Evaluation of Maintenance Management in Iraqi Governmental Buildings

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ABSTRACT

Impact of buildings in Iraq and other countries on the environment is obvious; this problem began to take scientific and humanitarian dimensions in order to reduce and eliminate this problem. This impact can be seen through the energy, water and raw materials consumed for the establishment, operation and maintenance of these buildings, as well as the emissions of hazardous gases and generations of solid wastes.

This work was conducted to assess the current maintenance managerial practice for the governmental buildings to stand on the main obstacle and extrapolation of measures by means of interviews with experts to determine the effective factors and closed questionnaire to state the features and the need for new building maintenance management system which may assist for modeling new building maintenance management system which may help to reduce the deterioration levels of governmental buildings and the emission of hazardous gases and solid waste with cost efficient approach.

Key words: Buildings, maintenance, sustainability, management.

تقييم اجراءات ادارة صيانة الابنية في العراق- نظرة مستدامة

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الخلاصة

ان تأثير المباني في العراق وغيرها من البلدان على البيئة يعتبر من الامور الجلية وان هذه المشكلة بدأت تأخذ ابعادها العلمية والانسانية بغية الحد من هذا التأثير، ويمكن ملاحظة ذلك من خلال استهلاك الطاقة والمياه والمواد الخام المستغلة لغرض انشاء وتشغيل وادامة هذه الابنية ,فضلا عن انبعاث الغازات الخطرة وتوليد النفايات الصلبة.

تم اجراء هذه الدراسة لغرض تقييم الممارسات الإدارية الحالية للمباني الحكومية بواسطة اجراء مقابلات مع الخبراء من اجل تحديد العوامل الرئيسية التي تؤثر على الصيانة المستدامة للأبنية واستخدام اسلوب الاستبيان المغلق لتحديد الحاجة والملامح الرئيسية لنظام اداري جديد لصيانة المباني الحكومية والوقوف على العقبات الرئيسية واستقراء التدابير التي يمكن أن تساعد في استحداث نظام إدارة لصيانة المباني والذي قد يساعد على خفض مستويات تدهور المباني الحكومية والحد من الاثر البيئي الناتج بسبب انبعاث الغازات السامة والنفايات الصلبة ضمن نهج فعال من حيث التكلفة.

الكلمات الرئيسية: ابنية, صيانة, استدامة, ادارة

1. INTRODUCTION

Governmental buildings share the same fact that all of them need to be maintained to perform as they designed and constructed for, and to meet the new requirements of sustainability represented by its three aspects (Environment, Social, and Economy).

While more recent studies have considered the maintenance of buildings of the most important phases of the project management due to of the long time period represented by the ratio to the period of the project life, it has been found that the number of researches and studies written in this area in Iraqi literature is still humble.

Buildings in general are responsible for 48% of the emissions that affected the ozone layer, consumed 40% of natural resources, and about 60% of the total consumption of energy to be used for air conditioning and lightening**, Ahn, 2008. Fig.1** shows the CO_2 emission according to sectors. Instead of that and according to natural wear and tear, buildings systems and components deteriorate and need to be maintained by different methods of building maintenance practices. Governmental buildings in Iraq as the main concern of this research is very important and considered essential because of the huge amount of resources spent for constructing them; therefore the need for maintaining them as well as the current practices and procedures need to be assessed in order to find the main characteristics and features of the current system which may assist in improving the maintenance management procedures basing on best available scientific practices.

2. BUILDING MAINTENANCE CLASSIFICATION

Several types of building maintenance are used according to the availability of resources, experts and the criticality and emergent status of the deteriorated or broken part of the building. Maintenance can be identified through a number of specific types and can be classified in a number of different ways (In BS 3811: 1984 and, the European EN 13306, maintenance can be subdivided in the way described in **Figs. 2 , 3,** and **4**, **Chanter, and Swallow, 2007.**

2.1. Corrective Maintenance

This type is also known as breakdown, failure based, run to failure or unplanned maintenance, is the simplest type of classical maintenance policies where an item is used until it breaks/faults with the only activity centering on repair and servicing of the parts. Corrective maintenance can be subdivided according to whether it is executive or deferred to a later date, and perhaps included in a longer run maintenance plan **Cruzan, 2009**.

Corrective maintenance approach leads to more degradation of the building structure and systems, and therefore, the progress of future maintenance activities will be more difficult and more expensive.

In real condition, corrective maintenance might not be avoided in the building life cycle, as an example, the damage caused to buildings by natural calamities or accidents like wars. Often, building fabrics are maintained on a corrective basis.

Corrective maintenance is unrestrained and involuntary in nature therefore, if no alternative strategy put in place, the building structure will continue to deteriorate until exhaust of proper maintenance and this will lead to further decay, degradation, and failure.

The emphasis of this research is that corrective maintenance should be reduced to the minimum and it should be applied with less disturbance and disruption to works taking place inside and/or around the building.

2.2. Preventive Maintenance

Refers to situations where repairs and/or replacement take place without the incidence of any specific fault. The plan is to prevent failures. In many preventive maintenance models, the system is assumed to be as good as new after each maintenance whereas a more realistic situation is one in which the failure pattern of a preventively maintained system changes to somewhere between as good as new and as bad as old**, Lind, and Muyingo, 2012.** The preventive maintenance effects can be subdivided into a perfect, a non-effect and an imperfect effect where:

a- The perfect effect restores the system to good-as-new,

b- A non-effect to bad-as-old,

c- An imperfect effect to partly good.

Ryan Cruzan judged that it is from the technical point of view "Preventive maintenance is a scheduled program of regular inspections, adjustments, lubrication, or replacement of worn or failing parts in order to maintain an asset's function and efficiency"**, Cruzan, 2009.**

Olanrewaju, and Abdul-Aziz, 2015 stated that preventive maintenance can make a reduction in the total maintenance costs by about 15 % if introduced properly**.** Preventive maintenance can be subdivided the following kinds:

2.2.1. Condition-based maintenance

Condition based maintenance (CBM) is kind of preventive maintenance where the object is inspected on a regular basis and the object serviced or replaced when a certain condition is observed. Sophisticated signal processing tools are used to monitor the condition of the buildings. As an example, vibration measurement, non-destructive testing, thermography, transducers, and spectroscopy make it possible to perform non-intrusive inspection in order to monitor the conditions of buildings. This kind of maintenance sometimes referred to as (predictive maintenance) **Saranga, 2002**.

