JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

INVESTIGATION OF MAINTENANCE AND COST CONTROL FOR BUILDING

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Abstract:- Building maintenance costs are increasing rapidly due to poor maintenance in the past. Thus, this research seeks to identify the characteristics of scheduled maintenance. It is found that the characteristics of scheduled maintenance always affect the cost performance. Therefore, this research aims to establish their relationships. Then, regression model is produced for purpose of maintenance prediction. Triangulation approach that includes literature review, questionnaire survey and interview, is adopted for data collection. Consequently, the regression model can be adopted by practitioners.

1. INTRODUCTION:

Building maintenance is work undertaken to keep, restore or improve every facility i.e. every part of a building, its services including Horticulture operations to a currently acceptable standard and to sustain the utility and value of the facility.

The objective of maintenance is: -

- To preserve machinery, building and services, in good operating condition.
- To restore it back to its original standards, and
- To improve the facilities depending upon the development that is taking place in the building engineering.

In spite of recent improvements in building technology all the buildings deteriorate from the time they are completed. The rate of deterioration depends upon a number of factors. Not all the factors are under the control of the occupants.

- During the design and construction stages, the following become essential Right choice of material.
- Suitable construction techniques.
- Adequate specifications for construction and installation work.
- Effective supervision throughout construction and rectification of defects prior to final certification.
- Provision of adequate space for landscaping with proper design, and the anticipated life of building is reduced.

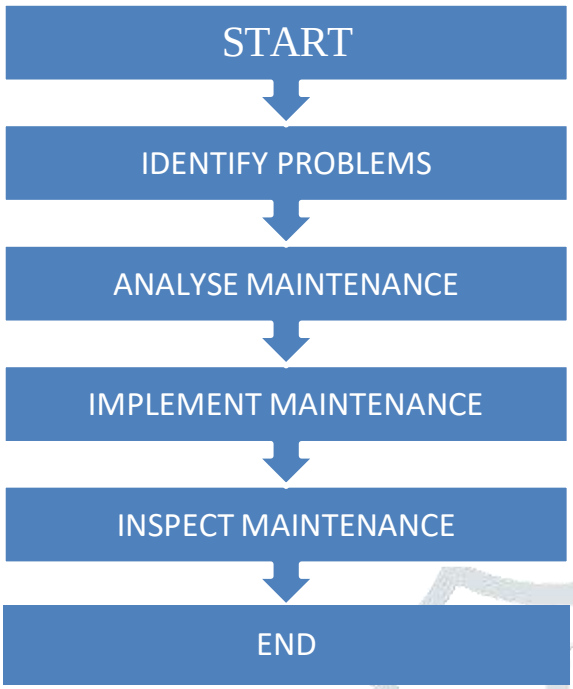
Types of Maintenance: Maintenance can be categorized according to why and when it happens and includes:-

Corrective maintenance - to keep the building at an acceptable standard. This includes cleaning gutters and changing light bulbs. Corrective maintenance would normally be carried out by the occupant.

Predictable (planned) maintenance - to prevent predictable failure of building infrastructure or capital items. This includes repainting surfaces or replacing roofcladding at the times specified by product manufacturers.

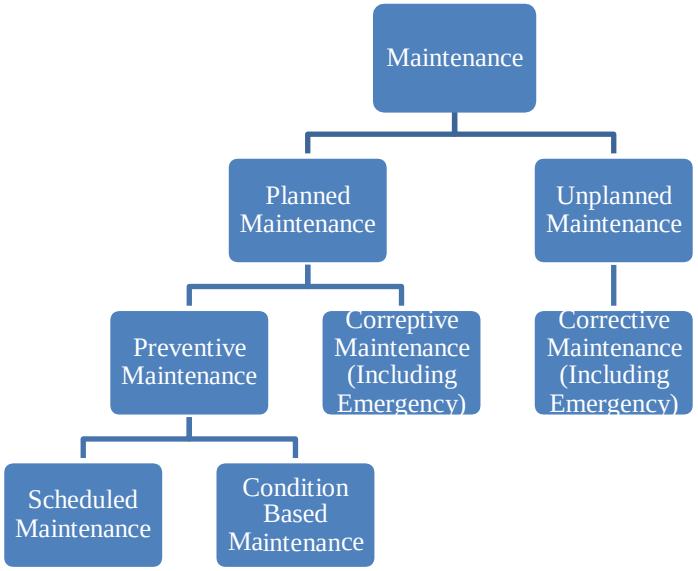
Emergency corrective maintenance - must happen immediately for health and safety or security reasons. This includes work that may result in the rapid deterioration of the structure or fabric if unattended to immediately. Such includes roof repairs after cyclones, graffiti removal or repair of broken glass.

