Facilities Management. Models incorporate CMMS, BIM, IWMS, and others [1].

-CMMS philosophy

The most significant goals for legitimate resource the board are to:

• Minimize fix costs. Hardware breakdown and street shutdown can cost a large number of dollars in costs identified with fixes, and low quality.

• Maximize resource accessibility to guarantee greatest proficiency and great assistance. The CMMS can:

• Use ace resource tables to record particular subtleties, strategies and booking dates to make work orders for preventive and remedial support.

• Record the aftereffects of these work orders including work performed, resource condition, evaluated substitution year and assessed costs.

• Serve a bunch of departmental needs in financials, HR, finance and obtainment. The various divisions can work freely from one another while permitting joining for explicit assignments.

• Generate reports that will help with refining support procedures and cost conjectures.

CMMS Interrelated Components

The significant segments of the CMMS are: Equipment Master, Preventive Maintenance, Corrective Maintenance , Procurement, Inventory Control, Work Orders and Reports [5]. Computerized maintenance management systems (CMMS) Modernized CMMS) incorporate programming that: Generates support, fix, and substitution related work orders, Stores recorded upkeep, fix, and cost information, Analyzes upkeep information (patterns) and stores costs lastly Calculates life-cycle costs for singular frameworks and hardware. Estimations required for CMMS can be recorded on upkeep logs, agendas, or hand held tablets. A portion of the information to be considered for the upkeep the board program incorporate the accompanying things: Equipment running hours, Ferrous wear molecule include in greasing up oils, Bearing and drive working

temperatures, Vibration of turning gear and Repair expenses of individual hardware [8]

Benefits of adopting CMMS

Leading computerized maintenance management systems designers keep on upgrading the usefulness and capacity of their product and administrations. It can expanded usefulness: the present CMMS have a wide scope of refined usefulness, and the more remarkable frameworks give: Work request the board, Planning markers and capacities, Automatic work booking and capacity to plan upkeep by resource type, Control of stock levels and materials over broadened timeframes, Equipment observing with caution producing capacity, Flexible resource register creation with the capacity to follow parts, Project the board abilities, Shutdown arranging usefulness, Immediate access to key records, photos and AV preparing helps, Real-time conveyance of data by email, SMS and Internet, Calibration [6, 19].

The subsequent advantage is Greater frameworks combination: An unmistakable sign that support the board is recognized to be a key driver in business benefit is the ascent of CMMS usefulness in a wide scope of big business apparatuses. It is discovered that CMMS, ERP (Enterprise Resource Planning) and EAM (Enterprise Asset Management) frameworks, all case to convey upkeep the executives abilities. The key contrasts between these are to do with the size of framework execution over your association, the degree to which the framework truly assesses the necessities of the upkeep activity and the time it will take to get an arrival on speculation at the support level.

The third advantage of CMMS is to upgraded versatility: Today Maintenance Engineers and Technicians are moving like never before, as they spread a more extensive territory with frequently less assets. Throughout the most recent five years the unfathomable ascent of remote interchanges has made it workable for CMMS suppliers to help the requirement for versatile support with simple remote electronic access to the CMMS. Supporting more prominent versatility and adaptability, new PDA based upkeep frameworks have been acquainted permitting Maintenance Engineers with abstain from their clasp board and rather utilize a Pocket Maintenance framework. Versatile innovation utilized related to a CMMS assists administrators with tending to an assortment of difficulties so as to limit vacation [6,19].

Other advantage of CMMS is offering more prominent adaptability and simpler to use: As an indispensable apparatus in the fight for lean assembling procedures and streets upkeep tasks, a CMMS ought to be utilized broadly over the association by proper staff. We live in a various world with a multi-ethnic workforce and a wide scope of PC education abilities. In this way the interface to even the most modern CMMS should be basic and instinctive. The more forward-thinking CMMS incorporate graphical UIs intended to give a predictable setting to clients acquainted with Microsoft XP and other standard work area applications, lessening the requirement for preparing and supporting the appropriation of the CMMS over all degrees of faculty. A few arrangements additionally permit various clients to have a similar PC, with client configurable work areas and reports guaranteeing that every client has the adaptability to work in a situation that suits their requirements and destinations [6].