2.2.2. Opportunistic maintenance

A new concept arises here that is Opportunistic maintenance: This concept covers the case where various things are done because there arises an "opportunity" to carry out a certain activity in a cost-effective way. Opportunistic maintenance figured as a sub form of condition-based maintenance (CBM) where maintenance and replacement decisions are based on the state of the rest of the system. Typically during the performance of a scheduled or unscheduled maintenance action, a situation might arise where it is cost effective to carry out corrective maintenance on another previously undetected failing item or to reschedule another maintenance activity so as to take the advantage of scale economies in the ongoing activity. Genetic algorithms or robust optimization can be used to decide on whether a particular item needs opportunistic maintenance and how cost effective this would be in comparison to a later grounding**, Lind, and Muyingo, 2012.**

2.2.3. Time-based maintenance

It is another kind of preventive maintenance, where tasks are performed at a frequency dictated by the passage of time, regardless of the actual condition of an item. This type of maintenance may at times create problems where not existed before**, Lind, and Muyingo, 2012.**

2.2.4. Proactive maintenance

Very similar to the condition based maintenance and is cheaper in the long run when compared with other strategies of maintenance **Olanrewaju, and Abdul-Aziz, 2015.**

It is focusing on the root cause instead of the symptoms of the damage. Cause and effect analysis, which is the determination of the mechanisms and causes of building faults, is crucial in proactive maintenance.
The basic assumption in proactive maintenance is the removal of the causes of defects from all sources. Then correction of the fundamental causes of building failures can be occurred, and the failure mechanisms can be gradually engineered out of each building system and this leads to improve the efficiency of the building. **Table1** describes the logic behind each maintenance type.

2.3. Maintenance vs. Improvement

It is essential to clarify the difference between maintenance and improvements; maintenance is the activities which return back the quality of service and the performance for each deteriorated system or sub system to the designed levels, while the improvement is meeting the new user and technical and regulations requirements **Fig. 5**, **Stanford, 2010**, sometimes maintenance concept has been referred to by the expression (adaptive concept) while improvement concept has been referred to by the expression (perfective concept).

2.3.1. Adaptive concept

This concept involves adjusting or adapting the service system for changing to a different service delivery. An example of this is changing the maintenance service of residential building to academic building or changing from lecturer's requirements to student's requirements

2.3.2 Perfective Concept

This concept involves developing or acquiring additional service system or improving the operation capability of the service system. This should not, however, be confused with refurbishment work, as it does not involve changing the physical outlook of the building but only the service provided.

3. METHODOLOGY

Building maintenance challenges need to be categorized and measured; therefore 18 key questions considered as the most important concerns on building maintenance management from the researcher point of view **Table2**, an open questionnaire built from these concerns in order to assess the current maintenance management practice in Iraq.
In order to prepare the assessment of the current maintenance management practice in Iraq the researcher conducted a survey for the governmental buildings maintenance management systems practice and procedures as:

3.1. Studying BMM System for Iraqi Governmental Buildings-Part One:

A form was designed with open questions stemmed from the main concerns **Table1** to determine the main characteristics and features of the current BMM system by means of personal interviews technique, the researcher spent around three months to make personal interviews with staff from the upper and middle grades in many governmental buildings management level personnel as shown in **Table3.**
The main inferences from this investigation were:
1- The BMM system is not clear, and on most cases the engineering affairs department is responsible for new constructions and major rehabilitations while maintenance department or units at most cases responsible for fixing the broken fixtures and broken systems; although there

is some kind of preventive maintenance processes in maintaining HVAC systems and electrical systems; there is no strict system for planning and execution for such practices. The maintenance of building parts are usually postponed until the availability of fund or to next rehabilitation.

2- Functional performance of building parts and components is more critical than conditional status on consideration of maintenance work.

3- Estimating of required funds basically based on the expenses of previous years, with a particular increment.

4- Replacement age and/or replacement models calculations are not conducted.

5- BMM software application was not detected.

6- Absence of electronic documentation for any of maintenance practices and information.

7- No user satisfaction evaluation was conducted.

8- No clear incentive system was connected with maintenance staff performance in order to encourage them.

9- Measuring maintenance works productivity is neglected.

10- Investigations of the causes of failure were not conducted in most cases.

11- The work of building maintenance is not subject to any quality standard.

12-The interviewees also asked to give their opinion about the main constraints that may affect the size and quality of the BMM system and the answers revealed that the main constraints are the building size, building type, number of stories, building age, type of use, type of occupiers and number of users. Another constraint is the budget deficits and the political, economic, environmental, cultural and social determinants of budget deficits.

13- The factors that most affecting maintenance management, from the interviewees' point of view depending on frequencies from the respondents answers. The researcher faced at this step one of the main difficulties which is the lack of understanding of sustainability and sustainable maintenance approach due to the recency of this concept which requires from the researcher strenuous efforts to clarify it to the interviewees. Initially, forty eight factors were identified then and by means of rigorous analysis, they were reduced to thirty two factors, the 32 factors were later reduced to 24 factors which agreed as the key factors or the criteria affecting the sustainable BMM, these factors are:

- Need for special experience.
- Building age.
- Initial cost.
- Maintenance cost.
- Community culture.
- Security aspects.
- Political issues.
- Need for special software.
- The ability to use recyclable materials.
- Time to response.
- Occupier health.
- Aesthetic appeal.
- Occupier safety.
- Occupier comfort.
- Wellbeing.
- Time to complete the work.
- Intense of use.
- Exposure to environmental effects.