2. METHODS TO CONTROL MAINTENANCE:



2.1 Maintenance Work Types:

Maintenance can be categorised according to answer questions why and when it Happens. Maintenance work classification which enables organisations to provide consistent services to customers' satisfaction. There are two common terms of maintenance types: planned/preventive maintenance and corrective/unplanned maintenance with other categories as shown in commonly, planned/preventive maintenance aims to prevent major break downs to ensure a building continues at peak efficiency through regular inspection and repair. Preventive maintenance is planned, based on cyclic maintenance actions such as cleaning, local repair and local replacement /treatment to prevent deterioration in advance Statutory maintenance, time-based, condition-based, predictive, reliability-centred maintenance are sub-categories of planned/preventive maintenance.



3. Identify the Problems:

Several techniques using risk-based analysis can be useful in this phase of the study including event tree analysis (ETA) or failure mode and effects analysis (FMEA). Snapshot model is a kind of hierarchical analysis where all possible failures are classified into different levels and groups. ETA can be used to identify various possible outcomes, given an initiating event. An example of this is a component failing,

Flow chart of the research design giving an indication to an area of equipment or process that requires further investigation. FMEA can identify possible failure modes and the effects on the system but can also give a potential severity to the effect, this being most useful when looking at environmental or safety critical items. Having spoken to maintenance managers, production managers and key shop floor staff, a thorough understanding of the process should now be possible. Problems such as lengthy breakdowns, especially in the case of high-volume equipment should all become apparent. Care should be taken as to whether a breakdown is a maintenance issue and not an engineering issue or operator issue. An example of an engineering issue may be working to an incorrect drawing or procedure, an operator issue may be performing of a task using incorrect tooling or running a machine at a higher rate than it was originally designed to run. Once the key plant items have been identified together with a list of dominant failures associated with the item, data can then be gathered.

4. CHARACTERISTICS OF SCHEDULED MAINTENANCE:

Scheduled maintenance is defined as the preventive maintenance carried out in accordance with predetermined interval of time, number of operations, mileage and others to ensure such components perform in good condition. Generally, maintenance activities performed at fixed time interval are mean to reduce the probability of failures and breakdowns. However, some researchers argued that scheduled maintenance is not cost effective, which the replacement of components is often performed regardless of the condition. Literature indicated that the maintenance performance of scheduled maintenance relies on the criteria as stated below:

Skilled Labour:

Since scheduled maintenance is carried out in a fixed time interval, it does require permanent maintenance personnel or technicians to perform the tasks. Commonly, the organisation allocates different amount of salary for the maintenance personnel based on their level of competency. In fact, qualification of the maintenance labour force is an important factor that affecting the maintenance outcome. For instance, some of the scheduled maintenance works are determined by experienced and skilled technician, who observes the wear and tear of the parts or components. Thus, the technicians should not only limit their capability in replacing and overhauling system components, but they must be capable to identify the need of scheduled maintenance. Furthermore, labour is highly demanded for scheduled maintenance activities. Thus, skilled labour is one of the main characteristics to be considered for implementation of scheduled maintenance, which includes:

- Skill and knowledge of labour
- Number of labour

Spare Part and Material:

Spare part and material is much required for scheduled maintenance compared to other maintenance strategies. Some parts of building systems or services need to be replaced with a new one in fixed interval as determined in the schedule maintenance program, no matter such items are damaged or not. Thus, accurate spare parts identification and stocking help to control and reduce the operation and maintenance costs. In addition, the quality of spare part and material always has an impact towards maintenance. Concern about cost saving, the quality of spare part and material is another essential aspect to be taken into consideration. In this research, the spare part and material cover:

- Level of stock of spare part and material
- Quality of spare part

Predetermined Interval for Maintenance:

The interval of maintenance activities is critically influencing the maintenance outcome. Unavailable or delay to perform maintenance task at the right time may cause further damages to the system components. Meanwhile, it is argued that the scheduled maintenance programs might not be able to avoid the risk of failure occurred on system components before the fixed replacement time. This problem occurs due to unknown condition of the system components. Hence, an adequate maintenance interval must be identified and performed to enhance the effectiveness of scheduled maintenance. Therefore, the criterion of predetermined interval for maintenance includes the length of predetermined maintenance interval.