The last advantage of CMMS is the noticeable revealing: Being ready to see initially the status of the key resources, the advancement of your upkeep group and the current hot issues is a huge advance forward

for Maintenance Managers. CMMS Dashboards acknowledge information from unique sources, make settled upon counts, and present the subsequent data as separately adaptable, handily filtered shows. A long way from being an "older sibling" innovation that is utilized to undermine and squeeze the upkeep group, dashboards help exhibit the estimation of the support office and are vital to sustaining a culture of precise, continuous, and exceptionally obvious information. This information underpins activity, permitting quick remedy of issues and progressing process enhancements. Dashboards can likewise improve the more extensive plant culture, with everybody working from a truly obvious report that assists with supporting collaboration and limit blame dealing [6].

CMMS Functional Needs: Roads maintenance and CMMS

Specific annual visual condition inspection of key assets of the roads Facility are: shoulders, Drainage systems, Planted vegetation, Fencing, Roadside slopes, resurfacing and cracking repair, potholes repair, Pavement markings, Highway illumination (conventional and high mast) and Barriers [1]. In light of conversations with Public Works and the detail study talked about over, the accompanying practical needs are necessities: Work Orders – Internal and outer help and restorative WOs, Scheduling – preventive support booking. Cost Accounting - necessary to the utilization of benefit the board. Staff/Equipment – asset arranging and usage, and agreement following for progressing support. Fleet Management (in the long run) – incorporate vehicles and hardware for which armada faculty are dependable. Lock-out/Tag-out – and different groupings. Kept Space Entry - for security. Timekeeping – to follow long stretches of WO fulfillment.

Asset Management – reviews, condition evaluations, hazard prioritization, staying helpful life assurance, recovery and substitution, situation examination. Mobile applications – available, useable, ready to get to and synchronize refreshes back to the CMMS in any event, when cell signal is briefly missing. Non-fundamental utilitarian necessities that Public Works might need to consider at some future time include: Inventory Management – Would like coordination with WOs and Capital Projects Tracking – just for recovery and substitution. Transport infrastructure like technical facilities, needs maintenance and reconstruction so that it can serve its users' needs properly. The users' comfort and travel time are in proportional to the effectiveness of those works [7, 15].

Previous studies

There are many papers discussed road maintenance and its quality, for example Mallawaarachchi1& Senaratne (2015) stated that construction projects like road constructions and buildings should always expected to create a balance between cost, time and quality. It is possible to have high quality and low cost, but at the expense of time, and conversely to have high quality and a fast project, but at a cost. High quality is not always the primary objective for the client; however, it is extremely important to a successful project [2]. Bin Rashid and Gupta (2017) in this study some test sections were identified on SH-4 Nagar (Mohali) road. The parameters influencing the performance of flexible pavements were studied and identified. For efficient maintenance of road pavements, the deficiencies in our existing highway system need to be clearly understood. All type of distresses/defects needs to be classified with causes and treatment as per different severity level [3].

Colonna, Fioretti, Fonzone, and Sasso (2014) described a new approach for road maintenance and enhancement, called Global Road Management System (GRMS). The basic idea was that transportation

infrastructures are elements of a territory, so -management has to improve the quality of life of users of road and territory as well [4]. In this study the quality of maintenance operations performed on highways, main roads, and ordinary roads in Kuwait are assessed using CMMS and also evaluated, in order to be improved and developed. The conventional method also led to inaccurate design and construction information, late updating of the required information, lack of coordination and integration (Ismail, 2014). The high quality of IBS building maintenance works level and the long life span of services required an efficient management to maintain the building structure and facility at the IBS building. According to Kamaruddin et al. (2013) and Rahman and Omar (2006), the management level in some countries like Malaysia, defect identification (DI) process, repairing method and use of technology in building and structures like roads defect diagnosis of IBS buildings is far behind some developed countries. Compared with the relatively high level of IBS construction in the USA and Japan, the supporting technologies and large-scale production systems (such as supervision systems and matching construction technologies) are used to improve the maintainability of components and could diagnose the maintenance problems with safety monitoring process including the avoidance of conflicts involving the parties in the construction (e.g., the designer and contractor) undesirable from happening (Zhang et al., 2014). Pasindu (2017) Proposed a replacement methodology to help native authorities create selections on maintenance works considering the present condition and value of repair works. the present condition is measured via smartphone primarily based pavement roughness measuring methodology. These roughness values area unit correlative to representative price values victimization HS R supported distress and roughness information. this could be wont to choose roads for maintenance works supported the present road condition additionally considering the fund constraints. Pavement management system performs AN analysis of the collected rating information and reports on the present and projected condition of the road system so as to judge the effectiveness of the design and funding priority and supply steerage in deciding} process [17]. International Roughness Index was developed by United Nations agency in 1982. The IRI was initial suggested as a customary for roughness measurements at the International Road Roughness Experiment conducted in 1982 [18]. Farouq et al. (2017) examined the categories of road defect on Kano metropolitan roads, the factors that contributes to the road defects, the road user's satisfaction on the upkeep works meted out by destiny and analyzed the issues on road defect news system in destiny. From the study, the categories of road defect on Kano metropolitan roads area unit potholes, fix and utility cut patching/Reinstatement of utility openings (electricity, water, telecommunication etc.) and edge cracks. The issue that contributes to the road defects area unit structural failure thanks to poor style and construction, inadequate maintenance policy and standards and therefore the traffic load and volume.