- Pollution.
- Need for special tools and appliances.
- Ability to recycling.
- Amount of resources consumed each year.
- Amount of resources consumed for constructing the asset.
- Need for special standards.

3.1.1. Actual maintenance practice

For Iraqi governmental BMM procedure, it is concluded from the previous part of the work that the current building maintenance work; in general, follows the steps represented by **Fig.6**

3.2. Studying BMM System for Iraqi Governmental Buildings-Part Two:

This part of the assessment done by means of closed questionnaire consisted from two sections, the first section prepared to collect the general information about the experts who conduct the assessment while the second section is consisted from four questions to assess the current BMM.

3.2.1. Characteristics of respondents

Five questions set to collect the respondent personal information, the analyzed data showed that the majority of respondents (79.2%) are public sector employees and the rest are private sector employees **Table4**, 20% of the respondents from private sector and most of them are engineers (90%) **Table5**, and some of them having PhD degree (20%), all the rest have BSc degree, and 70% of the respondent from the private sector have experience more than 15 years and 20% more than 10 years only one respondent have experience less than 10 years **Table6**. Most of the respondent from the public sector were engineers and 95% of them having experience more than 10 years. Only 5% of them having diploma, 52% have BSc degree, 23% having master degree and 15% having PhD degree. 94% of all the respondents were engineers and 6% working on administrative specialist **Table7**.

3.2.2. Analysis of Questionnaire

On the first question it is suggested that the maintenance management for governmental buildings is very essential and it needs special care from all employees and especially from the top management, 64.5% from the respondents agree with this suggestion and more than 33% strongly agree while 2% were neutral with this suggestion **Fig. 7**, the mean of the responses was 4.31 according to the equation

$$\overline{x} = \frac{\sum_i x_i}{n} \qquad (1)$$

While the standard deviation of 512 according to the equation

$$s^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2. \qquad (2)$$

It can be concluded that the respondent agree with this suggestion.

On the second question, the respondent asked to give their opinion if there is real need to reconsider the current system of building maintenance management by improving the procedures using the scientific approaches and considering the sustainability principles in order to improve the social and community outreach and decrease the environmental impact beside the economic growth, more than 60% of the respondents agree and about 30% strongly agree with this opinion (half of them from the private sector, which means 70% of the respondents from the private sector strongly agree), little more than 10% of the respondent were neutral with this opinion all of them from the public sector, **Fig. 8** and **Table8** explain the statistics about the need for new sustainable system for BBM with more detail.

Third question is built upon the main conclusion reached from the survey conducted on the current maintenance management system on the part one of this study **Paragraph 3.1**,where it is found that there is no obvious existing sustainable maintenance management system and what is happening is correction action by maintenance units for what is broken while the engineering affairs offices generally prepare and manage contracts for rehabilitation between whiles, therefore the researcher seeks the expert opinions if they agree or not with this conclusion and define the degree of agreement. The results in **Fig. 9** were showing that more than 50% of the respondents agree, about 20% strongly agree and around 30% had a neutral opinion.

Due to the importance of this question as a main conclusion from the surveys conducted in the current maintenance management systems in Iraqi government, it has been decided to further analysis should be accomplished on the results of the answers of this question, therefore, ANOVA test was conducted to measure the differences among scientific degrees groups, as there are four basic assumptions used in ANOVA test:

1- The expected values of the errors are zero
2- The variances of all errors are equal to each other.
3- The errors are independent
4- They are normally distributed

The results are tabulated in**Table9**, it has been shown that the mean of all respondents is 3.85 which means almost all the respondents agree on the scale of this question as (agree = 4) with Std. dev. of .684 according to equation 2. Considering the scientific degree of the respondents, only one category which is the respondents who have diploma degree had standard error equal to 1, and Std. dev. equal to 1.414, that result can be considered reasonable since there were only two respondents in this category, for all other categories, the results are showing smaller error value and Std. dev., so the answer of this question can be considered as agreed with the researcher suggestion.

The fourth question of this part of questionnaire dealt with the method of delivering the complaints. Seven methods suggested which were (internal mail, email, web site, fax, mobile, phone, oral) another option is also applicable if the respondent have another method, the results were as in Figure 10 as we can see that around 44% encourage the use of mobile and around 29% suggested to use the email, and around 15% suggested to use the website, 8% of the respondents seems they encourage the traditional method of internal mail 75% of them had an experience more than 15 years **Table10.**

4. CONCLUSIONS

As a one of the most sensitive stages of the construction management process, it has been found that the maintenance stage is suffering from many deficiencies; planning and management practices for managing the maintenance of governmental buildings in Iraq also has been found not sufficient and it has been discovered that there is a consensus from the experts to the need of rethinking and reviewing these practices in order to find a scientific way for modifying and

upgrading these practices to catch up with the rapidly developed international sustainable practices in this field of construction management.

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NOMENCLATURE

BMM= building maintenance management
BS= british standard
CBM= condition-based maintenance
CSR= corporate social responsibility
EN= european standard
HVAC= heating, ventilating, and air conditioning
Std. dev. = standard deviation
ANOVA= analysis of variance