Maintenance and Failure Downtime:

Since the scheduled maintenance is not able to prevent the risk of failure, the downtime and cost allocation for maintenance and failure should be considered when planning the maintenance approach. Sometimes, breakdown may cause collateral damage in a particular system. Relatively, additional downtime and cost will be incurred for the failures occurred before the predetermined maintenance time. Hence, the amount of downtime for maintenance and failure must be taken into consideration for the planning and execution of scheduled maintenance activities.

SPECIAL REPAIRS:

As the building ages, there is deterioration to the various parts of the building and services. Major repairs and replacement of elements become inevitable. It becomes necessary to prevent the structure from deterioration and undue wear and tear as well as to restore it back to its original conditions to the extent possible. The following types of works in general are undertaken under special repairs: -

- White Washing
- Color washing
- Distempering

After completely scrapping the existing finish and preparing the surface a fresh. Painting after removing the existing old paint from various members. Provision of water proofing treatment to the roof. All the existing treatments known are supposed to last satisfactorily only for a period of about ten years. Repairs of internal roads and pavements.

Repairs By,

- Replacement of flooring, skirting, dado and plaster.
- Replacement of doors, window frames and shutters. Replacement of door and window fittings .
- Replacement of water supply and sanitary installation like water tanks, WC cistern, Wash basins, kitchen sinks. Pipes.
- Re-grassing of lawns/grass plots within 5-1 0 years.
- Renovation of lawn in 5-6 years.
- Replanting of hedges in 8- 10 years.

Completely uprooting and removing hedges1 shrubbery, Replanting of:

- Rose beds in 5-6 years.
- Perennial beds in 5-6 years.
- Cana beds in 1-2 years.

Shifting of any garden feature from one site to another within building. The building services fixtures including internal wiring, water supply distribution system etc. is expected to last for 20-25 years. There afterwards it may be necessary to replace them after detailed inspection. Electrical special repairs in general are whole sale replacement of the wiring and the electrical installations. Earthling is also to be attended. Life of various electrical equipment's/Installations etc..are approved by The expected economic life of the building under normal occupancy and maintenance conditions is considered to be as below:

- Monumental buildings 100 years.
- RCC Framed construction *75* years
- Load bearing construction *55* years.
- Semi permanent structures 30 years
- Purely temporary structures *5* years

The life of the building mentioned above is only indicative and it depends on several actors like location. utilization, specifications, maintenance and keep caretaking. The replacement, renovation and major repairs become inevitable as the life of all the components are not identical.

All the three categories i.e. day to day, and special repairs/services are interrelated. Neglect of routine maintenance and preventive measures lead to more extensive periodical maintenance and in the long run major repair or restoration which could have been avoided or postponed. Quantum and yard stick of Special Repairs shall be worked out as under:

- Annual yard stick of Special Repairs for various types of buildings are given these yard sticks are suitably increased by approved maintenance cost index approved. Estimated cost of building repairs shall be within the yard stick.
- The amount of Special Repairs is permitted to be carried forward up to five years wherever considered necess0ary.
- At the beginning of the year, a Survey of the buildings shall be conducted to identify the items of Special Repairs which are required to be carried out. Special repairs, which are required to eliminate leakage and dampness in the buildings shall be given priority and completed before the monsoon. Special repairs to plastering, replacement of doors and windows and flooring shall be synchronized with the annual repairs, so that white washing, colour washing *1* distempering are carried out systematically. A time framework for carrying out special repairs shall be fixed by the EE at the commencement of the year.
- Other sources of information about special repairs are complaints of Special

Repairs made by allotter, which are entered in the register of special repairs.

Register of special repairs:

This register shall be maintained in form as at Annexure - 8. Complaints of special nature repairs, which cannot be attended on daily basis, shall be transferred to this register. The special repairs to buildings shall be divided in following six groups:

- Concrete work.
- Masonry works including plaster, flooring and brick work. -
- Wood work.
- Steel work.
- Sanitary and Water supply.
- Water proofing treatment.
- Electrical wiring and fittings

Few pages shall be allotted separately to each of these groups in the register and an index shall be prepared in the beginning of the register. The complaint of special repair nature shall be transferred from the complaint register to the relevant group in this register. All details about the complaint shall be properly filled in the columns of the register.