2. Methodology

The first step is examination followed right now to recognize Some of CMMS application utilized in streets upkeep like Fracttal's automated support the board framework (CMMS), which takes into account the observing of all portions of the city's foundation resources, including pipes,

channels, sewers, street framework, and significantly more. Timetable preventive upkeep reviews on gear and framework resources that should be kept up, track your temporary workers and representatives so as to improve their efficiency, guarantee security methodology are being followed and administrative examinations are agreed to, all from a solitary administration device. Expand the range of your CMMS by incorporating it with the city's shrewd resources so as to follow resource condition, execution and have protection support techniques trigger naturally dependent on conditions you set. The second step is to determine the CMMS Edge: CMMS software is designed to optimize maintenance tasks for easy sharing and smart working. Here are 5 ways it can automate your documentation process so that your team can accomplish more in less time:

-Lowers the Documentation Time Which Means Less Overtime: Maintenance experts regularly invest the vast majority of their energy managing the apparently perpetual desk work. The time they expend in finishing desk work, planning assignments and following requests, can be productively utilized in staying aware of support timetables and fixing gear issues. The lower is normal by 30%.

- Makes it Easy to Prioritize Work for Better Scheduling: CMMS programs encourage simple access to in-progress and up and coming work which permits your specialists to concentrate on basic upkeep undertakings. A CMMS offers a unified perspective on the work status for better dynamic and arranged support which in the end brings about less interruption and noteworthy reserve funds. The improvement in dynamic is about half and investment funds about 20% of time.

-Provides Information in Real-time for Better Accountability: A CMMS works like a solitary window system where it turns out to be anything but difficult to screen each work request. By following which assignment is past due, which is pending and which is in progress, it conveys the ongoing status of work to guarantee that there is no overlooking, continuous framework delay is 0.

- Instant Notifications Eliminate Delays and Keep You On-Track: CMMS sends computerized messages and notices to the assigned laborers to complete the work on schedule. This element brings about legitimate dispersion of work and better responsibility to keep away from postponements and vacation. Diminishing in Downtime in about 30%.

- Advanced Reporting Feature Facilitates Effective Use of Existing Data: The KPI details accessible from auto-produced reports can be utilized at all degrees of dynamic. From booking work and arranging stock to recording issues and dissecting vitality use, each activity gets streamlined when the information is aggregated on a solitary stage. At the point when organizations execute a CMMS framework, it turns out to be anything but difficult to perform preventive support which decreases the quantity of breakdowns and gives better control on upkeep spend for ideal plant execution. The breakdowns will be decreased by 25%.

Just about every business can profit by a support right hand CMMS programming like Linear Asset Management Enterprises: This is a specialty class of upkeep where organizations are required to oversee resources that range across several kilometers like streets, pipelines, links, and electrical wiring. These organizations can utilize a completely stacked upkeep right hand

CMMS for confirmation, examination, improved wellbeing, and hazard the board. By putting resources into a CMMS, organizations can make a serious edge in a worldwide market [9].

The third step of investigation is to utilizing Maintenance measurements, there are two classifications of upkeep key execution markers which incorporate the main and slacking pointers. The main pointers signal future occasions and the slacking markers follow the past occasions. The main marker contains from measurements like the Estimated versus genuine execution and PM Compliance, while the slacking marker are reflected in support measurements like the Mean Time To Failure (MTTR) , Overall Equipment Effectiveness OEE and Mean time between disappointment (MTBF).