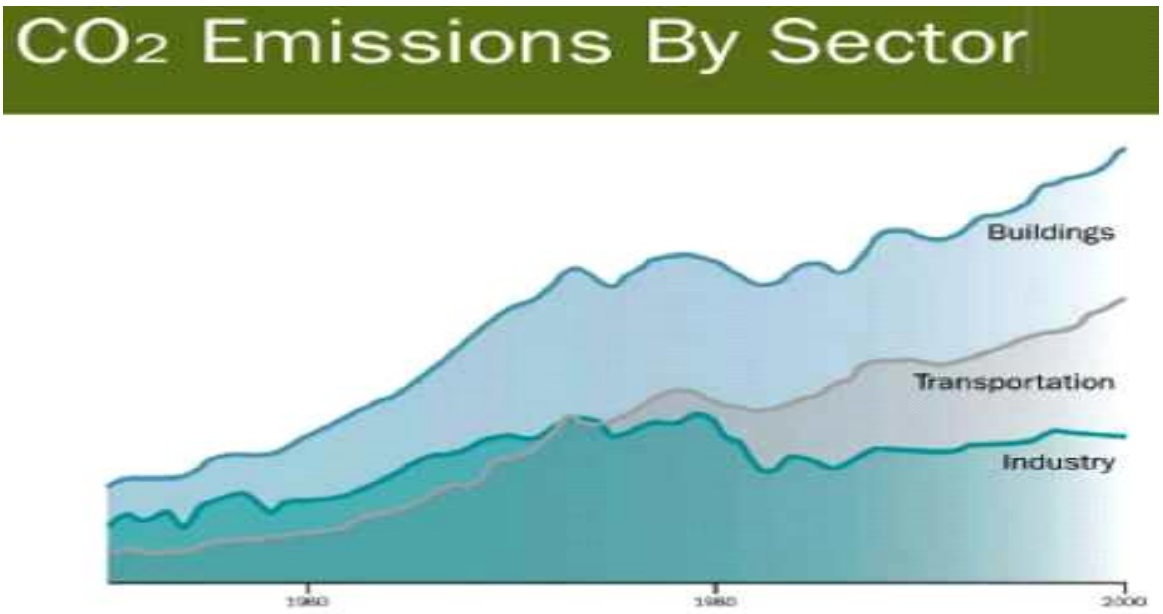

Figure1. The CO_2 emission according to sectors. **Ahn, 2008**

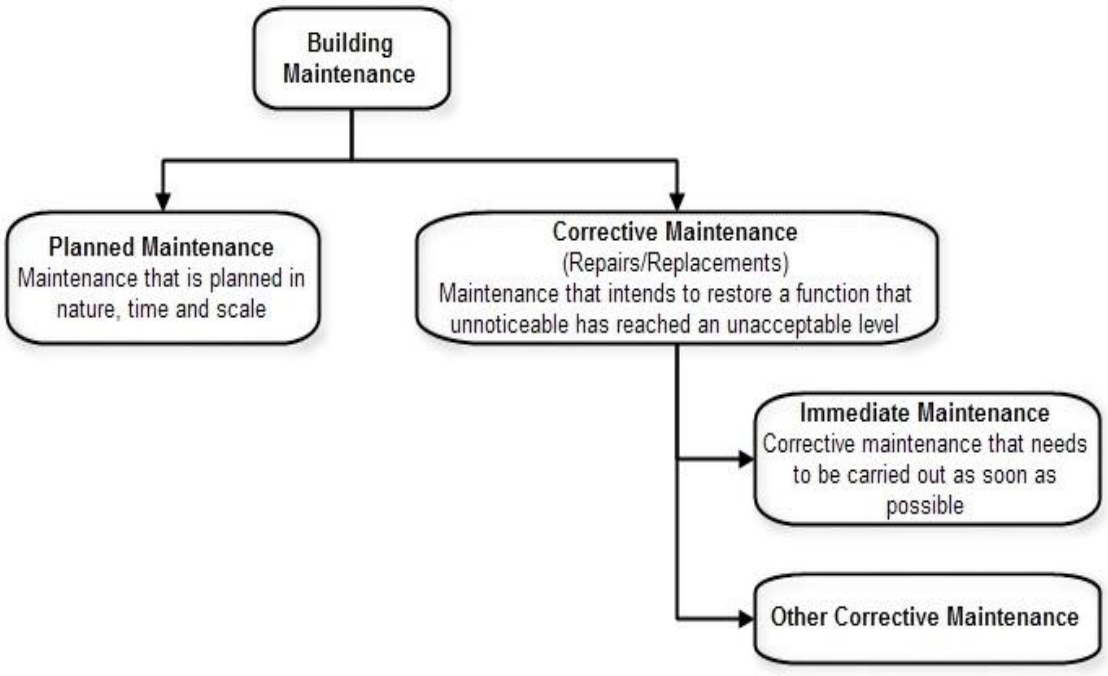

Figure2. Maintenance classifications according to planning requirements. **Chanter, and Swallow, 2007**