Extra Ordinary Special Repair:

When expenditure on Special Repair to a particular building is in excess of the permissible yardstick of Special Repair, the same come under the category of Extra Ordinary Special Repair. Expenditure on Special Repair up to permissible limit can be incurred by the Executive Engineer. Beyond the permissible limit however EE has to have the approval of the higher authorities. As a rule, Superintending Engineer is empowered to approve the extra ordinary special Repair Estimates within 15% of the permissible limit. Beyond this, approval of Chief Engineer would be necessary. Chief Engineers are empowered to approve the extra ordinary Special Repair Estimate to any amount so long as scope of expenditure is to retain the building in its original shape in loveable conditions without carrying out any additions to it.

MAINTENANCE PERFORMANCE:

Development of performance measurement in management is to improve quality and service, as well as meeting cost parameters. Measurement of maintenance performance is an assessment that helps to identify the strengths and weaknesses of the maintenance activities.

In addition, the result of performance measurement indicates the effectiveness of existing strategy. Consequently, the management team is able to plan and make appropriate decision for future maintenance strategy.

The measurement of performance can be obtained through the level of success or failure in terms of schedule, cost and functionality. Since the rising maintenance cost is one of the major issues concerned by the industry and public, the cost performance is concerned in this research as the dependent variable.
The aspect of cost or expenditure for building maintenance is mostly used in measuring the performance of buildings. Then, maintenance performance is calculated using variance of actual expenditure and planned cost for building maintenance activities. Comparison between actual and planned cost is made to identify the level of maintenance performance. For instance, maintenance performance of a building system is deemed below expectation when the actual spending for maintenance tasks is more than the planned cost. In contrast, high performance level is achieved when the total expenditure is less than the planned cost for the maintenance works.

RESEARCH METHODOLOGY:

This research was conducted through triangulation approach, which included literature review, questionnaire survey that is recognised as the most appropriate method for data collection, and semi- structured interview for validation of quantitative results. The characteristics of scheduled maintenance were identified by reviewing the journal articles and other reliable reference sources. Then, simple random sampling was adopted in questionnaire survey to identify the relevant respondents who have been or are currently involved in office building maintenance management. They were building manager, building supervisor or executive, technician and others. 33 per cent of valid return questionnaires were obtained from the research population to produce reliable and accurate results. In order to validate the questionnaire results, experienced building managers were interviewed. Semi- structured interview was conducted to obtain further details and understandings about the characteristics of scheduled maintenance. Indeed, the interview session reached saturation without new information after 15 respondents were interviewed. Whereby, the given answers or responses from the respondents were similarand predictable.

It is important to ensure the data is reliable in a study. Generally, reliability of data can be established by testing the consistency and stability. In social science research, Cranach's alpha is widely used to test the reliability of data. This measure indicates the consistency of data. In other words, it is computed in terms of the average inter correlations among the items measuring the outcome. By using Statistical Package for Social Science (SPSS) software, the Cranach's alpha coefficient can be computed and obtained easily. The alpha should be above 0.70 that reflects acceptable reliability.

A correlation test was used to measure the relationship between characteristics of maintenance strategy and performance through SPSS. In this study, the Pearson product-moment correlation was employed for analysis. It is a statistic designed to measure the strength of a supposed linear association between two variables. Generally, a correlation coefficient of -1.00 or +1.00 is a perfect negative or positive relationship respectively. A correlation coefficient of zero means that no linear relationship exists. In fact, the correlation coefficient indicates the strength of the linear relationship between two variables. In a research, a correlation coefficient of below 0.3 indicates weak relationship; a coefficient of 0.3 to 0.5 indicates moderate relationship; and a correlation coefficient of 0.5 or above indicates strong relationship between two variables. Thus, it was expected to obtain the correlation coefficient of 0.3 or above to demonstrate the strength of relationships between the variables. Meanwhile, it is important to test the significance of the relationships. The p-value of less than 0.05 is required to indicate the significant relationships statistically. Therefore, the significant relationship between variables in this study could be determined if both criteria are met. The findings of relationships between characteristics of scheduled maintenance and cost performance were referred to provide information for the prediction of maintenance performance. The prediction of the value of a dependent variable from the value of an independent variable is called regression. In this study, there was more than 1 significant independent variable identified. Thus, multiple regressions was used as it is a method of analysing collective and separate contributions of two or more independent variables to the variation of a dependent variable. In regression analysis, coefficient of determination assesses the strength of relationship between the dependent variable and independent variables