-Some roads Defects

There are numerous streets deformities can be seen, for example, potholes, which might be characterized as a sharp-edged gaps inside the upper layers of the street surface. Rutting imperfection: which is a nonstop longitudinal wretchedness in the wheel track that permits water to lake or makes moving troublesome. Another sort of street abandons: An open joint might be characterized as the enlarging of a development joint inside the street surface. Spelling and water entrance can quicken the extending. An open joint can be a security imperfection relying on their size, profundity and area. One of fundamental streets deformity appropriated in enormous number is Cracking imperfection: Cracking is a deformity that may demonstrate whether the carriageway layers are in incomplete or complete disappointment. A limit degree to help decide if this kind of imperfection ought to be delegated a wellbeing deformity. Such imperfection once in a while requires a pressing reaction and information on their essence contributes towards the general condition raking of the street surface. Anyway, the inability to address this imperfection will probably quicken the basic disappointment because of water entrance. That deformity that degree for some separation is typically fixed during customized work. Figure 1 shows street splits [3, 14].

Figure 1 roads cracks defect

-Planned maintenance percentage (PPC): this metrics represents the percentage of time spent on planned maintenance activities against the unplanned. In simpler terms, this metric tells you how much maintenance work done on a particular asset was a part of your preventive maintenance plan versus how much time you've spent repairing it because it unexpectedly broke down. In a great system, 90% of the maintenance should be planned. The calculation is as follows:

PPC= (scheduled maintenance time/total maintenance hours) x 100 (1)

- Overall Equipment Effectiveness (OEE): OEE is the measure of the productivity of a piece of equipment. It gives informed data on

how effective organization's maintenance processes is running based on factors like equipment quality, performance, and availability. A 100% OEE means that your system is producing no defects, as fast as possible, and with no stops in the production. Understanding OEE and the underlying losses, organizations can gain significant insights into how to improve their manufacturing processes. Using this metric, you can identify what has a negative impact on your production, so you can eliminate it. To calculate the OEE, you multiply the availability by the performance and quality. :

OEE = availability x performance x quality (2)

-Mean time to repair (MTTR): MTTR is the measure of the repairable items maintainability. The MTTR clock starts ticking when the repairs start and it goes on until operations are restored. This includes repair time, testing period, and return to the normal operating condition. The goal of every organizations is to reduce MTTR as much as possible. This is especially important for critical assets as ever additional hour you need to restore an asset to a working condition amount to huge losses for your firm. To calculate MTTR, you divide the downtime period by the total number of downtimes:

MTTR= (SUM of downtime periods/ total number of repairs) (3)

- Mean time between failures (MTBF): MTBF is the measure of the predicted time between one breakdown to the next during normal operation. In essence, MTBF tells you the expected lifetime for a specific piece of equipment. Higher MTBF means that the part (or product) you bought will work longer before it experiences failure. If you know how long a specific part/equipment will last, it gets much easier to predict and prepare for a failure or schedule some preventive work. To calculate the MTBF, you divide the total operational time by the number of failures:

MTBF= (SUM of operational time/total number of failures) (4)

-Preventive maintenance compliance (PMC): PM compliance is defined as the percentage of the preventive work scheduled and completed in a set time. For example, you might have 60 Work Orders (that are a part of the PM plan) scheduled but 51 completed at the end of the month. In this case:

PMC= (51/60) x 100 = 85% [6, 7, 9].

3. Results and Discussion

Data collected: the data collected here is derived from literature and executed projects in some countries, and their experiments in using CMMS in roads maintenance operations. As in table 1 below the time is one year, the road is 50 km length.

Table 1 collected data

Maintenance Work number	Maintenance operation	Total number of failures	Time to repair without using CMMS (hr)/F	Time to repair with using CMMS (hr)/F	Expected next failure without CMMS (hr)/F	Expected next failure with CMMS (hr)/F
1	Shoulders works	10	10	8	200	300
2	Drainage systems	5	16	12	400	600
	Roadside slopes,	3	8	4	500	800
3	resurfacing and cracking repair	10	16	13	500	800
4	potholes repair	5	4	2	400	600
5	Pavement markings	2	8	6	1000	1600
6	Highway illumination	7	8	6	1000	1600
7	Removing Debris and obstacles	10	8	5	200	300

Sources: LR and MPW-Kuwait

Using equations 3 and 4 mentioned above we can calculate MTTR and MTBF as shown in table 2. Also the analysis followed above can indicate about saving in both time and number of breakdowns and downtime as shown below in figure 2 and 3.