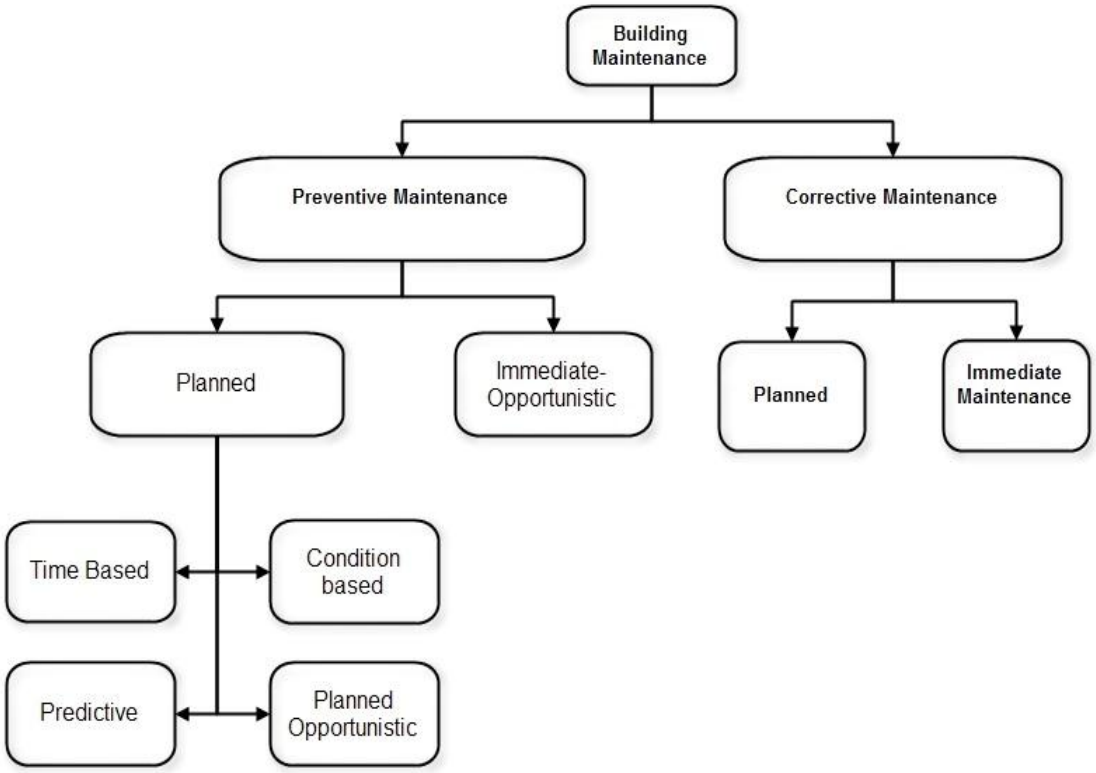

Figure3. Maintenance classifications according to maintenance type. **Chanter, and Swallow, 2007**

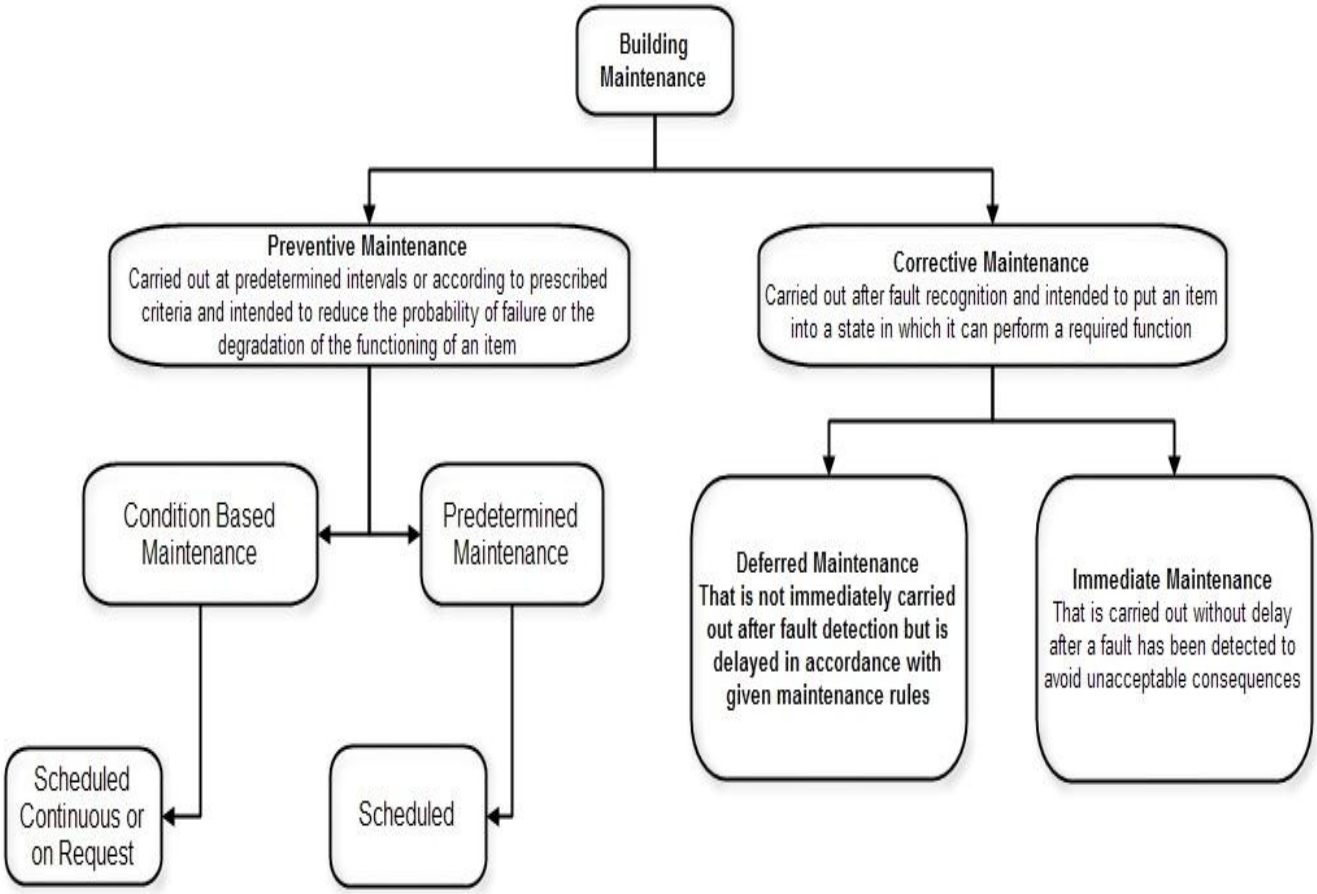

Figure4. Maintenance classifications according to maintenance type with details. **Chanter, and Swallow, 2007**