Accessibility for Maintenance:

It is necessary that the place to be maintained is capable of being reached for maintenance to be carried out. Access varies from day to day needs to access for a trained and experienced man to attend to a maintenance problem. In some of the structures regular shafts have been provided for water supply and sanitary installations. The shafts are too tight and there is no working space for workman. The problem is compounded by inadequate light in the shafts. Not only the elbow space has not been provided but there is no working platform for workman. The workmen refuse to attend to leakages and repair pipe lines in such circumstances. It is necessary to provide shafts with access working platform for the work men to attend to repairs. Replacement of glass panes in the windows have become another problem. In general the windows open outside and putty is also placed accordingly. In addition, for residential buildings, grill work is provided for safety of residents. The windows have generally a full sized glass sheet as a result it has become difficult to replace and even clean these glass panes. The problem is acute in buildings beyond three storeys'. It is necessary to provide proper accessibility to these windows through a regular arrangement in such a manner as to ensure fixing of glass and their cleaning from inside of the building, maintenance and upkeep. Of desert cooler & WTAC units installed at the windows.

Overhead tanks have been provided over the buildings. With a view to keep the roof inaccessible for the residents, no terrace staircase has been provided to reach the terrace. In the day to day maintenance, however the maintenance staff are called upon to go to the terrace to check the over flow and the like for which regular access is necessary. Ladders should be provided as a means of access, preferably on a permanent basis.
Buildings of monumental nature are finished with special treatment on roof, false ceiling, wall paneling and carpeting on wall which may require to be attended. It is necessary to have permanent arrangements for reaching such heights as a part of maintenance tools. It can be a dismantle tubular scaffolding system provided with Rollers as a standby for reaching the false ceiling.

Inspection of buildings and services

Periodical inspections

(a) Buildings and services
(b) Electrical Installations

Inspections for taking over of buildings

Buildings along with their services are designed and constructed to meet specific user requirement. So as to ensure full user satisfaction, it is necessary that the buildings and services on their completion should be subjected to intensive review by the team of construction and maintenance Engineers.

During the course of construction, certain tests and checks are carried out by the engineer-in-charge of the construction. Also whenever any works are entrusted to contracting agencies, these are tested and taken over by the Engineer-in-charge. Certain guarantee certificates from the suppliers/manufacturers are also received by Engineer-in-charge before accepting materials and equipment. Maintenance in charge should ensure that these are handed over to him at the time of handing over of Facility.

The formats for Handing taking over of completed buildings & services and
checklists for civil works, Electrical woks and Firefighting system are given.

Preventive maintenance:

As mentioned above, for carrying out preventive maintenance, inspection of
building has to be carried out. The building is to be inspected during the months of March-April and September-October. Two Monsoon winds bring rainfall to India.

- South West Monsoon(June-October)
- North East Monsoon(November-February)
-

Experience has taught that monsoon rains, winds and cyclone cause considerable damage to buildings, tall structures, uproot trees and lamp posts, cause floods, roof leakage into buildings. blow water through broken window panels, blow off thatched roofs, hutments and bus shelters, came disruptions in power supply, water supply and sewerage systems resulting in untold sufferings to people besides causing huge financial losses to the ex chequer and endangering lives. To minimize such losses and avoid danger to life it is necessary to undertake some specific pre-monsoon preventive measures which are briefly discussed below:

4.11.1 Attending to services before Monsoon Rains and Cyclones:

Buildings and Services are to be thoroughly checked for safety and functioning before monsoon. In coastal areas the same are checked before cyclones. Precautionary measures are to be taken for various items of the buildings/services, some of which are mentioned below.

a) Temporary Roofing:

Many buildings are provided with temporary roofing like AC Sheet roofing. Before the onset of the monsoon, the Engineer-in-charge of Maintenance should see that the LIJ hooks, bitumen washers, Limpet washers are in position. Precautionary measures against blowing off the roof should be taken by lightly loading the roof temporarily or providing MS flats rods fixed by bolts and nuts to purling for rows of AC Sheets.