Table 2 MTTR and MTBF for collected data

Road Maintenance operations	MTTR (Hrs)	MTBF (Hrs)
Without CMMS	10.31	452
With CMMS	7.61	707.7

It can be noticed that MTTR without using CMMS is greater than that without CMMS, in addition MTBF in the case of using CMMS is larger than that without using CMMS. Figure 2 shows a comparison between MTTR and MTBF values with and without using CMMS.

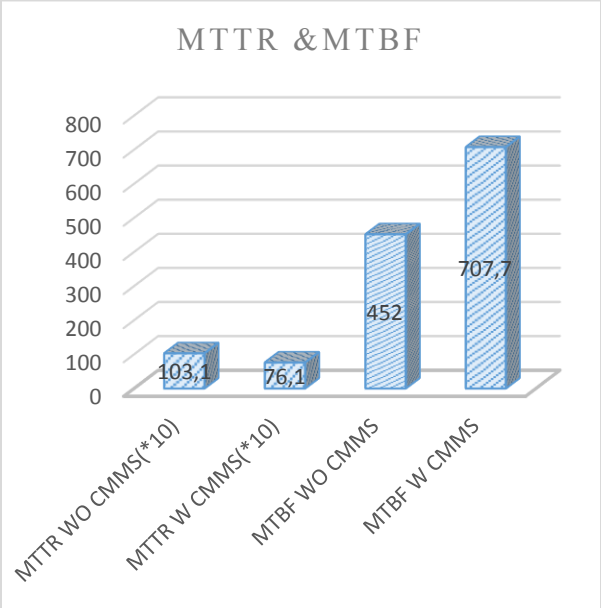

Figure 2 MTTR and MTBF without and with using CMMS

Figure 3 shows a comparison between number of failures and downtime when adopting and non-adopting CMMS in roads maintenance operations.

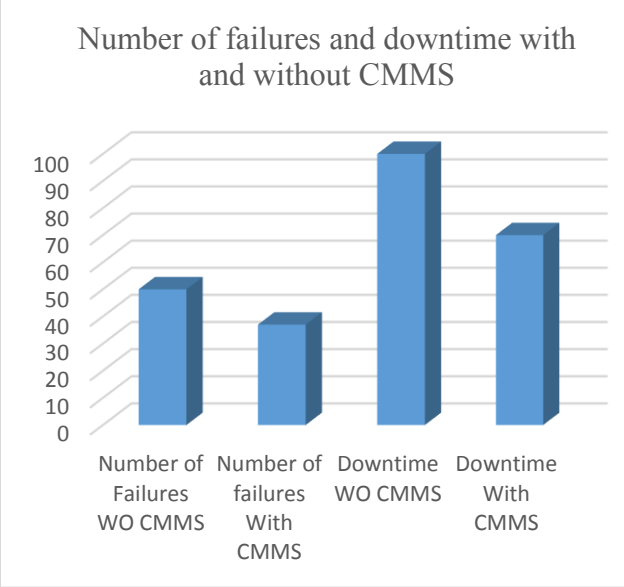

Figure 3 Number of failures and downtime with and without CMMS

It can be noticed from figures 2 and 3 that the CMMS improves road maintenance operations by decreasing MTTR increasing MTBF, reducing downtime and number of failures by a considerable ratios.

A comparison of maintenance performance with and without using CMMS in roads maintenance operations is executed, it is clear from all tables and figures above that the maintenance operations management with CMMS is more efficient and the so quality of such operations may improve. CMMS simplify maintenance management operation and monitoring of roads segments to be maintained.

4. Conclusions

This paper discussed applying CMMS in all roads and highways maintenance operations its requirements, principles and steps. Performance and effectiveness of applying CMMS in roads maintenance operations are measured by MTTR, Number of total failures, Downtime reduction, and MTBF. It is clear that the CMMS improves road maintenance operations by decreasing MTTR increasing MTBF, reducing downtime and number of failures by a considerable ratios.

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