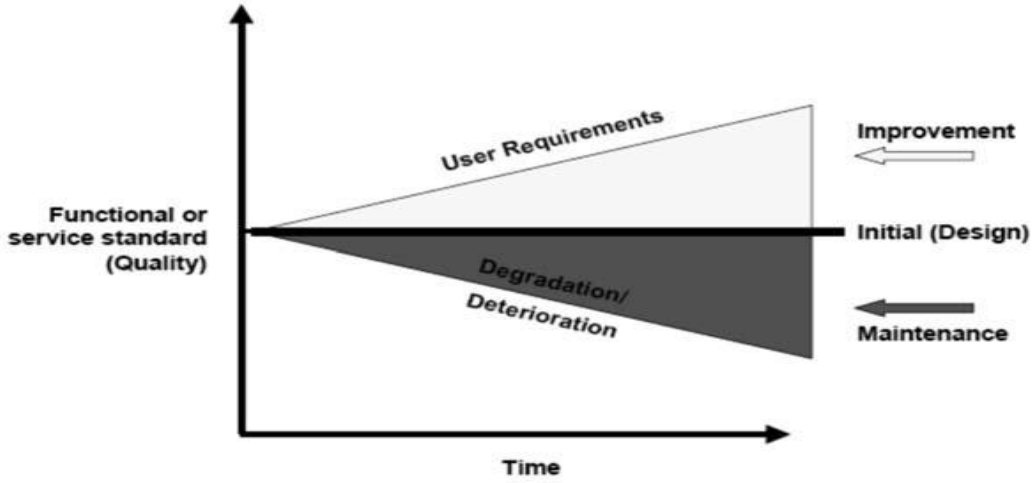

Figure5. Functionality/Quality vs. Time. , **Stanford, 2010**

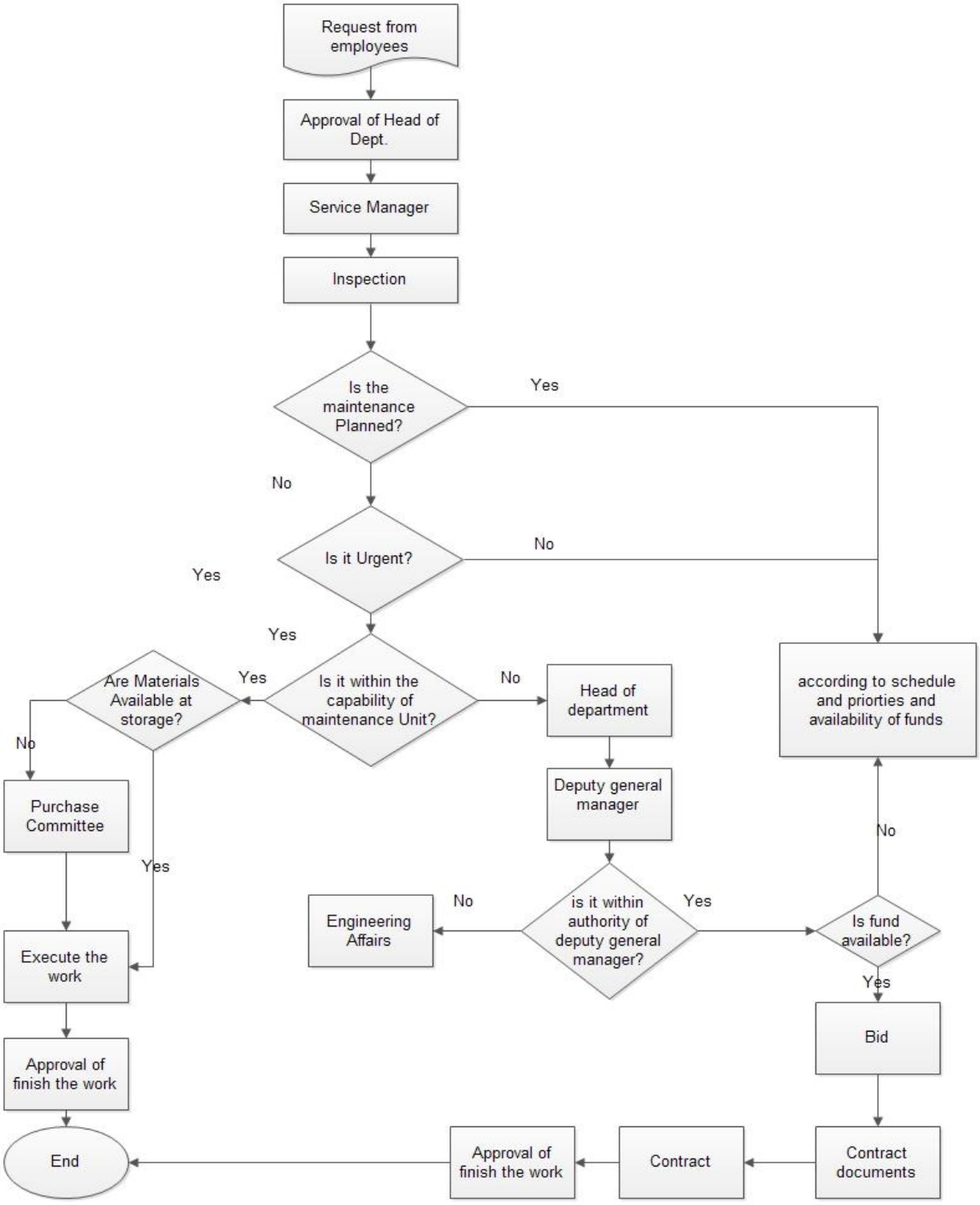

Figure6. Current building maintenance management procedure in Iraq.

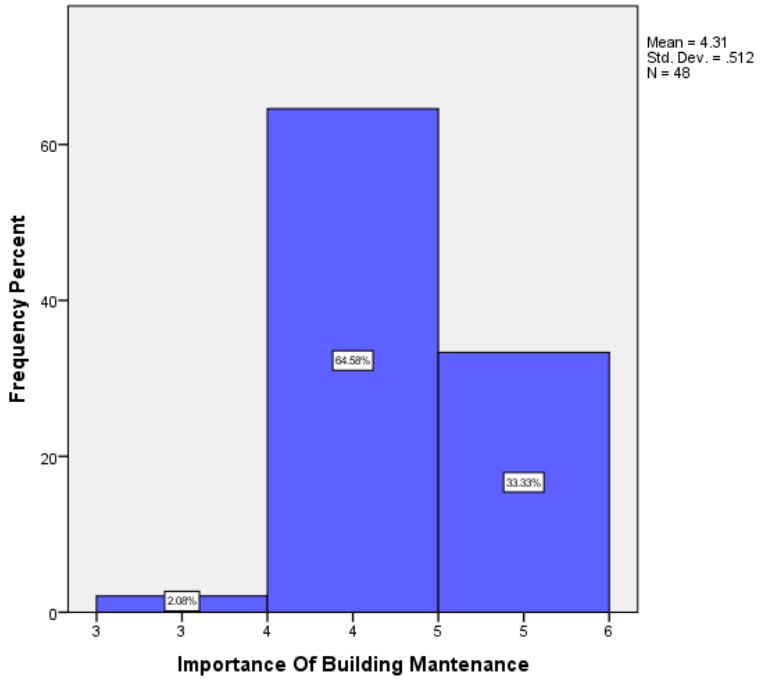

Figure7. Frequency of respondent's opinion on importance of building maintenance.