b) Door Window glazing:

All broken glazing's should be replaced and sufficient number of glass window panes and iron monger fittings should be kept in stock for emergency repairs. The tower bolts, hooks and eyes and other wind appliances should be made in working condition. Occupants should be advised to keep the doors and windows closed during cyclonic weather especially at nights.

c) Checking buildings against seepage:

Terraces of all the buildings may be inspected well ahead of the monsoon rains in June and December and necessary repairs carried out. The roofs should be cleaned and debris removed from the roof to avoid blockages in roof gutters and rain water pipes. Rainwater inlets should be checked and ensured that there are no damages around these. Vertical rain water pipes should be properly clamped to the walls. Seepage through cracks developed over chajjas is very common. It should be ensured that required repairs are carried out to the junction of chajjas with the walls.

d) Checking of external areas:

Open areas and lawns should be inspected and measures taken to ensure that rain-water does not accumulate therein. Wherever storm water drains are under the maintenance of the same should be detailed and paved surfaces or bunds repaired. Precaution should be taken against erosion of land and embankments.

e) Checking of sewers and sewage installations

All inspection chambers, manholes and sewer lines should be cleaned and flushed to establish free flow of sewage. Sewage sumps should be cleaned of accumulated grit. sand and sludge. Bunds of oxidation ponds should be strengthened wherever necessary.

f) Checking of electrical installations

Because of rise in ground water table at places, it may be necessary ro remove electric pumping sets installed in wells and sump, below ground water level and raise them temporarily to safe levels. Care should be taken to ensure availability of standby power supply arrangement to take care of breakdown in power supply in monsoon or at the time of cyclones. The Diesel Generating sets should be checked and kept in working condition and wiring should be checked for loose connections.

g) Checking of Air-conditioning installations

Wherever Central AC plants or package units are provided, the dehumidification system consisting of strip heaters, humidistat etc. should be checked for their functioning.

6.3.2 Post monsoon/cyclone measures:

Inspire of pre-monsoon measures taken various buildings/services, very often these are affected during the monsoon and cyclones. In coastal or cyclone prone areas, the services are affected more. Immediately after monsoon, all important structures/services should be inspected by a team of engineers from all disciplines concerned with the maintenance and work should be planned to put the services in order immediately.
Overhead cables, uprooted light poles, restoration of power supply, disinfecting of water supply lines/installations, ensuring normal water supply, restoration of sewage pumping operations, flood relief works, repair to breaches to embankments of ads and bunds are some of the important areas which are to be attended immediately after monsoon/cyclone. Detailed inspection of the buildings should be carried out to ensure that broken false ceiling, broken glass panes, blown off A.C. sheet roof, cladding, doors and rolling shutters etc, are attended immediately. Where breakdown would result in serious damage to the equipment and costly repairs. Preventive maintenance is necessary. Whereas Preventive maintenance is also justified where it improves performance and the cost is less, compared to cost of repair after a failure. The works of preventive maintenance in case of buildings are to be carried out latest by 15'~Ju ne and 3 1'' October. In case of machinery, periodic inspection of equipment is carried out to avoid the conditions leading to breakdown or harmful depreciation. It is also carried out for proper up-keep of Plant through servicing and repairs while they are still minor. However incase of machinery and equipment's, frequency of inspections should be decided and the system should be designed for improved maintenance techniques, low cost maintenance and avoiding the over maintenance on the basis of sta.risticl-11 data available for maintenance and manufactures recommendations.

5. Maintenance Cost Planning and Estimating:

Maintenance cost includes all costs of keeping the building up to an acceptable standard. It relates to the direct cost of maintenance such as spares, labours, equipment and tools as well as indirect costs such as administration, management and the inevitable overhead costs. When the demands of maintenance are identified, cost of the maintenance should be a prior estimate to measure resource availability and how much work should be scheduled in each period. Although cost estimates for building maintenance are normally prepared over the period to predict the likely cost of such works over the life of the buildings, they can be considered in a single annual maintenance programme. The main purposes of a cost plan for building maintenance are defined as listed below (RICS, 2015).

- Determine the target cost limit for maintaining programme works.
- Inform setting the annualised maintenance budgets and available funding constraint.
- Provide cost information to assist decision makers to make informed decisions.
- Inform what asset investment are funded or not funded and then revise life cycle cost plan.
- Ensure the employer is provided with best valuefor money from maintenance spent.

Like any program or plan, maintenance budgets will be subjected to change and adjustment and it must be based on forecasting or predicting aiming to best utilise fixed maintenance resource to meet the fluctuating maintenance. Total maintenance cost is the sum of the cost of preventive maintenance and corrective maintenance. Having a proper preventive maintenance strategy can reduce corrective maintenance cost, leading to reach optimal maintenance zone. The optimal zone is where the two costs are balanced. Once funds are approved for the maintenance budget, efficient use of this money requires wise internal allocation of the funding at the operational level or locating this optimal zone.

Douglas (2017) also summarised five stages in the optimisation process, that should be embedded in the design phase but will offer benefits to any state of a building lifecycle:

- identify critical functions/elements/areas;
- understand the failure models and effects;
- evaluate existing maintenance;
- apply predict maintenance technique; and
- recommend changes to maintenance strategy according to findings of best practice.

Cost planning and estimating of maintenance work require detailed information such as maintenance requirements or the employer's brief for maintenance work throughout the life of the building over the short, medium and long-term. Some agreements remain as maintenance works can be challenging to cost accurately due to lack of reliable information required as listed below:.

- Type of buildings/asset/facility and the functional usage.
- Occupancy details: tenure detail, hours of operations, usage of space.
- A statement of building/asset/facility (age of the building, last major Refurbishment, etc.).
- Location and building description.
- Aims of the maintenance programme, maintenance strategy.

A limited number of the building components such as roofs, paintwork, woodwork and building services play a large part in maintenance cost.. Therefore, identifying significant factors affecting the maintenance cost and the relationship between the factors such as building characteristics, tenant factors, maintenance factors, political factors might help to control the factors to optimise the maintenance cost. While planned maintenance works have different technical specifications resulting in differences in requirements for maintenance resource, leading to different approaches to calculating the costs for specific scheduled maintenance work , the unplanned maintenance costs usually are budget based on historical data showing by percentage of actual breakdown cost and total cost of maintenance.

6. Existing Cost Estimating Models for Maintenance:

Table presents a summary of cost estimating models for building maintenance, which is produced in recent years. produced the models basing on historical data of buildings in the University of Osijek to predict maintenance cost models over the periods, which used multiple-regression and Stepwise analysis to identify the relationship between the variables resulting in three models. Research to show how to establish a cost prediction model of maintenance for university buildings in Taiwan that used historical data on maintenance to predict the model, using three different methods: simple linear regression (SLR), multiple regression and a back propagation artificial neural network (BNP). Au-Yong, Ali and Ahmad (2013) established six significant characteristics that are correlated to the cost performance of high-rise office buildings. ASHRAE Owning and Operating database is a database of information on equipment service life and annual maintenance costs for a variety of building types and HVAC systems. The ASHRAE maintenance cost model is based on commercial office buildings in the US aiming at providing accurate and usable building owning and operating cost data to building owners and managers in respect of strategic decisions involving the life cycle and functionality of their buildings.

7. Role of Maintenance in Building:

As can be seen from Figure 3, maintenance plays and important role in the life cycle of cost analysis of building holistically. Buildings cannot remain impeccable throughout their entire life. Even though, that is a brand- new building which requires maintenance as well. Furthermore, it is hard to renovate and rebuild buildings at one time. In the meanwhile, the value of buildings declines as the aging of building unless specialist maintenance carried out on the building. Defect is regarded as part of design of building, construction or materials which are not in compliance with requirements of the contract and quality of norm. They can be categorized into two: latent and patent. The patent defects are incurred by normally wear and tear while the latent defects are related to construction workmanship defects.

8. Impacts of Building Maintenance on Life:

Building maintenance affects three aspects mainly with respect to our lives. Firstly, it links with safety and health of human and properties. Secondly, it is related with economy, from the small scale of economy that is a city or town's economy, but in the scale of large scale that is the whole country' economy. Finally, it is able to affect social and environmental issues to some extent.
The objectives of building maintenance are explained below:

- To ensure the building and its services are under a safety condition.
- To ensure the buildings are available for use.
- To ensure the condition of the building meets all statutory requirements.
- To maintain and retain the value of the physical assets of building stock by carrying out the building maintenance
- To ensure and retain the quality of building