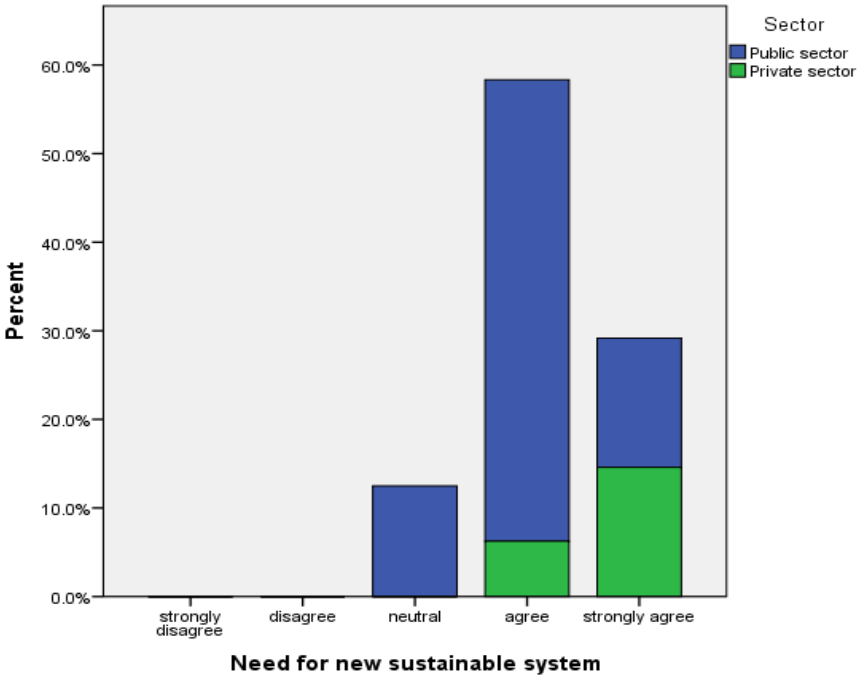

Figure8. Frequency of respondent's opinion on need for new sustainable system for maintenance management.

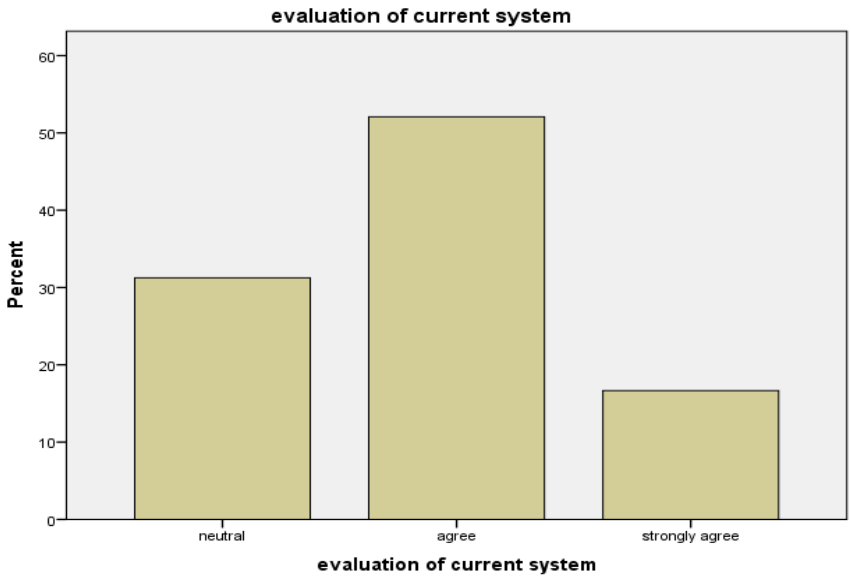

Figure9. Descriptive analysis for respondent's evaluation of current system.

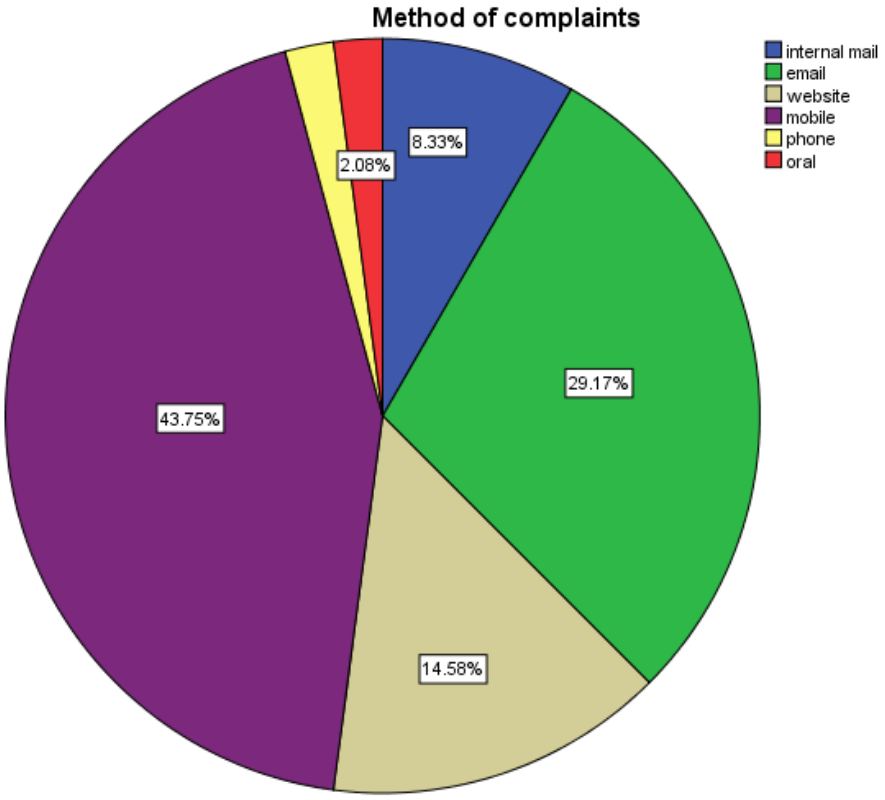

Figure10. Distribution of delivering maintenance complaint.