Four Ways to Cut Maintenance Costs
1. INNOVATE MAINTENANCE
2. TRACK INVENTORY MORE EFFICIENTLY
3. IMPROVE LONG-TERM PLANNING
4. OPTIMIZE ENERGY TRACKING

INNOVATE MAINTENANCE:

There are many unique facets to managing maintenance (whether you work at a school, manufacturing plant, hospital or government building), and the landscape of maintenance and operations is continually changing. Increasing workload and lack of resources are facility managers' top concerns, according to an industry survey .Many maintenance management teams use a combination of paper, spread sheets, sticky notes, whiteboards and voicemails to receive work orders, compile reports, schedule preventive maintenance, manage inspections and more. These manual processes invite in error with open arms and provide little visibility to outstanding requests, status, overall spend and other key metrics. In addition, there's no consistent recordkeeping, which can lead to a host of issues.

A computerized maintenance management system (CMMS) can allow your team to:

• **Plan:** Create, assign and manage recurring preventive maintenance tasks
• **Communicate:** Receive work orders electronically and email updates on pending requests
• **Report:** Track detailed metrics on building maintenance, repair spending, regulatory compliance and more
• **Ensure continuity**: When a team member is out for some time, retires or takes another job, it's easy for others to

TRACK INVENTORY MORE EFFECTIVELY:

NOBODY LIKES DEAD INVENTORY: Inventory is one of an organization's most costly assets. Managing it with manual and paper systems can contribute to shortages, inventory shrinkage, dead inventory and waste. Inventory is tied to these common reasons frontline technicians can't complete maintenance work: • Lack of parts • Work orders don't identify required parts • Parts cannot be found

TOOLS:

• **Track:** Use barcode and radio frequency identification (RFID) technology to number parts, maintain accurate records, link parts to work orders and count inventory instantly
• **Report:** Gather key data automatically to keep executives informed and simplify annual audits, while identifying inconsistencies to create opportunities for greater
• **Optimize:** Eliminate inaccuracies caused by human error, manual systems and paperwork, while validating the need for on-hand inventor.

9. SEEING THE FUTURE:

Even though we know that facility managers can't see the future, they're often asked to do just that. Forecasting future operational needs is a daunting task, but it has to be done. Whether it is replacing old equipment or planning for future renovations, it all needs to be taken into account.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10. CONTROLLABLE COST:

For most facilities, energy is the largest but most controllable fixed cost. Increasingly, building managers with few resources are turning to energy efficiency to cut fixed operational costs.

11. TOOLS:

- **Decide:** Review energy consumption to identify unusual spikes in usage. A spike in water consumption with no obvious reason could mean you have a leak.
- **Measure:** Watch and compare pre- and post-retrofitting effort usage, then follow up on repair projects to see if your team's repairs fixed a spike inconsumption.
- **Report:** Analyze and compare energy usage data to previous years to justify the time and money spent on energy efficient changes made by your team.

12. CONCLUSIONS:

Maintenance is needed throughout the entire period that the building remains in use or occupation as well as building inspection which is conducted from the inception of construction to the occupants living. Both of them are aiming to provide safety for users and building owners. Additionally, buildings may fail due to a number of reasons, such as faulty design, faulty construction, faulty maintenance, faulty materials and faulty use. Thus, the building is vulnerable to be affected and need indemnity for the building quality.

Building Maintenance management consists of managing, planning and also controlling the building maintenance. In spite of that there are four supporting factors that need to be considered in making building.

- The maintenance management for budgeting and cost controlling .

Therefore, there is a deficiency in the ways in which building's maintenance procedures are being managed. Various attempts have been made to improve the performance of buildings through maintenance. While such schedule procedures offer the potential to improve the performance of maintenance management systems, the systems have, however, been reactive, hypothetical and conditionally based. It is these substantial weaknesses in the proposed schedule procedures that have created the fundamental problems with the existing and proposed building maintenance management schedule procedure, causing their inability to improve the existing systems. Maintenance cannot be circumvented, but what is possible is that expenditure on building maintenance can be optimized through a proactive maintenance management system based on the concept of value.

Users measure the performance of their building in terms of various criteria that are consistent with their value systems. Maintenance management procedures must be based on the user's value systems. A significant impetus of value-based maintenance management is the progressive realization that maintenance must be viewed from engineering, scientific, technological, political and commercial perspectives.

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