Table1. The logic behind maintenance types.

Maintenance Type	Logic
Corrective maintenance	Maintain when it failed
Preventive maintenance (Time-based)	Maintain it regularly
Preventive maintenance (condition-based)	Maintain it (just) before it failed
Opportunistic maintenance	Maintain it if it is cost effective
Proactive maintenance	Maintain the root causes the failure

Table2. Key questions for Sustainable building maintenance assessment.

Q1	Do you know everything about your buildings and your building maintenance management (BMM) systems and procedures? What condition they are in, where they are, their contribution to value, and what function they perform? Do you know the degree of accuracy of this information?
Q2	Do you know what is required from your BMM in the short, medium and long-term consideration?
Q3	Can your BMM deliver your buildings management objectives cost effectively?
Q4	Are you getting the best value for money from your BMM? (How could you get more value from them)?
Q5	Do you have perception about the capability in your BMM portfolio? Have some BMM systems become redundant, underused, too expensive or unprofitable?
Q6	Are you sure about the risks of your BMM and if they causing harm to people or to environment or if the risks are tolerable and at legally accepted levels?
Q7	Are your BMM-related expenditure (initial cost or capital investment and operating costs) excessive, optimal or insufficient, and if they correctly assigned across the BMM portfolio?
Q8	Do you have method to evaluate the benefits (performance, compliance, sustainability and risk reduction) of proposed work and, in the other hand, quantify the total impact in case of not performing such work, or delaying such actions?
Q9	Do you measure future problems for developing (such as risks, performance deterioration, or expenditure requirements) while obtaining short-term gains?
Q10	Do you consider to the other aspects of the organization that affect your BMM plan(s), such as knowledge, finance, people, and intangibles? In the other hand, do you consider the impact of your BMM plan(s) on these other aspects?
Q11	Are you reviewing the appropriateness of your BMM strategy in the consideration of changes in the financial, operating, and regulatory environment?
Q12	Do you continually improve your BMM system performance, and recognizing the benefits of the improvements? Are you knowing where and what improvements will be the most effective?
Q13	Are you having the necessary BMM policy, strategy and plan in order to ensure that you manage your BMM in a sustainable way?
Q14	Is your approach to sustainable management of the BMM taking appropriate account of the requirements and needs of your stakeholders and if so, do you open in the communication with those stakeholders?
Q15	Are the skills and wellbeing of your employees, working conditions, and contracted service providers given the required consideration?
Q16	Do you optimize your BMM processes and procedures in the consideration of the latest innovation and developments in technology
Q17	What are the main factors that affecting the sustainable maintenance from your point of view?
Q18	Do you have the ability to answer all of these questions confidently, and declare the answers to the interested parties?

Table3. Interviewee positions and date of interviews.

Interviewee Position	Date of interview
Assistant chief-University	Oct. 2014
Associate Dean for administrative affairs-University	Oct. 2014
Engineering Department Director-Establishment	Oct. 2014
Chief of maintenance department- Ministry	Oct. 2014
Associate manager-Secondary school	Oct. 2014
Manager - Secondary school	Nov. 2014
Director General of Engineering affairs- Ministry	Nov. 2014
Head - Medical center	Nov. 2014
Head -Police department	Nov. 2014
Director General- real estate registration office	Nov.2014
Maintenance managers (different organizations) (14 maintenance manager)	Oct 2014- Dec. 2014
Engineers working in maintenance department (different organizations) (22 engineers)	Oct 2014- Dec. 2014

Table4. Public sector/ Private sector percentage.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Public sector	38	79.2	79.2	79.2
	Private sector	10	20.8	20.8	100.0
	Total	48	100.0	100.0	

Table5. Cross tabulation between sector and specialist.

		Specialist		Total
		Engineering	Administrative	
Sector	Public sector	36	2	38
	Private sector	9	1	10
Total		45	3	48

Table6. Sector vs. experience crosses tabulation.

		Experience				Total
		between 5 and 10 years	between 10 and 15 years	between 15 and 20 years	more than 20 years	
Sector	Public sector	2	19	11	6	38
	Private sector	1	2	7	0	10
Total		3	21	18	6	48

Table7. Specialist percentage.

Specialist

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Engineering	45	93.8	93.8	93.8
	Administrative	3	6.3	6.3	100.0
	Total	48	100.0	100.0	

Table8. Sector * Need for new sustainable system Cross tabulation.

Count

		Need for new sustainable system			Total
		neutral	agree	strongly agree	
Sector	Public sector	6	25	7	38
	Private sector	0	3	7	10
Total		6	28	14	48

Table9. Descriptive analysis for respondent's evaluation of current system depend on their scientific degrees.

evaluation of current system

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Diploma	2	4.00	1.414	1.000	-8.71-	16.71	3	5
B.Sc.	29	3.72	.649	.121	3.48	3.97	3	5
M.Sc.	9	4.22	.667	.222	3.71	4.73	3	5
PhD	8	3.88	.641	.227	3.34	4.41	3	5
Total	48	3.85	.684	.099	3.66	4.05	3	5

Table10. Experience * Method of complaints Cross tabulation.

		Method of complaints						Total
		internal mail	email	website	mobile	phone	oral	
Experience	between 5 and 10 years	0	1	1	0	0	1	3
	between 10 and 15 years	1	7	3	9	1	0	21
	between 15 and 20 years	2	5	2	9	0	0	18
	more than 20 years	1	1	1	3	0	0	6
Total		4	14	7	21	1	1	48